DOE/WIPP-07-3363

Basic Data Report For Drillhole SNL-10 (C-3221) (Waste Isolation Pilot Plant)

February 2009

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Basic Data Report For Drillhole SNL-10 (C-3221) (Waste Isolation Pilot Plant)

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February 2009

West Texas Water Well Service Rig #15 at SNL-10 on June 1, 2006. Toward east, with WIPP facilities in background. Taken by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-10 (permitted by the New Mexico State Engineer as C-3221) was drilled and completed from late May to mid-June 2006 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation in an area near the west central boundary of the Waste Isolation Pilot Plant (WIPP) site. The location is near the estimated margin of informal Rustler unit M-1/H-1 and where Culebra transmissivity is expected to be low. SNL-10 is located in the northwest quarter of section 30, T22S, R31E, in eastern Eddy County, New Mexico. SNL-10 was drilled to a total depth of 651 feet (ft) below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-10 encountered the Mescalero caliche, Gatuña, Dewey Lake, and Rustler Formations. Two intervals of the Rustler were cored: 1) from the base of the Forty-niner Member through Magenta Dolomite Member and into uppermost Tamarisk Member and 2) from lower A-3 of the Tamarisk through the Culebra Dolomite and into the upper Los Medaños Member. Geophysical logs were acquired from the open hole to a depth of ~630 ft. No evidence of water was encountered until the drillhole had nearly reached the Culebra; coring continued with mist and soap to total depth.

The upper part of the Los Medaños has normal lithology, thickness, and stratigraphic sequence for areas east of WIPP. The upper part of the lower mudstone-halite unit (M-1/H-1) of the Los Medaños indicates some displacive to poorly bedded halite. Corroded halite occurs below a thin anhydrite included in M-1/H-1. A silty claystone to sandy siltstone underlies Anhydrite 1 (A-1). A-1 is mainly laminated anhydrite with some fracturing near the top. The upper clastic-halite unit of the Los Medaños (M-2/H-2) at SNL-10 was well preserved in cores, and it is represented only by mudstone facies (M-2). The contact with the overlying Culebra was recovered. The uppermost core from M-2 is well-laminated gray silty claystone, does not indicate significant deformation, and grades sharply into the overlying dolomite.

Core recovery from the Culebra was complete, revealing a unit with little observable porosity. Vugs and sulfate nodules are present, but they are less abundant than in many other cores farther east, toward the center of WIPP. There are some subvertical fractures within the core, and porosity near the middle appears to have collapsed. Gypsum in some fractures appears crystallographically continuous with some coarse vug-filling gypsum. Some subhorizontal bedding occurs throughout the core, and there are concentrated laminae in the more organic-rich zone in the upper 1 ft. The basal dolomite has undeformed laminae. The Culebra is 22 ft thick as interpreted from geophysical logs and 23.1 ft thick based on marked core depths. This is in the lower range of normal for the WIPP site. Given the limited apparent porosity and fracturing, the Culebra is expected to show low transmissivity.

The Tamarisk has a normal stratigraphic sequence for the area west of the Rustler H-3 margin. The basal sulfate (A-2) is mainly gray anhydrite that displays horizontal beds and laminae. A 0.8-ft-thick laminated siltstone and claystone ~11 ft above the Culebra persists across the WIPP area. The upper surface appears eroded. At SNL-10, mudstone (M-3) of the Tamarisk shows sulfate and siltstone clasts (or peds) as well as some probable displacive gypsum. The upper Tamarisk sulfate (A-3) is nearly 67 ft thick, consistent with other encounters in the area where H-3 is not present and sulfate beds found in H-3 to the east are part of the upper sulfate. The basal part of A-3 shows little fracturing. Halite (H-3) was not deposited at the location of SNL-10.

The Magenta Dolomite is 30 ft thick as interpreted from geophysical logs and 26.0 ft thick as marked by core depths, normal for the

member. The core displays normal thin bedding and laminae ranging from wavy to cross- and ripple-bedded to horizontal. The basal zone shows higher amplitude wavy bedding consistent with evidence of stromatolite forms encountered elsewhere. Small nodules occur slightly below the top of the Magenta. Few fractures are present, and gypsum fills wider apertures. A sandier zone in the upper middle part of the Magenta appears more porous and differs in neutron count in geophysical logs. This zone occurs in many Magenta cores across the site.

