Supplier Document Status Stamp

BSC

A. Records Designator: ☐ QA: QA ☒ QA: NA

B. LSN Relevancy: ☐ LSN Relevant ☒ Not LSN Relevant

C. Privileged or Copyright Protected: ☐ Yes ______ ☒ No

D. Procurement Document No. NN-HC4-00197

E. BSC Standard Document No. V0-CY05-NHC4-00197-00007-001-004

F. SUPPLIER DOCUMENT STATUS

1. ☒ WORK MAY PROCEED.
2. ☐ REVISE AND RESUBMIT. WORK MAY PROCEED SUBJECT TO RESOLUTION OF INDICATED COMMENTS.
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(Attach 3, Attach 4, or SSRS Form as applicable)

J. William Garfield [signature]
RESPONSIBLE ENGINEER/ANALYST (Printed Name and Signature) DATE 9/5/07

Title: Ballast Quarry Report Caliente Rail Corridor

Supplier Document #: 21-1-20102-108

Supplier Rev.: 1

Supplier Date: 07/18/07

Reference #: NVT-CD-00184

NVM Nevada Transportation Manager Bill Garfield
NE Nevada Engineering Kathy Mrotek

BSC

Supplier Document Distribution

Complete only applicable items.

QA: N/A

1. Supplier/Subcontractor Name:	Purchase Order/Subcontract No. and Title:	
Shannon & Wilson	NN-HC4-00197 /Ballast Quarry Report	
2. BSC Submittal No.:	Revision:	Title:
V0-CY05-NHC4-00197-00007-001	004	Ballast Quarry Report Caliente Rail Corridor

Responsible Individual:	Wm. Garfield	WG	423	09/05/07	09/14/07
	Name (Print)	Initials	Mailstop	Date	Due Date

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6. Document transmitted contains OUO information? ☐ Yes ☒ No

*** Use these abbreviations on the Supplier Document Status stamp to indicate reviewers.**

BSC

Transportation Data Pedigree Form

Complete only applicable items.

Subcontractor:	Item Number/Title/Revision:	Submittal Date:	SRCT No.:
Shannon & Wilson, Inc.	Ballast Quarry Report – Caliente, Rev. 1 (Submittal No. 8.6)	18 Jul 2007	06-00074

Section I. Submittal Information (includes above information)

Submittal Description and Revision Summary for Entire Submittal:

This report documents information collected from a literature review and field reconnaissance performed for the purpose of describing geologic conditions and presenting preliminary geotechnical recommendations for the proposed Caliente alignment of the Nevada Rail Line for the Yucca Mountain Project.

Revision Summary:
Rev 0, 08 Mar 06: Original submittal
Rev 1, 18 Jul 07: Revised Table 2 and Appendix E to address copyrighted material

Special Instructions:

Section II. Data File Information (Add lines below if needed for additional files. Indicate "Last item" or "End of list" after last line used.)

Filename	Rev.	File Size	Description (File description and revision summary for file)	Application and Version/ Add-in or Extension and Version
__Cover 18 July 07.ppt	1	698 KB	Ballast Quarry Report Cover	MS Power Point 2003 SP2
SW-ColourMidWidth 100.ctb	1	5 KB	Ballast Quarry Report Cover	AutoCAD 2007
Spine 1.5.jpg	1	417 KB	Ballast Quarry Report Cover Spine	Corel PHOTO-PAINT 8.0 Image
_Spines 2007.dwg	1	301 KB	Ballast Quarry Report Cover Spine	AutoCAD 2007
BSC Logo.jpg	1	22 KB	Ballast Quarry Report Cover and CD Label Image	Corel PHOTO-PAINT 8.0 Image
Jacobs LOGO.jpg	1	29 KB	Ballast Quarry Report Image	Corel PHOTO-PAINT 8.0 Image
_CD Labels 2007.dwg	1	619 KB	Ballast Quarry Report CD Label	AutoCAD 2007
CD Background 2007.jpg	1	1,280 KB	Ballast Quarry Report CD Label	Corel PHOTO-PAINT 8.0 Image
21-1-20102-108-Rev1-X.doc	1	283 KB	Ballast Quarry Report Cover Sheet	MS Word 2003 SP2
21-1-20102-108-Change-History-C-Quar.doc	1	34 KB	Ballast Quarry Report Change History Sheet	MS Word 2003 SP2
21-1-20102-108-Rev1.doc	1	27,019 KB	Ballast Quarry Report Text, Appendix Flysheets, Appendix B, C, and D Text	MS Word 2003 SP2
21-1-20102-108-T1-Rev1.doc	1	43 KB	Table 1, Quarry Designations and Locations	MS Word 2003 SP2
21-1-20102-108-T2-Rev1.xls	1	25 KB	Table 2, Summary of Laboratory Test Results	MS Excel 2003 SP2
21-1-20102-108-T3-Rev1.xls	1	19 KB	Table 3, Schmidt Hammer Results	MS Excel 2003 SP2
21-1-20102-108-T4-Rev1.xls	1	19 KB	Table 4, Quarry Site Rating Table	MS Excel 2003 SP2
Field Evaluation ES-7-Rev1.doc	1	32,330 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2
Field Evaluation NS-3A-Rev1.doc	1	10,438 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2

BSC	Transportation Data Pedigree Form *Complete only applicable items.*	QA: N/A Page 2 of 3

Subcontractor: Shannon & Wilson, Inc.			Item Number/Title/Revision: Ballast Quarry Report – Caliente, Rev. 1 (Submittal No. 8.6)	Submittal Date: 18 Jul 2007	SRCT No.: 06-00074
Field Evaluation NS-3B-Rev1.doc	1	51,963 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation NN-8A-Rev1.doc	1	10,324 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation NN-8B-Rev1.doc	1	1,049 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation NN-8C-Rev1.doc	1	3,754 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation NN-8D-Rev1.doc	1	1,583 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation NN-9A-Rev1.doc	1	851 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation NN-9B-Rev1.doc	1	1,144 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation CA-8A South-Rev1.doc	1	5,517 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation CA-8A North-Rev1.doc	1	2,970 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation CA-8B-Rev1.doc	1	6,925 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation CA-11-Rev1.doc	1	3,340 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
Field Evaluation CA-12-Rev1.doc	1	28 KB	Appendix A, Quarry Field Evaluation Checklist	MS Word 2003 SP2	
NN-8B.jpg	1	109 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
NN-8C.jpg	1	160 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
NN-8D.jpg	1	130 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
NN-9A1.jpg	1	1,005 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
NN-9A2.jpg	1	349 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
NN-9B DACITE.jpg	1	530 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
NN-9B.jpg	1	138 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
CA-11.jpg	1	138 KB	Appendix A, Quarry Field Evaluation Checklist Image	Corel PHOTO-PAINT 8.0 Image	
BQR_Lab Results.pdf	1	6,446 KB	Appendix C, Laboratory Test Results, non-text pages	Adobe Acrobat 7.0	
ROCK FIELD REFERENCE, rev-jul07.pdf	1	624 KB	Appendix E, Field Reference – Rock Classification	Adobe Acrobat 7.0	

Complete only applicable items.

Subcontractor:			Item Number/Title/Revision:	Submittal Date:	SRCT No.:
Shannon & Wilson, Inc.			Ballast Quarry Report – Caliente, Rev. 1 (Submittal No. 8.6)	18 Jul 2007	06-00074
Caliente_S&W_BQR.mdb	1	5,288 KB	ESRI 9.2 Personal Geodatabase containing the following Shannon & Wilson, Inc. native files pertaining to studies related to the Ballast Quarry Report dated 18 July 2007.	ESRI Geodatabase	
CalienteBallastRpt,R1,18jul07.pdf	1	88,038 KB	Adobe Acrobat Report	Adobe Acrobat 7.0	
			----------------------Last Item---------------------		

Section III. Metadata

☒ **GIS Metadata** All GIS data is preferred in ArcGIS9.1 UTM, NAD1983, Zone11, Feet.	Projection: UTM
	Datum: NAD 83
	Zone: 11 N
	Units: Feet
☐ **CAD Metadata** CAD drawings are preferred in **Bentley MicroStation V8 and/or InRoads** and should adhere to established **CAD standards**.	Level descriptions:
	Scale:
	Units of Measurement:
	Horizontal and Vertical Datum:

Section IV. Data Screening (Completed by BSC personnel)

Acceptable for Review?	Screener Name:	Signature:	Date:
☒ Yes* ☐ No	Cathy Stettler	Cathy Stettler	8/22/07

*If "Yes", Data Storage Location: nvtdata\SW\Phase1\06-00074 Ballast Quarry Rpt CRC Rev 01 07-18-07

Comments: *(Justification for returning submittal is **required**; other comments are optional.)*

Section V. STR/STR Support Disposition of Submittal

Process for Review?	** If "No", date returned:	Comments:	
☐ Yes ☐ No**			
STR/STR Support Name: Wm. Garfield		Signature: Wm. Garfield	Date: 8/23/07

KAM 8/23/07

Data Definitions for Caliente Ballast Quarry Report GIS Features

Feature Class: alignment_rev8_20_mi_buffer

Description: 20 mile buffer created based on BSC Alignment

Purpose: Show the limit of 20 miles of the Rev 8 Caliente alignment

Revision History: No changes

Number of records: 1

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software

Feature Class: GPS_waypoints_BQR

Description: This point feature class represents areas of interest collected by Shannon & Wilson, Inc. in the field while individual teams investigated the Caliente Corridor for the Ballast Quarry Report.

Purpose: To identify areas visited in various team field reconnaissance trips

Revision History: No changes.

Number of records: 143

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.

Field Name	Data Type	Description of field
SHAPE	Geometry	Point
Waypoint	Text	Waypoint ID
Trip	Text	Trip ID

Feature Class: NTS_building_rev8

Description: Nevada Test Site building mock-up

Purpose: To show an approximate schematic of the Nevada Test Site buildings

Revision History: No changes.

Number of records: 14

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon.
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: NTS_rail_rev8

Description: Nevada Test Site rail mock-up

Purpose: To show an approximate schematic of the Nevada Test Site rail

Revision History: No changes.

Number of records: 28

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polyline
Type	Text	Type
SHAPE_Length	Double	Length of feature in feet generated by software.

Feature Class: potential_ballast_quarry_sites

Description: Polygons showing areas of potential ballast quarry sites

Purpose: To identify areas associated with the investigation of suitable ballast source areas.

Revision History: No changes.

Number of records: 100

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon.
Group_	Text	Ballast Quarry Site Group ID
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: potential_ballast_quarry_sites_13

Description: Subset of 13 ballast quarry sites from "potential_ballast_quarry_sites" feature class

Purpose: Identify a targeted set of sites for potential ballast quarries selected for further study

Revision History: No changes.

Number of records: 14

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon.
Group_	Text	Ballast Quarry Site Group ID
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: potential_ballast_quarry_sites_facilities

Description: Polygon features pertaining to quarry sites. Features include potential quarry pits, quarry spoil stockpiles, plant sites, and railroad sidings.

Purpose: To show the layout of potential ballast quarry sites

Revision History: No Changes

Number of records: 44

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon
Type	Text	Type of facility
SHAPE_Length	Double	Length of feature in feet generated by software.

Field Name	Data Type	Description of field
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: potential_ballast_quarry_sites_grouping

Description: Grouped areas for potential ballast quarry sites

Purpose: Simplification of "potential_ballast_quarry_sites" feature class

Revision History: No Changes

Number of records: 35

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: potential_ballast_quarry_sites_grouping_13

Description: Subset of 13 areas from "potential_ballast_quarry_sites" featureclass

Purpose: Simplification of 13 areas from "potential_ballast_quarry_sites" featureclass

Revision History: No Changes

Number of records: 14

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon

Field Name	Data Type	Description of field
Type	Text	Type of facility
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: potential_ballast_quarry_sites_roads

Description: Line features showing potential roads and rail within potential ballast quarry sites

Purpose: To show the potential layout of roads and rail within potential ballast quarry sites

Revision History: No Changes

Number of records: 31

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polyline
Type	Text	Type of line
SHAPE_Length	Double	Length of feature in feet generated by software.

Feature Class: project_outline_250000

Description: Polygon area of project extent at 250K

Purpose: Show the extent of the Caliente project

Revision History: No Changes

Number of records: 1

Field Name	Data Type	Description of field

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: sheet_index_fig6_bqr

Description: Polygons of sheet index for Figure 6

Purpose: To create the mapsheets for Figure 6

Revision History: No Changes

Number of records: 10

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon
Sht_No	Text	Sheet Number, from project-wide Sheet Index
Name	Integer	Sheet number for Figure 6
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: stationing_rev11_24000_anno

Description: Alignment stationing annotation at 24K scale for BSC alignment, rev 11.

Revision History: No Changes

Number of records: 249

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Annotation
TextString	Text	Annotation Text

Feature Class: stationing_rev11_24000_line

Description: Alignment stationing leader lines at 24K scale for BSC alignment, rev 11.

Revision History: No Changes

Number of records: 2509

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polyline
SHAPE_Length	Double	Length of feature in feet generated by software.

Feature Class: stationing_rev11_250000_anno

Description: Alignment stationing annotation at 250K scale for BSC alignment, rev 11.

Revision History: No Changes

Number of records: 55

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Annotation
TextString	Text	Annotation Text

Feature Class: stationing_rev11_250000_line

Description: Alignment stationing leader lines at 250K scale for BSC alignment, rev 11.

Revision History: No Changes

Number of records: 282

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polyline
SHAPE_Length	Double	Length of feature in feet generated by software.

Feature Class: title_block_250000

Description: Polygon area for title block of 250K scale maps and plates.

Purpose: To create white space for text to be inserted in the page layout on the map documents

Revision History: No Changes

Number of records: 2

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.

Feature Class: title_block_fig6

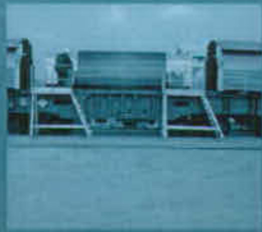
Description: Polygon area for title block for Figure 6

Purpose: To create white space for text to be inserted in the page layout on the map documents

Revision History: No Changes

Number of records: 1

Field Name	Data Type	Description of field
OBJECTID	Object ID	Unique identifier generated by the software. This identifier will act as a primary key.
SHAPE	Geometry	Polygon
SHAPE_Length	Double	Length of feature in feet generated by software.
SHAPE_Area	Double	Area of feature in feet generated by software.


Ballast Quarry Report
Caliente Rail Corridor

SRCT:
06-00074

Task 4.8: Ballast Quarry Report (Submittal No. 8.6)

Rev. 1

Prepared by:

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

In Association With:

JACOBS

Ninyo & Moore

Prepared for:

BECHTEL SAIC COMPANY, LLC

Nevada Rail Corridor
Yucca Mountain Project
Geotechnical Analysis
NN-HC4-00197

July 18, 2007

Ballast Quarry Report
Rev. 1
Caliente Rail Corridor
Yucca Mountain Project, Nevada

Subcontract No. NN-HC4-00197

18 July 2007

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

At Shannon & Wilson, our mission is to be a progressive, well-managed professional consulting firm in the fields of engineering and applied earth sciences. Our goal is to perform our services with the highest degree of professionalism with due consideration to the best interests of the public, our clients, and our employees.

Submitted To:
Bechtel SAIC Company
1180 Town Center Drive
Las Vegas, Nevada 89144

By:
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, Washington 98103

21-1-20102-108

Prepared using MS-WORD 2003

CHANGE HISTORY

Revision Number	Date	Description of Change
00	8 March 2006	Initial Issue
01	18 July 2007	Revised Table 2 and Appendix E

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES
(included with text)

Page

LIST OF FIGURES (cont.)

Figure No.

PLATE

Plate No.

LIST OF APPENDICES

Appendix

ACRONYMS AND ABBREVIATIONS

A	insufficient evidence for certainty rating (as relates to mineral potential)
AASHTO	American Association of State Highway and Transportation Officials
Ag	silver
ANSI	American National Standards Institute
AREMA	American Railway Engineering and Maintenance-of-Way Association
As	arsenic
ASTM	American Society for Testing and Materials
Au	gold
AWWA	American Water Works Association
B	low certainty rating (as relates to mineral potential)
Ba	barium
BBE	Busted Butte East
BCFG	billion cubic feet of gas
Be	beryllium
BGRR	Beatty Goldfield Railroad
Bi	bismuth
BLM	U.S. Bureau of Land Management
BMPs	Best Management Practices
BNSF	Burlington Northern Santa Fe Railway Company
BSC	Bechtel SAIC Company, LLC
C	moderate certainty rating (as relates to mineral potential)
CAPP	Chemical Accident Prevention Program
Cd	cadmium
cm	centimeter
Co	cobalt
CPT	cone penetrometer test
Cr	chromium
CRC	Caliente Rail Corridor
CS	common segment
Cu	copper
D	high certainty rating (as relates to mineral potential)
DCM	Design Criteria Manual
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
EOR	engineer of record
EPA	U.S. Environmental Protection Agency
EWDP	Early Warning Drilling Program
F	fluorine

ACRONYMS AND ABBREVIATIONS (cont.)

FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
FOB	free on board
FRA	Federal Railroad Administration
FY	fiscal year
GCMC	Goldfield Consolidated Mines Company
G-DCM	Geotechnical Design Criteria Manual
GF3	Goldfield 3 Route
GIS	Geographic Information System
gpm	gallons per minute
GPS	global positioning system
g/t	grams per ton
H	high mineral potential
HASP	Health and Safety Plan
Hg	mercury
HSA	hollow-stem auger
H:V	horizontal to vertical
HSU	hydrostratigraphic units
IDW	investigation-derived waste
in/sec	inches per second
ISRM	International Society of Rock Mechanics
Jacobs	Jacobs Engineering, Inc.
K	potassium
KGRA	known geothermal resource area
km	kilometer
L	low mineral potential
LV&TRR	Las Vegas and Tonopah Railroad
M	moderate mineral potential
Ma	million years old or million years ago or million years before present
MGR	Managed Geologic Repository
MILS	mineral property location database compiled by the U.S. Bureau of Mines
mm	millimeter
mm/sec	millimeters per second
mm/yr	millimeters per year
MMBO	million barrels of oil
Mn	manganese
MnO	manganese oxide
Mo	molybdenum
M&O	Maintenance and Operation
mph	miles per hour
MPR	Mineral Potential Report

ACRONYMS AND ABBREVIATIONS (cont.)

MRDI	Mineral Resource Development, Inc.
MRDS	mineral resource dataset compiled by U.S. Geological Survey
MS	mineral survey
MSE	mechanically stabilized earth
MSEW	mechanically stabilized earth wall
MVGI	Metallic Ventures Gold, Inc.
N&M	Ninyo & Moore, Inc.
Na	sodium
NAC	Nevada Administrative Code
NBMG	Nevada Bureau of Mines and Geology
NDEP	Nevada Division of Environmental Protection
NDOT	Nevada Department of Transportation
NEPA	National Environmental Policy Act
Ni	nickel
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRL	Nevada Rail Line
NRP	Nevada Rail Partners
NTS	Nevada Test Site
NTTR	Nevada Test and Training Range (formerly Nellis Air Force Base and Testing Range)
NVT	Nevada Transportation
NWRPO	Nuclear Waste Repository Project Office
O	no mineral potential
OCRWM	Office of Civilian Radioactive Waste Management
O.D.	outside diameter
opt	ounces per ton
oz	ounce, specifically troy ounce in this report
oz/t	ounces per ton
P	phosphorous
Pb	lead
PGA	peak ground acceleration
PGR	Preliminary Geotechnical Report
PM	particulate matter
ppb	parts per billion
ppm	parts per million
PSHA	probabilistic seismic hazard analysis
psi	pounds per square inch
PV	prefabricated vertical
PVC	polyvinyl chloride
QA	quality assurance

ACRONYMS AND ABBREVIATIONS (cont.)

QC	quality control
RFI	Request for Information
RFP	Request for Proposal
ROD	Record of Decision
ROE	right-of-entry
ROW	right-of-way
RQD	rock quality designation
RSS	reinforced soil slopes
S&W	Shannon & Wilson, Inc.
Sb	antimony
Sc	scandium
SCS	Soil Conservation Service
Se	selenium
SFRS	steel fiber-reinforced shotcrete
SI	International System of Units
Sm	samarium
Sn	tin
SPT	Standard Penetration Test
SR	State Route
Sr	strontium
SSURGO	Soil Survey Geographic Database
T&TRR	Tolicha and Tonopah Railroad
TBM	Tunnel Boring Machine
T N	Township North
T S	Township South
Tl	thallium
tpd	tons per day
tpy	tons per year
tsf	tons per square foot
U	uranium
UPRR	Union Pacific Railroad Company
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USBM	U.S. Bureau of Mines
USBR	U.S. Bureau of Reclamation
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
V	vanadium
W	tungsten

ACRONYMS AND ABBREVIATIONS (cont.)

WPCP	Water Pollution Control Permit
wt%	weight percent
YMP	Yucca Mountain Project
Zn	zinc

BALLAST QUARRY REPORT

CALIENTE RAIL CORRIDOR
YUCCA MOUNTAIN PROJECT, NEVADA

1.0 INTRODUCTION

This report documents preliminary information collected from detailed field reconnaissance and associated laboratory testing of surface samplings for identifying rock formations that may be potential sources of ballast for the proposed Nevada Rail Line (NRL) for the Yucca Mountain Project (YMP).

1.1 Purpose and Scope

This report provides information regarding sites that may have rock suitable for processing into ballast to support the Caliente Rail Corridor Draft Environmental Impact Statement (DEIS). The scope of work included (a) training and badging for the field geologists, (b) visiting 15 potential sites for geologic field reconnaissance along the proposed corridor, (c) laboratory testing of the rock obtained from outcrops at 13 of the sites, and (d) preparing this Ballast Quarry Report.

The purpose of the field reconnaissance was to observe exposures and outcrops of the deposits to assess if these deposits would likely constitute a suitable source, and to gather other important information that would affect the selection of the sites.

No subsurface explorations were conducted as part of this study. Evaluation of rock materials for use as ballast was based on visual observation of outcrops, samples removed from rock outcrops, and the results of laboratory testing of the rock samples. The rock samples were subjected to seven tests using laboratory facilities at four companies. For use in construction, it is assumed that ballast would have to satisfy the appropriate specifications listed in the 2005 edition of the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual of Railway Engineering (AREMA Manual, 2005).

1.2 Previous Studies

Two reports pertaining to potential ballast quarries were prepared during Phase 1 of the project. The Ballast Sourcing Cost Analysis (S&W, 2005a) presented ballast quarry criteria, permitting issues, typical quarry layout and equipment features, and estimated costs for several feasible scenarios of quarry development. The Preliminary Ballast and Construction Materials Sources Report (S&W, 2005b) was the first step in identifying potential sources of ballast along the 28 March 2005 (Rev. 5) NRL alignment. This report is the next step in the process of narrowing the number of choices for suitable ballast quarries. It used the 18 August 2005 (Rev. 11) alignment with a U.S. Geological Survey (USGS) contour base.

1.3 Acknowledgements

This report was prepared by Shannon & Wilson, Inc. (S&W). Paul Godlewski (Project Manager, S&W) and Steve McMullen (Project Engineer, S&W) provided oversight for the task. Bill Laprade (Supervising Geologist, S&W) supervised the field reconnaissance of the potential quarry sites. The field reconnaissance was performed by two S&W teams (Q1 and Q2), each comprised of two geologists. Team Q1 consisted of Art Geldon and Matt Grizzell, and team Q2 consisted of Keith Rauch and Cody Sorensen. Bill Laprade was the primary author of this report, with contributions from the field personnel. Dex McCulloch, Principal-in-Charge, reviewed this report.

1.4 Authorization

This work was performed in general accordance with YMP Technical Services contract No. NN-HC4-00197, Caliente Rail Corridor Geotechnical Analysis, Subcontractor Change Notice 6, effective 31 October 2005. This document was prepared under Work Item 4.8 of the contract and this draft is submittal number 8.6.

2.0 GENERAL PROJECT AND SITE DESCRIPTION

2.1 Railroad Description

The U.S. Department of Energy (DOE) has selected the Caliente Rail Corridor within which to determine an alignment for the construction and operation of a railroad to transport spent nuclear fuel and high-level waste to a repository planned near Yucca Mountain.

The 319-mile long corridor originates at the Union Pacific Railroad (UPRR) mainline track near Caliente, Nevada. It then extends northwest toward Tonopah. It wraps around the north and west sides of the Nevada Test and Training Range (NTTR) before entering the Nevada Test Site (NTS) near its southwest corner, terminating at the southern entrance to the Yucca Mountain site (Plate 1). The exact location of the connection between the proposed rail line and UPRR has not been identified and two alternatives are currently being evaluated. The rail line is anticipated to consist of a single track, with passing sidings at appropriate intervals.

The typical facilities associated with a quarry site and the assumptions governing quarry siting and costs were described in Ballast Sourcing Cost Analysis (S&W, 2005a). In summary, they are as follows:

- The quarry and appurtenant facilities located on U.S. Bureau of Land Management (BLM) land available through the BLM mineral materials leasing program.
- Quarry located within 20 miles of the rail alignment.
- Quarry site at least 80 to 120 acres.
- Ballast processed at or adjacent to the quarry site.
- Quarry highwalls approximately 80 feet high with slopes of 1 Horizontal to 1 Vertical (1H:1V).
- Waste dump approximately 40 feet high, with a 14-acre footprint and 3H:1V slopes.

The principal parts of the quarry site would include the quarry rock pit, waste dump, processing/production area, ballast stockpile, settling ponds, water well(s), power generation unit, offices/housing, scales, loading facility, and connecting access/haul roads. A drawing showing a conceptual layout of these components, previously presented in the Ballast Sourcing Cost Analysis (S&W, 2005a), is presented in Figure 1.

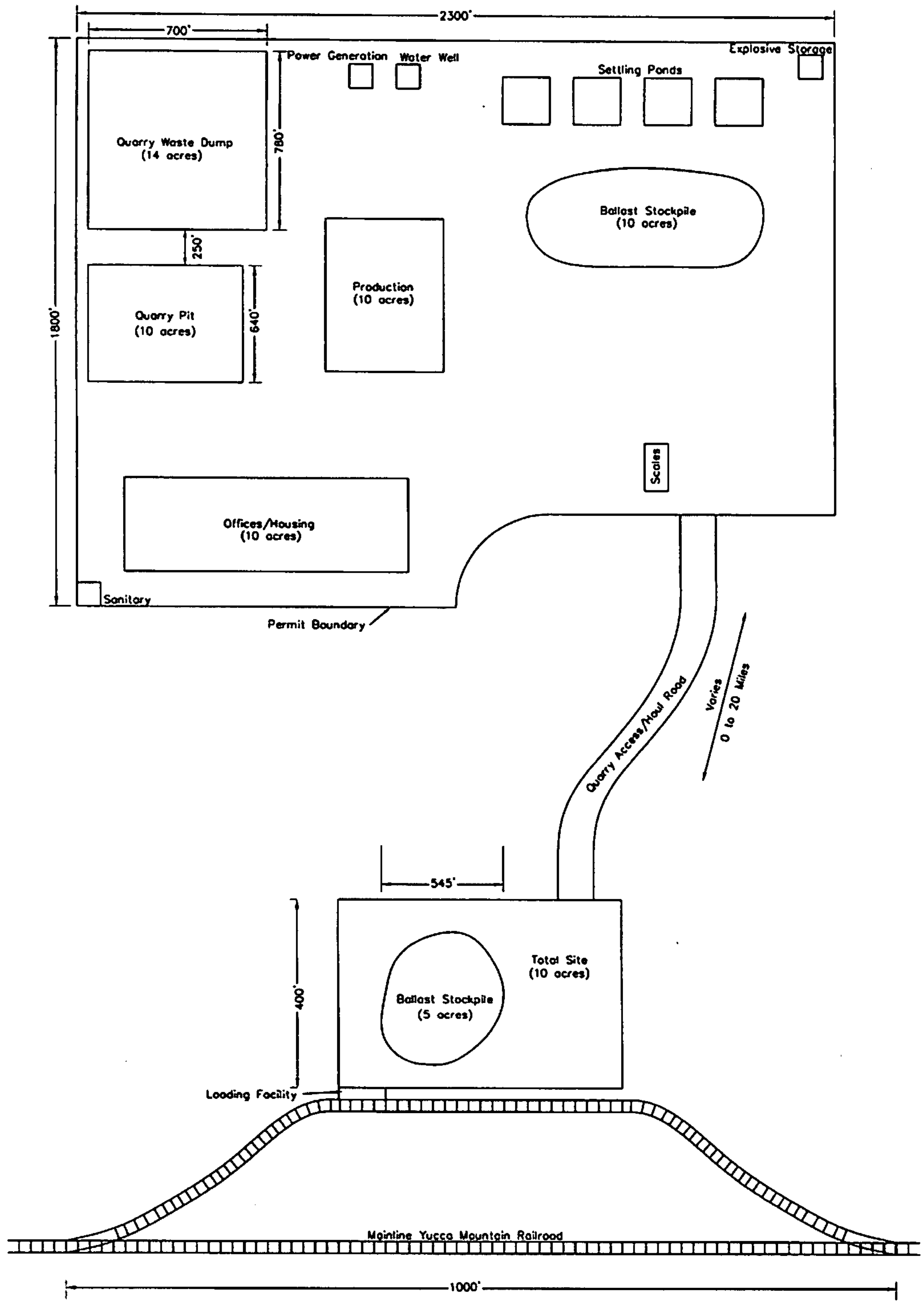


Figure 1. Typical Production Site Layout

A typical quarry headwall about 50 feet high is shown in Figure 2. Some typical parts of the quarry operation are shown in Figure 3 (Typical Blast Hole Drilling Rig on Headwall), Figure 4 (Portable Crushing/Screening Plant), and Figure 5 (Truck Haulage from Crushed Rock Stockpile).

Figure 2: Typical Quarry Headwall

Figure 3: Typical Blast Hole Drilling Rig on Headwall

Figure 4: Portable Crushing/Screening Plant

Figure 5: Truck Haulage from Crushed Rock Stockpile

Nevada Rail Partners' (NRP) latest estimate calls for approximately 3.1 million in-place tons of crushed rock ballast for new track construction (NRP, 2005). Industry references (Oriard, 2002) indicate that 5 to 25 percent of the in situ rock typically is lost in the hauling, crushing, screening, stockpiling, and transferring process; however, the in situ deposit likely would not be uniform. Some materials unsuitable for ballast would likely be encountered in the quarry pit, especially in layered basalt flows. These unsuitable materials can produce an average of about 25 percent natural loss. Together, the two different losses could add up to 30 to 50 percent loss. The total loss could be on the lower end of this range for granitic rock. At this time, it should be assumed that wastage at various stages of the processing and transportation of the ballast would necessitate a reserve of at least 6.2 million tons for this project. In both cases, these deposits should be considered to be possible or probable reserves (Barksdale, 1991), not proven. As such, the potential for loss (from the in situ condition to the railroad alignment) should remain on the high end of the range until subsurface information is available.

Other uses of the same processed rock could potentially be access road surfacing, siding surfacing, erosion control stone, and foundation stabilization material for structures and quarry processing equipment. Oversized rocks that are too large for the crusher jaws could be used for riprap. If the processed rock is used for any of these other purposes, additional tonnage would be necessary.

2.2 Quarry Site Selection List

An initial list of potential ballast quarry sites was generated by S&W and presented in the Ballast and Construction Materials Sources Report (S&W, 2005b). Based on a literature search, which included maps that showed formations of particular rock types, 56 possible sources areas were identified. Through a collaborative process among BSC, NRP, and S&W, the list of sites was eventually reduced to nine.

Because some of the areas were large, they were split into two pieces for study purposes. The final result was 13 potential quarry sites, as shown in Plate 1. Table 1 presents the designations of the sites, their county, and valley/range. Figure 6 (located at the end of the report) shows the sites on a series of 1:24,000 and 1:30,000 maps. Three of the sites are in the western end of the alignment, six in the central part, and four in the eastern end.

At the beginning of this field reconnaissance, the list included quarry site CA-12 in Clover Creek; however, a site visit by Quarry Team 2 (Q2) resulted in a determination that it was not viable for ballast production. A more detailed description of the observations near CA-12 is presented in Appendix A. One site, CA-8A(N), was added to the list, because discussions with the operator of an existing quarry at site CA-8A(S) indicated that a promising site may be located at the northern edge of the study area. After a site reconnaissance by Quarry Team 1 (Q1), CA-8A(N) was added to the list of potential ballast sources. The southern end of site NN-9B was preliminarily considered as a distinct site because its dacite outcrop was separated topographically from and contained a different rock type than the basalt flow to the north; however, after a one-day field evaluation and discussions with BSC, this site was dropped from consideration.

3.0 APPROACH TO FIELDWORK

Potential ballast source areas were visited by the two field reconnaissance teams to make geologic observations, assess site accessibility, and collect rock samples. Field procedures were outlined in the scope of work and in a NVT Work Authorization for Fieldwork dated 8 November 2005. Quarry teams and the supervising geologist, Bill Laprade, met with BSC managers on 14 November 2005, to discuss safety issues and field procedures. After training on communications and Global Positioning System (GPS) equipment, both field crews drove to Tonopah, Nevada, on 15 November 2005. On 16 November 2005, Mr. Laprade and the field crews performed a one-day training session at quarry site NN-9A in Reveille Valley to review field observation requirements, Schmidt Hammer operation, and rock sampling procedures. Mr. Laprade returned to Las Vegas on 17 November 2005, and the two crews stayed in Tonopah to perform fieldwork.

3.1 Field Reconnaissance

The first stage of field reconnaissance was conducted between 16 and 21 November 2005, in the Goldfield and Reveille Valley areas, after which the crews returned to Las Vegas on 22 November, delivered rock samples from eight sites to Ninyo & Moore's laboratory, and then returned to their homes for the Thanksgiving holiday. The teams resumed field assessments on 29 November 2005. One additional site was completed by Q2 in the Reveille Valley area and then the team moved to Caliente. Quarry team Q1 drove directly to Caliente upon its return from the holiday. Fieldwork was completed by team Q1 on 2 December, and Q2 finished fieldwork on 4 December, 2005. Samples of five sites were delivered to Ninyo & Moore's laboratory on 5 December, 2005.

In general, the quarry teams required an average of two days to complete an evaluation of a quarry area. The teams consisted of two geologists each, the lead of which had 25 to 30 years of experience. Biosketches of the geologists are presented in Appendix B. They used GPS units connected to software on laptop computers to track their locations and record waypoints of important features in the field. A field information form was created to facilitate collection of observations and sampling locations. Cursory information was emailed daily to the S&W project engineer, and completed field forms were submitted shortly after the completion of fieldwork. The completed Quarry Field Evaluation Checklists for each site are presented in Appendix A. They include site observations, sketches, and photographs.

3.2 Rock Characterization

Rock strengths were estimated from simple field tests, such as a geologist's rock hammer blows and a Schmidt Hammer, at each potential resource site visited because rock strength roughly correlates with abrasion resistance, toughness, and load bearing. Other attributes of the rock, such as lithology, mineral constituents, vesicularity, oxidation, weathering, and presence or absence of undesirable secondary mineralization, inclusions, or fillings, were assessed visually and recorded in the field notes.

Characteristics of the overall rock mass that could affect quarrying were observed. These included the nature and geometry of structural discontinuities, bedding or flow thickness, continuity of beds or flows, and the presence of voids and solution cavities. Additional geologic characteristics the team noted included the presence of partings or seams of undesirable lithologic variations within the rock mass, such as scoria, flow breccia or rubble zones, shale, and sandstone interbeds. Shannon & Wilson's Field Classification of Rock was used as a guide for the description of rock (Appendix E).

3.3 Quarry Site Characterization

Each potential ballast resource site visited was assessed for accessibility and potential quarry operational constraints. The distance in miles to existing dirt, gravel, and paved highways was noted, as well as the distance from the proposed rail alignment. The available site size and general site layout and outcrop geometry were assessed in relation to quarry operation and excavation methodology. This included general observations of site topography, estimated mineable thickness of the deposit, and structural attitudes of discontinuities that could adversely impact quarry operations. In general, the quarry teams reconnoitered the entire potential source area before choosing a preferred site for the quarry pit. An outcrop at or near the preferred site was then sampled.

3.4 Other Field Activities

Samples were collected from rock outcrops that were representative of the competent or potentially suitable material for ballast. Because the outcrops contained very hard rock, the samples were obtained by dislodging chunks from the outcrop with a 4-pound sledgehammer. Sixty to 100 pounds of rocks were placed in cloth sacks and labeled. In general, the individual pieces of rock ranged from about 1 to 10 pounds.

Daily work activities were planned each evening and communicated to Steve McMullen of S&W, the Task Leader. Mr. McMullen was informed of the Field Teams' itineraries for the next day. Before entering the field each day, team members discussed the planned work activities, conducted and documented a pre-shift safety meeting, and inspected the vehicle, field equipment, safety equipment, and the other team members' physical and mental condition. Each evening the team reviewed daily progress, reconciled field notes, and reviewed safety issues that came up in the course of the fieldwork. The observations and collected field data were backed up each day by making photocopies of field notebooks and downloading photographs into laptop computers.

Photographs of the areas visited during the field reconnaissance were taken at selected sites. The frame index numbers were recorded in the field notes and with GPS coordinates and azimuth-direction of view. Photographs are included in Appendix A in each quarry report.

4.0 BALLAST CRITERIA AND SUMMARIES OF POTENTIAL QUARRY SITES

4.1 Criteria for Ballast

Ballast from natural rock sources is produced by crushing, screening, and washing quarried rock. As discussed in the Geotechnical Design Criteria Manual (S&W, 2005c), aggregate gradations used as ballast include all five mainline ballast gradations (24, 25, 3, 4A, and 4) .

Ballast material should meet the specifications outlined in the AREMA Manual (2005). Material property requirements for processed material include gradation, specific gravity, absorption, degradation, soundness, undesirable particles (clay lumps, friable, flat, elongated) and for some aggregates, chemical analysis. Recommended limiting values of testing for ballast material property requirements are listed in Table 2. In general, it is not possible to evaluate with certainty if a particular source rock would yield material meeting the limiting test values by merely observing the source rock or by taking samples from limited field outcrops. However, at this stage of the project, it was only possible to take samples from field outcrops for testing. The goal of the field reconnaissance teams was to take samples that were representative of the suitable rock available in outcrop; however, the degree to which it is representative of the rest of the deposit is unknown. Unsuitable rock, for example weak or fractured, was not sampled, but could potentially be a significant percentage of the rock not exposed in outcrop.

Section 2.2 of the AREMA Manual (2005) lists typical properties of acceptable ballast materials as follows:

- Ballast rock should be both hard and dense.
- The rock should have an angular particle structure that provides sharp corners and cubical fragments when crushed.
- The rock should be free of deleterious materials or inclusions.
- The rock should provide high resistance to temperature changes and chemical attack.
- The rock should have high electrical resistance and low water-absorption properties.
- The rock should be free of cementing characteristics.
- The rock should have sufficient unit weight (pounds/cubic foot), and have a limited amount of flat or elongated particles after processing.

The lithologies recommended by AREMA that often yield acceptable materials include granite, traprock, quartzite, limestone, and dolomitic limestone, although limestone and dolomite are normally not used if other suitable rocks are available. All of the natural rock types listed above occur within 20 miles of the alignment. In addition, blast and steel furnace slags (byproducts of industrial processes) can be processed into ballast. Although in the 19^{th} and early 20^{th} centuries small smelters processing gold and silver ores operated in portions of central Nevada, slag in quantities sufficient to meet project requirements was neither observed during the field reconnaissance nor identified from the literature search.

Concrete ties produce greater crushing loads; therefore, the AREMA Manual (2005) limits the use of concrete ties to ballast comprised of granite, traprock, or quartzite. Additionally, limestone and dolomite rock fines generated during shipping, handling, placement, tamping, and especially under traffic commonly tend to re-cement, thereby causing problems with drainage, surface levelness, and line of the track structures (AREMA, 2005). Although limestone and dolomite were discussed as possible ballast rocks during 2005 screening studies (S&W, 2005b), they were not recommended in that study, and are not considered during the present study.

When in situ rock is blasted, it expands significantly to its "loose" or "bulked" condition. This percentage of volume transformation is used to approximate such information as the number of trucks for haulage and the size of crushing and processing equipment. Two reliable references (Church, 1981, and Caterpillar, 2001) indicate that the volume expansion to a loose condition is 64 to 67 percent for basalt and 61 to 72 percent for granite.

4.2 Potential Source Rocks

The locations of the 13 potential ballast sources are plotted on a 1:250,000-scale map (Plate 1). In addition, they are shown in greater detail on larger-scale, 1:24,000 and 1:30,000 maps on Figure 6, Sheets 1 through 11. Detailed maps and photographs of the sites are included in Appendix A. Three general rock types, basalt or traprock, quartzite, and granitic rock, were evaluated. Some characteristics of these rocks are presented below, followed by summaries of each of the 13 potential ballast source sites.

4.2.1 Basalt/Traprock

Basalt is a dark, fine-grained, extrusive igneous rock that forms at or just below the surface as volcanic lava flows and shallow intrusions. It generally cools very quickly and has a very fine-grained crystalline texture, often containing small, spherical voids (vesicles) formed by the expansion of gas or steam during the solidification of the rock, particularly on the top portion of a flow. Basalt is considered a variety of "traprock" in the AREMA Manual (2005). Seven of the sites contained basalt or basaltic rocks.

Traprock is a term used to describe any darker-colored, fine-grained, non-granitic igneous rock. In addition to basalt, this general definition also includes rhyolite, dacite, rhyodacite, andesite, diorite, and diabase, all of which occur within the search area. These igneous rocks either are subaerial flows or formed from magma emplaced at relatively shallow depths in the crust through intrusions into existing surrounding rock. Three of the sites contained types of traprock (rhyolite and andesite) other than basalt.

4.2.2 Granite

Granite is a plutonic igneous rock consisting chiefly of quartz and feldspars. "Plutonic" refers to rocks that form at considerable depths in the earth's crust from an igneous molten state (magma). Granites cool and crystallize very slowly deep beneath the earth's surface and develop a coarse, crystalline, "granitoid" texture. Eventually, the pluton may be uplifted and exposed at the earth's surface through erosion. Granitic rocks include many varieties, but the most prevalent are granite, granodiorite, pegmatite, and quartz monzonite. One granite site (quartz monzonite) was evaluated for this study.

4.2.3 Quartzite

Quartzite is a metamorphic rock consisting mainly of quartz formed through recrystallization of sandstone. Sandstone and other sedimentary rock buried deep in the earth's upper crust can undergo regional or contact-thermal metamorphism where heat and pressure cause recrystallization of silica in the sand to quartz. Quartzite may also include unmetamorphosed sandstone where the entire rock mass has been cemented with secondary silica, such that the rock breaks across individual sand grains rather than around them. Two quartzite sites were visited and evaluated for this study.

4.3 Summaries of 13 Potential Ballast Quarry Sites

The 13 ballast quarry sites are summarized in the following sections. Individual field descriptions are presented in Appendix A, Quarry Field Evaluation Checklists, in which detailed information is written by the field crews. In the summaries, small maps are included that show the conceptual layouts (Figures 7 through 19) at each site. They are shown in a broader context on 1:24,000 or 1:30,000 maps on Figure 6. An index and legend for these maps are presented in Figure 6 (Sheet 1).

4.3.1 Area ES-7 Quarry Site Characteristics

Area ES-7 is located on Malpais Mesa, about 1¼ miles west of Goldfield, Esmeralda County, Nevada (Figure 6, Sheet 2). Malpais Mesa is bordered on the east by the Montezuma Valley and on the west by the Montezuma Range. The surface of the mesa is moderately dissected by northeast-draining canyons and their tributary washes. The east side of the mesa slopes gently down toward an escarpment above the Montezuma Valley. Three northerly-aligned buttes rise above the general surface of the mesa on its west side. The two northern buttes, in part, slope gently toward washes separating Malpais Mesa from the Montezuma Range.

A potential ballast quarry site is located in Township 3S, Range 42E, Section 4, which is in the northwest corner of Malpais Mesa. The potential quarry site is located near the head of a northeast-trending canyon that emerges at Slaughterhouse Spring, at the bottom of the mesa's eastern escarpment. The potential quarry would be excavated into a bench between the top of the northernmost butte on the west side of Malpais Mesa and a terrace just above the floor of the northeast-trending canyon. Elevations decrease from approximately 6,430 feet above mean sea level at the top of the mesa to approximately 6,280 feet at the top of the bench and to approximately 6,130 feet on the canyon floor. There is an average 19 percent (11 degree) slope from the top of the mesa to the canyon floor, with a precipitous drop from the rim of the bench to the bottom of the canyon. Although mining claims are known to exist north, east, and south of this site, no such encumbrances are known to exist at the site.

There is no surface water at the potential quarry site; however, there are three springs, each about 1 mile to the east, north, and west of the site. The volume of the springs and their availability for use in the quarry are unknown. The northeast-trending canyon through the site, tributary washes, and other washes draining Malpais Mesa carry ephemeral flows from precipitation events and are dry for most of the year. Meteoric water percolates down through the unsaturated basalt and tuff layers that make up most of Malpais Mesa and issues as springs from Tertiary sedimentary rocks on the east, north, and west sides of the mesa. The city of Goldfield formerly used springs and wells on the east side of Malpais Mesa for water supplies (Albers and Stewart, 1972). The city now obtains water from wells completed in Alkali Flat, about 13 miles to the north (City of Goldfield, unpublished data). Wells in Alkali Flat typically are about 400 feet deep and produce water from Tertiary sedimentary rocks about 200 feet below the land surface (USGS, 2005).

The potential quarry site is reached from US-95 at Goldfield by taking 2.2 miles of all-weather gravel and dirt roads and 3.7 miles of primitive dirt roads (Figure 7). Existing roads would likely be sufficient for exploration access to the mesa top, but a pioneer road would likely be needed from the mesa top to the bench below it for a track rig to reach the bench. Primitive roads used for exploration access, which have 8 to 16 percent grades in places, would likely need to be improved to haul equipment and ballast to and from the ballast quarry.

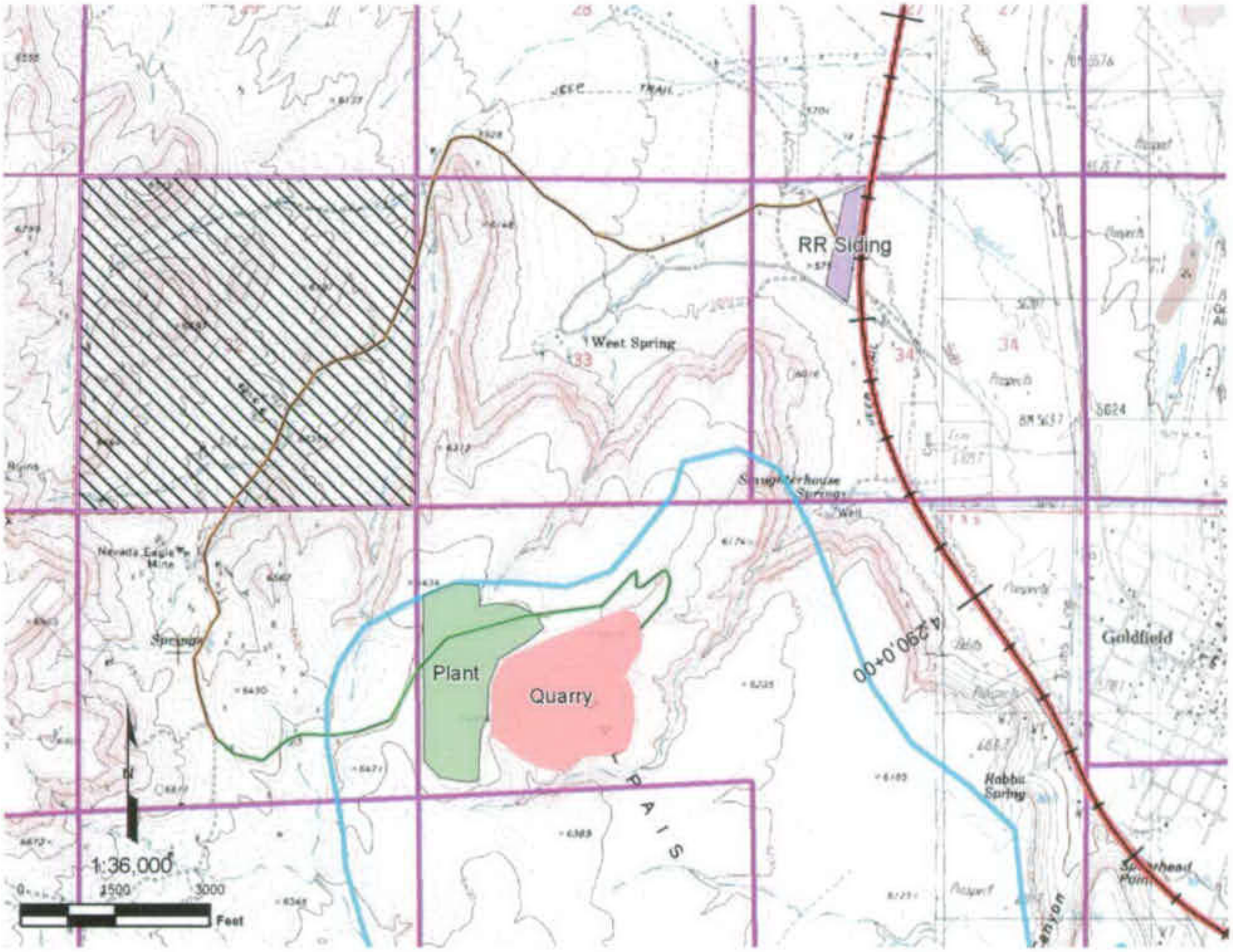


Figure 7: Area ES-7 Site Conceptual Layout

Miocene basalt flows near the top of Malpais Mesa would be quarried for ballast. These lava flows, which are about 100 to 150 feet thick, generally are medium to dark gray, porphyritic (with a finely crystalline groundmass), non-vesicular, and fresh to slightly weathered (typically containing a light gray or brown weathering rind). Fractures are very closely (less than ¼-inch) to widely (6-foot) spaced, with variable spacing at different outcrop locations.

Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
>2 ft	5 to 20
1 to 2 ft	60 to 65
.5 to 1 ft	15 to 25
<.5 ft	5

The rock quality designation (RQD) was estimated visually to range from 70 percent to 90 percent in outcrop. There is no preferred fracture orientation, except below the inner bench, where fractures that strike N 45 to 50° E and dip 84° NW to SE dominate. The rock generally has very high strength when struck with a rock hammer. The basalt tends to weather to rounded boulders and grus-like gravel.

Rock quality lessens above the bench, either as a result of different lava flows being present above the bench or fault offset of the lava flows exposed between the bench and the mesa top. Lava flows above the bench, which are approximately 150 feet thick, contain several shear zones with a strike of N 10 to 30° E and a dip of 77 to 80° NW, several intervals of megabreccia (basalt boulders in a disturbed matrix), many intervals of rubble interlayered with sound rock, and a few vesicular intervals. In contrast to well-exposed basalt flows below the bench, basalt flows above the bench are poorly exposed because of soil and vegetation on slopes.

If only the basalt between the top of the bench and the canyon floor is quarried, about 9 million tons of basalt might be available from this site for use as ballast. It is anticipated that quarrying would start at the northeast side of the inner bench and proceed by blasting. The basalt would be removed in tiers, probably corresponding to natural breaks, such as the tops and bottoms of lava flows. Most of the facilities needed to support quarrying, including a processing plant, a waste dump, an office complex, a ballast stockpile, and settling ponds, could be constructed on top of the western side of the mesa. A loading facility could be constructed northeast of Malpais Mesa, adjacent to the railroad tracks. The closest existing power is located along US-95 and north of Goldfield.

4.3.2 Area NS-3A Quarry Site Characteristics

Area NS-3A is located in the northern Goldfield Hills, about 2 miles south of the Mud Lake playa in Nye County, Nevada, and about 9.5 miles northeast of the town of Goldfield in Esmeralda County, Nevada (Figure 6, Sheet 3). A potential ballast quarry site in this area is contiguous with one in area NS-3B, and they could be developed together, sharing facilities. For the purpose of this report, the two sites are discussed separately.

The potential quarry site in area NS-3A is reached from US-95 at Goldfield by following 5.6 miles of all-weather gravel and dirt roads to Black Butte, 5.4 miles of primitive dirt roads from Black Butte to a northerly trending wash in the Mud Lake watershed, and 2.6 miles of the wash bed. The primitive roads cross two chains of hills and a medial valley at grades of 6 to 20 percent in the hills, before entering the Mud Lake watershed. Existing roads would likely be sufficient for a 4x4 vehicle or track rig to reach the potential quarry site for exploration purposes, but these roads beyond the initial all-weather road would likely need to be improved substantially and extended about 3 miles for quarry operations.

The potential quarry site is located in Township 1S, Range 43E, Sections 35 and 36. This site is bordered on its east side by the NTTR and on its west side by NRP alternative alignment GF3. No mining claims are known to exist at the site. The site encompasses three flat-topped hills, the largest of which extends into area NS-3B. With sidehill slopes of 5 to 36 percent (3 to 20°), these hills rise to elevations of 5,580 to 5,730 feet. Three northerly to northwesterly draining washes are incised into the hills. These washes descend to Mud Lake at grades of 2 to 3 percent and are at an elevation of approximately 5,390 feet where they leave the site.

There is no surface water at or near the potential quarry site. The washes that cut through the site carry ephemeral flows from precipitation events and are dry for most of the year. Based on a depth to water of 240 feet in Mud Lake (Bonham and Garside, 1979), which is the assumed discharge area for the local groundwater system, the water table is expected to be more than 300 feet deep in the lowest areas at the site. A borehole at least 500 feet deep may need to be drilled next to one of the washes at the northern end of area NS-3A to determine whether water can be obtained from wells at the site.

The Miocene Basalt of Blackcap Mountain forms the three hills at the potential quarry site. The basaltic andesite and basalt lava flows that form these hills generally are dark gray, very finely crystalline, variably vesicular (grading laterally and vertically from non-vesicular to very vesicular), and fresh to slightly weathered (typically containing a thin, brown weathering rind). Vesicles are mostly filled with zeolites and other secondary minerals. Fractures are extremely closely (less than ¼-inch) to widely (6-foot) spaced, with either slabby or rectangular fracturing prevailing at different locations.

Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
>2 ft	10 to 30
1 to 2 ft	20 to 25
.5 to 1 ft	10 to 60
<.5 ft	5 to 40

The RQD was estimated visually to range from 50 percent to 70 percent in outcrop. No preferred fracture orientation was observed throughout the site. The rock generally has very high strength when struck with a rock hammer, but its strength decreases to high where the rock breaks readily along extremely (less than ¼-inch) to very closely (2½-inch) spaced fracture planes. The basalt weathers to rounded boulders or angular talus. Basalt flows at the site appear from topographic contours to have a cumulative thickness of about 40 to 100 feet.

As shown in Appendix A, basalt flows at the potential quarry site cover an irregularly shaped area of about 526 acres. Taking into account interflow sediments, ash-fall tuff deposits and rubble layers, vesicular intervals, and zones of especially slabby fracturing, the mineable thickness of this deposit conservatively was estimated to average 60 feet. A deposit with these dimensions might produce as much as 110 million tons of ballast.

It is anticipated that quarrying would start on the north side of the basalt deposit and proceed by blasting to the south. The basalt would be removed in tiers, probably corresponding to natural breaks, such as the tops and bottoms of lava flows. All of the facilities needed to support quarrying, including a processing plant, a waste dump, a ballast stockpile, an office complex, power generators, and settling ponds, could be constructed in relatively flat areas north and west of the quarry. A 10-acre loading facility could be constructed adjacent to the railroad tracks where the GF3 alignment leaves area NS-3A and connects to other facilities by service roads. The closest existing power is Goldfield to the south or US-6 to the north.

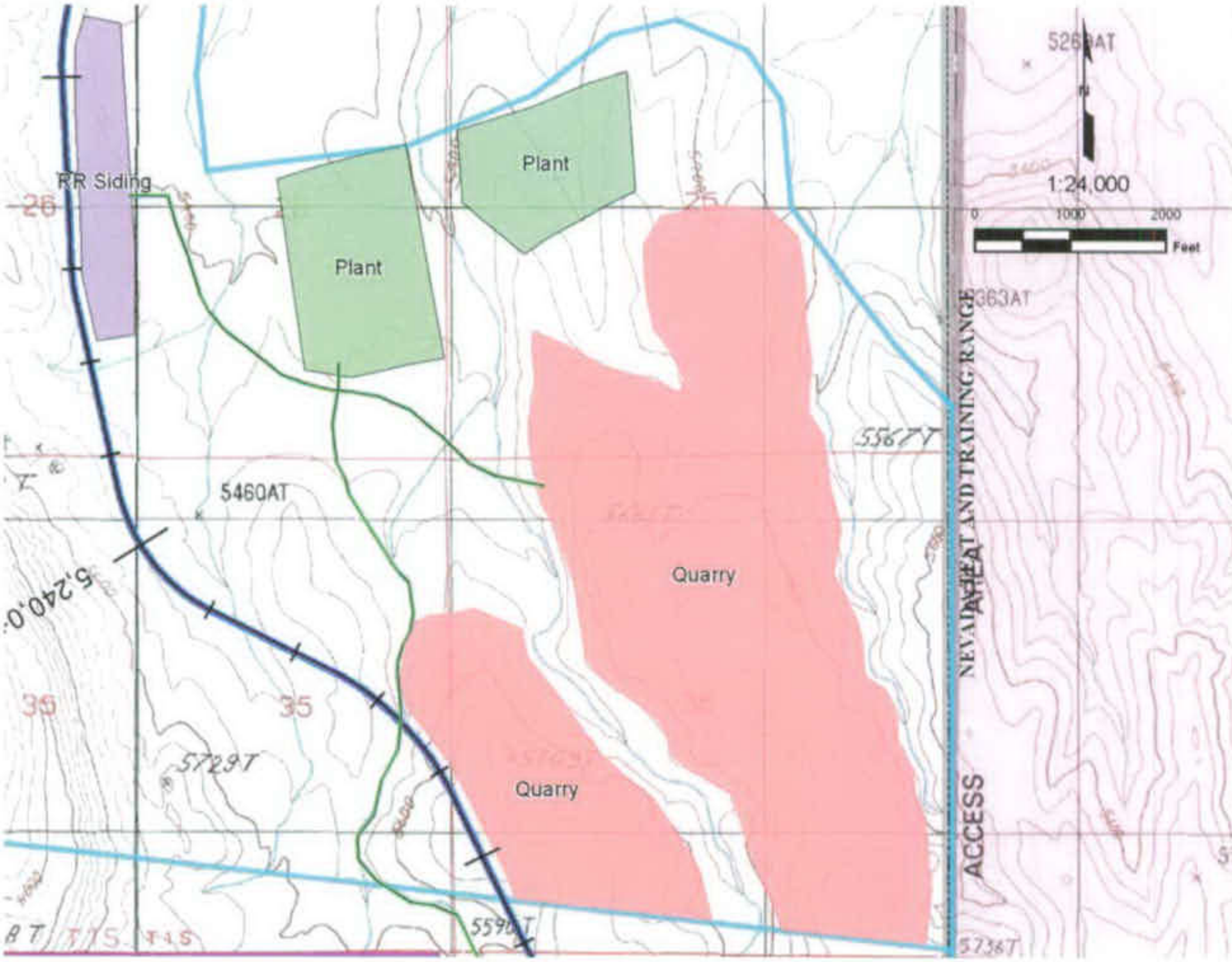


Figure 8: Area NS-3A Site Conceptual Layout

4.3.3 Area NS-3B Quarry Site Characteristics

Area NS-3B is located in the northern Goldfield Hills, about 4 miles south of the Mud Lake playa in Nye County, Nevada, and about 9 miles northeast of the town of Goldfield in Esmeralda County, Nevada (Figure 6, Sheet 3). The site is reached from US-95 at Goldfield by following 5.6 miles of all-weather gravel and dirt roads to Black Butte, 5.4 miles of primitive dirt roads from Black Butte to a northerly trending wash in the Mud Lake watershed, and 0.6 mile of the wash bed. The primitive roads cross two chains of hills and a medial valley at grades of 6 to 20 percent in the hills, before entering the Mud Lake watershed. Existing roads would likely be sufficient for a 4x4 vehicle or track rig to reach the potential quarry site for exploration purposes, but these roads beyond the initial all-weather road would likely need to be improved substantially and extended about a mile for quarry operations.

The potential quarry site is located in Township 2S, Range 43E, Section 1, where cuts 70 to 100 feet deep are planned along NRP alternative alignment GF3. This site is bordered on its east side by alignment GF3 and on its west side by the wash discussed in the previous paragraph and a hill rising to 5,961 feet, which is staked with mining claims. No mining claims are known to exist in the area where the potential quarry site is located. The site encompasses three flat-topped hills with sidehill slopes of 12 to 23 percent, which rise to elevations of 5,740 to 5,820 feet. One of the hills extends into quarry site NS-3A. The wash through the site descends northerly to Mud Lake at grades of 2 to 3 percent and is at an elevation of approximately 5,600 feet where it leaves area NS-3B.

There is no surface water at or near the potential quarry site. The northerly trending wash through the site carries ephemeral flows from precipitation events and is dry for most of the year. Based on a depth to water of 240 feet in Mud Lake (Bonham and Garside, 1979), which is the assumed discharge area for the local groundwater system, the water level is expected to be more than 300 feet deep in the lowest areas at the potential quarry site. A borehole at least 600 feet deep may need to be drilled next to the wash at the northern end of area NS-3B to determine whether water can be obtained from wells at the site.

The Miocene Basalt of Blackcap Mountain forms the three hills at the potential quarry site. The lava flows that form these hills generally are dark gray, very finely crystalline to porphyritic, variably vesicular (grading laterally and vertically from non-vesicular to very vesicular), and fresh to slightly weathered (typically containing a thin, brown weathering rind). Vesicles are mostly filled with zeolites and other secondary minerals. Fractures are extremely closely (less than ¼-inch) to widely (6-foot) spaced, with either slabby or rectangular fracturing prevailing at different locations.

Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
2 to 4 ft	5 to 30
1 to 2 ft	30 to 40
0.5 to 1 ft	20 to 60
<0.5 ft	5 to 10

The RQD was estimated visually to vary from 50 percent to 75 percent in outcrop. No preferred fracture orientation was observed throughout the site. The rock generally has very high strength when struck with a rock hammer, but its strength decreases to high where the rock breaks readily along extremely (less than ¼-inch) to very closely (2½-inch) spaced fracture planes. The basalt weathers to rounded boulders or angular talus. Basalt flows at the site appear to be about 70 to 100 feet thick.

As shown in Appendix A, basalt flows at the potential quarry site cover an irregularly shaped area of about 124 acres. Taking into account interflow sediments and ash-fall tuff layers, vesicular intervals, and zones of especially slabby fracturing, the mineable thickness of this deposit was conservatively estimated to average 70 feet. A deposit with these dimensions might produce as much as 30 million tons of ballast.

It is anticipated that quarrying would start on the southeast side of the basalt deposit and proceed by blasting to the northwest. The basalt would be removed in tiers, probably corresponding to natural breaks, such as the tops and bottoms of lava flows. Most of the facilities needed to support quarrying, including a processing plant, a waste dump, an office complex, power generators, and settling ponds, could be constructed in relatively flat areas south and east of the quarry. A ballast stockpile/loading facility complex could be constructed adjacent to the railroad southeast of the potential quarry site.

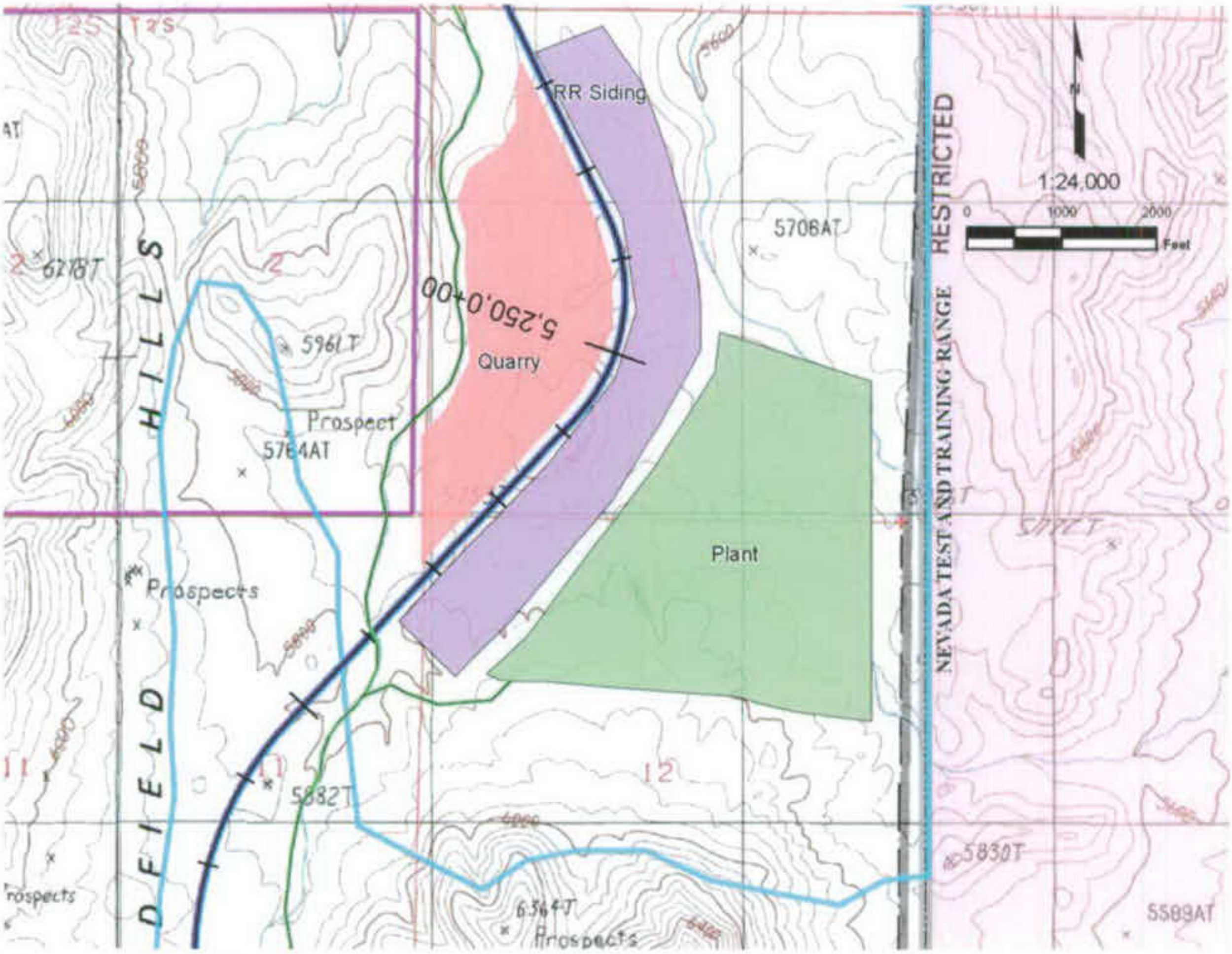


Figure 9: Area NS-3B Site Conceptual Layout

4.3.4 Area NN-8A Quarry Site Characteristics

Area NN-8A is located on the west side of Warm Springs Summit, a pass between the Kawich Range to the south and the Hot Creek Range to the north. Warm Springs Summit, at an elevation of about 6,290 feet, is about 43 miles east-northeast of Tonopah, Nye County, Nevada (Figure 6, Sheet 4). Within area NN-8A, slightly to moderately dissected alluvial fans slope northwest from the Kawich Range and southwest from the Hot Creek Range. Hills and mounds of Miocene volcanic rocks protrude from the fans. Where the fans from the two mountain ranges meet, the terrain is relatively flat.

No outcrops of basalt, andesite, dacite, or rhyodacite lava flows in quantities large enough to be considered a potential ballast source were found within area NN-8A. Limited outcrops indicate that a buried resource might exist just west of Warm Springs Summit, between US-6 on the north and a dirt road leading to the Clifford Mine on the east. This area, which is in Township 4N, Range 49E, Sections 25, 26, 35, and 36, was indicated by Gardner et al. (1980) to be underlain by the late Miocene (?) Basaltic andesite of the Clifford Mine area. The potential resource area slopes to the west at grades of 2 to 3 percent and is characterized by mounds three feet or less in height, that are incised by shallow washes. The mounds contain small exposures of volcanic rock, and they are mostly covered with 3 feet or less of colluvium consisting of gravel- to cobble-sized fragments of variably altered and weathered basaltic andesite in brown, silty sand. Quaternary fan and channel alluvium of unknown thickness is present between the mounds. The western third of this area is inaccessible because of mining claims.

There is no surface water in or near the potential resource area. Shallow washes incised into the area carry ephemeral flows from precipitation events of unknown frequency and are dry for most of the year. Dinwiddie and Schroder (1971) indicate that early Miocene to Oligocene tuffaceous rocks similar to those that make up most of the Kawich Range typically do not yield large quantities of water to wells. Wells drilled into the alluvium of Stone Cabin, Hot Creek, or Reveille Valley could possibly provide water for quarry operation.

Existing roads would likely be sufficient for 4x4 vehicles and track rigs to reach the potential resource area from US-6 for exploration purposes, but the dirt road to the Clifford Mine would likely need to be widened and paved, and service roads would likely need to be extended from this road if a quarry was developed in the area.

