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**Lithology and Stratigraphy of Holes Drilled
in LANL-Use Areas of the Nevada Test Site**

**Volume XIII
1991 - 1998**

July 1999

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**Lithology and Stratigraphy of Holes Drilled
in LANL-Use Areas of the Nevada Test Site**

**Volume XIII
1991 - 1998**

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July 1999

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LIST OF ACRONYMS AND ABBREVIATIONS

BN	Bechtel Nevada
cm	centimeter
DOE/NV	U.S. Department of Energy, Nevada Operations Office
ft	foot (feet)
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
m	meter(s)
mm	millimeter(s)
NTS	Nevada Test Site
RSN	Raytheon Services Nevada
TD	Total Depth
TDR	Time Domain Reflectometry
UGTA	Underground Test Area
USGS	U.S. Geological Survey

**Lithology and Stratigraphy of Holes Drilled in LANL-Use Areas of the Nevada Test Site
Volume XIII, 1991-1998**

Abstract

Geologic data for ten holes drilled in areas used by Los Alamos National Laboratory at the Nevada Test Site are presented in this report. The holes include emplacement holes, instrumentation holes, and Underground Test Area wells drilled during calendar years 1991 through 1995. For each hole a stratigraphic log, a detailed lithologic log, and one or two geologic cross sections are presented, along with a supplemental data sheet containing information about the drilling operations, geology, or references. For three of the holes, graphic data summary sheets with geologic and geophysical data are provided as plates.

Keywords: Nevada Test Site, Yucca Flat, Pahute Mesa, geology, alluvium, tuff.

Lithology and Stratigraphy of Holes Drilled in LANL-Use Areas of the Nevada Test Site Volume XIII

L. B. Prothro, S. L. Drellack, Jr., and B. M. Allen

INTRODUCTION

This report presents a compilation of data from ten holes drilled during calendar years 1991 through 1995 in areas used by Los Alamos National Laboratory (LANL) at the Nevada Test Site (NTS), Nye County, Nevada. Volume XIII is the latest in a series of reports produced by the Los Alamos Support Group of the Bechtel Nevada (BN) Geology/Hydrology Section and its predecessors. A primary purpose of this series of reports has been to provide readily accessible geologic data originated by BN (and predecessor) geologists for LANL drill holes at the NTS. Volumes I through XII contain information for holes completed in LANL-use areas of Yucca Flat (portions of Areas 1, 3, 4, 6, and 7) between August 1975 and December 1990. Holes completed prior to August 1975 are described in several U.S. Geological Survey (USGS) open-file reports ("blue books") and are listed in the earlier volumes of this series. Between 1982 and 1990, reports generally were produced on an annual basis. However, this publishing effort has been reduced due to the cessation of nuclear testing: fewer holes were drilled in the 1991-1995 interval, and none have been drilled in former test areas assigned to LANL since 1995. The need for future volumes is assessed on an annual basis and the decision to produce any additional volumes will depend upon the number of holes drilled in LANL-use areas of the NTS.

Volume XIII is the third to include drill holes in LANL-use areas of Pahute Mesa (Area 19). LANL holes on Pahute Mesa completed prior to 1989 will be compiled in a future volume(s). This edition marks the first time that geologic cross sections have been included for each drill hole. One or two cross sections are presented for most of the drill holes included in this report: a west-east section (typically perpendicular to structural trends) and a north-south section (typically parallel to structure).

DRILL HOLE DATA

Volume XIII provides geologic data for drill holes U-1g, Well ER-3-2, Well ER-6-1, U-7cd, U-7cd Satellite Hole #1, U-19bf, U-19bg, U-19bg Satellite Hole #1, U-19bh, and U-19bj. Although expended Emplacement Hole U-19bg was drilled in 1990, the detailed geologic characterization was not finalized until 1991 and so is included in this report. Emplacement Hole

U-19bf was also drilled in 1990, but was abandoned due to severe sloughing. Due to the limited usefulness of U-19bf and the small amount of data available for the hole, it was not included in Volume XII but is included in Volume XIII for completeness.

Emplacement Holes U-7cd, U-19bh, and U-19bj are inventory holes. The U-1g drill hole is a cable access/emergency egress hole associated with the U-1a Complex (Allen, 1995).

Wells ER-3-2 and ER-6-1 were drilled for the U.S. Department of Energy, Nevada Operations (DOE/NV) Environmental Restoration Division, and are now part of the Underground Test Area (UGTA) monitoring network. These holes are included because they are located in areas of Yucca Flat assigned to LANL. Several shallow boreholes were drilled in Area 3 within the last few years in support of various DOE/NV environmental restoration projects at the NTS (Table 1). These boreholes are relatively shallow and penetrate only alluvium, so additional details are not included in this report.

The following data are included for each drill hole in this report whenever available:

- Stratigraphic log with abbreviated lithologic descriptions
- Detailed lithologic log,
- Supplemental data (e.g., information on sample analyses, water levels, etc.)
- West-east geologic cross section
- North-south geologic cross section
- Graphic presentation of lithology, stratigraphy and the corresponding responses of selected geophysical logs.

Figure 1 is an index map of the NTS showing locations of drill holes presented in this report.

Table 2 lists the state plane coordinates and selected construction data for each drill hole.

Stratigraphic nomenclature used in this report is generally from Ferguson and others (1994) and is presented in Table 3. Terminology used in detailed lithologic descriptions (including quantities of rock constituents) is the same as that outlined in Volume X (drill holes completed in 1988). The lithologic descriptions presented here follow BN Geology/Hydrology Department Procedure NTS-GEO-003. Locations of stratigraphic contacts and lithologic divisions are verified with geophysical log data whenever possible. Other data, such as paleontological analyses, are incorporated where available.

Table 1
Recent Shallow Boreholes in Area 3

Borehole Name	Total Depth (Measured Depth in meters [m] and feet [ft])	Hole Orientation (Degrees from Vertical)	Year Drilled	Project
UE-3bL-D1	73.8 m (242 ft)	45	1994	Performance Assessment of the Area 3 Radioactive Waste Management Site (Schmeltzer et al., 1996).
UE-3bL-D2	146.3 m (480 ft)	45	1994	
UE-3bL-U1	76.2 m (250 ft)	45	1994	
ER-3-3	129.5 m (425 ft)	6	1994/ 1995	Site characterization for closure of the U-3fi Injection Well.

Table 2
Construction Data for Holes Included in this Report

Hole Name	State Plane Coordinates (Nevada Central)		Surface Elevation		Total Depth (TD)		Date TD Reached
	meters	feet	meters	feet	meters	feet	
U-1g	N 251,034 E 206,563	N 823,600 E 677,700	1220.2	4003.4	304.8	1000	11/20/1992
ER-3-2	N 253,932.92 E 208,488.12	N 833,111.6 E 684,014.8	1221.6	4007.9	914.4	3000	02/08/1994
ER-6-1	N 248,108.89 E 212,384.95	N 814,003.93 E 696,799.63	1200.9	3940	977.2	3206	10/16/1994
U-7cd	N 258,775.3 E 207,690.7	N 849,000.24 E 681,399.94	1254.2	4114.7	495.3	1625	04/14/1992
U-7cd Sat #1	N 258,775.7 E 207,700.0	N 849,001.66 E 681,430.57	1254.1	4114.4	518.2	1700	09/15/1992
U-19bf	N 288,079.24 E 184,223.31	N 945,140 E 604,406	2081.5	6829	471.2	1546	06/07/1990
U-19bg	N 279,898.31 E 179,617.37	N 918,299.72 E 589,294.68	2039.52	6691.35	657.5	2157	04/20/1990
U-19bg Sat #1	N 279,887.41 E 179,617.30	N 918,263.96 E 589,294.45	2040.3	6693.8	685.8	2250	07/15/1991
U-19bh	N 275,205.1 E 178,521.7	N 902,902 E 585,700	2062.9	6768	654.7	2148	06/14/1991
U-19bj	N 282,215.34 E 183,764.65	N 925,901.53 E 602,901.20	2140.9	7024	656.2	2153	06/02/1992

Table 3
Stratigraphic Nomenclature Used in this Report
 (Modified from Ferguson et al., 1994)

Stratigraphic Symbol	Stratigraphic Unit ^a
QTa	Quaternary and Tertiary Alluvium
Tt	Thirsty Canyon Group
Ttt	Trail Ridge Tuff
Ttp	Pahute Mesa Tuff
Tf	Volcanics of Fortymile Canyon
Tfbr	rhyolite of Chukar Canyon
Tfbw	rhyolite of Beatty Wash
Tm	Timber Mountain Group
Tma	Ammonia Tanks Tuff
Tma(b)	Ammonia Tanks Tuff (bedded)
Tmar	mafic-rich Ammonia Tanks Tuff
Tmap	mafic-poor Ammonia Tanks Tuff
Tmab	bedded Ammonia Tanks Tuff
Tmr	Rainier Mesa Tuff
Tmr(b)	bedded Rainier Mesa Tuff
Tmrr	mafic-rich Rainier Mesa Tuff
Tmrp	mafic-poor Rainier Mesa Tuff
Tmrh	tuff of Holmes Road
Tmrl/Th	pre-Rainier Mesa, post-Wahmonie bedded tuff, undifferentiated
Tp	Paintbrush Group
Tpb	rhyolite of Benham
Tpc	Tiva Canyon Tuff
Tpcm	Pahute Mesa lobe of Tiva Canyon Tuff
Tpd	rhyolite of Delirium Canyon
Tpe	rhyolite of Echo Peak
Tpr	rhyolite of Silent Canyon
Tpt	Topopah Spring Tuff
Tptm	Pahute Mesa lobe of Topopah Spring Tuff

Table 3
Stratigraphic Nomenclature Used in this Report (continued)
 (Modified from Ferguson et al., 1994)

Stratigraphic Symbol	Stratigraphic Unit ^a
Th	Calico Hills Formation
Thp	mafic-poor Calico Hills Formation
Tw	Wahmonie Formation
Twlb	tuff of Wahmonie Flat
Tc	Crater Flat Group
Tci	rhyolite of Inlet
Tcp	Prow Pass Tuff
Tcps	rhyolite of Sled
Tcpk	rhyolite of Kearsarge
Tcg	andesite of Grimy Gulch
Tcb	Bullfrog Tuff
Tct	Tram Tuff
Tcl	lower tuff
Tb	Belted Range Group
Tbd	Dead Horse Flat Formation
Tbg	Grouse Canyon Tuff
Tbgb	bedded Grouse Canyon Tuff
Tn	Tunnel Formation
Tn4	Tunnel 4 Member
Tn4K	beds 4K
Tn4J	beds 4J
Tn4FGH	beds 4FGH, undifferentiated
Tn4E	beds 4E (equivalent)
Tn4ABCD	beds 4ABCD, undifferentiated
Tn3	Tunnel 3 Member
Tn3D	beds 3D
Tn3BC	beds 3BC (equivalent)
Tn3A	beds 3A

Table 3
Stratigraphic Nomenclature Used in this Report (continued)
 (Modified from Ferguson et al., 1994)

Stratigraphic Symbol	Stratigraphic Unit ^a
Tu	Volcanics of Big Dome
Tub	Tub Spring Tuff
To	Volcanics of Oak Spring Butte (symbol also used for older tuffs, undifferentiated)
Ton2	tunnel bed 2
Toy	Yucca Flat Tuff
Ton1	tunnel bed 1
Tl	Paleocolluvium
Tlc	tuffaceous Paleocolluvium
Pz	Paleozoic Sedimentary Rocks
Dg	Guilmette Formation
Ds	Simonson Dolomite
Dv	Sevy Dolomite
Sl	Laketown Dolomite
Oes	Ely Springs Dolomite
Oe	Eureka Quartzite
Oa	Antelope Valley Limestone
On	Ninemile Formation

Notes

- a The units shown are in stratigraphic order, however, the list does not represent the complete stratigraphic sequence of the NTS.

Stratigraphic Log of Drill Hole U-1g
 (Logged by Brian M. Allen and Sigmund L. Drellack, Jr., Raytheon Services Nevada, December 1992)

Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
Meters	Feet				Meters	Feet
0 - 304.8 TD	0 - 1,000 TD	Tuffaceous Alluvium	Alluvium	QTa	304.8	1000

Lithologic Log of Drill Hole U-1g
(Logged by B. M. Allen and S. L. Drellack, Jr., Raytheon Services Nevada)
December 1992

Unless otherwise noted, the following descriptions refer to washed cuttings samples at 3.05-meter (m) (10-foot [ft]) intervals. Colors are determined by comparing wet sample color to the Geological Society of America Rock-Color Chart. Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible.

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
0 - 36.6 m (0 - 120 ft)	Alluvium: No samples collected.	Alluvium
36.6 - 115.8 m (120 - 380 ft)	Alluvium: Dominantly tuffaceous; grayish-orange (10YR7/4) to dark-yellowish-orange (10YR6/6); moderately to poorly indurated, moderately to poorly sorted, subrounded to subangular; average approximately 5 - 10 percent Paleozoic fragments with about 1 - 5 percent (of total sample) carbonates; moderately calcareous with caliche rinds on some grains; some MnO ₂ dendrites on clasts; slight increase in Paleozoic rock content in 54.9-m (180-ft), 67.1-m (220-ft), and 91.4-m (300-ft) samples.	Alluvium

Lithologic Log of Drill Hole U-1g (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
115.8 - 304.8 m (380 - 1,000 ft) TD	Alluvium: Dominantly tuffaceous; moderate-yellowish-brown (10YR5/4) to light-brown (5YR5/6); moderately to poorly indurated, moderately to poorly sorted, subrounded to subangular; approximately 25 - 40 percent Paleozoic rock fragments (increasing gradually with depth). Paleozoic rock fraction is mostly grayish-black (N2) to brownish-black (5YR2/1) argillite and quartzite; carbonate percentage (of total sample) is approximately 5 - 10 percent. Slight increase in Paleozoic rock percentage noticed in 125-m (410-ft), 259-m (850-ft), and 280.4-m (920-ft) samples; carbonate portion of total sample increases gradually with depth to approximately 15 percent from 292.6 m (960 ft) to TD. Common to abundant caliche rinds and MnO ₂ dendrites on larger grains; slight increase in moderate-yellow-brown (10YR5/4) tuff at 271.3 m (890 ft) and ash-flow detritus(?) at 207.3 m (680 ft).	Alluvium

Drill Hole U-1g Supplemental Data

1. For additional information regarding this site, see Allen (1994). Supplemental data listed below are also extracted from Allen (1994), unless noted otherwise.
2. No sidewall sampling has been performed to date.
3. Downhole photography available: Lawrence Livermore National Laboratory (LLNL) black-and-white format video. Two downhole runs were performed, one along the northwest portion of the borehole, and the other along the southeast portion of the borehole.
4. Static water level at the U-1g location is estimated to be at a depth of ~478 m (1,568 ft) which equates to an elevation of 742 m (2,435 ft). This water level depth is within the alluvium section, but is well below the TD of the U-1g drill hole.
5. The U-1g borehole was designed and constructed primarily as a cable access hole. The Lyner Complex vent drift intersects the U-1g borehole, with the invert level located at a depth of 296 m (972 ft) below ground level (Allen, 1995). U-1g also serves as an emergency-egress and ventilation-line passageway for the Lyner Complex.
6. See graphic data summary sheet in back pocket.

Figure 2
West-East Geologic Cross Section Through U-1g/U1a Complex

Bechtel Nevada Geology/Hydrology 2/98
 (modified from Allen, 1996)

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Stratigraphic Log of Well ER-3-2
(Logged by Lance B. Prothro, Raytheon Services Nevada, 24 April 1995)

	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
	0 - 801.9	0 - 2,631	Sand, Gravelly Sand, and Sandy Gravel: Fine sand to very coarse pebble gravel, poorly to moderately sorted.	Alluvium	QTa	801.9	2631
	801.9 - 846.1	2,631 - 2,776	Ash-Flow Tuff: Nonwelded to partially welded, vitric.	Ammonia Tanks Tuff, Timber Mountain Group	Tma	44.2	145
	846.1 - 851.9	2,776 - 2,795	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	5.8	19
	851.9 - 914.4 TD	2,795 - 3,000 TD	Ash-Flow Tuff: Nonwelded to moderately welded, vitric to devitrified.	Rainier Mesa Tuff, Timber Mountain Group	Tmr	>62.5	>205

Lithologic Log of Well ER-3-2
 Compiled by Lance B. Prothro, Raytheon Services Nevada
 April 1995

Unless otherwise noted, the following descriptions refer to washed cuttings samples at 3.05-m (10-ft) intervals. The lithologic descriptions follow Raytheon Services Nevada Department Procedure NTS-GEO-003, "Description of Rock Samples" (RSN, 1993), and were compiled using the IT Corp. field sample descriptions. In addition, petrographic analysis, quantitative X-ray diffraction analysis, and sample descriptions provided by R. G. Warren (LANL) were also used. Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible.