The Forty-niner is represented by a sequence of sulfate–halite and mudstone–sulfate sequence. The basal gypsum (A-4) is 12 ft thick. The short core from the base shows some gypsum as well as laminae with carbonate and some possible nodular textures. M-4 is 20 ft thick, and cuttings reveal gray siltstone in the upper part and reddish brown siltstone in the lower part. The upper gypsum (A-5) of the Forty-niner is 26 ft thick. The contact with the overlying Dewey Lake appears sharp on the logs.

The Dewey Lake is thinner at SNL-10 (374 ft) than in drillholes farther east where the upper part of the formation has not been eroded. The lower two general depositional sequences of the Dewey Lake are interpretable, but the upper part does not show typical decrease in natural gamma. Cuttings showed more gypsum below 100 ft and probable sulfate cement below 170 ft, at a location where the density log also changed. This is a lower stratigraphic position for this cement than has been encountered in WIPP drillholes to the east.

The Santa Rosa Formation at SNL-10 has been eroded.

The Gatuña at SNL-10 is a 25-ft-thick reddish brown siltstone; some cuttings display laminar bedding. The Gatuña is thicker at this location nearer Nash Draw compared to the central part of WIPP.

The Mescalero caliche is calcareous sandy siltstone and thin (2 ft) at SNL-10, and cuttings were insufficient to determine the stage of development as a pedogenic calcrete.

The Berino soil was encountered above the Mescalero as well as thick sand from the dune field at the well location.

SNL-10 was drilled (and reamed through cored intervals) with an original diameter of 11 inches to the depth for completion. Fiberglass reinforced plastic (FRP) casing (4.85 inches inside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 620.0–593.3 ft below the top of the connector on the conductor casing. A 10-ft blank with cap was added to the bottom of the casing. Approximately 2.5 ft of FRP casing was left above the connector. Aquagel® (bentonite) was placed in the bottom of the hole (651–631 ft) and the cored interval was reamed to 630 ft. Logging showed open hole to ~630 ft. The annulus was filled with 4/10 gravel to 589 ft, above the Culebra. Aquagel® was placed from 589–584 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface.

SNL-10 was completed June 14, 2006. The first water level recorded by Washington Regulatory and Environmental Services (WRES) was measured September 14, 2006; the initial depth to water was 323.24 ft below the top of casing.

Table of Contents

List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-10 are reported in the inch-pound, or English, system; metric equivalents are given in one figure. The following conversion factors for metric equivalents may be useful:

MULTIPLY ENGLISH UNIT	BY	TO OBTAIN METRIC UNIT
foot (ft)	0.3048	meter (m)
inch (in)	25.4	millimeter (mm)
inch (in)	2.54	centimeter (cm)
pounds (lb)	0.4536	kilogram (kg)

1.0 INTRODUCTION

SNL-10 was drilled in the northwest quarter of section 30, T22S, R31E, in eastern Eddy County, NM (Fig. 1-1). It is located 240 ft from the north line (fnl) and 2,284 ft from the west line (fwl) of the section (Fig. 1-2). This location places the drillhole west of the WIPP site center, but within WIPP boundaries. SNL-10 was begun on May 30, 2006, and was completed June 14. SNL-10 will be used to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for WIPP in an area of moderately low transmissivity.

SNL-10 was permitted by the NM State Engineer as C-3221. Official correspondence regarding permitting and regulatory information must reference this permit number.

Most drillholes at WIPP have been described after completion to provide an account of the geology, hydrology, or other basic data acquired during drilling and immediate completion of the drillhole. In addition, the basic data report provides an account of the drilling procedures and activities that may be helpful to later interpretations of data or for further work in the drillhole, including test activities and eventual plugging and abandoning activities. The basic data report also provides a convenient means of reporting information about administrative activities necessary to drill the hole.

1.1 Purpose of WIPP

WIPP is a U.S. Department of Energy (DOE) facility disposing of transuranic and mixed waste, byproducts of U.S. defense programs, as certified by the U.S. Environmental Protection Agency (EPA), and under a permit issued by the NM Environment Department. WIPP is located approximately 25 miles east of Carlsbad, New Mexico, in eastern Eddy County (Fig. 1-1). Disposal panels are being excavated in the Permian Salado Formation at a depth of about 2,150 ft bgl.