The andesite lava flows of the Clifford Mine area are dark gray (weathering purple with a brown rind), porphyritic (with a fine-grained, partly glassy groundmass), non-vesicular, and fresh to very weathered. Foliation observed north of US-6 strikes N 19° E and dips 16° SE. The rock is slightly to very hydrothermally altered in most outcrops, with alteration ranging from reddish- to yellowish-brown and white staining on fracture surfaces or red- and yellow-veined areas to complete destruction of the original color and texture. Fractures are extremely closely to medium spaced (<¼ to 24 inches) and appear to have no dominant orientation throughout the potential resource area. Neither block-size distribution nor RQD was estimated because of the very limited outcrop area. Rock strength determined with a geology hammer decreases from very high to medium high as the amount of alteration or weathering increases. According to

Gardner et al. (1980), the lava flows in this geologic unit cumulatively are as much as 65 feet thick.

As indicated by S&W (2005c), andesite flows at Warm Springs Summit between US-6 and the NRL are not encumbered by mining claims cover an area of about 74 acres. Assuming that the deposit is 60 feet thick, and that about 90 percent of it is too altered or weathered for use as ballast, then about 1.5 million tons of ballast might be obtainable from quarrying this deposit. As stated previously, considerable exploration and testing must be done before a quarry in this deposit could be developed.

It is anticipated that quarrying would start on the west side of the andesite deposit and proceed by blasting to the east. The andesite would be removed in tiers, probably corresponding to natural breaks, such as the tops and bottoms of lava flows. Most of the facilities needed to support quarrying, including a 10-acre processing plant, a 14-acre waste dump, a 10-acre office complex, and settling ponds, could be constructed in relatively flat areas south and east of the quarry (Figure 10). A ballast stockpile/loading facility complex could be constructed adjacent to railroad tracks east of the quarry and connected to other facilities by a service road. Energy for quarry operations could be obtained from power lines adjacent to US-6.

4.3.5 Area NN-8B Quarry Site Characteristics

Area NN-8B is located about 48 miles east of Tonopah, Nevada, and approximately 4 miles south of the intersection between US-6 and State Route (SR)-375. It is north of and adjacent to the Cow Canyon jeep trail, on the east slope of the Kawich Mountain Range (Figure 6, Sheet 5).

The study area encloses two NE-SW-trending ridges separated by dry washes (intermittent streams). The average slope is about 7 percent grade and ranges from 1 to 10 percent. Immediately west of the study area the topography becomes rougher and the slopes steeper (15 to 25 percent) on the flanks of the Kawich Range. Reveille Valley lies immediately east of the study area, with relatively flat (2 to 4 percent) terrain. The ridges in the study area are composed of dacitic lava flows. The dacite outcrops at elevations above 5,800 feet. Below 5,800 elevation, they are covered by poorly sorted alluvial silt, sand, and gravel.

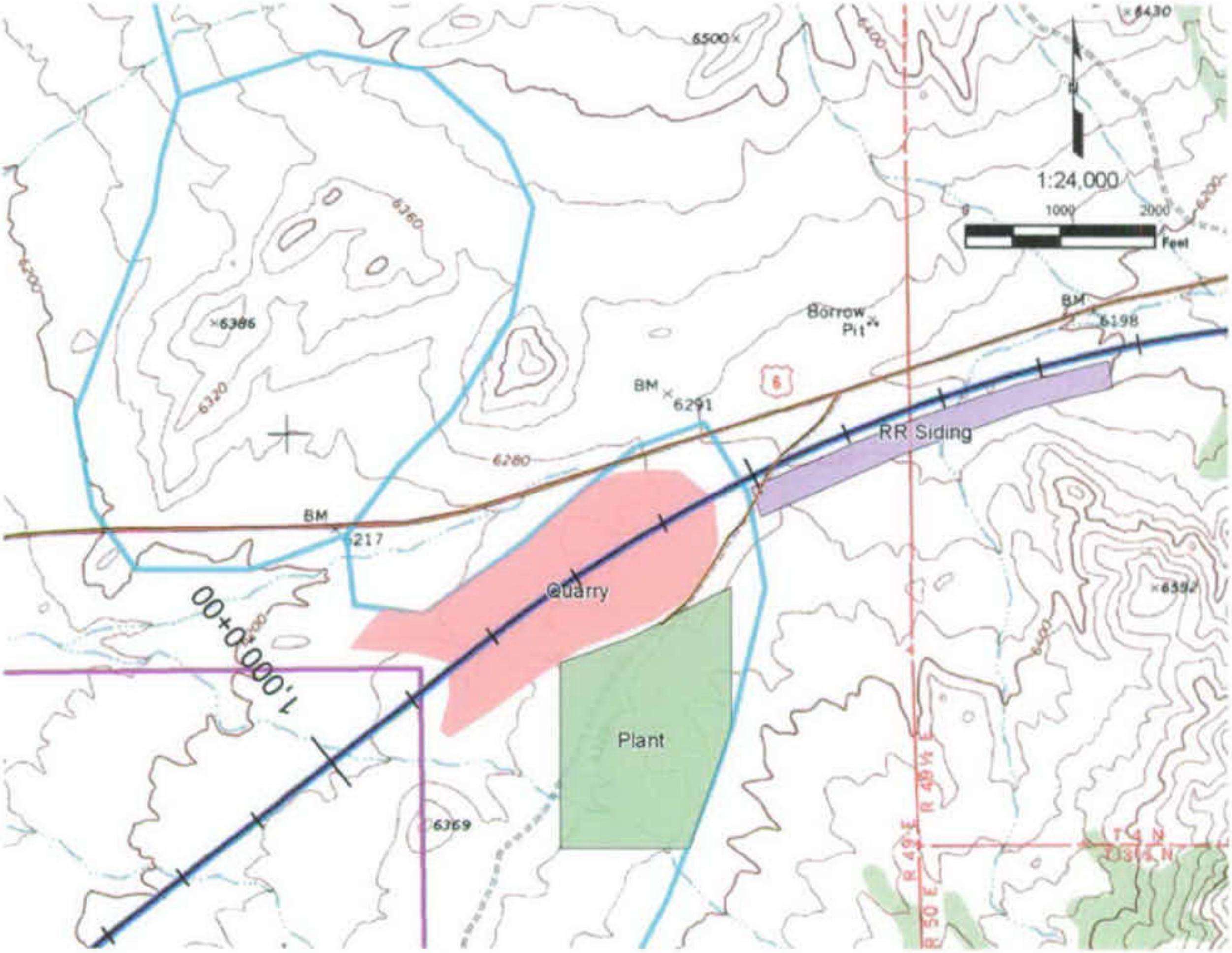


Figure 10: Area NN-8A Site Conceptual Layout

The potential quarry area is accessed by a narrow 1.3-mile jeep trail that enters Cow Canyon from the Reveille Valley road. Average slope on the trail is 5 percent. This trail is adequate for exploration drilling during dry weather, but would likely require significant improvement to withstand year-round use by heavy construction and mining equipment.

The NN-8B study area covers about 250 acres that include a quarry site to the north, an area for a railroad siding on the lower part of a fan, and a plant site area directly west of the proposed siding area.

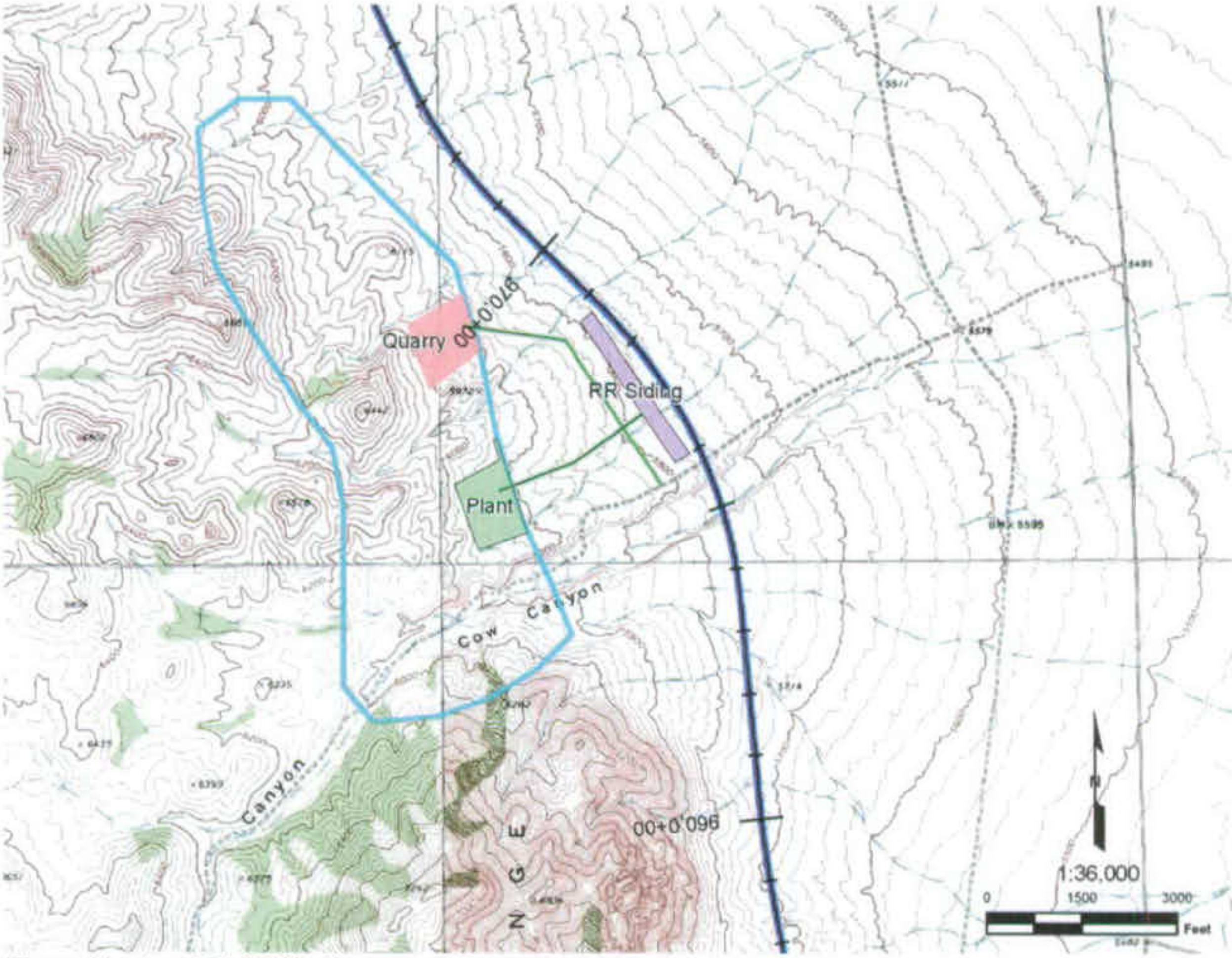


Figure 11: Area NN-8B Site Conceptual Layout

Cow Canyon, a dry wash adjacent to the current access road, has carved a 400- to 500-foot-wide, flat-bottomed canyon through the alluvium. This wash drains an area of approximately 10 square miles, including numerous peaks over 7,000 feet elevation. After winters with heavy snow accumulation in the mountains, spring thaws may release large volumes of water in this oversized channel. There are three small (4 to 5 feet wide) dry washes cutting through the study area. Each wash drains much smaller areas to the west and flows only during rain/snow melt events.

No mining claim monuments were encountered during the field investigation. There do not appear to be any active mining claims within the proposed quarry area.

The andesite typically fractures with 1 to 5 blows from a 4-lb hammer, indicating moderate to medium high strength. Visual field estimates of rock block size distribution were as follows:

Block Size	Percent Distribution
> 2.0 ft	10
2.0 to 1.0 ft	5
1.0 to 0.5 ft	70
< 0.5 ft	15

This distribution suggests that blasting would reduce most of the rock to fragments 1 foot or smaller in size, based on the close-spaced jointing visible in most outcrops. When crushed, this rock may tend to produce excessive fines, meaning that an unacceptable percentage (perhaps as high as 30 percent) of it may not be suitably sized for ballast. Estimated RQD of the sampled outcrop is 30 to 40 percent. This also reflects the jointing and fracturing visible in most outcrops.

A single-bench quarry, covering an area of 21 acres, with an average bench height of 58 feet, would produce roughly 4.2 million total tons of stone. Mining could commence on the east side of the site and proceed to the west. On completion of mining, the final high wall height would be about 100 feet on the west side.

Field observations suggest that the proposed pit area is covered with 0 to 5 feet of alluvial silt, sand, and gravel. Actual depths should be confirmed with borings. If the overburden is thin, it may be feasible to separate it from the stone by screening the shot rock rather than removing it mechanically from the bench top prior to drilling.

Groundwater inflow is not anticipated during mining operations; however, seasonal surface water inflow is possible. Sloping the pit floor downward from the bench face would reduce the potential for water accumulation in the pit.

The closest known water is at a corral approximately 4 miles northeast of the proposed quarry site. The nearest existing power is about 7 miles to the north, near Warm Springs Summit (along US-6).

4.3.6 Area NN-8C Quarry Site Characteristics

Area NN-8C is located on the west flank of the Reveille Range, about 48 miles east of Tonopah, Nevada, and approximately 10.5 miles SSE of the intersection of US-6 and SR-375 (Figure 6, Sheet 6). The potential quarry site sits on low lava flow foothills dissected by dry washes with about 100 feet of relief. The plant site is located on fan alluvium to the valley side of the edge of the lava flows.

The potential quarry site is accessed by a series of narrow, intersecting jeep trails on the valley floor. Travel distance from Reveille Mill spring to the study area is about 6.5 miles. Average slope on these trails is 1 percent. Roads are adequate for exploration drilling during dry weather, but would likely require significant improvement to withstand year-round use by heavy construction and mining equipment. No mining claim monuments were encountered during the field investigation. There do not appear to be any active mining claims within the study area.

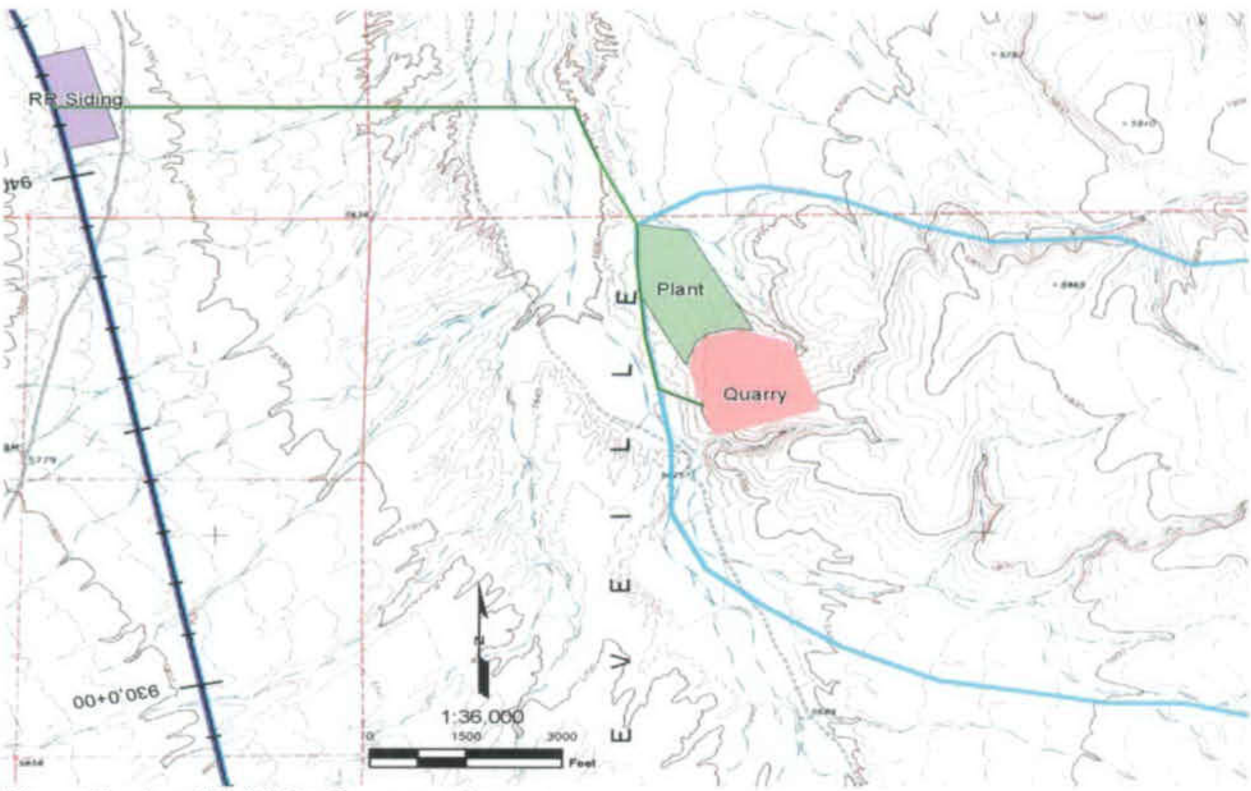


Figure 12: Area NN-8C Site Conceptual Layout

The NN-8C study area covers about 600 acres and includes a quarry pit site, a plant site, and a siding area about 2 miles northwest of the quarry and plant.

The proposed plant site lies north of the proposed quarry site. The area has an average slope of 3 percent. The siding area is located 2 miles northwest of the quarry location, on the east side of the NRL. The area has an average slope of 4 percent; minor grading may be required to achieve a level siding and loading area. The 2.75-mile haulage/access road between the quarry and the railroad siding has slopes as high as 10 percent. Minor cuts may be required in the steepest areas.

The potential ballast in this area is composed of dark, high strength porphyritic basalt, deposited in a series of flows. Each flow has an average thickness of 15 to 30 feet, with a total maximum thickness of about 120 feet. The average ground slope is about 7 percent grade and ranges from 1 to 12 percent. In outcrop, the upper 6 feet of each flow is slightly vesicular and the top 6 to 8 inches are scoriaceous, imparting a lightweight "frothy" texture to the rock. Most outcrops are coated with a thin rind of desert varnish.

The basalt resists breaking from many blows with a 4-lb hammer, indicating high strength. Visual field estimates of rock block size distribution were as follows:

Block Size	Percent Distribution
>2 ft	40
1 to 2 ft	40
6 in to 1ft	10
<6 in	10

This distribution suggests that blasting would reduce most of this rock to fragments 1 foot or larger in size. When crushed, this stone should produce a high proportion suitably sized for ballast, with a low proportion of fines. Estimated RQD of the sampled outcrop is 80 percent. This reflects the massive nature of the observed outcrops.

A single-bench quarry, covering an area of 72 acres, with an average bench height of 50 feet would produce about 12 million tons of stone. Mining could start on the northwest side of the pit and progress toward the southeast. On completion of mining, the final headwall would be about 90 feet high on the east side. It should be noted that a second, similarly sized quarry could be sited on the ridge adjacent to and north of the proposed quarry site.

Field observations suggest that the proposed pit area is covered with 0 to 10 feet of poorly sorted alluvial silt, sand, and gravel. Actual depths should be confirmed with borings. If the overburden is thin it may be feasible to separate it from the stone by screening the shot rock rather than removing it mechanically from the bench top prior to drilling.

Groundwater inflow is not anticipated during mining operations. Seasonal surface water inflow is possible, however. Sloping the pit floor downward from the bench face would reduce the potential for water accumulation in the pit. An artesian well is located about 3.2 miles north of the proposed quarry site. The nearest power is about 9½ miles north or 13 miles east of the site.

4.3.7 Area NN-8D Quarry Site Characteristics

Area NN-8D is located on the west flank of the Reveille Range, about 48 miles east of Tonopah, Nevada, and approximately 13 miles SSE of the intersection of US-6 and SR-375. The quarry and plant sites are situated on a broad coalesced alluvial fan complex with shallowly incised dry washes, through which protrude scattered outcrops of lava flows (Figure 6, Sheet 7).

The potential quarry area is accessed by a series of narrow, intersecting jeep trails crossing the Reveille Valley floor. Travel distance from Reveille Mill spring to the study area is about 4.8 miles. Average slope on these trails is 1 percent. They are adequate for exploration drilling during dry weather, but would likely require significant improvement to withstand year-round use by heavy construction and mining equipment. No mining claim monuments were encountered during the field investigation. There do not appear to be any active mining claims within the study area.

The NN-8D study area covers about 3,700 acres and contains a quarry pit, a plant site directly west of it, and a railroad siding area about 2 miles west of the plant site.

The proposed 3-mile haul road between the quarry and the railroad siding has slopes as high as 6 percent. Minor cuts may be required in the steepest areas, near the west edge of the plant site.

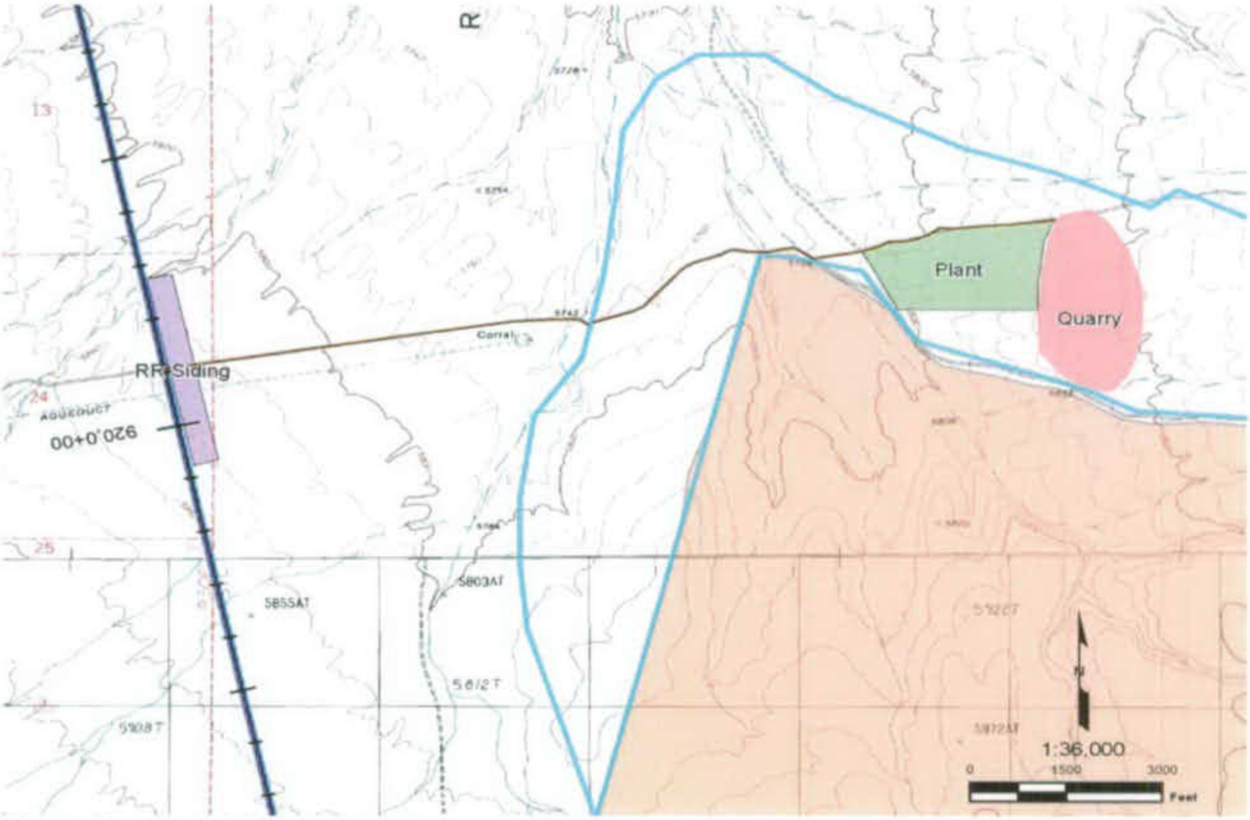


Figure 13: Area NN-8D Site Conceptual Layout

The potential ballast in this study area is composed of dark gray, high strength basalt porphyry. The thickness of the basalt cannot be determined due to the small and scattered nature of the outcrops. The average ground slope is about 3 percent and ranges from 1 to 6 percent. Most outcrops are fresh but coated with a thin rind of desert varnish. The basalt resists breaking from many blows with a 4-lb hammer, indicating high strength. Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
> 2.0 ft	40
1.0 – 2.0 ft	40
0.5 –1.0 ft	10
< 0.5 ft	10

This distribution suggests that blasting would reduce most of this rock to fragments 1 foot or larger in size. When crushed, this stone should produce a high proportion suitably sized for ballast, with a low proportion of fines. RQD was not estimated due to limited outcrops in the study area.

A single-bench quarry, covering an area of 109 acres, with an average bench height of 27 feet could produce about 10.4 million tons of stone. On completion of mining, the final head wall height would be about 70 feet high on the east side.

Field observations suggest that the proposed pit area is covered with 0 to 10 feet of poorly sorted alluvial silt, sand, and gravel. Actual depths should be confirmed with borings. If the overburden is thin it may be feasible to separate it from the stone by screening the shot rock rather than removing it mechanically from the bench top prior to drilling.

Groundwater inflow is not anticipated during mining operations. Seasonal surface water inflow is possible, however. Sloping the pit floor downward from the bench face would reduce the potential for water accumulation in the pit. The nearest water observed was at a corral about 1½ miles west of the site and at the Reveille Mill spring about 5 miles west of the site.

The nearest power is 29 miles north or 14 miles to the northeast of the site.

4.3.8 Area NN-9A Quarry Site Characteristics

Area NN-9A study area is located on the west flank of the Reveille Range, about 48 miles east of Tonopah, Nevada, and approximately 27 miles SSE of the intersection of US-6 and SR-375. This quarry area is a long (2½ mile), narrow (½ mile) contiguous lava flow tongue that is flanked by two major dry washes on its east and west and separated from coalesced fans of the Reveille Range (Figure 6, Sheet 8). The top of the flow is inclined slightly down to the west, but has a 60- to 100-foot face on its eastern side.

The potential quarry is accessed by an unimproved dirt road that traverses the Reveille Valley and crosses the NN-9A study area. It is contiguous with and north of site NN-9B. Average slope on this trail is 1 percent. It is adequate for exploration drilling during dry weather, but would likely require significant improvement to withstand year-round use by heavy construction and mining equipment. No mining claim monuments were encountered during the field investigation. There do not appear to be any active mining claims within the study area.

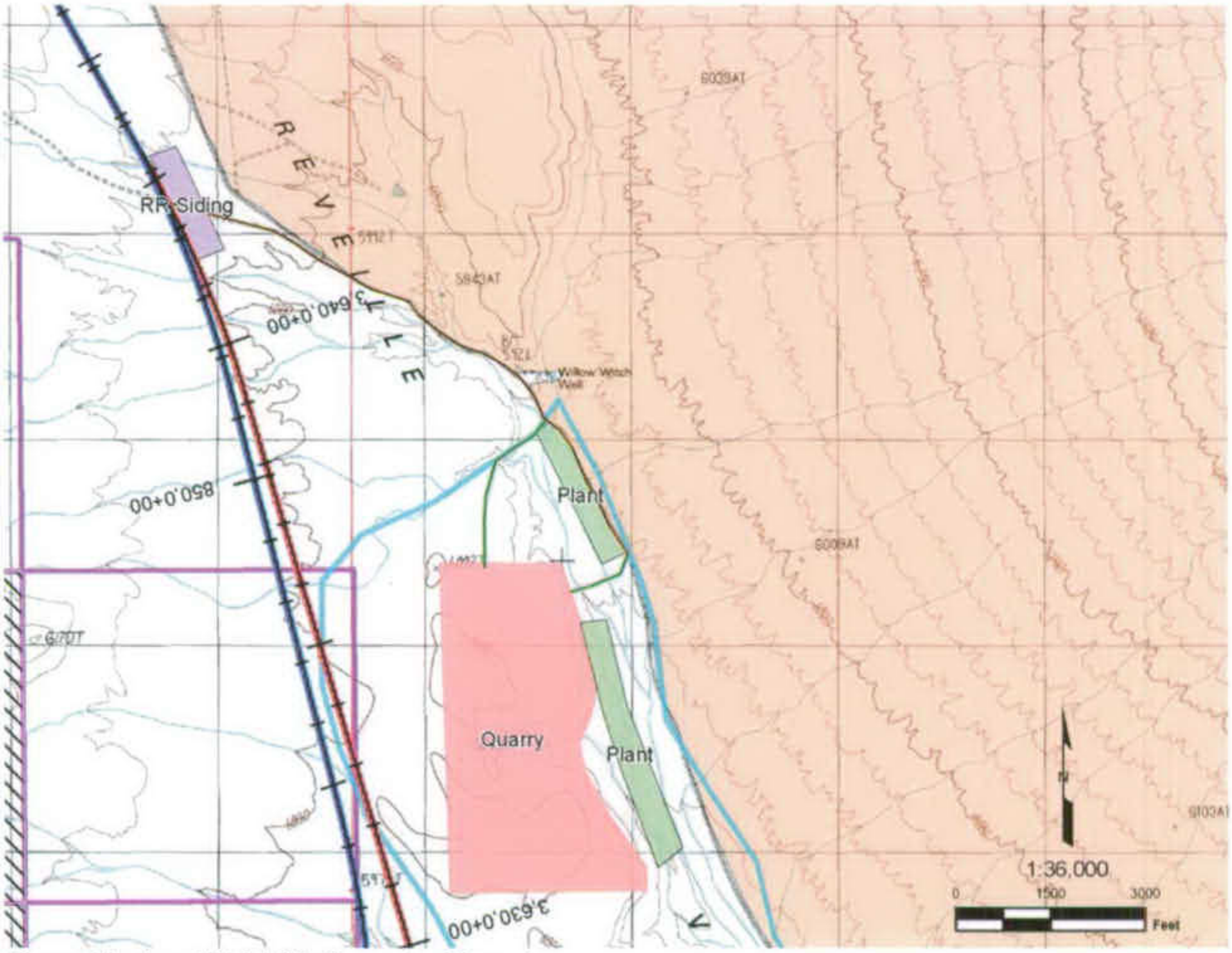


Figure 14: Area NN-9A Site Conceptual Layout

The NN-9A plant site covers about 5,700 acres and includes a quarry site, a plant site(s) to the east of it, and a railroad siding area located 1.6 miles northwest of the plant site. The siding area has an average slope of 1 percent. The haulage road between the quarry and siding areas has an average slope of 3 percent. Two plant sites are shown because a linear configuration may be necessary and either side of the dry wash may be suitable.

The potential ballast in this area is composed of dark gray, high-strength porphyritic basalt. Joint spacing of 8 to 24 inches was observed. The thickness of the basalt is estimated to be 30 to 80 feet, but would need to be confirmed with borings. The average ground slope in the quarry area is consistent at about 2 percent grade. Most outcrops are fresh but coated with a thin rind of desert varnish.

The basalt resists breaking from many blows with a 4-lb hammer, indicating high strength. Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
> 2.0 ft	50
1.0 – 2.0 ft	30
0.5 –1.0 ft	10
< 0.5 ft	10

This distribution suggests that blasting would reduce most of this rock to fragments 1 foot or larger in size. When crushed, this stone should produce a high proportion suitably sized for ballast, with a low proportion of fines. RQD is estimated at 70 to 90 percent in outcrop, reflecting the massive nature of the deposit.

A single-bench quarry, covering 325 acres, with an average bench height of 46 feet would produce about 52 million tons of stone. On completion of mining, the maximum final high wall height would be about 80 feet on the west side.

Field observations suggest that the proposed pit area is covered with 0 to 10 feet of poorly sorted alluvial silt, sand, and gravel. Actual depths should be confirmed with borings. If the overburden is thin it may be feasible to separate it from the stone by screening the shot rock rather than removing it mechanically from the bench top prior to drilling.

Groundwater inflow is not anticipated during mining operations. Seasonal surface water inflow is possible, however. Sloping the pit floor downward from the bench face would reduce the potential for water accumulation in the pit. Willow Witch well at the north end of this area reportedly flows about 5 gallons per minute, and is used for cattle.

The nearest power is about 27 miles to the north or 15½ miles to the southeast.

4.3.9 Area NN-9B Quarry Site Characteristics

Area NN-9B is located on the west flank of the Reveille Range, about 48 miles east of Tonopah, Nevada, and approximately 28.5 miles SSE of the intersection of US-6 and SR-375. The northern half of NN-9B (about 1 mile long) is contiguous with the narrow long lava flow of NN-9A. At the southern end of this ridge, a major dry wash cuts across the ridge. The hills to the south with 120 to 160 feet of relief are separated topographically and geologically from the flow ridge to the north (Figure 6, Sheet 9).

The potential quarry area is accessed by an unimproved jeep trail that traverses Reveille Valley and is contiguous with and lies south of the NN-9A area. Average slope on this trail is 1 percent. It is adequate for exploration drilling during dry weather, but would likely require significant improvement to withstand year-round use by heavy construction and mining equipment. No mining claim monuments were encountered during the field investigation. There do not appear to be any active mining claims within the study area.

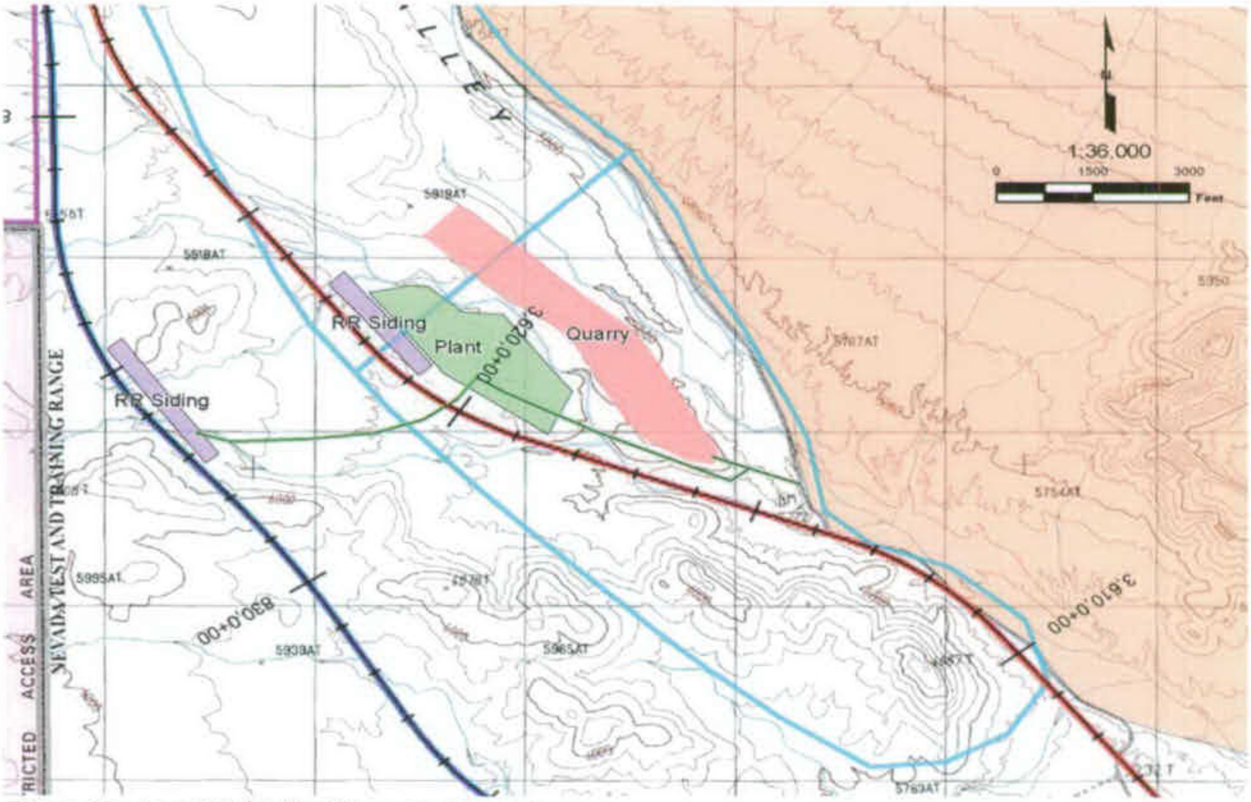


Figure 15: Area NN-9B Site Conceptual Layout

The NN-9B plant site covers about 1,650 acres and contains a long and very narrow quarry site, a plant site to the west, and a railroad siding area immediately west of the plant facilities. The plant site has an average slope of 1 percent. The siding area has an average slope of 1 percent. The haul road between the quarry and the railroad siding has an average slope of 1 percent.

The potential ballast in this area is composed of dark gray, high strength basalt. Average joint spacing of 36 inches was observed. The thickness of the basalt is estimated to be about 25 feet, but would need to be confirmed with borings. The ground slope in the quarry area ranges from 1 to 20 percent, and averages 9 percent grade. Most outcrops are fresh but coated with a thin rind of desert varnish.

The basalt resists breaking from many blows with a 4-lb hammer, indicating high strength. Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
> 2.0 ft	60
1.0 – 2.0 ft	20
0.5 –1.0 ft	10
< 0.5 ft	10

This distribution suggests that blasting would reduce most of this rock to fragments 1 foot or larger in size. When crushed, this stone should produce a high proportion suitably sized for ballast, with a low proportion of fines. RQD is estimated at 60 to 70 percent in outcrops, reflecting the massive nature of the deposit.

A single-bench quarry, covering 60 acres, with an average bench height of 17 feet, would produce about 3.6 million tons of stone. On completion of mining, the maximum final high wall height would be about 25 to 30 feet at the north end.

Field observations suggest that the proposed pit area is covered with 0 to 10 feet of poorly sorted alluvial silt, sand, and gravel. Actual depths should be confirmed with borings. If the overburden is thin, it may be feasible to separate it from the stone by screening the shot rock rather than removing it mechanically from the bench top prior to drilling.

Groundwater inflow is not anticipated during mining operations. Seasonal surface water inflow is possible, however. Sloping the pit floor downward from the bench face would reduce the potential for water accumulation in the pit. Willow Witch well is about 2½ miles north of the site, produces about 5 gallons per minute, and is used for cattle.

The nearest existing power is about 29 miles to the north or 14 miles to the southeast.

The southern half of NN-9B was reconnoitered for one day, but was deleted from consideration because the dacite there was weaker and more fractured than the deposit in the northern half of the area.

4.3.10 Area CA-8A(S) Quarry Site Characteristics

Area CA-8A(S) is located in the Chief Range about 0.5 to 0.75 mile northwest of Caliente, Lincoln County, Nevada (Figure 6, Sheet 10). The area includes two existing quarries – the Wilkin quarry and a community gravel pit – both of which are shown on the geologic map of the USGS 7½-minute Chief Mountain quadrangle (Rowley et al., 1994). The Wilkin quarry is located approximately 0.55 mile northwest of US-93 along a paved road into Antelope Canyon. The community gravel pit is located approximately 0.75 mile northwest of US-93 along a gravel road that branches off to the southwest of the road to the Wilkin quarry. According to Jim Wilkin, these quarries were developed in the 1950s by Morrison-Knudsen. Both quarries are on land administered by the Bureau of Land Management (BLM). Wilkin holds a lease from the BLM to operate the quarry bearing his name for commercial extraction of decorative stone and construction materials. The community gravel pit is open to the public to haul stone for private use.

The two quarries are located in Township 4S, Range 67E, Section 6. In the vicinity of the quarries, Antelope Canyon has steep walls (with a slope of approximately 40°) and a wide, relatively flat bottom. A wash runs down the center of the canyon, but its channel has been disturbed substantially by quarry operations. The canyon walls rise to elevations of 5,143 and 5,130 feet on the south and north sides, respectively. The wash on the canyon floor slopes down to the southeast to Meadow Valley Wash at an average gradient of 3 percent and at about elevation approximately 4,480 feet, where it leaves the quarry area.

There is no surface water in Antelope Canyon, but Meadow Valley Wash is an intermittent stream because of perennial flow from springs in segments of its channel. Both the wash in Antelope Canyon and Meadow Valley Wash carry ephemeral flows from precipitation events of unknown frequency. Shallow groundwater exists in Meadow Valley. Groundwater in Antelope Canyon at or near the Wilkin quarry and community pit might be relatively shallow.

The Wilkin quarry and the community pit were excavated along strike into the middle and lower members of the Cambrian Zabriskie Quartzite (Tschanz and Pampeyan, 1970; Rowley et al., 1994). Locations of the two quarries were constrained by the Stampede Detachment Fault on the north, the Gravel Pit Fault Zone on the east and south, north-northeast striking, high-angle faults on the west, and contacts with the underlying Cambrian Wood Canyon Formation and the overlying Cambrian Pioche Shale (Rowley et al., 1994). Cross-sections constructed from the geologic map of the Chief Mountain quadrangle (Rowley et al., 1994) indicate that a complete section of the Zabriskie Quartzite in lower Antelope Canyon is approximately 650 feet thick. The cliff-forming middle member of the Zabriskie Quartzite was targeted in the Wilkin quarry and community pit, because it consists entirely of quartzite, whereas the upper and lower members contain considerable interbeds of shale or siltstone. An incomplete section of the middle and lower members of the Zabriskie Quartzite in lower Antelope Canyon was determined by Stewart (1984) to be about 230 feet thick.

Zabriskie Quartzite observed in the Wilkin quarry and community pit was light to medium gray and pale purple, vitreous, and coarsely crystalline (recrystallized) where fresh. However, in zones that cut across bedding and appear to be most prevalent near the Gravel Pit Fault Zone, the quartzite is oxidized or altered red, black, or purple and slightly to very weathered. The rock has extremely close to wide fracture spacing (< ¼ inch to 6 feet), with the closest spacing in shear zones that occur randomly throughout the rock. The RQD in outcrop was estimated visually to range from 30 to 60 percent at the Wilkin quarry and 40 to 80 percent at the community pit. Depending on the degree of fracturing, the rock generally has medium high to very high strength when struck with a geology hammer. Internal fracture planes, which occur randomly and are more prevalent at the Wilkin quarry, cause the rock to shatter when struck with no more than a few hammer blows.

Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
2 to 6 ft	5 to 30
1 to 2 ft	30
0.5 to 1 ft	30 to 45
<0.5 ft	10 to 20

Assuming a thickness of 650 feet and a dip of 48° for the Zabriskie Quartzite at the Wilkin quarry, the width of outcrop would be 875 feet. If the middle member is 200 feet thick, 50 percent of the lower and upper members consist of quartzite, and 50 percent of the quartzite in the formation is neither extensively oxidized, weathered, nor fractured, a mineable thickness of about 210 feet might be present at this quarry. If the formation is mined for 1,000 feet along its strike, then it might be possible to produce about 15 million tons of quartzite for use as ballast from the Wilkin quarry. These figures are highly speculative and need to be confirmed by drilling.

Adequate space exists on the floor of Antelope Canyon for all facilities required to support operation of a quarry, as discussed by S&W (2005b) (Figure 16). However, ballast material obtained from the Wilkin quarry probably would be purchased from the quarry lessee. The community pit is a public resource, which probably would not be made available by the BLM for ballast extraction. According to Jim Wilkin, the UPRR tested the quartzite for use as railroad ballast in 1996, and found it to be inadequate, because it broke too easily under applied loads, and did not produce enough facets. It also reportedly would not stay confined beneath ties when used as ballast in the 1950s.

Power is available to existing facilities at the Wilkin pit.

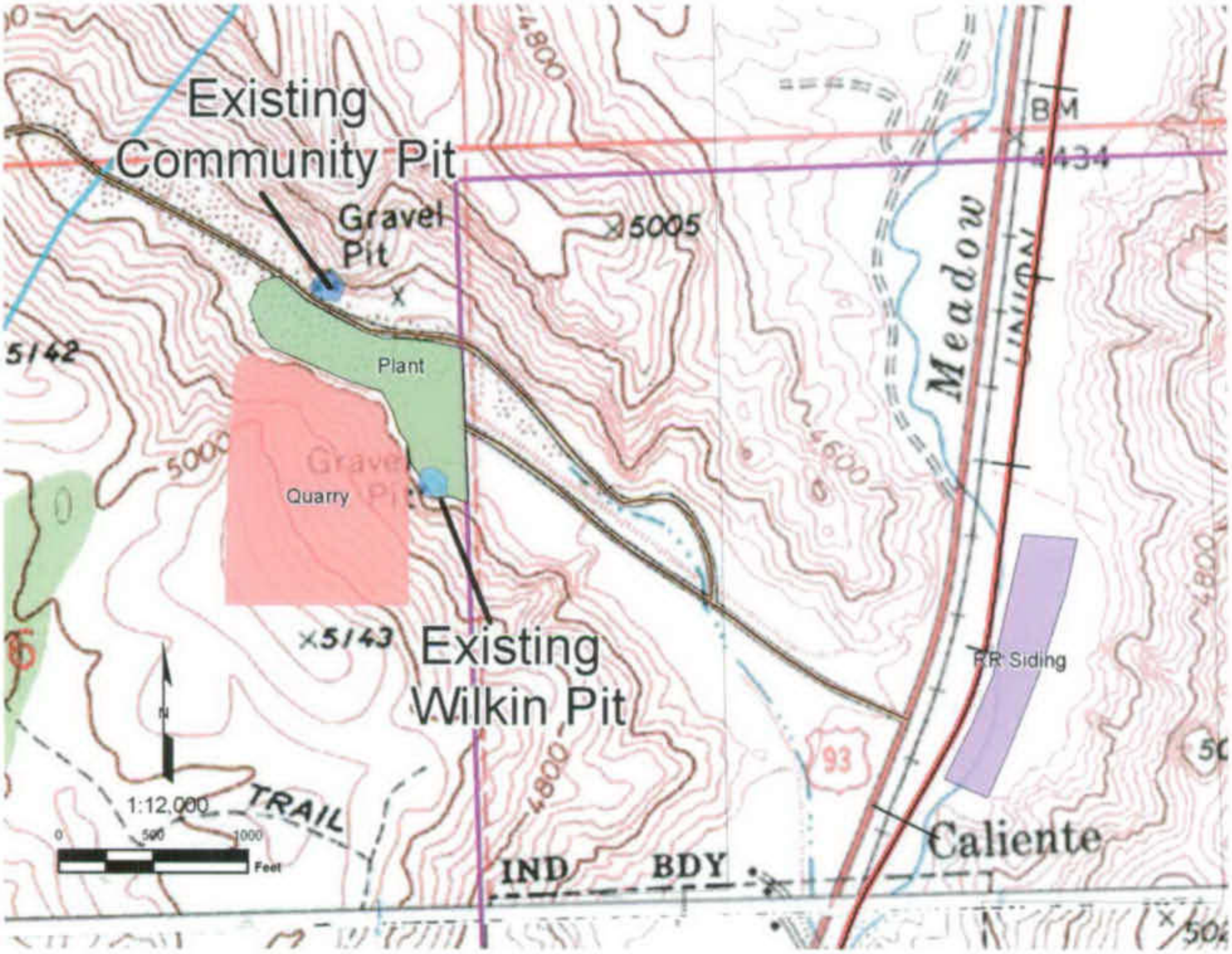


Figure 16: Area CA-8A(S) Site Conceptual Layout

4.3.11 Area CA-8A(N) Quarry Site Characteristics

Area CA-8A(N) is located in the Chief Range about 2.8 miles northwest of Caliente, Lincoln County, Nevada (Figure 6, Sheet 10). A potential ballast quarry site is reached from US-93 north of Caliente by following 4.4 miles of primitive dirt roads from the mouth of Cobalt Canyon or by following 4.5 miles of all-weather and primitive dirt roads from the mouth of Antelope Canyon (loop road). Roads into the site from Cobalt Canyon typically have grades of 6 to 22 percent, although in the last 0.1 mile, the road climbs from a wash to a saddle at a grade of 35 percent. The road in Antelope Canyon has grades that increase up the canyon from 2 to 4 percent; primitive roads north of the canyon ascend and descend very hilly terrain and have grades of 4 to 38 percent. Existing roads likely would be sufficient for a 4x4 vehicle or track rig to reach the potential quarry site for exploration purposes, but these roads would likely need to be improved substantially for quarry operations.

The potential quarry site is located in Township 3S, Range 67E, Sections 19 and 30. The site is a conical-shaped hill (Peak 5592) that rises to an elevation of 5,592 feet and is bordered by dry washes on its east and west sides at elevation 5,195 and 5,315 feet, respectively. Hill slopes are about 20 degrees. No mining claims are known to exist in the area.

There is no water in the vicinity of Peak 5592. Washes in the area carry ephemeral flows from precipitation events and are dry for most of the year. Because of the rugged terrain, groundwater is expected to be hundreds of feet deep; rock types present in the area can be expected to discharge small quantities of water to wells. Water supplies would most likely need to be transported by trucks.

The Cambrian Zabriskie Quartzite, the potential ballast source, caps Peak 5592 and extends northwest to a hill with a summit 5,700 feet (Rowley et al., 1994). The Zabriskie Quartzite terminates on its west side at a contact with siltstone, shale, and quartzite of the underlying Cambrian Wood Canyon Formation and is offset on its east side against the Tertiary Cobalt Canyon Stock by a fault that strikes N 30° W and dips 84° SW (Rowley et al., 1994). The Zabriskie Quartzite at Peak 5592 strikes N 2° E and dips 33° SE. A cross-section constructed from the geologic map of the Chief Mountain quadrangle (Rowley et al., 1994) indicates that the Zabriskie Quartzite at Peak 5592 is about 650 feet thick.

Zabriskie Quartzite exposed on Peak 5592 generally is white and light to medium gray, vitreous, coarsely crystalline, and fresh to slightly weathered. It is mottled gray, greenish-gray, red, and purple in an oxidized zone that occurs in the lower part of the formation, and it is banded red and gray and finely crystalline at the base of the formation. The rock generally has closely (2½-inch) to widely (6-foot) spaced, diversely oriented fractures, although in shear zones (which are not common) and in the basal red and gray-banded interval, fracture spacing can be extremely close.

Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
>2 ft	5
1 to 2 ft	20 to 30
0.5 to 1 ft	60 to 65
<0.5 ft	5 to 10

The RQD was estimated visually to vary from 50 to 80 percent. Depending on the degree of fracturing, the rock generally has medium high to very high strength when struck with a rock hammer. Internal fracture planes, which occur randomly, cause the rock to shatter when struck with no more than a few blows of a 4-lb hammer.

For the purpose of estimating the resource available at Peak 5592, it was assumed that a 600-foot-wide section of the formation would be quarried to a depth of 100 feet along strike for a distance of 1,500 feet. These assumptions result in a resource estimate of 7 million tons of quartzite. This estimate is conservative. If the mineable depth were doubled or tripled (which is supported by the known thickness and quality of quartzite at Peak 5592), the estimated resource would increase to 14 to 21 million tons of quartzite; however, this would require excavation below the bench on which processing and production would be performed.

It is anticipated that quarrying would start on the northeast side of Peak 5592 and would proceed to the southwest by blasting. Quartzite would be removed in tiers, probably corresponding to natural breaks, such as bedding or fracture planes. Most of the facilities needed to support quarrying, including a processing plant, a waste dump, an office complex, and settling ponds, could be constructed, with some grading, in relatively flat areas north and east of the quarry. If it is not feasible to extend power lines from Antelope Canyon to Peak 5592, power for quarry operations would likely need to be obtained from onsite generators. A ballast stockpile/loading facility complex could be constructed adjacent to the NRL in Meadow Valley either at the mouth of Cobalt Canyon or, less preferably, at the mouth of Antelope Canyon.

The nearest existing power is in Antelope Canyon, 2¼ miles south of the site or along US-93, about 4½ miles northeast of the site.

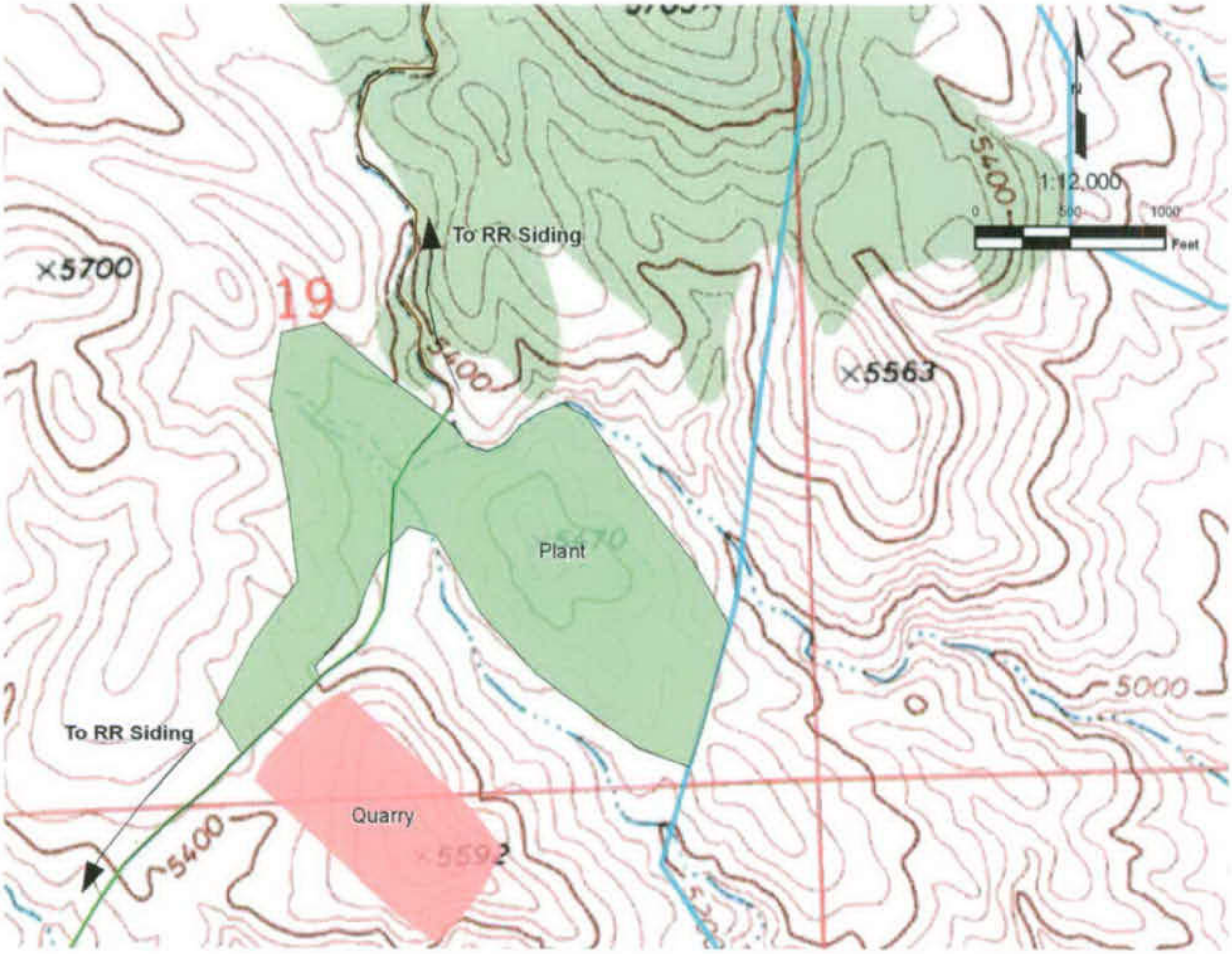


Figure 17: Area CA-8A(N) Site Conceptual Layout

4.3.12 Area CA-8B Quarry Site Characteristics

Area CA-8B is located in the Chief Range about 4 miles north of Caliente, Lincoln County, Nevada (Figure 6, Sheet 10). A potential ballast quarry site is reached from US-93 north of Caliente by following 3 miles of primitive dirt roads from the mouth of Cobalt Canyon. These roads typically have grades of 2 to 3 percent in the first 1.1 miles and grades of 5 to 22 percent thereafter. Existing roads would likely be sufficient for a 4x4 vehicle or track rig to reach the potential quarry site for exploration purposes.

The potential quarry site is located in Township 3S, Range 67E, Sections 17 and 20. This terrain in the vicinity of the site is very hilly, with washes moderately to deeply incised into the hills. Hills with summit elevations of 5,660 to 5,783 feet descend to washes that are at an elevation of about 4,960 feet where they leave the area. The terrain generally slopes down to the east and south at average gradients of 15 to 18 percent. Mining claim posts and prospects were observed north and west of the potential quarry site, in the Chief mining district, but no mining claims were observed east and south of Peak 5,734 (waypoint AG26), near which the field reconnaissance was conducted.

Water in area CA-8B is not readily available. Washes in the area carry ephemeral flows from precipitation events and are dry for most of the year. Because of the rugged terrain and the granitic bedrock that characterize most of the area, it is expected that wells drilled at or near the potential quarry site would produce small, possibly non-sustainable, quantities of water from randomly occurring fractures in granitic rocks. Wells developed in Quaternary alluvium in Meadow Valley or Tertiary fan alluvium in the Chief Range could potentially produce sufficient water to support quarry operations.

The Oligocene (approximately 24.8 Ma) Cobalt Canyon Stock (Rowley et al., 1994) is envisioned as a potential ballast source in area CA-8B. This stock, which contains a variety of silicic intrusive rock types but consists mostly of quartz monzonite, underlies about half of area CA-8B. On its east side, the stock intrudes the Cambrian Highland Peak Formation, and both geologic units are displaced upward against Cambrian sedimentary rocks, Oligocene lava flows and tuff, and Tertiary fan alluvium by a splay of the Chief Canyon Fault (Rowley et al., 1994). Conversely, the Cobalt Canyon Stock extends a considerable distance beyond the western boundary of area CA-8B. The Old Democrat Fault, which strikes about N 30° W and dips 74° SW (Rowley et al., 1994), is considered the western boundary of area CA-8B for this evaluation.

The Cobalt Canyon Stock in the vicinity of a hill with a summit elevation of 5,734 feet Peak 5734) appears to consist of rock ranging in composition from monzonite to granodiorite. Minerals in the rock consist of plagioclase feldspar ≥ potassium feldspar > quartz, with 10 to 15 percent pyroxene and subordinate biotite. The mafic minerals are slightly to largely altered to chlorite and subordinate epidote. The rock generally is gray to pink, phaneritic, and fresh to slightly weathered. The rock weathers by exfoliation and development of grus. Fractures are closely (2½-inch) to widely (6-foot) spaced and commonly in rectangular sets; locally dominant orientations do not persist throughout the area. The RQD in outcrop was estimated visually to be about 80 percent. The rock generally has very high strength when struck with a rock hammer.

Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
2 to 6 ft	5 to 30
1 to 2 ft	40 to 60
0.5 to 1 ft	10 to 45
<0.5 ft	5 to 10

For the purpose of estimating the resource available near Peak 5734, it was assumed that an area 1,000 feet long by 1,000 feet wide would be quarried to a depth of 200 feet. These arbitrary assumptions indicate that 16 million tons of the stock could be quarried in the vicinity of Peak 5734.

It is anticipated that quarrying would start on the east side of the wash below Peak 5734 and would proceed by blasting toward the west or where the Cobalt Canyon Stock is present. Access to the stock for quarrying could utilize primitive, low-gradient dirt roads that proceed 1.9 miles from the mouth of Cobalt Canyon at US-93 to a bench opposite the wash below Peak 5734. Existing roads could be extended across a deep, southerly draining wash to reach the wash below Peak 5734. The embankment spanning the deep wash could be constructed from Tertiary fan alluvium, which covers a large area in the vicinity of lower Cobalt Canyon and consists of medium high to high strength, poorly to well-indurated clasts of conglomerate and sandstone (Rowley et al., 1994). Abundant area exists at the current terminus of the proposed quarry access road for a processing plant, a ballast stockpile, a waste dump, an office complex, and settling ponds. The nearest existing power lines are 1 to 2 miles from the site, along US-93. A ballast stockpile/loading facility complex could be constructed adjacent to the NRL in Meadow Valley at the mouth of Cobalt Canyon.

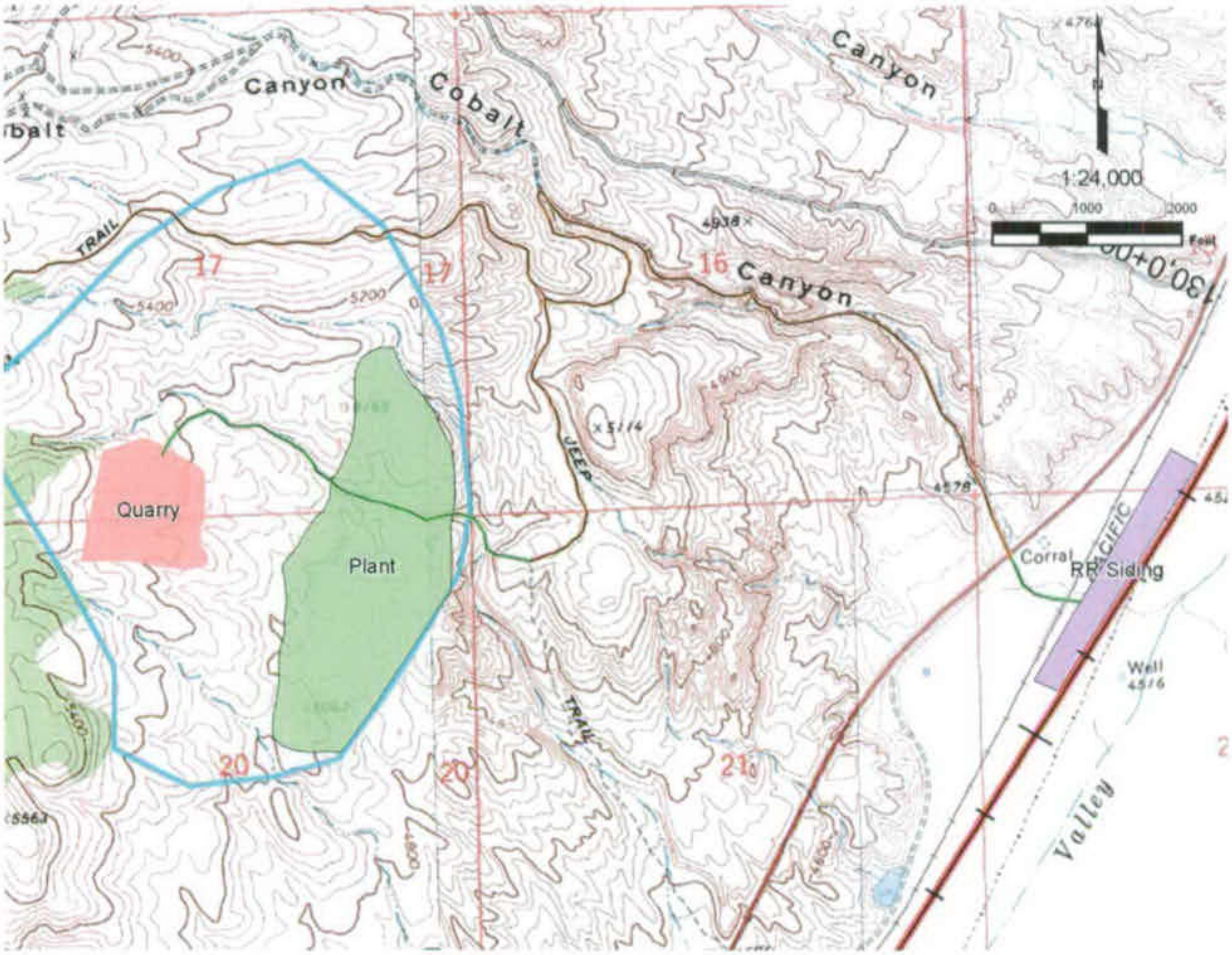


Figure 18: Area CA-8B Site Conceptual Layout

4.3.13 Area CA-11 Quarry Site Characteristics

Area CA-11 is located about 10 miles east of Caliente, Nevada, and about 3.7 miles northeast of the Union Pacific Railroad Minto station on Clover Creek. The site is a 150-foot-high plateau with reentrants on north and south sides, the result of erosion of weak rock (Figure 6, Sheet 11). The plateau tops out at about elevation 5,890 feet.

The study area is accessed by Beaver Dam Road, a gravel road that traverses the CA-11 area. The slope on this road, between the plant site and the railroad siding, ranges from 0 to 9 percent and averages about 3 percent. It is adequate for exploration drilling during dry weather.

Final access to the proposed quarry site is by a narrow jeep trail in Empy Wash. This trail is also adequate for exploration drilling equipment during dry weather.

Active mining claims limited this field evaluation to the far south portion of the study area. One mine claim post was discovered during the field investigation (shown in Appendix A). A rusty Prince Albert tobacco tin, nailed to a wooden post, contained no claim documents. This may be an inactive mining claim; however, detailed investigation of this claim has not been performed for this phase of evaluation.

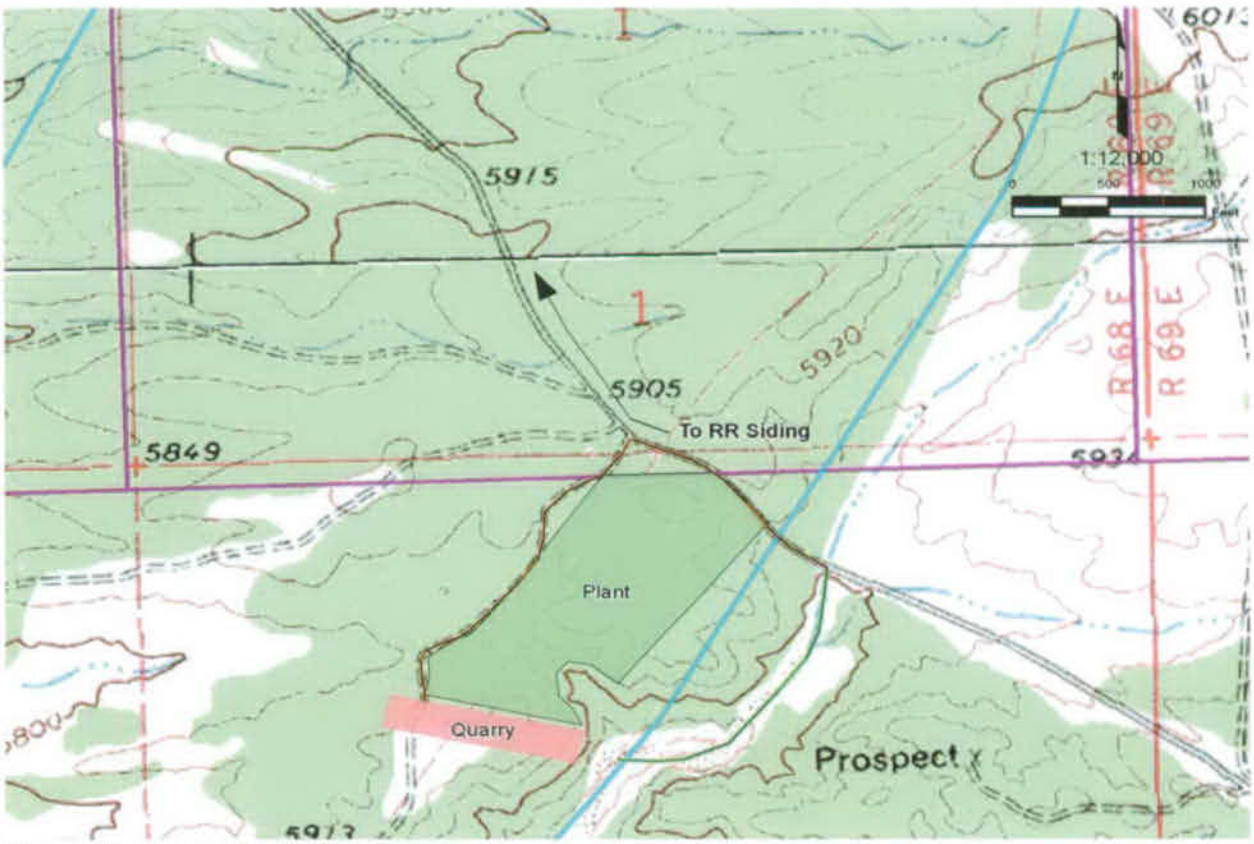


Figure 19: Area CA-11 Site Conceptual Layout

The CA-11 study area covers about 200 acres (excluding the railroad siding area) and contains a narrow quarry pit site, a plant site, and a distant railroad siding area.

The proposed plant site lies about 1,000 feet northeast of the quarry site. The plant site has an average slope of 3 percent. Little grading is anticipated to prepare a flat plant site. The railroad siding area is located 7.2 miles northwest of the plant site, adjacent to the NRL. Ground inclination in the siding area range from 0 to 8 percent, with an average slope of about 3 percent. Some earthwork may be required to prepare a flat siding area.

Slopes on the haul road between the plant site and the siding area range from 0 to 9 percent, with an average slope of about 3 percent. This road would likely require improvement to withstand year-round use by heavy construction and mining equipment. Road cuts are not likely to be required to prepare a suitably sloped roadbed.

The potential ballast stone in this study area is composed of light gray, medium strength, fine-grained rhyolite porphyry. Close- to medium-spaced (0.2 to 2.0 feet) joints and fractures were observed in the sampled outcrop. There is a persistent, 5- to 6-foot-wide, vertically oriented, hydrothermally altered, dark green zone in the center of the outcrop. The sample outcrop is roughly 100 feet wide (thick) and of unknown depth and strike length due to its near vertical orientation. Its subsurface dimensions and characteristics should be confirmed with borings. The unaltered dacite is bordered on both sides by brown stained, low to moderate strength, weathered (and possibly altered) rhyolite with very close-spaced fracture and joints.