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
0 - 115.8 m (0 - 380 ft)	Interbedded Sandy Gravel and Gravelly Sand: Samples are unconsolidated mixtures of the coarser clasts that make up the alluvium. Samples are moderate-yellowish-brown in overall color; consist of varying amounts of medium to coarse sand and very fine to medium pebble gravel; poorly to moderately sorted; subangular to subrounded. Gravel and coarse sand fractions consist predominately of tuffaceous clasts and much less siltstone clasts. The smaller sandstone fraction consists of tuffaceous clasts and quartz and feldspar crystals. Samples indicate sandy gravel intervals at 39.6 - 51.8 m (130 - 170 ft), 73.2 - 85.3 m (240 - 280 ft), 91.4 - 100.6 m (300 - 330 ft), and 109.7 - 115.8 m (360 - 380 ft).	Alluvium

Lithologic Log of Well ER-3-2 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
115.8 - 320.0 m (380 - 1,050 ft)	Sandy Gravel: Samples are unconsolidated mixtures of the coarser clasts that make up the alluvium. Samples are moderate-yellowish-brown in overall color; consist predominately of fine to medium pebble gravel; moderately sorted; subangular to subrounded. Gravel consists predominately of tuffaceous clasts and lesser siltstone, carbonate, and argillite clasts. Fine pebble gravel dominates samples to 146.3 m (480 ft) becoming mostly medium pebble gravel below.	Alluvium
320.0 - 466.3 m (1,050 - 1,530 ft)	Gravelly Sand: Samples are unconsolidated mixtures of the coarser clasts that make up the alluvium. Samples are moderate-yellowish-brown in overall color; consist predominately of medium to very coarse sand and lesser very fine to fine pebble gravel; poorly to moderately sorted; subangular to subrounded. Sand and gravel consist predominately of tuffaceous clasts and lesser siltstone, carbonate, and argillite clasts. Quartz and feldspar crystals make up a portion of the smaller sand fraction. Samples and geophysical logs indicate minor interbedded sandy gravel to 368.8 m (1,210 ft) and below 432.8 m (1,420 ft).	Alluvium

Lithologic Log of Well ER-3-2 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
466.3 - 533.4 m (1,530 - 1,750 ft)	Sandy Gravel: Samples are unconsolidated mixtures of the coarser clasts that make up the alluvium with very minor amounts of intact alluvium. Samples are moderate-yellowish-brown (based on intact fragments of alluvium); consist predominately of very fine to medium pebble gravel increasing in size to coarse pebble gravel near base; moderately sorted, becoming poorly sorted near base; subangular to subrounded. Clasts are mostly tuffaceous with lesser siltstone, carbonate, and sedimentary breccia. Intact fragments of alluvium are moderately cemented with calcite.	Alluvium
533.4 - 588.0 m (1,750 - 1,929 ft)	Sandy Gravel: Samples are unconsolidated mixtures of the coarser clasts that make up the alluvium with minor amounts of intact alluvium. Samples are moderate-yellowish-brown (based on intact fragments of alluvium); consist predominately of fine to very coarse pebble gravel (very coarse pebble gravel is conspicuous); poorly sorted; subangular to subrounded. Gravel consists predominately of tuffaceous clasts with lesser sedimentary clasts representing a variety of lithologies. Intact fragments of alluvium are moderately cemented with calcite.	Alluvium

Lithologic Log of Well ER-3-2 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
588.0 - 801.9 m (1,929 - 2,631 ft)	Tuffaceous Sand: Description is based on percussion gun sidewall core samples. Samples are predominately moderate-yellowish-brown; tuffaceous; mostly vitric, commonly zeolitic, as well as argillaceous and silicified in part; fine to medium sand; moderately sorted; subangular to subrounded; consisting predominately of tuffaceous rock and pumice clasts, quartz and feldspar crystals, and lesser mafic minerals; minor cross-bedded laminae.	Alluvium
801.9 - 837.3 m (2,631 - 2,747 ft)	Partially Welded Ash-Flow Tuff: Description is based on percussion gun sidewall core samples. Moderate-yellowish-brown to approximately 807.7 m (2,650 ft) becoming dark-yellowish-brown below; vitric; common very-light-gray and lesser dark-yellowish-orange pumice to approximately 807.7 m (2,650 ft) becoming minor in abundance and moderate-brown (5YR4/4) in color below; common felsic phenocrysts of feldspar and lesser quartz; rare mafic minerals of clinopyroxene and hornblende, and lesser biotite; rare lithic fragments; trace of sphene; conspicuous black glass shards. Tuff/Alluvium contact determined from sidewall core samples and gamma ray log #13.	mafic-poor Ammonia Tanks Tuff

Lithologic Log of Well ER-3-2 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
837.3 - 846.1 m (2,747 - 2,776 ft)	Nonwelded Ash-Flow Tuff: Description is based on percussion gun sidewall core samples. Very-pale-orange; vitric; rare to common white pumice; common to abundant felsic phenocrysts of feldspar and lesser quartz; rare tiny mafic minerals of clinopyroxene, hornblende, and lesser biotite; rare lithic fragments.	mafic-poor Ammonia Tanks Tuff
846.1 - 851.9 m (2,776 - 2,795 ft)	Bedded Tuff: Description is based on percussion gun sidewall core samples. Pale- to moderate-yellowish-brown; vitric; rare to common white pumice; common to abundant felsic phenocrysts of feldspar and lesser quartz; rare tiny mafic minerals of clinopyroxene, hornblende, and lesser biotite; rare lithic fragments.	bedded Ammonia Tanks Tuff
851.9 - 877.2 m (2,795 - 2,878 ft)	Nonwelded to Partially Welded Ash-Flow Tuff: Description is based on percussion gun sidewall core samples. Grayish-orange-pink; vitric, zeolitic in part; rare white pumice; common felsic phenocrysts of feldspar and lesser but conspicuous quartz; common mafic minerals of biotite and lesser clinopyroxene and hornblende; rare lithic fragments.	mafic-rich Rainier Mesa Tuff

Lithologic Log of Well ER-3-2 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
877.2 - 897.9 m (2,878 - 2,946 ft)	Moderately Welded Ash-Flow Tuff: Description is based on percussion gun sidewall core samples. Pale-yellowish- brown; devitrified; common white pumice; rare to common felsic phenocrysts of feldspar and lesser quartz; rare to common mafic minerals of large biotite and much less clinopyroxene; rare lithic fragments.	mafic-rich Rainier Mesa Tuff
897.9 - 914.4 m (2,946 - 3,000 ft) TD	Moderately Welded Ash-Flow Tuff: Description is based on percussion gun sidewall core samples. Grayish-pink; devitrified; minor pale-red pumice; rare to common felsic phenocrysts of feldspar and quartz; rare biotite; trace lithic fragments.	mafic-poor Rainier Mesa Tuff

Well ER-3-2 Supplemental Data

1. For additional information regarding Well ER-3-2, see DOE (1995). Supplemental data listed below are also extracted from DOE (1995).
2. Well ER-3-2 is part of the UGTA monitoring well network.
3. Time Domain Reflectometry (TDR) instrumentation used to detect the presence of water in the drilling effluent was tested by Desert Research Institute during drilling of Well ER-3-2. Analysis of TDR and drilling data indicated a water level depth of 490 m (1,608 ft).
4. Drill cuttings were collected continuously at 3.05 m (10 ft) intervals from 36.6 - 603.5 m (120 - 1,980 ft). However, due to lost circulation conditions below 603.5 m (1,980 ft), drill cuttings were obtained from only the 612.6 m (2,010 ft) and 623.6 m (2,046 ft) depths. Because of the lack of drill cuttings samples below 603.5 m (1,980 ft), 66 percussion gun sidewall samples were collected from 611.7 to 911.4 m (2,007 - 2,990 ft).
5. Drilling of Well ER-3-2 took longer than expected because the target formation was deeper than predicted, and because of complications due to unstable hole conditions. Shortly after the water table was penetrated, the saturated alluvium began to slough. Consequently, no open hole pre-completion development was attempted in Well ER-3-2.

Figure 3

West-East Geologic Cross Section Through ER-3-2

KEY TO STRATIGRAPHIC SYMBOLS

QTa - Quaternary/Tertiary Alluvium
Tma - Ammonia Tanks Tuff (includes Tmob)
Tmr - Rainier Mesa Tuff
Tmrh/Th - Pre-Rainier Mesa, post-Wahmonie tuffs, undifferentiated

Twlb - Tuff of Wahmonie Flat
Tc - Crater Flat tuffs, undifferentiated
Tn/To - Tunnel Formation and Older Volcanics, undifferentiated
Pz - Paleozoic Rocks, undifferentiated

(modified from DOE, 1995)

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Stratigraphic Log of Well ER-6-1
(Logged by Lance Prothro, Bechtel Nevada, June 1996)

Meters	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
		Feet				Meters	Feet
0 - 101.5		0 - 333	Tuffaceous Alluvium	Alluvium	QTa	101.5	333
101.5 - 134.1		333 - 440	Ash-Flow Tuff: Nonwelded to partially welded, vapor-phase to 111.3 m (365 ft), vitric below.	mafic-poor Rainier Mesa Tuff, Timber Mountain Group	Tmrp	32.6	107
134.1 - 137.2		440 - 450	Reworked Tuff: Vitric.	tuff of Holmes Road, Timber Mountain Group	Tmrh	3.1	10
137.2 - 152.7		450 - 501	Ash-Flow Tuff: Nonwelded to partially welded, vitric to silicified.	Tiva Canyon Tuff, Paintbrush Group	Tpc	15.5	51
152.7 - 166.1		501 - 545	Bedded Tuff: Zeolitized.	Paintbrush Group, undifferentiated	Tp	13.4	44
166.1 - 237.1		545 - 778	Ash-Flow Tuff: Nonwelded to densely welded, vitric to devitrified.	Topopah Spring Tuff, Paintbrush Group	Tpt	71.0	233
237.1 - 251.8		778 - 826	Bedded Tuff: Vitric, zeolitized below 240.2 m (788 ft).	mafic-poor Calico Hills Formation	Thp	14.7	48

Stratigraphic Log of Well ER-6-1 (cont.)

Meters	Depth	Lithology	Stratigraphic Unit	Symbol	Thickness	
	Feet				Meters	Feet
251.8 - 285.3	826 - 936	Bedded Tuff: Zeolitized, mafic rich.	tuff of Wahmonie Flat	Twlb ¹	33.5	110
285.3 - 307.2	936.- 1008	Air-Fall Tuff: Zeolitized.	Prow Pass Tuff, Crater Flat Group	Tcp	21.9	72
307.2 - 324.9	1,008 - 1,066	Ash-Flow Tuff: Partially welded, zeolitized.	Bullfrog Tuff, Crater Flat Group	Tcb	17.7	58
324.9 - 333.8	1,066 - 1,095	Bedded Tuff: Zeolitized.	Tram Tuff, Crater Flat Group	Tct	8.9	29
333.8 - 353.0	1,095 - 1,158	Air-Fall Tuff: Zeolitized.	lower tuff, Crater Flat Group	Tcl	19.2	63
353.0 - 381.0	1,158 - 1,250	Air-Fall Tuff: Zeolitized.	Tunnel Formation, Tunnel 4 Member, beds 4K	Tn4K	28.0	92
381.0 - 390.1	1,250 - 1,280	Air-Fall Tuff: Zeolitized.	Tunnel Formation, Tunnel 4 Member, beds 4J	Tn4J	9.1	30

Stratigraphic Log of Well ER-6-1 (cont.)

	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
	390.1 - 392.6	1,280 - 1,288	Air-Fall Tuff: Zeolitized.	Tunnel Formation, Tunnel 4 Member, beds 4FGH, undifferentiated	Tn4FGH	2.5	8
	392.6 - 401.7	1,288 - 1,318	Ash-Flow Tuff: Nonwelded, zeolitized.	Tunnel Formation, Tunnel 4 Member, beds 4E (equivalent)	Tn4E	9.1	30
	401.7 - 405.4	1,318 - 1,330	Bedded Tuffs: Zeolitized.	Tunnel Formation, Tunnel 4 Member, beds 4ABCD, undifferentiated	Tn4ABCD	3.7	12
	405.4 - 409.7	1,330 - 1,344	Bedded Tuff: Zeolitized to weakly argillized.	Tunnel Formation, Tunnel 3 Member, beds 3D	Tn3D	4.3	14
	409.7 - 414.5	1,344 - 1,360	Ash-Flow Tuff: Nonwelded, zeolitized.	Tunnel Formation, Tunnel 3 Member, beds 3BC (equivalent)	Tn3BC ²	4.8	16
	414.5 - 429.2	1,360 - 1,408	Bedded Tuff: Zeolitized.	Tunnel Formation, Tunnel 3 Member, beds 3A	Tn3A	14.7	48

Stratigraphic Log of Well ER-6-1 (cont.)

	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
429.2 - 432.2		1,408 - 1,418	Air-Fall Tuff: Peralkaline, zeolitized.	Tub Spring Tuff, Volcanics of Big Dome	Tub	3.0	10
432.2 - 455.7		1,418 - 1,495	Bedded Tuff: Zeolitized.	tunnel bed 2, Volcanics of Oak Spring Butte	Ton2	23.5	77
455.7 - 492.9		1,495 - 1,617	Ash-Flow Tuff: Nonwelded, zeolitized.	Yucca Flat Tuff, Volcanics of Oak Spring Butte	Toy	37.2	122
492.9 - 522.4		1,617 - 1,714	Bedded Tuff: Zeolitized.	tunnel bed 1, Volcanics of Oak Spring Butte	Ton1	29.5	97
522.4 - 538.0		1,714 - 1,765	Bedded Tuff: Zeolitized to argillized.	older tuffs, undifferentiated	To	15.6	51
538.0 - 539.5		1,765 - 1,770	Paleocolluvium: Paleozoic carbonate clasts in a tuffaceous argillized matrix.	tuffaceous Paleocolluvium	Tlc	1.5	5
539.5 - 680.9		1,770 - 2,234	Dolostone: Light-olive-gray to light-brownish-gray, fine to medium crystalline.	Sevy Dolomite	Dv	141.4	464

Stratigraphic Log of Well ER-6-1 (cont.)

Meters	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
		Feet				Meters	Feet
680.9 - 890.0		2,234 - 2,920	Dolostone: Alternating intervals of light-brownish-gray, finely crystalline, vuggy dolostone; and medium-dark-gray, medium-crystalline, cherty dolostone.	Laketown Dolomite	Sl	209.1	686
890.0 - 940.6		2,920 - 3,086	Dolostone: Medium-gray to dark-gray and pale-yellowish-brown, medium-crystalline, cherty.	Ely Springs Dolomite	Oes	50.6	166
940.6 - 977.2 TD		3,086 - 3,206 TD	Sandstone and Quartzite: Sandstone is light-brownish-gray to brownish-gray, fine- to medium-grained, well sorted, and dolomitic. Quartzite is light-brownish-gray and very-pale-orange, medium-grained, and well sorted.	Eureka Quartzite	Oe	>36.6	>120

- 1 Preliminary work for this site reinforces interpretations based on petrographic work by R. G. Warren (LANL) for the U-3mL site that complex Tw/Ta or Tc relationships exist in this area. Additional work is needed to understand this relationship.
- 2 Recent studies indicate that the informal unit "Tunnel Formation, Subunit 3BC-Equivalent" may be the Tuff of Tolicha Peak (verbal communication, R. G. Warren).

Lithologic Log of Well ER-6-1
 Compiled by Lance B. Prothro, Bechtel Nevada
 June 1996

Lithologic descriptions for the interval 0 - 648.9 m (2,129 ft) are from Drellack and others (1992) and were compiled by Sigmund L. Drellack Jr. and Robert L. McCall of Raytheon Services Nevada. These descriptions are from drill cuttings samples at 3.0-m (1- ft) intervals. Descriptions below 648.9 m (2,129 ft) are from IT Corporation (1995) and were compiled by Lance B. Prothro of Raytheon Services Nevada. These descriptions are from 8.4-centimeter (3.3-inch) conventional cores. Only minor modifications for consistency and continuity were made to the original logs. The lithologic descriptions follow Raytheon Services Nevada Department Procedure NTS-GEO-003, "Description of Rock Samples." Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible. Stratigraphic nomenclature is generally from Ferguson and others (1994). Paleontological analysis by J. C. Cole and A. G. Harris of the United States Geological Survey (USGS) (Cole and Harris, 1996) confirmed most of the original stratigraphic assignments below 648.9 m (2,129 ft). The analysis indicated that the original assignment of Laketown Dolomite for the interval 648.9 - 680.9 m (2,129 - 2,234 ft) is incorrect. The interval is actually Sevy Dolomite and has been reassigned accordingly. Based on this reassignment and previous paleontological work by A. G. Harris (USGS) on drill cuttings from the overlying interval of dolostone (Cole and Harris, 1996), the interval from 539.5 - 648.9 m (1,770 - 2,129 ft) has also been reassigned to the Sevy Dolomite. Notes 1 and 2 are listed at end of log, page 46.

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
0 - 101.5 m (0 - 333 ft)	Tuffaceous Alluvium: Light-brown to moderate-brown (5YR3/4) and moderate-yellowish-brown; nonindurated to poorly indurated, rare fairly indurated caliche-cemented aggregates; poorly sorted, silt to pebble sizes; tuffaceous with less than 2 percent Paleozoic rock fragments; less than 1 percent total carbonate fragments; subrounded to subangular; calcareous. Sandy in parts, particularly above 61 m (200 ft). Granule and larger sized pieces are largely Rainier Mesa Tuff (Tmr) lithology with lesser Topopah Spring Tuff (Tpt) and other pre-Rainier units. Tpt constituent increasing in 67 - 88 m (220 - 290 ft) interval.	Alluvium
101.5 - 111.3 m (333 - 365 ft)	Partially Welded Ash-Flow Tuff: Light-gray with purplish tint; devitrified; strong vapor-phase mineralization; fair induration; minor light-brownish-gray to moderate-yellowish-brown pumice; minor dipyramidal quartz and feldspar phenocrysts; scarce mafic minerals; scarce lithic fragments.	mafic-poor Rainier Mesa Tuff

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
111.3 - 117.3 m (365 - 385 ft)	Partially Welded Ash-Flow Tuff: Grayish-red to moderate-brown; well indurated; becoming moderate-reddish-brown and less indurated below 113 m (370 ft); vitric; common pale-red pumice; abundant clear glass shards.	mafic-poor Rainier Mesa Tuff
117.3 - 128.0 m (385 - 420 ft)	Nonwelded Ash-Flow Tuff: Pale-reddish-brown to moderate-reddish-brown; friable; vitric; common pumice, sizes to greater than 1 centimeter (cm) in diameter; common quartz and feldspar phenocrysts; scarce to rare mafic minerals; rare lithic fragments; very abundant clear glass shards.	mafic-poor Rainier Mesa Tuff
128.0 - 134.1 m (420 - 440 ft)	Nonwelded Ash-Flow Tuff: Pale-reddish-brown to moderate-orange-pink; fair induration to friable; vitric; common grayish-orange-pink to pinkish-gray pumice; minor to common quartz and feldspar phenocrysts; scarce mafic minerals; rare lithic fragments.	mafic-poor Rainier Mesa Tuff
134.1 - 137.2 m (440 - 450 ft)	Reworked Tuff: Light-brown to moderate-brown; well indurated; vitric to devitrified; calcareous to weakly silicified; rare pumice; common to abundant feldspar and quartz phenocrysts; rare small mafic minerals of hornblende, biotite, and magnetite; rare lithic fragments.	tuff of Holmes Road

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
137.2 - 143.3 m (450 - 470 ft)	Nonwelded Ash-Flow Tuff: Moderate-yellowish-brown; moderate induration; vitric; dark-yellowish-orange to dark-yellowish-brown pumice to > 2 cm in diameter; shard rich; scarce feldspar phenocrysts; very scarce mafic minerals, including biotite and clinopyroxene; very scarce lithic fragments.	Tiva Canyon Tuff
143.3 - 149.3 m (470 - 490 ft)	Nonwelded to Partially Welded Ash-Flow Tuff: Dark-yellowish-brown; well indurated; vitric (glass shards) to devitrified (matrix) to silicified, some sucrosic secondary mineralization, possibly weakly zeolitized; minor moderate-brown pumice; phenocryst poor; porous texture, voids 0.1 millimeter (mm) in size.	Tiva Canyon Tuff
149.3 - 152.7 m (490 - 501 ft)	Nonwelded Ash-Flow Tuff: Moderate to dark-yellowish-brown; poorly indurated, friable; vitric; shard rich; very (Shard-rich base) scarce pumice; phenocryst poor; trace biotite; trace lithic fragments.	Tiva Canyon Tuff