The rhyolite shatters easily, sometimes from one blow with a 4-lb hammer, indicating medium strength. Visual field estimates of block size distribution are as follows:

Block Size	Percent Distribution
> 2.0 ft	10
1.0 – 2.0 ft	30
0.5 –1.0 ft	50
< 0.5 ft	10

This distribution suggests that blasting would reduce most of this rock to fragments 1 feet or smaller in size. When crushed, this stone may produce a low proportion of suitably sized ballast, with a high proportion of fines. RQD in outcrop is estimated at 30 percent, reflecting the fractured and jointed nature of the deposit.

A narrow, multiple-bench quarry, covering 9.6 acres, with an average height of 61 feet would produce about 2.1 million tons of stone. On completion of mining, the maximum final high wall height would be about 90 feet at the west end. The ground slope in the quarry area averages 4 percent grade.

In addition to the slot-like excavation required for extraction of the suitable rock, the sidewalls in fractured, weathered rock would need to be sloped back adequately for safety purposes. This would result in additional waste rock from this site.

Field observations suggest that the proposed pit area is covered with 0 to 5 feet of poorly sorted alluvial silt, sand, and gravel. Actual depths should be confirmed with borings. If the overburden is thin it may be feasible to separate it from the stone by screening the shot rock rather than removing it mechanically from the bench top prior to drilling.

Groundwater inflow is not anticipated during mining operations. Seasonal surface water inflow is possible, however. Sloping the pit floor downward from the bench face would reduce the potential for water accumulation in the pit.

5.0 FIELD AND LABORATORY TESTING AND RESULTS

In order to provide an initial characterization of rock properties that were observed and sampled from outcrops at the 13 sites, the field crews performed one field test and six types of tests were performed in laboratories. Consideration must be given to whether the rock samples taken from these surface outcrops are representative of the rock mass at depth, which would comprise the majority of source rock produced at the quarry. Rock samples taken from cores during future stages of quarry investigation would likely provide more representative characteristics of the source rock for the production ballast.

No one test is sufficient to "make or break" a quarry site, as there are numerous warnings in the technical literature regarding the limitations of the tests for choosing a site for borrow materials. For this reason, several tests were performed, some of which yielded more than one index value, to obtain multiple indicators of a rock's potential performance in the field. All of the test results must be considered in order to evaluate the suitability of a rock to perform as ballast.

5.1 Field Testing

To obtain an estimate of the strength of rock in the field, Schmidt Hammers were used by the field crews on outcrops. In every case, at least one set of readings was obtained on the outcrop where rock samples were taken. Additional outcrops were also tested at five of the potential quarry sites. The Schmidt Hammer was developed for testing concrete hardness, but was later adopted as a non-destructive method for estimating the strength of rock in outcrop and cores. Empirical relationships were developed between the hammer readings and uniaxial compressive strength, Young's modulus, and density (Katz et al., 2000).

The readings were taken and tabulated in accordance with American Society for Testing and Materials (ASTM) C 805-79, Rebound Number of Hardened Concrete. The readings were converted to uniaxial compressive strength using a relationship presented by Stagg and Zienkiewicz (1968). The results are presented in Table 3. The unit weight of the sampled rock is included in the table, as the compressive strength is dependent on the dry unit weight. Because rock outcrop surfaces are variable in orientation and the Schmidt Hammer is sensitive to the angle at which it strikes the rock, all readings were normalized to vertical for calculation of the strength of the rock in the outcrop.

5.2 Laboratory Testing

Rock samples retrieved in the field were transported to the Ninyo & Moore laboratory, where sufficient rock was retained to perform two of the tests listed below. The balance of the rock samples were sent to Shannon & Wilson's Seattle office for observation and distribution to the other laboratories. A portion of each sample was retained in Seattle for point load testing. The six laboratory tests performed by five laboratories are:

Bulk Specific Gravity/Absorption	Shannon & Wilson-Fairbanks, AK
Degradation	Ninyo & Moore-Las Vegas, NV
Sulfate Soundness	Ninyo & Moore-Las Vegas, NV
Point Load	Shannon & Wilson-Seattle, WA
Petrographic Analysis	Schurer & Fuchs-American Canyon, CA
Total Free Silica	ALS Chemex-Vancouver, BC

The laboratory test results and an explanation of the tests are presented in Appendix C. Table 2 is a summary of the laboratory test results, including the test method (i.e., ASTM and

International System of Units [SI]), and the acceptable AREMA standard for the tests, where applicable. Although not specified as part of the rock evaluation, the petrographic analysis also produced an estimate of the alteration of the rock sample, so it was included in Table 2.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Quarry Site Rating Criteria

Thirteen sites were evaluated for suitability as ballast production sources for the 319-mile-long rail line. In order to rate the potential quarry sites, nine criteria were chosen to represent the factors that should be considered important for differentiating the sites:

- Rock quality
- Rock volume potential
- Mining encumbrances
- Appurtenant structure space
- Overburden removal
- Length of access road to highway
- Length of access road to railroad
- Potential for inundation/harm
- Ease of exploration

Definitions of each of these criteria are presented in Appendix D, including an explanation of the range of rating values assigned to each of the criteria.

6.2 Quarry Site Rating System

The assignment of a rating value was based on information in the Quarry Field Evaluation Checklist forms (Appendix A), the summaries of the potential quarry sites in Section 4.3 of this report, and the field (Table 3) and laboratory (Appendix C) test results. Engineering and geologic judgment was also used to assign the score values that are presented in Table 4, Quarry Site Rating Table.

Certain of these factors were considered to be essential and others accessory, so some means of differentiating their importance was necessary. For instance, without suitably hard and durable rock, no quarry site was viable; whereas, a lengthy access road adds cost for site improvements and travel time, but may be accommodated within the budget of the project. Based on the experience of six geotechnical engineers and geologists at Shannon & Wilson, weighting factors were assigned to each of the criteria, as shown in Table 4. Weighing factors ranged from 10 (rock quality) to 1 (ease of exploration). The total weighted score for each potential quarry site was obtained by multiplying the raw score for each criterion by the weighting factor, and then summing the total weighted scores for each category. The total weighed scores ranged from 169 points (NN-9A) to 121 points (CA-11).

Non-geotechnical considerations, such as archeological, cultural, biological, and water resources would influence the selection of ballast quarry sites. The presence of these resources in the areas of our reconnaissance and the impacts caused by quarry development were beyond our scope of services, and are being evaluated by others.

6.3 Discussion

Thirteen sites were evaluated for their potential to supply ballast to the NRL based on geological, geotechnical and other related factors. They are located in three geographic areas: four in the east, six in the central area, and three in the west. The details of the aerial distribution of ballast supply sites would be determined by others as design of the project progresses.

Of the nine criteria that contributed to the rating of the quarries (Table 4), only two are of ultimate importance. These are reflected in the weighting factors in Table 4. For a hard rock quarry, it is absolutely necessary that the rock is of high quality. Without hard, durable rock, the quarry would be a failure, and the rail line would incur difficulties with alignment and grade in the future. Regarding quantity, it is possible to develop a pit without sufficient volume to supply all or a large section of the alignment; however, because of the expense of opening and decommissioning a quarry, it is more economical to operate quarries that have proven reserve to fulfill their purpose.

Therefore, whereas other factors are helpful in assessing the overall characteristics of the quarries, quality and quantity of rock are the two factors that are used below to accept/reject the quarries that were considered. We recommend that all quarries that scored 4 or 5 in the quality and volume potential categories be carried forward to be evaluated by others, based on other environmental, socioeconomic, and engineering factors.

6.3.1 Eastern Quarries

In the Caliente area, two quartzite quarry sites (CA-8A(S) and CA-8A(N)) performed relatively well in laboratory testing for this study; however, microfractures were noted in the petrographic analysis. This could be the result of their location in a tectonically disturbed zone and the rock's brittle nature. Additionally, the owner of the existing open pit at CA-8A(S) reported that this source had been rejected by the UPRR in the past because it did not break with an adequate amount of facets (planar surfaces), fractured too easily, and moved around under railroad ties.

In addition to the limiting physical characteristics of the quartzite, laboratory testing indicated that the free silica content of the quartzite was approximately double the silica content of the extrusive volcanic rocks. It was also about 50 percent more than the intrusive rock at CA-8B. Therefore, significantly more dust controls would be necessary to reduce airborne silica at the quartzite sites than at the other sites. We do not recommend the use of sites CA-8A(S) and CA-8A(N).

The quartz monzonite at CA-8B was of moderate quality and sufficient quantity. The test values for this rock were not in compliance with AREMA standards for specific gravity and absorption, but not significantly so. Based on observations of the outcrops, it is likely, but not assured, that these non-complying values are the result of surface weathering. The values for other tests were suitable. The deposit may be suitable with respect to specific gravity and absorption once the weathering rind of the rock is removed. Confidence in the quantity is relatively high due to its widespread extent and the likelihood that it also extends deeply owing to its intrusive genesis. We recommend that this site be advanced; however, further drilling and testing would need to be performed to increase confidence in this source; perhaps before the next phase of geotechnical exploration and testing. The most limiting factor in the development of this site is the access. An existing 3-mile-long road to the site is primitive and contains steep gradients. Considerable improvements would be necessary to create and maintain construction access to this site.

The rhyolite porphyry at site CA-11 was of moderate to poor quality. Test values for specific gravity were significantly lower and absorption test values were significantly higher than AREMA standards. Because the relatively suitable rock (that which was sampled and tested) was sandwiched between hydrothermally altered rock on two sides, it would be necessary to remove the more suitable material in a slot-like excavation and slope the adjacent altered rock to a stable angle. For this reason, the quantity of rock would not be sufficient for the ballast operation. We do not recommend the use of site CA-11.

Rock from site CA-12 was not sampled or tested due to the inability of the field reconnaissance crew to gain access to areas that contained suitable rock for ballast during the time of the field investigation. Details of the difficulties are presented in Appendix A. We do not recommend use of Site CA-12 in the area that was reconnoitered. If other parts of CA-12 become available for access, they could be evaluated, sampled and tested in the future.

6.3.2 Central Quarries

The porphyritic basalt and basalt in sites NN-9A and NN-9B, respectively, met all of the AREMA standards for ballast, were of high strength, had relatively low silica, and contained almost no alteration. The two sites were artificially separated for this study due to the large size of a contiguous basalt flow ridge. For purposes of quarry development, they could be considered one source that could be developed from north, east or south. Outcrops along the eastern edge indicated the widespread extent of the flow; however, because all but the upper 10 to 20 feet of the eastern escarpment are covered with talus, the vertical geologic section is unconfirmed. Based on geologic conditions in other basalt flows in the area, it appears that this ridge could be comprised of multiple flows 5 to 20 feet thick separated by soil interbeds, and rubble or scoriaceous zones a few to several feet thick. Our confidence in the quantity for this site is high. Although there could be 20 to 25 percent waste due to interbeds and broken zones, the deposit is extensive. We recommend that these sites be carried forward for further evaluation.

The porphyritic basalt and basalt porphyry in sites NN-8C and NN-8D, respectively, met all of the AREMA standards for ballast, were of high strength, had relatively low silica, and contained almost no alteration. The sites are adjacent, but not adjoining; and based on geologic mapping and on the similarities of the test results, could be considered the same formation. Both are suitable from a quality perspective. NN-8C has a high confidence level for quantity of rock because of a reasonable number of outcrops available for inspection and an extensive area of the mapped formation. However, NN-8D has only a moderate confidence for quantity. Whereas the formation is shown to be extensive, the amount of outcrop for confirmation was limited. We recommend that both NN-8C and NN-8D be carried forward for further evaluation, but substantially more exploration work must be performed to confirm the quantity for NN-8D.

Andesite porphyry at site NN-8B did not meet AREMA standards for relative density, absorption and sulfate soundness, and was altered 7 to 8 percent. Due to the topographic constraints of the site, only a moderate volume could be produced from this site and the final highwall would be 100 feet or more on the west side. We do not recommend the use of NN-8B for a ballast quarry site.

Andesite porphyry at site NN-8A met all of the AREMA standards for ballast, was of high strength, and had relatively low silica. Its degradation resistance was suitable but only marginally so, and it was altered 8 percent. The most significant drawback to this site is its lack of outcrop from which to confirm the presence of suitable rock. The outcrop sampled and tested was the only outcrop available in the designated area, and it is unlikely that other adjacent areas are suitable for ballast rock, owing to mines and mining claims in hydrothermally altered rocks and pyroclastic materials. We do not recommend the use of NN-8A for a ballast quarry site.

6.3.3 Western Quarries

Basaltic andesite at site NS-3A did not meet AREMA standards for relative density and absorption, but met other standards and had reasonably favorable strength and alteration values. Due to the large extent of the formation, there is high confidence that it contains adequate quantities to supply the ballast needs of the project. It is likely that this material could be used if additional sampling proved that the rock could meet the quality specifications, particularly because this deposit is most likely geologically the same as that at NS-3B, but that would require additional sampling and testing of rock collected from other outcrops in the NS-3A area.

Basalt at site NS-3B met all of the AREMA standards for ballast, was of high strength, and had relatively low silica. The alteration percentage was about 8 percent, indicating slight weathering of the sampled rock. The confidence in a large quantity for this site is high, owing to the wide exposure of outcrops and the extent of the deposit, based on geologic maps. One drawback to this site is its position in close proximity to a dry wash that could interrupt the flow of blasted and processed rock to the rail head. A unique advantage of this site is its location on alternative alignment GF3, such that high quality rock would be excavated to create the necessary grade for the railroad. We recommend NS-3B be carried forward for consideration as a ballast quarry site.

Basalt porphyry at site ES-7 met all of the AREMA standards for ballast, was of high strength, had very little alteration, and had relatively low silica. The confidence for a large quantity is high due to the widespread amount of outcrop that displayed characteristics similar to that sampled and tested. A significant amount of road would likely need to be constructed for this site to reach the top of Malpais Mesa from the west side. We recommend that this site be carried forward for consideration as a ballast quarry site.

6.4 Recommendations for Future Geologic/Geotechnical Studies

Once quarry sites are chosen for a next stage of evaluation, we recommend that additional geologic/geotechnical studies be undertaken to learn more about the rock deposits in the quarry sites. Such studies should include detailed outcrop mapping, selection of specific drilling locations, exploratory core drilling, laboratory testing of the cores retrieved from the borings, and geophysical explorations to correlate conditions between borings, if necessary.

The first stage of subsurface explorations at the potential quarry sites should consist of three to six borings in locations that might best represent the geologic conditions and anticipated quarry configuration. Borings should be extended to about 20 feet below the lowest expected floor level of the pit. When the final one or more sites are chosen for the quarry site, a patterned grid of core borings should then be drilled to obtain detailed information for quarry design.

SHANNON & WILSON, INC.

Paul M. Godlewski, P.E.
Vice President
Project Manager

William T. Laprade
Vice President
Supervising Geologist

DEX:PMG:WTL/srm

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TABLE 1
QUARRY DESIGNATIONS AND LOCATIONS

Quarry Designation (west to east)	County	Valley/Range
ES-7	Esmeralda	Goldfield
NS-3A	Nye	Goldfield
NS-3B	Nye	Goldfield
NN-8A	Nye	Kawich
NN-8B	Nye	Kawich
NN-8C	Nye	Reveille
NN-8D	Nye	Reveille
NN-9A	Nye	Reveille
NN-9B	Nye	Reveille
CA-8A(S)	Lincoln	Meadow Wash
CA-8A(N)	Lincoln	Meadow Wash
CA-8B	Lincoln	Meadow Wash
CA-11	Lincoln	Clover Creek
CA-12*	Lincoln	Clover Creek

* Quarry site CA-12 was not sampled and is not considered as a viable source because of the lack of suitable rock in the area available for access during site reconnaissance.

TABLE 2
SUMMARY OF LABORATORY TEST RESULTS

TESTS	TEST	AREMA STANDARD	ES-7/S1	NS-3A/S1	NS-3B/S1	NN-8A/S1	NN-8B/S1	NN-8C/S1	NN-8D/S1	NN-9A/S1	NN-9B/S1	CA-8A(S)/S1	CA-8A(N)/S2	CA-8B/S1	CA-11/S1
Bulk Specific Gravity	ASTM C 127	>2.60	2.8	2.56	2.72	2.68	2.56	2.7	2.81	2.79	2.79	2.64	2.62	2.56	2.42
Absorption (Percent)	ASTM C 127	<1.0%	0.4	1.7	0.8	0.4	1.6	0.9	0.7	0.5	0.4	0.2	0.3	1.3	2.5
Degradation (Percent)	ASTM C535	<25% Traprock <30% Quartzite <35% Granite	17 t	18 t	15 t	21 t	17 t	15 t	17 t	16 t	20 t	19 q	23 q	14 g	17 t
Sulfate Soundness (Sodium Sulfate) 5 cycles	ASTM C 88	<5.0%	1	1.6	1.7	0.3	5.5	0.7	0.45	0.7	0.3	0.03	1.1	1.2	3.6
Point Load (psi)	ASTM D5731-02	NA	33,000	31,000	33,000	27,000	31,000	31,000	26,000	32,000	38,000	33,000	25,000(fresh) 12,000(altered)	35,000	25,000
Total Free Silica (percent)	SI ICP 81	NA	22.2	24.4	22.5	28.5	28.9	22.6	21.5	22.4	21.9	45.7	44.6	31.1	35.5
Petrographic Analysis		NA	Leucobasalt Porphyry	Basaltic Andesite	Leucobasalt	Andesite Porphyry	Andesite Porphyry	Porphyritic Leucobasalt	Leucobasalt Porphyry	Porphyritic Leucobasalt	Leucobasalt	Quartzite	Quartzite	Quartz Monzonite	Rhyolite Porphyry
Alteration (percent)		NA	2	3	8	8	7-8	<1	2.5-3	<0.5	<0.5	<1	<1	5	2

NOTES:
(1) ASTM D 535 was performed on materials having gradations containing particles retained on the 1-inch seive.
(2) Point load test ASTM D5731-02 is also known as ISRM RTH 325-80. Values are means of multiple tests.
(3) Alteration (percent) was a product of the petrographic analysis.

ASTM: American Society for Testing and Materials
ICP: Inductively Coupled Plasma spectrometer
ISRM: International Society of Rock Mechanics
SI: International System of Units

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TABLE 3
SCHMIDT HAMMER RESULTS

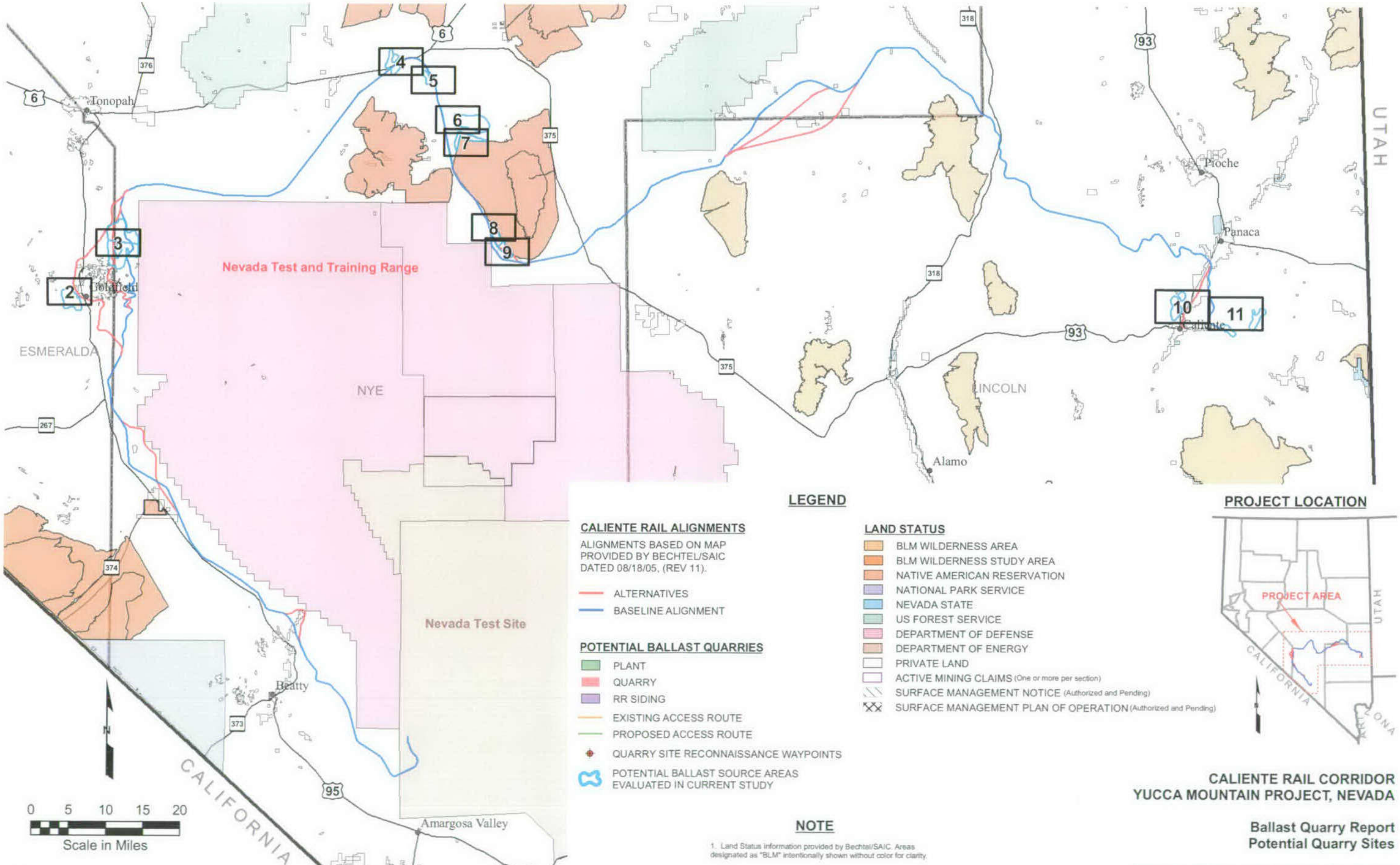
QUARRY	LOCATION	DRY UNIT WEIGHT (pcf)	AVERAGE FIELD READING	CALCULATED UCS (psi)
ES-7	Goldfield	175	47	20,000
NS-3A	Goldfield SM389	160	57	26,500
	Goldfield SM390	160	51	19,700
	Goldfield SM391	160	49	18,400
NS-3B	Goldfield AG15	170	51	23,500
	Goldfield AG16	170	54	27,100
	Goldfield AG18	170	57	32,200
NN-8A	Warm Springs	167	57	30,700
NN-8B	Warm Springs	160	50	19,100
NN-8C	Reveille Valley	168	52	24,000
NN-8D	Reveille Valley	175	55	32,000
NN-9A	Reveille Valley	174	54	29,000
NN-9B	Reveille Valley	174	50	23,500
CA-8A (S)	Caliente AG28A	165	57	29,000
	Caliente AG28B	165	65	45,200
	Caliente AG29	165	62	39,400
CA-8A (N)	Caliente AG31	164	60	34,000
	Caliente AG32	164	59	32,500
CA-8B	Caliente AG22	160	53	22,000
	Calienta AG23	160	51	20,000
CA-11	Caliente (fresh)	151	51	17,700
CA-11	Caliente (weath.)	151	32	8,500
CA-12	Caliente	NA	No readings	NA

NOTES:
(1) Schmidt Hammer model L
(2) Calculation method per ASTM C805
pcf: pounds per cubic foot
psi: pounds per square inch
UCS: Unconfined compressive strength

TABLE 4
QUARRY SITE RATING TABLE

CRITERIA	WEIGHTING FACTOR	RAW SCORE FOR EACH QUARRY SITE [5 (HIGH) TO 1 (LOW)]												
		ES-7	*NS-3A*	*NS-3B*	*NN-8A*	*NN-8B*	*NN-8C*	*NN-8D*	*NN-9A*	*NN-9B*	*CA-8A(S)*	*CA-8A(N)*	*CA-8B*	*CA-11*
Rock Quality	10	5	4	5	4	2	5	5	5	5	3	3	4	3
Rock Volume Potential	6	5	5	5	3	4	5	4	5	4	5	5	5	3
Mining Encumbrances	4	3	5	3	3	5	5	5	5	5	3	5	3	3
Appurtenant Structure Space	3	5	5	5	5	5	5	5	5	5	5	5	5	5
Overburden Removal	3	5	5	5	4	5	4	4	4	4	5	5	5	5
Length of Access Road to Highway	3	3	2	2	4	4	2	3	5	5	5	3	3	4
Length of Access Road to Railroad (RR)	3	3	5	5	5	4	3	3	4	3	5	3	3	2
Potential for Inundation/Harm	2	5	3	4	5	5	5	5	5	5	5	5	5	4
Ease of Exploration	1	5	3	5	3	5	3	5	5	5	5	2	1	5
Total Weighted Score:		**155**	**150**	**156**	**137**	**133**	**155**	**154**	**169**	**160**	**147**	**140**	**141**	**121**

NOTE:
Archaeological, cultural, biological, and water supply resources are being evaluated by others.



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Ballast Quarry Report
Potential Quarry Sites

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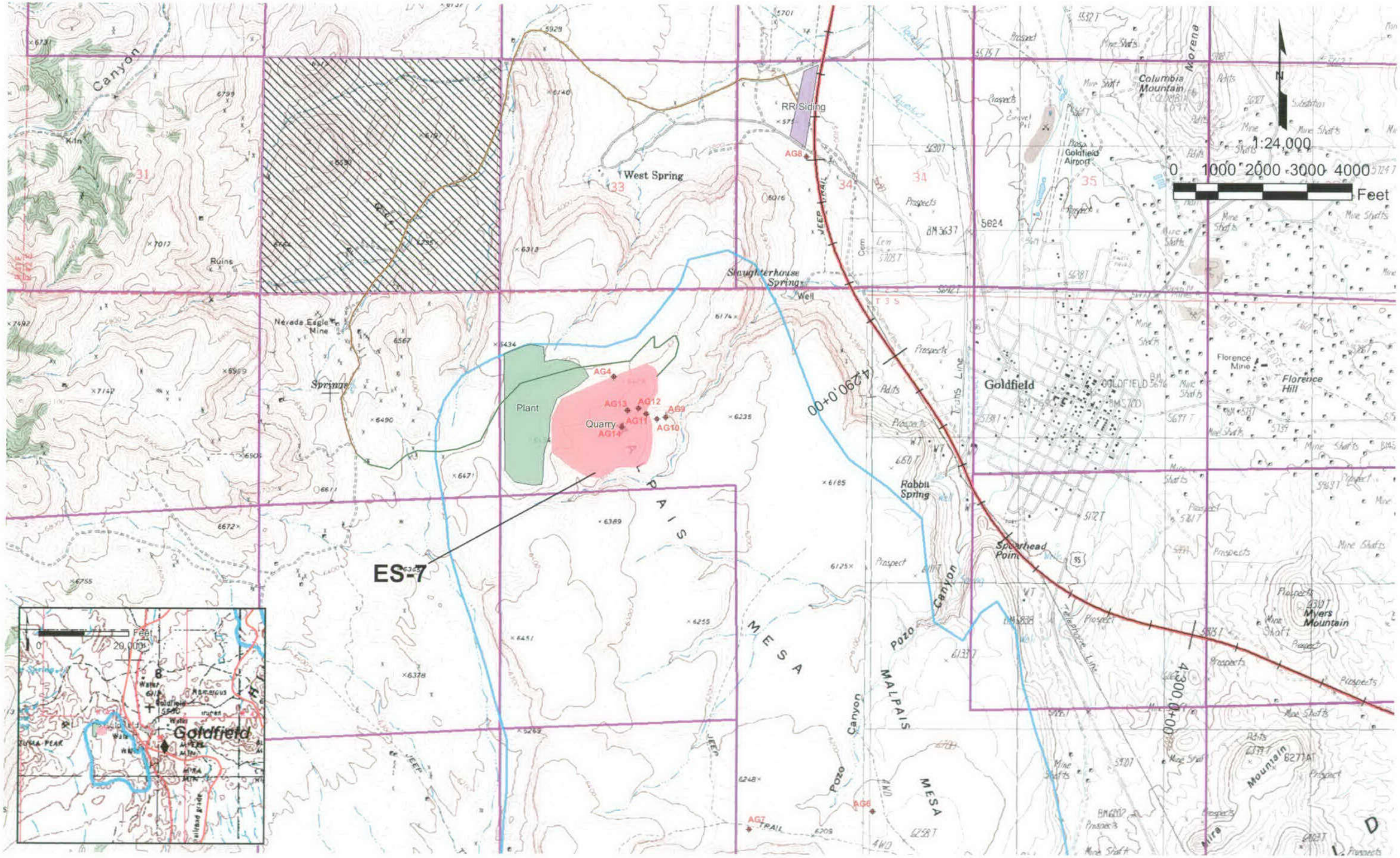

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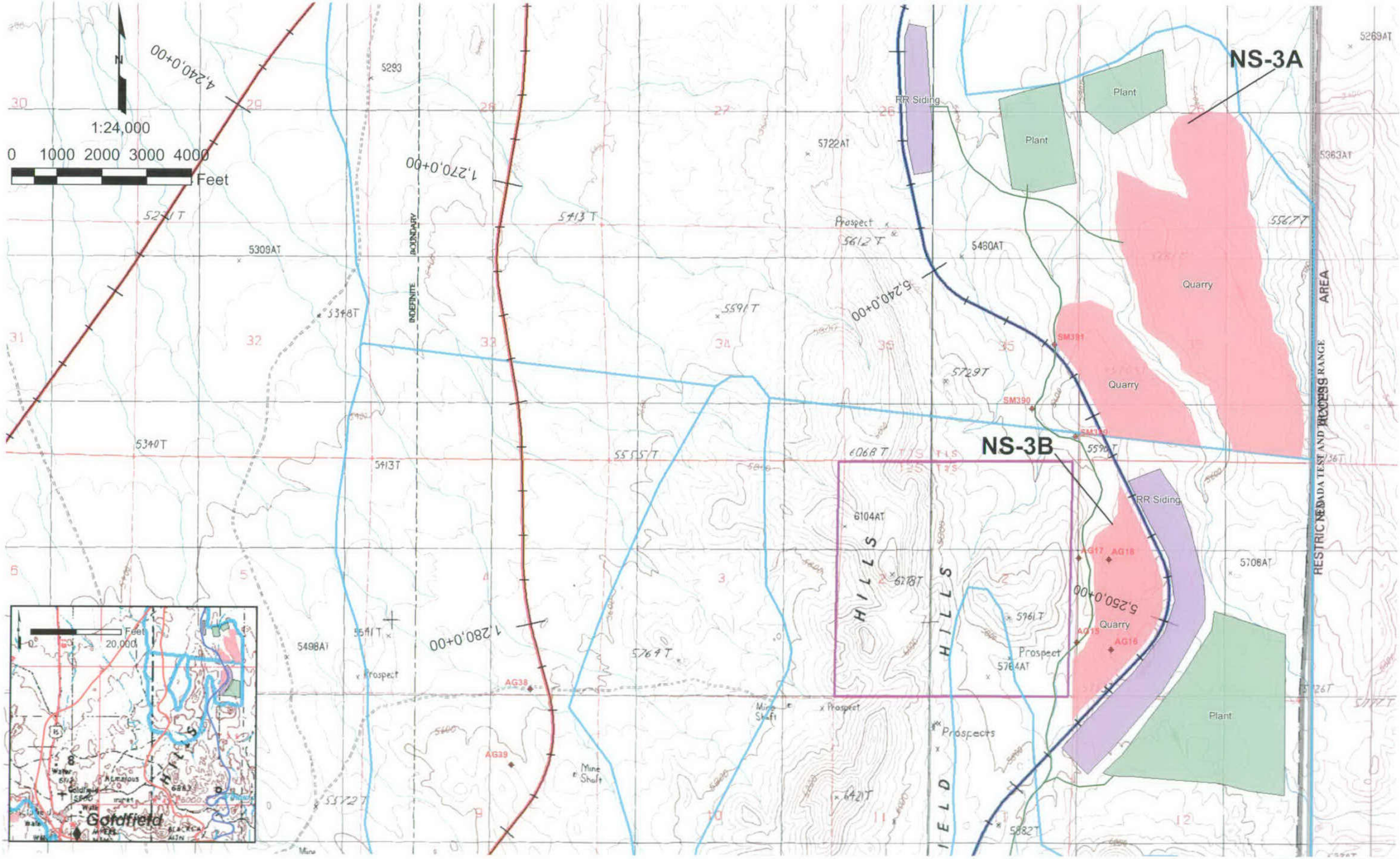

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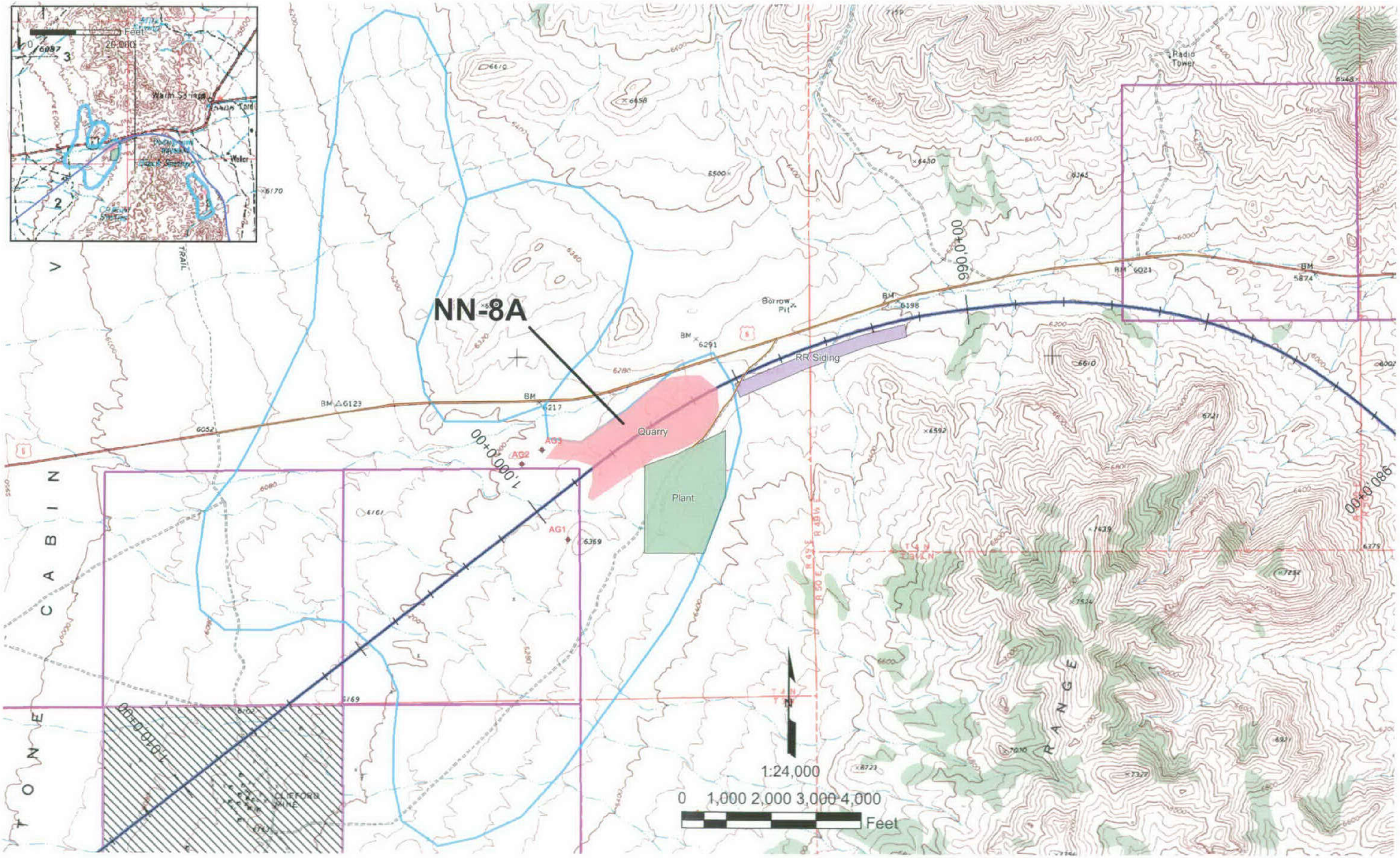

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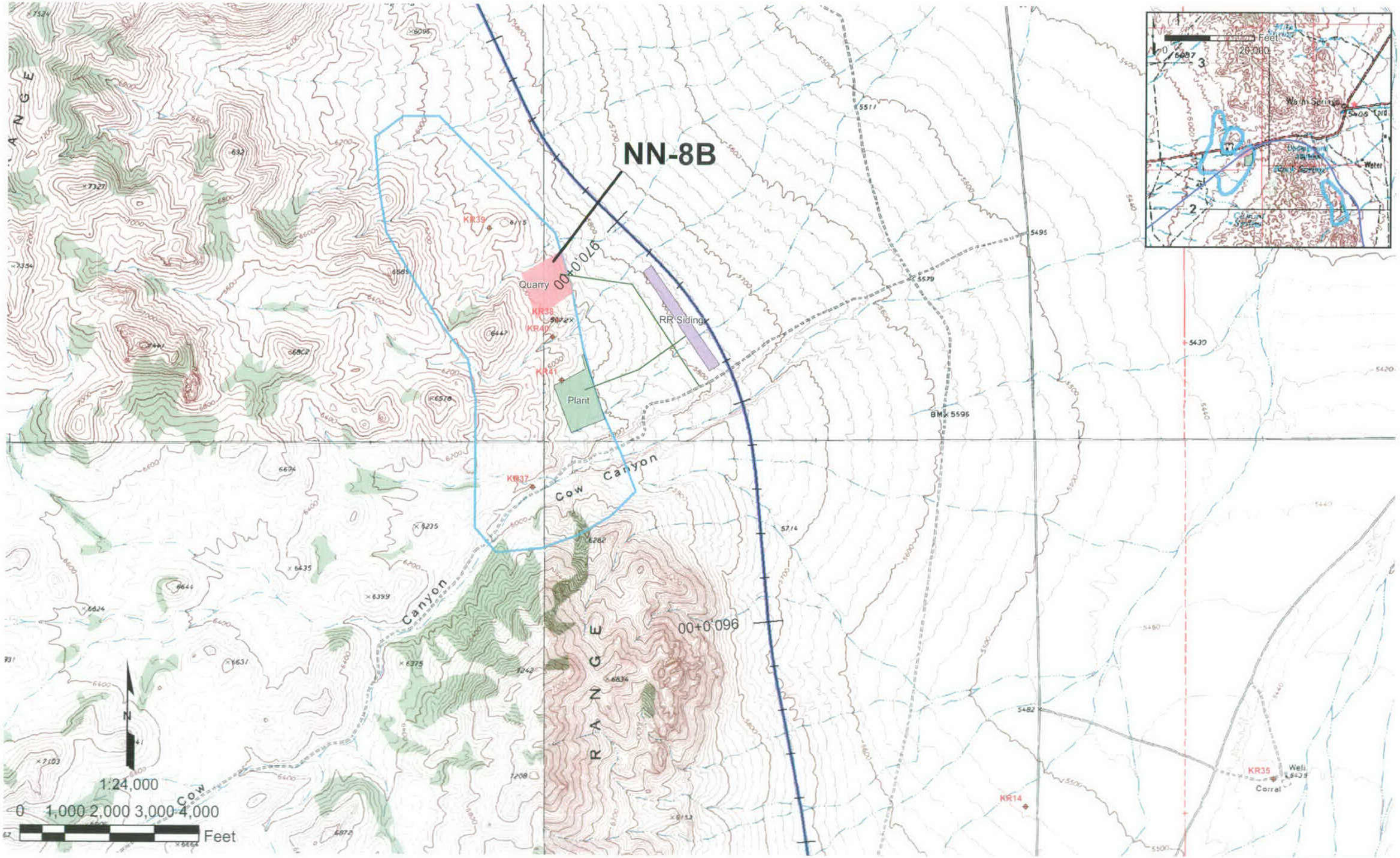

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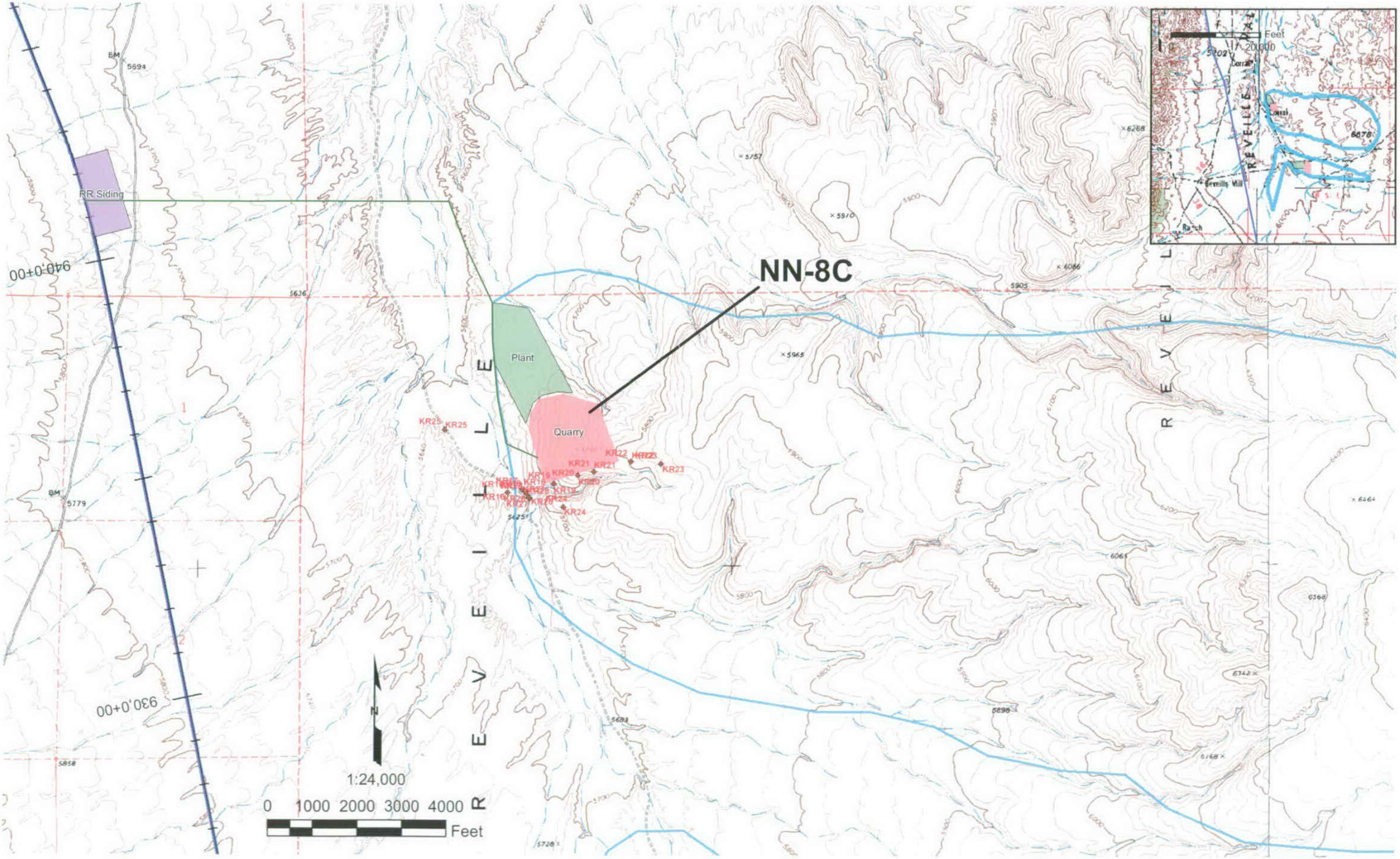

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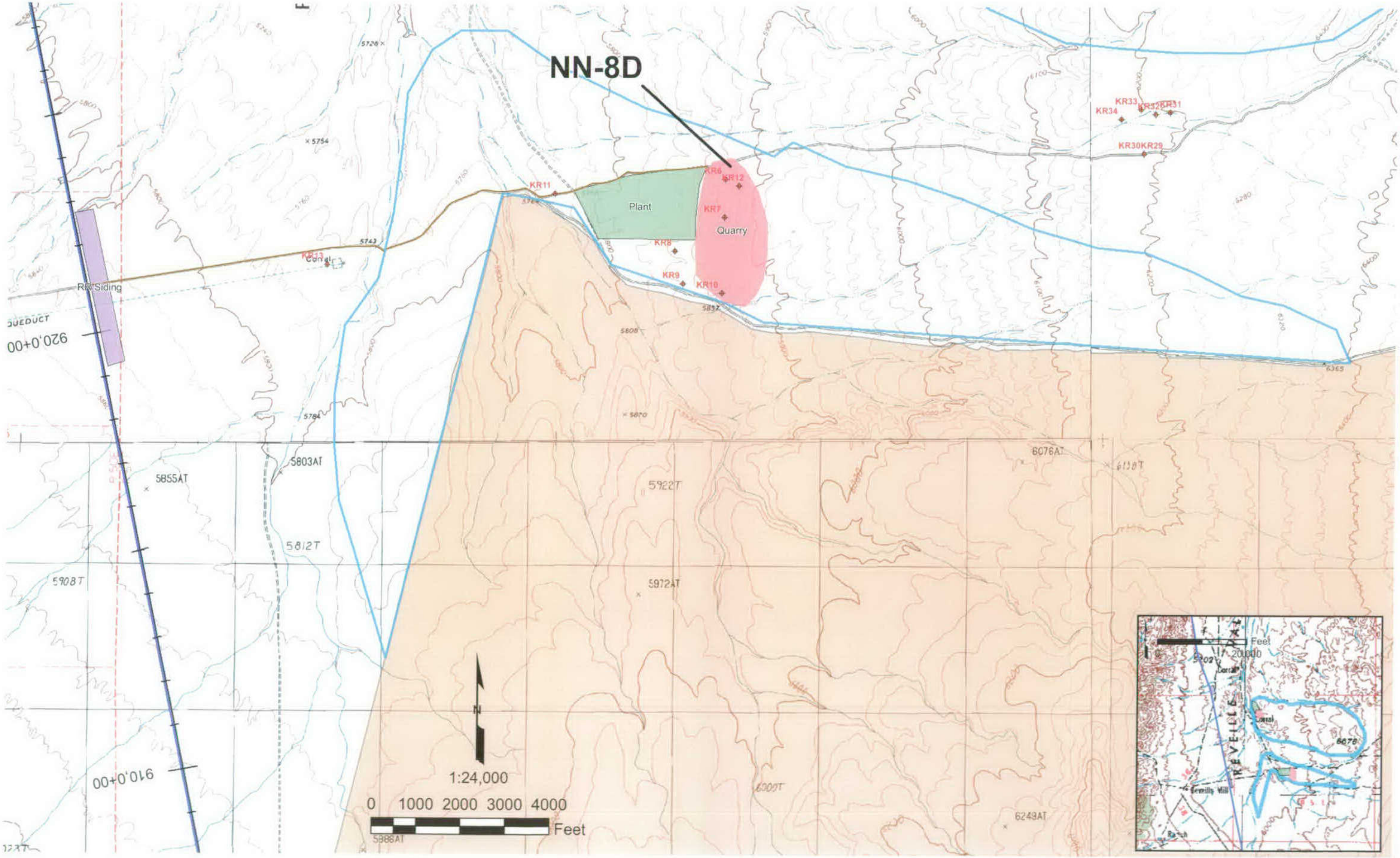

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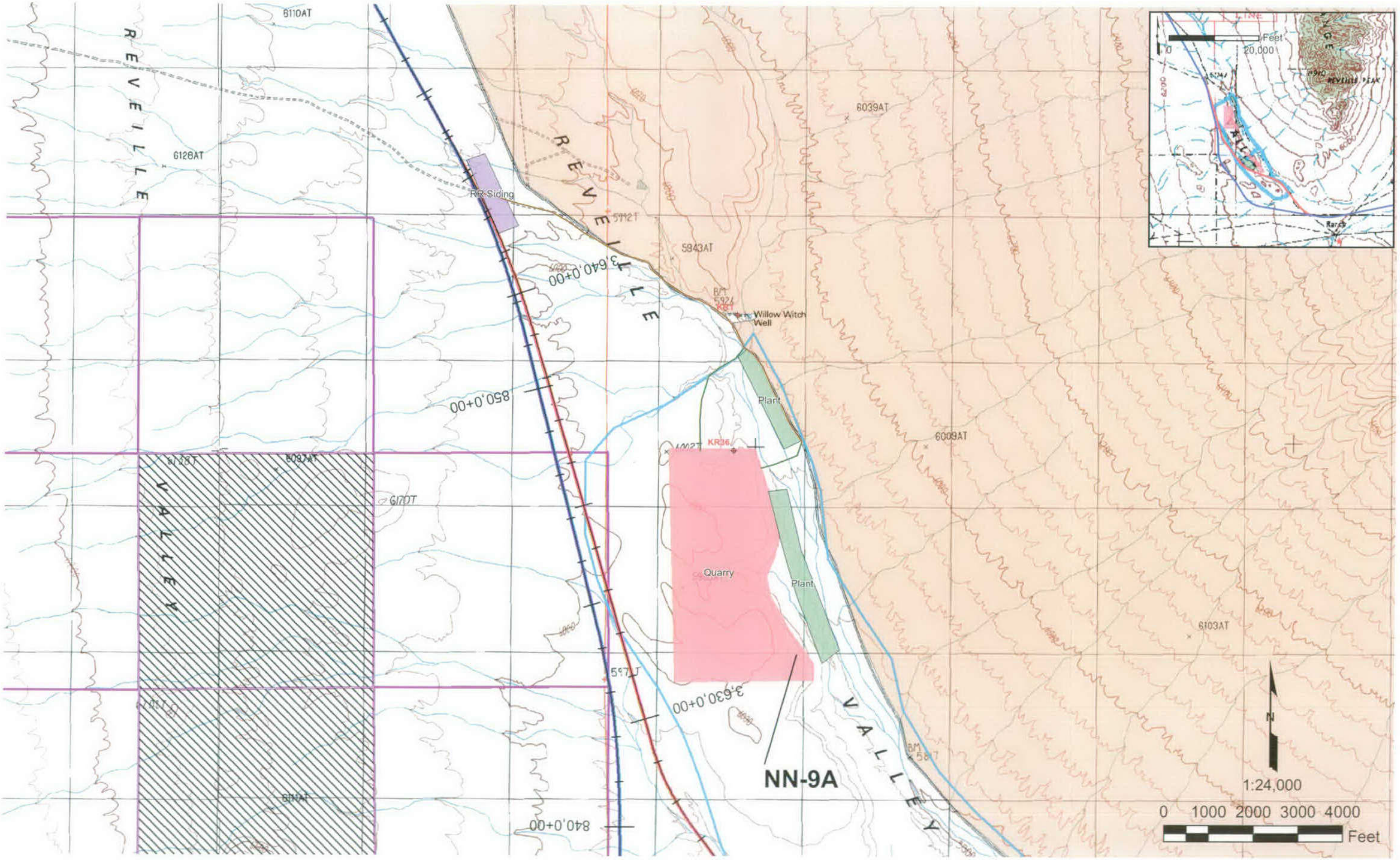

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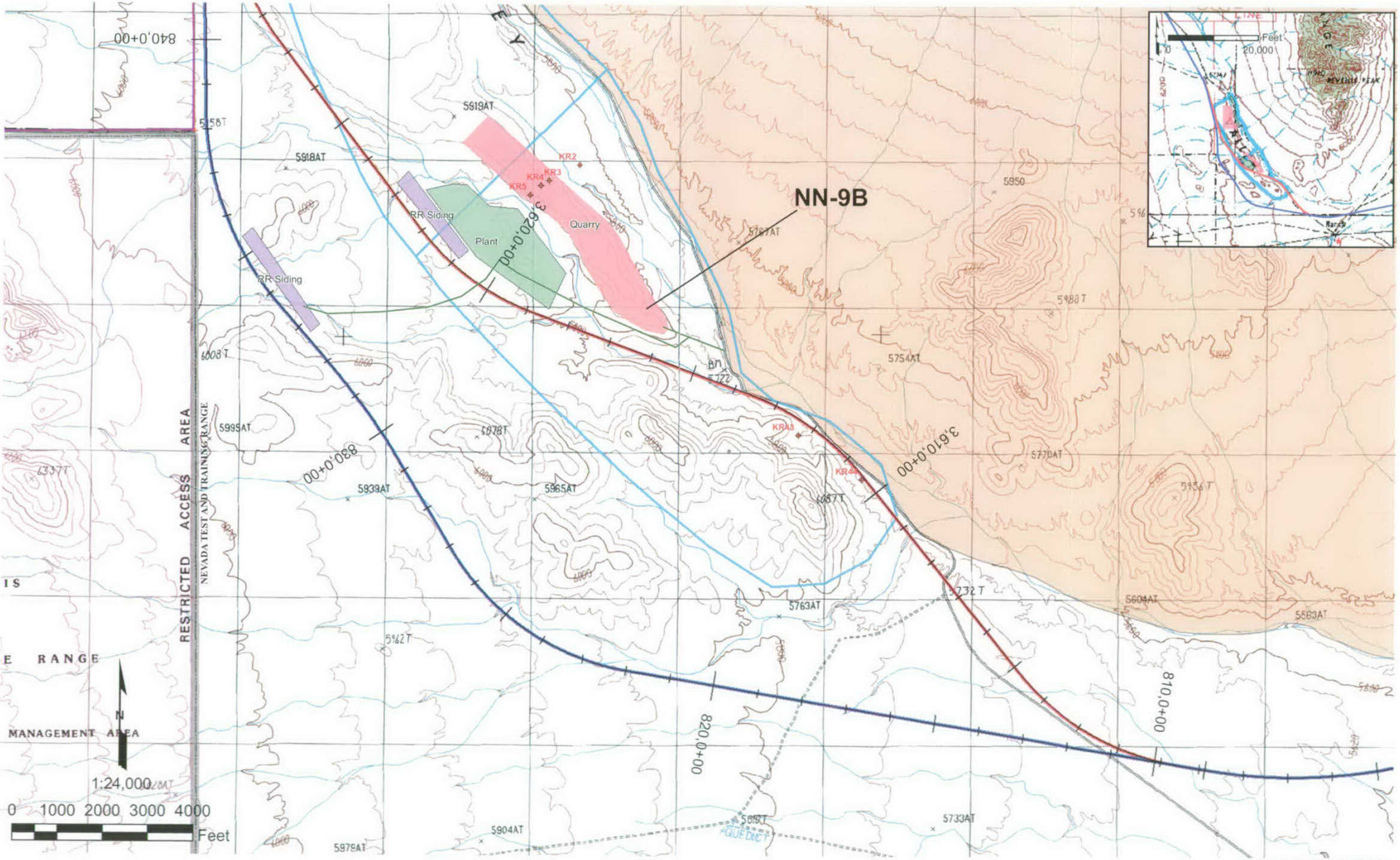

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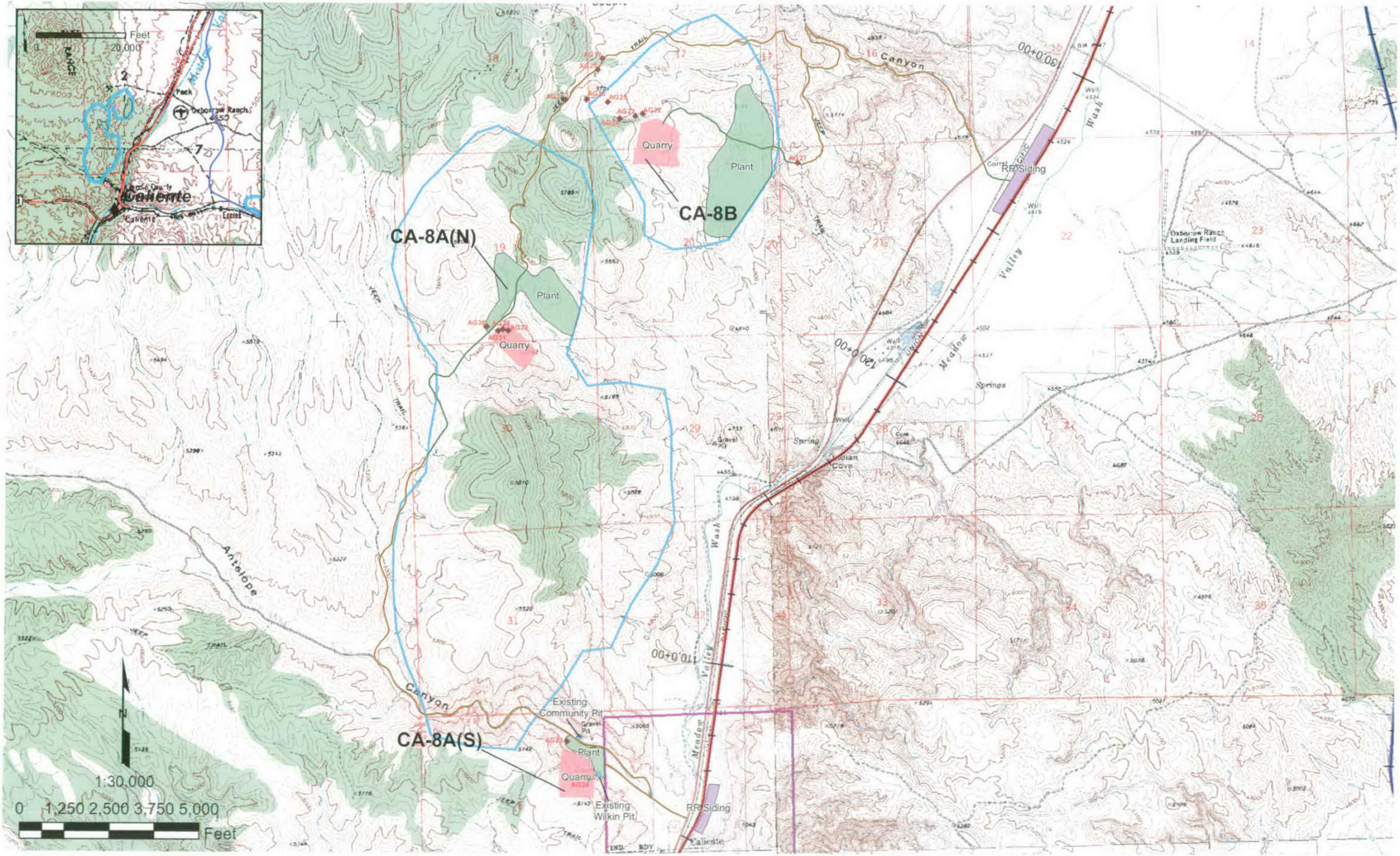

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POTENTIAL QUARRY SITES

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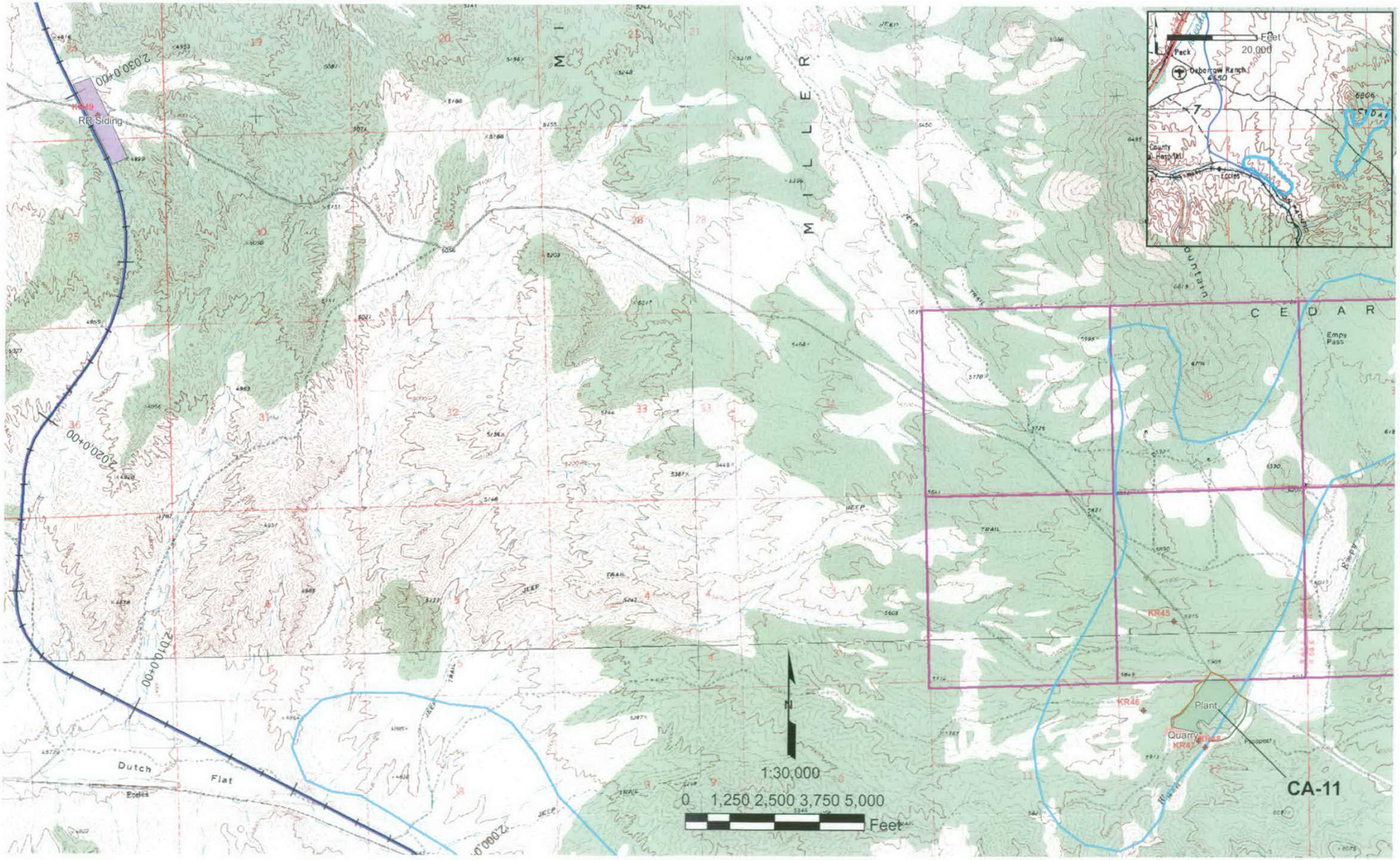

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FIGURE 6 (Sheet 11 of 11)

APPENDIX A

QUARRY FIELD EVALUATION CHECKLISTS

APPENDIX A

QUARRY FIELD EVALUATION CHECKLISTS

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QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: ES-7
FIELD TEAM: Art Geldon and Matt Grizzell
November 18-19, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)
Access road to mesa climbs or goes around small hills at grades of <5 to 16 percent before ascending the gently sloping backside of Malpais Mesa. Grades there are ≤ 8 percent. The mesa top is relatively flat. The east face of the mesa drops 150 feet in about 600 feet (a slope of 14°) to a bench. Flat on top, the bench gradually descends about 60 feet in 700 feet (a slope of about 5°) to the rim of a canyon. It then drops about 100 feet near vertically to the floor of a wash.

B. Surface Water (near stream/river?), what flow?, intermittent)
No surface water. Eastward-draining washes with several tributaries each are present throughout Malpais Mesa. Ephemeral flow from precipitation occurs in washes. A deeply incised wash drains the quarry site.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)
Plant and office facilities would be located on the mesa top.

D. Existing Access roads (where are they?, can they be improved? show on maps)
Exiting access roads (see log) extend 5.2 miles from the intersection of US-95 and the cemetery road north of Goldfield to the top of Malpais Mesa. For 2.2 miles, the road is bladed dirt and appears to be maintained as an all-weather road. Road after that is one-lane dirt and would have to be improved. Proposed haul road from mesa top to quarry would need to be built.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)
A railroad siding would be located 0.8 mile from Goldfield between the alignment on the east and the dirt roads on the west, north, and south, in an area about 2,000 feet north-south by 800 feet east-west.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)

A waste dump could be located on top of Malpais Mesa by the processing plant and ballast pile.

G. **Access Roads** (to highway and RR alignment)

i. Topographic conditions for new road
See road log.

ii. Cut slopes (soil/rock)
Needed to improve existing access road to Malpais Mesa from 2.2 to 5.0 miles from US-95 and to build a haul road from the quarry to the top of Malpais Mesa.

2. DEPOSIT FEATURES

A. **Location** (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)
The deposit is in T3S, R42E, S4, on surveyed land.

B. **Tonnage** (provided in this deposit [W x L x H])
Primary deposit (best rock) is on lower bench. It is about 1,300 x 900 x 100 feet = 4,333,333 yd^3 x 2.16 $tons/yd^3$ = 9,360,000 tons. A secondary deposit of variable quality rock is about 500 x 800 x 100 feet = 1,481,000 yd^3 = 3,200,000 tons.

C. **Overburden** (note thickness/type)
Shallow (<1 ft.) to no colluvium.

D. **Deposit Features**

i. Rock Type/Description (use S&W rock descriptions)
BASALT LAVA flows: very high strength, medium to dark gray, porphyritic, finely crystalline to fine-grained ground mass, generally fresh to slightly weathered. Rock quality deteriorates above lower bench because there are many intervals of poorer quality rock interlayered with sound rock. Poorer rock can be brecciated, sheared, rubbly (i.e., boulders of basalt in a grungy matrix), or toward the top of the mesa, vesicular. Above the lower bench, there is poor exposure because of soil and vegetation where rock deteriorates. Below the bench, nearly continuous exposure to a wash. Rock generally has a light gray or brown weathering rind. Rock tends to weather to rounded boulders and glass-like gravel.

ii. Thickness/Depth (need minable thickness)
Primary, about 100 feet; secondary ≤100 feet, exact thickness is uncertain because of variable rock quality of interstratified sound and rubbly or sheared intervals.

iii. Rock Structure (block sizes/joint or fracture spacing)
Generally no preferred orientation, but below the lower bench, the walls have a preferred joint orientation of N45-50°E, 84°NW to SE. Variable fracture spacing occurs at different locations. In general very closely to widely spaced.

	Block Spacing (%)			
Location (waypoint)	**> 2 feet**	**1 to 2 feet**	**6 inches to 1 foot**	**<6 inches**
AG4	20	60	15	5
AG10	55	30	10	5
AG11	5	65	25	5
AG12	10	60	25	5

Type	Strike	Dip	Description
Joint	N45-50° E	84° NW to SE	Prominent joint set in canyon walls below bench
Shear zone	N10-20°	77-80° NW	Typical shear orientation between lower bench and about 30 feet below mesa top
Dip(?)	N18°E	36° SE	Could be top of a flow because of weathering apparent tops of columnar joints on surface

iv. Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)
See previous rock description. Possible fault zone exists between the upper slope and the bench, creating numerous shear zones and mega-breccia intervals at and above base of upper slope.

E. Rock Quality
RQD generally 70 to 90 percent.

i. Samples for testing (100 pounds minimum; describe sample; taken)
Collected samples from wash to top of mesa to get a distributed sample (omitted poor-quality rock, e.g., from rubble or shear zones).

ii. Rock hammer test
Rock has very high strength.

iii. Schmidt hammer test readings:

Location (waypoint)	45° Face	Vertical Face	Horizontal Face
AG4	46-57 (Avg. 50)		
AG9	39-52 (Avg. 47)	36-43 (Avg. 41)	49-65 (Avg. 54)
AG10	None	44-54 (Avg. 49)	42-52 (Avg. 45)
AG14	45-52 (Avg 30)	45-48 (Avg. 47)	52 (No average)

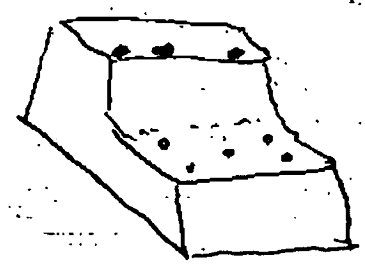
F. **Groundwater** – Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.
No groundwater at quarry site near the surface.

G. **Future Explorations**

i. Drill rig access
Dirt roads with ≤16 percent grade from Goldfield to top of Malpais Mesa. No existing road to recommended primary deposit (i.e., bench below mesa top).

ii. Type of rig
4WD or track rig.

iii. Locations and depths of borings
Eight borings 250 to 420 feet deep, as in sketch; three borings at mesa top each 420 feet deep. Five borings in lower bench - two at each end and one in the middle - each 250 feet deep.



iv. Geophysics alignments
Borehole geophysics to determine lithology only.

3. ENVIRONMENTAL FEATURES

A. **Vegetation** (what type/how much/where)
On Malpais Mesa, there are sparse shrubs and forbs on basalt colluvium and scattered Joshua trees, pinon pine, and juniper. Cheat grass and other vegetation is on the east-facing slope to the wash.

B. **Visibility** (would quarry be visible from road?)
Quarry would not be visible from US-95 or Goldfield. It might be visible from roads crossing Malpais Mesa outside of the quarry area.

4. OTHER FEATURES

A. **Power** (is power nearby or need on-site generation)
A power line parallels US-95. It is crossed under about 0.1 mile past the intersection of the cemetery road with US-95.

B. **Water** (groundwater studies by others)
Depth to water generally is unknown, but several springs issue from the base of Malpais Mesa. Slaughterhouse Spring issues from the Siebert Tuff (actually a sedimentary rock unit here) on the east side of the mesa. West Spring issues from Siebert Tuff on the north side of the mesa. An unnamed spring issues from Pozo Formation on the west side of the mesa. A well must be drilled for a water supply. Water near Goldfield might have poor quality from mining pollution.

ROAD LOG TO QUARRY SITE

0.0 Intersection of US-95 and cemetery road
0.2 Road forks; cemetery nearby on left fork. Take right fork.
0.6 Goldfield Bike Trail access.
0.7 Ballast stockpile area.
1.3 Road right to city dump.
1.5 West Spring at outlet of canyon descending from quarry site, about 2,000 feet SW of road. Left fork to spring. Stay on right fork. Note steep east face of Malpais Mesa.
2.2 Jeep road and borrow pit on right. Main road narrows to one lane here.
3.4 Nevada Eagle Mine workings on right (west).
4.2 Spring with a tank. Road grade here is 10 to 20 percent, rising to south.
4.4 Crossed a wash.
4.5 Turn left (east) onto a dirt road that leads up to Malpais Mesa—14 percent grade.
4.6 Road descends a hill at 16 percent grade.
4.7 Road forks, take right, gently sloping fork.
4.9 ES-7 area boundary. Road from here to top of mesa has ≤8 percent grade.
5.2 Area to east is permissible for quarrying (no mining rights).
5.9 Road ends on top of mesa—altitude 642 feet AMSL.

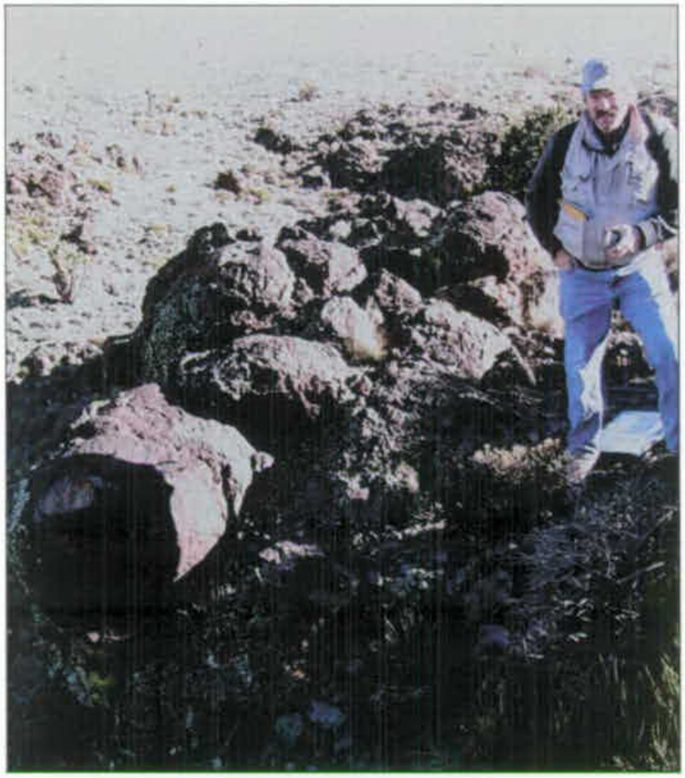
PHOTOGRAPHS

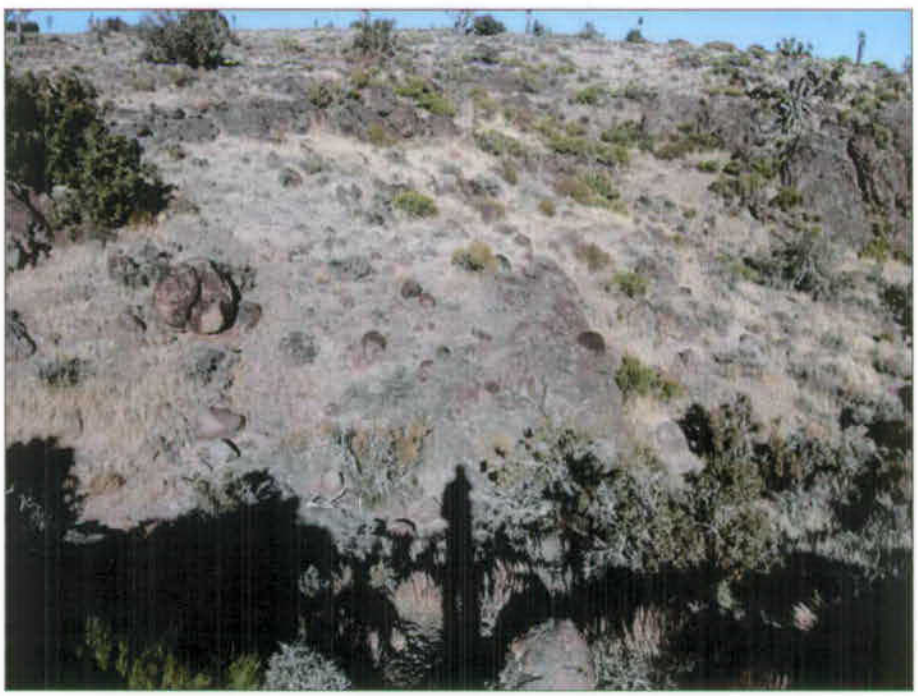
MG-13: (waypoint AG-4) View NE down canyon – note steep basalt walls

AG0004-0007: (waypoint AG-4) Panorama NE to SE of Malpais Mesa, Goldfield, and Goldfield Hills

MG-18 to 22: (waypoint AG-8) Photos along access road to Malpais Mesa

MG-24 to 26: (AG 9) Views NE down canyon, east to cliff face across wash, up a tributary canyon





MG-27-28: (AG 9) Views below bench in basalt-walled canyon



MG-29-32: (AG-12-14) Views of outcrops between lower bench and mesa top

MG-33: (AG-4): Basalt outcrop on top of mesa

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NS-3A
FIELD TEAM: Art Geldon and Matt Grizzell
November 20, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)
Valley slopes north toward Mud Lake at grades of 2-39°; wash down center of valley. Basalt hills on both sides of valley covered with Joshua trees, shrubs, and cheat grass.

B. Surface Water (near stream/river?), what flow?, intermittent)
Wash down center of valley drains north toward Mud Lake; ephemeral flows from precipitation events at unknown frequency.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)
Yes, see map.

D. Existing Access roads (where are they?, can they be improved? show on maps)
Dirt roads from Goldfield to within about 2 miles of quarry site. Roads will have to be improved in places, and a new road to the quarry site must be built from end of existing road.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)
Yes, see map.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)
Yes, see map.

G. Access Roads (to highway and RR alignment)

i. Topographic conditions for new road
See road log for existing access roads. However, instead of using existing areas, it might be easier to reach the area by improving and extending existing roads south from US-6 past Mud Lake and up the valley.

ii. Cut slopes (soil/rock)
See road log

2. DEPOSIT FEATURES

A. Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)
Deposit in T15, R43E, S35 E ½ and S 36 W ½.

B. **Tonnage** (provided in this deposit [W x L x H])
Width x length = 22,907,500 feet^2; thickness varies from 40 to 100 feet (based on topographic contours; average assumed to be ~60 feet, thus volume =1/4 x 109 feet^3=51,000,000 yards^{3}x 2.16 tons/yards^3= 110,000,000 tons

C. **Overburden** (note thickness/type)
Shallow soil, colluvium, and vegetation, except in wash. Wash filled with alluvium of unknown thickness, believed to be <30 feet.

D. **Deposit Features**

i. Rock Type/Description (use S&W rock descriptions)
Basalt lava flows: very high strength, dark-gray, fine-grained, varies from non-vesicular in interior of flows to vesicular at tops and other intervals; vesicles commonly filled with zeolites and other white minerals; generally fresh, but with a thin, brown weathering rind.

ii. Thickness/Depth (need mineable thickness)
From topographic contours, thickness of basalt flows estimated to range from 40 to 100 feet throughout the resource area. An average thickness of 60 feet is assumed. Variably vesicular and slabby to blocky fractured, actual minable thickness averages <60 feet.

iii. Rock Structure (block sizes/joint or fracture spacing)
Generally random oriented fractures are extremely closely to widely spaced

	Block Size Distribution (%)			
Waypoint	> 2 feet	1-2 feet	6 inches-1 feet	< 6 inches
SM 389	10	25	60	5
SM 390	30	20	10	40
SM 391	Too many boulders covering rock in place to estimate block size distribution			

iv. Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)
Interlayered with non-vesicular, very hard rock are layers of vesicular basalt (also very hard), slabby fractured basalt, rubble layers, intervals of gravel-cobble alluvium, and pockets of ash-fall tuff.

E. **Rock Quality**
RQD is expected to vary from <50% to possibly ≥ 70% from place to place. Actual RQD cannot be determined without exploration drilling.

i. Samples for testing (100 pounds minimum; describe sample; taken)
Samples collected at waypoints SM 389, 390, and 391 and mixed; 3 bags

ii. Rock hammer test
Very high strength

iii. Schmidt hammer test
SM 389 50-63, average 58
SM 390 43-59, average 51
SM 391 46-59, average 50

F. Groundwater – Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.
No evidence of near-surface groundwater. Abundant Joshua trees in area suggest water table is deep.

G. Future Explorations

i. Drill rig access
Dirt roads from Goldfield (see road log)

ii. Type of rig
Track rig or possibly 4WD rig with high clearance without substantial road improvement.

iii. Locations and depths of borings
A minimum of 8 borings is needed to help determine the volume and quality of basalt present.

iv. Geophysics alignments
Borehole geophysics needed to help clarify subsurface geology and hydrology.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)
Moderately dense shrubs, Joshua trees common throughout the resource area.

B. Visibility (would quarry be visible from road?)
Quarry might be visible from Mud Lake.

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)

No power nearby. Would have to be extended from Goldfield on the south, or US-6, east of Tonopah, on the north.

B. **Water** (groundwater studies by others)
Water table might be deep, because Joshua trees prefer rocky slopes and flats with considerable depth to water. Boreholes needed to define the potentiometric surface and identify water supplies.

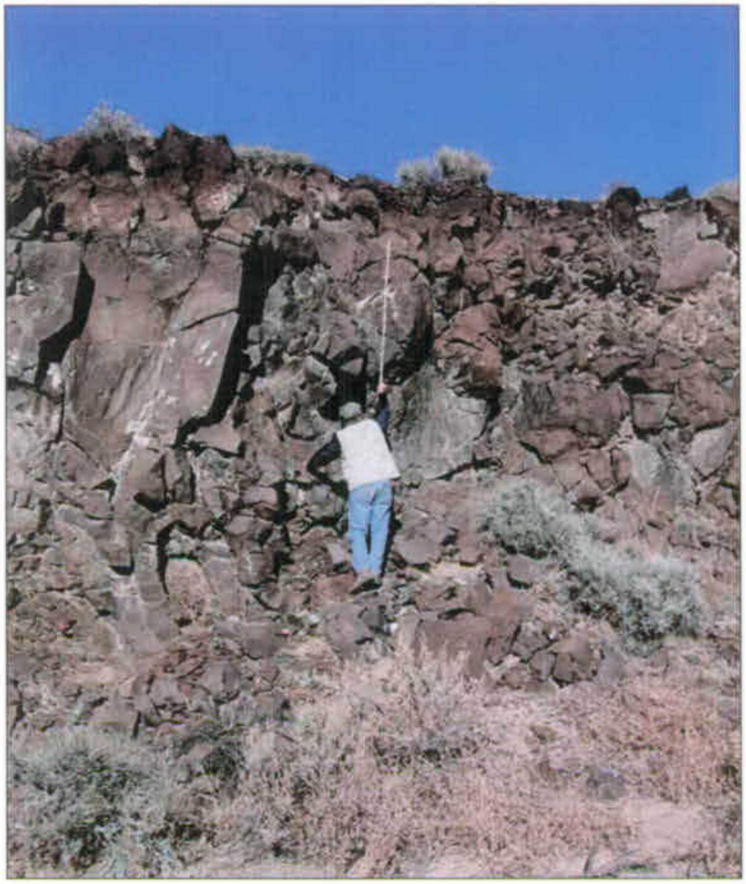
ROAD LOG TO QUARRY SITE

0.0	Goldfield at US-95.
4.9	Diamondfield (site) reached from Goldfield on well graded roads. Road forks; take right fork.
5.4	Road right to private property.
5.6	Black Butte; road forks; take right fork.
5.9	Road right to private property, road now is dirt, on rolling terrain.
6.2	View ENE of 2 basalt flows, together ~25-30 feet thick, capping hills.
7.2	Road begins to ascend a northerly aligned range of hills. Road rocky, rutted, rough; grades 6-11%.
7.9	Top of pass.
8.0	Road descends to a valley at a grade of ≤15% and curves through the valley.
8.2	Road forks; take left fork.
8.6	Road begins climbing another northerly aligned range of hills at grades of 6-20%.
9.3	Top of pass.
9.4	Road descending pass at grades of 8-12%; needs cuts and fills.
9.8	In valley; road forks; take the left fork, a dirt track.
10.2	On GF3 alignment.
10.25	Top of pass between alluvial fans sloping SE and NW; wpt SM 381.
10.4	Road left to a prospect; road becomes obscure.
11.0	Road ends; route descends a wash at 2-3% grades.
11.1	WPT SM 387: Hill of basalt on left.
11.2	Basalt in left bank of wash.
11.5	WPT SM 388 on GF3 in wash; basalt in right bank.
12.0	Basalt crops out on left, in a small hill.
12.1	Basalt crops out in right bank of wash.
12.4	WPT SM 393, basalt in right bank.
12.6	Basalt continuous from left bank to skyline.
13.0	WPT SM 389, basalt cliff on right bank.
13.3	WPT SM 390, basalt on both sides of wash.
13.6	On GF3 at SM 391; basalt outcrops on both banks.

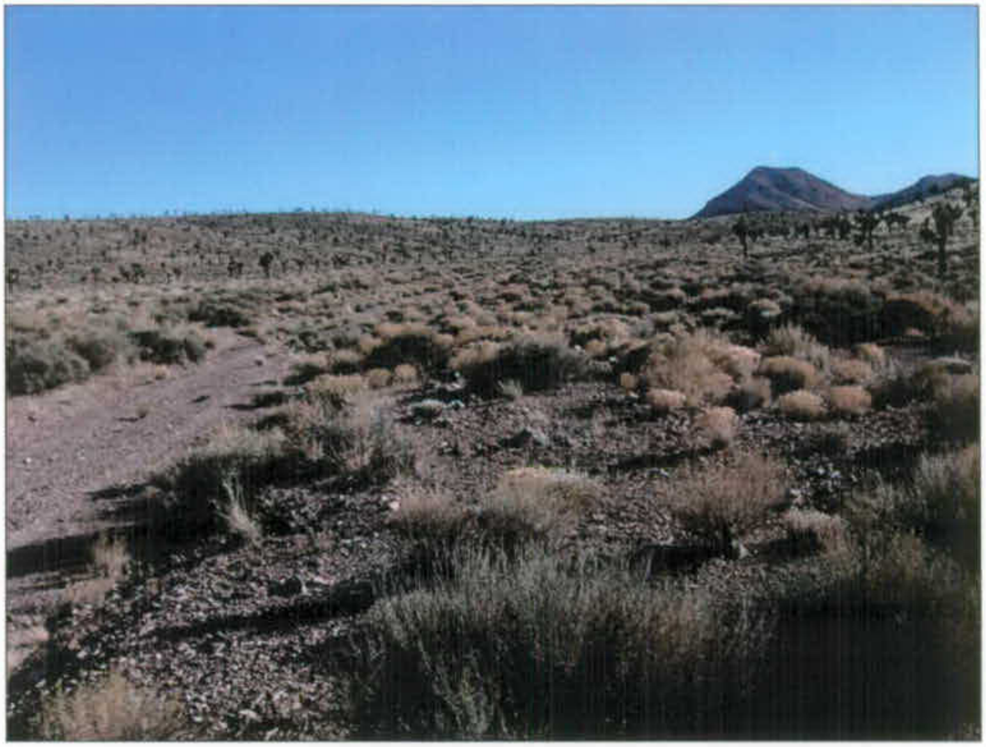
PHOTOGRAPHS

MG-35: (No waypoint) View NE across a valley to another chain of hills, mile 7.9

MG-36/37: (No waypoint) At pass in hills, views NE to Mud Lake in area crossed by GF 3, mile 9.3



MG-38 AG0012: (waypoint SM 389) Basalt cliff on right bank of wash with rubble zones, mile 13.0



MG-39: (waypoint SM 389) View up wash (south) of vegetation 2.3 % slope

MG-40: (waypoint SM 389) Basalt outcrop, mile 13.3; basalt here on both sides of wash

MG-42/45: (waypoint SM 391) Pan NW to NE, down valley, showing basalt hills on both sides of valley, mile 13.6; on GF 3 alignment where it crosses the valley from SE to NW

MG-46: (waypoint SM 391) Basalt hills bordering valley; Mud Lake in distance.

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NS-3B
FIELD TEAM: Art Geldon and Matt Grizzell
November 21, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)
The potential quarry site is on the east side of a valley flanked by low hills. The valley descends north to Mud Lake at a grade of 2-3%. A wash incised into the valley borders the quarry site on the west; the alignment borders it on the east.

B. Surface Water (near stream/river?), what flow?, intermittent)
The wash bordering the quarry site carries ephemeral flow from precipitation events of unknown frequency.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)
A flat area south of basalt that would be quarried is suitable for plant/office facilities.

D. Existing Access roads (where are they?, can they be improved? show on maps)
A graded road extends from Goldfield to Black Butte, east of the site of Diamondfield, 5.6 miles from US-95 (see road log). From there, dirt roads wind their way across two chains of hills and a valley between them about 11 miles at grades of 2-20%. The route then follows a wash 0.6 miles to the quarry site.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)
A loading facility could be built near the railroad, but the proximity of the quarry to the railroad negates the need for a ballast pile in addition to that at the processing plant.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)
A waste dump can be located in a flat area south of the quarry.

G. Access Roads (to highway and RR alignment)

i. **Topographic conditions for new road**
An existing graded road extends about 5.6 miles from Goldfield to Black Butte, in the Goldfield Hills. Roads that become increasingly primitive along the way (ending in a dirt track) then cross two northerly aligned ranges of hills, separated by a valley before reaching the valley in which the quarry would be located.

This valley slopes gently to Mud Lake, north of the quarry site. The existing roads from Goldfield have several steep stretches (Grades ≤20%) that are rocky or cut into sides of hills. Cuts and fills are needed to make these roads suitable for hauling ballast.

ii. **Cut slopes (soil/rock)**
The existing roads from Goldfield have several steep stretches (grades ≤20 percent) that are rocky or cut into the sides of hills. Cuts and fills are needed to make these roads suitable for hauling ballast.

2. DEPOSIT FEATURES

A. Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)
The quarry site is located in T2S, R43E, S01.

B. Tonnage (provided in this deposit [W x L x H])
The basalt tube quarried is located where 70- and 100-foot cuts are planned along GF3. Thus, an average thickness of 70 feet is assumed. The area is about 5,400,000 ft^2. Volume is about 70 ft x 5,400,000 ft^2 = 14,000,000 yd^3. Tonnage is about 14,000,000 yd^3 x 2.16 tons/yd^3 = 30,000,000 tons.

C. Overburden (note thickness/type)
Thin soil and colluvium with vegetation and areas of talus.

D. Deposit Features

i. **Rock Type/Description (use S&W rock descriptions)**
BASALT LAVA flows: high to very high strength, dark-gray, very finely crystalline to porphyritic, non-vesicular grading vertically and horizontally to slightly to very vesicular vesicles mostly filled with zeolites and other secondary minerals; fresh, with a thin, brown, weathering rind; extremely closely to widely spaced, rectangular to slabby fractures; weathered to rounded boulders or talus.

ii. **Thickness/Depth (need mineable thickness)**
Hills in the area appear to be basalt from top to bottom. Maximum observed thickness is 70 to 100 feet. Zones of poorer quality rock (see below) make minable thickness generally ≤70 feet.

iii. **Rock Structure (block sizes/joint or fracture spacing)**

	Block Spacing (%)			
Location (waypoint)	**2 to 4 feet**	**1 to 2 feet**	**6 inches to 1 foot**	**< 6 inches**
AG-16	30	40	20	10
AG-18	5	30	60	5

Extremely closely to widely spaced fractures; spacing and orientation variable from place to place. A dominant set of fractures, weathering from foliation planes ≤2 inches apart at AG-18 oriented N37°E, 27°NW.

iv. **Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)**
Zones of slabby fracturing, vesicular intervals and interflow gravel, sandy, and tuff in small areas, were observed at outcrops.

E. **Rock Quality**
RQD is variable and might range locally from <50 percent to >75 percent.

i. **Samples for testing (100 pounds minimum; describe sample; taken).**
An area-integrated sample (probably ≥100 lbs or three bags) was collected.

ii. **Rock hammer test**
The rock generally has very high strength, but strength decreases to high where slabby (extremely close to very close) fracture spacing prevails.

iii. **Schmidt hammer test**
AG-15: 51 to 60, avg. = 54
AG-16: 50 to 63, avg. = 56
AG-18: 52 to 65, Avg. = 58

F. **Groundwater** – Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.
Abundant Joshua trees indicate deep groundwater.

G. **Future Explorations**

i. **Drill rig access**
Along existing roads and wash from Goldfield NE to the site.

ii. **Type of rig**
4 x 4 or track rig, depending on amount of road improvement undertaken.

iii. **Locations and depths of borings**
A minimum of six borings, three along the alignment at and near 70- to 100-foot cuts are needed to determine subsurface lithology. Borings should be about 100 to 150 feet deep.

iv. **Geophysics alignments**
Recommend borehole geophysics to interpret subsurface geology and lithology, but surface geophysics unnecessary.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)
Shrubs, forbs, and grass, with common Joshua trees on slopes and hilltops.

B. Visibility (would quarry be visible from road?)
The quarry might be visible from the Mud Lake area.

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)
Power lines are far away. Generators would be needed to supply power.

B. Water (groundwater studies by others)
A well would be needed to supply water for processing ballast and for use by personnel. Depth to water at Mud Lake (Bonham and Garside, 1976), the low point of local drainage and groundwater flow systems, together with common Joshua trees, implies that depth to groundwater probably exceeds 300 feet.

ROAD LOG TO QUARRY SITE

0.0	Goldfield at US-95.
4.9	Diamond field (site, graded roads to here.
5.4	Road right to private property.
5.6	Black Butte, take right fork.
5.9	Road right to private property; road now is dirt, undulating.
6.2	View ENE of two basalt flows, about 10 and 15 feet thick capping hills. Only basalt in this part of Area NS-3B.
72.	Rocky road ascends chain of hills at grades of 6 to 11 percent.
7.9	Top of pass.
8.0	Road descends to a valley at grades of ≤15 percent.
8.2	Take left fork.
8.6	Road ascends a chain of hills at grades of 6 to 20 percent.
9.3	Top of pass.
9.4	Road descending pass at grades of 8 to 12 percent; needs cuts and fills.
9.8	In valley; take left fork.
10.25	Pass between alluvial falls sloping SE and NW; wpt SM381.
10.4	Road left to a prospect.
11.0	Road ends; route descends a wash at 2 to 3 percent grades.
11.5	Wpt SM388 on GF3 in wash; basalt on right bank.
11.6	Vicinity of facilities for Area NS-3B quarry.

PHOTOGRAPHS

MG-34: (Mile 6.2) View East/Northeast of thin (cumulatively ~25-ft-thick) basalt flows capping hills on west side of area NS-3B.

MG-47 to 51: (Mile 11.6) Pan NW to NE of basalt hills bordering a valley in which GF3 and the potential quarry site are located. Note vegetation consisting of Joshua trees, shrubs, forbs, and cheat grass.

MG-53 (Near waypoint AG 15) View east from wash of basalt hill with planned 70-ft cut

MG-54a: (AG 15) Outcrop of slightly to moderately vesicular, porphyritic basalt flow (QTb)

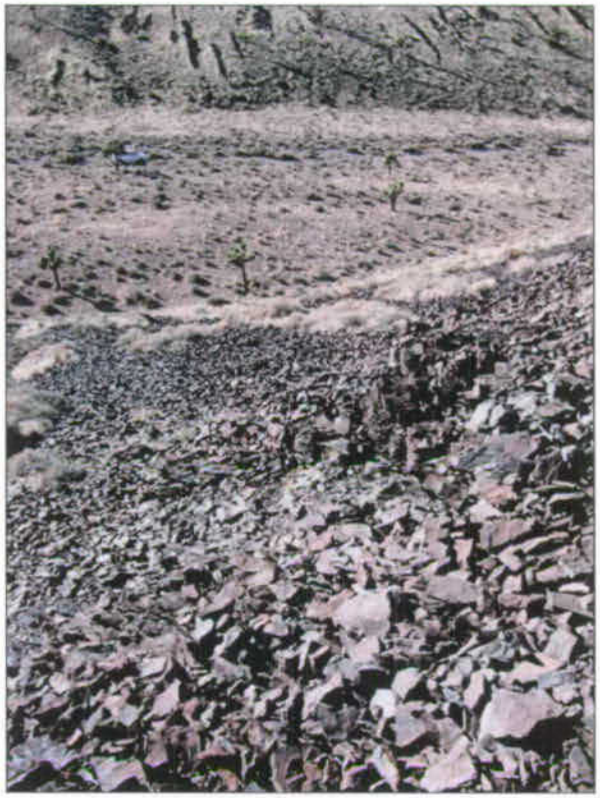
MG-55 to 58: (waypoint AG 16) Pan NW to NE of basalt hills covered with Joshua trees from top of hill with planned 70-ft cut

AG-0013 (waypoint AG 16) Outcrop of non-vesicular, finely crystalline basalt flow (QTb)

MG-59, AG-0014: (waypoint AG-17) View east from wash of hill with basalt ledge at top and talus on slopes

MG-60: (waypoint AG 17) Outcrop of non-vesicular, finely crystalline basalt flow (QTb)

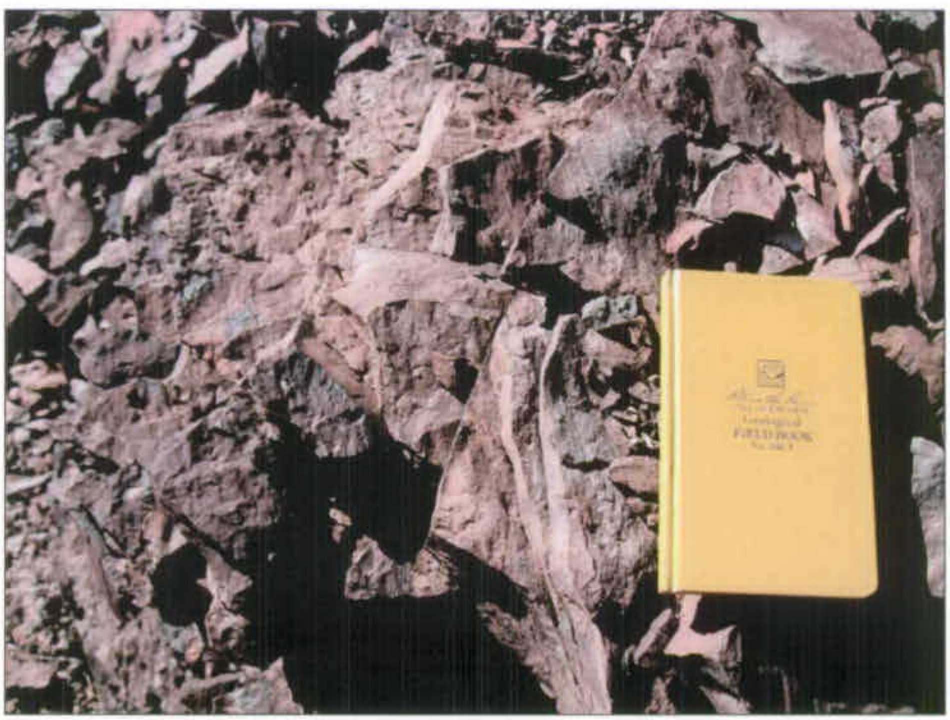
AG-0015 to 0016: (waypoint AG 17) View S to SE, upwash, of terrain and vegetation in area where quarry facilities could be constructed



MG-61a: (waypoint AG 18) View west from top of hill of basalt talus covering hillside

MG-62a: (waypoint AG 18/SM 393) View south, up wash, of terrain and vegetation are where quarry facilities could be constructed

MG-66a: (waypoint AG 18/SM 393) View north of area NS-3A



MG-67: (waypoint AG 18) Crenulations (slickensides?) on surface of dominant, extremely to very closely spaced fractures

MG-68: (waypoint AG 18) Outcrop of non-vesicular, fine crystalline basalt flow (QTb), showing intersecting fracture sets

MG-69 (waypoint AG 17/18) View east from wash of basalt hill, with Art at base of outcrop, 30 to 40 ft below rim; talus below to base of hill.

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NN-8A
FIELD TEAM: Art Geldon and Matthew Grizzell
November 16-17, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)
Alluvial fans sloping NW and South from Kawich Range to Warm Springs Summit, where terrain is relatively flat. Bedrock, tuff (Tt_3) and basaltic andesite flows (Ta_4) protrude from alluvium as low mounds and hills. Washes up to about 6 feet deep dissect terrain.

B. Surface Water (near stream/river?), what flow?, intermittent)
No flow observed in the area. Shallow washes with ephemeral flow during storm events. Recent flow evidenced by road washouts. May need a well.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)
Abundant area around AG-3, where best rock in area NN-8A was observed. Minor ephemeral washes and low hills may interrupt some flat areas. Most sound rock (near AG-3) located between proposed alignment and US-6; to avoid disturbance of car and train traffic, facilities for processing rock may need to be located between and US-6 as well.

D. Existing Access roads (where are they?, can they be improved? show on maps)
Existing roads directly to quarry pit site are not present. Can either cut new road from US-6 southward to quarry, or cut new road westward from southwestward-trending track along Kawich Range front. Existing track will need resurfacing, and may potentially need small culverts and fills in washes.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)
Abundant space. Setdown south of railroad alignment east of Warm Springs Summit.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)
Adequate space for waste dump on flat topo across tracks (will require heavy equipment to cross tracks to haul waste). This area was chosen to minimize impact to mapped area of Ta_4 (a potential resource).

G. Access Roads (to highway and RR alignment)

i. Topographic conditions for new road
Existing dirt track (25 percent grade) can be resurfaced and utilized. A new road from the existing track westward (3 percent grade) will need to be driven to quarry pit.

ii. Cut slopes (soil/rock)
No cuts necessary; only small (<6 feet deep) fills and culverts along gullies and washes.

2. DEPOSIT FEATURES

A Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)
The most sound-appearing outcrop observed during reconnaissance is a low hill of basaltic andesite (Ta4) about 500 x 1000 feet in areal extent of exposure. The potential resource area is located mostly in SW/4, SW/4, Sec. 26, T4N, R49E. About ⅓ of this exposure is in Sec. 35, T4n, R49E, a section with active mining claims. No additional outcrop noted in mapped area of Ta_4, but resource needs additional exploration.

B. Tonnage (provided in this deposit [W x L x H])
Unknown depth; highest exposure only about 3 feet high. Assuming exposure is at least 15 feet thick (typical of similar flows observed in the region), and assuming about ⅔ of deposit is located in unclaimed section, volume is as follows: [[(500 ft. x 1000 ft x 15 ft) x 66%] / 27 ft^3/yd^3] x 2.16 tons/cy = 400,000 tons

C. Overburden (note thickness/type)
Alluvium may be present in low-lying areas at margin of outcrop exposure. Weathered zone present on most of exposure. Colluvial soil composed of rock fragments cover ground. Uncertain thickness of colluvial soil/alluvium.

D. Deposit Features

i. Rock Type/Description (use S&W rock descriptions)
BASALTIC ANDESITE: Medium high to very high strength, dark gray, weathered and altered to purple with areas of red and yellow rock. Very little unaltered rock observed in outcrops. Porphyritic with fine-grained groundmass.

ii. Thickness/Depth (need mineable thickness)
Unknown. Thickest observed deposits less than 5 feet thick. Only a few small exposures protruding through alluvium.

iii. Rock Structure (block sizes/joint or fracture spacing)
Outcrop too small to determine block sizes. Joints extremely closely to medium spaced. Widely variable across outcrop. Fractures typically 2 to about 18 inches spacing.

iv. **Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)**
Most rock observed at site is mildly to significantly hydrothermally altered. Iron-oxide coatings were observed on fracture surfaces, also some closely spaced veins (>1 inch thick) with white mineral infilling.

E. Rock Quality

i. **Samples for testing (100 pounds minimum; describe sample; taken)**
About 60 lbs. of sample collected at waypoint AG-3, taken mostly from in-place rock. Largest boulders adjacent to outcrop were also used.

ii. **Rock hammer test**
Samples larger than about a 6-inch cube cannot be broken with a rock pick (when fresh). Very high strength. Altered rock easily breaks with a single blow.

iii. **Schmidt hammer test**
45° face
60, 58, 53, 62, 53, 61, 60, 46, 56, 49, 61. (Taken on best rock exposed. Altered outcrop much lower.)

F. Groundwater – Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.

No evidence of shallow groundwater. Consistent vegetation throughout area. Quarry near waypoint SM85 (from Geotech Report) about 20 feet deep, and no water was encountered.

G. Future Explorations

Surface outcrop area limited. Some areas mapped as Ta_4—basaltic andesite—actually appear to be weathered tuff, or are covered by alluvium. Deposit will need to be drilled to define area extents and depth.

i. **Drill rig access**
Cross-country (roadless) access from US-6 or dirt track east of area.

ii. **Type of rig**
Either high clearance 4x4 rig or (preferred) track rig.

iii. **Locations and depths of borings**
Boring depth unclear because of limited deposit outcrop. Will need to drill throughout mapped area of Ta_4 to define possible resources at depth under cover.

iv. **Geophysics alignments**
Surface and borehole geophysics may describe size, lithology, and hydrology of outcrop. Surface seismic lines may indicate depth to unweathered bedrock.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)
Grasses and shrubs, isolated pinon pines and juniper.

B. Visibility (would quarry be visible from road?)
Quarry would be located on the gently sloping surfaces immediately adjacent to US-6. Quarry would be visible from entire length of US-6 in Stove Cabin Valley.

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)
Power line between US-6 and proposed alignment.

B. Water (groundwater studies by others)
No surface flow or springs at site. Warm Springs is present about 5 miles NE of site.

WAYPOINTS FOR NN-8A

Designation	Description
AG-1	Faulted welded tuff outcrop at Pt. 6369.
AG-2	Exposure of hydrothermally altered intermediate flow rock (Ta4).
AG-3	Exposure of hydrothermally altered intermediate flow rock (Ta4); less altered than at AG-2.

PHOTOGRAPHS

MG-1: Pt. 6367 view to WSW. Welded tuff at top of hill.

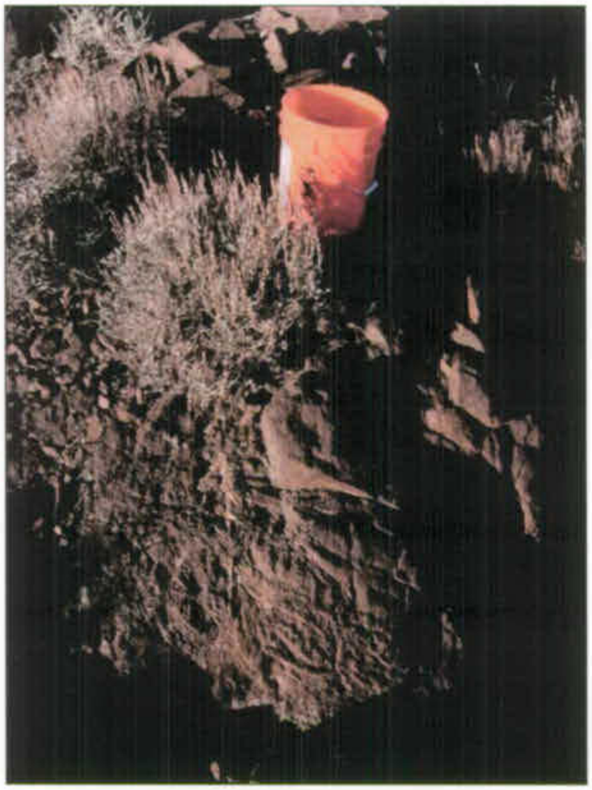
MG-2a: Fault scarp in altered silicified tuff west of Pt. 6170 (N of US-6).

MG-3a

MG-4 to 8: Panorama from west (MG-4) to ENE (MG-8) from top of Pt. 6369. Note welded tuff outcrop in foreground. Low hill with dark –appearing soil below and to right of white tractor trailer in MG-5 is resource described for NN-8A.

MG-9: View to east at waypoint AG-2. Notes lack of outcrop.

MG-10: View to east of outcrop 50 feet north of AG-2



MG-11: Altered rock at AG-3. Note extremely closely spaced fractures

MG-12: Photograph shows all of the outcrop exposed at the site.

AG-0003

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NN-8B
FIELD TEAM: Keith Rauch and Cody Sorensen
November 29-30, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)

The boundary area for the proposed quarry site NN-8B is located on the east side of the Kawich Mountain Range on the north side of Cow Canyon. The western side of the area consists of a steep (30-50% grade) east facing slope typically above 6000 ft elevation composed of moderate to medium strength Tuff. At around 6000 ft, there is typically a thin bench area below the steep slopes typically composed of Dacite which gently slopes to the east (5-15% grade) leading to alluvium just outside the site boundary and sloping to the east (1-5% grade). The dacite bench and steep slopes to the west are cut by dry wash ravines flowing from southwest to northeast. The south side of the site boundary is Cow Canyon which is a large approximately 400 ft wide, flat bottomed, dry wash which flows to the northeast. The proposed location for the quarry is on two lobes of dacite approximately 500-600 feet wide sitting below and to the east of a large 6442 ft tall peak. The two lobes are bordered on the north and on the east sides with dry washes that have cut ravines approximately 20-30 feet deep and approximately 100 feet wide. The proposed location of the Plant office area is a gently sloping (2-8% grade) area approximately 1100 feet south of the quarry lobes.

B. Surface Water (near stream/river?), what flow?, intermittent)

There is Cow Canyon, a dry wash to the south which appears to only flow during rain events but has created a large approx 400 ft wide flat bottomed canyon. And there are three small (4-5 feet wide) dry washes cutting across the proposed boundary area draining the mountains to the west and only flowing during rain events.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)

The Plant Site will occupy approx. 10.69 acres in the gently sloping area (5-9% grade) approximately 200 feet north of the existing access road on the north side of Cow Canyon. Some grading will be required for the Plant/Office site area to achieve a level flat ground surface. The area is wide enough to accommodate a larger Plant/Office facility as well, with some grading required for a level surface.

D. Existing Access roads (where are they?, can they be improved? show on maps)

There is an existing access road to the site along the north side of Cow Canyon. The road is a single lane primitive gravel road with slopes typically between 0-10% leading off of the access road through Reveille Valley. The road will need to require improvement and maintenance to handle the increased traffic loads.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)

Adequate room for railroad siding and loading yard approximately 3000 ft northeast of the plant site between the plant site and the sproposed alignment, an area of approximately 10 acres with plenty of room for expansion. The grade at the proposed siding and loading area is approx. 2-5%.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)

There is adequate room for a waste dump within the boundaries of the proposed plant/office site, gently slopes to the east.

G. Access Roads (to highway and RR alignment)

There is access to the proposed quarry site from Route 375 to the north. The proposed site is 5.6 miles from paved Route 375 on primitive gravel single lane roads. A new road will have to be constructed between the access road on the north side of Cow Canyon and the quarry site and railroad siding total estimated distance of new road construction is approx. 1.1 miles. New construction of roads could be reduced by constructing access road to the quarry along the eastern site boundary line and placing the siding/loading area adjacent to the existing primitive road and alignment intersection.

i. Topographic conditions for new road

The slopes for the proposed new roads are typically 2-10% grade, with most of the construction on or through slightly silty, sandy GRAVEL alluvium.

ii. Cut slopes (soil/rock)

Most slopes that will be cut for the proposed roads are gently sloping (2-9% grade), and are in alluvium areas able to be graded fairly easily by dozer or motor grader.

2. DEPOSIT FEATURES

A. Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)

B. Tonnage (provided in this deposit [W x L x H])
This site could produce approximately 4.2 million tons (in-situ) of material based on an area of 21 acres of mineable material averaging 57.5 feet thick.

C. Overburden (note thickness/type)
We anticipate 0-5 feet of slightly silty, sandy GRAVEL as overburden. This will have to be confirmed with borings.

D. Deposit Features
Ta4 (Dacite flow)

i. Rock Type/Description (use S&W rock descriptions)
DACITE; moderate to medium strength grey; slightly porphyritic; non-vesicular, smooth undulating, thin to medium spaced joints.

ii. Thickness/Depth (need mineable thickness)
Estimated maximum thickness 60 feet, estimated minimum thickness 20 feet, to be confirmed with borings.

iii. Rock Structure (block sizes/joint or fracture spacing)
Thin to Medium spaced joints, 2½ -24 inches
Smooth undulating joints; open (no cement)
Block size distribution on 7'H by 15'W outcrop

Block Size	% Distribution
>2'	10
1-2'	5
6"-1'	70
<6"	15

iv. Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)
We anticipate slightly vesicular weathered zones at the top of the Dacite flow 8-12 inches thick.

E. Rock Quality
Estimated RQD= 30-40%

i. **Samples for testing (100 pounds minimum; describe sample; taken)**
We collected approx. 3 bags (100 lbs) NN-8B, from N38.13151°, W116.37430°, the location of a small, 7' tall by 15' wide outcrop on north side of ravine.

ii. **Rock hammer test**
Rock typically fractures with 1 blow to more than 1 blow, indicating moderate to medium high strength.

iii. **Schmidt hammer test**
(horiz oriented hammer)= 56, 56, 49, 44, 49, 54, 49, 54, 46, 53

F. **Groundwater — Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.**
No evidence of groundwater in the immediate pit area.

G. **Future Explorations**
We recommend nine borings for the footprint of the quarry pit.

i. **Drill rig access**
There are no existing roads leading to the top of the quarry area however due to the gentle slope angles (5-10% grade) and smooth cobble free ground surface, the offroad terrain is adequate for a 4WD or track drill access, under normal dry conditions.

ii. **Type of rig**
4WD or track mounted drill recommended.

iii. **Locations and depths of borings**
Each boring should bottom at an elevation of 5850 ft. (boring location and depth table)

iv. **Geophysics alignments**
Due to good outcrop exposures, no surface geophysics anticipated.

3. **ENVIRONMENTAL FEATURES**

A. **Vegetation (what type/how much/where)**
Sage bushes 1-1.5 ft tall and desert grasses, approx 5-10% ground cover.

B. Visibility (would quarry be visible from road?)

Quarry site is visible from the primitive single lane road leading through Reveille Valley also from primitive road on the north side of Cow Canyon, Quarry site is approx 7 miles from nearest paved road (SR 375).

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)

Nearest electric lines are approx. 7 miles to the north.

B. Water (groundwater studies by others)

There is an aqueduct leading to an outflow at a corral approximately 4 miles northeast of the site. The corral has a holding tank and storage pond, approx. flow rate 3 gpm.

BORING LOCATIONS AND DEPTHS

BORING	LATITUDE	LONGITUDE	COLLAR ELEV	FLOOR ELEV	EST DEPTH	OVER DRILL	TOTAL DEPTH
B-1	N38.13693°	W116.37418°	5860	5850	10	10	20
B-2	N38.13632°	W116.37556°	5900	5850	50	10	60
B-3	N38.13553°	W116.37704°	5940	5850	90	10	100
B-4	N38.13637°	W116.37361°	5850	5850	0	10	10
B-5	N38.13557°	W116.37502°	5910	5850	60	10	70
B-6	N38.13478°	W116.37629°	5850	5850	0	10	10
B-7	N38.13570°	W116.37294°	5850	5850	0	10	10
B-8	N38.13489°	W116.37430°	5900	5850	50	10	60
B-9	N38.13409°	W116.37577°	5950	5850	100	10	110
TOTAL ESTIMATED DRILLING FOOTAGE							450


QUARRY SITE - 20.94 AC
NEW ROAD CONSTRUCTION - 4476 FT
5875
SIDING SITE - 10.04 AC
NN-8B SAMPLES
NEW ROAD CONSTRUCTION - 2915 FT
RAIL ALIGNMENT
RAIL ALIGNMENT
PLANT SITE - 10.69 AC
NORTH
0 ft
750
NN-8B STUDY AREA

PHOTOGRAPHS

Photo 2399: View of potential quarry site, looking west (29 Nov 2005)

2400: View of potential quarry site, looking southwest (29 Nov 2005)

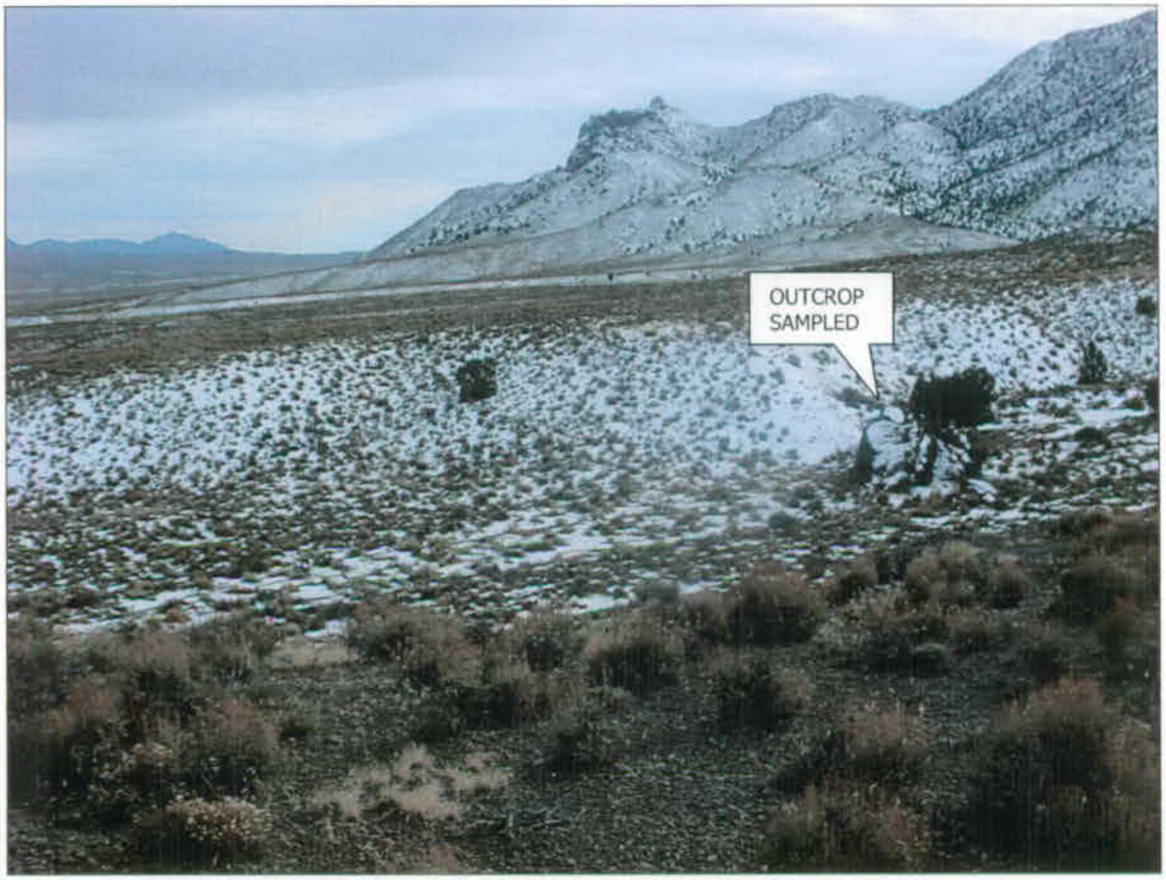


Photo 2401: View of typical small outcrops in study area. Sampled outcrop at right side of photo (29 Nov 2005)

Photo 403: View of aqueduct-fed water trough and stock pond at corral (29 Nov 2005)

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NN-8C
FIELD TEAM: Keith Rauch and Cody Sorensen
November 17-18, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)

The location of the proposed site of Quarry NN-8C is the bottom edge lobe of a series of basalt outcrops showing approximately 5-6 basalt flows, each flow having an average thickness of 15-30 feet. The basalt flows are typically interbedded with 3-4 feet thick ash layers and are steeply sloped to the west at a grade of typically 3-10%, appearing to emanate from the mountain range to the east. The proposed quarry office/crusher site sits at the bottom edge of the flows in a large flat valley with a grade of approx. 0-1%. There is a dry wash approximately 4-8 feet wide along the eastern edge of the flat valley floor at the bottom toe of the outcrops. There is a ravine along the southern edge of the Quarry pit area and also to the north of the area creating a large lobe for the pit area approximately 2000 feet wide and rising approximately 160 feet from the valley floor at an average slope of 16%.

B. Surface Water (near stream/river?), what flow?, intermittent)

There is as dry wash along the western edge of the pit area approximately 4-8 feet wide and based on the topography maps, it would appear that this flat valley is a main drainage for the slopes to the southeast and water flowing off of the mountains to the east and down the ravine on the south side of the pit area. This should be considered when deciding the placement of the offices and plant site since during and after rain events there will most likely be water flowing through the valley in the wash. Another consideration is the large ravine bordering the quarry areas southern edge, which appears to drain the mountainous area to the east of the site. During rain events it could run the possibility of flooding the quarry if the mined benches are cut too close to the ravine.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)

There is adequate acreage available for a plant facility on the east side of the valley 2000 ft north of the quarry site, approximately 14.54 acres at an average grade of 3%. The site size could be limited by drainage channels running through the area. There is also the possibility of moving the Plant/Office site south towards the quarry site, however as you move south the west side of the Plant/Office area gets steeper with slopes around 10% which will require more grading.

D. Existing Access roads (where are they?, can they be improved? show on maps)
There is an existing gravel access road to the site from state route 375 to the north. The access road is a primitive single lane gravel road that will need improving if it is to be the main access road to the quarry site. At the quarry site there are no roads leading to the top of the slope, due to the steep grade of the slope the access road to the top of the quarry area will have to be cut into the slope.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)
There is adequate room for railroad siding and loading yard 2.75 miles east of the quarry location on the east side of the alignment approximately 40.27 acres. The area has a slope of 0-3% so some grading will be required to achieve a flat level siding and loading area.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)
There is adequate room for a waste dump within the boundaries of the proposed plant/office site on the east side of the valley floor.

G. Access Roads (to highway and RR alignment)
There is access to the proposed quarry site from Route 375. From the site, the existing primitive road leads north intersecting another primitive road, and intersects Route 375 after approximately 10.5 miles. The primitive road will need slight improvements and grading to allow better access to the proposed site.

The road between the proposed quarry site and the proposed railroad siding is a distance of approximately 2.75 miles, and has a slope of 0-10% so some cuts will need to be made through the sections of steep grade. The siding/loading area has a grade of approximately 0-3% sloping to the east.

i. Topographic conditions for new road
The road between the quarry site and the railroad siding will need to be cut into the slope leading to the proposed alignment due to some steep 10% slopes. Generally the cuts will be no more than 0-10 feet to achieve an adequate road grade for transport equipment.

ii. Cut slopes (soil/rock)
A road will have to be constructed leading from the access road to the quarry pit a distance of approximately .5 mile. A road will also have to be constructed into the area on top of the quarry pit slope which due to the steep grade will have to be cut into the side of the slope in order to allow access to the top of the pit.

2. DEPOSIT FEATURES

A. Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)

B. Tonnage (provided in this deposit [W x L x H])

This site could produce approximately 19 million tons (in-situ) of material based on an area of 72 acres of mineable material averaging 78 feet thick.

C. Overburden (note thickness/type)

We anticipate 0-10 feet of fine sandy, silty GRAVEL, with a trace of cobbles as overburden. This will have to be confirmed with borings.

D. Deposit Features

Qtb (Series of Basalt flows)

i. Rock Type/Description (use S&W rock descriptions)

BASALT; medium high to high strength; dark grey; slightly vesicular throughout upper 6 feet of flow, scoriaceous in top 6-8 inches of flow, slightly porphyritic; fresh, approx. 1mm of desert varnish

ii. Thickness/Depth (need mineable thickness)

Approximate thickness of Basalt flows in the quarry area is 78 feet based on outcrop elevations, and field observations. To be confirmed with borings.

iii. Rock Structure (block sizes/joint or fracture spacing)

Medium spaced joints, avg. approx. 1.5-2.5 feet
Smooth undulating joints; open (no cement)
Block size distribution on 15'H by 40'W outcrop

Block Size	% Distribution
>2'	40
1-2'	40
6"-1'	10
<6"	10

iv. Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)

We anticipate slightly vesicular zones within 6 feet of the top of each basalt flow layer, and the top 6-8 inches to be scoreaceous. Also observed on the southern edge of the site at location (N38.02026°, W116.24380°, waypoint

KR31) were inter-basalt flow ash layers approximately 4 feet thick which could reduce the deposit size

E. **Rock Quality**
Estimated RQD= 80% in face.

i. **Samples for testing (100 pounds minimum; describe sample; taken)**
Collected approx. 100 lbs NN-8C-S1, 3 bags

ii. **Rock hammer test**
More than one blow too many blows required to fracture the rock indicates medium high to high strength.

iii. **Schmidt hammer test**

(Horiz. Oriented hammer) = 53, 53, 64, 51, 56, 52, 51, 52, 60, 56, 62

F. **Groundwater — Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.**
No evidence of groundwater in the immediate pit area, some dry washes leading into the proposed quarry area and across the access road leading to the quarry area.

G. **Future Explorations**
We recommend nine borings within the footprint of the quarry as shown in the figure.

i. **Drill rig access**
No existing road leading to top of quarry area and rough cobbly conditions on the slope. We recommend a track rig climbing the more gradual slope to the north of the quarry area where the grade is 5-10%.

ii. **Type of rig**
Track mounted drill rig recommended due to rough conditions and steep slope grades.

iii. **Locations and depths of borings**
See boring locations and depths table and map.

iv. **Geophysics alignments**
Due to good outcrop exposures, no surface geophysics anticipated.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)
Sage and desert grasses, approx 5-10% ground cover.

B. Visibility (would quarry be visible from road?)
Quarry site is visible from the primitive single lane road.

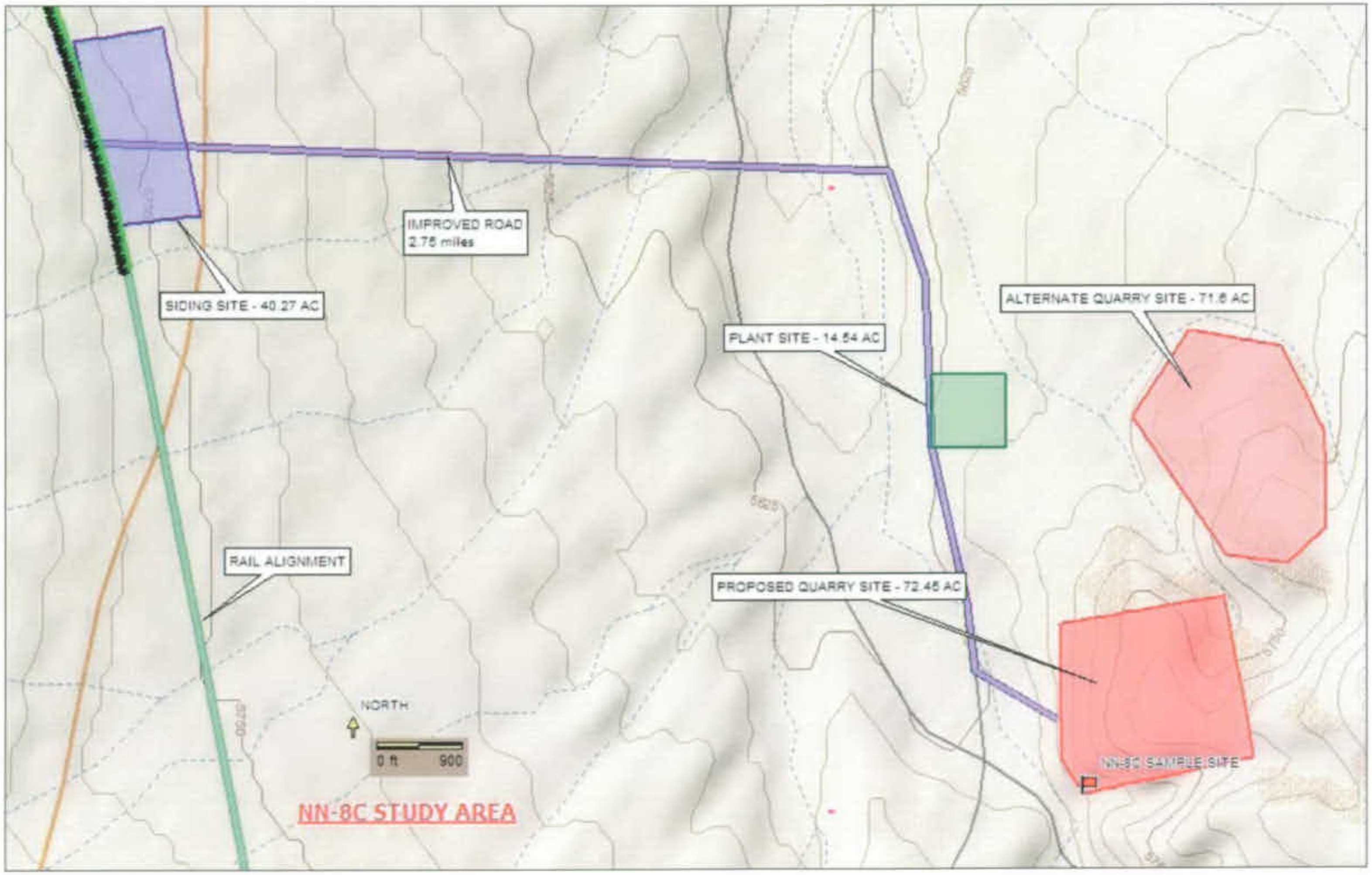
4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)
Nearest electric lines are approx. 9.6 miles to the north and 13 miles to the east.

B. Water (groundwater studies by others)
Nearest Water source is the artesian well approximately 3.2 miles north of the proposed quarry site approx. 2gpm, currently being used for cattle.

NN-8C: BORING LOCATIONS AND DEPTHS

BORING	LAT	LONG	COLLAR ELV	BTM ELV	DEPTH
B-1	N38.05102°	W116.30845°	5683	5673	10
B-2	N38.05143°	W116.30556°	5758	5680	78
B-3	N38.05184°	W116.30263°	5716	5680	36
B-4	N38.04863°	W116.30845°	5677	5667	10
B-5	N38.04909°	W116.30528°	5780	5680	100
B-6	N38.04958°	W116.30208°	5765	5680	85
B-7	N38.04626°	W116.30764°	5670	5660	10
B-8	N38.04678°	W116.30460°	5733	5680	53
B-9	N38.04729°	W116.30157°	5781	5680	101
TOTAL DRILLING FOOTAGE					483


IMPROVED ROAD
2.76 miles
SIDING SITE - 40.27 AC
ALTERNATE QUARRY SITE - 71.6 AC
PLANT SITE - 14.54 AC
RAIL ALIGNMENT
PROPOSED QUARRY SITE - 72.46 AC
NORTH
0 ft 900
NN-8C SAMPLE SITE
NN-8C STUDY AREA

PHOTOGRAPHS

Photo 2371: View of ravine from N38.04684, W116.30550 (waypoint KR19), looking WNW (300 Az) 20 Nov 2005

Photo 2372: View of ravine from N38.04684, W116.30550 (waypoint KR19), looking ENE (070 Az) 20 Nov 2005

Photo 2373: View of ravine from N38.04737, W116.30367 (waypoint KR20), looking SW (200 Az), 20 Nov 2005

Photo 2374: View of ravine from N38.04737, W116.30367 (waypoint KR20), looking E (095 Az)
20 Nov 2005

Photo 2375: View of ravine from N38.04821, W116.29949 (waypoint KR22), looking w (260 Az)
20 Nov 2005

Photo 2376: View of ravine from N38.04540, W116.30481 (waypoint KR24), looking SW (220 Az), 20 Nov 2005

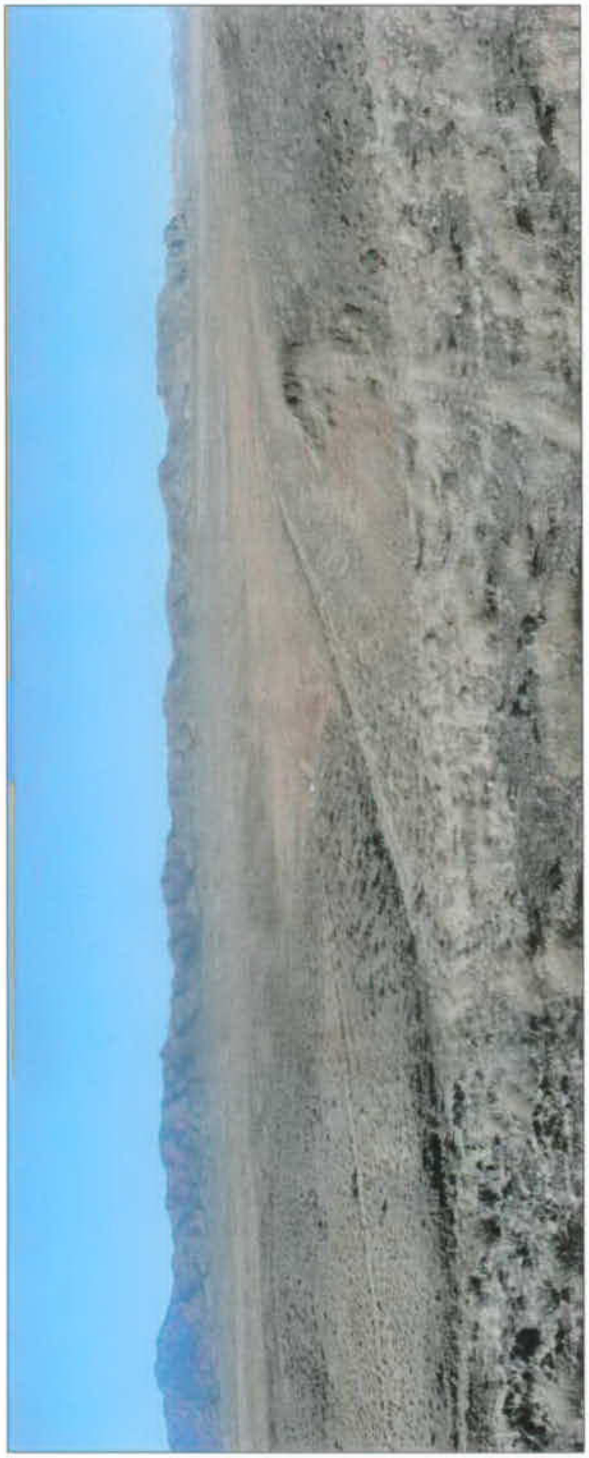


Photo 2377-79: Panoramic view of lowest basalt outcrops and large, flat alluvial terrace from N38.04521, W116.30714, looking SW (320-350 Az). This is the recommended plant site. Outcrop on right side of photo would be a good place to start mining the lowest basalt layer. 20 Nov 2005.

Photo 2380: View of basalt outcrop from N38.04596, W116.30743 (waypoint KR26), looking N (355 Az). This outcrop would be a good place to start mining the lowest basalt layer. 20 Nov 2005

Photo 2381-2: View of basalt outcrop and adjacent alluvium from N38.04596, W116.30743 (waypoint KR26), looking N (340-010 Az). 20 Nov 2005

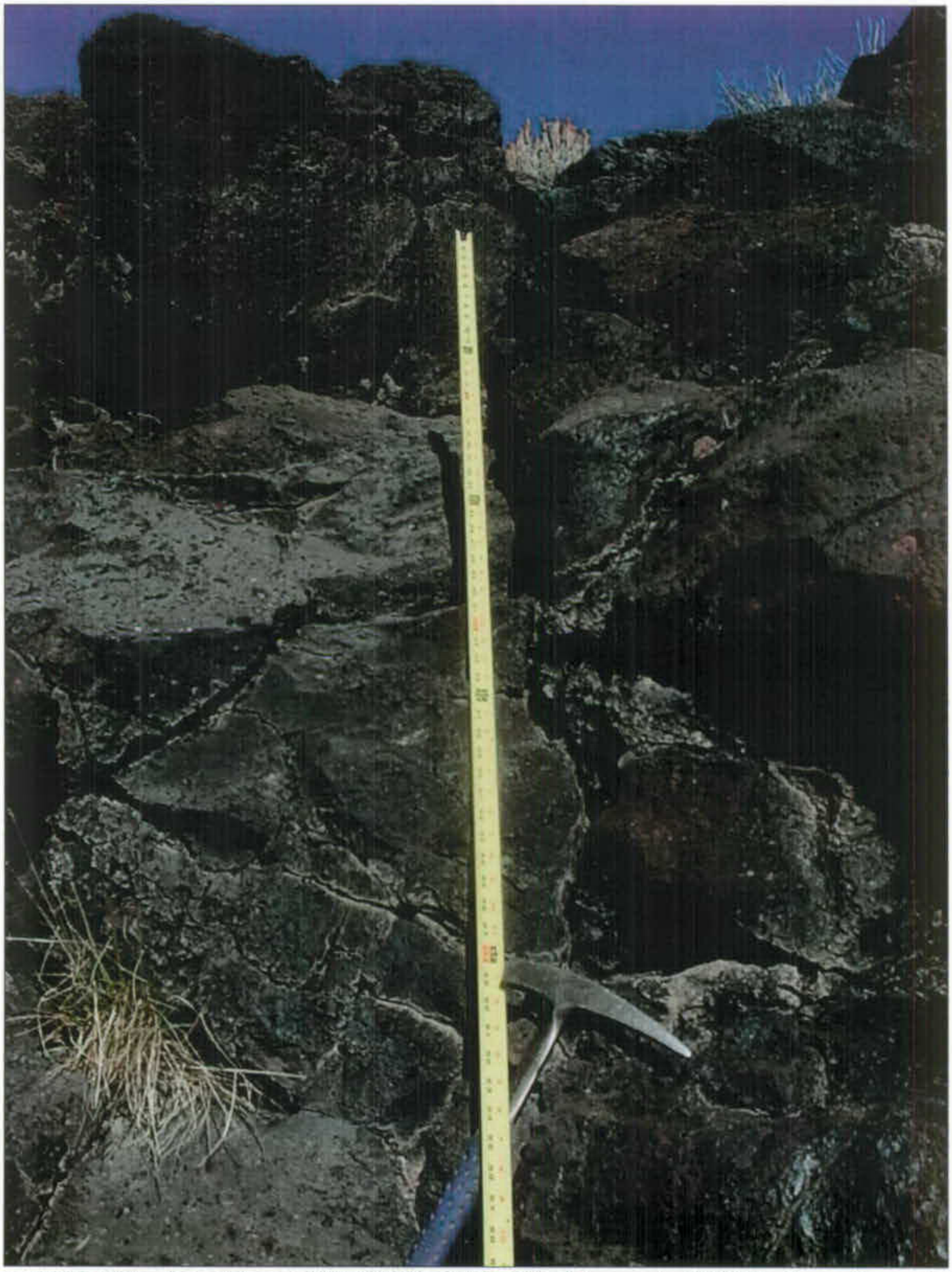


Photo 2383: This photo taken at N38.04626, W116.30763 (waypoint KR28), shows the vesicular nature of the basalt near top of outcrop. 20 Nov 2005.