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
152.7 - 166.1 m (501 - 545 ft)	Bedded Tuff: Grayish-orange and moderate-yellowish-brown to yellowish-gray to pale-greenish-yellow; moderately to well indurated; zeolitized; some sucrosic secondary mineralization; common pale-greenish-yellow pumice to 1 cm in diameter; scarce feldspar phenocrysts; scarce to rare mafic minerals including clinopyroxene, including distinct small MnO ₂ stains, an increase in mafic minerals around 160 - 163 m (525 - 535 ft); rare to minor lithic fragments.	Paintbrush Group, undifferentiated
166.1 - 169.2 m (545 - 555 ft)	Nonwelded Ash-Flow Tuff: Moderate-yellowish-brown; moderately indurated to friable; zeolitized; possibly sucrosic secondary mineralization; common light-olive-gray to dark-yellowish-brown pumice; rare felsic phenocrysts; scarce mafic minerals; very scarce lithic fragments.	Topopah Spring Tuff
169.2 - 170.7 m (555 - 560 ft)	Moderately to Densely Welded Ash-Flow Tuff: Moderate-brown; very hard and dense; devitrified; minor feldspar phenocrysts.	Topopah Spring Tuff
170.7 - 175.3 m (560 - 575 ft)	Densely Welded Ash-Flow Tuff: Black; vitrophyre; perlitic glass texture minor to common black flattened pumice; minor feldspar phenocrysts. Some (vitrophyre) mottled with moderate-brown, densely welded, and devitrified.	Topopah Spring Tuff (Vitrophyre)

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
175.3 - 184.1 m (575 - 604 ft)	Moderately to Densely Welded Ash-Flow Tuff: Mottled moderate-brown and grayish-red; devitrified; minor pumice; minor feldspar phenocrysts; very scarce mafic (minerals, including clinopyroxene and biotite; scarce lithic fragments. Conspicuous lithophysae cavities to 5 cm in diameter noted in downhole camera video. Euhedral quartz clusters with individual crystals <1 mm to 3 mm in length present in cuttings samples.	Topopah Spring Tuff (Lithophysal zone)
184.1 - 213.4 m (604 - 700 ft)	Moderately to Densely Welded Ash-Flow Tuff: Pale-brown; very hard and dense; devitrified; rare pumice with some vapor-phase mineralization; rare feldspar phenocrysts; scarce mafic minerals (bronze biotite); very scarce lithic fragments.	Topopah Spring Tuff
213.4 - 225.6 m (700 - 740 ft)	Densely Welded Ash-Flow Tuff: Moderate-brown; very hard and dense; vitric to partially devitrified; some anastomosing devitrification ("leopard spots"), dark-grayish-red and moderate-brown; phenocryst poor; very scarce mafic minerals; very scarce lithic fragments.	Topopah Spring Tuff
225.6 - 231.6 m (740 - 760 ft)	Moderately Welded Ash-Flow Tuff: Olive-black glass shards in a moderate-brown matrix; well indurated; vitric; "basal vitrophyre;" very abundant translucent olive-black glass shards; phenocryst poor.	Topopah Spring Tuff ("Basal Vitrophyre")

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
231.6 - 237.1 m (760 - 778 ft)	Nonwelded to Partially Welded Ash-Flow Tuff: Moderate-yellowish-brown; moderate- to dark-yellowish-brown matrix and very abundant olive-black glass shards; well indurated; vitric; phenocryst poor.	Topopah Spring Tuff
237.1 - 240.2 m (778 - 788 ft)	Air-Fall Tuff: Pale-yellow-brown; vitric; moderate induration; abundant clear to translucent very-light-gray glass shards; minor to common light-gray pumice, 3 mm to several centimeters in diameter, and light-brown pumice, 1 to 6 mm in diameter; minor felsic phenocrysts; scarce mafic minerals; rare lithic fragments.	mafic-poor Calico Hills Formation
240.2 - 251.8 m (788 - 826 ft)	Bedded Tuff: Grayish-orange to moderate-yellowish-brown; moderately to well indurated; zeolitized; generally common to abundant very-pale-orange pumice, common feldspar and quartz phenocrysts; rare mafic minerals; rare to minor lithic fragments.	mafic-poor Calico Hills Formation
251.8 - 254.5 m (826 - 835 ft)	Bedded Tuff: Moderate-yellowish-brown; moderate induration; zeolitized; minor pumice; mafic rich, mostly biotite, some hornblende; minor lithic fragments.	tuff of Wahmonie Flat

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
254.5 - 257.6 m (835 - 845 ft)	Bedded Tuff: Pale-greenish-yellow to grayish-yellow; good induration; zeolitized; mafic rich, mostly biotite and magnetite, some hornblende, trace clinopyroxene; common to indistinct pale-greenish-yellow pumice; abundant feldspar phenocrysts; rare lithic fragments; possibly interbedded with dark-yellowish-brown reworked tuff and tuffaceous sandstone described below.	tuff of Wahmonie Flat
257.6 - 260.6 m (845 - 855 ft)	Tuffaceous Sandstone: Dark-yellowish-brown; moderate induration; zeolitized; fine grained; bedded; mafic rich, mostly biotite; common small lithic fragments. NOTE: The 259-m (850-ft) cuttings sample is contaminated with cavings from up-hole.	tuff of Wahmonie Flat
260.6 - 269.4 m (855 - 884 ft)	Air-Fall Tuff: Pale-greenish-yellow; good induration; zeolitized; mafic-rich, mostly biotite; minor feldspar phenocrysts; rare lithic fragments. Possibly some tuffaceous sandstone as above.	tuff of Wahmonie Flat
269.4 - 279.8 m (884 - 918 ft)	Air-Fall Tuff: Grayish-yellow; good induration; zeolitized; abundant to indistinct pale-greenish-yellow pumice; scarce quartz and feldspar phenocrysts; scarce mafic minerals, rare MnO ₂ stains; minor lithic fragments 0.5 m to 2 mm in diameter. Trace botryoidal chalcedony vein material in the 277.4 m (910 ft) sample.	Crater Flat Group, undifferentiated or Calico Hills Formation ¹

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
279.8 - 285.3 m (918 - 936 ft)	Reworked Tuff grading to Tuffaceous Sandstone: Dark-yellowish-brown; good induration; zeolitized; minor small, very-pale-orange pumice; mafic-rich; common feldspar phenocrysts; minor small lithic fragments. This lithology is represented in the 286.5-m and 289.6-m (940-ft and 950-ft) cuttings samples.	tuff of Wahmonie Flat ¹
285.3 - 300.5 m (936 - 986 ft)	Bedded Tuff: Grayish-orange; well indurated; zeolitized; common pale-greenish-yellow pumice to 1 cm in diameter; minor to common feldspar and quartz phenocrysts; common small lithic fragments 0.25 to 1 mm in diameter; rare mafic minerals of biotite, magnetite, trace hornblende.	Prow Pass Tuff
300.5 - 307.2 m (986 - 1,008 ft)	Bedded Tuff: Grayish-yellow; well indurated; zeolitized; small to indistinct pale-greenish-yellow pumice; abundant feldspar and quartz phenocrysts; minor mafic minerals, biotite dominant, magnetite, trace hornblende; minor lithic fragments, typically 0.5 to 1 mm in diameter. Grades to tuffaceous sandstone in parts.	Prow Pass Tuff
307.2 - 324.9 m (1,008 - 1,066 ft)	Partially Welded Ash-Flow Tuff: Grayish-orange; well indurated; zeolitized; minor to common pumice; rare felsic phenocrysts; rare mafic minerals, mostly biotite, some hornblende; rare lithic fragments; trace silicified in upper 3 m (10 ft).	Bullfrog Tuff

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
324.9 - 333.8 m (1,066 - 1,095 ft)	Air-Fall Tuff: Grayish-yellow; fairly indurated; zeolitized; common grayish-yellow to pale-greenish-yellow pumice; minor feldspar and quartz phenocrysts; rare mafic minerals of biotite, hornblende, and magnetite; scarce moderate-brown (5YR4/4) lithic fragments up to 1 cm in diameter.	Tram Tuff
333.8 - 353.0 m (1,095 - 1,158 ft)	Air-Fall Tuff: Moderate-yellowish-brown; well indurated; zeolitized; abundant very pale-orange to pale-greenish-yellow pumice 0.5 to 2 mm in diameter; minor felsic phenocrysts; minor mafic minerals; rare lithic fragments.	lower tuff
353.0 - 364.5 m (1,158 - 1,196 ft)	Bedded Tuff: Moderate-yellowish-brown, some mottled with moderate-reddish-brown; moderately indurated; zeolitized; common very-pale-orange pumice; minor felsic phenocrysts; minor to common mafic minerals including biotite, trace pyroxene; rare lithic fragments.	Tunnel Formation, Tunnel 4 Member, beds 4K
364.5 - 377.3 m (1,196 - 1,238 ft)	Air-Fall Tuff: Moderate-reddish-brown; well indurated; zeolitized; abundant grayish-orange-pink pumice, 0.5 to 3 mm in diameter, some with mafic minerals; minor felsic phenocrysts; common mafic minerals, mostly biotite with lesser hornblende; rare lithic fragments.	Tunnel Formation, Tunnel 4 Member, beds 4K

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
377.3 - 381.0 m (1,238 - 1,250 ft)	Air-Fall Tuff: Yellowish-gray to very-light-gray; fair induration; zeolitized; mafic-rich, mostly biotite and hornblende; common felsic phenocrysts; indistinct very-light-gray pumice; scarce lithic fragments.	Tunnel Formation, Tunnel 4 Member, beds 4K
381.0 - 390.1 m (1,250 - 1,280 ft)	Air-Fall Tuff: Moderate-reddish-brown; moderately to well indurated; zeolitized to argillized; common very-pale-orange pumice; rare felsic phenocrysts, feldspar and lesser quartz; rare mafic minerals (biotite, magnetite, clinopyroxene); scarce lithic fragments.	Tunnel Formation, Tunnel 4 Member, beds 4J
390.1 - 392.6 m (1,280 - 1,288 ft)	Reworked Tuff: Grayish-orange to pale-yellowish-orange to moderate-reddish-orange; moderately indurated; zeolitized to weakly argillized; minor very-pale-orange pumice; rare felsic phenocrysts; scarce mafic minerals (biotite); rare lithic fragments.	Tunnel Formation, Tunnel 4 Member, beds 4FGH, undifferentiated
392.6 - 401.7 m (1,288 - 1,318 ft)	Partially Welded Ash-Flow Tuff: Mottled grayish-orange and moderate-reddish-brown; moderately indurated; zeolitized; minor pale-yellowish-orange to grayish-yellow pumice to 8 mm in diameter; rare felsic phenocrysts, generally feldspar with lesser quartz; rare mafic minerals (biotite and magnetite); rare to minor lithic fragments to 7 mm in diameter.	Tunnel Formation, Tunnel 4 Member, beds 4E (equivalent)

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
401.7 - 405.4 m (1,318 - 1,330 ft)	Bedded Tuff: Grayish-orange to moderate-yellowish-brown; moderately indurated; zeolitized; common grayish-orange pumice; common felsic phenocrysts; scarce mafic minerals; rare lithic fragments.	Tunnel Formation, Tunnel 4 Member, beds 4ABCD, undifferentiated
405.4 - 409.7 m (1,330 - 1,344 ft)	Bedded Tuff: Moderate-reddish-brown; well indurated; zeolitized to weakly argillized; abundant very-pale-orange pumice up to 2 mm in diameter; minor felsic phenocrysts; rare mafic minerals, rare lithic fragments.	Tunnel Formation, Tunnel 3 Member, beds 3D
409.7 - 414.5 m (1,344 - 1,360 ft)	Nonwelded Ash-Flow Tuff: Mottled with grayish-yellow and moderate-reddish-orange; moderately indurated; rare grayish-yellow to very-pale-orange pumice; very scarce felsic phenocrysts; very scarce mafic minerals; scarce lithic fragments. Abundant glass shard molds.	Tunnel Formation, Tunnel 3 Member, beds 3BC (equivalent) ²
414.5 - 429.2 m (1,360 - 1,408 ft)	Bedded Tuff: Moderate-reddish-brown; well indurated; zeolitized to argillized; minor very-pale-orange pumice; rare to scarce felsic phenocrysts; rare mafic minerals (biotite, magnetite); very scarce lithic fragments.	Tunnel Formation, Tunnel 3 Member, beds 3A
429.2 - 432.2 m (1,408 - 1,418 ft)	Bedded Tuff: Dusky-yellow; peralkaline; well indurated; zeolitized; indistinct pumice; common felsic phenocrysts including dipyrarnidal quartz; scarce magnetite; rare lithic fragments.	Tub Spring Tuff

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
432.2 - 440.3 m (1,418 - 1,445 ft)	Bedded Tuff: Grayish-yellow; well indurated; zeolitized; common pale-greenish-yellow pumice; common felsic phenocrysts; rare to minor mafic minerals (biotite, magnetite); minor lithic fragments.	tunnel bed 2
440.3 - 446.5 m (1,445 - 1,465 ft)	Bedded Tuff: Grayish-yellow to pale-greenish-yellow, some mottled with grayish-orange-pink; moderately indurated; zeolitized; minor pale-greenish-yellow to grayish-orange-pink pumice to 1.5 cm in diameter; minor felsic phenocrysts; minor mafic minerals (magnetite, biotite); very scarce lithic fragments.	tunnel bed 2
446.5 - 455.7 m (1,465 - 1,495 ft)	Bedded Tuff: Moderate-reddish-brown; well indurated; zeolitized, possibly weakly argillized in some intervals; abundant very-pale-orange pumice up to 2 mm in diameter; rare felsic phenocrysts; rare mafic minerals and lithic fragments.	tunnel bed 2
455.7 - 492.9 m (1,495 - 1,617 ft)	Partially Welded Ash-Flow Tuff: Yellowish-gray; well indurated; zeolitized; minor grayish-yellow to pale-greenish-yellow pumice, some with sucrosic secondary mineralization; common felsic phenocrysts of feldspar and quartz, decreasing to minor with depth; common mafic minerals, biotite dominant; minor lithic fragments to 2 cm in diameter.	Yucca Flat Tuff

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
492.9 - 506.0 m (1,617 - 1,660 ft)	Bedded Tuff: Grayish-yellow; well indurated; zeolitized; common to indistinct grayish-yellow pumice to 5 mm in diameter; felsic phenocrysts variable from rare to abundant; minor mafic minerals, mostly biotite and magnetite; rare lithic fragments.	tunnel bed 1
506.0 - 510.5 m (1,660 - 1,675 ft)	Bedded Tuff: Dark-reddish-brown; well indurated; zeolitized to weakly argillized; common pale-red pumice exhibiting corroded texture; minor felsic phenocrysts; minor mafic minerals; scarce lithic fragments; sugrosic texture.	tunnel bed 1
510.5 - 513.6 m (1,675 - 1,685 ft)	Bedded Tuff: Grayish-yellow; well indurated; zeolitized; common to indistinct grayish-yellow pumice; abundant large felsic phenocrysts, including some quartz; common biotite; rare lithic fragments.	tunnel bed 1
513.6 - 516.6 m (1,685 - 1,695 ft)	Reworked Tuff: Moderate-reddish-brown; well indurated; zeolitized to weakly argillized; common very-pale-orange pumice, becoming rare in lower half of interval; abundant felsic phenocrysts; rare mafic minerals of biotite and magnetite; rare small lithic fragments.	tunnel bed 1

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
516.6 - 522.4 m (1,695 - 1,714 ft)	Bedded Tuff: Moderate- to dark-reddish-brown; poorly to fairly indurated; zeolitized to strongly argillized; scarce to rare pumice; common felsic phenocrysts; rare mafic minerals; lithic fragments vary from rare to common in reworked zones. Lower contact is probable fault zone.	tunnel bed 1
522.4 - 526.7 m (1,714 - 1,728 ft)	Bedded Tuff: Grayish-orange-pink to moderate-orange-pink; fair to moderate induration; zeolitized; rare grayish-yellow pumice up to 4 mm in diameter; rare to minor felsic phenocrysts; rare mafic minerals; rare lithic fragments.	older tuffs, undifferentiated
526.7 - 530.4 m (1,728 - 1,740 ft)	Bedded Tuff: Moderate- to dark-reddish-brown; poor to fair induration; zeolitized and argillized; generally common very-pale-orange pumice. Some argillized reworked lithologies with rare pumice; minor felsic phenocrysts; rare mafic minerals and lithic fragments.	older tuffs, undifferentiated
530.4 - 538.0 m (1,740 - 1,765 ft)	Bedded Tuff(?): Grayish-orange, delicately mottled with moderate-reddish-brown; fairly indurated; zeolitized to weakly argillized; minor very-pale-orange pumice; minor felsic phenocrysts; minor mafic minerals (biotite and magnetite); rare lithic fragments. Thin calcite filled fractures.	older tuffs, undifferentiated

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
538.0 - 539.5 m (1,765 - 1,770 ft)	Paleocolluvim: Moderate to dark-reddish-brown; poorly indurated to friable; argillized; tuffaceous; minor grayish-orange-pink pumice; minor felsic phenocrysts; scarce small Paleozoic rock fragments.	tuffaceous Paleocolluvium
539.5 - 648.9 m (1,770 - 2,129 ft) Temporary TD (drill hole)	Dolostone: Light-olive-gray; fine to medium crystalline; dense; hard; trace vuggy porosity with euhedral dolomite crystals. Some sucrosic texture (on fracture surfaces), trace calcareous; trace moderate-reddish-orange argillaceous fracture fill/coatings. Trace grayish-red to moderate-reddish-brown iron-oxide stain on some fracture surfaces. Moderate-reddish-brown finely laminated/fissile clay fracture fill in the 612.6-m (2,010-ft) cuttings sample.	Sevy Dolomite
648.9 - 680.9 m (2,129 - 2,234 ft)	Dolostone: Light-brownish-gray; cryptocrystalline to medium crystalline; vuggy, with <5 percent vuggy porosity. Vugs are <1 cm in size and lined in part with euhedral dolomite crystals.	Sevy Dolomite
680.9 - 701.0 m (2,234 - 2,300 ft)	Dolostone: Medium-dark-gray to dark-gray; medium crystalline; vuggy in part; scattered nodules and lenses of pale-reddish-brown, black, and very-pale-orange chert; brecciated in part.	Laketown Dolomite

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
701.0 - 724.2 m (2,300 - 2,376 ft)	Dolostone: Light-brownish-gray; finely crystalline; vuggy, with <5 percent vuggy porosity. Vugs are <1 cm in size and lined in part with euhedral dolomite crystals. Brecciated from approximately 712.9 - 713.5 m (2,339 - 2,341 ft).	Laketown Dolomite
724.2 - 748.9 m (2,376 - 2,457 ft)	Dolostone: Medium-gray to medium-dark-gray; finely to medium crystalline. Abundant dark-yellowish-orange clay occurs as fracture fillings from approximately 730.6 - 742.2 m (2,397 - 2,435 ft).	Laketown Dolomite
748.9 - 890.0 m (2,457 - 2,920 ft)	Dolostone: Light-brownish-gray to brownish-gray; finely crystalline; vuggy, with <5 percent vuggy porosity. Vugs are less than 1 cm in size and lined in part with euhedral calcite and dolomite crystals. Fossiliferous from approximately 800.1 - 809.2 m (2,625 - 2,655 ft) consisting of relic shell fragments. Brecciated in part to 823.0 m (2,700 ft) with conspicuous moderate-reddish-brown clay as fracture fillings.	Laketown Dolomite
890.0 - 940.6 m (2,920 - 3,086 ft)	Dolostone: Medium-gray to medium-dark-gray to 906.2 m (2,973 ft), pale-yellowish-brown from 906.2 - 915.0 m (2,973 - 3,002 ft), and medium-dark-gray to dark-gray below 915.0 m (3,002 ft); medium crystalline; abundant lenses of pale-yellowish-brown to dark-yellowish-brown chert from 918.4 - 936.7 m (3,013 - 3,073 ft).	Ely Springs Dolomite

Lithologic Log of Well ER-6-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
940.6 - 952.2 m (3,086 - 3,124 ft)	Sandstone: Light-brownish-gray to brownish-gray, mottled in part; well indurated; 70 percent fine- to medium-grained, well sorted, subrounded quartz sand; 30 percent dolomite cement becoming mostly silica cemented near base of interval.	Eureka Quartzite
952.2 - 977.2 m (3,124 - 3,206 ft) Final TD (core hole)	Quartzite: Light-brownish-gray to pale-yellowish-brown to 965.9 m (3,169 ft); very-pale-orange to grayish-orange below; very well indurated; 85 percent medium-grained, very well sorted, subrounded to rounded quartz sand; 15 percent silica cement.	Eureka Quartzite

Notes

- 1 Preliminary work for this site reinforces interpretations based on petrographic work by R. G. Warren (LANL) for the U-3mL site that complex Tw/Ta or Tc relationships exist in this area. Additional work is needed to understand this relationship.
- 2 Recent studies indicate that the informal unit "Tunnel Formation, Subunit 3BC-Equivalent" may be the Tuff of Tolicha Peak (verbal communication, R. G. Warren).