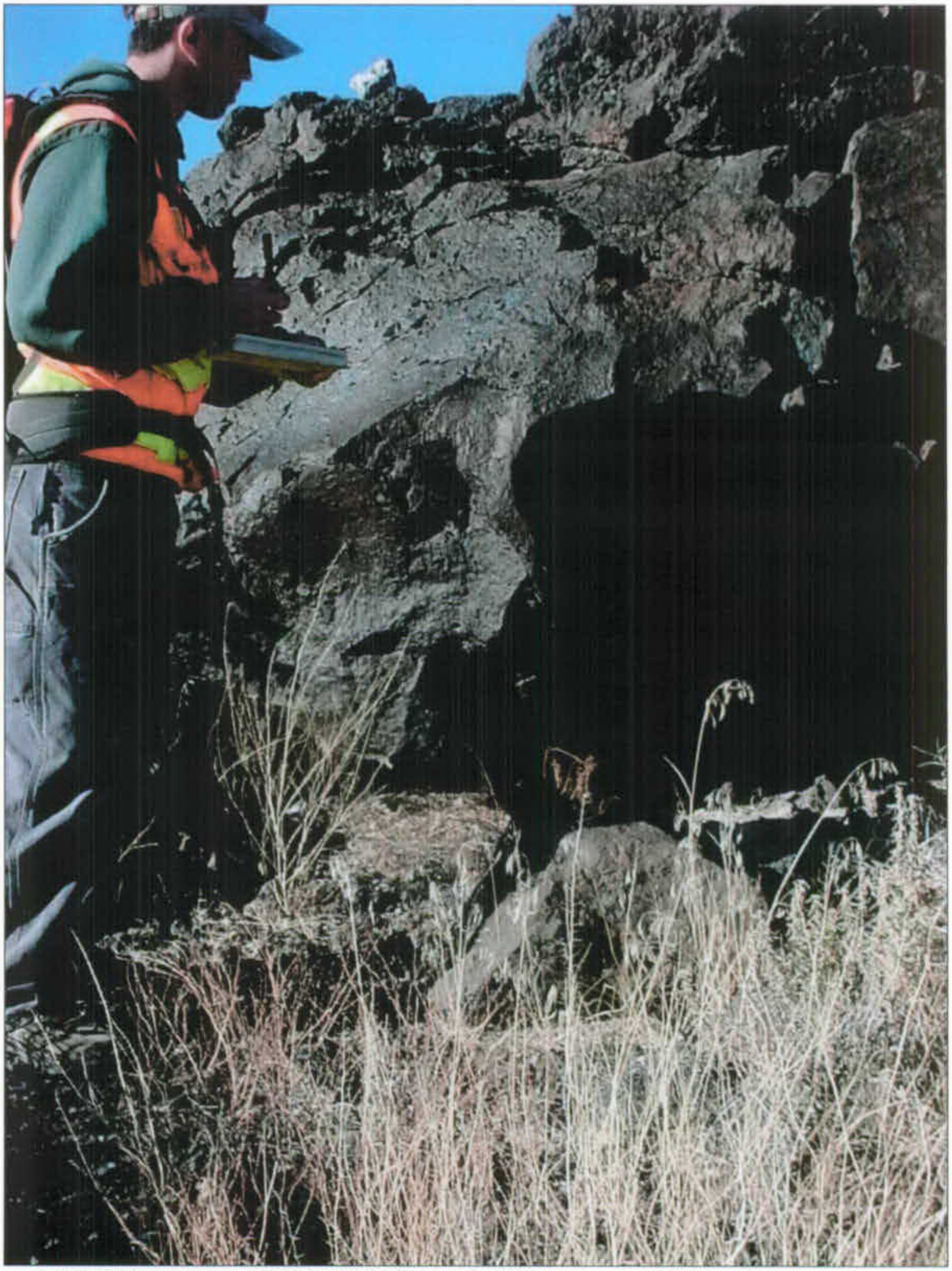


Photo 2384: This outcrop at N38.02026, W116.24380 (waypoint KR31), shows the lowest basalt layer overlying weathered volcanic ash bed. 20 Nov 2005.

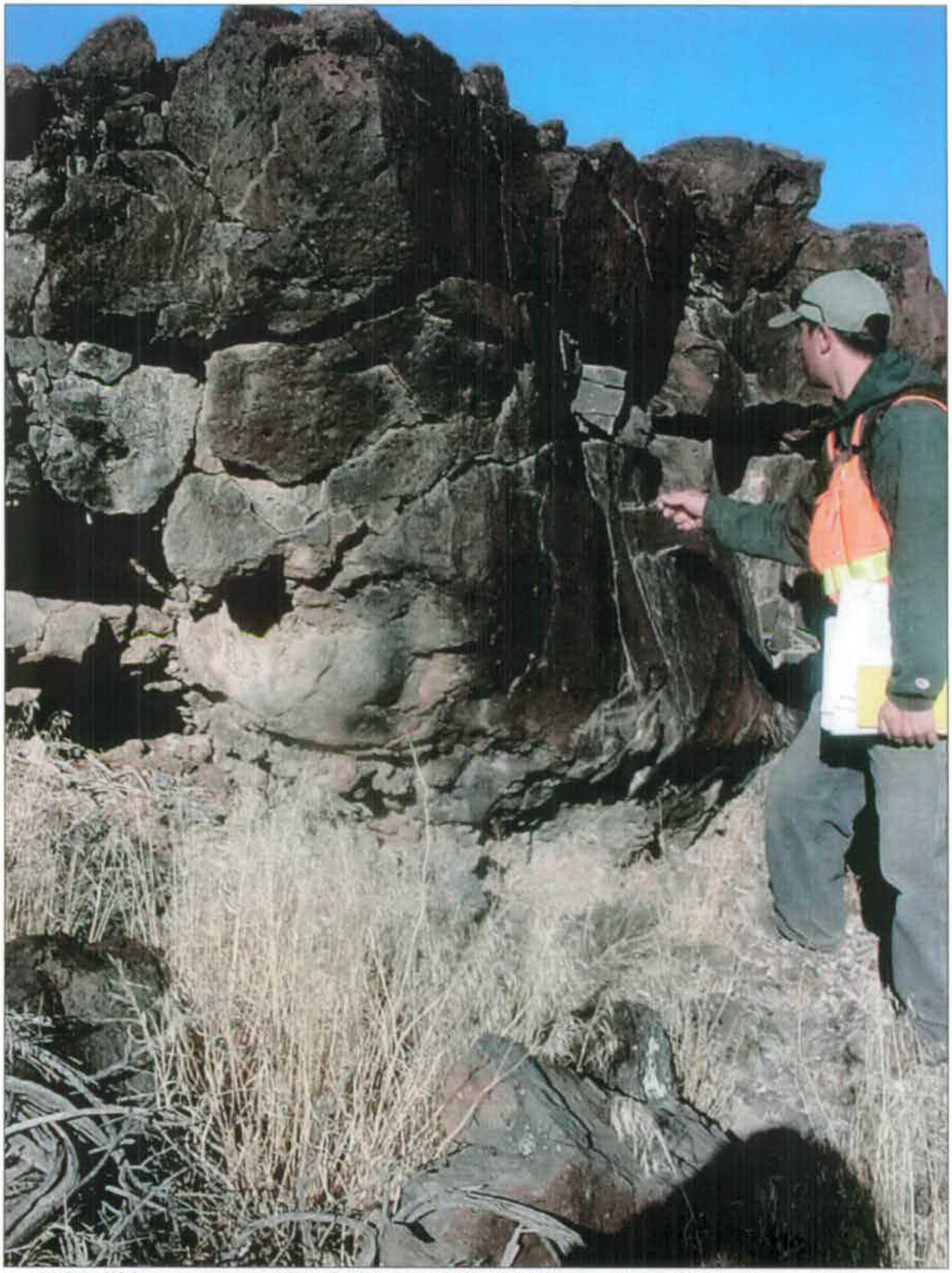


Photo 2385: This outcrop at N38.02026, W116.24380 (waypoint KR31), shows the lowest basalt layer overlying weathered volcanic ash bed. Becoming vesicular near top of bed. 20 Nov 2005.

Photo 2386: This outcrop at N38.02045, W116.24607 (waypoint KR33), is about 20 ft thick and appears to be composed of two flow layers. 20 Nov 2005.

Photo 2387: This outcrop at N38.01985, W116.24760 (waypoint KR34), is about 20 ft thick and appears to be composed of two flow layers with 4 ft thick ash bed between layers. 20 Nov 2005.

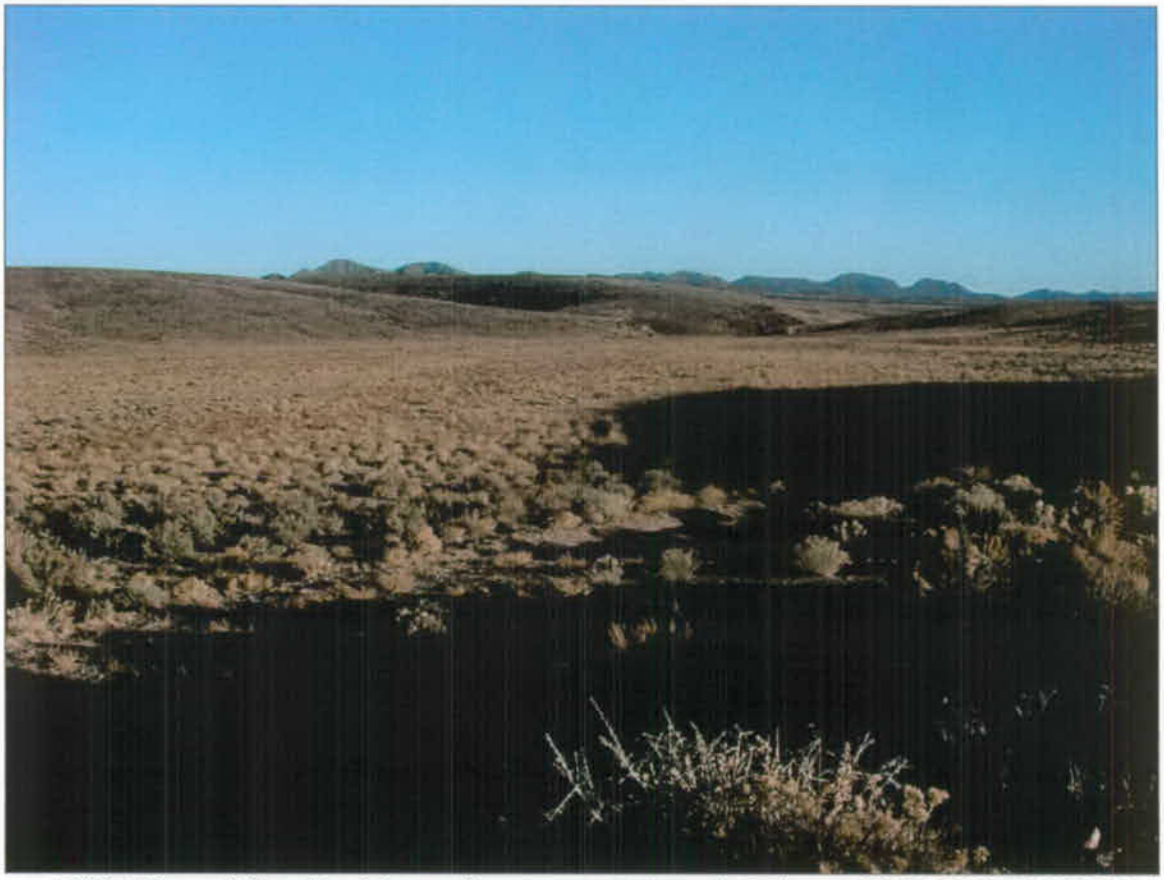


Photo 2388: View of flat alluvial area for proposed plant site taken at N38.04931, W116.31428, looking ESE (105 Az). 20 Nov 2005.

Photo 1067: View of the proposed quarry location and the basalt outcrop at valley floor elevation, looking east from N38.050227°, W116.314023° (waypoint KR25).

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NN-8D
FIELD TEAM: Keith Rauch and Cody Sorensen
November 18-19, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)

The location for the proposed quarry site NN-8D is a broad slope on the eastern side of Reveille Valley with a grade of 3-5%. The area is between two primitive access roads outside the northern boundary of the wilderness study area which lead up the slope and into the mountains to the east. The slope is composed of a Quaternary-Tertiary Basalt flow which is currently covered in alluvium (gravelly, silty SAND) and outcrops in three areas only one of which appears to be in-place and well exposed which was sampled.

B. Surface Water (near stream/river?), what flow?, intermittent)

There are two small dry washes both approximately 2-3 feet wide leading from east to west which should only flow in times during and after large rain events.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)

The proposed plant site (shown in blue) covers approximately 27 acres on a flat, gently sloping alluvial surface, with a average 2.5-3% grade. It is located between the two primitive access roads approximately ft southwest of the quarry site. Some grading will be necessary to achieve a flat level surface for the Plant/Office facility site.

D. Existing Access roads (where are they?, can they be improved? show on maps)

The quarry, plant and RR siding sites are all currently accessible by existing dirt roads. These roads are adequate for exploration drilling, surveying, etc., during dry weather. The roads would probably be temporarily impassable after a significant rain.

About 3 mi of all weather gravel or paved roads (shown in blue) will be needed during site construction and afterward, when the quarry is in operation. This report proposes upgrading existing roads, beginning at the quarry, through the plant site and terminating at the RR siding. Additional access roads will be required in the quarry and plant sites, but are not considered here.

E. **Room for Railroad Siding (where would siding be for loading ballast cars?)**
The proposed RR siding (shown in blue) covers about 65 acres on a flat, gently sloping alluvial surface. It is located approximately 2 mi west of the plant site (N38.00962°, W116.32862°) at the nearest proposed rail alignment location.

F. **Room for Waste Dump (need ~flat to ~gently sloping topo)**
There is adequate room for a waste dump within the boundaries of the proposed plant/office site in the area between the two existing roads.

G. **Access Roads (to highway and RR alignment)**
The quarry, plant and RR siding sites are all currently accessible by existing dirt roads. These roads are adequate for exploration drilling, surveying, etc., during dry weather. The roads would probably be temporarily impassable after a significant rain.

About 3 mi of all weather gravel or paved roads (shown in blue) will be needed during site construction and afterward, when the quarry is in operation. This report proposes upgrading existing roads, beginning at the quarry, through the plant site and terminating at the RR siding. Additional access roads will be required in the quarry and plant sites, but are not considered here.

i. **Topographic conditions for new road**
The road between the quarry site and the railroad siding will need be improved, it is on a very gradual slope with a grade of approximately 1-3%.

ii. **Cut slopes (soil/rock)**
Most roads will only have to be improved and not cut into new slope areas.

2. DEPOSIT FEATURES

A. **Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)**

B. **Tonnage (provided in this deposit [W x L x H])**
If the average 30 ft depth is achievable this pit will be capable of producing roughly 11.6 million tons of basalt ballast rock.

C. **Overburden (note thickness/type)**
We anticipate 0-10 feet of gravelly, silty fine SAND with a trace of cobbles as overburden. This will have to be confirmed with borings.

Deposit Features
Qtb (Basalt flow)

i. **Rock Type/Description (use S&W rock descriptions)**
BASALT; edium high to high strength; dark grey; slightly vesicular throughout upper 6 feet of flow,slightly porphyritic; fresh

ii. **Thickness/Depth (need mineable thickness)**

iii. **Rock Structure (block sizes/joint or fracture spacing)**
Medium to thick spaced joints, avg. approx. 3 feet
Smooth undulating joints; open (no cement)
Block size distribution on 15'H by 40'W outcrop

Block Size	% Distribution
>2'	40
1-2'	40
6"-1'	10
<6"	10

iv. **Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)**
We anticipate slightly vesicular zones at the top of each basalt flow layer (avg. 2-5 feet thickness).

E. **Rock Quality**
Estimated RQD= 60% in face.

i. **Samples for testing (100 pounds minimum; describe sample; taken)**
Collected approx. 100 lbs NN-8D/S1, 2 bags

ii. **Rock hammer test**
More than one blow to many blows required to fracture the rock indicates medium high to high strength.

iii. **Schmidt hammer test**
(Horiz. Oriented hammer) = 58, 52, 58, 46, 58, 62, 56, 52, 60, 56

F. **Groundwater — Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.**
No evidence of groundwater in the immediate pit area, some dry washes leading into the proposed quarry area and across the access road leading to the quarry area.

G. **Future Explorations**
We recommend 8 borings for the footprint area of the quarry.

i. **Drill rig access**
The existing road leading to the top of the proposed quarry location is adequate for a 4WD or track drill access, under normal dry conditions.

ii. **Type of rig**
The terrain is rough, with abundant basalt cobbles on the surface. A track-mounted drill or a 4WD is recommended.

iii. **Locations and depths of borings**
The locations and depths of borings are shown below in the boring table.

iv. **Geophysics alignments**
Recommend borings instead of geophysics.

3. ENVIRONMENTAL FEATURES

A. **Vegetation (what type/how much/where)**
Sage and desert grasses, approx 5-10% ground cover.

B. **Visibility (would quarry be visible from road?)**
Quarry site is visible from the primitive single lane road although the road is 3-4 miles away.

4. OTHER FEATURES

A. **Power (is power nearby or need on-site generation)**
Nearest electric lines are approx. 29 miles to the north and 14 miles to the southeast.

B. **Water (groundwater studies by others)**
There is no water for drilling available at the quarry site. The nearest water source is at a corral approximately 1.5 miles west of the pit site and less than a mile from the plant site, estimated flow at 2gpm. The Reveille Mill spring, approximately five miles west of the quarry (N38.00470, W116.36385 waypoint KR15). This spring produces about 7 gpm and flows into a stock tank that holds about 800 gal (9 ft diam x 1.75 ft deep).

QUARRY PIT DESIGN

This pit (shown in red) covers approximately 110 acres. The assumed average depth is 30 ft. Because the outcrops are small and sparse in this area, the final pit design will be contingent upon exploration drilling results.

Eight exploration corings are proposed to define the thickness and characteristics of the basalt within the quarry footprint. Boring locations and depths are presented in the following table. A total of 285 ft of coring at eight sites is anticipated.

BORING LOCATIONS AND DEPTHS

BORING	LAT	LONG	COLLAR ELV	BTM ELV	DEPTH	SUBDRILLING	DEPTH
B-1	N38.01615°	W116.27887°	5884	5860	24	10	34
B-2	N38.01555°	W116.27676°	5909	5860	49	10	59
B-3	N38.01425°	W116.28026°	5870	5860	10	10	20
B-4	N38.01238°	W116.28139°	5868	5860	8	10	18
B-5	N38.01366°	W116.27730°	5907	5860	47	10	57
B-6	N38.01150°	W116.27811°	5897	5860	37	10	47
B-7	N38.01021°	W116.28213°	5862	5860	2	10	12
B-8	N38.00942°	W116.27908°	5888	5860	28	10	38
TOTAL DRILLING FOOTAGE							285

PHOTOGRAPHS

Photo 2355: Small basalt outcrop at N38.01626, W116.27840. Looking north. Outcrop is about 40 ft diameter. Yellow field notebook for scale. 19 Nov 2005.

Photo 2356: Small basalt outcrop/subcrop at N38.01389, W116.27848. Looking NE (035 Az). 19 Nov 2005.

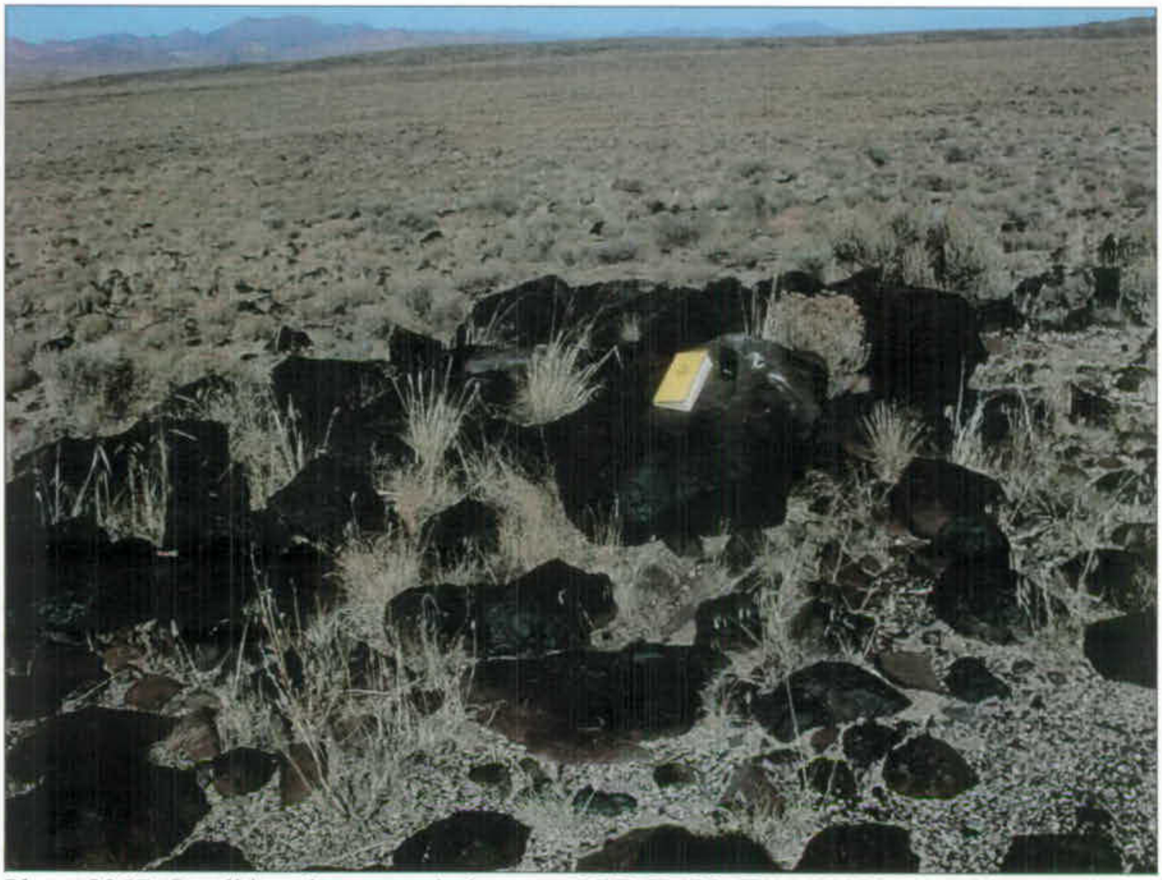


Photo 2357: Small basalt outcrop/subcrop at N38.01183, W116.28237. Looking north. Yellow field notebook for scale. 19 Nov 2005.

Photo 2358: Small basalt outcrop/subcrop at N38.00920, W116.27871. Looking SE. 19 Nov 2005.

Photo 2359: Sampled this small basalt outcrop/subcrop at N38.01583, W116.27734. Looking NW. 19 Nov 2005.

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NN-9A
FIELD TEAM: Keith Rauch, Cody Sorensen, Art Geldon, and Matt Grizzell
November 16, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)

Basalt ridge approximately 2500 feet wide, with a gently sloping 1-5% slope on the west side of the ridge leading into a mining claim approx. 1000 feet west of the ridge peak. On the east side of the ridge is a 20-30 feet vertical walled basalt outcrop with a steep, approximately 30% grade slope leading to the flat (1% grade) approximately 1500 feet wide valley between the primitive gravel road and the toe of the east side of the ridge. Within this flat valley area are two approximately 3-5 feet wide dry washes or ephemeral streams which possibly flow during or after rain events.

B. Surface Water (near stream/river?), what flow?, intermittent)

Two dry washes, first at the toe of the slope on the east side of the ridge and the other approximately 500 feet east of the first dry wash. Both appear to flow in a southeasterly direction.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)

There is adequate acreage available for a plant facility southwest of Willow Witch Well, approx. 19.05 acres, approx. slope 1-3%, some grading of the plant area may be required to achieve a flat level surface. There is also the option of shifting the Office/Plant area south away from the Willow Witch Well area, since the valley bottom appears to remain relatively flat throughout the boundary limits.

D. Existing Access roads (where are they?, can they be improved? show on maps)

There is an existing access road to the site from state route 375 to the north. The access road is a single lane gravel road that will need improving if it is to be the main access road to the quarry site. At the quarry site there is a primitive gravel road leading to the top of the ridge. However, there are some sections of steep grade of less than 500 feet in length that will need improvement to allow better access to the top of the ridge. Approximately 2.9 miles of road will need to be improved at the site and between the site and the railroad siding.

E. **Room for Railroad Siding (where would siding be for loading ballast cars?)**
Adequate room for railroad siding and loading yard approximately 1 mile northwest of the quarry site at the intersection of the proposed alignment and an existing primitive road, approximately 37.05 acres. The grade at the proposed siding and loading area is approx. 1%.

F. **Room for Waste Dump (need ~flat to ~gently sloping topo)**
There is adequate room for a waste dump within the boundaries of the proposed plant/office site.

G. **Access Roads (to highway and RR alignment)**
There is access to the proposed quarry site from both Route 375 to the north and there is also access to Route 375 to the east. From the site, the existing primitive road leads north and intersects Route 375 after approximately 27.7 miles. Also from the site, the existing primitive road leads south then east and intersects Route 375 after approximately 15.5 miles. Both primitive roads will need slight improvements and grading to allow better access to the proposed site.

The road between the proposed site and the proposed railroad siding is a distance of approximately 1.1 miles. There is currently an existing primitive road leading to the siding area however, it will need improvements and grading to accommodate transport vehicle traffic.

i. **Topographic conditions for new road**
The road between the quarry site and the railroad siding will need to be graded due to a section of steep grade leading out of a wash 1/4 mile northwest of Willow Witch Well approximately 50 feet long and at a grade of approx 15%.

ii. **Cut slopes (soil/rock)**
A road will have to be constructed leading from the access road to the quarry pit a distance of approximately 1000 feet.

2. DEPOSIT FEATURES

A. **Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)**

B. **Tonnage (provided in this deposit [W x L x H])**
This site could produce approximately 40 million tons (in-situ) of material based on an area of 325 acres of mineable material averaging 36 feet thick.

C. **Overburden (note thickness/type)**
We anticipate 0-10 feet of gravelly, silty fine SAND with a trace of cobbles as overburden. This will have to be confirmed with borings.

D. Deposit Features
Qtb (Basalt flow)

i. Rock Type/Description (use S&W rock descriptions)
BASALT; high to very high strength; dark grey; slightly vesicular in upper 2-3 feet of face (otherwise non-vesicular) slightly porphyritic

ii. Thickness/Depth (need mineable thickness)
Estimated maximum thickness 50 feet, estimated minimum thickness 30 feet, to be confirmed with borings.

iii. Rock Structure (block sizes/joint or fracture spacing)
Medium spaced joints, 8-24 inches
Smooth undulating joints; open (no cement)
Block size distribution on 15'H by 40'W outcrop

Block Size	% Distribution
>2'	50
1-2'	30
6"-1'	10
<6"	10

iv. Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)
We anticipate slightly vesicular zones at the top of each basalt flow layer (avg. 20ft thickness); i.e. 2-3 weak zones each approx. 2 ft thick in a 50 ft high quarry face (approx. 10% dilution)

E. Rock Quality
Estimated RQD= 70-90%

i. Samples for testing (100 pounds minimum; describe sample; taken)
Collected approx. 4 bags NN-9A-S1

ii. Rock hammer test
Clear ringing sound when hammered, indicating very high to high strength.

iii. Schmidt hammer test
(45°)= 50, 60, 52, 54, 49
(horiz oriented hammer)= 54, 60, 58, 58, 52

F. Groundwater — Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.
No evidence of groundwater in the immediate pit area.

G. Future Explorations
We recommend 15 borings for the footprint of the quarry pit as shown in the figure.

i. Drill rig access
Existing road leading to top of ridge is adequate for a 4WD or track drill access, under normal dry conditions.

ii. Type of rig
4WD or track mounted drill recommended.

iii. Locations and depths of borings
Each boring should bottom at an elevation of 5985 ft. (see map for locations)

iv. Geophysics alignments
Due to good outcrop exposures, no surface geophysics anticipated.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)
Sage and desert grasses, approx 5-10% ground cover.

B. Visibility (would quarry be visible from road?)
Quarry site is visible from the primitive single lane road, Quarry site is approx 20-30 miles from nearest paved road (SR 375).

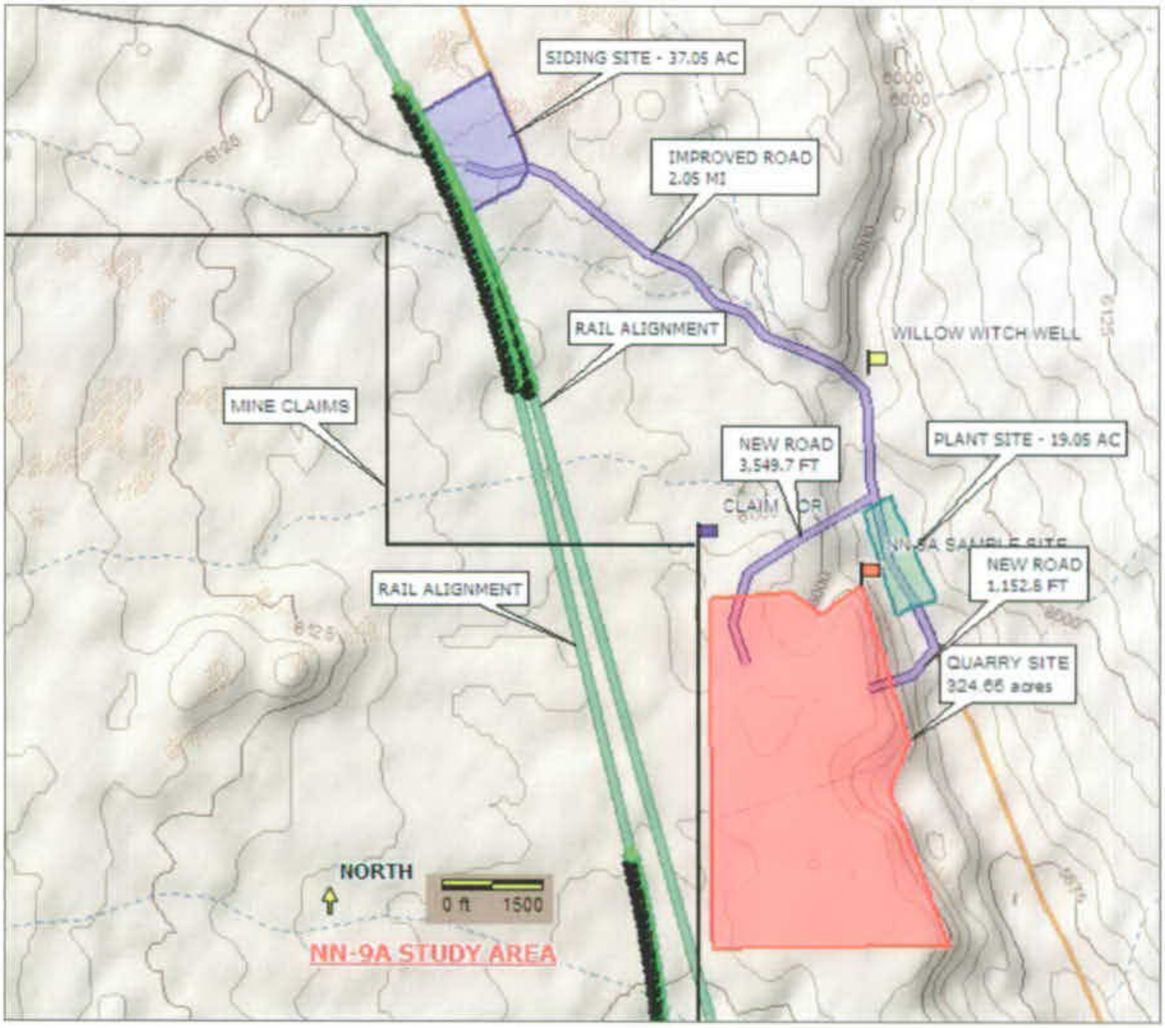
4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)
Nearest electric lines are approx. 27 to the north and 15.5 miles to the southeast.

B. Water (groundwater studies by others)
Willow Witch Well (N37.8413°, W116.2096°), flows approx. 5 gpm (artesian), currently being used for cattle, adjacent to quarry processing site.

NN-9A BORING LOCATIONS AND DEPTHS

Boring	Latitude	Longitude	Collar Elev.	Floor Elev.	Overdrill	Total Depth
B-1	N37.83101°	W116.21759°	6026	5970	10	66
B-2	N37.83115°	W116.21363°	6018	5970	10	58
B-3	N37.83134°	W116.20943°	5993	5970	10	33
B-4	N37.82822°	W116.21753°	6034	5970	10	74
B-5	N37.82848°	W116.21299°	6048	5970	10	88
B-6	N37.82873°	W116.20837°	5973	5970	10	13
B-7	N37.82553°	W116.21766°	6030	5970	10	70
B-8	N37.82576°	W116.21287°	6041	5970	10	81
B-9	N37.82592°	W116.20807°	5947	5970	10	-13
B-10	N37.82275°	W116.21758°	6017	5970	10	57
B-11	N37.82297°	W116.21265°	6030	5970	10	70
B-12	N37.82314°	W116.20779°	5973	5970	10	13
B-13	N37.82009°	W116.21750°	6020	5970	10	60
B-14	N37.82034°	W116.21204°	6039	5970	10	79
B-15	N37.82056°	W116.20655°	6002	5970	10	42
TOTAL ESTIMATED DRILLING FOOTAGE						791


SIDING SITE - 37.05 AC
IMPROVED ROAD
2.05 MI
RAIL ALIGNMENT
WILLOW WITCH WELL
MINE CLAIMS
NEW ROAD
3,549.7 FT
PLANT SITE - 19.05 AC
RAIL ALIGNMENT
NEW ROAD
1,152.6 FT
QUARRY SITE
324.66 acres
NORTH
0 ft 1500
NN-9A STUDY AREA

PHOTOGRAPHS

Photo 1075: View of the proposed office/crusher site in the flat valley bottom, also in photo is the primitive access road leading to the top of the proposed quarry, View is northeast (N38.83336°, W116.209801°).

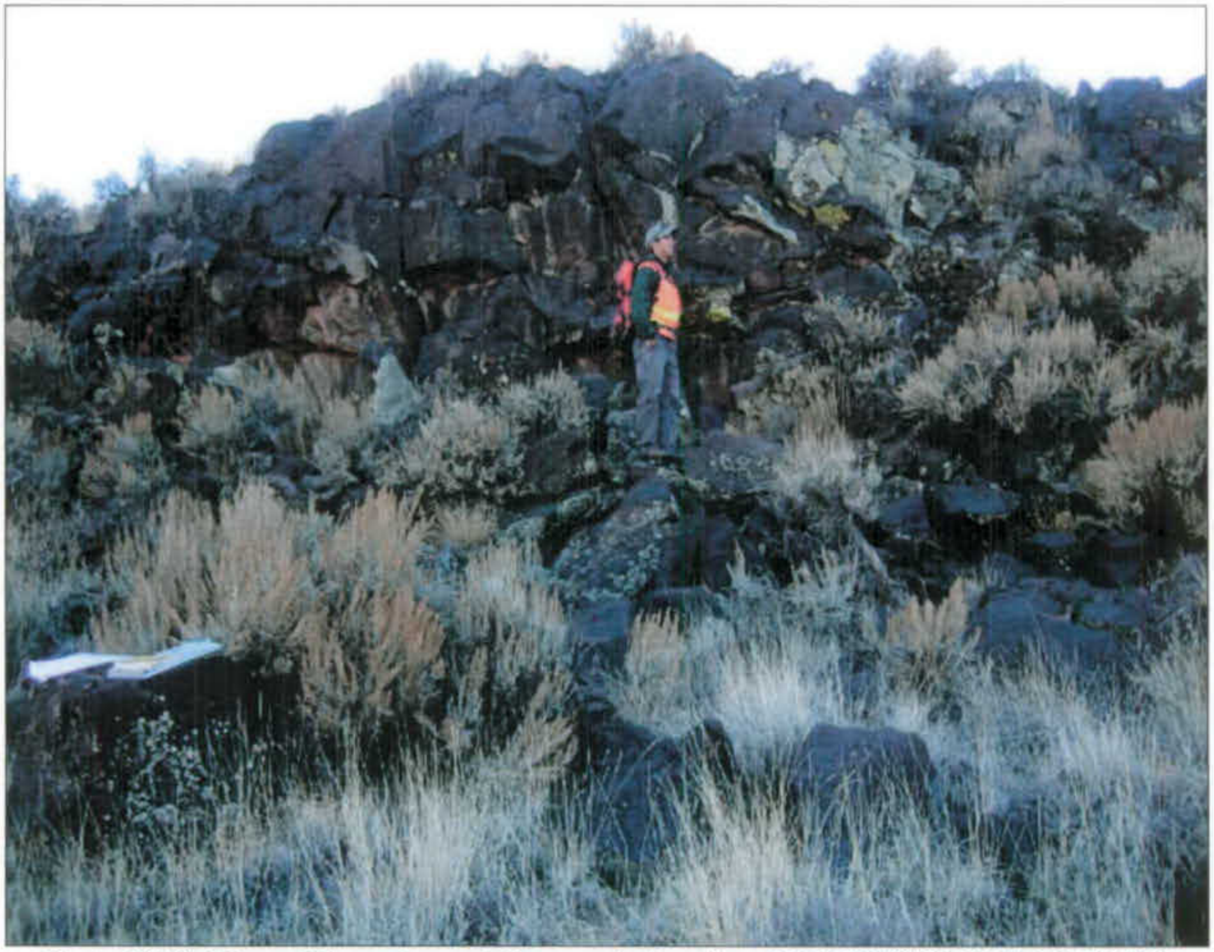


Photo 1048: View of the outcrop at the sample location. (N37.832878°, W116.209542°)

View of the Willow Witch Well showing storage tank approx. 12 ft. tall and 20 ft. in diameter. Water flowing from outlet pipe 10 feet above ground surface. Level of water in the tank was approx. 5 feet deep flowing out of outlet at 5 gpm.

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: NN-9B
FIELD TEAM: Keith Rauch and Cody Sorensen
November 17-18, 2005

Note: The potential quarry site NN-9B consists of large exposures of basalt and dacite. We classified and sampled both rock types. We also prepared Field Evaluation Checklists for both rock types. Based on our observations in the field, we determined that the basalt has superior potential for ballast production within NN-9B. Therefore, we are not including the NN-9B Dacite in the list of ranked sites. We will retain the dacite samples, but we do not intend to submit them for laboratory testing.

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)

A narrow ridge composed of basalt extending from northwest to southeast terminating in the south at approximately N37.79346°, W116.18642°, and approximately 500 feet wide at the 5900 ft. elevation line at N37.800778°, W116.193686°. Both the east and west sides of the ridge are steep with slopes of 10-20%. There are outcrops of basalt on both the east and west sides of the ridge with vertical faces approximately 15-25 feet tall. There is a terrace on the east side of the ridge approximately 1000 feet wide and 70 feet in elevation above the floor of the valley to the east which has a base elevation of 5790 ft. There is an ephemeral stream (dry wash) at the toe of the west facing slope of the ridge and a dry wash at the toe of the east facing slope of the ridge, between the terrace and the ridge.

B. Surface Water (near stream/river?), what flow?, intermittent)

Three dry washes, the first is located at the toe of the slope on the west side of the ridge, the other is between the terrace to the east and the toe of the east slope, and the third is between the terrace and the primitive access road to the east. All dry washes appear to flow in a southeasterly direction and are typically 3-4 feet wide.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)

The proposed plant site (shown in blue) covers approximately 16.5 acres on a flat, gently sloping alluvial surface. It is located roughly 1500 ft southwest of the quarry site.

D. Existing Access roads (where are they?, can they be improved? show on maps)

The quarry, plant and RR siding sites are not currently accessible by existing roads. Approximately 3.5 mi of new road construction will be required for access. In addition, about 4 mi of existing dirt roads from the Cedar Pipeline Ranch (N37.75280°, W116.12736°) will need to be improved to permit all-weather access to the site.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)
The proposed RR siding, located at N37.79775°, W116.20053° (shown in blue) covers about 16 acres on a flat, gently sloping alluvial surface. It is located approximately 1200 ft. northwest of the plant site at the nearest rail alignment location.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)
There is adequate room for a waste dump within the boundaries of the proposed plant/office site and the grade is approx. 1-3%.

G. Access Roads (to highway and RR alignment)
Currently there are no access roads to the proposed railroad siding or to the top of the quarry site. There is a primitive access road leading to the area east of the site and from this access road approximately 2.6 miles of new road will need to be constructed. From the existing primitive access road there is access to Route 375 to the north, a distance of approximately 31 miles, additionally there is access to Route 375 by following the primitive access road to the south where it meets a paved road at Cedar Pipeline Ranch after a distance of 4 miles. From Cedar Pipeline Ranch to Route 375 the road is paved and intersects Route 375 after approximately 8.5 miles.

i. Topographic conditions for new road
The proposed road leading from the existing primitive access road to the top of the quarry, cuts up a steep slope on the south tip of the ridge, approx. slope 10-15%. Because there are some sections of 10-15% slope these steep sections will have to be graded to allow better access to the site and siding. The road connecting the quarry to the Office/Plant site follows a gently sloping valley parallel to the proposed alignment and minimal grading will be required for the construction of the new road.

ii. Cut slopes (soil/rock)
The proposed roads will have to cut into the steep areas to allow a more gradual sloped road capable of large machinery travel, typically the material being cut through is alluvium consisting of a silty, gravelly SAND, however there may be some small sections particularly the road leading to the quarry area that may have to be cut through rock.

2. DEPOSIT FEATURES

A. Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)

B. Tonnage (provided in this deposit [W x L x H])

This pit (shown in red in the site map) covers approximately 60 acres. The estimated average depth is 15 ft, based on measurement of numerous outcrops on the east side of the ridge. Core drilling is required to confirm this estimate.

If the average 15 ft depth is achievable this pit will be capable of producing roughly 3 million tons of basalt ballast rock.

C. Overburden (note thickness/type)

We anticipate 0-10 feet of gravelly, silty fine SAND with a trace of cobbles as overburden. This will have to be confirmed with borings.

D. Deposit Features

Qtb (Basalt flow)

i. Rock Type/Description (use S&W rock descriptions)

BASALT; medium high to high strength; dark grey; slightly vesicular in upper 5 feet of face (otherwise non-vesicular) slightly porphyritic; fresh with 1mm. of desert varnish.

ii. Thickness/Depth (need minable thickness)

Estimated maximum thickness 25 feet, estimated minimum thickness 15 feet, to be confirmed with borings.

iii. Rock Structure (block sizes/joint or fracture spacing)

Medium to thick spaced joints, avg. approx. 3 feet
Smooth undulating joints; open (no cement)
Block size distribution on 12'H by 40'W outcrop

Block Size	% Distribution
>2'	60
1-2'	20
6"-1'	10
<6"	10

iv. **Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)**
We anticipate slightly vesicular zones at the top of each basalt flow layer (avg. 3-5 feet thickness).

E. **Rock Quality**
Estimated RQD= 60-70% in face.

i. **Samples for testing (100 pounds minimum; describe sample; taken)**
Collected approx. 100 lbs NN-9B-S1

ii. **Rock hammer test**
More than one blow to many blows required to fracture the rock indicates medium high to high strength.

iii. **Schmidt hammer test**
(Horiz. Oriented hammer) = 52, 50, 56, 50, 42, 52, 53, 56, 54, 48

F. **Groundwater — Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.**
No evidence of groundwater in the immediate pit area, some dry washes leading across the access roads leading to the quarry area and the siding and office areas.

G. **Future Explorations**
Five exploration core drill holes are proposed to define the thickness and characteristics of the basalt within the quarry footprint. Boring locations and depths are presented in the boring table included. A total of 134 ft of coring at eight sites is anticipated.

i. **Drill rig access**
We recommend accessing the top of the quarry from the ridgeline to the north. There is access to the top of the ridge and a track mount drill rig could follow the peak of the ridge south to the proposed quarry area.

ii. **Type of rig**
The terrain is steep and rough, with abundant basalt boulders up to 3 ft diameter on the surface. A track-mounted drill is recommended.

iii. **Locations and depths of borings**
See figure and borings and locations table.

iv. **Geophysics alignments**
Due to good outcrop exposures, no surface geophysics anticipated.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)

Sage and desert grasses, approx 5-10% ground cover.

B. Visibility (would quarry be visible from road?)

Quarry site is visible from the primitive single lane road, Quarry site is approx 20-30 miles from nearest paved road (SR 375).

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)

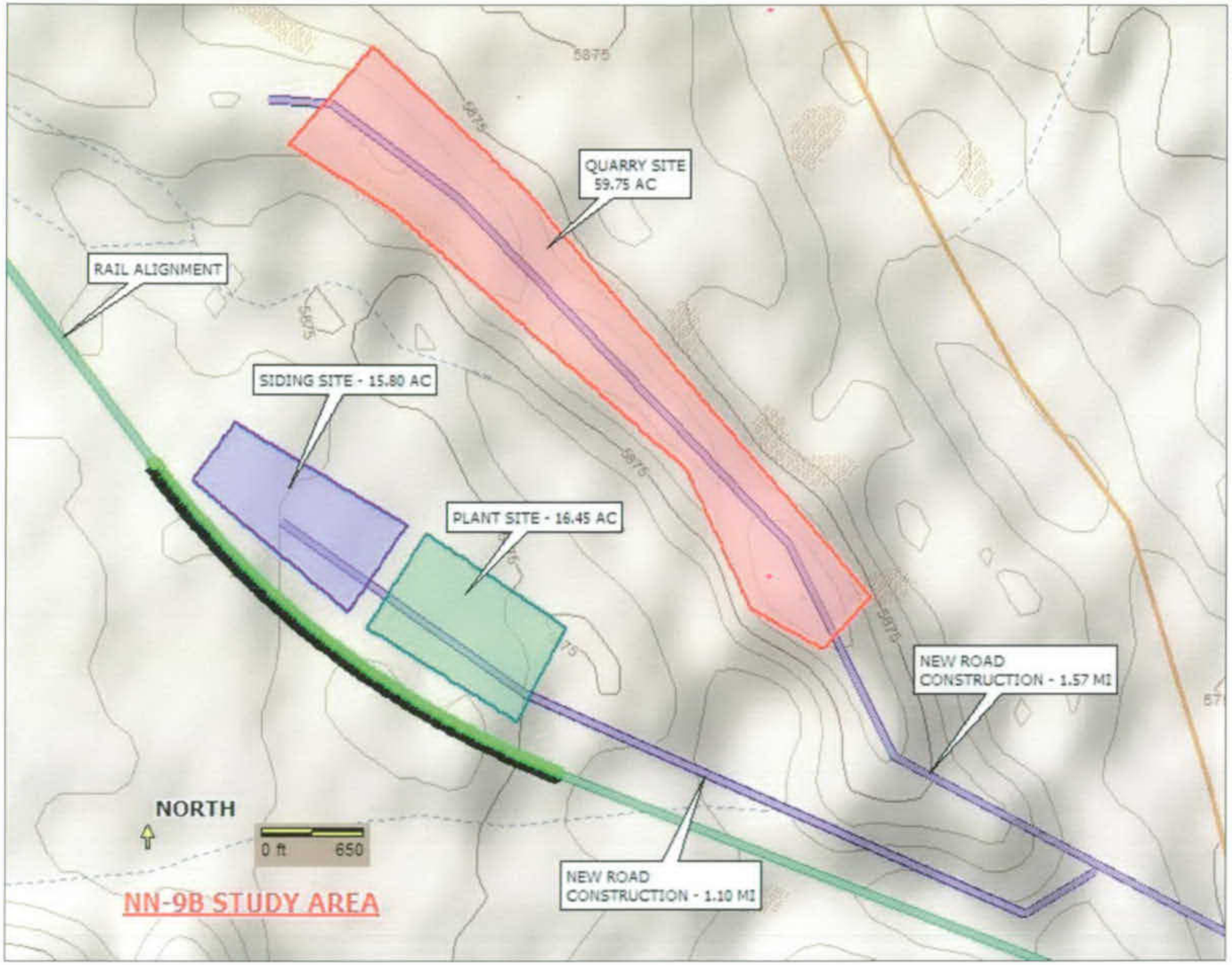
Nearest electric lines are approx. 29 miles to the north and 14 miles to the southeast.

B. Water (groundwater studies by others)

There is no water for drilling available at the quarry site. The nearest water source is at the Willow Witch well, located about 2.6 mi north of the quarry site (at N37.84155° W116.20970°, waypoint KR1). This spring produces about 5 gpm and flows into a tank that held about 10,000 gal (20 ft diam x 5 ft deep).

NN-9B: BORING LOCATIONS AND DEPTHS

BORING	LAT	LONG	COLLAR ELV	BTM ELV	OVERDRILL	DEPTH
B-1	N37.80460°	W116.19971°	5947	5920	10	37
B-2	N37.80305°	W116.19666°	5941	5920	10	31
B-3	N37.80095°	W116.19422°	5925	5920	10	15
B-4	N37.79898°	W116.19194°	5933	5920	10	23
B-5	N37.79696°	W116.18950°	5938	5920	10	28
TOTAL DRILLING FOOTAGE						134


5875
QUARRY SITE
59.75 AC
RAIL ALIGNMENT
SIDING SITE - 15.80 AC
PLANT SITE - 16.45 AC
NEW ROAD
CONSTRUCTION - 1.57 MI
NORTH
0 ft
650
NEW ROAD
CONSTRUCTION - 1.10 MI
NN-9B STUDY AREA

PHOTOGRAPHS

Photo 2341: view of basalt outcropping on narrow ridge. Looking southeast. 11/17/2005.

Photo 2342: view of basalt outcropping on narrow ridge. Looking northwest. 11/17/2005.

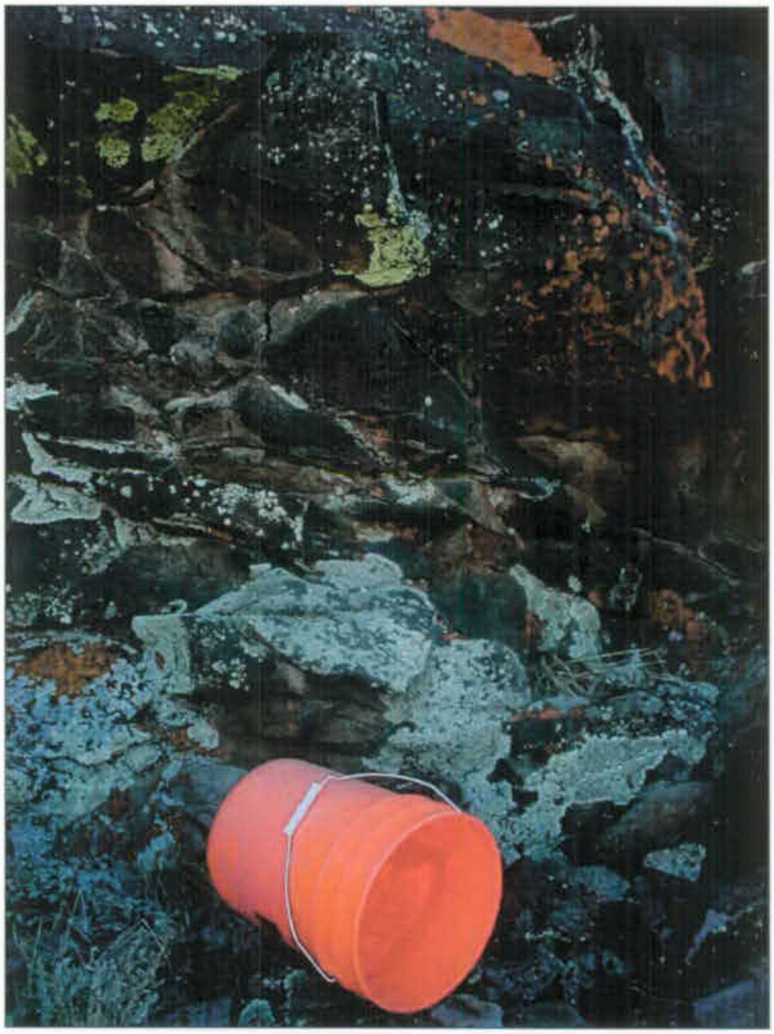


Photo 2346: View of outcrop sample area. Looking southwest. 11/17/2005.

Quarry Field Evaluation Checklist

QUARRY DESIGNATION: CA-8A(S)
FIELD TEAM: Art Geldon and Matt Grizzell
December 1, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)

Two existing quarry sites are located in Antelope Canyon, the Jim Wilkin quarry (waypoint AG28) and a community gravel pit (waypoint AG29). This checklist pertains to the potential for expansion of these existing resources to provide railroad ballast. Both quarries are shown as gravel pits on USGS geologic and topographic quadrangle maps for the area. In the vicinity of these quarries, the canyon has steep walls (approximately 40 degrees) and has a wide, relatively flat bottom.

B. Surface water (near stream/river?) what flow? intermittent?)

A wash through Antelope Canyon carries ephemeral flow from precipitation events.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)

Facilities for rock processing at the Jim Wilkin quarry already are present on the canyon floor. No facilities are present at the community pit. Sufficient area exists on the quarry floor to construct a processing plant, office, waste dump, ballast storage area, and other required structures (see "Plant Area" on the accompanying map).

D. Existing Access roads (where are they? Can they be improved? show on maps)

The Jim Wilkin quarry is located ~0.55 mile northwest of US highway 93 along a paved road into Antelope Canyon. The community gravel pit is located ~0.75 miles northwest of US highway 93 along a gravel road that branches off the road to the Wilkin quarry.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)

There is sufficient area for locating a railroad siding either on the west side of US highway 93 on land administered by the BLM or on the east side of US highway 93 on private land. A facility on the west side of US-93 will require a mechanized conveyance system over the highway; a facility east of US-93 will require road access across the highway.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)

Existing waste dumps are present at the Wilkin quarry. The "Plant Area" shown on the accompanying map can accommodate a new dump approximately 14 acres in size.

Access Roads (to highway and RR alignment)

i. Topographic conditions for new road

A new road is not necessary. Suitable roads exist from US highway 93 to the two quarry sites on the flat-bottomed floor of Antelope Canyon. Heavy trucks were observed driving throughout the Jim Wilkin quarry site.

ii. Cut slopes (soil/rock)

New road cuts will not be required to accommodate haulage.

2. DEPOSIT FEATURES

A. Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)

T4S, R67E, S6, as shown on the accompanying map.

B. Tonnage (provided in this deposit [W x L x H])

For the purposes of this investigation, an area 1000 feet by 1000 feet oriented parallel to the strike of the bedding is assumed for expansion of the Wilkin Quarry to the southwest. The assumed area is 1,000,000 ft^2. With a mineable thickness of 150 feet (perpendicular to the dip of bedding planes), the estimated volume of the mineable deposit is 150,000,000 ft_3 = 5,600,000 yd_3 x 2.16 tons/cu. yard = 12,000,000 tons.

C. Overburden (note thickness/type)

There is virtually no overburden. The canyon walls are covered locally by thin soil supporting sparse brush and grass. In most locations, the canyon walls consist of bare rock

D. Deposit Features

Cambrian Zabriskie Quartzite (Cz)

i. Rock Type/Description (use S&W rock descriptions)

QUARTZITE: medium-high to very high strength (depending on degree of fracturing; the rock shatters along internal fracture planes); light- to medium-gray and pale-purple, vitreous, and coarsely crystalline (recrystallized) where fresh; oxidized or altered red, black, or purple in zones that cut across bedding and appear to become more prevalent in the vicinity of faults that form northern, eastern, and southern boundaries of the deposit. These faults are the Stampede Detachment Fault and the Gravel Pit Fault zone *(Approximate fault locations to be shown on final site map).* The quartzite can be very weathered in zones of intense oxidation or alteration. The rock has extremely close to wide fracture spacing (<2 inches to ~6 feet), with the closest spacing in shear zones that occur randomly throughout the rock.

According to Jim Wilkin, Morrison-Knudsen developed the two existing quarries in Antelope Canyon in the 1950's. Mr. Wilkin holds a lease from the BLM to operate his quarry. We understand that the UPRR tested the quartzite in about 1990 for use as railroad ballast. They found it to be inadequate because it broke too easily under applied loads and it would not stay in place under the track. Rock from the quarry is now used mainly for ornamental stone.

ii. Thickness/Depth (need mineable thickness)

The Wilkin quarry and the community pit were excavated in the middle and lower members of the Zabriskie Quartzite (Tschanz and Pampeyan, 1970). Rowley et al. (1994) indicate that an incomplete section of the middle and lower members of the Zabriskie Quartzite in lower Antelope Canyon are about 230 feet thick. For the purposes of this estimate, a mineable stratigraphic thickness of 150 feet is assumed.

iii. Rock Structure (block sizes/joint or fracture spacing)

Jim Wilkin quarry pit:

Block Size	% Distribution
>2 feet	5
1-2 feet	30
6 inches-1 feet	45
<6 inches	20

Community pit:

Block Size	% Distribution
2-6 feet	30
1-2 feet	30
6 inches-1 feet	30
<6 inches	10

iv. Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)

Deleterious materials include shale partings, shear zones, zones of oxidation/alteration, and zones of intense fracturing.

E. Rock Quality

i. Estimated RQD

Jim Wilkin quarry: 30-60% (areally variable)

Community pit: 40-80% (areally variable)

ii. Samples for testing (100 pounds minimum; describe sample taken)

A composite, depth-integrated sample was collected from three areas in the Jim Wilkin quarry. The total sample size is estimated at 120 pounds.

iii. Rock hammer test

The quartzite has medium-high to very high strength. It generally is stronger in the community pit than in the Wilkin quarry.

iv. Schmidt hammer test

Site	45^0 Face	Horiz. Face	Vert. Face
AG 28, Site A	52-68, avg=58		5 1-69, avg=60
AG 28, Site B	62-7 1, avg=67		61-72, avg=66
AG 29	60-66, avg=62	5 8-64, avg=61	57-69, avg=64

F. **Groundwater — Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.**

There is no evidence of ground water in the immediate area of the quarries.

G. **Future Explorations**

i. **Drill rig access**

A paved road exists to the Wilkin quarry, where exploration with angle holes or horizontal holes into quarry faces can be done.

ii. **Type of rig**

Any kind of rig with angle-hole capability can be driven to the Wilkin quarry to drill into working faces.

iii. **Locations and depths of borings**

At the Wilkin quarry in Zabriskie Quartzite, the exposed rock is mostly very fractured or oxidized. The best rock there might have been removed years ago. A substantial deposit of sound quartzite behind worked faces at the Wilkin quarry might be revealed by drilling. Two to three angled or horizontal boreholes could be drilled through these faces to the contact with the Wood Canyon Formation below the Zabriskie Quartzite to evaluate the reserves of quartzite present at this site. Exploration at the Community pit is not recommended, because faulting above and immediately west of this quarry would appear to limit the extent of any resource present at this site.

iv. **Geophysics alignments**

Geophysical tools run in boreholes drilled at the Wilkin quarry might reveal changes in rock character within the Zabriskie Quartzite.

3. ENVIRONMENTAL FEATURES

A. **Vegetation (what type/how much/where)**

Sparse shrubs and grass on canyon walls. The vegetation on the canyon floor is severely disturbed by existing quarry operations.

B. **Visibility (would quarry be visible from road?)**

Parts of the existing quarry site are visible from US highway 93. Expanded operations would be more visible.

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)

Power lines already extend to the Wilkin quarry.

B. Water (groundwater studies by others)

Shallow ground water exists in Meadow Valley, but withdrawal from wells would be subject to resolving water rights issues. Ground water in Antelope Canyon at or near the Wilkin quarry might be relatively shallow.

PHOTOGRAPHS

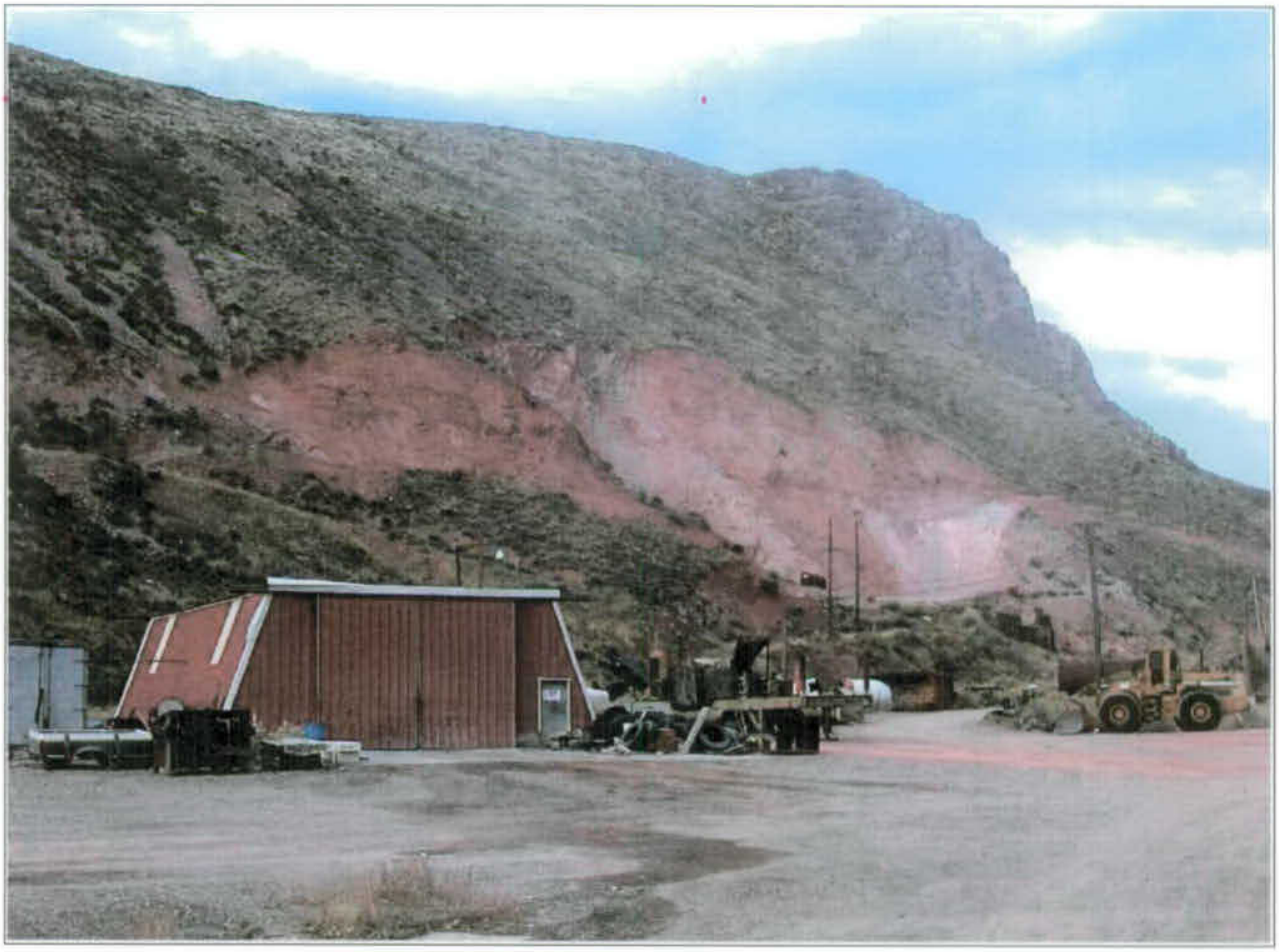


Photo MG90: (Mile 0.3) View northwest up Antelope Canyon of the Jim Wilkin quarry in the Cambrian Zabriskie Quartzite.

Photo MG97: (waypoint AG28) Site B: Blocky-fractured Zabriskie Quartzite, Wilkin quarry.

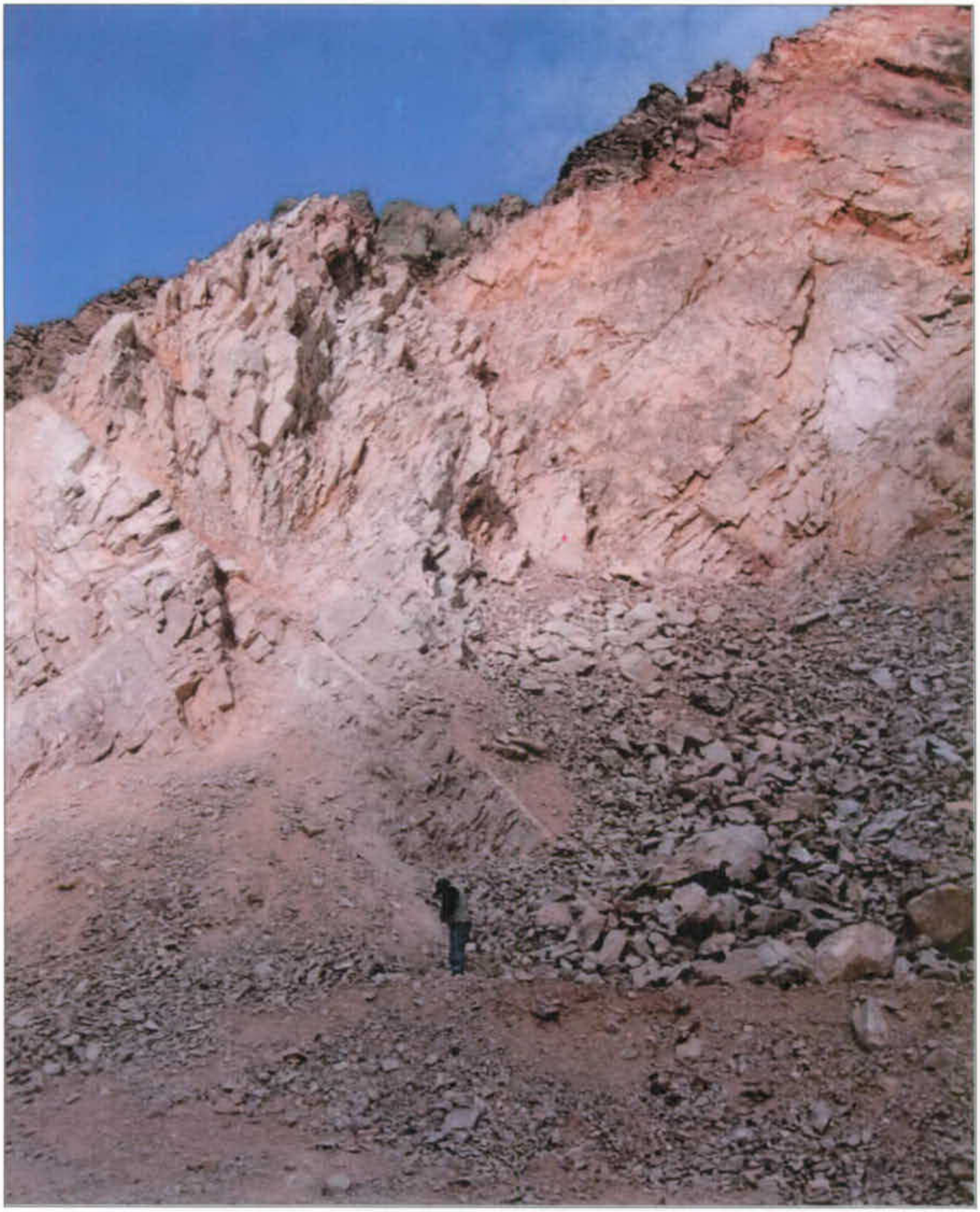


Photo MG98: (waypoint AG29) Steeply dipping, blocky-fractured Zabriskie Quartzite in the Community pit (quarry).

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: CA-8A(N)
FIELD TEAM: Art Geldon and Matt Grizzell
December 2, 2005

1. **SITE FEATURES (show on map to the extent possible)**

   A. **Topography (use degrees for slope gradients)**
   Steep hills with deeply incised washes. Highest peaks are ≤5,800 feet. Lowest elevations in area above 5,200 feet AMSL. Peak 5592 slopes descend to a wash at 5,200 feet AMSL over a distance of about 1100 feet, 12 to 20° (about a 36 percent slope).

   B. **Surface Water (near stream/river?), what flow?, intermittent)**
   Ephemeral flows in washes.

   C. **Room for Plant/Office Facilities (need 10 to 20 acres of flat land)**
   Space available in a relatively flat area on a hilltop NE of the quarry for an office (will require some leveling). This hill is along a flat area where two washes converge. There is room in this flat area (with some leveling) for a plant (see map).

   D. **Existing Access roads (where are they?, can they be improved? show on maps)**
   Existing access from Cobalt Canyon 4.4 miles from US-93 to NE or Antelope Canyon 4.5 miles from US-93 to SE over very rough, rocky, steep, and narrow roads. Major improvements are needed for haul and drill rig access.

   E. **Room for Railroad Siding (where would siding be for loading ballast cars?)**
   A railroad siding can be located next to the alignment in Meadow Valley (see map), subject to resolving private land issues.

   F. **Room for Waste Dump (need ~flat to ~gently sloping topo)**
   An area at the confluence of two washes NE of the potential quarry site can be leveled to accommodate a waste dump (within the limits of the "Plant Area" shown on the map).

   G. **Access Roads (to highway and RR alignment)**

      i. **Topographic conditions for new road**
      Very hilly (see #1A above).

      ii. **Cut slopes (soil/rock)**
      Cuts and fills will be needed to improve existing roads, mostly in rock at approximately 1 horizontal to 1 vertical (1H:1V) slopes.

2. DEPOSIT FEATURES

A Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)
T3S, R67E, S19 and 30

B. Tonnage (provided in this deposit [W x L x H])
600 x 1500 x 100 ft = 90 million ft^3 x 1 $yd^3/27ft^3$ = 3,300,000 yd^3 x 2.16 ton/yd^3 = 7,000,000 tons

C. Overburden (note thickness/type)
Essentially none. Generally thin soil, if any, present over quartzite outcrops.

D. Deposit Features

i. Rock Type/Description (use S&W rock descriptions)
Zabriskie Quartzite (Cz) – QUARTZITE: Generally very high strength but brittle and easily broken where very fractured (medium high strength); generally white, light-gray, and medium gray, but gray, greenish-gray, red, and purple where oxidized. Vitreous/coarsely crystalline, fresh to slightly weathered.

ii. Thickness/Depth (need mineable thickness)
Based on altitudes in the area and strike and dip of quartzite beds, 130-foot-thick deposit appears to exist. A thickness of 100 feet is assumed, to be conservative.

iii. Rock Structure (block sizes/joint or fracture spacing)

wpt	< 2 feet	1 to 2 feet	6 inches to 1 foot	< 6 inches
AG-31	5%	30%	60%	5%
AG-32	5%	20%	65%	10%

Generally closely to widely spaced fractures, but fractures can be extremely closely spaced to closely spaced in shear zones and brecciated zones.

iv. Deleterious Materials, including orientation and thickness. (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)
Shear zones are present but not common. Rock in shear zones has many fracture surfaces, with oxidation and black streaks. Locally dominant fracture sets oriented N63°E, 88°NW or N17°E, 51°NW. Bedding oriented N02°E, 33°SE. At base of deposit is a red and gray-banded, very fractured interval. Oxidized zones also present, wherein rock is discolored and fractures contain iron-oxide on surfaces.

E. Rock Quality

i. Samples for testing (100 pounds minimum; describe sample; taken)
Collected four bags, estimated to be >100 lbs., which contain a depth-integrated sample of quartzite beds over nearly continuous outcrop between AG-31 and AG-33 (see map).

ii. Rock hammer test
Generally very high strength, but strength decreases as fracturing increases. Rock that has many internal fracture planes can have medium high to high strength.

iii. Schmidt hammer test

	45° Face	Horizontal Face	Vertical Face
AG-31	50 (no avg.)	55 to 70, avg. = 63	58 to 63, avg. = 60
AG-32	53 to 61, avg. = 57	60 to 67, avg. = 63	60 to 66, avg. = 62

F. Groundwater – Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.
No evidence of groundwater.

G. Future Explorations

i. Drill rig access
Primitive roads requiring major improvement.

ii. Type of rig
Track rig recommended.

iii. Locations and depths of borings
Two to four borings, each about 400 feet deep.

iv. Geophysics alignments
Not needed, except possibly to delimit zones of excessive fracturing and related alteration/oxidation.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)
Hillsides in the immediate vicinity of the quarry site are covered with shrubs, grass, and trees of pinon and juniper. Trees are sparse on hillsides and common, but not dense, within and adjacent to washes.

B. Visibility (would quarry be visible from road?)

The quarry is not likely to be visible from US-93, Cobalt Canyon, or Antelope Canyon because of intervening hills.

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)

Nearest power lines are in Antelope Canyon, 2¼ miles south of the potential quarry site, and at US-93, where the Cobalt Canyon Road joins it, about 4.4 miles NE of the site. On-site power generation should be considered.

B. Water (groundwater studies by others)

In this hilly terrain, in quartzite, groundwater can be expected to be deep. A water supply would have to be transported by pipeline or trucks from Meadow Valley well(s) up Cobalt or Antelope Canyon, subject to resolving water rights issues. Antelope Canyon, from the quarry site, is reached by traveling south over steep hills and deeply incised washes, using rough, dirt roads. Once in Antelope Canyon, a road runs ESE past the existing quarries to US-93. US-93 is about 4.5 miles from the potential quarry site via the Antelope Canyon access route.

ROAD LOG OF COBALT CANYON ACCESS

Mileage	
0.0	Intersection of US-93 with Cobalt Canyon Road.
2.7	Waypoint AG-20 (see CA-8B road log for details to here).
2.9	Wpt AG-21 on ridge to left.
3.1	Rocky, narrow road descends a wash at a 10 percent grade.
3.3	Road crosses a wash.
3.35	Road to left. Stay right.
3.4	Below the confluence of two washes, road follows the combined wash. Grade behind = 20 percent, ahead = 6 percent in Tcc.
3.6	Road in a sinuous wash with outcrops of Tcc on both banks; grade 10 to 15 percent. Road is very rough and requires high clearance.
3.9 to 4.0	Road climbs out of the wash, grade 13 percent, and crosses a drainage divide.
4.1	Road forks. Take left fork, which is in another wash. Hill 5592 is underlain by Cz, to south.
4.15	Road forks. Take right fork.
4.2	Road, now a track, descends to a wash at a grade of 8 percent.
4.3	Road has crossed the wash and is at the base of a hill of Cz.
4.4	Road has climbed to a saddle on Cz at a grade of 35 percent.

Tcc= Cobalt Canyon stock
Cz = Zabriskie Quartzite
Cw= Wood Canyon formation

PHOTOGRAPHS

Photo AG0028: (Mile 4.1) View south of Peak 5592, underlain by Cz, which strikes N and dips 34°E

Photo AG0034: (waypoint AG-30) Peak 5592 underlain by Cz and surrounding hilly terrain

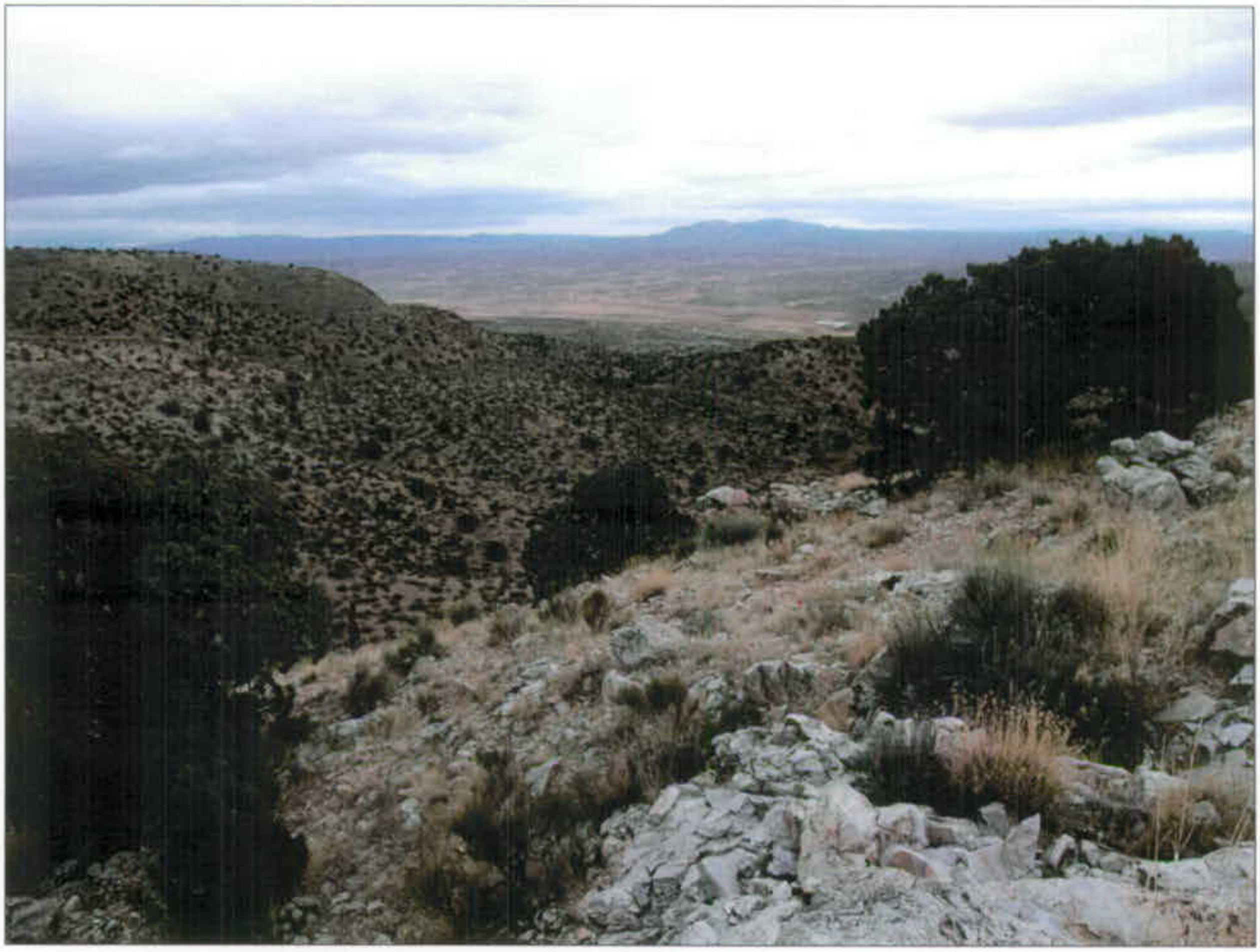


Photo AG0040: (waypoint AG-31) View NE across Cz outcrop to Meadow Valley

Photo AG0043: (waypoint AG-33) Red and white, concentrically banded quartzite (Cz)

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: CA-8B
FIELD TEAM: Art Geldon and Matt Grizzell
November 29 and 30, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)
Hilly, with washes incised into hills. Road grades commonly 7 to 10 percent (see log), with stretches ≤19 percent. Benches adjacent to north part of area CA-8B considered for facilities have gradients of ≤5 percent. Road for SE approach to quarry site.

B. Surface Water (near stream/river?), what flow?, intermittent)
Mostly has grades of <3 percent. None at site. Deeply entrenched washes carry ephemeral flow from precipitation events of unknown frequency. About 2 miles SE of the northern part of CA-8B, Meadow Valley Wash is an intermittent stream, with water use subject to water rights.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)
Very little room. Benches and flats just outside of the north boundary of Area CA-8B could be used (see map). However, a SE approach to the quarry is recommended (see map). Location of facilities at the southeast site would require leveling.

D. Existing Access roads (where are they?, can they be improved? show on maps)
Primitive roads (rocky, rutted, narrow tracks) lead 2.5 to 3.0 miles from US-93, in and just south of Cobalt Canyon to the part of area CA-8B examined. Roads will require paving, side hill cuts, and fill. Fill with culverts required to cross canyon to preferred facilities site (see map).

E. Room for Railroad Siding (where would siding be for loading ballast cars?)
Very little room, considering private property issues, but with land acquisition, there is adequate room for a siding/loading facility (see map).

F. Room for Waste Dump (need ~flat to ~gently sloping topo)
Very little room. Benches and flats just outside of the north boundary of Area CA-8B could be used (see map). A gently sloping bench, which would require leveling, offers more room for a dump and is the preferred site. The preferred site is reached by a SE approach (see map).

G. Access Roads (to highway and RR alignment)

i. Topographic conditions for new road
Hills with narrow canyons incised.

ii. Cut slopes (soil/rock)
Cut slopes in rock could approach 1 Horizontal to 1 Vertical (1H:1V). Tertiary fanglomerate/tuff beds hold steep slopes in canyons, but they would require slopes about 0.5 to 0.75H:1V.

2. DEPOSIT FEATURES

A Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)
The Cobalt Canyon stock in area CA-8B is in T3S, R67E, S17 and 20. Only that part in S17 was examined.

B. Tonnage (provided in this deposit [W x L x H])
1,000 x 1,000 x 200 ft = 2 x 108 ft^3 = 7,400,000 yd^3 x 2.16 tons/yd^3 = 16,000,000 tons. Dimensions arbitrarily assumed the deposit within area CA-8B is much larger, and as shown on the map, it extends far beyond area CA-8B in S18 to 20, 29, and 30.

C. Overburden (note thickness/type)
Grass and soil with vegetation (see below). Bedrock has substantial exposure. Overburden thin to none.

D. Deposit Features

i. Rock Type/Description (use S&W rock descriptions)
Oligocene Cobalt Canyon stock is a zoned intrusion. Where examined in T3S, R67E, S17, the stock appears to range from Monzonite to Granodiorite: very high strength, gray to pink, phaneritic, fresh to slightly weathered. Weathers largely by exfoliation and grus development. Minerals: Plagioclase ≥ K-Spar > quartz, with 10 to 15 percent mafics (mostly pyroxene) that are purely or largely altered chloride + epidote. Less alteration and fresher toward top of exposure.

ii. Thickness/Depth (need mineable thickness)
Assume ≥200 ft, based on reported thickness of about 1,000 feet by Rowley and others (1994).

iii. Rock Structure (block sizes/joint or fracture spacing)
Commonly rectangular, closely to widely spaced fractures. Locally, certain sets are dominant, but no set is dominant throughout the area.

	Block Size Distribution (%)			
Waypoint	**2 to 6 feet**	**1 to 2 feet**	**6 inches to 1 foot**	**< 6 inches**
AG-22	5	50	45	5
AG-24	25	40	25	10
AG-25	25	60	10	5
AG-26	30	50	15	5

iv. **Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)**
Thin intervals observed on bench between AG-24 and AG-25 of altered/weathered rock. Poor exposure, but intervals appear to be thin, interstratified with sand and rock.

E. **Rock Quality**
RQD probably ≥80 percent.

i. **Samples for testing (100 pounds minimum; describe sample; taken)**
≥100 pounds, collected at AG-22, -23, -24, -25, and -26. Composite sample is depth integrated, extending up a drainage at the head of which is Peak 5734.

ii. **Rock hammer test**
Very high strength.

iii. **Schmidt hammer test**
AG-22: 50 to 63, avg. = 54
AG-24: 51 to 56, avg. = 53
AG-25: 52 to 62, avg. = 55
AG-26: 50 to 60, avg. = 52

F. **Groundwater – Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.**
No evidence of groundwater. Probably deep because of the type of rock at the site—granitic. Perched water might be available in fractures at variable depths throughout the area.

G. **Future Explorations**

i. **Drill rig access**
Roads to northern boundary of site would allow access for a track rig. Canyon required to cross on SE approach could make access by a track rig difficult. A road might be needed to cross this canyon. Helicopter access should be considered.

ii. **Type of rig**
Track rig

iii. **Locations and depths of borings**
A minimum of four borings in projected quarry area needed to determine variations in composition, alteration, and fracturing of the rock mass.

iv. **Geophysics alignments**
Surface Geophysics might be needed to locate zones of excessive alteration, especially near major faults.

3. ENVIRONMENTAL FEATURES

A. Vegetation (what type/how much/where)
Pinon and juniper woodland; juniper trees are moderately abundant; pinon pine is subordinate. Much desert scrub covers the area: mesquite, scrub oak, Mormon tea, sage, and other various shrubs.

B. Visibility (would quarry be visible from road?)
Although hills are present between the quarry and the facilities and US-93, it is possible that part of the quarry operation might be visible from US-93.

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)
Power lines are 1 to 2 miles from the proposed quarry area by US-93. On-site generators should be considered.

B. Water (groundwater studies by others)
No water is available at the site. Groundwater in Meadow Valley is shallow, but availability from wells is subject to water rights issues.

C. Consider using fan alluvium of Antelope Canyon.
Moderately to well-consolidated conglomerate, gravelly sandstone, sandstone, and subordinate tuffaceous sediments and possibly tuff beds—for fill. Rock has medium-high to high strength, locally moderate strength, and should be rippable.

ROAD LOG TO NORTHERN PART OF AREA CA-8B

Mileage	
0.0	Junction of US-93 with road up a Cobalt Canyon, which is a 4WD dirt track.
0.1	Road forks under a power line that parallels US-93. Take the left fork, which is rocky, rutted, and narrow.
0.6	Road forks. Take left fork.
0.7	On fan alluvium of Antelope Canyon (Tfa).
1.1	Road forks. Take the right fork.
1.3	Road forks. Take the right fork. Left fork leads to potential quarry access from the SE (see auxiliary road log).
2.0	Road gradient ahead is 7 percent, gradient behind is > 9 percent.
2.3	Crossing splay of Chief Canyon Fault Zone. Road is on Cambrian Highland Peak. Formation limestone.
2.4	Road forks. Take left, poorly defined fork.
2.5	Still on Ch, gradient is 19 percent.
2.55	Road forks. Take right fork.

2.6 Waypoint AGU. Road is on a bench underlain by Ch. To the south is the boundary of Area CA-8B. Inside this area, Tce crops out as hills, the highest visible being Peak 5734. Road grade below is 9 percent, although grade on individual benches is ≤ 5 percent.
2.7 Road forks. Take left fork.
2.75 Waypoint AG-20; Tce granodiorite outcrops in wash.
3.0 Waypoint AG-21; just west of Peak 5734, on Old Democrat Fault, rock is prominently jointed Tce granodiorite.

AUXILIARY ROAD LOG (TO SE ACCESS TO POTENTIAL QUARRY)

Mileage

0.0 Junction of US-93 with Cobalt Canyon Road.
1.1 Road forks. Take right fork.
1.3 Road forks. Take left fork, a 4WD road, south.
1.4 Road forks. Take left fork past a butte.
1.7 Grade of road behind = 2 to 3 percent. Road ahead dips, curves, and is rocky, but the road is relatively flat.
1.9 Road has been on a bench, which begins to drop off here. Directly ahead (west) is a drainage bordered by cliffs, with Peak 5734 at its head. The drainage turns from a SE trend to a northerly trend here. The northerly segment is in a deeply incised canyon related to the Chief Canyon Facilities. This canyon must be crossed to reach the potential quarry site. Fill derived from nearby fan alluvium of Antelope Canyon (Tfa) can be used to span the canyon, with culverts installed at the base of the fill for drainage in the canyon. Outcrops of granitic rock (tonalite?) are present throughout the area of this bench.

PHOTOGRAPHS

Photo 1: (waypoint AG19) – Benches underlain by Ch (Highland Peak Formation)

Photo 2: (waypoint AG19) Outcrop of Cobalt Canyon Stock on Peak 5734

Photo 3: (waypoint AG20) Outcrop of Cobalt Canyon Stock

Photo 4: (waypoint AG21) Outcrop of Cobalt Canyon Stock on Peak 5734

Photo 5: (waypoint AG21) View down drainage to SE quarry access area

Photo 6: (waypoint AG21) View east of Peak 5734

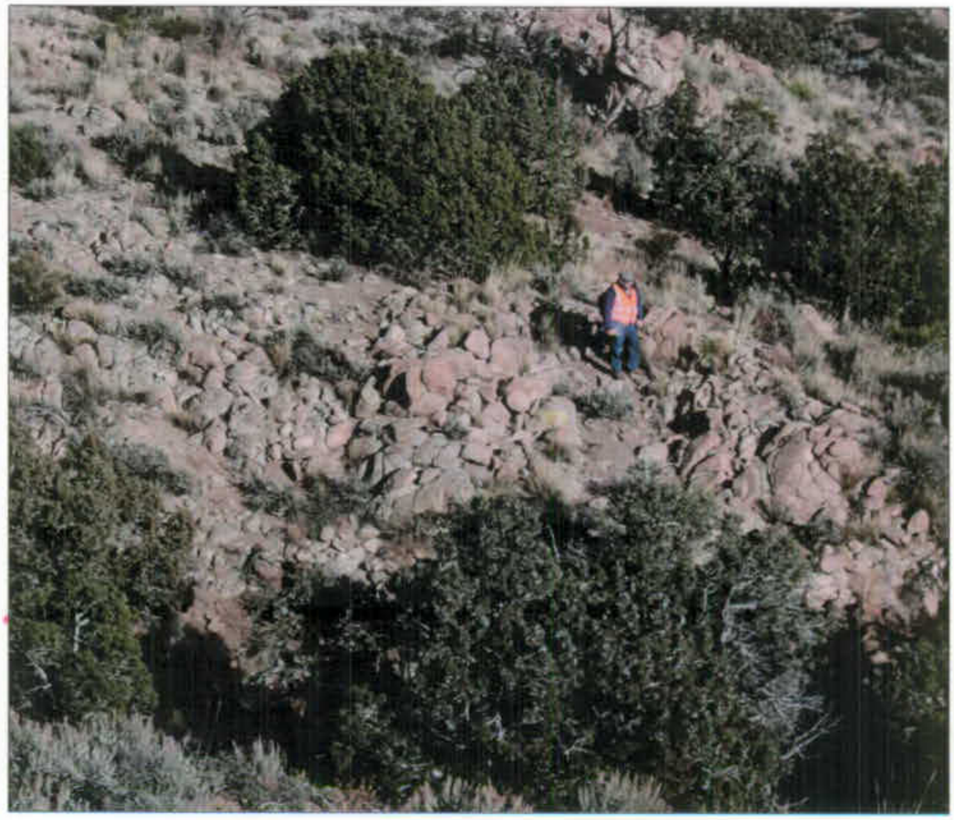


Photo 7: (waypoint AG22) Outcrop of Cobalt Canyon Stock

Photo 8: (waypoint AG23) Outcrop of Cobalt Canyon Stock

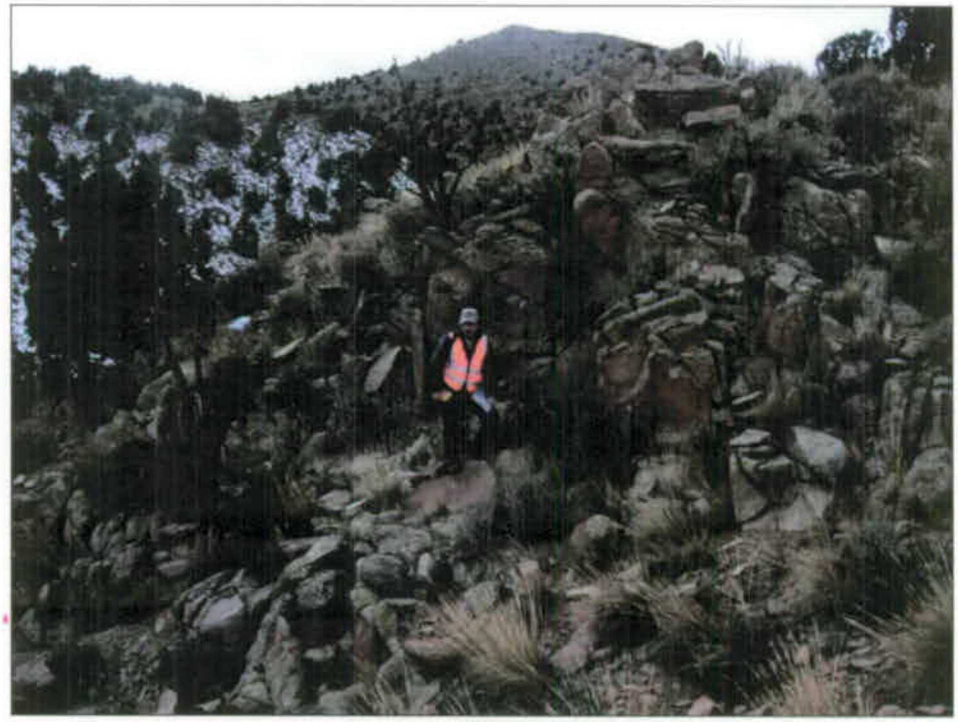


Photo 9: (waypoint AG24) Outcrop of Cobalt Canyon Stock

Photo 10: (waypoint AG25) Outcrop of Cobalt Canyon Stock and Meadow Valley

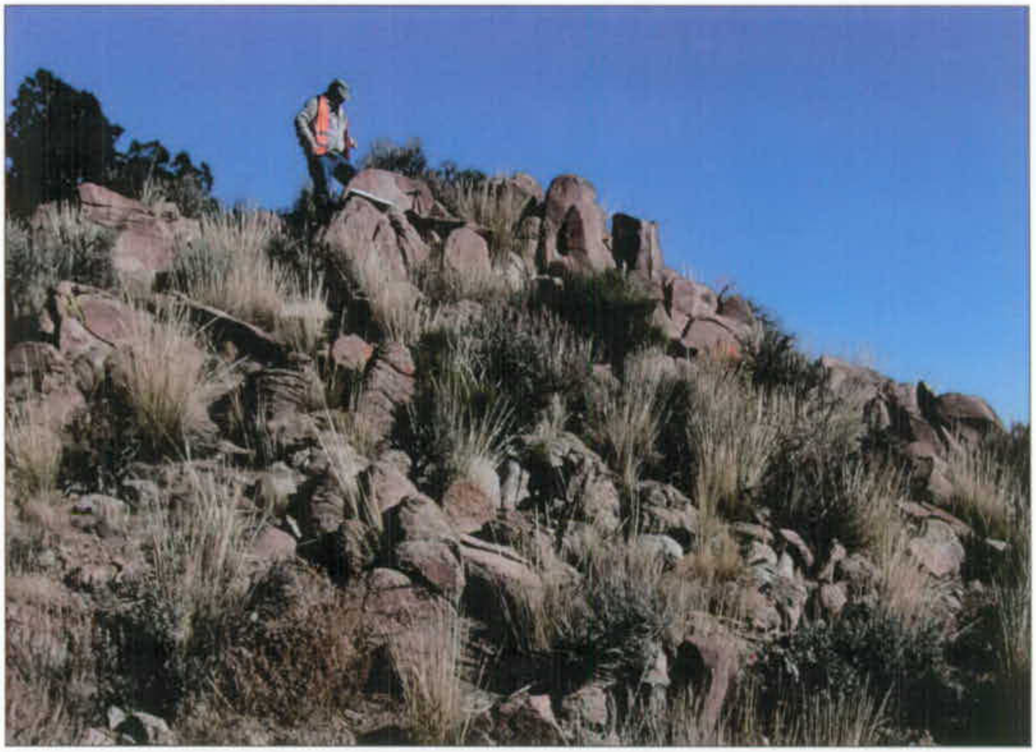


Photo 11: (waypoint AG25) Outcrop of Cobalt Canyon Stock

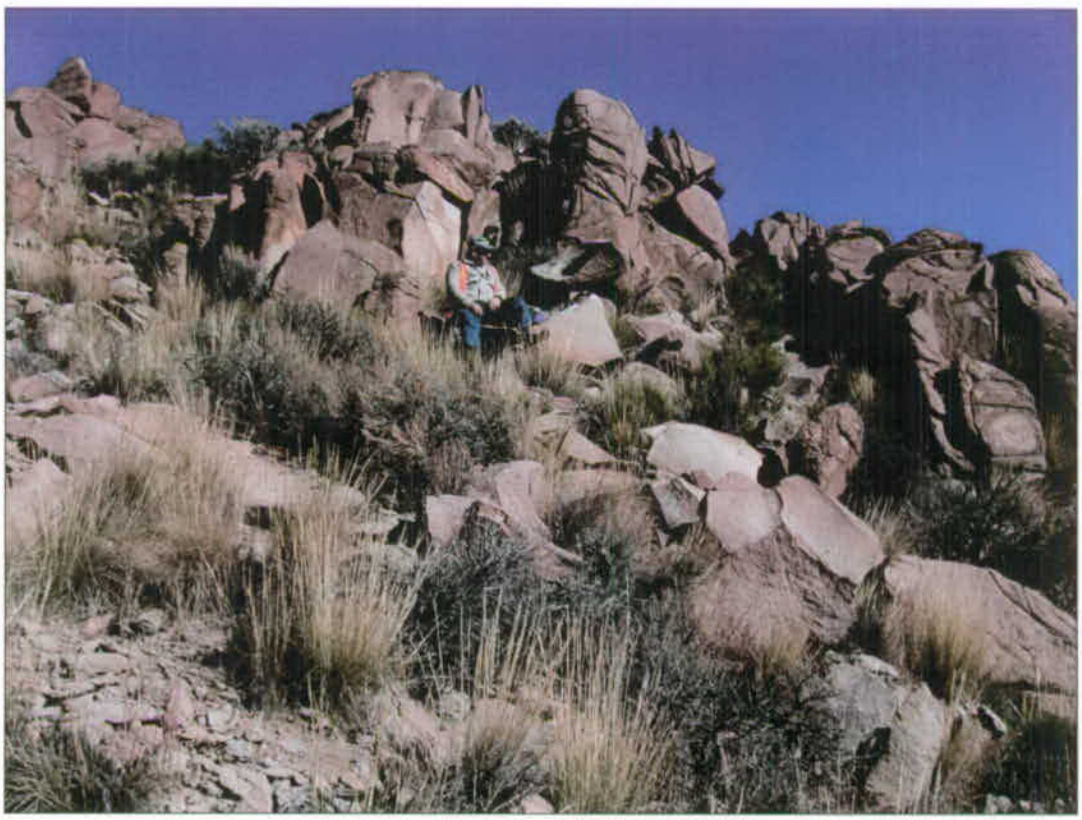


Photo 12: (waypoint AG26) Outcrop of Cobalt Canyon Stock

Photo 13: (waypoint AG27) Biotite tonalite at SE access to quarry site

Photo 14: (waypoint AG27) View up drainage to Peak 5734

Photo 15: (Mile 1.1) Cliff of Tt2 unit on road to SE quarry site access

Photo 16 (Mile 1.1) Tfa in Cobalt Canyon

Photo 17: (Mile 1.1) View east down Cobalt Canyon

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: CA-11
FIELD TEAM: Keith Rauch and Cody Sorensen
December 1-2, 2005

1. SITE FEATURES (show on map to the extent possible)

A. Topography (use degrees for slope gradients)

Due to the existing mining claims in the area of CA-11 the proposed boundary for the quarry site is limited to the very southern tip of the boundary area. The area is accessible from the maintained gravel road from Meadow Valley (Beaver Dam Road). The proposed quarry pit lies on the northwest side of Empy Wash, a gully starting from the gravel road and generally deepening and widening as it extends southwest eventually draining into Clover Creek. The proposed quarry pit site is approximately 1700 ft southwest of the gravel road down a primitive, unmaintained, and unmapped road in the bottom of Empy Wash. The road has a slope of approximately 5-12% and the wash is about 300 ft. wide.

The pit area consists of a narrow, approx. 110-150 ft. wide east facing outcrop of fresh dacite bordered on the north side by a highly weathered and eroded dacite and further north an eroded tuff, and bordered on the south side by a moderate to highly weathered and stained outcrop of dacite. The outcrop of fresh dacite is intersected down the center by a narrow approximately 5-6 feet wide zone of dark green hydrothermally altered dacite, trending vertically through the outcrop. The proposed Plant/Office site sits on the top of the wide flat to gently sloping (0-10% grade) ridge to the northeast of the quarry pit (see site plan).

B. Surface Water (near stream/river?), what flow?, intermittent)

There is a dry wash along the west side of the gully approximately 5-10 feet wide which appears to flow only during rain events or snow melts.

C. Room for Plant/Office Facilities (need 10 to 20 acres of flat land)

There is more than adequate room for a Plant/Office area of on the flat area north of the quarry pit an area of 23.2 acres is possible with gently sloping 2-7% grades. Some grading will be required to remove existing vegetations and to achieve a flat level surface.

D. Existing Access roads (where are they?, can they be improved? show on maps)

There is an existing light-duty maintained gravel road to the proposed location from Highway 93 a distance of approximately 10.5 miles. Typically the road is gently sloping with grades of 5-10% and will require slight improvement and ongoing maintenance especially during rain events to accommodate heavier traffic loads.

E. Room for Railroad Siding (where would siding be for loading ballast cars?)

The proposed railroad siding/loading area is a location approximately 7.9 miles northwest of the quarry plant at the intersection of the light-duty maintained gravel road from Meadow Valley and the proposed railroad alignment. The area sits just north of the ridge marked with a vertical control point on the map of 4899 ft elevation. The proposed area at location N37.66706°, W114.43192° (waypoint KR49), is approximately 20-30 acres, of gently sloping (1-7% grade) slightly silty gravelly SAND, alluvium with moderate grading required to achieve a flat level surface. The proposed loading area would be on the east side of the tracks and the south side of the road.

F. Room for Waste Dump (need ~flat to ~gently sloping topo)

There is more than adequate room for a waste dump at the proposed area of the plant/office site with a average slope within the site of 2-8%.

G. Access Roads (to highway and RR alignment)

The quarry site can be accessed from U.S. 93 and the railroad alignment via Beaver Dam Road, an existing, maintained, light-duty gravel road. An improved surface and/or frequent maintenance (dust control/grading) would be required for Beaver Dam Road to be used as a truck transport route. An unmaintained dirt road that comes off Beaver Dam Road and runs along the west edge of the plant and quarry sites will need to be improved or a new one constructed for a distance of approx. 1900 ft. The primitive road through Empy Wash would need to be replaced with a new road to provide access to the pit face from Beaver Dam Road. The length of the new road would be approximately 1700 ft.

i. Topographic conditions for new road

The pit road would follow the bottom of the gully created by Empy Wash, which is a typically flat area approx. 300 ft wide and gently sloping to the southwest with grades of 2-8%.

ii. Cut slopes (soil/rock)

The pit road would cut through alluvium composed of slightly silty, gravelly SAND with a trace of cobbles. The new road follows the bottom of the gully and no cuts into steep slopes should be needed.

2. DEPOSIT FEATURES

A. Location (show on 1:24,000 scale topo to the extent possible; record T, R, Sec)

B. Tonnage (provided in this deposit [W x L x H])

The Quarry could produce 3.5 million tons of useable dacite ballast, however in the process approximately 3 million tons (estimate) of unusable waste would be produced and selective sorting of usable ballast material would be required to lessen the waste tonnage.

C. Overburden (note thickness/type)

We estimate 0-5 ft. to be determined at a later date by drilling.

D. Deposit Features

Td (Tertiary Dacite)

i. Rock Type/Description (use S&W rock descriptions)

DACITE; moderate to medium high strength; light grey; slightly porphyritic; close to medium spaced, smooth undulating joints; fresh to slightly weathered; outcrop has a thin 5-6 ft wide vertically oriented hydrothermally altered dark green vein intersecting the outcrop up the center, outcrop is bordered to the south by low to moderate strength, moderately to highly weathered and brown stained, smooth, very closely to closely jointed, dacite.

ii. Thickness/Depth (need mineable thickness)

The fresh dacite outcrop appears to be approximately 100 ft wide (thick) and of unknown strike length due to near vertical orientation of bed.

iii. Rock Structure (block sizes/joint or fracture spacing)

Close to medium spaced joints, avg. approx. 2.5-24 inches
Smooth undulating joints; open (no cement)
Block size distribution on 25'H by 40'W outcrop

Block Size	% Distribution
>2'	10
1-2'	30
6"-1'	50
<6"	10

iv. Deleterious Materials, including orientation and thickness (Note: Ash layers/faults/weather contacts, shear zones, fillings, scoriaceous zones, rubble zones, etc. This is internal waste that reduces deposit size.)

Possible shear zone and hydrothermally altered zone 5-6 feet wide down center of outcrop vertically oriented. Mineable material limited on south side by highly weathered dacite.

E. Rock Quality

Estimated RQD= 30%

i. Samples for testing (100 pounds minimum; describe sample; taken)

CA-11 samples taken from the east facing outcrop on west side of Empy Wash, at location N37.61689°, W114.32700°. Three bags of material taken from site, approx. 110 lbs.

ii. **Rock hammer test**
Rock fractures typically after one blow to a couple of blows indicating moderate strength.

iii. **Schmidt hammer test**
On fresh outcrop of dacite (horiz oriented hammer) =63, 59, 38, 48, 52, 59, 49, 35, 49, 68, 60

On highly weathered outcrop of dacite (horiz oriented hammer) =22, 20, 38, 49, 48, 32, 18, 24, 37, 32, 46

F. **Groundwater — Is there evidence groundwater is near surface? Want to avoid groundwater in pit as this causes permitting problem.**
No evidence of groundwater in the immediate pit area, some dry washes leading into the proposed quarry area and across the access road leading to the quarry area.

G. **Future Explorations**
We recommend approximately 15 borings area of the quarry pit to better determine the altered zones of the dacite. See Boring and locations Table and map below.

i. **Drill rig access**
There is access to the top of the quarry pit from the existing primitive road along the northwest side of the proposed quarry plant location. The ground is typically smooth with scattered trees and occasional cobbles allowing access by both 4WD mounted rigs and track mounted rigs. A road could be cut to the top of the quarry but is not needed.

ii. **Type of rig**
We recommend the use of a 4WD or track mounted drill rig.

iii. **Locations and depths of borings**
See Borings and Locations Table and Map below.

iv. **Geophysics alignments**
A geophysics study may need to be performed oriented northeast to southwest across the quarry pit to determine extent of usable material.

3. ENVIRONMENTAL FEATURES

A. **Vegetation (what type/how much/where)**
Sage bushes, desert grasses and scattered trees, approx. groundcover 10-20%

B. Visibility (would quarry be visible from road?)

The proposed quarry pit would not be visible from the maintained gravel road from Meadow Valley. However, due to the proximity to the road the plant/office area of the site is visible from the gravel road, as is the RR siding/loading area.

4. OTHER FEATURES

A. Power (is power nearby or need on-site generation)

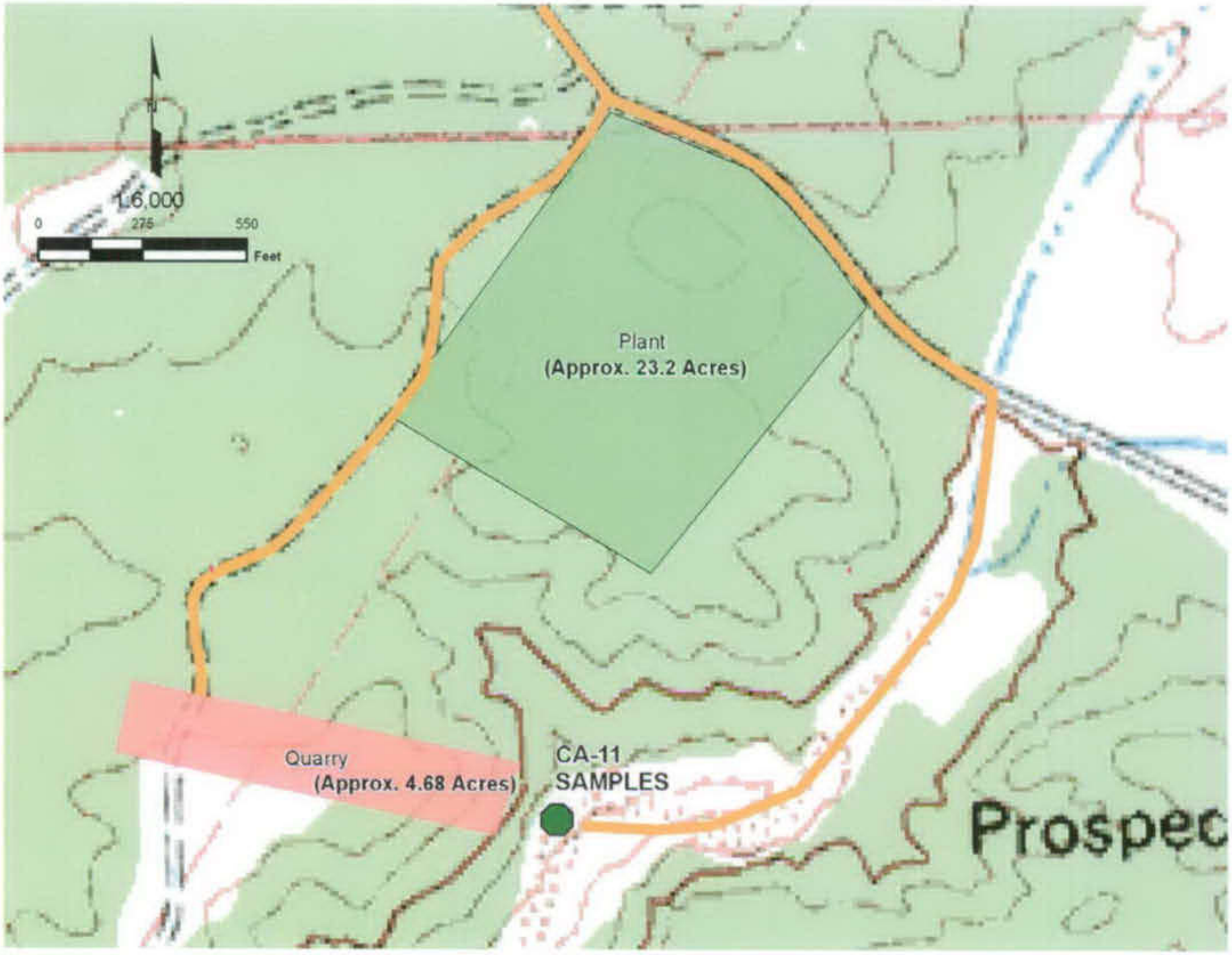
Nearest powerlines are located approx 8.5 miles northwest of the proposed site in Meadow Valley.

B. Water (groundwater studies by others)

Nearest water source is unknown, according to the map there is a possible water source at Crossroads approx. 5 miles southeast of the proposed site, or in Meadow Valley approx. 8.5 miles northwest of the proposed site.

BORING LOCATION TABLE:

BORING	UTM E	UTM N	ELEV	FLOOR	DEPTH	OVERDRILL	TOTAL
B-1	739340	415911	5840	5800	40	10	50
B-2	739320	415823	5840	5800	40	10	50
B-3	739301	415736	5850	5800	50	10	60
B-4	739481	415880	5840	5800	40	10	50
B-5	739461	415792	5840	5800	40	10	50
B-6	739442	415704	5850	5800	50	10	60
B-7	739622	415849	5840	5800	40	10	50
B-8	739603	415761	5840	5800	40	10	50
B-9	739583	415673	5850	5800	50	10	60
B-10	739763	415818	5840	5800	40	10	50
B-11	739744	415730	5840	5800	40	10	50
B-12	739725	415642	5850	5800	50	10	60
B-13	739905	415787	5840	5800	40	10	50
B-14	739885	415699	5840	5800	40	10	50
B-15	739866	415611	5850	5800	50	10	60


N
1:6,000
0 275 550
Feet
Plant
(Approx. 23.2 Acres)
Quarry
(Approx. 4.68 Acres)
CA-11
SAMPLES
Prospec

PHOTOGRAPHS

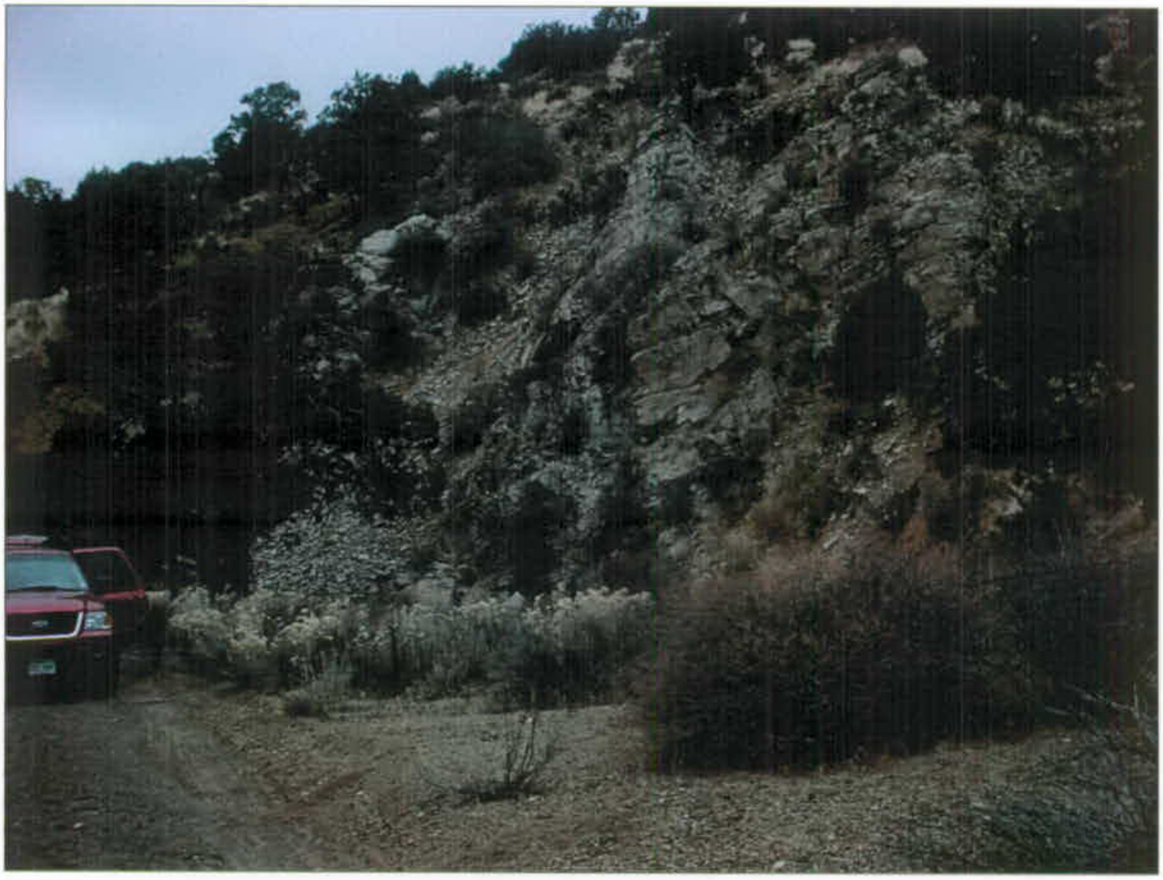


PHOTO 2408: View of sampled dacite outcrop, looking SW (02 Dec 2005)

PHOTO 2409: View of sampled dacite outcrop, looking W (02 Dec 2005)

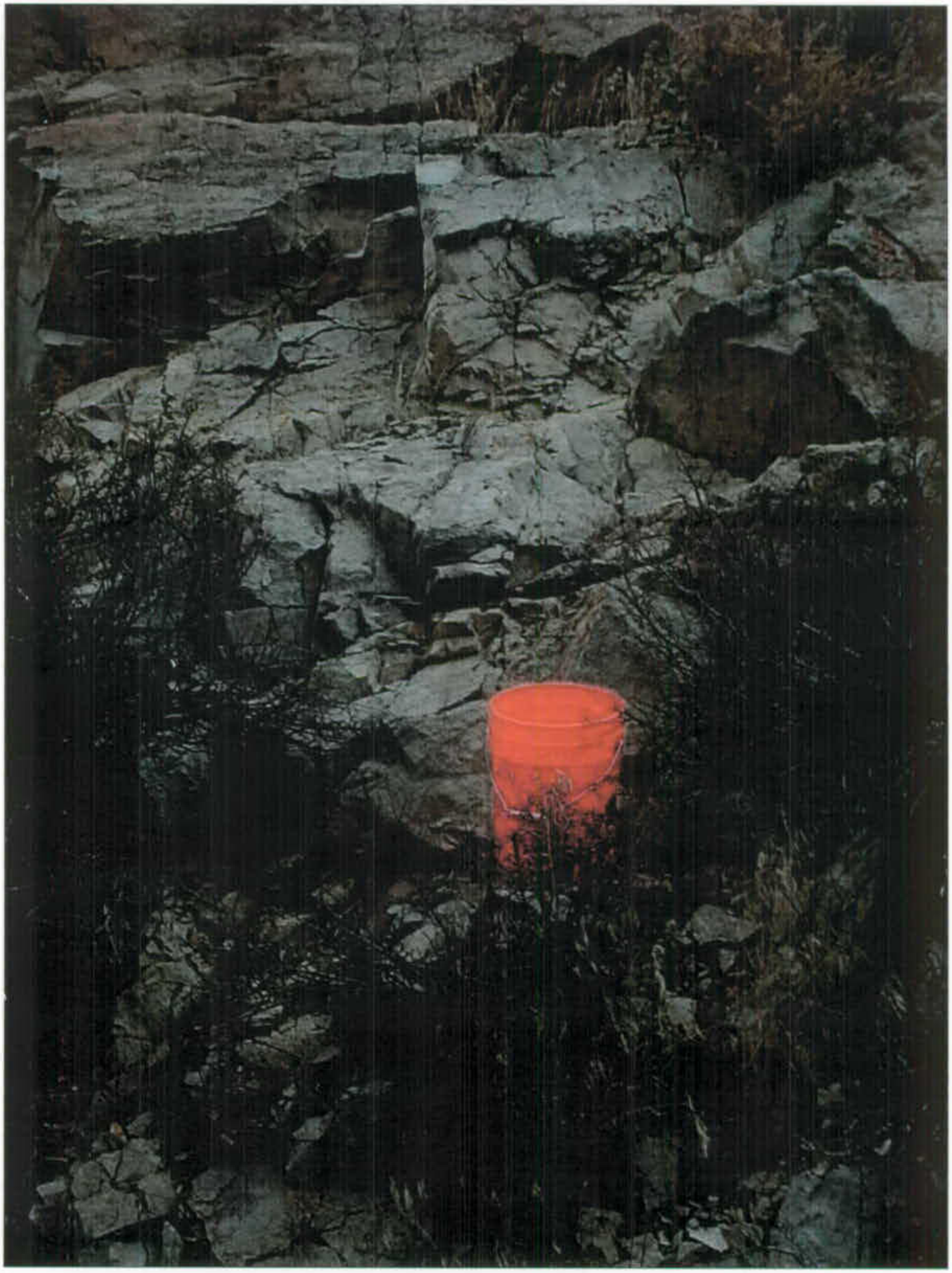


PHOTO 2410: View showing fractured & blocky nature of dacite outcrop, looking W. (02 Dec 2005)

PHOTO 2411: View of altered dacite zone, adjacent to sampled outcrop on south, looking W (02 Dec 2005)

Photo 1087: View of narrow dark green to dark gray hydrothermally altered dacite vein up the center of picture and of eroded ravine up slope, between two fresh dacite outcrops.

PHOTO 2412: View of altered dacite zone (dark brown), adjacent to sampled outcrop (light gray) on south, looking NW (02 Dec 2005)

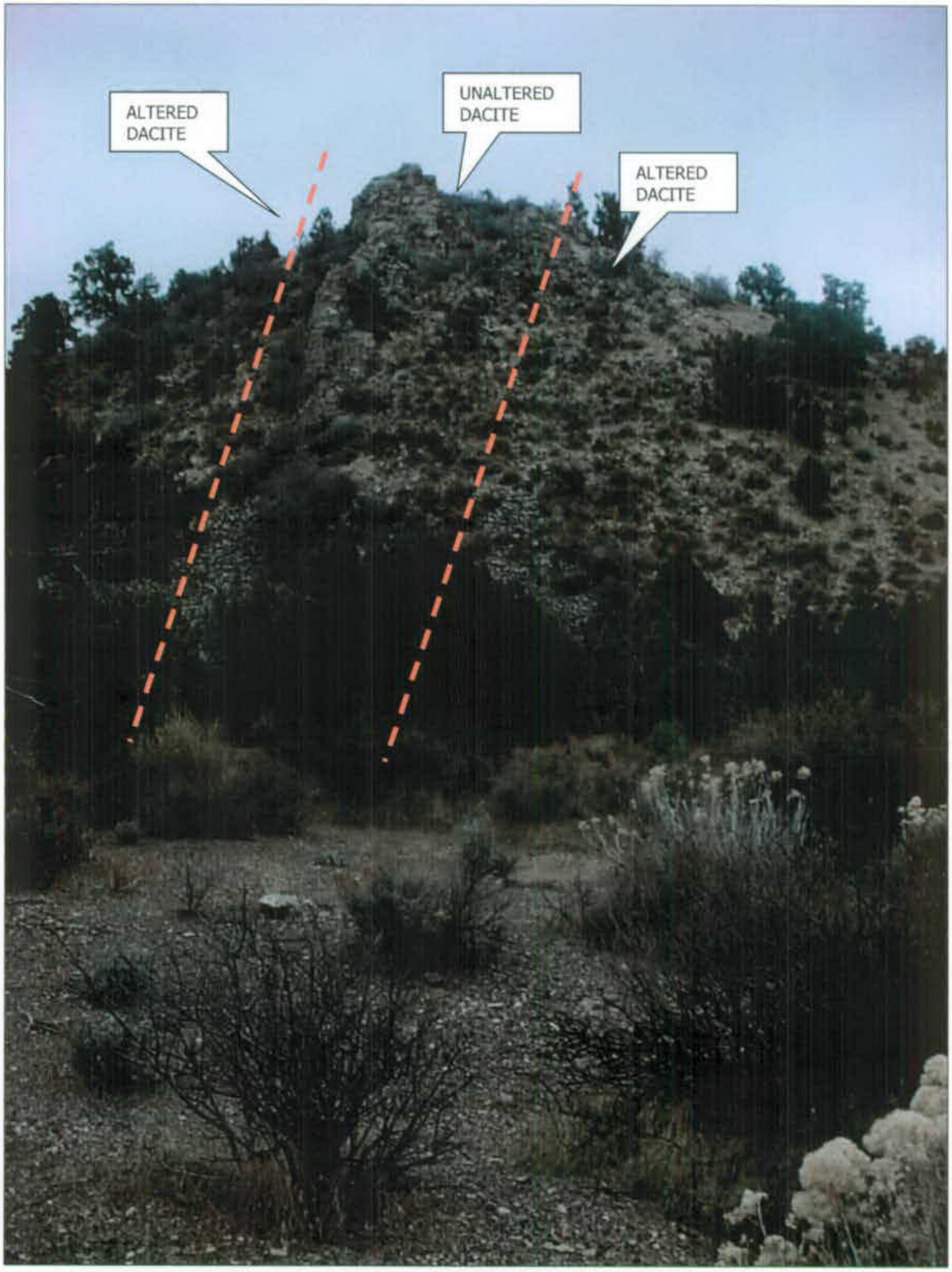


PHOTO 2413: Outcrops on opposite side of wash suggest that unaltered dacite zone may be about 100 ft thick, with unknown strike length, looking S (02 Dec 2005)

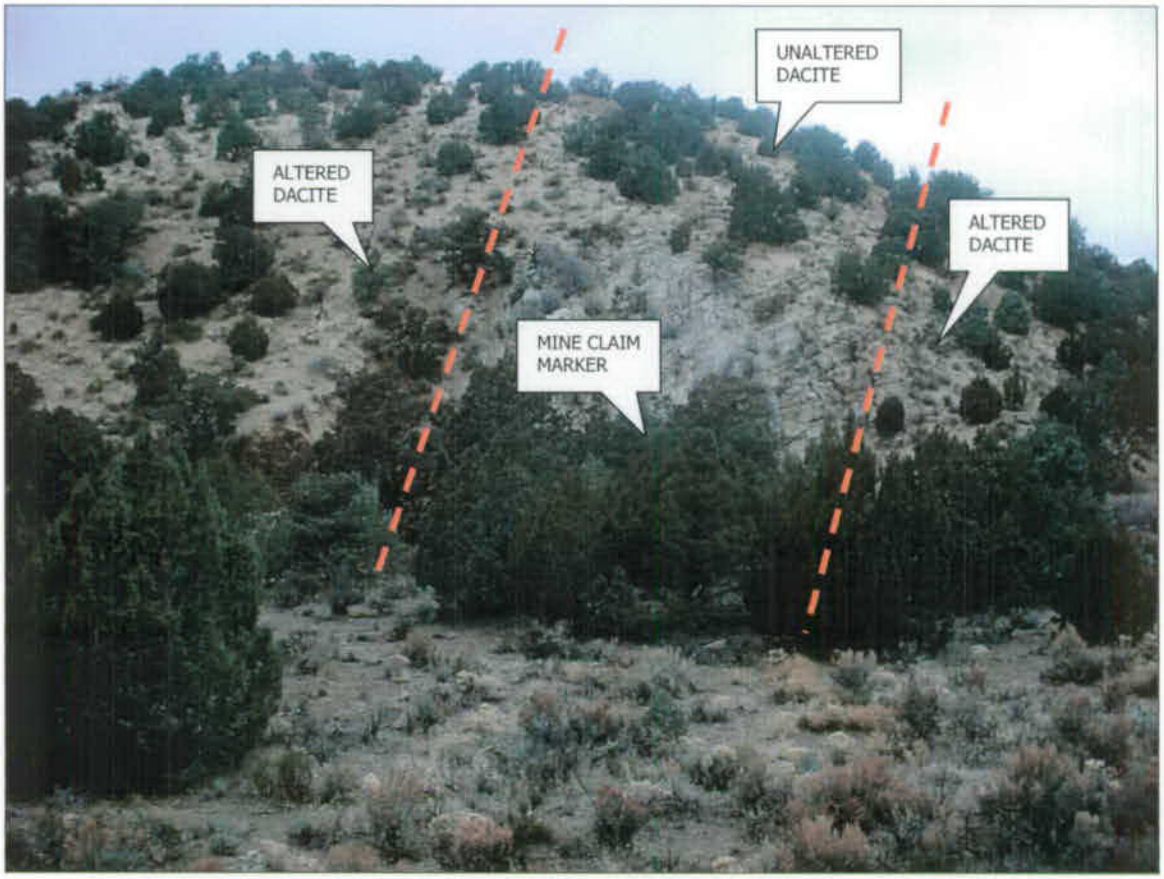


PHOTO 2414: View of sampled outcrop from opposite side of wash, looking N (02 Dec 2005)

PHOTO 2415: Old mine claim marker at N37.61632° W114.32606° (02 Dec 2005)

PHOTO 2416: View of potential RR siding site at N37.66706°, W114.43192° (waypoint KR49), looking S (02 Dec 2005)

PHOTO 2417: View of potential RR siding site at N37.66706°, W114.43192° (waypoint KR49), looking N (02 Dec 2005)

QUARRY FIELD EVALUATION CHECKLIST

QUARRY DESIGNATION: CA-12
FIELD TEAM: Keith Rauch and Cody Sorensen
December 3-4, 2005

The original area designated as CA-12 in the Ballast and Construction Materials Sources Report (S&W, 22 June 2005) included several basalt areas, mainly on upland benches on the south side of Clover Creek and southeast of Eccles. During the Phase 1 reconnaissance in September 2004, access restrictions along the UPRR track made it difficult to classify and sample these outcrops. The 2004 recon team accessed and sampled an outcrop at the southern tip of the CA-12 area at a location near Pine Wash about 9.5 miles southeast of Eccles and 3 miles south of the UPRR track at Islen. They had also noted a basalt outcrop north of Clover Creek near Eccles. Based on their observations, they determined that the entire CA-12 group would be a good candidate for additional reconnaissance.

In 2005, the northernmost basalt area of the CA-12 group was selected for more detailed reconnaissance. The area is located on the northeast side of Clover Creek just east of Dutch Flat. Roads between Eccles and Islen were washed out during flooding in January 2005. UPRR has rebuilt the road within their railroad right-of-way. There have been no repairs to the washed out primitive public road between Eccles and Islen. Therefore, the CA-12 site must be accessed via the UPRR road with their permission. Our 2005 recon team obtained permission from UPRR to access Dutch Flat and observe the southwest side of the CA-12 area.

This area of CA-12 is composed primarily of Tertiary gravels, tuffs, pyroclastic flow deposits and sedimentary lake deposits. Most of the outcrops are very low to moderate strength, and do not meet the guidelines for railroad ballast (AREMA Section 2.3.1). **We determined that no potential ballast quarry site exists within the area currently designated as CA-12 north of the alignment near Eccles.**

We attempted to gain access to the basalt areas farther southeast of Eccles but had difficulty locating the road. The following day (12/3/05), we were able to access the UPRR track at Islen. It appeared possible to drive along the track westward toward Eccles, but we did not have permission from UPRR to be in their right-of-way at the time. If the basalt areas southeast of Eccles are to be considered, pre-trip coordination with UPRR will be required.

APPENDIX B

QUARRY FIELD TEAM BIOSKETCHES

APPENDIX B

QUARRY FIELD TEAM BIOSKETCHES

Quarry Team 1 (Q1)

(Lead) Art Geldon is a Senior Geologist with Shannon & Wilson's Denver office. He graduated from the City College of New York in 1970 with a B.S. in Geology. In 1972, he obtained an M.S. in Geology from the University of Minnesota, with a specialty in igneous and metamorphic petrology. In 1980, he obtained another M. S. in Geology from the University of Montana, with specialties in groundwater hydrology and geomorphology. From 1987 to 1991, he completed more than 40 hours of graduate studies in groundwater hydrology, geochemistry, and geology at the Colorado School of Mines.

In 1974, Mr. Geldon was hired by Shannon & Wilson in Portland, Oregon, to log core from exploratory boreholes near Boardman, Oregon, and to perform laboratory analyses of soil engineering properties. From 1975 to 1977, he logged core and cuttings at dam sites and performed geologic mapping of prospective dam sites for the U.S. Army Corps of Engineers in Oregon, Washington, and Montana. From 1977 to 1978, he worked as a research assistant for the University of Montana, interpreting the groundwater hydrology of the Missoula basin. From 1978 to 1979, he evaluated mining claims and wrote environmental assessments and impact statements for the Lolo National Forest Service in Montana. From 1979 to 2001, he worked as a hydrologist for the U.S. Geological Survey (USGS) in Arizona and Colorado. His principal tasks with the USGS were evaluating the impacts of coal mining on streams and groundwater quality in the Raton Basin of Colorado and New Mexico; studying the regional geology and groundwater hydrology of the Upper Colorado River Basin; and designing, analyzing, and interpreting aquifer tests at Yucca Mountain, Nevada, and within the surrounding Great Basin region of Nevada and California.

Mr. Gelden has written and published numerous reports and has presented his work at numerous professional meetings. In 2003, his studies of the geology and groundwater hydrology of the Paleozoic rocks of the Upper Colorado River Basin of Wyoming, Colorado, Utah, Arizona, and New Mexico were published by the USGS. In 2004, he was honored by the Geological Society of America to have a special paper published on the groundwater hydrology of the Yucca Mountain and Pahute Mesa areas of Nevada.

Matthew T. Grizzell is a Geologist II from Shannon & Wilson's Denver office. Mr. Grizzell attended Colorado State University where he won numerous academic awards and scholarships, including Outstanding Senior in the College of Natural Resources and the Chevron Scholarship. After graduating with a B.S. in Geology (cum laude) in December 2002, Mr. Grizzell mapped geology in parts of the Dawson Butte, Colorado, 1:24,000 scale quadrangle for the Colorado Geological Survey. He then worked as an environmental geologist with Terranext, LLC in Denver, Colorado, where he assisted in management of State-funded cleanup of leaking underground storage tank sites. Since joining Shannon & Wilson in January 2005, Mr. Grizzell has assisted with emergency response operations for the Union Pacific Railroad in Colorado and California, and co-authored the Mineral Potential Report for the DOE Land Withdrawal for the Caliente Rail Corridor.

Quarry Team 2 (Q2)

(Lead) Bryan "Keith" Rauch is a Senior Engineering Geologist in Shannon & Wilson's St. Louis office, assigned mainly to construction oversight in tunneling projects. Keith has earned a B.S. in Geology from the University of Idaho, College of Mines (1976) and a B.S. in Computer Information Systems from Columbia (MO) College (1999). He is currently pursuing a M.S. in Engineering Management at University of Missouri-Rolla.

For 25 years, prior to joining Shannon & Wilson, Keith held a variety of geologic, engineering and management positions at major producers of base metals, precious metals and industrial minerals. Significant experience and responsibilities include:

- Prepared mine design and development plans at operating mines.
- Prepared ore reserve estimates at operating mines and undeveloped mineral deposits.
- Designed and supervised exploration drilling programs at operating mines.
- Designed and supervised exploration drilling programs for regional exploration projects.
- Supervised production at multi-level underground mining operation.
- Designed experimental blasting patterns, supervised field tests and evaluated results.
- Selected, tested and evaluated mining explosives and detonation systems.
- Monitored blasting vibrations with seismic detection systems.
- Designed, supervised installation, and evaluated results of underground roof support systems.

From 1986 to 1990, Keith held the position of senior geologist with Woodward-Clyde Consultants (now URS) in St. Louis. During this period, he supervised geotechnical investigations and UST removals at sites nationwide.

Cody K. Sorensen is a Geologist I with Shannon & Wilson's Seattle office. Mr. Sorensen attended the University of Oregon in Eugene, Oregon, where he received the James Stovall Fellowship Fund Rock Hammer Award and graduated with a B.S. in Geological Sciences in 2000. He joined Shannon & Wilson, Inc. in 2004 and since then he has been involved in landslide slope restoration, tunnel air quality monitoring, monitoring of 60 miles of new track construction in Deming New Mexico, a 65-acre, 130-home low income housing project in West Seattle, and subsurface exploration in Lakewood Washington. He has certificates of Contractor Safety Instruction with both the Union Pacific Railroad and the Burlington Northern Santa Fe Railway.

APPENDIX C

LABORATORY TEST RESULTS

APPENDIX C

LABORATORY TEST RESULTS

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LIST OF SUBAPPENDICES

Subappendix

APPENDIX C

LABORATORY TEST RESULTS

C-1 Specific Gravity/Absorption

The test for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate, American Society for Testing and Materials (ASTM) C 127, is used to determine the average density of a quantity of coarse aggregate particles (not including the volume of voids between the particles), the relative density, and the absorption of the rock sampled at the quarry sites. The relative density or specific gravity is used in calculations for volume and the computation of voids in the material. It pertains to the solid material making up the constituent particles, not including the pore space within the particles that are accessible to water.

Absorption values, obtained by soaking the samples for about 24 hours, are used to calculate the change in the mass of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition. This test was performed by Shannon & Wilson, Inc. in its Fairbanks, Alaska, location.

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/9/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1969
Sample #: ES-7/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description non-vesicular, scattered vugs

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 11:00 a.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	8961
Mass of SSD Soil in Air (B) (g)	8961
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	5772
Mass of Soil in Water (C) (g)	5772
Temperature of Water (Celsius)	21.7
Tare Mass (g)	1590
Mass of Dry Soil and Tare (g)	10513
Mass of Dry Soil (A) (g)	8923
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.80
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.81
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.83
Absorption % (Ac) = [(B - A) / A]	0.4%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	174.2
Density (SSD), lb/ft3= 62.27* B / (B - C)	175.0
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	176.3

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/9/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1969
Sample #: NS-3A/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description 5-30% vesicular

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 11:30 a.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	14799
Mass of SSD Soil in Air (B) (g)	14799
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	9109
Mass of Soil in Water (C) (g)	9109
Temperature of Water (Celsius)	21.7
Tare Mass (g)	3368
Mass of Dry Soil and Tare (g)	17920
Mass of Dry Soil (A) (g)	14552
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.56
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.60
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.67
Absorption % (Ac) = [(B - A) / A]	1.7%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	159.3
Density (SSD), lb/ft3= 62.27* B / (B - C)	162.0
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	166.5

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/9/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1969
Sample #: NS-3B/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description: Mostly solid, scattered rocks, 0-5% vesicular

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 1:00 p.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	15805
Mass of SSD Soil in Air (B) (g)	15805
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	10034
Mass of Soil in Water (C) (g)	10034
Temperature of Water (Celsius)	22.5
Tare Mass (g)	3371
Mass of Dry Soil and Tare (g)	19043
Mass of Dry Soil (A) (g)	15672
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.72
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.74
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.78
Absorption % (Ac) = [(B - A) / A]	0.8%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	169.1
Density (SSD), lb/ft3= 62.27* B / (B - C)	170.5
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	173.1

[signature]
Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/9/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1969
Sample #: NN-8A/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description non-vesicular, realatively more weathered

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 1:30 p.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	9229
Mass of SSD Soil in Air (B) (g)	9229
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	5794
Mass of Soil in Water (C) (g)	5794
Temperature of Water (Celsius)	22.5
Tare Mass (g)	3363
Mass of Dry Soil and Tare (g)	12555
Mass of Dry Soil (A) (g)	9192
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.68
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.69
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.71
Absorption % (Ac) = [(B - A) / A]	0.4%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	166.6
Density (SSD), lb/ft3= 62.27* B / (B - C)	167.3
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	168.4

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/15/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1970
Sample #: NN-8B/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12/13/05 9:00 a.m.
End of the Soak Time	12/14/05 10:15 a.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	16050
Mass of SSD Soil in Air (B) (g)	16050
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	9873
Mass of Soil in Water (C) (g)	9873
Temperature of Water (Celsius)	22
Tare Mass (g)	3371
Mass of Dry Soil and Tare (g)	19174
Mass of Dry Soil (A) (g)	15803
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.56
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.60
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.66
Absorption % (Ac) = [(B - A) / A]	1.6%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	159.3
Density (SSD), lb/ft3= 62.27* B / (B - C)	161.8
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	165.9

Reviewed by

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ver: 4/8/00

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/9/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1969
Sample #: NN-8C/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description: 2-20% vesicular

Specific Gravity of Coarse Aggregate

Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 2:00 p.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	12345
Mass of SSD Soil in Air (B) (g)	12345
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	7811
Mass of Soil in Water (C) (g)	7811
Temperature of Water (Celsius)	21.8
Tare Mass (g)	1876
Mass of Dry Soil and Tare (g)	14108
Mass of Dry Soil (A) (g)	12232

Relative Denstiy (Specific Gravity):

Relative Density (Specific Gravity) (OD) = A / (B - C)	2.70
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.72
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.77
Absorption % (Ac) = [(B - A) / A]	0.9%

Density:

Density (OD), lb/ft3 = 62.27*A / (B - C)	168.0
Density (SSD), lb/ft3= 62.27* B / (B - C)	169.6
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	172.3

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/9/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1969
Sample #: NN-8D/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description 0-1% vesicular

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 3:00 p.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	15396
Mass of SSD Soil in Air (B) (g)	15396
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	9952
Mass of Soil in Water (C) (g)	9952
Temperature of Water (Celsius)	21.5
Tare Mass (g)	1862
Mass of Dry Soil and Tare (g)	17152
Mass of Dry Soil (A) (g)	15290
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.81
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.83
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.86
Absorption % (Ac) = [(B - A) / A]	0.7%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	174.9
Density (SSD), lb/ft3= 62.27* B / (B - C)	176.1
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	178.4

Reviewed by

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ver: 4/8/00

Shannon Wilson, Inc.
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Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date:	12/9/2005
Technician:	Michael Lecorchick, Jr. C.E.T.
Workorder:	1969
Sample #:	NN-9A/S1
Project:	Yucca Mountain: Shannon & Wilson, Seattle

Soil Description 0-1% vesicular, scattered vugs

<u>Specific Gravity of Coarse Aggregate</u>	
Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 10:30 a.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	15444
Mass of SSD Soil in Air (B) (g)	15444
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	9933
Mass of Soil in Water (C) (g)	9933
Temperature of Water (Celsius)	21.2
Tare Mass (g)	1896
Mass of Dry Soil and Tare (g)	17256
Mass of Dry Soil (A) (g)	15360
<u>Relative Denstiy (Specific Gravity):</u>	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.79
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.80
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.83
Absorption % (Ac) = [(B - A) / A]	0.5%
<u>Density:</u>	
Density (OD), lb/ft3 = 62.27*A / (B - C)	173.6
Density (SSD), lb/ft3= 62.27* B / (B - C)	174.5
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	176.2

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/9/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1969
Sample #: NN-9B/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description 0-25% vesicular

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12-7-05 3:00 p.m.
End of the Soak Time	12-8-05 3:30 p.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	10237
Mass of SSD Soil in Air (B) (g)	10237
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	6584
Mass of Soil in Water (C) (g)	6584
Temperature of Water (Celsius)	21.6
Tare Mass (g)	1842
Mass of Dry Soil and Tare (g)	12034
Mass of Dry Soil (A) (g)	10192
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.79
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.80
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.82
Absorption % (Ac) = [(B - A) / A]	0.4%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	173.7
Density (SSD), lb/ft3= 62.27* B / (B - C)	174.5
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	175.9

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/15/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1970
Sample #: CA-8A/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description

Specific Gravity of Coarse Aggregate

Beginning of the Soak Time	12/13/05 10:00 a.m.
End of the Soak Time	12/14/05 9:00 a.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	17790
Mass of SSD Soil in Air (B) (g)	17790
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	11061
Mass of Soil in Water (C) (g)	11061
Temperature of Water (Celsius)	24
Tare Mass (g)	3373
Mass of Dry Soil and Tare (g)	21135
Mass of Dry Soil (A) (g)	17762

Relative Denstiy (Specific Gravity):

Relative Density (Specific Gravity) (OD) = A / (B - C)	2.64
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.64
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.65
Absorption % (Ac) = [(B - A) / A]	0.2%

Density:

Density (OD), lb/ft3 = 62.27*A / (B - C)	164.4
Density (SSD), lb/ft3= 62.27* B / (B - C)	164.6
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	165.1

Reviewed by

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2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
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(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/15/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1970
Sample #: CA-8A/S2
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12/13/05 10:30 a.m.
End of the Soak Time	12/14/05 12:00 p.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	15475
Mass of SSD Soil in Air (B) (g)	15475
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	9591
Mass of Soil in Water (C) (g)	9591
Temperature of Water (Celsius)	22
Tare Mass (g)	3366
Mass of Dry Soil and Tare (g)	18795
Mass of Dry Soil (A) (g)	15429
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.62
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.63
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.64
Absorption % (Ac) = [(B - A) / A]	0.3%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	163.3
Density (SSD), lb/ft3= 62.27* B / (B - C)	163.8
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	164.6

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/15/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1970
Sample #: CA-8B/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12/13/05 8:45 a.m.
End of the Soak Time	12/14/05 9:45 a.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	16843
Mass of SSD Soil in Air (B) (g)	16843
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	10354
Mass of Soil in Water (C) (g)	10354
Temperature of Water (Celsius)	22
Tare Mass (g)	3360
Mass of Dry Soil and Tare (g)	19979
Mass of Dry Soil (A) (g)	16619
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.56
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.60
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.65
Absorption % (Ac) = [(B - A) / A]	1.3%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	159.5
Density (SSD), lb/ft3= 62.27* B / (B - C)	161.6
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	165.2

Reviewed by

Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

Specific Gravity and Absoption of Coarse Aggregate Worksheet

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

(for use with AT-8, Specific Gravity and Absorption of Coarse Aggregate, C127)

Date: 12/15/2005
Technician: Michael Lecorchick, Jr. C.E.T.
Workorder: 1970
Sample #: CA-11/S1
Project: Yucca Mountain: Shannon & Wilson, Seattle

Soil Description

Specific Gravity of Coarse Aggregate	
Beginning of the Soak Time	12/13/05 9:30 a.m.
End of the Soak Time	12/14/05 12:00 p.m.
Tare Mass (g)	0
Mass of SSD Soil and Tare in Air (g)	17124
Mass of SSD Soil in Air (B) (g)	17124
Mass of Sample Container in Water (g)	0
Mass of Sample Container and Soil in Water (g)	10235
Mass of Soil in Water (C) (g)	10235
Temperature of Water (Celsius)	22
Tare Mass (g)	3365
Mass of Dry Soil and Tare (g)	20065
Mass of Dry Soil (A) (g)	16700
Relative Denstiy (Specific Gravity):	
Relative Density (Specific Gravity) (OD) = A / (B - C)	2.42
Relative Density (Specific Gravity) (SSD) = B / (B - C)	2.49
Apparent Relative Density (Apparent Specific Gravity) = A / (A - C)	2.58
Absorption % (Ac) = [(B - A) / A]	2.5%
Density:	
Density (OD), lb/ft3 = 62.27*A / (B - C)	151.0
Density (SSD), lb/ft3= 62.27* B / (B - C)	154.8
Apparent Density, lb/ft3 = 62.27 * A / (A - C)	160.9

Reviewed by

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Shannon Wilson, Inc.
2055 Hill Road
Fairbanks, Alaska 99709

C-2 Degradation

The test for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine, ASTM C 535, is used to test material larger than ¾ inch for resistance to degradation. It is a measure of degradation of the mineral aggregates of standard gradings resulting from a combination of actions, including abrasion or attrition, impact, and grinding in a rotating drum containing 12 steel spheres. The rotation and grinding simulate an impact-crushing effect.