Well ER-6-1 Supplemental Data

1. Well ER-6-1 was the second hole drilled for the Groundwater Characterization Project. No completion strings have been installed at this time, but when the well is completed it will be part of the UGTA monitoring well network of the DOE/NV Environmental Restoration Program at the NTS.
2. The 1992 preliminary report for Well ER-6-1 contains data collected through 1 September 1992 (Drellack, et al., 1992). Supplemental data listed below are also extracted from this reference, unless noted otherwise.
3. The lower 328.3 m (1,077 ft) of Well ER-6-1 was continuously cored in 1994. A draft well-completion report has been prepared that includes data for this phase of drilling (DOE, 1997). This report will be finalized when the completion string(s) have been installed.
4. Approximately 73.2 m (240 ft) of the stratigraphic section has been faulted out of the lower Tertiary section. This west-dipping fault was intersected at 522.4 m (1,714 ft).
5. Paleontology samples collected from within the Paleozoic section are available. For further information see Cole and Harris (1996).
6. A fracture analysis report for Well ER-6-1 is available. For further information see IT, 1995.
7. Downhole camera video log for Well ER-6-1 (surface to 460.2 m [1,510.0 ft]) interval is available. 35-mm slides documenting drilling activities, equipment, and samples at Well ER-6-1 are also available.
8. Listings of chloride, bromide, and inorganic carbon content for unwashed drill cuttings samples from the 3.0 - 125.0 m (10 - 410 ft) depth interval are available.
9. Eleven polished thin sections from cuttings samples are available from the interval 146.3 - 563.9 m (480 - 1,850 ft).
10. Water samples were collected during drilling. A fluid level depth of 470.9 m (1,545 ft) was measured on 09/07/1992.
11. Well ER-6-1 Satellite Hole #1 is located approximately 16.5 m (54 ft) south-southeast of Well ER-6-1. Due to the close proximity of this satellite hole to Well ER-6-1, the geology is assumed to be the same.

Figure 4
West-East Geologic Cross Section Through Well ER-6-1

QTa - Tuffaceous Alluvium
 Tmr - Rainier Mesa Tuff
 Tmrh/Tpc - Tuff of Holmes Road/Tiva Canyon Tuff
 Tpt - Topopah Spring Tuff
 Th /Twlb - Calico Hills Tuff/Wahmonie Tuff
 Tc - Crater Flat Tuff
 Tn - Tunnel Beds
 Toy - Yucca Flat Tuff
 To - older volcanics undifferentiated

Dg - Guilmette Formation
 Ds - Simonson Dolomite
 Dv - Sevy Dolomite
 S1 - Laketown Dolomite
 Oes - Ely Springs Dolomite
 Oe - Eureka Quartzite
 Oa - Antelope Valley Limestone
 On - Ninemile Formation

SWL - Static Water Level

MSL - Mean Sea Level

Scale (meters)

Figure 5
North South Geologic Cross Section Through Well ER-6-1

QTa - Tuffaceous Alluvium
 Tmr - Rainier Mesa Tuff
 Tmrh/Tpc - Tuff of Holmes Road/Tiva Canyon Tuff
 Tpt - Topopah Spring Tuff
 Th /Twlb - Calico Hills Tuff/Wahmonite Tuff
 Tc - Crater Flat Tuff
 Tn - Tunnel Beds
 Toy - Yucca Flat Tuff
 To - older volcanics undifferentiated

Dv - Sevy Dolomite
 Sl - Laketown Dolomite
 Oes - Ely Springs Dolomite
 Oe - Eureka Quartzite
 Oa - Antelope Valley Limestone

SWL - Static Water Level
 MSL - Mean Sea Level

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Stratigraphic Log of Emplacement Hole U-7cd
 Logged by Robert L. McCall, Raytheon Services Nevada, July 1992

	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
	0 - 115.5	0 - 379	Tuffaceous Alluvium	Alluvium	QTa	115.5	379
	115.5 - 169.5	379 - 556	Ash-Flow Tuff: Nonwelded to moderately welded, vitric to devitrified.	Ammonia Tanks Tuff, Timber Mountain Group	Tma	54	177
	169.5 - 175.6	556 - 576	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	6.1	20
	175.6 - 328.6	576 - 1078	Ash-Flow Tuff: Nonwelded to densely welded, vitric to devitrified.	Rainier Mesa Tuff, Timber Mountain Group	Tmr	153.0	502
	328.6 - 438.9	1,078 - 1,440	Bedded Tuff: Zeolitized.	pre-Rainier Mesa, post-Wahmonie bedded tuff, undifferentiated	Tmrl/Th	110.3	362

Stratigraphic Log of Emplacement Hole U-7cd (cont.)

Meters	Depth	Lithology	Stratigraphic Unit	Symbol	Thickness	
	Feet				Meters	Feet
438.9 - 460.2	1,440 - 1,510	Bedded Tuff: Zeolitized.	tuff of Wahmonie Flat, Wahmonie Formation	Twlb	21.3	70
460.2 - 495.3 TD	1,510 - 1,625 TD	Bedded Tuff: Zeolitized.	Crater Flat Group, undifferentiated	Tc	>35.1	>115

Lithologic Log of Emplacement Hole U-7cd
 Logged by Robert L. McCall, Raytheon Services Nevada
 July 1992

Unless otherwise noted, the following descriptions refer to washed cuttings samples at 3.05-m (10-ft) intervals. Colors are determined by comparing wet sample color to the Geological Society of America Rock-Color Chart. Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible.

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
0 - 36.6 m (0 - 120 ft)	No samples.	Alluvium
36.6 - 54.9 m (120 - 180 ft)	Tuffaceous Alluvium: Moderate and dark-yellowish-brown to pale-yellowish-brown; nonindurated; subangular to subrounded; moderately sorted; sand to gravel sizes; tuffaceous with 5 to 10 percent Paleozoic rock fragments; weakly calcareous.	Alluvium
54.9 - 76.2 m (180 - 250 ft)	Tuffaceous Alluvium: Samples are varicolored; poorly indurated; subrounded; poorly sorted; conspicuous increase of pebble-sized tuffaceous fragments with 10 percent Paleozoic rock fragments of which more than 5 percent are carbonate; moderately calcareous; carbonate-rich pebble bed from 73.2 - 76.2 m (240 - 250 ft).	Alluvium
76.2 - 115.5 m (250 - 379 ft)	Tuffaceous Alluvium: Grayish-orange to moderately-yellowish-brown; nonindurated; well sorted; subangular to subrounded; fine to very coarse sand sizes; tuffaceous alluvium with 5 percent Paleozoic rock fragments; calcareous; increasing to 10 percent Paleozoic rock fragments (< 2 percent are carbonate) below 106.7 m (350 ft).	Alluvium

Lithologic Log of Emplacement Hole U-7cd (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
115.5 - 133.8 m (379 - 439 ft)	Nonwelded Ash-Flow Tuff: Moderate-yellowish-brown to grayish-orange; vitric; poorly indurated; minor pinkish-gray to dark-yellowish-gray pumice; minor felsic phenocrysts of quartz and feldspar; rare mafic minerals of biotite and magnetite; scarce dark-reddish-brown lithic fragments.	Ammonia Tanks Tuff
133.8 - 139.0 m (439 - 456 ft)	Partially Welded Ash-Flow Tuff: Grayish-orange; partially devitrified; minor felsic phenocrysts of quartz, chatoyant sanidine, and other feldspars; rare mafic minerals of biotite and magnetite; scarce dark-reddish-brown lithic fragments up to 5 mm in diameter; common black cusped glass shards.	Ammonia Tanks Tuff
139.0 - 149.4 m (456 - 490 ft)	Nonwelded Ash-Flow Tuff: Grayish-orange becoming pale-brown below 146.3 m (480 ft); vitric to partially devitrified; poorly indurated; minor light-gray pumice; common felsic phenocrysts of chatoyant sanidine, quartz, and lesser amounts of other feldspars; rare mafic minerals of biotite and magnetite; scarce grayish-red-purple lithic fragments up to 5 mm in diameter; minor black cusped glass shards.	Ammonia Tanks Tuff

Lithologic Log of Emplacement Hole U-7cd (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
149.4 - 169.5 m (490 - 556 ft)	Nonwelded Ash-Flow Tuff: Pale-yellowish-brown; sample is enriched in felsic phenocrysts; vitric; poorly indurated; common chatoyant sanidine, quartz and feldspars; scarce biotite, magnetite and clinopyroxene; scarce lithic fragments; trace of grayish-orange glass shards.	Ammonia Tanks Tuff
169.5 - 175.6 m (556 - 576 ft)	Bedded Tuff: Very-pale-orange; poorly indurated; vitric; minor felsic phenocrysts of quartz and feldspar; scarce mafic minerals of biotite and magnetite; scarce lithic fragments.	bedded Ammonia Tanks Tuff
175.6 - 203.0 m (576 - 666 ft)	Nonwelded Ash-Flow Tuff: Grayish-orange becoming dark-yellowish-brown to pale-brown below 179.8 m (590 ft); poorly indurated; vitric becoming partially devitrified below 179.8 m (590 ft); minor light-brown pumice; felsic phenocrysts of quartz and feldspar; scarce mafic minerals of biotite, hornblende, and magnetite; scarce lithics; "crystal slurry" from 173.7 - 192.0 m (570 - 630 ft).	mafic-rich Rainier Mesa Tuff
203.0 - 211.8 m (666 - 695 ft)	Partially Welded Ash-Flow Tuff: Moderate-yellowish-brown; moderately indurated; devitrified; minor moderate-reddish-brown pumice; minor felsic phenocrysts of dipyrarnidal quartz and feldspar; rare mafic minerals of biotite, hornblende, clinopyroxene and magnetite.	mafic-rich Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-7cd (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
211.8 - 214.3 m (695 - 703 ft)	Moderately Welded Ash-Flow Tuff: Light-brown (5YR5/6) to moderate-yellowish-brown; moderate induration; devitrified; minor varicolored pumice with vapor-phase mineralization present; minor felsic phenocrysts of dipyrarnidal quartz and feldspar; rare mafic minerals of biotite, clinopyroxene, and magnetite; trace of lithic fragments.	mafic-rich Rainier Mesa Tuff
214.3 - 217.6 m (703 - 714 ft)	Densely Welded Ash-Flow Tuff: Moderate-brown (5YR4/4); well indurated; partially devitrified with some silicification; minor felsic phenocrysts of quartz and feldspar; rare mafic minerals of biotite, clinopyroxene, and magnetite; trace of lithic fragments; minor pieces of black vitrophyre in cuttings samples.	mafic-rich Rainier Mesa Tuff
217.6 - 230.7 m (714 - 757 ft)	Moderately Welded Ash-Flow Tuff: Light-brown (5YR6/4) to moderate-brown (5YR4/4); moderately indurated; devitrified; minor to rare felsic phenocrysts of dipyrarnidal quartz and feldspar; trace of mafic minerals of biotite and magnetite; trace of dark-reddish-brown lithic fragments.	mafic-rich Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-7cd (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
230.7 - 243.2 m (757 - 798 ft)	Moderately Welded Ash-Flow Tuff: Light-brown (5YR6/4); fairly indurated; devitrified; minor grayish-orange-pink pumice; minor felsic phenocrysts of quartz and feldspar; trace of biotite and magnetite; trace of dark-reddish-brown lithics.	mafic-poor Rainier Mesa Tuff
243.2 - 264.6 m (798 - 868 ft)	Densely Welded Ash-Flow Tuff: Light-brown (5YR6/4) to moderate-brown (5YR4/4); moderately indurated; devitrified; minor quartz and feldspar; trace of biotite.	mafic-poor Rainier Mesa Tuff
264.6 - 283.8 m (868 - 931 ft)	Moderately Welded Ash-Flow Tuff: Moderate-brown (5YR4/4); moderately indurated; devitrified; minor varicolored pumice exhibiting vapor-phase mineralization; minor felsic phenocrysts of quartz and feldspar; scarce mafic minerals of biotite and magnetite; rare dark-reddish-brown lithic fragments; rare black to dusky-yellowish-brown glass shards.	mafic-poor Rainier Mesa Tuff
283.8 - 291.1 m (931 - 955 ft)	Partially Welded Ash-Flow Tuff: Moderate-reddish-brown; poorly indurated; vitric; minor varicolored pumice exhibiting vapor-phase mineralization; minor felsic phenocrysts of quartz and feldspar; scarce mafic minerals of biotite and magnetite; rare black to dusky-yellowish-brown glass shards.	mafic-poor Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-7cd (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
291.1 - 317.0 m (955 - 1,040 ft)	Nonwelded Ash-Flow Tuff: Pale-red (10R6/2); ("crystal slurry") friable; vitric; very-light-gray pumice; felsic phenocrysts of quartz and feldspar; trace of mafic minerals of biotite and magnetite; minor varicolored lithic fragments.	mafic-poor Rainier Mesa Tuff
317.0 - 328.6 m (1,040 - 1,078 ft)	Nonwelded Ash-Flow Tuff: Very-pale-orange to grayish-orange; fairly indurated; weakly zeolitized; minor very small grayish-orange pumice; minor felsic phenocrysts of quartz and feldspars; trace mafic minerals of biotite, hornblende and magnetite; scarce lithic fragments.	mafic-poor Rainier Mesa Tuff
328.6 - 341.4 m (1,078 - 1,120 ft)	Bedded Tuff: Very-pale-orange to grayish-orange; fairly indurated; weakly zeolitized; minor felsic phenocrysts of quartz and feldspars; trace of biotite and magnetite; scarce lithic fragments; minor clear glass shards; "crystal slurry" from 335.3 - 341.4 m (1,100 - 1,120 ft).	pre-Rainier Mesa, post-Wahmonie bedded tuff, undifferentiated
341.4 - 359.7 m (1,120 - 1,180 ft)	Bedded Tuff: Very-pale-orange to grayish-orange; fairly indurated; zeolitized; minor felsic phenocrysts of quartz and feldspars; trace of biotite and magnetite; scarce lithic fragments.	pre-Rainier Mesa, post-Wahmonie bedded tuff, undifferentiated

Lithologic Log of Emplacement Hole U-7cd (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
359.7 - 393.2 m (1,180 - 1,290 ft)	Bedded Tuff: Grayish-orange to moderate-yellowish-brown; moderately indurated; zeolitized; minor very-pale-orange pumice; minor felsic phenocrysts of quartz and feldspar; trace mafic minerals of biotite, magnetite and hornblende; minor dusky-brown lithic fragments up to 5 mm in diameter.	pre-Rainier Mesa, post-Wahmonie bedded tuff, undifferentiated
393.2 - 402.3 m (1,290 - 1,320 ft)	Bedded Tuff: Very-pale-orange; fairly indurated; zeolitized; common feldspars with scarce quartz; sample enriched in felsics and lithics from 396.2 - 402.3 m (1,300 - 1,320 ft); rare mafic minerals of biotite; common grayish-red (10R4/2) lithic fragments up to 3 mm in diameter.	pre-Rainier Mesa, post-Wahmonie bedded tuff, undifferentiated
402.3 - 414.5 m (1,320 - 1,360 ft)	Bedded Tuff: Grayish-orange; zeolitized; poorly indurated; common very-pale-orange pumice; minor felsic phenocrysts of quartz and feldspar; scarce mafic minerals of biotite; scarce grayish-red (10R4/2) lithic fragments.	Calico Hills Formation
414.5 - 417.6 m (1,360 - 1,370 ft)	Air-Fall Tuff: Grayish-yellow; zeolitized; poorly indurated; minor felsic phenocrysts of quartz and feldspar; scarce mafic minerals of biotite; scarce lithic fragments.	Calico Hills Formation

Lithologic Log of Emplacement Hole U-7cd (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
417.6 - 438.9 m (1,370 - 1,440 ft)	Bedded Tuff: Very-pale-orange; zeolitized; moderately indurated; common very-light-gray pumice; rare felsic phenocrysts of quartz and feldspar; scarce mafic minerals of biotite; rare dark-reddish-brown lithic fragments up to 1 mm in diameter.	Calico Hills Formation
438.9 - 460.2 m (1,440 - 1,510 ft)	Bedded Tuff: Grayish-orange to dark-yellowish-brown; zeolitized; poorly to moderately indurated; white to light-gray pumice; common felsic phenocrysts of feldspar; scarce mafic minerals of biotite, hornblende and magnetite; scarce light-brown (5YR5/6) lithics.	tuff of Wahmonie Flat
460.2 - 495.3 m (1,510 - 1,625 ft) TD	Bedded Tuff: Grayish-orange; zeolitized; moderately indurated; very-pale-orange pumice; common felsic phenocrysts of feldspar and quartz; rare mafic-minerals of biotite, hornblende and magnetite; common dusky-brown lithic fragments; minor mottling with moderate-reddish-orange color at 478.5 m (1,570 ft); air-fall with large felsic phenocrysts from 484.6 - 490.7 m (1,590 - 1,610 ft).	Crater Flat Group (undifferentiated)

Emplacement Hole U-7cd Supplemental Data

1. For additional information regarding Emplacement Hole U-7cd, see McCall (1993). Supplemental data listed below are also extracted from McCall (1993) except as noted.
2. The equilibrated water level as measured in open boreholes in the U-7cd/U-7cd Sat #1 area is higher than had been predicted from older drill hole data. This is thought to be due to the presence of a pressurized aquifer resulting from nearby nuclear tests. Pre-drill estimate of depth to water level at U-7cd was 515.1 m (1,690 ft). However, fluid-level measurements in the U-7cd borehole on 02/16/1993 recorded a depth to fluid of 474.9 m (1,558 ft).
3. The latest water-level tag in U-7cd, made on 4/9/1997, indicated a depth to fluid of 438.9 ± 0.9 m ($1,440 \pm 3$ ft). The original pump installed in the hole was found to be inoperable at that time, and estimated to be buried by approximately 12.2 m (40 ft) of fill at the bottom of the hole (BN, 1997). A bottom-hole tag was made at 475 ± 0.9 m ($1,559 \pm 3$ ft) on 4/9/1997.
4. U-7cd Sat #1 is located approximately 9 m (29.5 ft) north-northeast of U-7cd.
5. See graphic data summary sheet in back pocket.

Figure 6
West-East Geologic Cross Section Through U-7cd

Figure 7
North-South Geologic Cross Section Through U-7cd

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Stratigraphic Log for U-7cd Satellite Hole #1
 Logged by Robert L. McCall, Raytheon Services Nevada, July 1992

Meters	Depth	Lithology	Stratigraphic Unit	Symbol	Thickness	
	Feet				Meters	Feet
0 - 110.6	0 - 363	Tuffaceous Alluvium.	Alluvium	QTa	110.6	363
110.6 - 166.1	363 - 545	Ash-Flow Tuff: Nonwelded to moderately welded, vitric to devitrified.	Ammonia Tanks Tuff, Timber Mountain Group	Tma	55.5	182
166.1 - 171.6	545 - 563	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	5.5	18
171.6 - 327.4	563 - 1074	Ash-Flow Tuff: Nonwelded to densely welded, vitric to devitrified.	Rainier Mesa Tuff, Timber Mountain Group	Tmr	155.8	511
327.4 - 434.9	1,074 - 1,427	Bedded Tuff: Zeolitized.	pre-Rainier Mesa, post-Wahmonie bedded tuff, undifferentiated	Tmrl/Th	107.5	353

Stratigraphic Log of U-7cd Satellite Hole #1 (cont.)

	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
	434.9 - 457.5	1,427 - 1,501	Bedded Tuff: Zeolitized.	tuff of Wahmonie Flat	Twlb	22.6	74
	457.5 - 505.4	1,501 - 1,658	Bedded Tuff: Zeolitized.	Crater Flat Group, undifferentiated	Tc	47.9	157
	505.4 - 511.5	1,658 - 1,678	Air-Fall Tuff: Zeolitized.	bedded Grouse Canyon Tuff, Belted Range Group	Tbgb	6.1	20
9	511.5 - 518.2 TD	1,678 - 1,700 TD	Bedded Tuff: Zeolitized.	Tunnel Formation, Tunnel 4 Member, beds 4K	Tn4K	>6.7	>22

U-7cd Satellite Hole #1 Supplemental Data

1. For additional information regarding this site, see McCall (1993). The supplemental data listed below are also extracted from McCall (1993).
2. U-7cd Sat #1 is located approximately 9 m (29.5 ft) north-northeast of U-7cd. The satellite hole was used to help define the geology and provide drilling-related data useful in evaluation of this site for containment purposes.
3. The equilibrated water level as measured in open boreholes in the U-7cd/U-7cd Sat #1 area is higher than had been predicted from older drill hole data. The higher water level observed is believed to be the potentiometric level of a pressurized aquifer resulting from nearby nuclear tests.
4. Water level measurements at U-7cd Sat #1 recorded a depth to fluid level of 433.1 m (1,421 ft) on 01/29/1993.

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Stratigraphic Log of Emplacement Hole U-19bf
 Compiled by Lance Prothro, Bechtel Nevada, June 1996

Emplacement Hole U-19bf was abandoned in January 1990 due to severe sloughing while at a temporary total depth of 471.2 m (1,546 ft). A bottom hole measurement on July 9, 1992 indicated a total depth of 155.4 m (510 ft). The geology provided below is based on the following information: (1) results of examination of unwashed U-19bf drill cuttings samples from 18.3 - 402.3 m (60 - 1,320 ft) (Rayburn, 1990); (2) geology encountered in emplacement hole U-19ak reported in Ferguson et al. (1994); and (3) surface geology depicted in Noble et al. (1967). Because no geophysical logs were run at U-19bf, the stratigraphic contacts listed below are approximate. Stratigraphic nomenclature is from Ferguson et al. (1994).

	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
	0 - 36.6	0 - 120	Ash-Flow Tuff: Nonwelded to partially welded, vitric to devitrified.	Ammonia Tanks Tuff, Timber Mountain Group	Tma	36.6	120
69	36.6 - 42.7	120 - 140	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	6.1	20
	42.7 - 149.4	140 - 490	Ash-Flow Tuff: Nonwelded to densely welded.	Rainier Mesa Tuff, Timber Mountain Group	Tmr	106.7	350
	149.4 - 292.6	490 - 960	Bedded Tuff: Very friable, sloughing zone.	Calico Hills Formation, Volcanics of Area 20	Tac	143.2	470
	292.6 - 471.2 TD	960 - 1,546 TD	Lava: Vitric to approximately 341.4 m (1,120 ft), devitrified below.	Dead Horse Flat Formation, Belted Range Group	Tbd	>178.6	>586

Emplacement Hole U-19bf Supplemental Data

1. Emplacement Hole U-19bf was abandoned in January 1990 due to severe sloughing while at a temporary total depth of 471.2 m (1546 ft). A bottom hole measurement on 9 July 1992 indicated a total depth of 155.4 m (510 ft) with no fluid.
2. Borehole erosion occurred from 90.5 - 116.1 m (297 - 381 ft) with a large diameter (6.1 - 9.1 m [20 - 30 ft]) sloughed section below 148.7 m (488 ft). Vertical fractures are present from 70.1 - 76.8 m (230 - 252 ft) (RSN, 1991).
3. Sandia National Laboratory color video, used to observe and measure caving intervals, is available (Rayburn, 1989).
4. No geophysical logs were run at U-19bf.

Stratigraphic Log of Emplacement Hole U-19bg
 Logged by Lance B. Prothro, Raytheon Services Nevada, August 1991

Meters	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
		Feet				Meters	Feet
0 - 9.1		0 - 30	No samples.	Thirsty Canyon Group, undifferentiated	Tt	9.1	30
9.1 - 29.0		30 - 95.3	Ash-Flow Tuff: Partially welded, devitrified.	Pahute Mesa Tuff, Thirsty Canyon Group	Ttp	19.9	65.3
29.0 - 36.0		95.3 - 118	Bedded Tuff: Vitric, partly zeolitic, calcareous.	rhyolite of Chukar Canyon, Volcanics of Fortymile Canyon	Tfbr	7.0	22.7
36.0 - 48.9		118 - 160.5	Bedded Tuff: Vitric.	rhyolite of Beatty Wash, Volcanics of Fortymile Canyon	Tfbw	12.9	42.5
48.9 - 50.9		160.5 - 167	Bedded Tuff: Vitric.	Ammonia Tanks Tuff (bedded), Timber Mountain Group	Tma(b)	2.0	6.5

Stratigraphic Log of Emplacement Hole U-19bg (cont.)

Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
Meters	Feet				Meters	Feet
50.9 - 119.7	167 - 392.6	Ash-Flow Tuff: Nonwelded to moderately welded, vitric to devitrified.	Ammonia Tanks Tuff, Timber Mountain Group	Tma	68.8	225.6
119.7 - 132.9	392.6 - 436	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	13.2	43.4
132.9 - 134.6	436 - 441.5	Bedded Tuff: Vitric.	bedded Rainier Mesa Tuff, Timber Mountain Group	Tmrb	1.7	5.5
134.6 - 433.4	441.5 - 1,421.9	Ash-Flow Tuff: Nonwelded to vitrophyric, vitric to devitrified.	Rainier Mesa Tuff, Timber Mountain Group	Tmr	298.8	980.4
433.4 - 446.6	1,421.9 - 1,465.3	Bedded Tuff: Vitric, partly zeolitic.	tuff of Holmes Road, Timber Mountain Group	Tmrh	13.2	43.4
446.6 - 450.8	1,465.3 - 1,478.9	Nonwelded Tuff: Vitric.	rhyolite of Benham, Paintbrush Group	Tpb	4.2	13.6

Stratigraphic Log of Emplacement Hole U-19bg (cont.)

Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
Meters	Feet				Meters	Feet
450.8 - 479.1	1,478.9 - 1,572	Ash-Flow Tuff: Moderately welded to vitrophyric, vitric to devitrified.	Pahute Mesa lobe of Tiva Canyon Tuff, Paintbrush Group	Tpcm	28.3	93.1
479.1 - 487.7	1,572 - 1,600.1	Nonwelded and Bedded Tuff: Vitric, partly zeolitic.	rhyolite of Delirium Canyon, Paintbrush Group	Tpd	8.6	28.1
487.7 - 559.5	1,600.1-1,835.5	Flow Breccia, Lava, and Nonwelded Tuff: Vitric to devitrified, pumiceous.	rhyolite of Echo Peak, Paintbrush Group	Tpe	71.8	235.4
559.5 - 657.5 TD	1,835.5 - 2,157 TD	Flow Breccia and Lava: Vitric, pumiceous.	rhyolite of Silent Canyon, Paintbrush Group	Tpr	>98.0	>321.5

Lithologic Log of Emplacement Hole U-19bg
 Logged by Lance Prothro, Raytheon Services Nevada
 August 1991

Unless otherwise noted, the following descriptions refer to washed cuttings samples at 3.05-m (10-ft) intervals. Colors are determined by comparing wet sample color to the Geological Society of America Rock-Color Chart. Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible. Geologic information gathered from the LANL Borehole Inspection System video and LLNL 16-mm film, and notes from R.G. Warren have been incorporated into the descriptions.

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
0 - 9.1 m (0 - 30 ft)	Ash-Flow tuff: No samples. (Stratigraphy inferred from Noble et al., USGS Geologic Map of the Dead Horse Flat quadrangle, 1967.)	Thirsty Canyon Group, undifferentiated
9.1 - 29.0 m (30 - 95.3 ft)	Partially Welded Ash-Flow Tuff: Pale-brown to grayish-red (5R4/2); devitrified with vapor-phase mineralization; common medium-gray pumice; minor felsic phenocrysts of sanidine; rare mafic minerals of clinopyroxene and olivine; minor grayish-brown lithic fragments up to 1 mm in diameter. Moderate fractures emerging from behind casing to 29.0 m (95.3 ft).	Pahute Mesa Tuff
29.0 - 32.9 m (95.3 - 108 ft)	Bedded Tuff: Light (5YR5/6) to moderate (5YR4/4) brown; poorly indurated; vitric; minor very pale-orange pumice; common felsic phenocrysts of feldspar and lesser quartz; minor mafic minerals of magnetite and hornblende with lesser biotite and pyroxene; minor dark-reddish-brown and light-bluish-gray lithic fragments up to 5 mm in diameter. Upper contact strikes approximately N40°E and dips 6°SE.	rhyolite of Chukar Canyon

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
32.9 - 36.0 m (108 - 118 ft)	Bedded Tuff: Pale-yellowish-brown; poorly indurated; partly vitric; partly zeolitic; moderately calcareous; abundant white pumice; common felsic phenocrysts of feldspar and lesser quartz; rare mafic minerals of magnetite, hornblende and biotite; common brownish-gray to very-light-gray lithic fragments up to 5 mm in diameter. Trace of sphene in percussion gun sample at 35.4 m (116 ft).	rhyolite of Chukar Canyon
36.0 - 48.9 m (118 - 160.5 ft)	Bedded Tuff: White and pale-yellowish-brown; vitric; abundant white pumice; minor felsic phenocrysts of feldspar; minor mafic minerals of biotite, hornblende and magnetite; minor pale-reddish-brown lithic fragments; trace of sphene. Description is from percussion gun samples at 36.6 m (120 ft) and 47.8 m (157 ft).	rhyolite of Beatty Wash
48.9 - 50.9 m (160.5 - 167 ft)	Bedded Tuff: Moderate-yellowish-brown; vitric; minor white pumice; abundant felsic phenocrysts of feldspar; minor mafic minerals of biotite, clinopyroxene and magnetite; minor moderate-red (5 R 4/6) and grayish-red-purple lithic fragments up to 10 mm in diameter. Upper contact strikes approximately N55°E and dips 6°SE.	mafic-rich Ammonia Tanks Tuff (bedded)