The test has been widely used as an indicator of the relative quality or competence of various sources of aggregate having similar mineral compositions. The results do not automatically permit valid comparisons to be made between sources of distinctly difference origin, composition, or structure. This test was performed by Ninyo & Moore in its Las Vegas, Nevada, location.

Ninyo & Moore
Geotechnical and Environmental Sciences Consultants

Revised January 3, 2006
Revised December 15, 2005
December 14, 2005
Project No. 301530002

Mr. William T. Laprade
Shannon and Wilson
P.O. Box 300303
400 North 34th Street, Suite 100
Seattle, Washington 98103

Subject: Laboratory Test Results

Dear Mr. Laprado:

We have run L.A. Abrasion and Sulfate Soundness tests on samples delivered by your personnel.

Below, please find test results available to date:

Quarry Site	Location	L.A. Abrasion	Sodium Soundness
NN-9A/S1	N37.81226 W116.20976	16%	0.7%
NN-9B/S1	N37.80219 W116.18999	20%	0.3%
NN-8C/S1	N38.04626 W116.30763	15%	0.7%
NN-8D/S1	N38.01583 W116.27734	17%	0.45%
NS-3A/S1	SM389, SM390, SM391	18%	1.6%
NS-3B/S1	SM 388, AG15, AG16, AG17, AG18	15%	1.7%
NN-8A/S1	AG3	21%	0.3%
ES-7/S1	AG4, AG9, AG10, AG11, AG12, AG13, AG14	17%	1.0%
CA-8B	AG21, AG22, AG23, AG24, AG25, AG26	14%	1.2%
CA-8A (S)	AG28,	19%	0.03%
CA-8A (N)	AG32, AG31, AG33	23%	1.14%
CA-11	N37.61689 W114, 32700	17%	3.6%
NN-8B	N38.13151 W116.37430	17%	5.5%
NN-9B Dacite	N37.78543 W116.17309	37%	25.8%

If you have any questions please contact the undersigned.

Sincerely,
NINYO & MOORE

Fintan L. Gaffney
Principal, Construction Services

FLG/ltk

C-3 Sulfate Soundness

The test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate, ASTM C 88, is used to estimate the soundness of aggregates when subjected to weathering action. This is accomplished by repeated immersion in saturated solutions of sodium sulfate followed by oven drying to partially or completely dehydrate the salt precipitated in the permeable pore spaces of the rock sample. The internal expansive force, derived from the rehydration of the salt upon re-immersion, simulates the expansion of water on freezing.

Since the precision of this test method is poor, it may not be suitable for outright rejection of aggregates without confirmation from other tests that are related to the use of the aggregate. This test was performed by Ninyo & Moore in its Las Vegas, Nevada, location.

Revised January 3, 2006
Revised December 15, 2005
December 14, 2005
Project No. 301530002

Mr. William T. Laprade
Shannon and Wilson
P.O. Box 300303
400 North 34th Street, Suite 100
Seattle, Washington 98103

Subject: Laboratory Test Results

Dear Mr. Laprado:

We have run L.A. Abrasion and Sulfate Soundness tests on samples delivered by your personnel.

Below, please find test results available to date:

Quarry Site	Location	L.A. Abrasion	Sodium Soundness
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NN-9B/S1	N37.80219 W116.18999	20%	0.3%
NN-8C/S1	N38.04626 W116.30763	15%	0.7%
NN-8D/S1	N38.01583 W116.27734	17%	0.45%
NS-3A/S1	SM389, SM390, SM391	18%	1.6%
NS-3B/S1	SM 388, AG15, AG16, AG17, AG18	15%	1.7%
NN-8A/S1	AG3	21%	0.3%
ES-7/S1	AG4, AG9, AG10, AG11, AG12, AG13, AG14	17%	1.0%
CA-8B	AG21, AG22, AG23, AG24, AG25, AG26	14%	1.2%
CA-8A (S)	AG28,	19%	0.03%
CA-8A (N)	AG32, AG31, AG33	23%	1.14%
CA-11	N37.61689 W114, 32700	17%	3.6%
NN-8B	N38.13151 W116.37430	17%	5.5%
NN-9B Dacite	N37.78543 W116.17309	37%	25.8%

If you have any questions please contact the undersigned.

Sincerely,
NINYO & MOORE

Fintan L. Gaffney
Principal, Construction Services

FLG/ltk

C-4 Point Load

The test of Determination of the Point Load Strength Index of Rocks, ASTM D5731 (International Society of Rock Mechanics [ISRM] RTH 325), is used to classify and characterize the rock, based on strength characteristics. Its versatility is that rock specimens can be in the form of rock cores, blocks, or irregular lumps. For this project, irregular lumps were tested. The test is performed by subjecting the rock specimen to an increasingly concentrated load until failure occurs by splitting the specimen. The concentrated load is applied through coaxial, truncated conical platens. The failure load is used to calculate the point load strength index and to estimate the uniaxial compressive strength.

This test is to be used as an index test for strength classification of rock. The test results should not be used for design or analytical purposes. This test was performed by Shannon & Wilson, Inc. in its Seattle, Washington, location.

Point Load Test **ES-7**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawling 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
ES-7	S-1a			L	1.32	2.34	4636	I		3.93	1178	1.00	1182	1.98	23	27190
	S-1b			L	1.78	2.14	6146	I		4.83	1272	1.05	1336	2.20	23.5	31400
	S-1c			L	0.83	1.36	2172	I		1.42	1526	0.80	1218	1.19	19	23140
	S-1d			L	1.02	1.28	3433	I		1.67	2053	0.83	1699	1.29	19.5	33120
	S-1e			L	1.15	1.51	4179	I		2.22	1879	0.88	1657	1.49	20.5	33980
	S-1f			L	1.63	1.98	7547	I		4.10	1839	1.01	1862	2.03	23	42830
	S-1g			L	1.65	1.91	8979	I		4.01	2240	1.01	2257	2.00	23	51900
														Light Gray: Excluded from Mean		
													Mean			32830

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test

NS-3A

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawlow 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Boring No.	Run No.	Depth Interval (feet) From	Depth Interval (feet) To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
NS-3A	S-1a			L	1.49	1.93	5128	I		3.64	1409	0.99	1389	1.91	22.5	31250
	S-1b			L	1.47	2.11	4687	I		3.95	1188	1.00	1192	1.99	23	27430
	S-1c			L	1.03	1.60	3925	I		2.10	1872	0.87	1630	1.45	20.5	33410
	S-1d			L	0.75	0.98	2376	I		0.93	2564	0.72	1858	0.96	18	33440
	S-1e			L	1.45	1.60	3981	I		2.95	1348	0.94	1268	1.72	22	27890
	S-1f			L	1.57	1.88	3952	I		3.75	1054	0.99	1046	1.94	23	24060
	S-1g			L	1.08	1.60	4316	I		2.21	1956	0.88	1723	1.49	20.5	35310
	S-1h			L	1.55	2.13	4361	I		4.19	1041	1.02	1059	2.05	23	24360
	S-1i			L	1.34	2.17	6531	I		3.71	1763	0.99	1744	1.92	23	40120
	S-1j			L	1.44	1.83	5249	I		3.36	1561	0.97	1511	1.83	22.5	34000
														Light Gray: Excluded from Mean		
													Mean:			31240

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test **NS-3B**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106
Date: 12/29/05
Core Diameter: Irregular Lumps
Test By: JFL
Reviewed By/On: Scott Pawlicki / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
NS-3B	S-1a			L	0.59	1.77	2819	I		1.33	2126	0.79	1670	1.15	19	31720
	S-1b			L	0.56	1.19	2003	I		0.84	2390	0.71	1693	0.92	18	30470
	S-1c			L	1.76	2.74	9746	I		6.13	1590	1.11	1762	2.48	24.5	43180
	S-1d			L	0.78	1.68	3766	I		1.67	2259	0.83	1868	1.29	20	37350
	S-1e			L	1.10	2.64	8961	I		3.70	2422	0.99	2396	1.92	23	55110
	S-1f			L	0.65	1.66	3125	I		1.36	2299	0.79	1816	1.17	19	34500
	S-1g			L	1.26	1.35	2792	I		2.16	1294	0.88	1134	1.47	20	22680
	S-1h			L	0.97	1.97	3961	I		2.43	1629	0.90	1466	1.56	21	30790
	S-1i			L	1.17	1.91	3586	I		2.84	1264	0.93	1178	1.68	21.5	25330
	S-1j			L	0.60	1.68	2954	I		1.29	2293	0.78	1789	1.13	19	34000
														Light Gray: Excluded from Mean		
													Mean:			33140

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test

NN-8A

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawling / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	Depth Interval (feet) To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
NN-8A	S-1a			L	1.30	2.40	5078	I		3.97	1279	1.01	1286	1.99	23	29570
	S-1b			L	1.29	1.54	4699	I		2.52	1861	0.91	1690	1.59	21	35480
	S-1c			L	0.87	2.15	2525	I		2.39	1057	0.90	947	1.55	21	19890
	S-1d			L	1.00	1.55	3145	I		1.98	1590	0.86	1367	1.41	20.5	28010
	S-1e			L	1.04	1.88	3051	I		2.49	1224	0.91	1108	1.58	21	23270
														Light Gray: Excluded from Mean		
													Mean			26950

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test **NN-8B**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawley / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
NN-8B	S-1a			L	1.03	1.43	2354	I		1.88	1251	0.85	1063	1.37	20	21260
	S-1b			L	1.12	1.47	2992	I		2.09	1435	0.87	1248	1.44	20.5	25580
	S-1c			L	1.38	1.64	4806	I		2.89	1665	0.94	1558	1.70	21.5	33500
	S-1d			L	1.16	2.03	5719	I		3.00	1908	0.94	1800	1.73	22	39600
	S-1e			L	1.24	1.91	4901	I		3.01	1629	0.94	1539	1.73	22	33850
	S-1f			L	0.98	1.56	3691	I		1.94	1905	0.86	1629	1.39	20	32590
														Light Gray: Excluded from Mean		
													Mean:			31380

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

NN-8C

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL   Reviewed By/On: Scott Pawlo [signature] 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
NN-8C	S-1a			L	1.34	1.94	5944	I		3.31	1793	0.97	1731	1.82	22	38070
	S-1b			L	1.13	2.14	5598	I		3.07	1826	0.95	1732	1.75	22	38100
	S-1c			L	0.66	1.76	2486	I		1.48	1681	0.80	1353	1.22	19	25710
	S-1d			L	1.43	1.71	3802	I		3.11	1223	0.95	1163	1.76	22	25590
	S-1e			L	1.69	1.82	5746	I		3.90	1472	1.00	1474	1.98	23	33890
	S-1f			L	1.49	1.68	4579	I		3.18	1441	0.96	1377	1.78	22	30300
	S-1g			L	0.72	1.82	1846	I		1.68	1100	0.83	911	1.30	20	18220
	S-1h			L	1.50	1.48	4804	I		2.83	1695	0.93	1579	1.68	21.5	33960
													Mean			30970

Light Gray: Excluded from Mean

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test **NN-8D**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name:_ Caliente
Job No.:_ 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawling 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
NN-8D	S-1a			L	1.60	1.84	4402	I		3.74	1176	0.99	1166	1.935	22.5	26240
	S-1b			L	1.60	2.54	3028	I		5.18	584	1.07	623.5	2.277	24	14960
	S-1c			L	1.25	2.03	5658	I		3.24	1749	0.96	1679	1.799	22	36930
													Mean:			26040

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test **NN-9A**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name:_ Caliente
Job No.: _ 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL Reviewed By/On: Scott Pawling 11-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data											Calculations						
Boring No.	Run No.	Depth Interval (feet)		Type of Test	Diameter D	Width W	Point Load P	Type of Break	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	USC (psi)
		From	To	(D/A/B/L)	(inches)	(inches)	(lbs)	(I/S/C)								
NN-9A	S-1a			L	2.01	2.59	6810	I		6.62	1029	1.13	1160	2.57	25	29010
	S-1b			L	1.21	2.47	5708	I		3.79	1506	0.99	1498	1.95	23	34460
	S-1c			L	1.55	2.84	5175	I		5.59	925.7	1.09	1005	2.36	24.5	24620
	S-1d			L	1.46	2.70	7113	I		5.02	1417	1.06	1502	2.24	20	30030
	S-1e			L	1.60	2.00	6234	I		4.07	1530	1.01	1547	2.02	23	35580
	S-1f			L	1.01	1.85	3930	I		2.39	1645	0.90	1475	1.55	21	30980
	S-1g			L	1.81	2.68	9006	I		6.19	1455	1.11	1616	2.49	24.5	39590
	S-1h			L	0.83	1.98	3566	I		2.10	1700	0.87	1480	1.45	20	29600
	S-1i			L	1.42	1.59	5883	I		2.87	2052	0.93	1917	1.69	22	42180
	S-1j			L	1.11	2.12	4919	I		3.00	1640	0.94	1548	1.73	22	34050
														Light Gray: Excluded from Mean		
													Mean			32450

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test **NN-9B**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawley / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
NN-9B	S-1a			L	1.76	2.37	7468	I		5.30	1410	1.07	1512	2.30	24	36280
	S-1b			L	1.45	2.61	4427	I		4.82	919	1.05	965	2.20	23.5	22670
	S-1c			L	1.17	1.96	5395	I		2.91	1856	0.94	1739	1.71	22	38260
	S-1d			L	1.36	2.10	5739	I		3.63	1579	0.99	1556	1.91	22.5	35010
	S-1e			L	1.44	2.30	8129	I		4.24	1919	1.02	1957	2.06	23.5	45990
	S-1f			L	0.88	1.56	3882	I		1.74	2232	0.83	1863	1.32	20	37260
	S-1g			L	1.43	1.58	6569	I		2.88	2283	0.93	2135	1.70	22	46960
	S-1h			L	1.55	1.61	6218	I		3.17	1960	0.96	1873	1.78	22	41200
														Light Gray: Excluded from Mean		
													Mean:			38250

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

CA-8A SOUTH

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawling / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	Depth Interval (feet) To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
CA-8A	S-1a			L	1.03	1.17	3473	I		1.52	2283	0.81	1849	1.23	19	35130
South	S-1b			L	1.08	1.48	3799	I		2.03	1873	0.86	1619	1.42	20	32370
	S-1c			L	1.17	1.39	4267	I		2.06	2066	0.87	1793	1.44	20	35860
	S-1d			L	1.18	1.80	5483	I		2.70	2029	0.92	1870	1.64	21	39270
	S-1e			L	0.81	1.45	3664	I		1.50	2449	0.81	1977	1.22	19	37560
	S-1f			L	0.70	1.00	1884	I		0.88	2133	0.72	1529	0.94	18	27520
	S-1g			L	1.36	2.65	4584	I		4.60	997	1.04	1036	2.14	23.5	24340
	S-1h			L	1.17	1.53	4854	I		2.27	2142	0.89	1898	1.51	21	39860
	S-1i			L	0.95	1.42	3159	I		1.72	1836	0.83	1529	1.31	20	30570
	S-1j			L	1.20	3.02	3413	I		4.62	739	1.04	769	2.15	24	18450
														Light Gray: Excluded from Mean		
													Mean:			33170

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

CA-8A North

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name:_ Caliente
Job No.: _ 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawling / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	Depth Interval (feet) To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
CA-8A	S-2a			L	1.22	2.16	3120	I		3.34	935	0.97	904	1.83	22	19880
North	S-2b			L	0.95	1.13	2543	I		1.36	1877	0.79	1481	1.16	19	28140
	S-2c			L	1.35	1.81	3691	I		3.11	1186	0.95	1128	1.76	22	24820
	S-2d			L	0.72	1.38	2176	I		1.27	1719	0.78	1336	1.13	19	25380
													Mean			24560

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test
Lab Data Collection
ASTM D5731-02/ ISRM RTH 325-89

Altered CA-8A North

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name:_ Caliente
Job No.: _ 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawley (signature) 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet)		Type of Test	Diameter D	Width W	Point Load P	Type of Break	Remarks	De^2	Is	F	Is(50)	Correlated Core Size	C applied	UCS
		From	To	(D/A/B/L)	(inches)	(inches)	(lbs)	(I/S/C)		(sq. in.)	(psi)		(psi)			(psi)
CA-8A	S-2e			L	0.74	1.35	380	C		1.28	297	0.78	231	1.13	19	4390
North	S-2f			L	1.12	1.71	704	C		2.43	290	0.90	261	1.56	21	5480
	S-2g			L	1.20	1.59	2136	I		2.43	878	0.90	791	1.56	21	16600
	S-2h			L	0.68	0.94	1299	I		0.81	1598	0.70	1124	0.90	18	20240
													Mean:			11680

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test **CA-8B**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawling / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
CA-8B	S-1a			L	0.95	1.51	4833	I		1.84	2633	0.84	2225	1.35	20	44490
	S-1b			L	1.16	1.53	4618	I		2.27	2034	0.89	1803	1.51	20.5	36960
	S-1c			L	1.19	1.63	4386	I		2.47	1775	0.90	1604	1.57	21	33680
	S-1d			L	1.55	2.10	6650	I		4.14	1606	1.01	1630	2.03	23	37480
	S-1e			L	1.62	1.84	4732	I		3.80	1245	1.00	1239	1.95	23	28500
	S-1f			L	1.35	1.65	4343	I		2.84	1528	0.93	1425	1.69	21.5	30630
													Mean:			34690

Light Gray: Excluded from Mean

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

Point Load Test **CA-11**

Lab Data Collection

ASTM D5731-02/ ISRM RTH 325-89

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 N 34th St Suite 100, Seattle, WA 98103
Tel: (206) 632-8020 Fax: (206) 633-6777

Project Name: Caliente
Job No.: 21-1-20102-106

Date: 12/29/05
Core Diameter: Irregular Lumps

Test By: JFL
Reviewed By/On: Scott Pawling / 1-4-06
Point Load Tester (type/serial no.): GCTS PLT 100

Lab Data										Calculations						
Boring No.	Run No.	Depth Interval (feet) From	To	Type of Test (D/A/B/L)	Diameter D (inches)	Width W (inches)	Point Load P (lbs)	Type of Break (I/S/C)	Remarks	De^2 (sq. in.)	Is (psi)	F	Is(50) (psi)	Correlated Core Size	C applied	UCS (psi)
CA-11	S-1a			L	1.00	2.96	3622	I		3.75	966	0.99	958	1.94	23	22040
	S-1b			L	1.14	3.00	3939	I		4.36	903	1.03	927	2.09	23.5	21780
	S-1c			L	1.12	1.51	1520	I		2.15	708	0.88	620	1.47	20.5	12710
	S-1d			L	1.32	2.92	4820	I		4.92	980	1.05	1034	2.22	24	24810
	S-1e			L	1.09	1.93	5027	I		2.68	1873	0.92	1724	1.64	21	36200
	S-1f			L	1.14	1.67	4116	I		2.41	1710	0.90	1535	1.55	21	32240
	S-1g			L	1.26	2.24	4768	I		3.59	1328	0.98	1305	1.90	22.5	29360
	S-1h			L	1.02	1.88	3219	I		2.45	1316	0.90	1186	1.56	21	24910
														Light Gray: Excluded from Mean		
													Mean:			25280

Abbreviations:

Type of Test:
D = Diametral
A = Axial
B = Block
L = Lump

Type of Break:
I = Intact
S = Structure
C = Combined

Calculations:

De^2 = D^2 (diametral test)
De^2 = (4*W*D)/Pi (axial, block, lump test)
F = (De/1.97)^0.45 or (De/2)^1/2, approx.
Is = P/De^2
Is(50) = F*Is
UCS= C*Is(50)

Correction Factor, C:

Core Size (in.)	C (approx.)
0.79	17.5
1.18	19
1.57	21
1.97	23
2.36	24.5

C-5 Total Free Silica

The test of Total Free Silica, ME-ICP 81, is used to determine the percentage of free silica in a rock sample. The test, using fusion assay methods, is used for evaluating the concentrations of specific elements. The results of this test were also shared with Schurer & Fuchs to aid in their petrographic analysis.

This test was performed by ALS Chemex, in its Vancouver, British Columbia (BC) location.

ALS Chemex
EXCELLENCE IN ANALYTICAL CHEMISTRY
ALS USA Inc.
994 Glendale Avenue, Unit 3
Sparks NV 89431-5730
Phone: 775 356 5395 Fax: 775 355 0179 www.alschemex.com

To: SHANNON AND WILSON, INC
400 N. 34TH ST. STE. 100
PO BOX 300303
SEATTLE WA 98103

Finalized D[illegible]-DEC-2005
This copy reported on 9-DEC-2005
Account: SHAWIL

CERTIFICATE VA05105986

Project: 21-1-20102-106
P.O. No.: 21-1-20102-106
This report is for 8 Rock samples submitted to our lab in Vancouver, BC, Canada on 1-DEC-2005.
The following have access to data associated with this certificate:

BILL FUCHS	BILL LAPRADE	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-ICP81	ICP Fusion - Ore Grade	ICP-AES

To: **SHANNON AND WILSON, INC**
ATTN: BILL LAPRADE
400 N. 34TH ST. STE. 100
PO BOX 300303
SEATTLE WA 98103

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.

Signature:

ALS Chemex
EXCELLENCE IN ANALYTICAL CHEMISTRY
ALS USA Inc.
994 Glendale Avenue, Unit 3
Sparks NV 89431-5730
Phone: 775 356 5395 Fax: 775 355 0179 www.alschemex.com

To: SHANNON AND WILSON, INC
400 N. 34TH ST. STE. 100
PO BOX 300303
SEATTLE WA 98103

Finalized Date: 8-DEC-2005
Account: SHAWIL

Project: 21-1-20102-106

CERTIFICATE OF ANALYSIS VA05105986

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	ME-ICP81 Si % 0.01
NN-9A/SI		0.10	22.4
NN-9B/SI		0.12	21.9
NN-8C/SI		0.10	22.6
NN-8D/SI		0.08	21.5
NS-3A/SI		0.18	24.4
NS-3B/SI		0.10	22.5
NN-8A/SI		0.10	28.5
ES-7/SI		0.02	22.2

ALS Chemex

EXCELLENCE IN ANALYTICAL CHEMISTRY

ALS USA Inc.

994 Glendale Avenue, Unit 3
Sparks NV 89431-5730
Phone: 775 356 5395 Fax: 775 355 0179 www.alschemex.com

To: SHANNON AND WILSON, INC
400 N. 34TH ST. STE. 100
PO BOX 300303
SEATTLE WA 98103

Finalized Date: [illegible]-DEC-2005
Account: SHAWIL

CERTIFICATE VA05108920

Project: Caliente Rail Corridor

P.O. No.:

This report is for 5 Rock samples submitted to our lab in Vancouver, BC, Canada on 12-DEC-2005.

The following have access to data associated with this certificate:

BILL FUCHS	BILL LAPRADE	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-ICP81	ICP Fusion - Ore Grade	ICP-AES

To: **SHANNON AND WILSON, INC**
ATTN: BILL LAPRADE
400 N. 34TH ST. STE. 100
PO BOX 300303
SEATTLE WA 98103

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.

Signature:

ALS Chemex
EXCELLENCE IN ANALYTICAL CHEMISTRY
ALS USA Inc.
994 Glendale Avenue, Unit 3
Sparks NV 89431-5730
Phone: 775 356 5395 Fax: 775 355 0179 www.alschemex.com

To: SHANNON AND WILSON, INC
400 N. 34TH ST. STE. 100
PO BOX 300303
SEATTLE WA 98103

Finalized Date: 15-DEC-2005
Account: SHAWIL

Project: Caliente Rail Corridor

CERTIFICATE OF ANALYSIS VA05108920

Sample Description	Method Analyte Units LOR	WEI-21 Recvd Wt. kg 0.02	ME-ICP81 Si % 0.01
CA-8B		0.04	31.1
CA-11-S-1		0.10	35.5
NN-8B		0.04	28.9
CA-8A S-1		0.08	45.7
CA-8A S-2		0.06	44.6

C-6 Petrographic Analysis

Petrographic analyses were performed on rock samples to determine the rock type and the mineral constituents. The percentage of alteration of the sample was an ancillary characteristic provided by the analyst. Thin sections of the rock samples were prepared by Burnham Petrographics of Rathdrum, Idaho, and the analysis was performed by Schurer & Fuchs of American Canyon, California. As there is no directly applicable ASTM procedure, the petrographic analysis was performed using methods standard to the mineral exploration industry. They are similar, but not identical to those recommended by the Commission on Standardization of Laboratory and Field Tests established by the International Society for Rock Mechanics.

The mineral percentages from the rock thin sections were obtained by visual estimation utilizing published comparison charts, which is standard practice.

PETROGRAPHY OF EIGHT ROCK SAMPLES, CALIENTE RAIL CORRIDOR, YUCCA MOUNTAIN PROJECT

Prepared for: Bill Laprade, Vice President
Shannon & Wilson, Inc.
400 N. 34th Street, Suite 100
Seattle, Washington 98103

Schurer & Fuchs
2180 Arcane Avenue
Reno, Nevada 89503
(702) 746-8839

December 2005

SAMPLE LIST

ES-7/S1	Leucobasalt Porphyry
NN-8A/S1	Andesite Porphyry
NN-8C/S1	Porphyritic Leucobasalt
NN-8D/S1	Leucobasalt Porphyry
NN-9A/S1	Porphyritic Leucobasalt
NN-9B/S1	Leucobasalt
NS-3A/S1	Basaltic Andesite
NS-3B/S1	Leucobasalt

ES-7/S1 **Thin Section Description**

Rock Classification (IUGS): Leucobasalt Porphyry

Alteration: 2% total alteration; very minor calcite (+ dolomite?) + clay + chlorophaeite(?) alteration and microfracture filling; variable alteration of olivine to iddingsite and chlorophaeite

Hand Specimen: Dark gray massive porphyritic volcanic rock with plagioclase (labradorite?) phenocrysts and equant light brown-olive (olivine) phenocrysts; strongly magnetic; orange to brown iron oxide on weathered surfaces; traces of carbonate (calcite and possibly some dolomite), including carbonate in a microfracture

Silica Analysis: 22.2% Si (47.5% SiO_2)

Thin Section (half K-stained):

Plagioclase: 73% (including 35% phenocrysts); anhedral to euhedral in groundmass; subhedral to euhedral in phenocrysts; twinning and normal zoning (step and progressive zoning) common; typical phenocryst size = 0.3-3.2 mm (long dimension), maximum size = 6.2 mm; typical grain sizes in groundmass = 0.1-0.24 mm; most calcic composition (of phenocrysts) is An_{54} (labradorite)

Clinopyroxene (var. Augite?): 15%; confined to groundmass; distinct very pale green color; euhedral to subhedral, occasionally anhedral; biaxial(+), moderate 2V angle; rare twinning; stubby elongate crystals; extinction angles ≈ 45°; probable augite by optical properties and association; typical grain size = 0.04-0.14 mm (long dimension)

Olivine: 4.5% (including 1-1.5% phenocrysts); anhedral to euhedral, in phenocrysts and groundmass; biaxial(+) and (-), very large 2V angle (close to 90°); weak r>v dispersion; classic olivine form and fracturing; variable alteration to orange iddingsite (25%) and light green chlorophaeite (5%); typical grain size = 0.2-0.6 mm, maximum size = 2.3 mm (long dimension)

Opaques: 4%; disseminated in groundmass; occasional inclusions in phenocrysts; grain sizes commonly 0.02-0.10 mm (dia.); strong magnetism of hand specimen indicates magnetite

Iddingsite: 1.5%; orange alteration product of olivine

(continued)

K-Feldspar or Zeolite: <1%; anhedral; intergranular sporadic grains in groundmass; moderate negative relief agains plagioclase; occasionally in microfractures in plagioclase; somewhat weak K stain; biaxial(-) and (+), moderate 2V angle; typically along margins of plagioclase phenocrysts; commonly found with carbonate ± biotite ± apatite (± clinopyroxene); if this is (nonfibrous) zeolite, then variety chabazite would be a possibility based upon dual optic signs, calcite association and anhedral aspect

Clay + Chlorophaeite?: 0.5%; locally intersertal in groundmass and alteration along microfractures in plagioclase (particularly intracrystalline microfractures in plagioclase phenocrysts); olive-green and light brown colors; length-slow, parallel extinction; sporadic alteration of olivine; also intersertal (± occasional carbonate) in groundmass

Biotite: 0.25%; anhedral; sparse small patches, somewhat sieve-textured; medium-light orange-brown color; biaxial(-), moderate 2V angle

Carbonate (Calcite + possible Dolomite): <0.25%; anhedral; intersertal in groundmass; in rare discontinuous microfractures ± clay; also some association with biotite; calcite and possibly some dolomite based on acid reaction of section slab

Clinoamphibole (probable Hornblende): Minor (<0.25%); anhedral to subhedral patch, attached to biotite; biaxial(-), moderate 2V angle; medium to light brown pleochroism; amphibole cleavage on basal sections

Apatite: Very minor (much less than 0.25%); subhedral-prismatic; sparse grains in groundmass (with plagioclase); occasional long rods in plagioclase phenocrysts

Microfracturing: There is significant microfracturing of plagioclase phenocrysts without noticeable dislocation; many of these fractures terminate at the surrounding groundmass, but some are definitely more through-going, although they almost never traverse the entire section. Because groundmass dominates over phenocrysts, the rock still seems to have good integrity, and in hand specimen this appears to be a very solid, hard rock.

Fabric: There is a subtle (more distinct under higher magnification) but wavy preferred orientation of plagioclase laths in groundmass and elongated plagioclase phenocrysts. This fabric is probably not strong enough to significantly affect rock breakage. Plagioclase phenocrysts comprise 35% of the section.

(continued)

Summary

This rock is classified as a leucobasalt porphyry based upon a combination of the IUGS modal and chemical (total alkali-silica) classification systems. It is probably a calc-alkaline basalt, but this determination is not definitive. The color index is 26. The dominant minerals are plagioclase (73%), clinopyroxene (probable augite, 15%), olivine (4.5%), opaques (4%), and iddingsite (1.5%). There are also relatively minor amounts of K-feldspar (or possibly zeolite), clay + chlorophaeite(?), biotite, clinoamphibole (probable hornblende), carbonate (calcite and possible dolomite), and apatite. Phenocrysts comprise 36-37% of the section and consist of plagioclase and minor (1-1.5%) olivine.

Total alteration amounts to only 2% and consists of very minor calcite (and possible dolomite) and clay/chlorophaeite(?) alteration, both ocurring as minor intersertal material in the groundmass and along intracrystalline or discontinuous microfractures.

There is significant microfracturing of plagioclase phenocrysts, but fractures tend to terminate at the groundmass, although there are some through-going fractures (not completely traversing the section); carbonate ± clay rarely fills these microfractures. Nevertheless, the rock is overall solid and hard.

There is a subtle fabric consisting of wavy preferred orientation of both plagioclase laths in the groundmass and elongated plagioclase phenocrysts. This fabric is probably not strong enough to significantly affect rock breakage.

Petrographers: Victoria S. Fuchs
William A. Fuchs

NN-8A/S1 **Thin Section Description**

Rock Classification (IUGS): Andesite Porphyry

Alteration: 8% total alteration; minor-moderate carbonate alteration; minor iron oxidation

Hand Specimen: Dark gray massive (intermediate) volcanic rock with small plagioclase crystals (phenocrysts), variably oriented; orange-brown iron oxide staining on weathered surfaces; dark orange iron oxide staining of some small phenocrysts; moderate (distinct) magnetism; reaction of section slab to dilute hydrochloric acid indicates presence of calcite and possibly some dolomite

Silica Analysis: 28.5% Si (61.0% SiO_2)

Thin Section (half K-stained):

Felsitic Groundmass Material: 62%; anhedral; patchy extinction; indistinct material (probable plagioclase and some quartz) clouded by a dense dusting of minute opaque grains partly altered to hematite; scattered small twinned plagioclase laths with higher refractive indices (i.e., positive relief) against finer grained micro- to cryptocrystalline? felsitic material; rare granophyric quartz-plagioclase in large glomerocryst; grain sizes indeterminable

Plagioclase Phenocrysts & Microphenocrysts: 21%; euhedral to subhedral; normal compositional zoning common (and occasional oscillatory-normal zoning); come carbonate alteration in calcic cores and along fractures; most calcic composition may be $An_{46.5}$ (andesine); typical grain size = 0.1-2.0 mm (long dimension), maximum size = 4.4 mm

Carbonate (Calcite + some possible Dolomite): 7%; four modes of occurrence: 1) alteration of mafic phenocrysts and microphenocrysts, forming pseudomorphs after, and minor alteration on rims of, hypersthene, 2) alteration of larger plagioclase phenocrysts, particularly in calcic cores and along fractures, 3) small disseminated patches and pseudomorphs throughout felsitic groundmass material, and 4) along microfractures ± iron oxide; calcite and possibly some dolomite indicated by acid reaction of section slab

Green Clinoamphibole (probable Hornblende + possible Uralite): 3%; small phenocrysts and microphenocrysts with associated carbonate alteration and occasional remanent pyroxene; biaxial(-), small or small-moderate 2V angles with dispersions of strong r>v and moderate v>r, respectively; inclined extinction; also with carbonate in possible pseudomorphs after pyroxene; typical grain size = 0.1-0.3 mm (long dimension)

Clinopyroxene (probable var. Augite): 3%; phenocrysts and microphenocrysts; sometimes prismatic; occasional twinning; biaxial(+), r>v dispersion; commonly altered to carbonate along rims and fractures; strong carbonate alteration of some microphenocrysts; typical grain size = 0.15-0.8 mm (long dimension)

Opaques + minor Iron Oxide: 2%; opaques partly oxidized (mainly to hematite); extremely fine disseminations or dusting throughout groundmass; scattered microphenocryst-sized grains; opaque grains are octahedral and cubic, subhedral, often rounded, and sometimes anhedral or embayed; one large opaque pseudomorph after amphibole; rare concentrations in biotite microphenocrysts; bimodal grain sizes: extremely fine grains up to 2.5 microns in size, larger grains 0.02-0.20 mm in dia.; sparse dark orange iron oxide ± carbonate along hairline fractures; magnetite indicated by magnetic response of hand specimen

Biotite: 1%; dark brown; mainly phenocrysts, alone and in glomerocrysts with plagioclase; rarely bleached to lighter orange-brown

Quartz Phenocrysts: 0.4-0.5%; two local phenocrysts; embayed or angular; fractured

Orthopyroxene (var. Hypersthene): <0.25%; phenocrysts and microphenocrysts; euhedral; pale red-brown (and green) pleochroism; biaxial(-), moderate 2V angle, r>v dispersion

Dark Brown Hornblende: Minor (<0.25%); slender phenocrysts and smaller crystals with sparse plagioclase and pyroxene phenocrysts in a plagioclase-quartz groundmass within a large xenolith

Clinopyroxene (var. Pigeonite): Trace; phenocrysts; uniaxial or biaxial(+) with very small 2V angle; twinned; very pale green; attached to plagioclase phenocrysts in a glomerocryst

Apatite: Trace; small rounded stubby prismatic grains in groundmass

Microfracturing: Roughly half of the phenocrysts have significant microfracturing, which usually does not extend into the groundmass, but occasionally is more through-going. Almost never does a microfracture extend across the entire section. Sparse through-going fractures are frequently "healed" with iron oxide and/or carbonate. Overall rock integrity is good and the hand specimen is solid and hard.

(continued)

Fabric: There is a subtle statistical alignment of plagioclase phenocrysts. Overall, grain alignment is not a very significant feature. Total phenocryst content is 28%, and plagioclase phenocrysts constitute 21% of the section.

Summary

This rock is classified as an andesite porphyry based upon a combination of the IUGS modal and chemical (total alkali-silica) classification systems. The total phenocryst content is 28%, and the color index is 16. The dominant material is an indistinct felsitic groundmass of probable plagioclase and some quartz clouded by a dense dusting of partly oxidized opaque grains. Plagioclase phenocrysts and microphenocrysts (21%) are set in the groundmass. Carbonate (7%), which includes calcite and some possible dolomite, is the dominant alteration mineral. There are small amounts of green clinoamphibole (3%, probable hornblende and possible uralite), clinopyroxene (3%, probable augite), opaques + minor iron oxide (2%), biotite (1%), and phenocrysts of quartz (0.4-0.5%). Also found in very minor to rare amounts are orthopyroxene (hypersthene), dark brown hornblende, clinopyroxene (pigeonite), and apatite.

The microfracturing is minor, but overall rock integrity is good and the hand specimen is solid and hard. There is also a fabric of subtle statistical alignment of plagioclase phenocrysts, but it is not significant.

Petrographers: Victoria S. Fuchs
William A. Fuchs

NN-8C/S1 **Thin Section Description**

Rock Classification (IUGS): Porphyritic Leucobasalt

Alteration: Total alteration <1%; minor-moderate alteration of olivine to iddingsite

Hand Specimen: Dull, medium-hard, gray, massive volcanic rock, slightly vesicular; glassy granular appearance; very sparse narrow elongate colorless plagioclase laths (phenocrysts); light red-brown iron oxide lining and filling vesicles; moderate to strong magnetism; no reaction to dilute hydrochloric acid

Silica Analysis: 22.6% Si (48.4% SiO_2)

Thin Section (half K-stained):

Plagioclase: 84% (incuding 7%? phenocrysts); euhedral to subhedral twinned laths exhibiting crude, erratic alignment; a few phenocrysts are anhedral; some phenocrysts exhibit normal-progressive (or occasional normal step zoning or oscillatory zoning); a few phenocrysts have cores with cellular structure; common grain size in groundmass = 0.06-0.40 mm (long dimension), phenocryst size = 0.4-2.0 mm

Opaques: 8%; cubic and lesser octahedral forms, euhedral to subhedral; largely occurs as intergranular intergrowths in plagioclase-rich groundmass; some concentrations in olivine; also fills very small gaps produced by cellular structure in a few plagioclase phenocrysts; common grain diameter = 0.04-0.10 mm; magnetite indicated by magnetic response of hand specimen

Olivine: 5%?; subhedral to euhedral, occasionally rounded; typically fractured; groundmass constituent; intergranular and rare subophitic grains; minor microphenocrysts; biaxial(+) and (-), very large 2V angle, r>v dispersion when the optic sign is negative; commonly exhibits minor alteration to orange-red iddingsite on rims and fractures, with very subordinate grains exhibiting strong or complete alteration; typical grain size <0.40 mm (long dimension), maximum size = 0.64 mm

Clinopyroxene: 1-2%?; intergranular in groundmass; unaltered; prismatic-subhedral, and rounded; brown and lesser green tint; biaxial(+), v>r dispersion; rarely twinned; common grain size = 0.025-0.06 mm (long dimension)

Iddingsite: 0.5%?; orange-red alteration of olivine

Apatite: <1%; acicular; usually forms inclusions in plagioclase

Page 2, NN-8C/S1 Thin Section Description

Microfracturing: There is a slight fracturing of the plagioclase phenocrysts, but this fracturing does not carry through into the groundmass. In hand specimen, the rock is hard and has good integrity.

Fabric: There appears to be a statistical preferred orientation of the sparse (7%) plagioclase phenocrysts; likewise, plagioclase laths in the groundmass exhibit a crude, erratic alignment. In hand specimen (when viewed in the right light on an uncut surface) there is a distinct preferred grain orientation or fabric. Vesicles (about 2% of the section) exhibit a slight flattening concordant with the observed fabric.

Summary

This volcanic rock is classified as a porphyritic leucobasalt on the basis of mineralogy and chemically determined silica content, using both the IUGS modal classification and a portion of the TAS (total alkali-silica) chemical classification for volcanic rocks; the color index is about 16, which is low for a basalt and, hence, the "leuco" designation by IUGS standards. Furthermore, phenocrysts of plagioclase and minor olivine constitute about 7% of the section (As the phenocryst content is below 12%, the rock has a "pophyritic" rather than a "porphyry" designation.). The sample is composed of plagioclase (84%) and very subordinate opaques (8%, probably largely magnetite), olivine (5%?), clinopyroxene (1-2%?), iddingsite (0.5%), and accessory apatite (<1%). The rock displays seriate texture. Plagioclase laths themselves are variably oriented, exhibiting only crude, erratic alignment (more on this below). The mafic minerals occur as intergranular intergrowths in plagioclase.

The only alteration evident is some alteration of olivine to iddingsite, which is minor overall but strong in some olivine grains. Total alteration is less than 1%, making this a very fresh rock.

There appears to be a statistical preferred orientation of the sparse phenocrysts conforming to the crude erratic alignment of plagioclase in the groundmass. This fabric is noticeable in the hand specimen (when viewed in the right light). Vesicles, which constitute about 2% of the rock, exhibit a slight flattening that is concordant with the observed rock fabric. In addition, there is slight fracturing of the plagioclase phenocrysts, but this fracturing does not carry through into the groundmass.

Petrographers: Victoria S. Fuchs
William A. Fuchs

NN-8D/S1 **Thin Section Description**

Rock Classification (IUGS): Leucobasalt Porphyry

Alteration: 2.5-3% total alteration; minor calcite vesicle filling; moderate iddingsite alteration of olivine; minor opaline silica in vesicles

Hand Specimen: Medium-dark gray massive porphyritic volcanic rock; some very small vesicles (± leached/weathered phenocrysts?); moderate-strong magnetism; minor calcite in amygdules and local (larger) round/spherical amygdules

Silica Analysis: 21.5% Si (46.0% SiO_2)

Thin Section (half K-stained):

Plagioclase: 80% (includes 17% as phenocrysts); subhedral to euhedral laths and crystals, except for a few anhedral phenocrysts; twinned; some normal-progressive and oscillatory compositional zoning, and occasional (normal) step zoning; unaltered; crude alignment of phenocrysts and smaller laths; grain sizes in groundmass commonly 0.06-0.4 mm (long dimension), phenocrysts commonly 0.4-2.4 mm, maximum size = 3.72 mm

Opaques: 9%?; cubic and very subordinate octahedral grains in groundmass, commonly 0.010-0.015 mm in dia., and larger sparsely disseminated grains 0.12-0.28 mm in dia.; magnetite indicated by magnetic response of hand specimen

Olivine: 5%? (including 1% as microphenocrysts); subhedral; often fractured; some compositional zoning; variable alteration to iddingsite; grain sizes generally up to 0.4 mm (long dimension), maximum size = 1.60 mm

Clinopyroxene: 3%?; in groundmass; prismatic-subhedral; grain sizes commonly in the 0.025-0.050 mm range (long dimension)

Calcite: 1.5%; anhedral; in amygdules; porous where vesicles only partly filled; calcite indicated by acid reaction of hand specimen; occasional intersertal carbonate in groundmass

Iddingsite: 1%?; orange-brown alteration product of olivine, particularly along fractures and rims; some preferential alteration of inner zones

Opaline Silica: Minor (much less than 0.25%); occasionally lines vesicles or pores; very light brown/tan color; slightly botryoidal; negative relief agains epoxy; weak birefringence

(continued)

Microfracturing: Most phenocrysts have mild-moderate fracturing without noticeable dislocation, but only rarely does this fracturing extend into the groundmass, and it never traverses the entire section. In hand specimen, the rock is hard and has good integrity.

Fabric: There is a crude alignment of plagioclase laths in both the phenocrysts and groundmass. This is evident in hand specimen as well. Vesicles generally less than one mm in size comprise about 1% of the thin section. Plagioclase phenocrysts total 17% , and olivine phenocrysts, another 1%.

Summary

This slightly amygdaloidal/vesicular volcanic rock is classified as a leucobasalt porphyry utilizing both the modal and chemical IUGS classifications for volcanic rocks. The color index is 18. The rock is composed largely of plagioclase (80%) along with subordinate opaques (9%?, mainly magnetite), olivine (5%?), clinopyroxene (3%?), calcite (1.5%), iddingsite (1%?), and minor (<0.25%) opaline silica. Phenocrysts, comprising about 18% of the section, consist of plagioclase and minor olivine. The groundmass consists largely of twinned plagioclase laths accompanied by lesser extremely fine-grained opaques (magnetite) and clinopyroxene, as well as olivine.

The secondary or alteration phases, namely calcite, iddingsite, and opaline silica, constitute 2.5-3% of the section (by volume). Olivine exhibits varying degrees of alteration to iddingsite. Calcite forms amygdules and partial vesicle filling, and opaline silica occasionally lines vesicles.

Most plagioclase phenocrysts have mild-moderate fracturing without noticeable dislocation, but only rarely does this fracturing extend into the groundmass, and it never traverses the entire section. In hand specimen, the rock is hard and has good integrity. There is a crude alignment of plagioclase laths, both phenocrysts and groundmass. This is evident in hand specimen as well. Vesicles constitute about 1% of the section and are generally under one mm in size.

Petrographers: Victoria S. Fuchs
William A. Fuchs

NN-9A/S1 **Thin Section Description**

Rock Classification (IUGS): Porphyritic Leucobasalt

Alteration: Total alteration <0.5%; minor calcite vesicle filling; minor iddingsite alteration of olivine; possible very minor iron oxidation

Hand Specimen: Medium gray (with white dusting) volcanic rock with scattered, variably oriented and sized, colorless plagioclase laths; very dark brown desert varnish (and minor orange iron oxide) on weathered surfaces; weak-moderate magnetism; minor/moderate? calcite alteration (disseminated pattern), probably mainly of small phenocrysts (or vesicles?), may be sporadic

Silica Analysis: 22.4% Si (47.9% SiO_2)

Thin Section (half K-stained):

Plagioclase: 75% (including 10-12%? as phenocrysts); subhedral laths, twinned; normal-progressive zoning common; occasional cellular texture in phenocrysts; general subparallel alignment of coarser plagioclase in groundmass and plagioclase phenocrysts; occasional microfractures (in phenocrysts) contain carbonate or clay; phenocrysts ≥1.2 mm long (up to 6.4 mm); groundmass bimodal, with grain sizes commonly 0.24-1.0 mm (long dimension), and a subordinate population of grains under 0.20 mm in size

Clinopyroxene (var. Titanaugite): 10%; intergranular in plagioclase-rich groundmass; brownish-purple and lesser light green tints; subhedral to anhedral; rare classic (and somewhat diagnostic) "hourglass" zoning; one anhedral cellular-textured phenocryst; biaxial(+), smaller moderate 2V angle, r>v dispersion; typical grain size = 0.04-0.40 mm (long dimension)

Olivine: 8%; anhedral and sometimes subhedral with characteristic fracturing; often rounded; biaxial(-), r>v dispersion, very large 2V angle (almost 90°); typical grain size = 0.12-0.40 mm (long dimension), with a smaller population of grains under 0.12 mm

Opaques: 5% (<0.5% as phenocrysts); mostly cubic and less commonly octahedral; possible very minor alteration to iron oxide; mainly a groundmass constituent associated with clinopyroxene and olivine; rare phenocrysts; typical grain dia. = 0.06-0.10 mm, generally under 0.2 mm; includes magnetite, as indicated by magnetic response of hand specimen

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Alkali Feldspar: <1%?; anhedral; very small intergranular intergrowths in groundmass, and narrow partial mantles on plagioclase (phenocrysts); biaxial(-), small to moderate 2V angle; occasional very poor K stain; low birefringence

Apatite: 0.5%; acicular-prismatic; colorless to very pale green; randomly oriented; in plagioclase and sometimes penetrating(?) clinopyroxene

Iddingsite: ≤0.25%; orange-brown alteration product of olivine, particularly along fractures

Carbonate (mainly Calcite): <0.25%; occasional intersertal material and partial vesicle filling in groundmass; minor in intracrystalline microfractures and in some very short intercrystalline microfractures, in plagioclase; in leached core and adjacent microfractures in one plagioclase phenocryst; commonly very light brown or tan in color; rare concentric banding (in vesicles); calcite composition indicated by acid reaction of hand specimen

Clay: Minor (<0.25%); colorless to very light brown; found in sparse intracrystalline and intercrystalline microfractures in plagioclase

Microfracturing: Sparse intracrystalline and short intercrystalline microfractures occur in plagioclase; some microfractures contain carbonate or clay.

Fabric: Plagioclase phenocrysts and coarser plagioclase in the groundmass exhibit a subparallel alignment. Vesicles (and possible dissolution pores) comprise 1-2% of the section.

Summary

This volcanic rock is classified as a porphyritic leucobasalt on the basis of mineralogy and silica content using the IUGS modal and chemical (total alkali-silica) classifications for volcanic rocks. The color index is 24. The sample consists of plagioclase (75%) and subordinate titanaugite (10%), olivine (8%), and opaques (5%), and minor amounts of alkali feldspar (<1%), accessory apatite (0.5%), iddingsite (≤0.25%), calcite (<0.25%), and clay (<0.25%). Phenocrysts, which comprise 10-12% of the section, consist mainly of plagioclase, except for rare olivine.

Plagioclase phenocrysts and coarser plagioclase in the groundmass exhibit a subparallel alignment. Titanaugite and olivine (and associated opaque grains) form intergranular anhedral and subhedral grains in the plagioclase-rich groundmass. Alkali feldspar forms occasional interstitial intergrowths in

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plagioclase and partial mantles on plagioclase. Very fine acicular apatite occurs as inclusions in plagioclase. Vesicles or pore spaces not filled by calcite constitute 1-2% of the section.

Secondary minerals are minor (<0.5%). Iddingsite is an alteration product of olivine. Calcite fills (or partly fills) vesicles. Sporadic calcite and clay separately occur in discontinuous or intracrystalline microfractures primarily in plagioclase. Very minor oxidation of opaque grains may have occurred.

Petrographers: Victoria S. Fuchs
William A. Fuchs

NN-9B/S1 **Thin Section Description**

Rock Classification (IUGS): Leucobasalt

Alteration: Total alteration <0.5%; minor iddingsite alteration of olivine; very minor calcite in vesicles; possible very minor iron oxidation of opaques

Hand Specimen: Light-medium gray, slightly porphyritic volcanic rock with variably oriented plagioclase laths in a plagioclase-rich groundmass; very dark brown desert varnish on weathered surface; somewhat weak magnetism in larger rock and moderate magnetism in smaller rock; possible trace of calcite; very fine disseminated black grains in groundmass observed under a hand lens

Silica Analysis: 21.9% Si (46.9% SiO_2)

Thin Section (half K-stained):

Plagioclase: 85% (including about 2% as phenocrysts); general crude subparallel alignment of plagioclase laths (including some phenocrysts); commonly subhedral and twinned, with very subordinate interstitial anhedral grains in groundmass; some normal-progressive and occasional oscillatory compositional zoning; a few laths have sodic rims; occasional cellular texture in phenocrysts; plagioclase grains in groundmass generally in the 0.4-1.20 mm size range (long dimension), with a subordinate population under 0.2 mm in size; phenocrysts, 1.6-5.4 mm long, are subhedral to euhedral

Olivine: 5%; mainly a groundmass constituent; anhedral (sometimes rounded), subhedral, and occasionally euhedral; typically fractured; typical grain size = 0.1-0.40 mm (long dimension) except for a few larger grains up to 1.2 mm in length

Clinopyroxene (var. Titanaugite): 5%; groundmass constituent; often prismatic-subhedral, but sometimes anhedral; purplish brown tint; biaxial(+), smaller moderate 2V angle, distinct r>v dispersion; rare "hourglass" zoning; grain sizes commonly in the 0.06-0.24 mm size range (long dimension), generally ≤0.40 mm

Opaques: 4%?; groundmass constituent associated with clinopyroxene and olivine; subhedral-cubic and less common octahedral grains and small aggregates; rare larger aggregates up to 0.60 mm (long dimension); grain sizes commonly 0.04-0.12 mm in diameter; possible occasional incipient iron oxidation (on grain rims); includes magnetite, as indicated by magnetic response of hand specimen

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Apatite: 0.25%; very narrow acicular grains or inclusions in plagioclase; sometimes has a light green tint

Iddingsite: <0.25%; minor occasional alteration product of olivine, particularly along fractures; orange-brown

Carbonate (possible Calcite): <0.25%; sparse in small vesicles; calcite composition suggested by acid reaction of hand specimen

Microfracturing: Most plagioclase phenocrysts (and some slightly smaller plagioclase laths) exhibit some degree of intracrystalline fracturing; occasionally the microfractures extend slightly into adjacent plagioclase grains.

Fabric: Plagioclase laths (including some phenocrysts) display a crude subparallel alignment. Vesicles and other pore spaces comprise 1.5-2% of the section and are relatively small (i.e., up to 1.2 mm in size).

Summary

This slightly porphyritic volcanic rock is classified as a leucobasalt utilizing a combination of the IUGS modal and chemical (total alkali-silica) classification systems for volcanic rocks. The color index is 14. The sample is composed largely of plagioclase (85%), along with subordinate olivine (5%), clinopyroxene (5%, variety titanaugite), and opaques (4%?). Minor accessory apatite (0.25%), iddingsite (<0.25%), and carbonate (possible calcite, <0.25%) are also present. The bulk of the plagioclase is distinctly coarser grained than either clinopyroxene or olivine. Plagioclase phenocrysts make up 2% of the section; most of these phenocrysts have undergone some intracrystalline fracturing

Both plagioclase laths in the groundmass and plagioclase phenocrysts exhibit a crude subparallel alignment. Vesicles or pore spaces, which are relatively small (the largest being 1.2 mm in dia.), constitute 1.5-2% of the rock in this section.

Alteration phases together comprise less than 0.5% of the section. Carbonate is found in some small vesicles. Iddingsite is a minor alteration product of loivine. Some opaque grains may have undergone very minor iron oxidation.

Petrographers: Victoria S. Fuchs
William A. Fuchs

NS-3A/S1 **Thin Section Description**

Rock Classification (IUGS): Basaltic Andesite

Alteration: 3% total alteration; minor calcite in amygdules; minor-moderate iddingsite alteration of olivine; very minor iron oxidation

Hand Specimen: Medium gray, massive, slightly vesicular volcanic rock (intermediate composition) with scattered small plagioclase crystals and laths; orange and brown iron oxide coating on fracture surface; moderate to weak magnetism; minor sporadic calcite in very small vesicles

Silica Analysis: 24.4% Si (52.2% SiO_2)

Thin Section (half K-stained):

Plagioclase: 87% (including 1-2% phenocrysts); commonly forms subhedral laths, occasionally euhedral; twinned; some normal-progressive zoning; occasional narrow sodic rims; cellular texture common in cores of phenocrysts; overall crude subparallel alignment of groundmass plagioclase; typical grain size in groundmass = 0.05-0.60 mm (long dimension); phenocrysts (subhedral to almost anhedral) 0.6-1.60 mm long, maximum length = 4.4 mm; the largest phenocryst has cellular texture and is porous except for some calcite pore filling

Clinopyroxene (probable var. Augite): 4% (including <0.25% phenocrysts); groundmass constituent except for one phenocryst (1.2 mm long); light olive-green and brown color; often rounded and equant or subequant; less commonly subhedral-prismatic, rarely euhedral; concentric and hourglass zoning common; occasional simple twinning; biaxial(+), moderate 2V angle, strong r>v dispersion; grain sizes similar to those of olivine

Opaques: 3%; cubic (euhedral to subhedral), occasionally octahedral; small grains and aggregates; grain diameters commonly 0.04-0.08 mm (and down to 0.01 mm); very minor iron oxidation in places; includes magnetite, as indicated by magnetic response of hand specimen

Olivine: 2.5%; groundmass constituent; subhedral to anhedral and occasionally euhedral; larger grains commonly fractured; biaxial(-), very large 2V angle, r>v dispersion; minor to moderate iddingsite alteration common in larger grains, somewhat stronger alteration in finer grained fraction; bimodal grain sizes: 0.2-0.4 mm and 0.025-0.10 mm (long dimension)

Calcite: 2.5%; forms amygdules, the largest being 0.6-2.8 mm in dia. or length; calcite indicated by acid reaction of hand specimen

Iddingsite: 0.25%; alteration product of olivine; minor to moderate alteration of larger olivine crystals; alteration somewhat stronger in finer grained fraction

Iron Oxide: Trace; very minor oxidation product of opaque grains

Microfracturing: Intracrystalline fracturing in groundmass plagioclase is sporadic, and occasionally the fracturing extends to immediately adjacent plagioclase grains; plagioclase phenocrysts (laths) also exhibit some intracrystalline fracturing.

Fabric: Plagioclase laths display only a crude subparallel alignment. Vesicles (and other open spaces) comprise about 3% of the thin section, and calcite amygdules, another 2.5%. Plagioclase phenocrysts constitute 1-2% of the section.

Summary

This volcanic rock is classified as a basaltic andesite on the basis of the silica analysis, using the IUGS chemical (total alkali-silica) classification for volcanic rocks and the compatibility of the modal analysis. The sample consists of plagioclase (87%), clinopyroxene (4%), opaques (3%), olivine (2.5%), calcite (2.5%), iddingsite (0.25%), and traces of iron oxide. Phenocrysts (mainly plagioclase) comprise 1-2% of the section. The color index is 10.

Plagioclase laths exhibit a crude subparallel alignment overall. Vesicles (and other open spaces) constitute about 3% of the section. Some pore spaces may be the result of leaching or weathering. Calcite (2.5%) forms scattered amygdules (calcite-filled vesicles).

Secondary minerals comprise no more than 3% of the section, including calcite amygdules (2.5%). Alteration is limited to minor-moderate alteration of olivine to iddingsite and very minor oxidation of opaque grains.

Petrographers: Victoria S. Fuchs
William A. Fuchs

NS-3B/S1 **Thin Section Description**

Rock Classification (IUGS): Leucobasalt

Alteration: 8% total alteration; strong alteration of olivine to iddingsite; minor carbonate and clay alteration (of plagioclase); minor calcite amygdules

Hand Specimen: Massive medium gray volcanic rock (intermediate composition); sparse minute plagioclase crystals; very dark brown desert varnish on weathered surface; red-orange-brown iron oxide rimmed by desert varnish on fracture surface; weak to moderate magnetism; rare calcite in vesicles

Silica Analysis: 22.5% Si (48.1% SiO_2)

Thin Section (half K-stained):

Plagioclase: 73% (including 0.5-1% phenocrysts); subhedral twinned laths in subparallel alignment throughout the section, resulting in trachytic texture; occasional moderate to strong carbonate alteration of individual laths (larger grains and phenocrysts), particularly in more calcic cores; also some minor to moderate carbonate and clay alteration along intracrystalline microfractures; occasional cellular texture in phenocrysts, controlling carbonate alteration in those instances; common grain size = 0.025-0.20 mm (long dimension), phenocrysts 0.4-0.52 mm in length

Clinopyroxene (probable var. Augite or Titanaugite): 12%; groundmass constituent; subhedral to euhedral, prismatic; grain orientation conforms to plagioclase crystal alignment; brownish tint and minor to rare green or purplish brown tint; rare zoning, including characteristic hourglass zoning; biaxial(+), moderate 2V angle (ranging from smaller to larger moderate angles), moderate to strong r>v dispersion; grain sizes commonly 0.01-0.05 mm (long dimension), sparse larger grains 0.24-0.40 mm in size

Iddingsite: 7%?; groundmass constituent; alteration product of olivine, usually forming euhedral to anhedral (commonly subhedral, occasionally prismatic) pseudomorphs after olivine; red-orange(-yellow) color; occasionally forms alteration rims on incompletely altered olivine grains; pseudomorphs commonly 0.02-0.10 mm in size (long dimension), rare altered phenocrysts 0.52-0.60 mm in size

Opaques: 5-6%; fairly evenly distributed in the groundmass; usually cubic and less commonly octahedral (and rare elongate-rectangular grains), euhedral to subhedral; grain dia. commonly 0.005-0.025 mm, up to 0.05 mm, and some small aggregates up to 0.075 mm in size (long dimension); includes magnetite, as indicated by magnetic response of hand specimen

Carbonate: 1%; calcite (identified by acid reaction of hand specimen) in sparse amygdules; occasional moderate-strong carbonate alteration of individual plagioclase grains (particularly the cores); scattered minor-moderate alteration of plagioclase along intracrystalline fractures; occasional intersertal intergrowths in groundmass; some association with biotite

Olivine: <1%; groundmass constituent; remanent cores rimmed by iddingsite in a few incompletely altered grains

Biotite (possible var. Phlogopite): 0.25%; sporadic intergranular material in groundmass; subhedral to anhedral; usually associated with calcite; brownish orange and lighter orange pleochroism

Clay: Minor (<0.25%); extremely fine-grained; light red-brown and very light brown colors; intersertal in groundmass; occasional alteration along microfractures in larger plagioclase grains and phenocrsyts; length-slow

K-Feldspar: Trace; rare subhedral crystals in, and on the edges of, local calcite amygdules; biaxial(-), small 2V angle

Orthopyroxene (probable var. Hypersthene): Trace; two subhedral-prismatic grains (up to 0.22 mm long) in calcite; very pale brown and green color; parallel extinction, length-slow; biaxial(-), moderate 2V angle, r>v dispersion

Microfracturing: Plagioclase phenocrysts and larger laths in the groundmass tend to be slightly to moderately fractured. This fracturing is restricted to individual plagioclase grains and is often the focus of either carbonate or clay alteration.

Fabric: The rock is marked by trachytic texture resulting from the subparallel alignment of plagioclase laths and (much smaller) prismatic clinopyroxene grains. Phenocrysts of plagioclase and (rare) clinopyroxene comprise 0.5-1% of the section.

Summary

This volcanic rock is classified as a leucobasalt utilizing the IUGS modal and chemical (total alkali-silica) classification systems for volcanic rocks; the silica analysis was used for the chemical classification. The sample consists of major plagioclase (73%) and very subordinate clinopyroxene (12%), iddingsite (7%?), and opaques (5-6%), along with minor carbonate (1%), olivine (<1%), biotite (0.25%),

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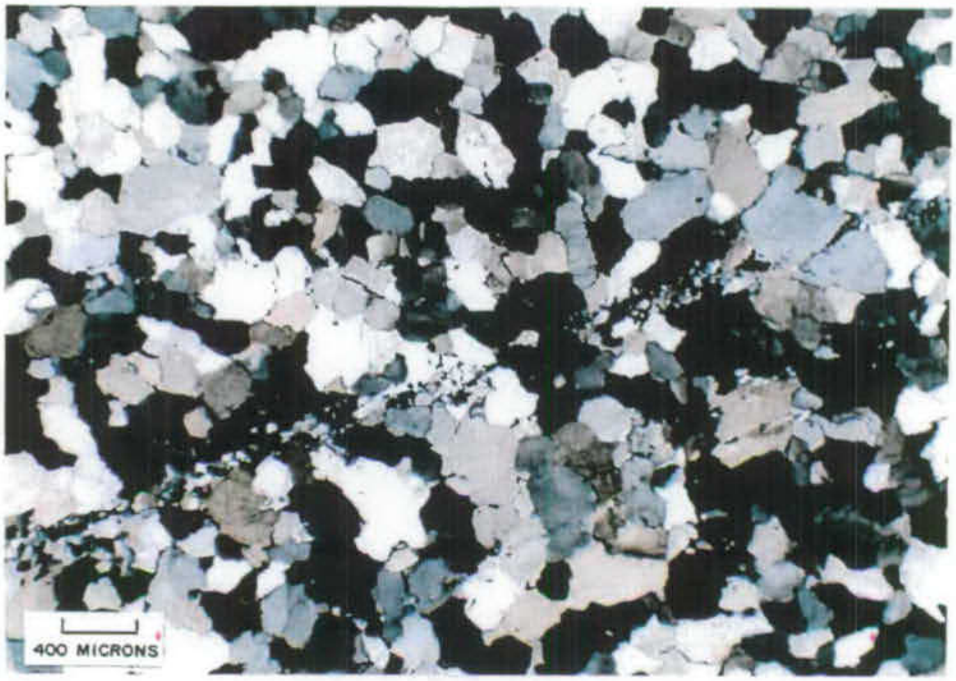
and clay (<0.25%); trace amounts of K-feldspar and orthopyroxene are also present. The rock is characterized by trachytic texture as a result of subparallel alignment of plagioclase and clinopyroxene grains. Phenocrysts (mainly plagioclase) constitute 0.5-1% of the section. The color index is about 25.

Alteration minerals total 8%. Most of the olivine has been altered to iddingsite. Calcite forms sparse amygdules. Carbonate and (lesser) clay are minor alteration products of plagioclase. Clay alteration and some of the carbonate alteration are controlled by microfractures in larger plagioclase grains and phenocrysts.