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
50.9 - 60.2 m (167 - 197.6 ft)	Nonwelded Ash-Flow Tuff: Moderate-reddish-brown; vitric; minor white pumice; minor felsic phenocrysts of feldspar and much less quartz; common mafic minerals of biotite with lesser clinopyroxene and magnetite; minor light-brownish-gray and moderate-red (5R4/6) lithic fragments up to 3 mm in diameter. Percussion gun sample at 51.8 m (170 ft) contained very abundant white pumice and a trace of sphene.	mafic-rich Ammonia Tanks Tuff
60.2 - 69.8 m (197.6 - 229 ft)	Partially Welded Ash-Flow Tuff: Light-gray; devitrified; minor very-light-gray and dark-yellowish-orange pumice; minor felsic phenocrysts of feldspar, including chatoyant sanidine, and quartz; common mafic minerals of biotite and clinopyroxene; minor light-brownish-gray lithic fragments up to 3 mm in diameter, trace of sphene. Poorly developed lithophysae below 68.0 m (223 ft).	mafic-rich Ammonia Tanks Tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
69.8 - 102.4 m (229 - 336 ft)	Partially Welded Ash-Flow Tuff: Light-gray; devitrified; minor very-light-gray and dark-yellowish-orange pumice; common felsic phenocrysts of feldspar, including chatoyant sanidine, and quartz; rare to minor mafic minerals of biotite, clinopyroxene, and magnetite; minor light-brownish-gray lithic fragments up to 3 mm in diameter; trace of sphene. Moderate fractures below 90.0 m (295.3 ft). Poorly developed lithophysae from approximately 69.8 - 85.3 m (229 - 280 ft)	mafic-poor Ammonia Tanks Tuff
102.4 - 119.7 m (336 - 392.6 ft)	Moderately Welded Ash-Flow Tuff: Medium-light-gray to pale-brown; devitrified with vapor-phase mineralization; approaching densely welded from 113.7 - 115.8 m (373 - 380 ft); minor yellowish-gray (5Y7/2) pumice; common felsic phenocrysts of feldspar, including chatoyant sanidine, and quartz; rare mafic minerals of biotite and magnetite; rare grayish-brown lithic fragments up to 3 mm in diameter. Moderate fractures from 102.4 - 116.9 m (336 - 383.6 ft).	mafic-poor Ammonia Tanks Tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
119.7 - 132.9 m (392.6 - 436 ft)	Bedded Tuff: White, grayish-orange, and moderate-brown (5YR4/4); vitric; minor white to light-brown (5YR5/6) pumice becoming abundant and mostly white near base of interval; common felsic phenocrysts of feldspar and lesser quartz; minor mafic minerals of biotite and magnetite; rare pale-red-purple and light-bluish-gray lithic fragments up to 3 mm in diameter; trace of sphene. Description is from percussion gun samples at 130.1 m (427 ft), 131.7 m (432 ft), and 132.3 m (434 ft). Hornblende was observed in the cuttings samples from this interval.	bedded Ammonia Tanks tuff
132.9 - 134.6 m (436 - 441.5 ft)	Bedded Tuff: Not represented in cuttings. Stratigraphic contacts from geophysical logs. Percussion gun sample at 133.5 m (438 ft) is moderately to well sorted, medium-grained ash: Pale-reddish-brown; partly vitric, partly zeolitic; minor felsic phenocrysts; minor biotite; minor lithic fragments less than 1 mm in diameter.	bedded Rainier Mesa Tuff
134.6 - 143.2 m (441.5 - 469.8 ft)	Nonwelded Tuff: Moderate-brown (5YR 4/4); poorly indurated; vitric; common white to grayish-orange pumice; common felsic phenocrysts of feldspar and quartz; common mafic minerals of biotite, clinopyroxene and lesser orthopyroxene, rare pale-reddish-brown lithic fragments up to 2 mm in diameter.	mafic-rich Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
143.2 - 154.2 m (469.8 - 506 ft)	Partially Welded Ash-Flow Tuff: Grayish-red (10R4/2); devitrified with vapor-phase mineralization; minor medium-light-gray pumice; common felsic phenocrysts of feldspar and quartz; abundant mafic minerals of biotite, clinopyroxene and orthopyroxene; rare lithic fragments up to 1 mm in diameter. Poorly developed fractures throughout interval.	mafic-rich Rainier Mesa Tuff
154.2 - 159.1 m (506 - 522 ft)	Moderately Welded Ash-Flow Tuff: Pale-red (5R6/2); devitrified with vapor-phase mineralization; minor light-gray pumice; common felsic phenocrysts of feldspar and quartz; abundant mafic minerals of biotite, clinopyroxene and orthopyroxene; rare lithic fragments up to 1 mm in diameter. Poorly developed fractures to 156.9 m (514.6 ft) becoming moderately developed throughout remaining interval.	mafic-rich Rainier Mesa Tuff
159.1 - 164.6 m (522 - 540 ft)	Densely Welded Ash-Flow Tuff: Moderate-brown; mostly devitrified; minor white to pale-pink pumice; common felsic phenocrysts of feldspar and quartz; abundant mafic minerals of biotite and clinopyroxene; rare lithic fragments; black to medium-dark-gray glass sphericles. Moderate fractures throughout.	mafic-rich Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
164.6 - 167.3 m (540 - 549 ft)	Moderately Welded Ash-Flow Tuff: Pale-brown; devitrified; minor white pumice; common felsic phenocrysts of feldspar and quartz; abundant mafic minerals of biotite and clinopyroxene; rare lithic fragments. Moderate fractures throughout.	mafic-rich Rainier Mesa Tuff
167.3 - 182.9 m (549 - 600 ft)	Moderately Welded Ash-Flow Tuff: Pale-brown; devitrified; minor white pumice; minor felsic phenocrysts of feldspar and quartz; minor biotite; rare lithic fragments. Poorly developed fractures throughout.	mafic-poor Rainier Mesa Tuff
182.9 - 194.5 m (600 - 638 ft)	Densely Welded Ash-Flow Tuff: Grayish-red (5R4/2); devitrified; minor white to medium-gray pumice; minor felsic phenocrysts of feldspar and quartz; minor mafic minerals of biotite; rare lithic fragments. Poorly developed fractures to 190.0 m (623.2 ft).	mafic-poor Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
194.5 - 373.1 m (638 - 1,224 ft)	Moderately Welded Ash-Flow Tuff: Grayish-red (10R4/2); devitrified; common white and light-bluish-gray pumice; minor to common felsic phenocrysts of feldspar and quartz; rare to minor biotite; rare lithic fragments. Moderate fractures from 229.1 - 245.2 m (751.6 - 804.6 ft). Poorly developed fractures from 194.7 - 201.2 m (638.9 - 660.2 ft), 245.2 - 255.8 m (804.6 - 839.2 ft), and below 366.1 m (1,201 ft). Moderately developed lithophysae from 201.2 - 221.7 m (660.2 - 727.2 ft) and below 303.9 m (997 ft). Poorly developed lithophysae from 280.2 - 297.0 m (919- 974 ft).	mafic-poor Rainier Mesa Tuff
373.1 - 388.6 m (1,224 - 1,275.1 ft)	Densely Welded Ash-Flow Tuff: Grayish-red (5R4/2); devitrified; minor medium-light-gray to medium-bluish- gray pumice; minor felsic phenocrysts of feldspar and quartz; rare biotite; trace of lithic fragments. Poorly developed fractures to 387.4 m (1,271 ft). Moderately developed lithophysae throughout interval.	mafic-poor Rainier Mesa Tuff
388.6 - 395.0 m (1,275.1 - 1,296 ft)	Vitrophyre: Grayish-black; vitric; minor felsic phenocrysts of feldspar and quartz; minor biotite; trace of lithic fragments. Directional break-out oriented N80°W throughout interval.	mafic-poor Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
395.0 - 405.3 m (1,296 - 1,329.6 ft)	Moderately Welded Ash-Flow Tuff: Moderate-reddish-brown; vitric; becoming moderately welded at base; minor dark-gray to medium-light-gray pumice; minor felsic phenocrysts of feldspar and quartz; minor biotite; rare lithic fragments up to 2 mm in diameter; common black to medium- gray glass sphericles. Directional break-out oriented N80°W from 395.0 - 402.7 m (1,296 - 1,321.2 ft).	mafic-poor Rainier Mesa Tuff
405.3 - 408.1 m (1,329.6 - 1,339 ft)	Partially Welded Ash-Flow Tuff: Pale-reddish-brown; vitric; minor medium-light-gray pumice; minor felsic phenocrysts of feldspar and quartz; rare biotite; minor pale-yellow to moderate-yellow, vesiculated glass shards.	mafic-poor Rainier Mesa Tuff
408.1 - 433.4 m (1,339 - 1,421.9 ft)	Nonwelded Ash-Flow Tuff: Samples are a concentrate of predominately felsic minerals and pumice; moderate- reddish-orange (color obtained from thin matrix coatings on pumice and glass shards); vitric; white pumice; felsic minerals of feldspar and quartz; mafic minerals of biotite and lesser orthopyroxene; moderate to dark- reddish-brown lithic fragments up to 2 mm in diameter; grayish-yellow to very-pale-orange vesiculated glass shards which markedly decrease in abundance below approximately 414.5 m (1,360 ft).	mafic-poor Rainier Mesa tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
433.4 - 438.2 m (1,421.9 - 1,437.5 ft)	Bedded Tuff: Grayish-orange-pink; vitric; abundant white to moderate-orange-pink pumice at 434.0 m (1,424 ft), absent at 436.2 m (1,431 ft); minor felsic phenocrysts of feldspar and quartz; rare biotite; minor moderate-red lithic fragments up to 4 mm in diameter. Description is from percussion gun samples at 434.0 m (1,424 ft) and 436.2 m (1,431 ft).	tuff of Holmes Road
438.2 - 446.6 m (1,437.5 - 1,465.3 ft)	Bedded Tuff: Moderate-reddish-brown; poorly indurated; partly vitric; partly zeolitic; slightly calcareous; minor white, mostly vitric pumice; minor felsic phenocrysts of feldspar and quartz; rare to minor mafic minerals of biotite, hornblende, clinopyroxene and magnetite; minor pale to dark-reddish-brown and medium-light-gray lithic fragments up to 2 mm in diameter; minor very-pale-orange hydroclastic glass shards. Bedding is approximately horizontal throughout interval.	tuff of Holmes Road

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
446.6 - 450.8 m (1,465.3 - 1,478.9 ft)	Nonwelded Tuff: Very-pale-orange; vitric; common felsic phenocrysts of feldspar (grain mount by Warren indicated 12 percent total felsic phenocrysts of which 60 percent were potassium feldspar and 40 percent plagioclase; quartz absent); minor biotite and a trace of hornblende; minor moderate-brown (5YR3/4) lithic fragments up to 4 mm in diameter; conspicuous sphene. Description is from percussion gun sample at 449.3 m (1,474 ft).	rhyolite of Benham
450.8 - 452.4 m (1,478.9 - 1,484.4 ft)	Moderately Welded Ash-Flow Tuff: Moderate-brown (5YR3/4); vitric; rare very-light-gray pumice; rare felsic phenocrysts of feldspar; rare mafic minerals of biotite, clinopyroxene and magnetite.	Pahute Mesa lobe of Tiva Canyon Tuff
452.4 - 455.5 m (1,484.4 - 1,494.5 ft)	Vitrophyre: Dusky-yellowish-brown; vitric; minor felsic phenocrysts of feldspar; rare biotite; trace of medium-gray lithic fragments; common dark-reddish-brown glass shards.	Pahute Mesa lobe of Tiva Canyon Tuff
455.5 - 460.9 m (1,494.5 - 1,512 ft)	Densely Welded Ash-Flow Tuff: Dark-yellowish-brown; vitric; rare felsic phenocrysts of feldspar; rare biotite; trace of chalcedony.	Pahute Mesa lobe of Tiva Canyon Tuff

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
460.9 - 479.1 m (1,512 - 1,572 ft)	Moderately Welded Ash-Flow Tuff: Dark-yellowish-brown to pale-brown; devitrified with vapor-phase mineralization below 472.4 m (1,550 ft); rare yellowish-gray (5Y8/1) pumice; rare felsic phenocrysts of feldspar; rare mafic minerals of biotite, clinopyroxene and lesser hornblende; trace of sphene below 472.4 m (1,550 ft).	Pahute Mesa lobe of Tiva Canyon Tuff
479.1 - 484.0 m (1,572 - 1,587.9 ft)	Nonwelded Tuff: Sample is a concentrate of mainly felsic crystals, pumice, and lithic fragments; white to yellowish-gray (color obtained from matrix coatings on lithic fragments); vitric; white pumice; felsic crystals of feldspar and dipyramidal quartz; mafic minerals of biotite, hornblende, magnetite and a trace of clinopyroxene; moderate-reddish-brown to grayish-brown lithic fragments up to 4 mm in diameter. Percussion gun sample at 483.1 m (1,585 ft): Light-gray-orange-pink; vitric; minor felsic phenocrysts of feldspar; rare mafic minerals of hornblende and lesser biotite; trace of sphene.	rhyolite of Delirium Canyon

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
484.0 - 487.7 m (1,587.9 - 1,600.1 ft)	Bedded Tuff: Light-brown (5YR5/6); poorly indurated; partly vitric; partly zeolitic; rare felsic phenocrysts of feldspar; rare biotite, hornblende and magnetite; trace of lithic fragments; clear vesiculated glass shards showing varying degrees of devitrification and/or zeolitization. Washout preferentially oriented N10°E from 485.1 - 487.7 m (1,591.4 - 1,600.1 ft).	rhyolite of Delirium Canyon
487.7 - 500.0 m (1,600.1 - 1,640.3 ft)	Flow Breccia: Light-gray; poorly to moderately indurated; vitric; minor felsic phenocrysts of feldspar; rare mafic minerals of biotite and magnetite with a trace of clinopyroxene; trace of sphene. Upper contact is irregular and strikes approximately N60°W and dips 31°SW.	rhyolite of Echo Peak
500.0 - 526.1 m (1,640.3 - 1,726 ft)	Lava: Medium-gray to brownish-gray; well indurated; devitrified; minor felsic phenocrysts of feldspar; rare mafic minerals of biotite and magnetite with a trace of clinopyroxene; trace of sphene.	rhyolite of Echo Peak

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
526.1 - 552.9 m (1,726 - 1,814 ft)	Flow Breccia: Very-light-gray to grayish-black; poorly to moderately indurated; vitric; becomes pumiceous below 542.5 m (1,779.7 ft); minor felsic phenocrysts of feldspar; rare mafic minerals of biotite and magnetite with a trace of clinopyroxene; conspicuous sphene; common black glass sphericles. Note: Sample 545.6 - 548.6 m (1,790 - 1,800 ft) is contaminated with rhyolite of Delirium Canyon (Tpd) due to sloughing from approximately 484.0 - 487.7 m (1,587.9 - 1,600.1 ft).	rhyolite of Echo Peak
552.9 - 559.5 m (1,814 - 1,835.5 ft)	Nonwelded Tuff: White; poorly indurated; vitric; minor felsic phenocrysts of feldspar; rare mafic minerals of biotite and magnetite with a trace of free clinopyroxene; minor grayish-red-purple and moderate-brown (5YR3/4) lithic fragments up to 4 mm in diameter; conspicuous sphene.	rhyolite of Echo Peak
559.5 - 581.2 m (1,835.5 - 1,906.8 ft)	Flow Breccia: Light-gray to dark-gray; poorly to moderately indurated; vitric; minor felsic phenocrysts of feldspar; common to abundant mafic minerals of biotite and magnetite.	rhyolite of Silent Canyon

Lithologic Log of Emplacement Hole U-19bg (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
581.2 - 600.8 m (1,906.8 - 1,971 ft)	Lava: Light-gray to dark-gray; poorly to moderately indurated; vitric; minor felsic phenocrysts of feldspar; common to abundant mafic minerals of biotite and magnetite. Poorly developed fractures throughout. Flow foliation from 591.3 - 597.9 m (1,940 - 1,961.7 ft):	rhyolite of Silent Canyon
600.8 - 657.5 m (1,971 - 2,157 ft) TD	Flow Breccia: Light-gray to dark-gray; poorly to moderately indurated; vitric; pumiceous in part; minor felsic phenocrysts of feldspar; common to abundant mafic minerals of biotite and magnetite. Directional breakout oriented approximately N80°W from 600.8 - 640.1 m (1,971 - 2,100 ft). Note: Sample 652.3 - 655.3 m (2,140 - 2,150 ft) is contaminated with rhyolite of Echo Peak (Tpe) due to sloughing from approximately 522.9 - 559.5 m (1,814 - 1,835.5 ft).	rhyolite of Silent Canyon

Emplacement Hole U-19bg Supplemental Data

1. Downhole photography available: LANL Borehole Inspection System video (Prothro, 1991b); LLNL 16-mm film (Prothro, 1991c); and Sandia color video (Prothro, 1991a).
2. Atlas Wireline Service wireline rotary sidewall cores available for the interval 492.6 - 637.6 m (1,616 - 2,092 ft) (Prothro, 1991e).
3. Percussion gun sidewall samples available for the interval 35.4 - 611.1 m (116 - 2,005 ft) (Prothro, 1991d).
4. Physical property data (from wireline rotary sidewall samples) (Prothro, 1991h):

Depth		Bulk Density (g/cc)	Grain Density (g/cc)	Moisture Content (%)
Meters	Feet			
492.6	1,616	142.8	2.39	1.40
524.3	1,720	131.8	2.39	1.72
527.3	1,730	124.5	2.40	3.66
543.8	1,784	131.8	2.38	7.19
543.8	1,794	108.9	2.38	7.46
557.8	1,830	91.0	2.33	17.79
568.4	1,865	127.5	2.41	3.90
568.4	1,865	120.4	2.41	5.52
576.1	1,890	119.9	2.38	5.24
583.4	1,914	106.7	2.41	8.72
590.1	1,936	147.5	2.40	0.31
590.1	1,936	148.1	2.41	0.35
614.5	2,016	141.0	2.40	1.35
614.5	2,016	138.9	2.41	1.28

5. In accordance with Protocols of the Treaty between the U.S. and the former Soviet Union on the Limitation of Underground Nuclear Weapons Tests, geotechnical activities related to verification of the JUNCTION test were conducted by Soviet Designated Personnel at this site (Drellack, 1991).
6. U-19bg Satellite Hole #1 is located 11.0 m (36.1 ft) due south of Emplacement Hole U-19bg (Prothro, 1991f).
7. A bottom-hole measurement at U-19bg on 01/30/1992 indicated a total depth of 641.9 m (2,106 ft), and no fluid present.
8. For additional information on Emplacement Hole U-19bg see Prothro (1991g).

Figure 8
West-East Geologic Cross Section Through U-19bg

(from Warren, 1991)

Figure 9
North-South Geologic Cross Section Through U-19bg

(from Warren, 1991)

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Stratigraphic Log of U-19bg Satellite Hole #1
 Logged by Lance Prothro, Raytheon Services Nevada, August 1991

Meters	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
0 - 9.1	0 - 30	No samples.		Thirsty Canyon Group, undifferentiated	Tt	9.1	30
9.1 - 29.3	30 - 96	Ash-Flow Tuff: Partially welded, devitrified.		Pahute Mesa Tuff, Thirsty Canyon Group	Ttp	20.2	66
29.3 - 35.5	96 - 116.5	Bedded Tuff: Vitric, partly zeolitic, calcareous.		rhyolite of Chukar Canyon, Volcanics of Fortymile Canyon	Tfbr	6.2	20.5
35.5 - 49.4	116.5 - 162	Bedded Tuff: Vitric.		rhyolite of Beatty Wash, Volcanics of Fortymile Canyon	Tfbw	13.9	45.5
49.4 - 51.2	162 - 168	Bedded Tuff: Vitric.		Ammonia Tanks Tuff (bedded), Timber Mountain Group	Tma(b)	1.8	6

Stratigraphic Log of U-19bg Satellite Hole #1 (cont.)

Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
Meters	Feet				Meters	Feet
51.2 - 120.7	168 - 396	Ash-Flow Tuff: Nonwelded to moderately welded, vitric to devitrified.	Ammonia Tanks Tuff, Timber Mountain Group	Tma	69.5	228
120.7 - 133.5	396 - 438	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	12.8	42
133.5 - 135.3	438 - 444	Bedded Tuff: Vitric.	bedded Rainier Mesa Tuff, Timber Mountain Group	Tmrb	1.8	6
135.3 - 434.2	444 - 1,424.5	Ash-Flow Tuff: Nonwelded to vitrophyric, vitric to devitrified.	Rainier Mesa Tuff, Timber Mountain Group	Tmr	298.9	980.5
434.2 - 445.6	1,424.5 - 1,462	Bedded Tuff: Vitric, partly zeolitic.	tuff of Holmes Road, Timber Mountain Group	Tmrh	11.4	37.5
445.6 - 451.4	1,462 - 1,481	Nonwelded Tuff: Vitric.	rhyolite of Benham, Paintbrush Group	Tpb	5.8	19

Stratigraphic Log of U-19bg Satellite Hole #1 (cont.)

Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
Meters	Feet				Meters	Feet
451.4 - 479.8	1,481 - 1,574	Ash-Flow Tuff: Moderately welded to vitrophanic, vitric to devitrified.	Pahute Mesa lobe of Tiva Canyon Tuff, Paintbrush Group	Tpcm	28.4	93
479.8 - 490.7	1,574 - 1,610	Nonwelded and Bedded Tuff: Vitric, partly zeolitic.	rhyolite of Delirium Canyon, Paintbrush Group	Tpd	10.9	36
490.7 - 556.0	1,610 - 1,824	Flow Breccia, Lava, and Nonwelded Tuff: Vitric to devitrified, pumiceous.	rhyolite of Echo Peak, Paintbrush Group	Tpe	65.3	214
556.0 - 656.2	1,824 - 2,153	Flow Breccia and Lava: Vitric, pumiceous.	rhyolite of Silent Canyon, Paintbrush Group	Tpr	100.2	329
656.2 - 667.5	2,153 - 2,190	Nonwelded Tuff: Vitric, partly zeolitic.	Pahute Mesa lobe of Topopah Spring Tuff, Paintbrush Group	Tptm	11.3	37

Stratigraphic Log of U-19bg Satellite Hole #1 (cont.)

Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
Meters	Feet				Meters	Feet
667.5 - 685.8 TD	2,190 - 2,250 TD	Nonwelded Tuff: Vitric.	Calico Hills Formation	Th	>18.3	>60

NOTE: Due to the close proximity of this satellite hole to the U-19bg emplacement hole, only a cursory examination was made of the 21.3 - 655.3 m (70 - 2,150 ft) drill cuttings samples. Drill cuttings samples below 655.3 m (2,150 ft) were examined in detail. A detailed correlation of wireline geophysical logs for the entire borehole was conducted and the resultant formation tops are presented here.

Lithologic Log of U-19bg Satellite Hole #1
 Logged by Lance Prothro, Raytheon Services Nevada
 August 1991

Unless otherwise noted, the following descriptions refer to washed cuttings samples at 3.05-m (10-ft) intervals. Colors are determined by comparing wet sample color to the Geological Society of America Rock-Color Chart. Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible.

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
656.2 - 659.1 m (2,153 - 2,162.5 ft)	Nonwelded Tuff: Light-brown (5YR5/6); vitric; minor very-pale-orange and white pumice; minor felsic phenocrysts of feldspar; rare biotite; trace of clinopyroxene.	Pahute Mesa lobe of Topopah Spring Tuff
659.1 - 667.5 m (2,162.5 - 2,190 ft)	Nonwelded Tuff: White to yellowish-gray; mostly vitric; partly zeolitic; silicified in part; minor white pumice; minor felsic phenocrysts of feldspar; rare biotite; trace of clinopyroxene; rare to minor moderate-reddish-brown silicified lithic fragments up to 10 mm in diameter and brownish-black subangular vitrophyre fragments up to 4 mm in diameter.	Pahute Mesa lobe of Topopah Spring Tuff
667.5 - 682.8 m (?) (2,190 - 2,240 ft(?))	Nonwelded Tuff: Very-light-gray; vitric; minor white pumice; rare felsic phenocrysts of feldspar and quartz; trace of biotite.	mafic-poor Calico Hills Formation
682.8(?) - >685.8 m (2,240(?) - >2,250 ft) TD	Nonwelded Tuff: Grayish-orange-pink; vitric; minor moderate-orange-pink pumice; minor felsic phenocrysts of feldspar and quartz; trace of biotite.	mafic poor Calico Hills Formation

U-19bg Satellite Hole #1 Supplemental Data

1. U-19bg Satellite Hole #1 is located 11.0 m (36.1 ft) due south of Emplacement Hole U-19bg (Prothro, 1991f).
2. Bottom-hole measurements at U-19bg Sat #1 on 01/31/1992 indicated a total depth of 672.4 m (2,206 ft) and a depth to fluid level at 645.6 m (2,118 ft).

Stratigraphic Log of Emplacement Hole U-19bh
 Logged by Lance Prothro, Raytheon Services Nevada, August 1995

	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
	Meters	Feet				Meters	Feet
	0 - 40.8	0 - 134	Ash-Flow Tuff: Partially welded, vitric to devitrified.	Ammonia Tanks Tuff, Timber Mountain Group	Tma	40.8	134
	40.8 - 57.9	134 - 190	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	17.1	56
8	57.9 - 62.2	190 - 204	Bedded Tuff: Vitric.	bedded Rainier Mesa Tuff, Timber Mountain Group	Tmr _b	4.3	14
	62.2 - 260.9	204 - 856	Ash-Flow Tuff: Nonwelded to vitrophyric, vitric to devitrified.	Rainier Mesa Tuff, Timber Mountain Group	Tmr	198.7	652
	260.9 - 281.6	856 - 924	Nonwelded Tuff: Vitric.	tuff of Holmes Road, Timber Mountain Group	Tmr _h	20.7	68
	281.6 - 301.7	924 - 990	Ash-Flow Tuff: Partially welded to vitrophyric, vitric to devitrified.	Pahute Mesa lobe of Tiva Canyon Tuff, Paintbrush Group	Tpcm	20.1	66

Stratigraphic Log of Emplacement Hole U-19bh (cont.)

Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
Meters	Feet				Meters	Feet
301.7 - 327.7	990 - 1,075	Nonwelded Tuff: Zeolitic, silicified and argillized in part.	rhyolite of Delirium Canyon, Paintbrush Group	Tpd	26.0	85
327.7 - 538.9	1,075 - 1,768	Lava: Vitric to devitrified.	rhyolite of Echo Peak, Paintbrush Group	Tpe	211.2	693
538.9 - 649.2	1,768 - 2,130	Ash-Flow Tuff: Nonwelded to densely welded, vitric to devitrified.	rhyolite of Echo Peak, Paintbrush Group	Tpe	110.3	362
649.2 - 654.7 TD	2,130 - 2,148 TD	Nonwelded Tuff: Devitrified, zeolitic in part.	rhyolite of Silent Canyon, Paintbrush Group	Tpr	>5.5	>18

Lithologic Log of Emplacement Hole U-19bh
 Logged by Lance Prothro, Raytheon Services Nevada
 August 1993

Unless otherwise noted, the following descriptions refer to washed cuttings samples at 3.05-m (10-ft) intervals. Colors are determined by comparing wet sample color to the Geological Society of America Rock-Color Chart. Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible. Geologic information gathered from the LLNL 16 mm film has been incorporated into the descriptions.

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
0 - 21.3 m (0 - 70 ft)	Ash-Flow Tuff: No samples.	Ammonia Tanks Tuff
21.3 - 32.3 m (70 - 106 ft)	Partially Welded Ash-Flow Tuff: Light-brown (5YR5/6); devitrified with vapor-phase mineralization; common pale-yellowish-orange pumice; common felsic phenocrysts of feldspar, including chatoyant sanidine, and dipyramidal quartz; rare mafic minerals of biotite with a trace of clinopyroxene and hornblende; rare moderate-brown lithic fragments less than 3 mm in diameter; trace of sphene.	mafic-poor Ammonia Tanks Tuff
32.3 - 40.8 m (106 - 134 ft)	Partially Welded Ash-Flow Tuff: Dark-yellowish-brown; vitric; minor white and dusky-yellowish-brown pumice; minor felsic phenocrysts of feldspar, including chatoyant sanidine, and quartz; rare mafic minerals of biotite and clinopyroxene; rare moderate-reddish-brown lithic fragments less than 2 mm in diameter; conspicuous black cusped glass shards; trace of sphene.	mafic-poor Ammonia Tanks Tuff

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
40.8 - 57.9 m (134 - 190 ft)	Bedded Tuff: Light-brownish-gray; vitric; common white to yellowish-gray pumice at 57.3 m (188 ft); common felsic phenocrysts of feldspar and quartz; rare to minor mafic minerals of biotite, clinopyroxene, and magnetite; minor grayish-brown lithic fragments less than 2 mm in diameter at 41.5 m (136 ft). Description is from percussion gun samples at 41.5 m (136 ft) and 57.3 m (188 ft). Drill cuttings samples are unconsolidated mixtures consisting mainly of felsic crystals and pumice. Bedding contact at 44.8 m (147 ft) is approximately horizontal.	bedded Ammonia Tanks Tuff
57.9 - 62.2 m (190 - 204 ft)	Bedded Tuff: Grayish-orange to dark-yellowish-orange; vitric; common white pumice; minor felsic phenocrysts of feldspar and quartz; minor mafic minerals of biotite and clinopyroxene. Percussion gun sample at 58.5 m (192 ft) is partially zeolitic with abundant grayish-orange and grayish-orange-pink pumice and minor bronze colored biotite.	bedded Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
62.2 - 64.6 m (204 - 212 ft)	Nonwelded Ash-Flow Tuff: Pale-red (5R6/2) and light-brown (5YR5/6); partially devitrified with the pale-red fragments showing a higher degree of devitrification and some vapor-phase mineralization; minor white and pale-yellowish-orange vitric pumice; common felsic phenocrysts of feldspar and quartz; abundant biotite, trace of orthopyroxene, trace of clinopyroxene in percussion gun sample at 63.1 m (207 ft); rare moderate-red (5R5/4) lithic fragments less than 2 mm in diameter; rare pale-yellowish-orange cusped glass shards.	mafic-rich Rainier Mesa Tuff
64.6 - 85.9 m (212 - 282 ft)	Partially Welded Ash-Flow Tuff: Dark-reddish-brown to grayish-red; devitrified; minor light-gray pumice; minor felsic phenocrysts of feldspar and quartz; common mafic minerals of biotite and clinopyroxene; rare moderate-red (5R5/4) lithic fragments less than 3 mm in diameter; numerous pieces of botryoidal opal occur in samples near base of interval. Poorly developed fractures throughout interval.	mafic-rich Rainier Mesa Tuff
85.9 - 90.2 m (282 - 296 ft)	Moderately Welded Ash-Flow Tuff: Grayish-red; devitrified; common white to pale-greenish-yellow pumice; minor felsic phenocrysts of feldspar and quartz; minor mafic minerals of biotite and clinopyroxene. Prominent fractures throughout interval.	mafic-rich Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
90.2 - 245.1 m (296 - 804 ft)	Moderately Welded Ash-Flow Tuff: Grayish-red; devitrified; common white to pale-greenish-yellow pumice; minor felsic phenocrysts of feldspar and quartz; rare biotite. Poorly developed lithophysae from 194.0 - 240.9 m (637 - 790 ft). Moderately developed lithophysae from 240.9 - 245.1 m (790 - 804 ft). Poorly developed fractures from 125.3 - 188.4 m (411 - 618 ft). Moderately developed fractures from 117.0 - 125.3 m (384 - 411 ft). Prominent fractures from 86.6 - 117.0 m (284 - 384 ft).	mafic-poor Rainier Mesa Tuff
245.1 - 249.0 m (804 - 817 ft)	Vitrophyre: Brownish-black; vitric; minor felsic phenocrysts of feldspar and quartz; rare biotite; abundant clear to black glass spherules. Poorly developed fractures throughout interval.	mafic-poor Rainier Mesa Tuff
249.0 - 250.8 m (817 - 823 ft)	Moderately Welded Ash-Flow Tuff: Not represented in cuttings; lithology inferred from geophysical logs.	mafic-poor Rainier Mesa Tuff
250.8 - 252.1 m (823 - 827 ft)	Partially Welded Ash-Flow Tuff: Not represented in cuttings; lithology inferred from geophysical logs.	mafic-poor Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
252.1 - 260.9 m (827 - 856 ft)	Nonwelded Ash-Flow Tuff: Pale-red (10R6/2); mostly vitric, devitrified in part; minor felsic phenocrysts of feldspar and lesser quartz; trace of biotite; rare dusky-yellowish-brown lithic fragments less than 3 mm in diameter. Description is from percussion gun sample at 260.6 m (855 ft). Drill cuttings samples are unconsolidated mixtures consisting mainly of felsic crystals with lesser amounts of pumice and lithic fragments. Contact with underlying Tmrh is approximately horizontal.	mafic-poor Rainier Mesa Tuff
260.9 - 269.4 m (856 - 884 ft)	Nonwelded Tuff: Light-brown (5YR5/6); vitric; common white to very-pale-orange pumice; minor felsic phenocrysts of feldspar and quartz; minor very small mafic minerals of biotite and hornblende; common light-brownish-gray to brownish-gray lithic fragments less than 5 mm in diameter.	tuff of Holmes Road
269.4 - 281.6 m (884 - 924 ft)	Nonwelded Tuff: Grayish-orange-pink (5YR7/2); vitric; minor felsic phenocrysts of quartz and lesser feldspar; rare very small mafic minerals of biotite and magnetite. Description is from percussion gun sample at 281.3 m (923 ft). Drill cuttings samples are poor in quality and consist mainly of pumice and lithic fragments with a trace of sphene.	tuff of Holmes Road

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
281.6 - 290.8 m (924 - 954 ft)	Vitrophyre: Brownish-black; vitric; minor feldspar; rare mafic minerals of biotite and clinopyroxene. Poorly developed fractures throughout interval.	Pahute Mesa lobe of Tiva Canyon Tuff
290.8 - 296.9 m (954 - 974 ft)	Densely Welded Ash-Flow Tuff: Moderate-brown (5YR4/4); devitrified; rare feldspar; minor mafic minerals of biotite and clinopyroxene. Poorly developed fractures throughout interval.	Pahute Mesa lobe of Tiva Canyon Tuff
296.9 - 301.7 m (974 - 990 ft)	Partially Welded Ash-Flow Tuff: Dark-yellowish-brown; partially devitrified with minor vapor-phase mineralization; rare feldspar; minor mafic minerals of biotite and clinopyroxene; trace of dark-reddish-brown lithic fragments less than 2 mm in-diameter; common dusky-yellowish-brown cusped glass shards; trace of sphene.	Pahute Mesa lobe of Tiva Canyon Tuff
301.7 - 305.7 m (990 - 1,003 ft)	Nonwelded Tuff: Sample quality is poor. Pinkish-gray; partly vitric, partly zeolitic; minor feldspar; rare mafic minerals of biotite and hornblende; rare pale-brown lithic fragments less than 1 mm in diameter; minor clear platy glass shards; trace of sphene.	rhyolite of Delirium Canyon

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
305.7 - 323.1 m (1,003 - 1,060 ft)	Nonwelded Tuff: Samples consist mainly of white and translucent pumice and moderate-red (5R4/6) and light-brownish-gray to medium-light-gray devitrified lava fragments. A thin, white, vitric matrix coats some of the pumice and lava fragments. Samples also contain feldspar; trace of biotite and clinopyroxene, clear glass spherules and fragments, and a trace of sphene.	rhyolite of Delirium Canyon
323.1 - 327.7 m (1,060 - 1,075 ft)	Nonwelded Tuff: Sample quality is poor. Grayish-pink and pale-brown; mostly zeolitic, partially vitric, silicified and argillized in part; minor very-pale-orange zeolitized pumice and translucent vitric pumice; minor feldspar; rare biotite, minor medium-dark-gray lithic fragments less than 3 mm in diameter; trace of sphene.	rhyolite of Delirium Canyon
327.7 - 332.2 m (1,075 - 1,090 ft)	Flow Breccia: Medium-dark-gray; poorly indurated; vitric; minor feldspar; minor biotite; trace of sphene. Poorly developed fractures throughout interval.	rhyolite of Echo Peak
332.2 - 339.8 m (1,090 - 1,115 ft)	Lava: Medium-dark-gray; poorly indurated; vitric; minor feldspar; minor biotite; trace of sphene. Poorly developed fractures throughout interval.	rhyolite of Echo Peak

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
339.8 - 356.0 m (1,115 - 1,168 ft)	Lava: Pale-yellowish-brown to dark-yellowish-brown, mottled; moderately indurated; devitrified with vapor-phase mineralization producing concentric layers and conspicuous opaline botryoidal masses; minor feldspar; minor biotite, trace of clinopyroxene; numerous pale-red silicified fragments. Poorly developed fractures throughout interval.	rhyolite of Echo Peak
356.0 - 420.0 m (1168 - 1378 ft)	Lava: Light-olive-gray and medium-light gray; moderately indurated; vitric becoming partially devitrified below 398.1 m (1,306 ft); minor feldspar; minor biotite. Poorly developed fractures throughout interval.	rhyolite of Echo Peak
420.0 - 531.0 m (1,378 - 1,742 ft)	Lava: Light-brownish-gray; moderately indurated; devitrified; minor feldspar, minor biotite, trace of clinopyroxene; trace of sphene. Flow banded from 444.8 - 449.6 m (1,459 - 1,475 ft). Poorly developed lithophysae from 414.5 - 444.7 m (1,360 - 1,459 ft). Poorly developed fractures throughout interval.	rhyolite of Echo Peak
531.0 - 538.9 m (1,742 - 1,768 ft)	Lava (basal vitrophyre): Brownish-black; vitric; minor feldspar; minor biotite; abundant black glass spherules. Poorly developed fractures throughout interval.	rhyolite of Echo Peak

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
538.9 - 608.4 m (1,768 - 1,996 ft)	Densely Welded Ash-Flow Tuff: Pale-brown to moderate-brown (5YR4/4); mostly devitrified with vitric intervals from 538.9 - 542.5 m (1,768 - 1,780 ft), 581.2 - 581.6 m (1,907 - 1,908 ft), and 583.0 - 585.6 m (1,913 - 1,921 ft); minor moderate-reddish-orange pumice below 600.5 m (1,970 ft); minor feldspar; minor biotite, trace of clinopyroxene; common moderate-brown (5YR4/4) lithic fragments less than 5 mm in diameter; trace of sphene. Poorly developed fractures to 600.1 m (1,969 ft). Moderately developed fractures below 600.1 m (1,969 ft).	rhyolite of Echo Peak
608.4 - 626.1 m (1,996 - 2,054 ft)	Densely Welded Ash-Flow Tuff: Dark-yellowish-brown; vitric, devitrified in part below 621.8 m (2,040 ft); common black flattened pumice; minor feldspar; rare biotite; trace of sphene. Moderately developed fractures throughout interval.	rhyolite of Echo Peak

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
626.1 - 635.8 m (2,054 - 2,086 ft)	Partially Welded Ash-Flow Tuff: Pale-reddish-brown; devitrified, zeolitic in part; minor pale-yellowish-orange to dark-yellowish-orange pumice; minor feldspar; minor biotite. Sample at 637.0 m (2,090 ft) contains abundant grayish-red and moderate-reddish brown lithic fragments. These fragments are probably related to the interval of reversely graded, cobble- to boulder-size fragments observed on the 16 mm film from 632.0 - 635.0 m (2,073.4 - 2,083.5 ft). Moderately developed fractures to 631.8 m (2,073 ft).	rhyolite of Echo Peak
635.8 - 649.2 m (2,086 - 2,130 ft)	Nonwelded Ash-Flow Tuff: Light-brown (5YR6/4); devitrified, zeolitic in part; common very-pale-orange pumice; minor feldspar; minor biotite, trace of clinopyroxene near base; minor brownish-gray to grayish-red (10R4/2) lithic fragments less than 8 mm in diameter; conspicuous sphene. Sample at 649.2 m (2,130 ft) is dominated by grayish-red (5R4/2) lithic(?) fragments.	rhyolite of Echo Peak

Lithologic Log of Emplacement Hole U-19bh (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
649.2 - 654.7 m (2,130 - 2,148 ft) TD	Nonwelded Tuff: Moderate-reddish-orange to moderate-reddish-brown; devitrified, zeolitic in part; rare grayish-orange pumice; common feldspar; minor biotite (abundant biotite in percussion gun sample at 650.7 m (2,135 ft); rare dusky-red lithic fragments less than 1 mm in diameter. Reddish color of sample is the result of prevalent hematitic staining. (Assignment of this interval to Tpr is partly based on a cursory examination of a grain mount of the drill cuttings by R.G. Warren.)	rhyolite of Silent Canyon

Emplacement Hole U-19bh Supplemental Data

1. For additional information regarding U-19bh, see Prothro (1995). Supplemental data listed below are also extracted from Prothro (1995).
2. LLNL 16-mm film and Sandia color video are available through BN Geology/Hydrology, Mercury, NV.
3. Percussion-gun samples are available from the interval 41.5 - 650.7 m (136 - 2,135 ft).
4. The borehole is significantly enlarged at approximately 315.8 m (1,036 ft). Prominent vertical fractures are present from 86.6 - 117.1 m (284 - 384 ft).
5. Fluid level measurements on 11/15/1994 indicated a depth to fluid level of 638.6 m (2,095.2 ft).
6. See graphic data summary sheet in back pocket.

Figure 10
West-East Geologic Cross Section Through U-19bh

KEY TO STRATIGRAPHIC SYMBOLS

- Tf - Volcanics of Fortymile Canyon, undifferentiated
- Tma - Ammonia Tanks Tuff
- Tmb/Tmrb - bedded Ammonia Tanks Tuff and bedded Rainier Mesa Tuff, undifferentiated
- Tmr - Rainier Mesa Tuff
- Tmrh - tuff of Holmes Road
- Tpc - Pahute Mesa lobe of the Tiva Canyon Tuff
- Tpd - rhyolite of Delirium Canyon
- Tpe - rhyolite of Echo Peak
- Tpr - rhyolite of Silent Canyon
- Thp - mafic-poor Calico Hills Formation
- Tci - rhyolite of Inlet

NOTE: Qac (alluvium, colluvium, and talus) not shown on cross section.