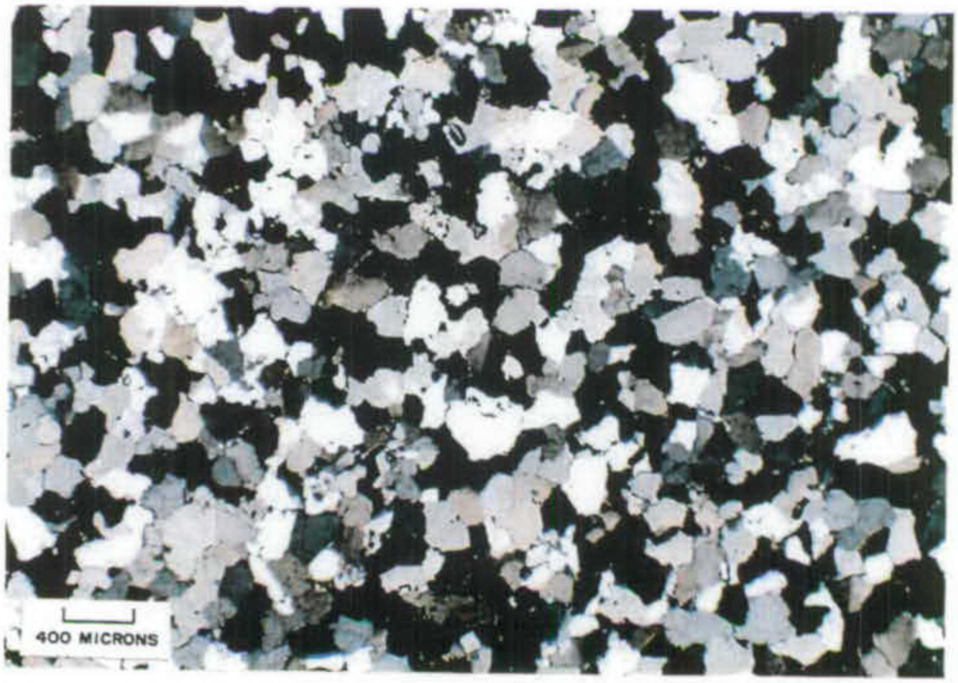
Petrographers: Victoria S. Fuchs
William A. Fuchs

PHOTOMICROGRAPHS



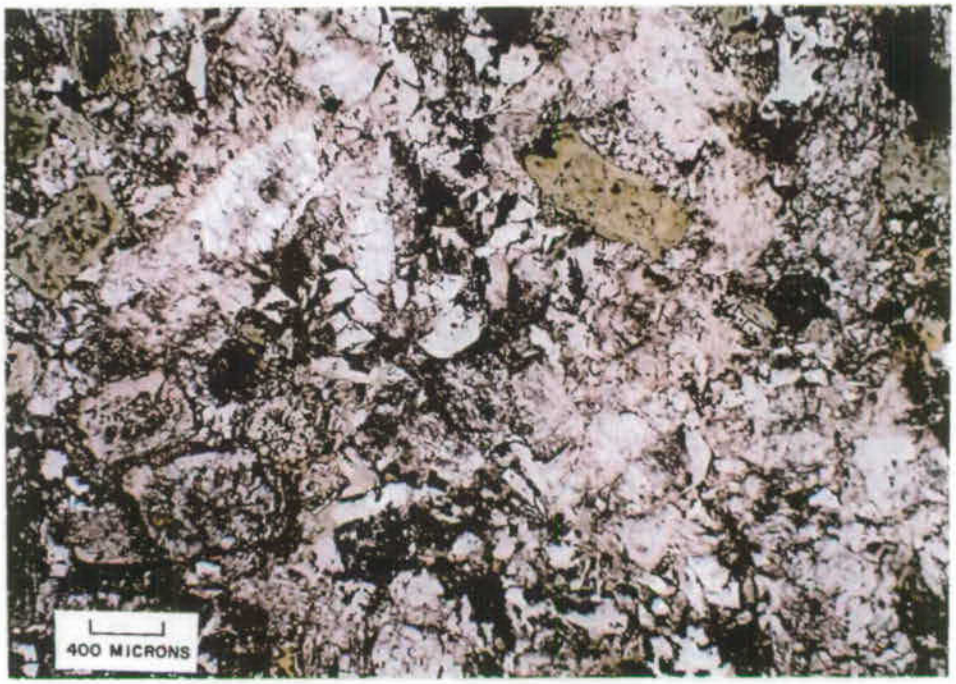
CA-8A/S-1 24x magnification (cross polarized light)

Quartzite



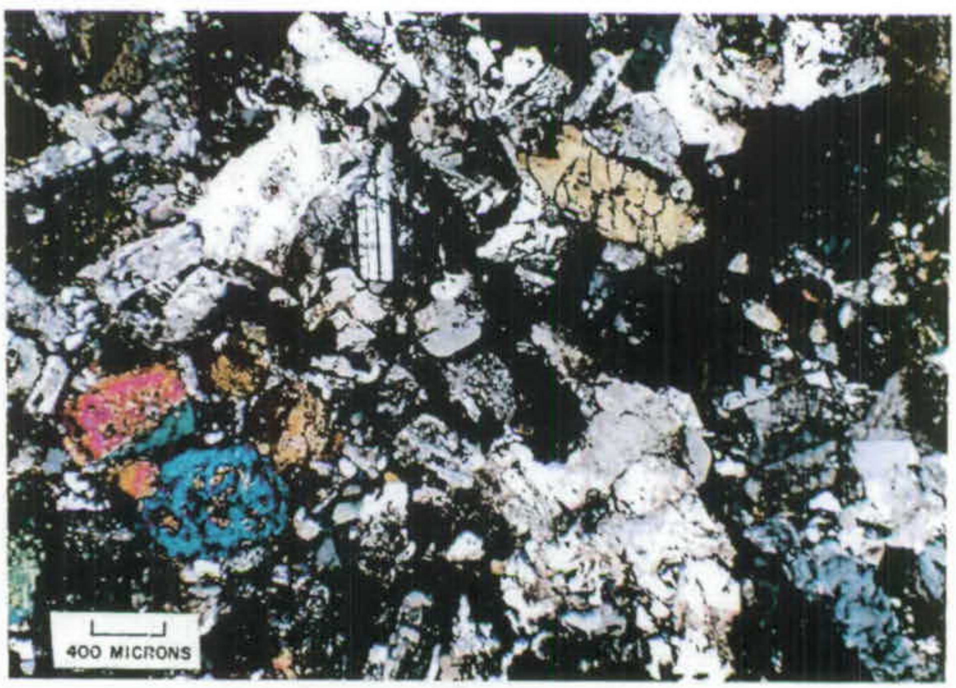
CA-8A/S-2 24x magnification (cross polarized light)

Quartzite



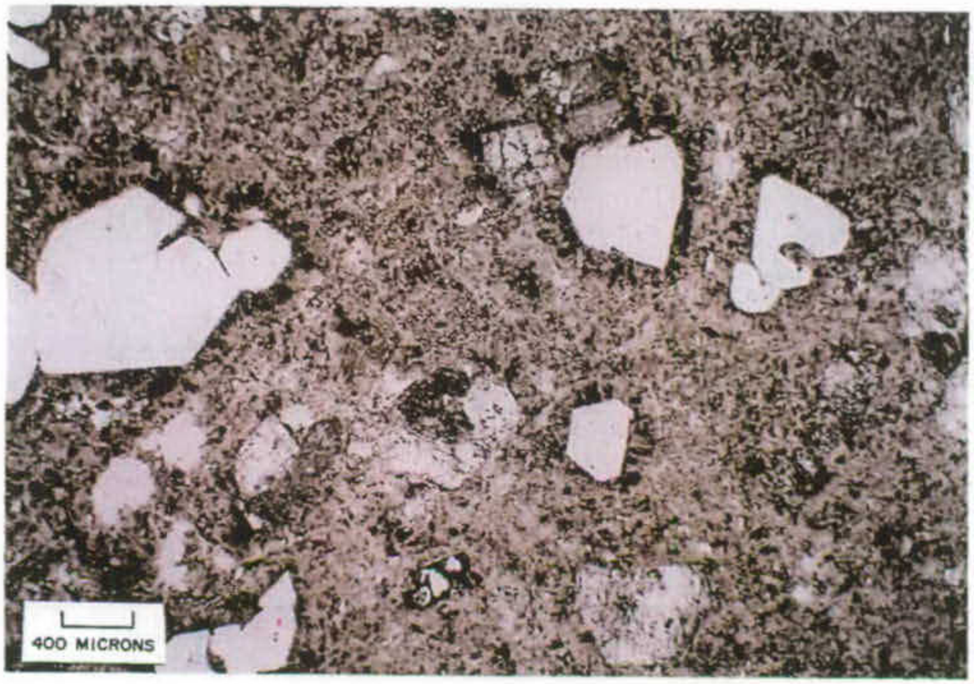
CA-8B/S-1   24x magnification (plane polarized light)

Quartz Monzonite



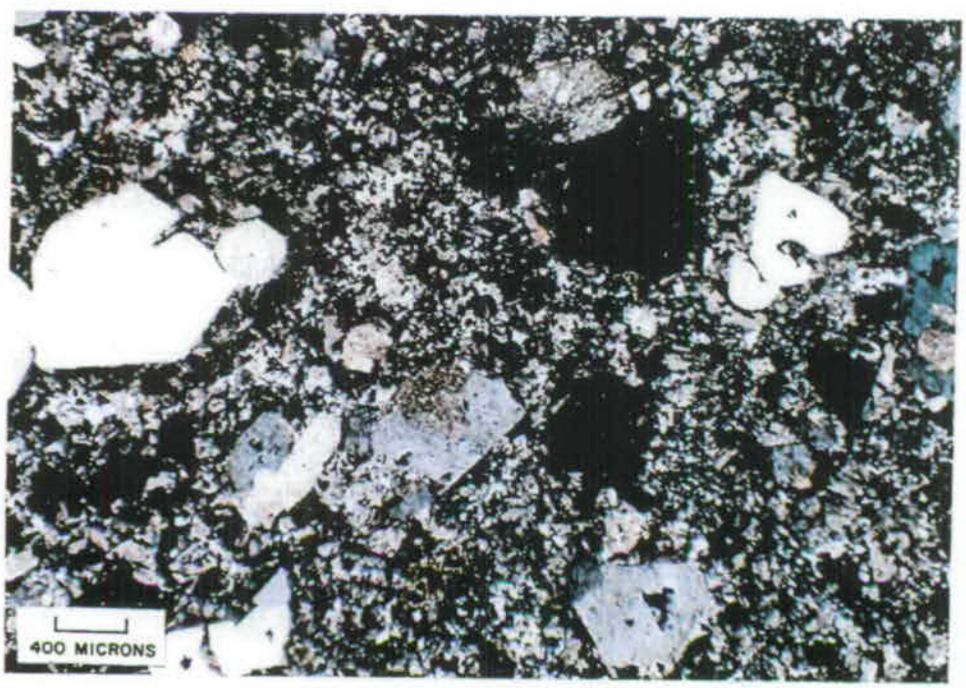
CA-8B/S-1   24x magnification (cross polarized light)

Quartz Monzonite



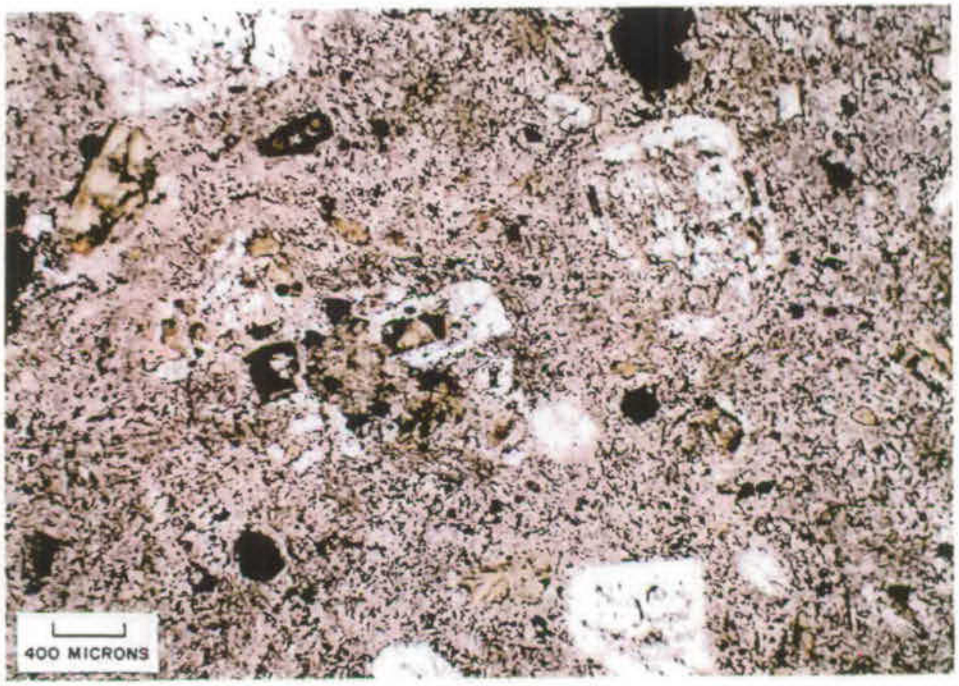
CA-11/S-1 24x magnification (plane polarized light)

Rhyolite Porphyry



CA-11/S-1 24x magnification (cross polarized light)

Rhyolite Porphyry



NN-8B/S-1 24x magnification (plane polarized light)

Andesite Porphyry

NN-8B/S-1 24x magnification (cross polarized light)

Andesite Porphyry

PETROGRAPHY OF FIVE ROCK SAMPLES, CALIENTE RAIL CORRIDOR, YUCCA MOUNTAIN PROJECT

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SAMPLE LIST

CA-8A/S-1	Quartzite
CA-8A/S-2	Quartzite
CA-8B/S-1	Quartz Monzonite
CA-11/S-1	Rhyolite Porphyry
NN-8B/S-1	Andesite Porphyry

CA-8A/S-1 **Thin Section Description**

Rock Classification: Quartzite

Alteration: Diagenetic quartz cementation (unquantifiable); minor (≤1%) quartz microveining; iron oxidation

Hand Specimen: Slightly lavender-tinted, white, massive, hard, very clean quartzite (metaquartzite?); some fractures; no reaction to dilute hydrochloric acid; nonmagnetic

Silica Analysis: 45.7% Si (97.8% SiO_2)

Thin Section (half K-stained):

Quartz (wall rock): 98%; original detrital framework grains (some preserved rounded rims) with very subordinate quartz cement (up to 2%, or perhaps more) as syntaxial quartz overgrowths; forms alternating layers of coarser and finer quartz grains; ubiquitous undulatory extinction; subgrain development common; occasional deformation lamellae (varying orientations); secondary (liquid-vapor) fluid inclusions (and some minute opaque inclusions) common along incipient or healed fractures; sporadic sutured grain boundaries; grain sizes typically 0.24-1.20 mm (long dimension), maximum size = 1.60 mm; rare interstitial open pores

Quartz Microveins: ≤1%; sparse discontinuous microveins (or quartz-healed fractures) 0.02-0.32 mm wide at moderate to high angles to layering or bedding in wall rock, and rarely intersecting one another; some internal brecciation and possible shearing

Lithic Fragments: ≤0.25%; metachert/metaquartzite fragments; well-rounded, detrital; smaller than quartz framework grains; rarely foliated; one silicified(?) rock fragment (0.30 mm in size) of quartz and subordinate intergrown sericite

Sericite: <0.25%; located along quartz grain contacts; occasionally along contacts between quartz grains and syntaxial quartz overgrowths, and along intragranular microfractures in quartz; inclusions (with carbonate) in one quartz grain; rare (angular) sericitized framework grain; grain sizes 7.5-15 microns (long dimension)

Iron Oxide (mainly Hematite): <0.25% (more common in one part of the section, not ubiquitous); dark red, very fine-grained; occurs along intra- and intergranular microfractures, quartz grain contacts, and contacts between quartz grains and syntaxial quartz overgrowths; sometimes found with sericite; occasional small (equant) pseudomorphs after an opaque mineral

Alunite(?): <0.25%; cubic euhedral grains 5-15 microns in diameter, in open spaces along a through-going fracture; colorless; low birefringence; strong positive relief against quartz

Rutile: Minor (<0.25%); subhedral or elongate, anhedral-angular, and rarely prismatic; found at or near quartz grain contacts and quartz grain triple junctions; also forms inclusions in quartz; occasional rutilated quartz grains (with acicular rutile inclusions); found with leucoxene in one detrital grain; grain sizes 10-50 microns (long dimension); one large red-brown grain or aggregate 100 microns long (on quartz-quartz grain contact)

Carbonate: Very minor (well under 0.25%); very small to minute inclusions (≤25 microns, long dimension) in a few quartz grains; rare in intra-granular microfracture; generally anhedral

Opaques: Very minor/trace; euhedral to subhedral, cubic and occasionally octahedral?; rare inclusions in quartz grains; grain sizes 5-25 microns (long dimension)

Zircon: Very minor/trace; euhedral-prismatic and variably rounded grains or fragments in quartz; pale yellow or yellow-green color; grain sizes 20-70 microns (long dimension)

Leucoxene: Trace; brown, opaque; in one detrital grain (0.20 mm, long dimension) with subordinate rutile; rare elsewhere

Tourmaline?: Trace; rare rounded and euhedral, slightly colored inclusions (32.5 and 35 microns long) in quartz; rare blue-green pleochroism

Apatite(?): Trace; rounded 30-micron-long inclusion in quartz

Biotite: Trace; rare dark green and dark brown inclusions (30 and 35 microns long) in quartz

Kaolinitic Clay?: Trace; found with sericite in pockets or patches in one quartz grain

Unknown Accessory: Trace; pale yellow-green or pale pink color; anhedral, somewhat rounded inclusions in quartz; one grain biaxial(+), moderate 2V angle

Microfracturing: Sparse discontinuous quartz microveins or quartz-healed fractures (0.02-0.32 wide) cut layering or bedding at moderate to high angles and rarely intersect one another. Some internal brecciation and

(continued)

Microfracturing (continued):
possible shearing are apparent. There is also a later set of very narrow open fractures. The fracturing is apparent at the hand specimen scale. Intragranular incipient or healed microfractures are not uncommon in quartz; some contain concentrations of fluid inclusions, sericite, or iron oxide, and iron oxide occurs along some healed or incipient intergranular microfractures as well.

Fabric: There is a preserved layering or bedding defined by about four sorted layers of alternating coarser and finer grained quartz. Open pores in the wall rock itself are rare.

Summary

This rock is a quartzite composed of detrital quartz grains cemented by quartz in the form of syntaxial quartz overgrowths. Minor constituents include quartz microveins (≤1%), lithic fragments (≤0.25%, mainly metachert/metaquartzite), and lesser sericite, iron oxide (mainly hematite), alunite(?), rutile, carbonate, opaques, and zircon; trace amounts of leucoxene, tourmaline(?), apatite(?), biotite, and kaolinitic clay(?) are also present. Sericite and iron oxide tend to be concentrated along intragranular microfractures in quartz and along quartz grain contacts (and along contacts between quartz grains and quartz cement overgrowths); iron oxide is also found along intergranular microfractures. Most of the other minor phases occur as inclusions in quartz. Alunite(?) fills open spaces in one late(?) fracture.

The section exhibits preserved layering or bedding defined by alternating layers of coarser and finer grained quartz. This layering is cut at moderate to high angles by discontinuous quartz microveins or quartz-healed microfractures and a later set of very narrow open fractures.

Petrographers: Victoria S. Fuchs
William A. Fuchs

CA-8A/S-2 **Thin Section Description**

Rock Classification: Quartzite

Alteration: Diagenetic quartz cementation (unquantifiable); very minor iron oxidation

Hand Specimen: Three rocks; white to gray-white, massive, hard, very clean quartzite (metaquartzite?); minor fractures; no reaction to dilute hydrochloric acid; nonmagnetic

Silica Analysis: 44.6% Si (95.4% SiO_2)

Thin Section (half K-stained):

Quartz: 99%; anhedral; interlocking, quartz-cemented framework grains; visible syntaxial quartz overgrowths (cement) in places; some weak-moderate undulatory extinction; sporadic subgrain development; secondary fluid inclusions common along healed intragranular (and some intergranular) microfractures; typical grain sizes = 0.12-0.48 mm (long dimension), maximum size = 0.80 mm

Sericite: 0.5-1%; matrix constituent; almost ubiquitous along quartz grain boundaries and sparse intragranular microfractures; larger interstitial concentrations between quartz grains; occasionally occurs along contacts between quartz grains and syntaxial quartz overgrowths (cement); rare small pockets or sericitized inclusions in quartz; grain sizes ≤25 microns (long dimension)

Rutile +/- Leucoxene: <0.25%; anhedral, sometimes rounded; sporadic small grains and aggregates, often partly translucent or opaque and brown (leucoxene); rare sagenetic (acicular) rutile in individual quartz grains; sparse very small skeletal silicified grains with leucoxene rims; grain sizes ≤80 microns (long dimension)

Apatite? or Collophane: <0.25% (not uncommon); found with sericite; anhedral to subhedral; small grains and aggregates heavily clouded by small dark inclusions; isotropic or nearly isotropic; grain sizes generally ≤50 microns (long dimension), maximum size = 80 microns

Zircon: Very minor/trace; anhedral-granular and subhedral-rounded grains 25-60 microns in size (long dimension)

Opaques: Very minor/trace; very small rounded opaque grains 5 to 10 microns in diameter and smaller

Iron Oxide (mainly Hematite): Trace; dark red

(continued)

Page 2, CA-8A/S-2 Thin Section Description

Microfracturing: There are very minor irregular open-space fractures that do not traverse the entire thin section. Some fracturing is evident in the hand specimen.

Fabric: No definitive fabric could be readily identified.

Summary

This quartzite consists of quartz (99%), sericite (0.5-1%), rutile ± leucoxene (<0.25%), apatite? or collophane (<0.25%), and very minor or trace amounts of zircon, opaques, and iron oxide (mainly hematite). The rock consists mainly of a framework of quartz grains cemented by an undetermined amount of quartz, the latter forming syntaxial quartz overgrowths. Sericite is a ubiquitous matrix constituent, occurring along quartz grain boundaries and sparse intragranular microfractures, as well as interstitially between quartz grains. The quartz grains are well-sorted, and the rock is more homogeneous than sample CA-8A/S-1.

There are very minor discontinuous open fractures in the section. Some fracturing is apparent in the hand specimen.

Petrographers: Victoria S. Fuchs
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CA-8B/S-1 **Thin Section Description**

Rock Classification (IUGS & Middlemost): Quartz Monzonite

Alteration: 5% alteration; strong chlorite ± epidote ± minor uralite alteration of mafic minerals; minor sericite + clay (± epidote ± chlorite) alteration of plagioclase; very minor prehnite

Hand Specimen: Three rocks; two-feldspar granitic-looking rock, fine- to medium-grained; light green and pink color; white and pink feldspars and green amphibole; fairly homogeneous, massive; minor epidote with carbonate; very spotty acid reaction (calcite + dolomite?) associated with epidote but also elsewhere; mildly magnetic

Silica Analysis: 31.1% Si (66.5% SiO_2)

Thin Section (half K-stained):

Plagioclase: 46%; subhedral, twinned; randomly oriented; some normal-progressive compositional zoning (and occasional/rare oscillatory-normal zoning); most calcic composition is An_{36} (sodic andesine); rarely contains small K-feldspar patches (antiperthitic?); common grain sizes = 0.4-1.6 mm (long dimension), fine- to medium-grained, and a few crystals 2.0-4.0 mm long

K-Feldspar (probable Orthoclase): 36%; generally microperthitic; subhedral and occasionally euhedral; randomly oriented grains; some Carlsbad twinning; typically turbid (clouded by minute inclusions); also forms micrographic intergrowths with quartz; rare small euhedral inclusions in quartz; biaxial(-), smaller to moderate 2V angle, moderate r>v dispersion; grain sizes similar to plagioclase but more commonly in the 0.2-0.8 mm range (and much finer grained in micrographic K-feldspar-quartz patches)

Quartz: 5-6%; anhedral; intergranular; also in frequent symplectic and micrographic intergrowths (patches) with K-feldspar; occasional small euhedral K-feldspar inclusions; grain sizes commonly in the 0.08-0.40 mm range, except for micrographic quartz-K-feldspar patches

Chlorite: 4%; main alteration product (± epidote) of clinoamphibole and biotite; light green pleochroism; length-slow; uniaxial or biaxial(-), 2V angle at or near 0° (possible Fe-chlorite)

(continued)

<u>Clinopyroxene (probable Augite)</u>: 3%; subhedral and rarely prismatic, often with (partial) brown hornblende reaction rims; occasional simple twinning; pale green tint; inclined extinction (up to 40° to elongation); biaxial(+), moderate 2V angle, weak r>v dispersion; grain sizes similar to plagioclase, but more commonly in the 0.40-mm range

<u>Clinoamphibole (probable Hornblende)</u>: 2%?; subhedral to euhedral, olive-green (incipiently altered) hornblende crystals, usually partly chloritized; rare simple twins; also common as (brown) magmatic reaction rims on clinopyroxene; biaxial(-), moderate to large 2V angle, strong r>v and v>r dispersion; grain sizes similar to plagioclase but some smaller grains (under 0.4 mm long)

<u>Opaques</u>: 2%; small cubic and lesser octahedral grains, euhedral to subhedral, also anhedral; disseminated grains and aggregates usually in the 0.04-0.40 mm size range; often associated with mafic minerals, but also found elsewhere; includes magnetite, as indicated by magnetic response of hand specimen

<u>Epidote</u>: 1%; yellow pleochroism; biaxial(-), large 2V angle, v>r dispersion; occurs with chlorite in altered mafic grains and occasionally in plagioclase; occasionally in K-feldspar

<u>Sericite</u>: <0.25%, but common; colorless; minor alteration product of plagioclase, with epidote and chlorite

<u>Biotite</u>: <0.25% (but not uncommon); brown; variably chloritized

<u>Uralite?</u>: <0.25%?, sporadic; fibrous/acicular, with almost parallel to inclined extinction; occurs with chlorite and epidote in altered amphibole

<u>Clay</u>: <0.25%; brown; alteration product of plagioclase, particularly along (intracrystalline) fractures

<u>Prehnite</u>: Very minor (<0.25%); local partial alteration of biotite?; occasional/rare possible minor alteration in plagioclase; colorless; fan-like aggregates

<u>Apatite</u>: Trace; euhedral to anhedral, rare rounded grains; sparse very small prismatic inclusions in plagioclase; rare subhedral grains with chloritized amphibole; occasionally associated with opaques or mafic minerals; grain sizes up to 120 microns (long dimension)

(continued)

Zircon: Trace; one almost euhedral 65-micron-long crystal with sphene, opaque grains, and clinoamphibole

Sphene: Trace; rare very small subhedral to anhedral grains with chlorite in partly chloritized biotite

Microfracturing: A few larger grains are cracked, but there is no other fracturing in the section. The hand specimens are also unfractured.

Fabric: The rock displays classic interlocking texture with no preferred crystal orientation.

Summary

This fine- to medium-grained plutonic rock is classified as a quartz monzonite using both the IUGS modal plutonic rock classification and the chemical classification (total alkali versus silica) of plutonic rocks by Middlemost*; only the silica analysis was available for the chemical classification. The color index is 12. The sample consists of plagioclase (46%), K-feldspar (36%, probable orthoclase), quartz (5-6%), chlorite (4%), clinopyroxene (3%, probable augite), clinoamphibole (2%?, probable hornblende), opaques (2%), epidote (1%), minor biotite, sericite, clay, uralite, and prehnite, and trace amounts of accessory apatite, zircon, and sphene. Plagioclase, K-feldspar, and lesser clinopyroxene, clinoamphibole (hornblende), and biotite form randomly oriented subhedral crystals, while quartz and K-feldspar form very subordinate micrographic and symplectic intergrowths. Opaque grains (including magnetite) are often associated with the mafic minerals. Brown hornblende commonly forms magmatic reaction rims on clinopyroxene.

Alteration phases constitute about 5% of the section, the bulk being comprised of chlorite and lesser epidote. Amphibole and biotite have undergone strong chloritic and lesser epidote alteration. Sericite, clay, and epidote are minor alteration products of plagioclase.

There is no fracturing in the section other than intracrystalline fracturing in a few larger crystals. Clay fills microfractures in plagioclase grains.

Petrographers: Victoria S. Fuchs
William A. Fuchs

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* Middlemost, E.A.K., 1994, Naming materials in the magma / igneous rock system: Earth-Science Reviews 37, p. 222.

CA-11/S-1 **Thin Section Description**

Rock Classification (IUGS): Rhyolite Porphyry

Alteration: 2% alteration; minor sericite + very minor kaolinitic clay alteration; minor iron oxidation; minor leaching (K-feldspar phenocrysts); very minor late fluorite vesicle filling

Hand Specimen: Two rocks; slightly pinkish white, fine-grained, somewhat porphyritic volcanic or microintrusive rock; quartz, plagioclase, hornblende?, and biotite? phenocrysts; fairly massive; sparse purple fluorite in small vesicles; no reaction to dilute hydrochloric acid; nonmagnetic

Silica Analysis: 35.5% Si (75.9% SiO_2)

Thin Section (half K-stained):

Groundmass:

Spherulitic Felsitic Material: 63%; K-stained; composed of probable K-feldspar and quartz

K-Feldspar Crystals: 1-2%?; small euhedral crystals less than 0.20 mm long, commonly 0.08-0.12 mm long

Quartz: ≤1%; anhedral, intergranular (between spherulites); occasional subhedral crystals in vesicle walls

Opaques: 0.75-1%; local partly oxidized (anhedral) material along short microfractures within, and on rims of, feldspar (K-feldspar and plagioclase) phenocrysts; anhedral interstitial material in spherulitic groundmass; scattered subhedral cubic and rounded octahedral grains (2.5-240 microns in diameter) and small aggregates ± associated rutile, zircon, sphene, apatite, and bleached biotite; occasional minor to complete oxidation

Phenocrysts & Microphenocrysts:

K-Feldspar (mainly Orthoclase): 20%?; microperthitic; euhedral to subhedral, sometimes somewhat porous (as a result of leaching); rare strongly leached phenocrysts (almost entirely leached out); some Carlsbad twinning; crystal sizes generally 0.20-4.0 mm (long dimension)

Quartz: 5%; subhedral and occasionally euhedral; sometimes rounded, occasionally embayed; some incipient or healed microfractures; similar size range as K-feldspar phenocrysts

Plagioclase: 4%; subhedral, twinned; often attached to a K-feldspar phenocryst; typically clouded by mild to moderate sericitic alteration; one subhedral-embayed phenocryst with thick mantle of (microperthitic) K-feldspar; similar size range as K-feldspar phenocrysts

Biotite: 1%; bleached or partly bleached, with very fine-grained accessory sphene; occasional olive-green and medium brown colors

Sericite: 1.5-2%; disseminated alteration of plagioclase phenocrysts; coarser grained and more abundant alteration in the groundmass

Kaolinitic Clay: ≤0.25%; sparse pockets or patches in groundmass and in one K-feldspar phenocryst; vermicular?

Fluorite: <0.25%; in vesicles, but often not visibly attached to vesicle walls; pinkish and purple color, especially along cleavage traces; good cleavage; also observed in hand specimen

Iron Oxide: <0.25%; mainly hematite; dark red; oxidation product of (cubic) opaque grains; also sporadic orange-brown iron oxide staining in groundmass

Sphene: Minor (<0.25%); subhedral; small grains (up to 25 microns long) in bleached biotite; rare grains in felsitic (spherulitic) groundmass; maximum grain size = 0.14 mm (long dimension)

Rutile: Minor (<0.25%); euhedral to subhedral; sparse small clusters associated with larger opaque grains ± zircon ± sphene; grain sizes 30-50 microns (long dimension); rare sagenitic (acicular) rutile in bleached green biotite phenocryst

Zircon: Trace; euhedral to subhedral; occasionally found with larger opaque grains, rutile, biotite, and elsewhere; grain sizes = 25-160 microns (long dimension)

Apatite: Trace; euhedral or subhedral grains 20-25 microns in diameter, associated with biotite

Leucoxene: Trace; brown opaque titanium oxide; associated with biotite

Unknown Accessory: Trace; anhedral with very uneven (or corroded?) edges; colorless to very pale yellow; local small aggregates; grain sizes = 10-50 microns (long dimension); possible anatase, rutile, or sphene

Microfracturing: Other than slight cracking of a few phenocrysts, no fracturing was observed in thin section. Some probable fracture surfaces were observed in hand specimen.

Fabric: The rock is characterized by strong porphyritic texture, and spherulitic texture in the groundmass. Phenocrysts comprise 30% of the section. Sparse small vesicles are variably filled by fluorite. Vesicles and other pore spaces (owing to leaching of K-feldspar phenocrysts) constitute perhaps 1-2% of the section area.

Summary

This volcanic rock is classified as a rhyolite porphyry using both the IUGS chemical (total alkali versus silica) and modal classifications for volcanic rocks; only the silica analysis was available for the chemical classification. The color index of the rock is 2. Phenocrysts and microphenocrysts, comprising 30% of the rock, consist of K-feldpsar (20%, microperthitic orthoclase), quartz (5%), plagioclase (4%), and biotite (1%). The groundmass consists primarily of felsitic K-feldspar-bearing spherulites (63%) and minor discrete quartz (≤1%) and euhedral K-feldspar (1-2%?); minor fine-grained opaque material (0.75-1%) is commonly concentrated between spherulites, along short microfractures, and along rims of feldspar phenocrysts.

Alteration phases, which total about 2%, consist mainly of sericite (1.5-2%) and lesser kaolinitic clay (≤0.25%) and iron oxide (<0.25%). Plagioclase phenocrysts are typically clouded by minor to moderate sericitization, but sericite is coarser grained and more abundant in the groundmass. Fluorite partly fills sparse small vesicles. Pore spaces in some K-feldspar phenocrysts are probably the result of leaching.

No fracturing was observed in thin section with the exception of some micro-fracturing of feldspar phenocrysts. The main textures are porphyritic and spherulitic, the latter texture characterizing the groundmass. Sparse small vesicles and other pore spaces (in partly leached K-feldspar phenocrysts) comprise 1-2% of section volume.

Petrographers: Victoria S. Fuchs
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NN-8B/S-1 **Thin Section Description**

Rock Classification (IUGS): Andesite Porphyry

Alteration: 7-8% alteration; strong calcite-chlorite-uralite? alteration of mafic phenocrysts; minor clay-calcite alteration

Hand Specimen: Two rocks; massive, hard, light gray (slight greenish tint) porphyritic rock; calcite alteration in phenocrysts (mafic and plagioclase phenocrysts); nonmagnetic

Silica Analysis: 28.9% Si (61.8% SiO_2)

Thin Section (half K-stained):

Groundmass:

Plagioclase: 73%; subhedral twinned laths most common; local trachytic texture, otherwise variably oriented; some normal-progressive compositional zoning; grain sizes = 0.015-0.16 mm (long dimension)

Opaques + minor? Iron Oxide: 2%; small subhedral cubic and octahedral grains (commonly 0.08-0.40 mm, long dimension), and some small bladed or tabular grains or pseudomorphs with minor iron oxidation; also very fine granular opaque rims on biotite phenocrysts and some green altered (pyroxene?) phenocrysts; forms heavy alteration rims and partial replacement of amphibole phenocrysts; numerous grains under 0.08 mm in diameter; evenly distributed, ubiquitous in the groundmass

Quartz: 1.5%?; anhedral; forms oikocrystic patches containing very small plagioclase laths and occasional K-feldspar crystals; also intergranular in groundmass; occasional striated or acicular? ghost texture

K-Feldspar: <1%; very small subhedral crystals poikilitically enclosed in quartz; sporadic; grain sizes commonly in the 0.01-0.015 mm range (long dimension), rarely coarser grained when intergranular

Chlorite: <1%?; sporadic alteration in groundmass; very light green color; sometimes transitional with light brown clay

Apatite: <0.25%, but not uncommon; sporadic; euhedral to subhedral grains up to 0.16 mm long; associated with biotite, opaques, clinopyroxene, and green altered (pyroxene?) phenocrysts, but also found alone in the groundmass; rarely embayed

Zircon: Trace; rare euhedral prismatic grain 0.16 mm long, in groundmass; subhedral 35-micron grain in altered amphibole phenocryst

Phenocrysts & Microphenocrysts: Originally 20%

Plagioclase: 12%; subhedral and occasionally euhedral or anhedral; usually twinned, and some compositional zoning (normal-progressive and oscillatory-normal); occasional sieve texture; most calcic composition is An_{47} (calcic andesine) ; grain sizes = 0.16-3.20 mm (long dimension), more commonly 0.32-2.0 mm

Chlorite + Uralite?: 3-4%; completely altered euhedral and subhedral-rounded, prismatic phenocrysts (and glomerocrysts) of pyroxene and minor? clinoamphibole; some altered phenocrysts are partly leached or plucked out

Clinopyroxene: 2%; remanent clinopyroxene in phenocrysts and glomerocrysts altered to carbonate ± chlorite; subhedral to euhedral; occasionally twinned; very pale green/brown tint; biaxial(+), very moderate 2V angle, r>v dispersion

Biotite: 1%; brown, sometimes slightly bleached to light orange-brown; typically rimmed by very fine opaque grains; occasionally embayed

Altered Hornblende: 1%?; phenocrysts clouded and heavily rimmed by very fine disseminated opaque grains; turbid transparent alteration phase uncertain (possible augite), accompanied by minor biotite

Fibrous Zeolite?: 0.25%; occasional/rare alteration in plagioclase phenocrysts (i.e., calcic cores); fibrous or platy, forming radial or fan-like aggregates; colorless; parallel and inclined extinction, length-slow

Unknown Alteration Phase: Very minor (<0.25%); very fine-grained, framboidal; dark, turbid; high relief; occasional alteration product with carbonate, chlorite(?), and clay in altered phenocrysts; possible epidote mineral

Sericite: Trace; rare alteration of plagioclase phenocrysts

Clay: 2%; dark to very light brown color; alteration (in more calcic zones) of plagioclase phenocrysts; occasional alteration of clinopyroxene? phenocrysts; sporadic alteration in groundmass

Carbonate (probable Calcite): 0.5-1%; alteration product of mafic phenocrysts ± opaque iron oxide, the latter on rims and fractures; alteration of plagioclase phenocrysts, namely in calcic cores and along microfractures; alteration on fractures and rims of clinopyroxene phenocrysts; occasional patchy alteration of groundmass; occasionally in microveins (0.01-0.04 mm wide) with quartz and albite(?)

Secondary/Vein Quartz: <0.25%; in sparse microveins ± albite(?) or carbonate, 0.01-0.04 mm in width

Secondary/Vein Plagioclase: Minor (<0.25%); probable albite; occasionally in sparse microveins with quartz ± carbonate

Microfracturing: There is a single quartz(-plagioclase-carbonate)-filled fracture 0.005-0.04 mm wide that traverses the entire section by occasionally ending and jumping over (in en echelon fashion) to a new, slightly displaced fracture; a second fracture may represent an anastomosing branch. The hand specimen is minimally fractured.

Fabric: There is no preferred grain orientation or fabric other than localized trachytic texture of plagioclase laths in the groundmass. The rock exhibits both porphyritic and seriate textures.

Summary

This volcanic rock is classified as an andesite porphyry on the basis of mineralogy and silica content, using both the IUGS modal and chemical (total alkali versus silica) classifications for volcanic rocks. The color index is about 10. The phenocrysts and microphenocrysts, comprising 20% of the section, consist of plagioclase (12%), altered green mafic phenocrysts (3-4%, chlorite + uralite?), clinopyroxene (2%), biotite (1%), and altered hornblende (1%). The groundmass consists primarily of plagioclase (73%), along with minor quartz (1.5%), K-feldspar (<1%), and slightly oxidized opaques (2%), the last forming very fine to coarser grained material evenly distributed and ubiquitous in the groundmass; apatite is a common accessory, and zircon is rare.

Alteration minerals, which comprise 7-8%, include chlorite + uralite? (3-4%), clay (2%), carbonate (0.5-1%, probable calcite), zeolite? (0.25%), a very minor unidentified alteration phase (possible epidote mineral), minor iron oxide, and rare sericite. The alteration phases are concentrated in phenocrysts, but clay, chlorite, and occasional carbonate also occur sporadically in the groundmass. Sparse microveins contain quartz (<0.25%) and sporadic plagioclase and carbonate.

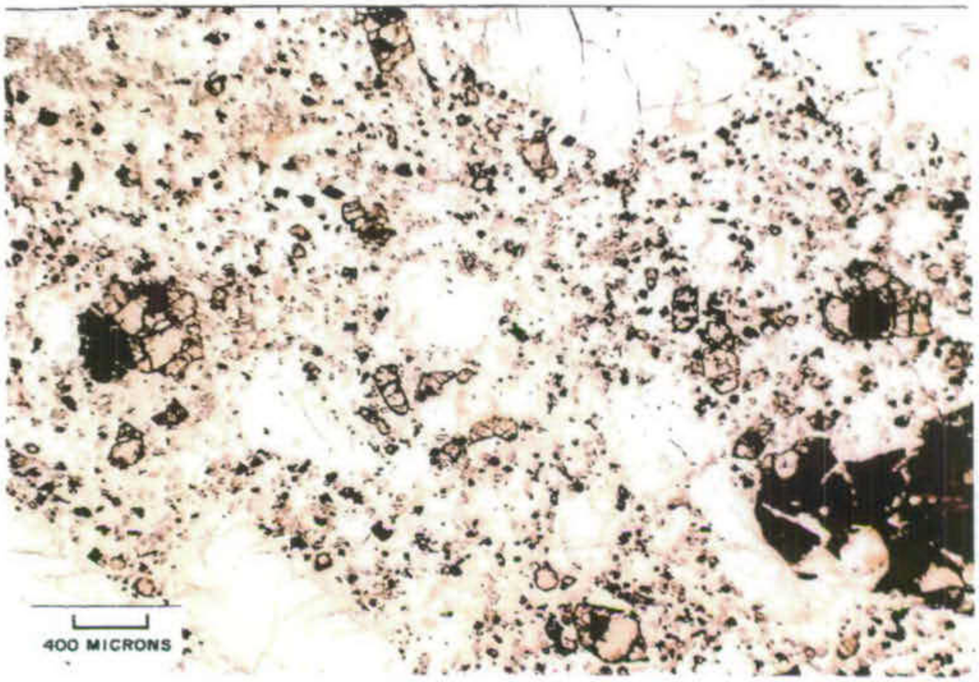
(continued)

The rock exhibits both porphyritic and seriate textures. Plagioclase laths, which dominate the groundmass, are variably oriented except for local trachytic texture.

The one or two quartz(-plagioclase-carbonate) microveins traversing the section are the only fracture phenomena observed in the section. The hand specimen is minimally fractured.

Petrographers: Victoria S. Fuchs
William A. Fuchs

PHOTOMICROGRAPHS



ES-7/S1 24x magnification (plane polarized light)

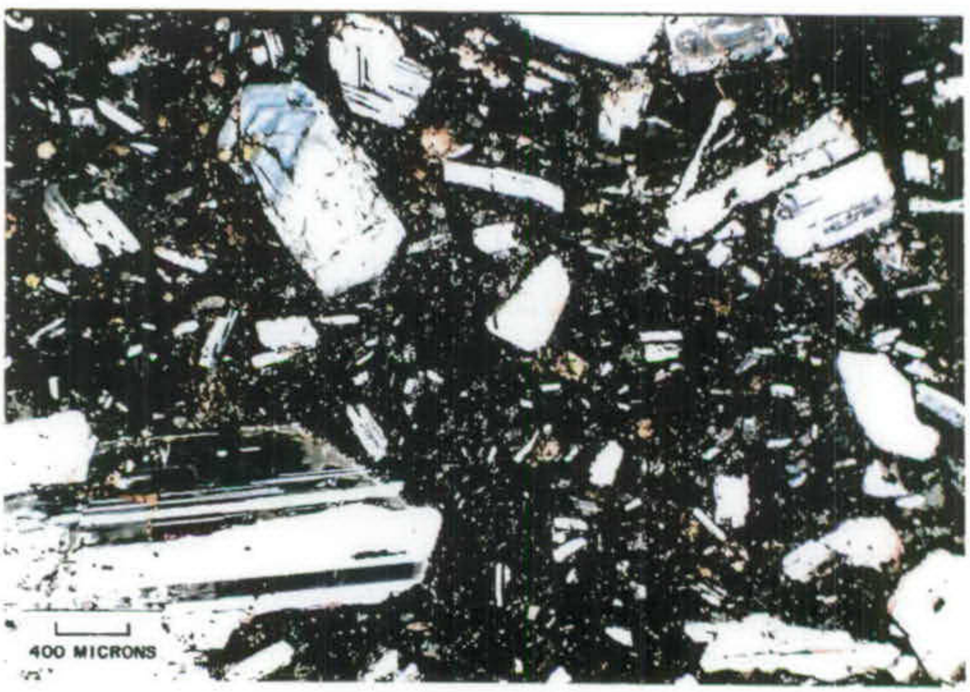
Leucobasalt Porphyry

ES-7/S1 24x magnification (cross polarized light)

Leucobasalt Porphyry

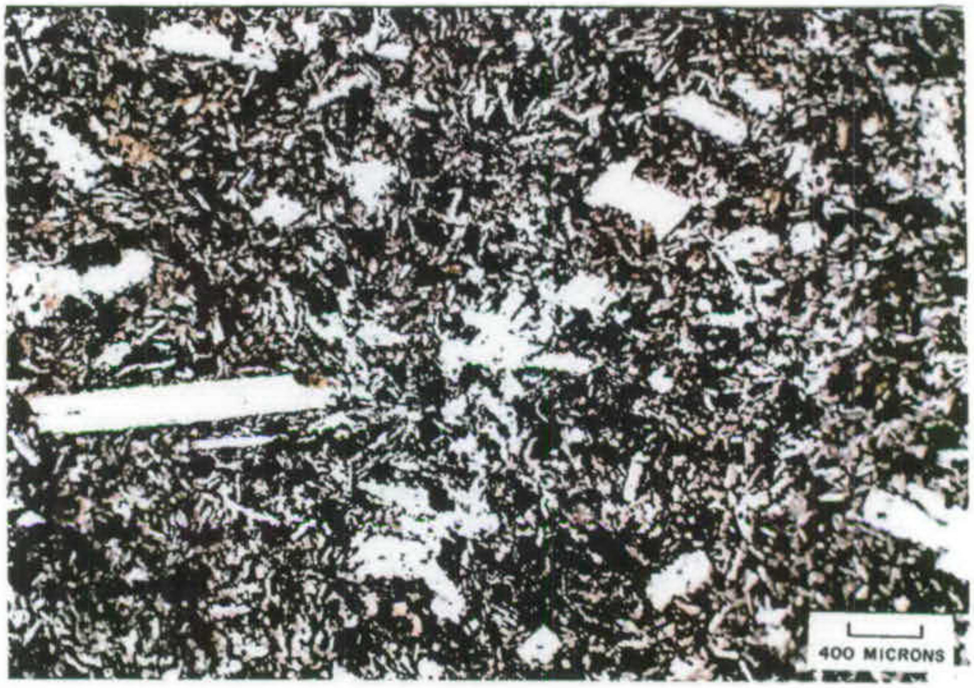
NN-8A/S1 24x magnification (plane polarized light)

Andesite Porphyry



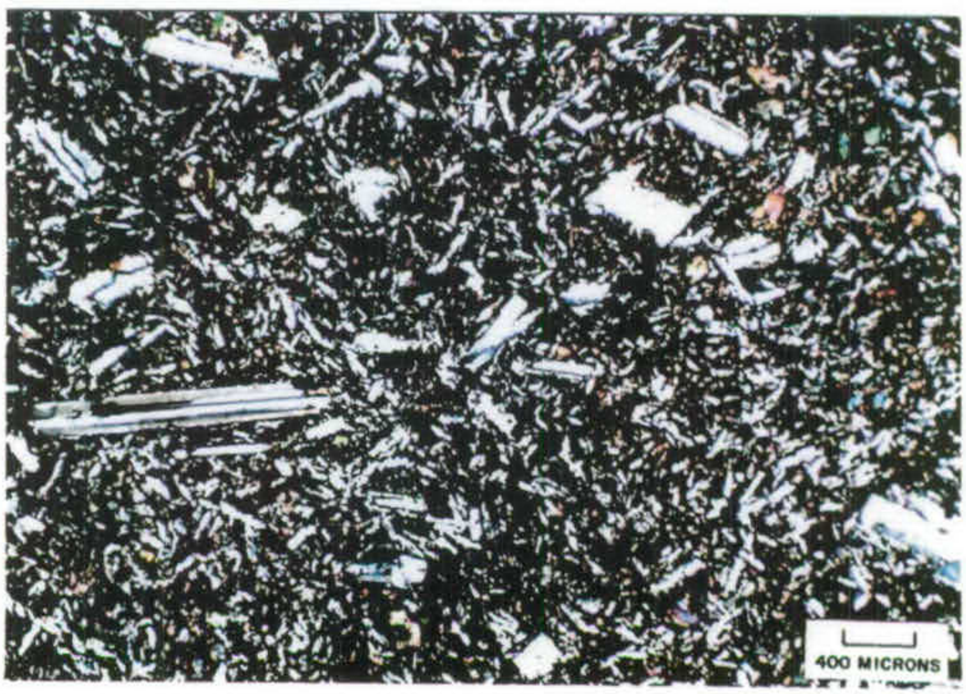
NN-8A/S1 24x magnification (cross polarized light)

Andesite Porphyry



NN-8C/S1 24x magnification (plane polarized light)

Porphyritic Leucobasalt

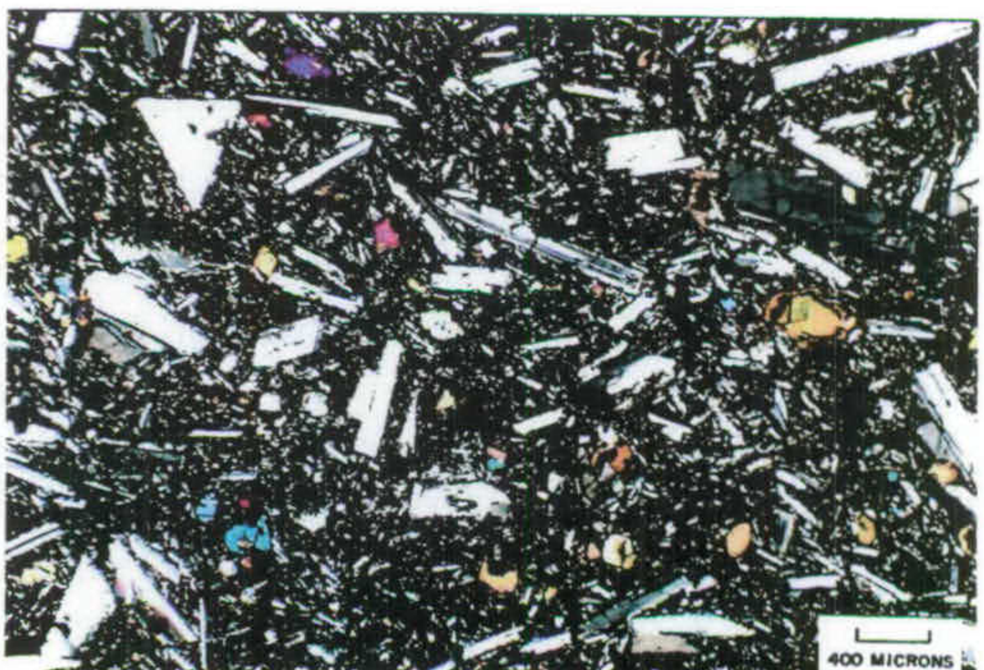


NN-8C/S1 24x magnification (cross polarized light)

Porphyritic Leucobasalt

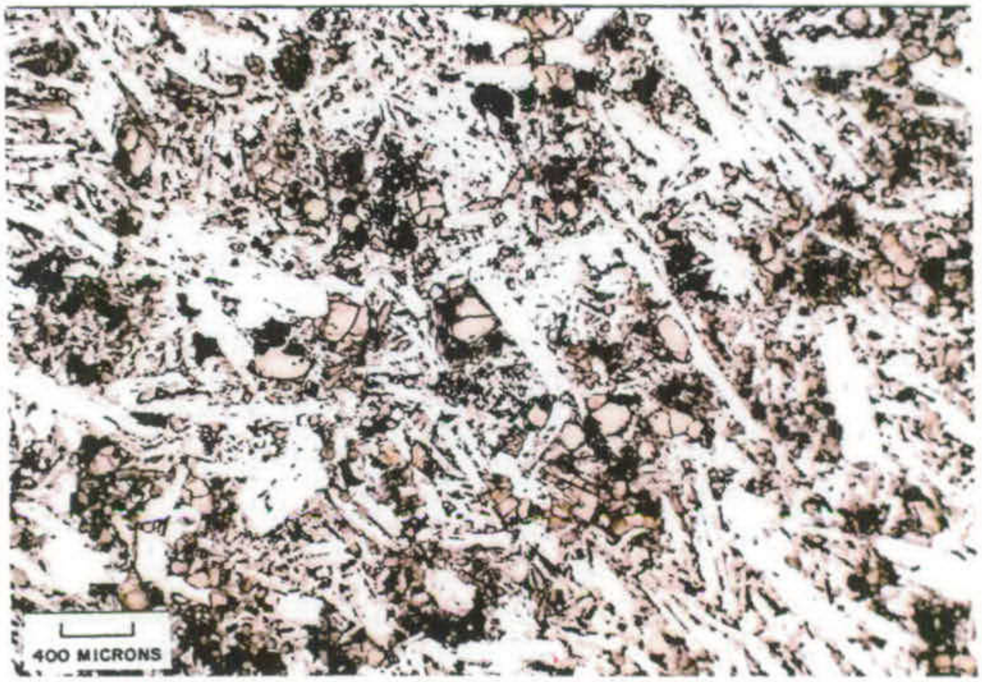
NN-8D/S1 24x magnification (plane polarized light)

Leucobasalt Porphyry



NN-8D/S1 24x magnification (cross polarized light)

Leucobasalt Porphyry

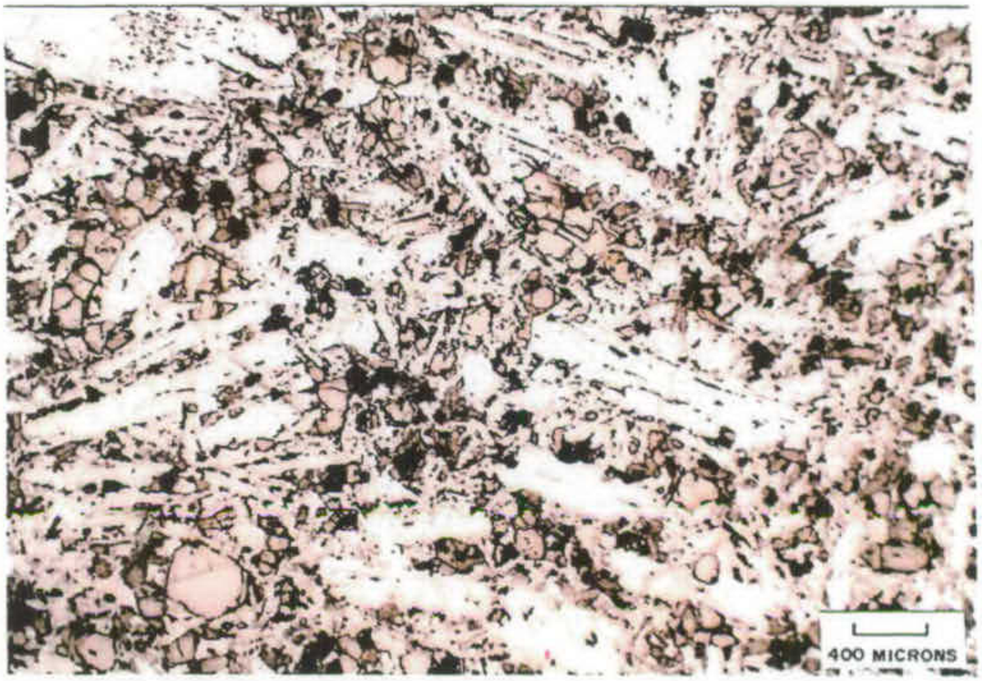


NN-9A/S1 24x magnification (plane polarized light)

Porphyritic Leucobasalt

NN-9A/S1 24x magnification (cross polarized light)

Porphyritic Leucobasalt

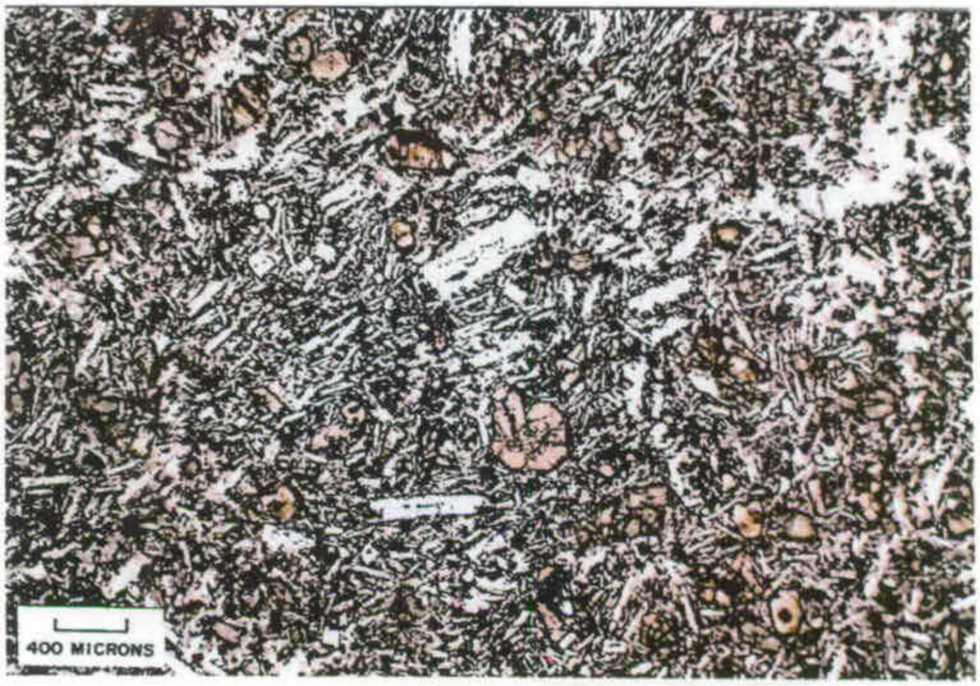


NN-9B/S1 24x magnification (plane polarized light)

Leucobasalt

NN-9B/S1 24x magnification (cross polarized light)

Leucobasalt



NS-3A/S1 24x magnification (plane polarized light)

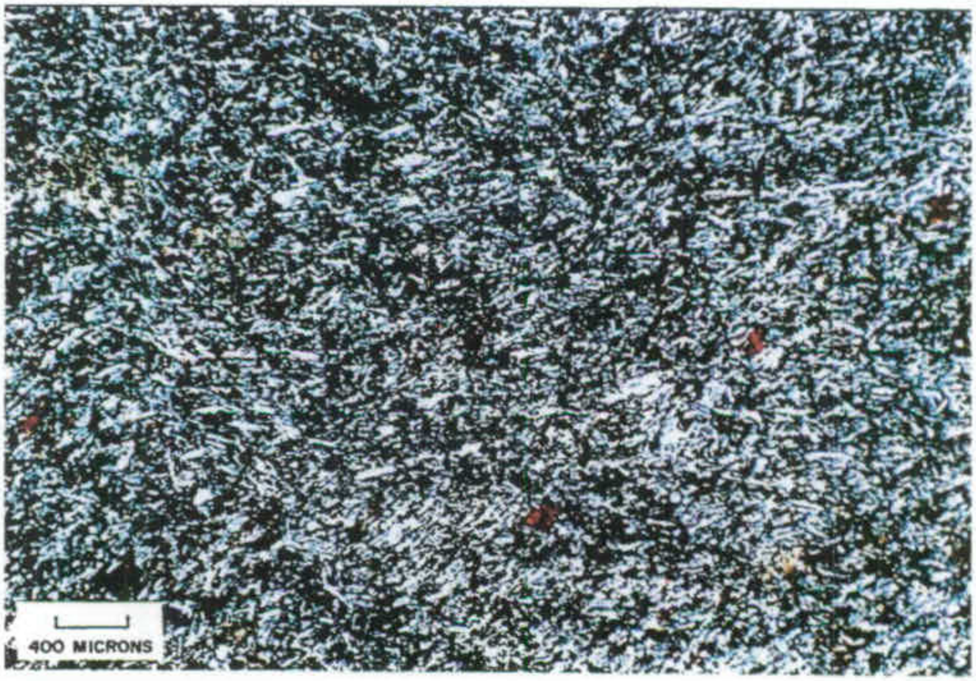
Basaltic Andesite

NS-3A/S1 24x magnification (cross polarized light)

Basaltic Andesite

NS-3B/S1 24x magnification (plane polarized light)

Leucobasalt



NS-3B/S1 24x magnification (cross polarized light)

Leucobasalt

APPENDIX D

DEFINITIONS FOR QUARRY RATING CRITERIA

APPENDIX D

DEFINITIONS FOR QUARRY RATING CRITERIA

Definitions for Quarry Rating Criteria

Rock Quality – The durability and soundness of the outcropping rock, as expressed by a combination of its field hardness (rock hammer test and Schmidt hammer test) and laboratory testing (Durability by L.A. Abrasion test and Sulfate Soundness test, specific gravity and point load test)

5 – Very sound rock with high field tests and higher than standards set by American Railway Engineering and Maintenance-of-Way Association (AREMA) for lab test values
4 – Moderately sound rock with good field tests and suitable lab test values, compared to AREMA standards
3 – Moderately sound rock with disparate values of field and lab values
2 – Low field hardness values and lower than acceptable (by AREMA standards) laboratory test values
1 – Very low field hardness and laboratory test values

Rock Volume Potential – Potential of site to produce a suitable volume of rock ballast, including natural deleterious zones such as weak, weathered, highly vesicular, and fractured zones and processing losses.

5 – greater than 6 million tons
4 – less than 6 million, but more than 3 million tons
3 – less than 3 million, but more than 1 million tons
2 – less than 1 million, but more than 0.5 million tons
1 – less than 500,000 tons

Mining Encumbrances – Restrictions on the proposed quarry site by mining claims
5 – No mining claims on or adjacent to the proposed site
3 – Mining claims on adjacent or adjoining properties that could impact the operation of the quarry
1 – Existing mining claim that would prohibit the development of a quarry

Appurtenant Structure Space – Adequate space near the quarry site for spoils, processing plant, living quarters, and offices.

5 – Abundant space for the support facilities adjacent to the quarry and with minimal grading required

4 – Adequate space for the support facilities, but the site is more than 1 mile from the quarry or requires a moderate amount of grading (cut and/or fill) to make the site suitable
3 – Adequate space for the support facilities, but the site is more than 5 miles from the quarry or requires a significant amount of grading to make the site suitable
2 – Marginal space for the support facilities
1 – Less than suitable space for the support facilities within 5 miles of the site.

Overburden Removal – The removal of soil, weathered rock or other unsuitable materials from the surface of the quarry site prior to production.

5 – 0 to 5 feet of overburden
4 – 5 to 10 feet of overburden
3 – 10 to 20 feet of overburden
2 – 20 to 40 feet of overburden
1 – greater than 40 feet of overburden

Length of Access Road to Highway – The length of a new access road from the quarry site/processing plant to a well-traveled, packed dirt road.

5 – less than ¼ mile
4 – more than ¼, but less than 1 mile
3 – more than 1, but less than 5 miles
2 – more than 5, but less than 20 miles
1 – more than 20 miles

Length of Access Road to Proposed Railroad Alignment – The length of a new access road from the quarry site/processing plant to the alignment of the proposed railroad alignment.
5 – less than ¼ mile
4 – more than ¼, but less than 1 mile
3 – more than 1, but less than 5 miles
2 – more than 5, but less than 20 miles
1 – more than 20 miles

Potential for Inundation or Other Harmful Phenomena – The potential for natural phenomena/processes, such as alluvial flooding or proximity to sensitive area, to negatively impact the quarry or appurtenant structures

5 – No perceived potential impacts to project components
4 – Minor potential impacts to quarry site or appurtenant structures
3 – Appurtenant structures in jeopardy of periodic damage
2 – Quarry site in jeopardy of periodic damage
1 – Quarry site and appurtenant structures in jeopardy of periodic damage

Ease of Exploration – Relative ease of access to exploratory drilling sites by drill rig for evaluation of the quarry site.

5 – Paved or existing packed dirt road within ¼ mile of the drilling locations and favorable terrain between road and drill sites
4 – Paved or existing packed dirt road within ¼ mile of the drilling locations, but difficult terrain between road and drill sites that would require grading (cut-and-fill)
3 – Paved or existing packed dirt road within 2 miles of the drilling locations
2 – Paved or existing packed dirt road more than 2 miles from the drilling locations
1 – Helicopter access only

APPENDIX E

SHANNON & WILSON, INC.
FIELD REFERENCE – ROCK CLASSIFICATION

ORDER OF CLASSIFICATION TERMS

1. ROCK NAME: (see back of sheet)
2. strength,
3. basic rock description;
4. structure;
5. weathering;
6. other or unique features
7. (Formation or Member name)

EXAMPLE

BASALT: moderate strength, gray, fine grained; moderately vesicular, smooth, closely-spaced, high angle joints with iron-oxide staining; slightly weathered (Wanapum Basalt).

FIELD REFERENCE ROCK CLASSIFICATION

3. BASIC ROCK DESCRIPTION

COLOR

TEXTURE (see back side of sheet)

CEMENTATION: Weakly / Strongly

INDURATION: Slightly / Highly

4. STRUCTURE

a) FABRIC: Bedding, foliation, etc.; Describe type, spacing, orientation

b) VESICULARITY: Describe percent by volume and size of holes (range and typical)

c) DISCONTINUITIES: Describe type, number of sets, spacing or intercept (range and typical), roughness, healing, aperture (width), filling type and consistency (use soil terms), and orientation or dip (low / high or angle)

4a. FABRIC TERMS

Sedimentary Rocks:

MASSIVE - Rock without significant structure

BEDDED - Regular layering from sedimentation

FISSILE - Tendency to break along laminations

Metamorphic Rocks:

FOLIATED - Parallel arrangement or distribution of minerals

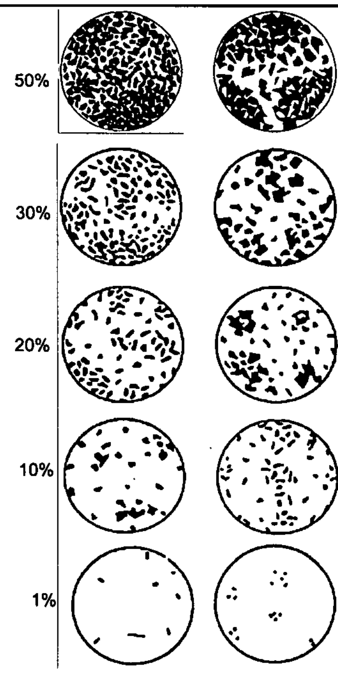
SCHISTOSE - Parallel arrangement of tabular minerals giving a planar fissility

GNEISSOSE - Segregation of minerals into bands

CLEAVAGE - Tendancy to split along secondary, planar textures or structures

4b. VESICULARITY

Slightly Vesicular	1 to 10%
Moderately Vesicular	10 to 30%
Highly Vesicular	30 to 50%
Scoriaceous	>50%



COMPARISON CHART
(percent by volume)

4c. DISCONTINUITY TERMS

FRACTURE - Collective term for any natural break excluding shears, shear zones, and faults

JOINT (JT) - Planar break with little or no displacement

FOLIATION JOINT (FJ) or BEDDING JOINT (BJ) - Joint along foliation or bedding

INCIPIENT JOINT (IJ) or INCIPIENT FRACTURE (IF) - Joint or fracture not evident until wetted and dried; breaks along existing surface

RANDOM FRACTURE (RF) - Natural, very irregular fracture that does not belong to a set

BEDDING PLANE SEPARATION or PARTING - A separation along bedding after extraction from stress relief or slaking

FRACTURE ZONE (FZ) - Planar zone of broken rock without gouge

MECHANICAL BREAK (MB) - Breaks due to drilling or handling; drilling break (DB), hammer break (HB).

SHEAR (SH) - Surface of differential movement evident by presence of slickensides, striations, or polishing

SHEAR ZONE (SZ) - Zone of gouge and rock fragments bounded by planar shear surfaces

FAULT (FT) - Shear zone of significant extent; differentiation from shear may be site-specific

4c. OUTCROP DATA

When collecting outcrop data, fracture orientation, aperture, roughness, and filling type / consistency, should be described in greater detail than is possible with core. Depending on the nature or investigation, additional data should also be recorded:

Fracture WALL STRENGTH

Fracture CONTINUITY OR LENGTH

Fracture ENDS OBSERVED (0, 1, 2)

Fracture MOISTURE CONDITIONS (dry, dry but stained, damp, wet, dripping, flowing)

BLOCK SIZE

When this level of detail is required, a special data collection form should be used.

cm 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Inches 1 2 3 4 5 6

NOTES

1. Locations and boundaries of potential ballast sources shown on this plate should be considered approximate.
2. Potential ballast sources based on literature review conducted for "Preliminary Construction Aggregate Report by Shannon & Wilson, dated 2006"
3. Not all potential ballast sources shown on this plate have a map identification number.
4. Land Status information provided by Bechtel/SAIC.
5. Boundaries of Wilderness and Wilderness Study Areas (WSA's) current as of April 2004.

CALIENTE RAIL CORRIDOR
YUCCA MOUNTAIN PROJECT, NEVADA

Ballast Quarry Report

POTENTIAL BALLAST SOURCE AREAS
PLATE 1