(modified from Prothro, 1995)

Figure 11
North-South Geologic Cross Section Through U-19bh

Stratigraphic Log of Emplacement Hole U-19bj
 Logged by Lance Prothro, Bechtel Nevada, 10 July 1996

Meters	Depth	Lithology	Stratigraphic Unit	Symbol	Thickness	
	Feet				Meters	Feet
0 - 64.6	0 - 212	Ash-Flow Tuff: Nonwelded to densely welded; mostly devitrified.	mafic-poor Ammonia Tanks Tuff, Timber Mountain Group	Tmap	64.6	212
64.6 - 73.5	212 - 241	Bedded Tuff: Vitric.	bedded Ammonia Tanks Tuff, Timber Mountain Group	Tmab	8.9	29
73.5 - 76.8	241 - 252	Bedded Tuff: Vitric.	bedded Rainier Mesa Tuff, Timber Mountain Group	Tmrb	3.3	11
76.8 - 108.2	252 - 355	Ash-Flow Tuff: Nonwelded to moderately welded; vitric to devitrified.	mafic-rich Rainier Mesa Tuff, Timber Mountain Group	Tmrr	31.4	103
108.2 - 367.9	355 - 1,207	Ash-Flow Tuff: Nonwelded to vitrophyric; vitric to devitrified.	mafic-poor Rainier Mesa Tuff, Timber Mountain Group	Tmrp	259.7	852

Stratigraphic Log of Emplacement Hole U-19bj (cont.)

Meters	Depth		Lithology	Stratigraphic Unit	Symbol	Thickness	
		Feet				Meters	Feet
367.9 - 381.0		1,207 - 1,250	Bedded Tuff: Vitric.	tuff of Holmes Road, Timber Mountain Group	Tmrh	13.1	43
381.0 - 509.0		1,250 - 1,670	Bedded Tuff, Nonwelded Tuff, and Pumiceous Lava: Vitric to zeolitic.	mafic-poor Calico Hills Formation	Thp	128.0	420
509.0 - 656.2 TD		1,670 - 2,153 TD	Lava and Flow Breccia: Vitric, devitrified, and zeolitic; perlite, pumiceous, and vitrophyric in part.	rhyolite of Kearsarge	Tcpk	>147.2	>483

Lithologic Log of Emplacement Hole U-19bj
 Logged by Lance Prothro, Bechtel Nevada
 July 1996

The lithologic descriptions follow Bechtel Nevada Department Procedure NTS-GEO-003, "Rock Sample Descriptions" (RSN, 1993). Stratigraphic and lithologic divisions are tied to geophysical logs whenever possible. Information utilized in the construction of the log included unpublished petrographic, lithologic, and stratigraphic data from R.G. Warren (LANL) and lithologic and stratigraphic data from Drellack (1990). Stratigraphic nomenclature is from Ferguson et al. (1994).

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
0 - 21.3 m (0 - 70 ft)	Partially Welded Ash-Flow Tuff: No samples or geophysical logs available for this interval. Geology inferred from surface geology.	mafic-poor Ammonia Tanks Tuff
21.3 - 41.1 m (70 - 135 ft)	Partially Welded Ash-Flow Tuff: Light-brownish-gray; partially devitrified; minor white and moderate-yellowish-brown pumice; minor felsic phenocrysts of quartz and feldspar including conspicuous chatoyant sanidine; rare mafic minerals of biotite and lesser clinopyroxene; trace of sphene.	mafic-poor Ammonia Tanks Tuff
41.1 - 50.9 m (135 - 167 ft)	Moderately Welded Ash-Flow Tuff: Brownish-gray; devitrified; minor felsic phenocrysts of quartz and feldspar including chatoyant sanidine; rare mafic minerals of biotite and lesser clinopyroxene; trace of sphene. A few fragments of white chalcedony are present in samples.	mafic-poor Ammonia Tanks Tuff

Lithologic Log of Emplacement Hole U-19bj (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
50.9 - 59.1 m (167 - 194 ft)	Densely Welded Ash-Flow Tuff: Brownish-gray; devitrified; minor felsic phenocrysts of quartz and feldspar; rare mafic minerals of biotite and lesser clinopyroxene; trace of sphene. A few fragments of white chalcedony are present in samples.	mafic-poor Ammonia Tanks Tuff
59.1 - 63.1 m (194 - 207 ft)	Moderately Welded Ash-Flow Tuff: Brownish-gray; devitrified; minor felsic phenocrysts of quartz and feldspar; rare mafic minerals of biotite and lesser clinopyroxene; trace of sphene. A few fragments of white chalcedony are present in samples.	mafic-poor Ammonia Tanks Tuff
63.1 - 64.6 m (207 - 212 ft)	Partially Welded to Nonwelded Ash-Flow Tuff: Sample consists of loose felsic crystals of quartz and feldspar, white and moderate-orange-pink (5YR8/4) vitric pumice fragments, tuffaceous rock fragments, and mafic minerals of biotite and clinopyroxene. Lithology is partly based on geophysical logs.	mafic-poor Ammonia Tanks Tuff

Lithologic Log of Emplacement Hole U-19bj (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
64.6 - 73.5 m (212 - 241 ft)	Bedded Tuff: Samples consist of loose felsic crystals of quartz and feldspar; mafic minerals of biotite, clinopyroxene and lesser orthopyroxene; white to light-brown (5YR5/6) vitric pumice containing rare felsic phenocrysts of feldspar and quartz, and a trace of biotite, clinopyroxene and sphene; and tuffaceous rock fragments.	bedded Ammonia Tanks Tuff
73.5 - 76.8 m (241 - 252 ft)	Bedded Tuff: Interval not recognized in samples. Lithology inferred from geophysical logs.	bedded Rainier Mesa Tuff
76.8 - 81.7 m (252 - 268 ft)	Nonwelded Tuff: Moderate-yellowish-brown; vitric; common white pumice; minor felsic phenocrysts of quartz and feldspar; minor mafic minerals of biotite and lesser clinopyroxene and orthopyroxene; rare grayish-black lithic fragments less than 3 mm in diameter.	mafic-rich Rainier Mesa tuff
81.7 - 95.4 m (268 - 313 ft)	Partially Welded Ash-Flow Tuff: Pale-reddish-brown to grayish-red (10R4/2); devitrified with minor vapor-phase mineralization; rare very-pale-orange pumice; rare felsic phenocrysts of quartz and lesser feldspar; minor mafic minerals of biotite and much less clinopyroxene; rare moderate-red lithic fragments less than 2 mm in diameter.	mafic-rich Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bj (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
95.4 - 108.2 m (313 - 355 ft)	Moderately Welded Ash-Flow Tuff: Pale-reddish-brown to grayish-red (10R4/2); devitrified; rare white to very-light-brownish-gray pumice; minor felsic phenocrysts of feldspar and quartz; minor mafic minerals of biotite and much less clinopyroxene. Interval approaches densely welded and becomes partially devitrified from 98.8 - 100.3 m (324 - 329 ft).	mafic-rich Rainier Mesa Tuff
108.2 - 332.8 m (355 - 1,092 ft)	Moderately Welded Ash-Flow Tuff: Grayish-red (10R4/2) to pinkish-gray, mottled; devitrified; minor pinkish-gray pumice; minor felsic phenocrysts of feldspar and quartz; rare biotite; rare grayish-red lithic fragments less than 2 mm in diameter. Interval becomes densely welded and partially devitrified from 120.7 to 132.0 m (396 - 433 ft) and at base below approximately 329.2 m (1,080 ft).	mafic-poor Rainier Mesa Tuff
332.8 - 340.2 m (1,092 - 1,116 ft)	Vitrophyre: Brownish-black to grayish-black; vitric; minor felsic phenocrysts of quartz and feldspar; rare biotite.	mafic-poor Rainier Mesa Tuff
340.2 - 343.2 m (1,116 - 1,126 ft)	Densely Welded Ash-Flow Tuff: Light-brownish-gray; vitric; minor felsic phenocrysts of feldspar and quartz; rare biotite.	mafic-poor Rainier Mesa Tuff

Lithologic Log of Emplacement Hole U-19bj (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
343.2 - 346.3 m (1,126 - 1,136 ft)	Moderately Welded Ash-Flow Tuff: Moderate-reddish-brown; vitric; minor felsic phenocrysts of feldspar and quartz; rare biotite; common pale-yellowish-brown glass shards.	mafic-poor Rainier Mesa Tuff
346.3 - 349.0 m (1,136 - 1,145 ft)	Partially Welded Ash-Flow Tuff: Moderate-reddish-orange; vitric; minor white pumice; minor felsic phenocrysts of quartz and feldspar; rare biotite; common dusky-yellowish-brown glass shards.	mafic-poor Rainier Mesa Tuff
349.0 - 367.9 m (1,145 - 1,207 ft)	Nonwelded Ash-Flow Tuff: Samples consist of loose felsic crystals of quartz and feldspar, fragments of white vitric pumice, and moderate-yellowish-brown glass shards. A moderate-reddish-orange vitric matrix coats many of the constituents of the samples. Lithic fragments and loose biotite flakes are present, but in much less quantity than the above constituents.	mafic-poor Rainier Mesa Tuff
367.9 - 381.0 m (1,207 - 1,250 ft)	Bedded Tuff: Light-brown (5YR5/6); vitric; rare to common pumice; minor felsic phenocrysts of quartz and feldspar; rare very small mafic minerals of biotite, clinopyroxene and hornblende; minor various colored lithic fragments up to 3 mm in diameter; trace of sphene; rare to common glass shards.	tuff of Holmes Road

Lithologic Log of Emplacement Hole U-19bj (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
381.0 - 410.0 m (1,250 - 1,345 ft)	<p>Pumiceous Lava: White to very-light-brownish-gray; vitric; rare felsic phenocrysts of quartz and feldspar; rare biotite. Samples from upper portion of interval from approximately 381.0 - 393.2 m (1,250 - 1,290 ft) consist of loose felsic crystals of feldspar and quartz, various lithic fragments including pumiceous and devitrified lava fragments, and loose mafic minerals of biotite and clinopyroxene. Vitric and devitrified Rainier Mesa ash-flow tuff and vitrophyre fragments from uphole are also present in samples.</p> <p>The upper portion of this interval may be a bedded tuff (tephra envelope) overlying pumiceous lava.</p>	mafic-poor Calico Hills Formation
410.0 - 430.4 m (1,345 - 1,412 ft)	<p>Bedded Tuff: Grayish-orange, becoming grayish-yellow below approximately 426.7 m (1,400 ft); vitric to partially zeolitic, becoming zeolitic and partially silicified below approximately 426.7 m (1,400 ft); abundant grayish-orange pumice; rare to minor felsic phenocrysts of quartz and feldspar; rare biotite; trace of hornblende; minor to common grayish-red (5R4/2) lithic fragments (rhyolite lava) up to 10 mm in diameter; common botryoidal chalcedony present, particularly as coatings on lithic fragments, below approximately 426.7 m (1,400 ft).</p>	mafic-poor Calico Hills Formation

Lithologic Log of Emplacement Hole U-19bj (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
430.4 - 470.9 m (1,412 - 1,545 ft)	Nonwelded Tuff: Dark-yellowish-orange, becoming grayish-orange towards base of interval; zeolitic; rare felsic phenocrysts of quartz and feldspar; rare biotite; rare moderate-brown (5YR4/4) lithic fragments up to 3 mm in diameter, becoming minor in abundance and up to 7 mm in diameter below approximately 457.2 m (1,500 ft).	mafic-poor Calico Hills Formation
470.9 - 509.0 m (1,545 - 1,670 ft)	Bedded Tuff: Very-pale-orange, grayish-yellow, and yellowish-gray; mostly zeolitic, vitric in part; rare felsic phenocrysts of feldspar and quartz; rare biotite; rare to common mostly dark-reddish-brown lithic fragments up to 5 mm in diameter.	mafic-poor Calico Hills Formation
509.0 - 533.4 m (1,670 - 1,750 ft)	Lava: Grayish-yellow to moderate-yellow; zeolitic, vitric and perlitic in part, becoming pumiceous towards base of interval; minor feldspar phenocrysts; abundant mafic minerals of biotite and lesser clinopyroxene.	rhyolite of Kearsarge

Lithologic Log of Emplacement Hole U-19bj (cont.)

Depth Meters/(feet)	Lithologic Description	Stratigraphic Unit
533.4 - 553.5 m (1,750 - 1,816 ft)	Flow Breccia: Dusky-yellow and grayish-red (10R4/2); zeolitic and devitrified, pumiceous in part; minor feldspar phenocrysts; abundant mafic minerals of biotite and lesser clinopyroxene; common botryoidal chalcedony. Interval consists of grayish-red (10R4/2) devitrified lava fragments in a dusky-yellow, zeolitic, pumiceous matrix.	rhyolite of Kearsarge
553.5 - 653.8 m (1,816 - 2,145 ft)	Lava: Pale-red (10R6/2) to grayish-red (10R4/2); devitrified to partially devitrified to 609.6 m (2,000 ft), becoming partially zeolitic below; common feldspar phenocrysts; abundant mafic minerals of biotite and lesser clinopyroxene.	rhyolite of Kearsarge
653.8 - 656.2 m (2,145 - 2,153 ft) TD	Vitrophyric Lava: Dusky-yellowish-brown and grayish-black; vitric; minor feldspar phenocrysts; common biotite.	rhyolite of Kearsarge

Emplacement Hole U-19bj Supplemental Data

1. Sandia color video available (Prothro, 1992).
2. Bottom-hole measurements on 07/18/1994 indicated a depth to fluid level of 650.7 m (2,135 ft) and a total depth of 655.3 m (2,150 ft).

Figure 12
West-East Geologic Cross Section Through U-19ba *

* U-19ba is approximately 304.8 m (1000 ft) north of U-19bj.

(from Warren 1991)

Figure 13
North-South Geologic Cross Section Through U-19ba *

* U-19ba is approximately 304.8 m (1000 ft) north of U-19bj.

(from Warren, 1990)

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QTd

QTd

Approximate depth of
U-1a.01 vent drift invert
= 296 m (972 ft)

TD = 304.8 m
(1000 ft)

Bit #4

Bit #3

Bit #2

GRAPHIC DATA SUMMARY FOR DRILL HOLE U-1g

DOE/NV/11718-254

LOCATION

N 251,003.8 E 206,563.4 m
N 823,600 E 677,700 (ft)

GROUND LEVEL ELEVATION

1,220.2 (m)
4003.4 (ft)

TOTAL DEPTH (TD)

304.8 (m)
1000 (ft)

DATE TD REACHED

11/20/92

HOLE DIAMETER

3.65 m (144 in) hole to 35.96 m (118 ft)
2.74 m (108 in) to 304.8 m (1000 ft) (TD)

DRILLING TECHNIQUE

Dry-hole auger 2.64 m (104 in) hole from surface to 3.96 m (13 ft).
Open hole to 4.11 m (162 in) diameter, to 2.44 m (8 ft) depth. Set CMP.
Dry-hole auger 2.64 m (104 in) hole to 36.6 m (120 ft). Open hole
to 3.66 m (144 in) diameter, to 35.97 m (118 ft) depth. Set surface casing.
Rotary drill using dual-reverse air/water (with Cydri) circulation system.
2.74 m (108 in) diameter hole to 304.8 m (1000 ft) (TD). Set intermediate casing string.

CASING RECORD

3.76 m (148 in) CMP to 1.98 m (6.5 ft)
3.09 m (122 in) ID to 35.05 m (115 ft)
1.22 m (48 in) ID to 300.8 m (987 ft)

WELL SITE GEOLOGY BY

B.M. Allen and S.L. Dreilack, Jr.

GEOPHYSICAL LOGS BY

Atlas Wireline Services

EXPLANATION

Alluvium

Casing depth

Bit #1
to depth of insertion

Graphic data summary for drill hole U-7cd.

Abridged drill hole statistics for emplacement hole U-7cd.

Location

Coordinates: N 258,762.6 E 207,680.6 (m)
N 849,000.24 E 681,399.94 (ft)

Elevation: 1254.1 (m) 4114.7 (ft)

Drilling Data

Spud Date: 2-13-92 (Auger #2); 3-5-92 (Ideco 2500)

Hole Diameter: 3.05 m (120 in) to 36.0 m (118.0 ft):
2.44 m (96 in) 495.3 m (1625 ft)

Total Depth (TD): 495.3 m (1625 ft)

Date Reached TD: 4-14-92

Drilling Technique: Rotary using air/water and dual reverse circulation

Drilling Problems: None

Casing Record

Surface: From surface to 35.7 m (117 ft), 2.49 m (98 in) ID

Purpose of Hole: Emplacement

Explanation

DOE/NV/11718-254

Alluvium

Ash Flow
Tuff

Bedded
Tuff

Air Fall
Tuff

v vitric

c Calcareous

s Silicified

vp Vapor-phase
mineralization

dv Devitrified

z Zeolitized

m Mafic-rich

Geophysical Logs by
Atlas Wireline Services

Stratigraphy

Resistivity RLML in OHMM (from RDL#1)

Lithology

Borehole gauge in inches (from CAL#1)

Bulk Density in gm/cc (from DBS#2)

Penetration rate in minutes per foot

LOCATION

3.7 m (144 in) hole to 1.7 m (5.5 ft)
3.0 m (120 in) hole to 21.9 m (72 ft)
2.4 m (96 in) hole to TD

HOLE DIAMETER

3.7 m (144 in) hole to 1.7 m (5.5 ft)
3.0 m (120 in) hole to 21.9 m (72 ft)
2.4 m (96 in) hole to TD

GROUND LEVEL ELEVATION

2062.9 (m) 6768 (ft)

DRILLING TECHNIQUE

Augured surface hole to 21.9 m (72 ft). Rotary drilled using dual string and reverse circulation with air and water from 21.9 m (72 ft) to TD.

TOTAL DEPTH (TD)

654.7 (m) 2148 (ft)

DATE REACHED TD

06/14/91

GEOLOGY BY

L. B. Prothro

CASING RECORD

3.4 m (136 in) ID surface casing to 1.7 m (5.5 ft).
2.5 m (98 in) intermediate casing to 21.3 m (70 ft).

GEOPHYSICAL LOGS BY

Atlas Wireline Services

EXPLANATION

BEDEDDED TUFF	v dv z vt	Vitric Devitrified Zeolitized Vitrophyric
NONWELDED TUFF
ASH-FLOW TUFF		Base of Casing
FLOW BRECCIA		Fluid Level (from Fluid Density Log on 08-28-91)
LAVA