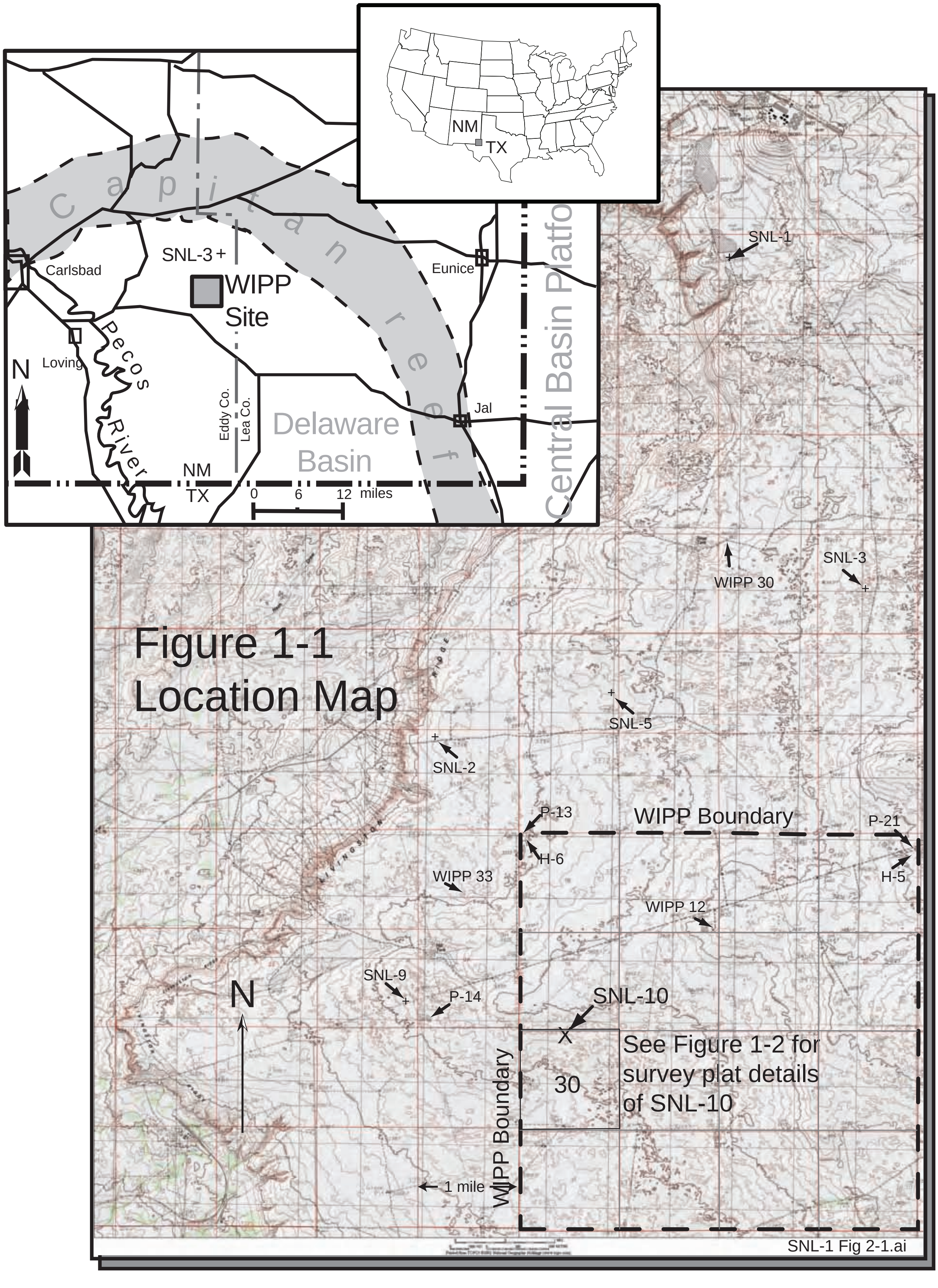
1.2 Purpose of SNL-10

SNL-10 was designed and located to provide information for the integrated hydrology program for the WIPP (Sandia National Laboratories [SNL], 2003). Among the objectives of the integrated hydrology program, SNL-10 will help "… resolve questions related to observed water-level changes around the WIPP site, provide data needed for comprehensive modeling of WIPP groundwater hydrology, [and] construct a groundwater monitoring network that can be maintained throughout the operational period of WIPP …" (p. 1).

Culebra water levels in many of the wells monitored for WIPP have been rising in recent years, contrasting with the conditions used to calibrate models of the Culebra across the site area (SNL, 2003) for the Compliance Certification Application (CCA; U.S. DOE, 1996). Hydraulic properties of the Culebra vary spatially, and three factors (overburden, upper Salado dissolution, and Rustler halite distribution) appear to explain most of the variability in transmissivity (Holt and Yarbrough, 2002; Holt and Powers, 2002; Powers and others, 2003). The Compliance Recertification Application (CRA; U.S. DOE, 2004) submitted to the EPA models release scenarios through the Culebra using transmissivity fields based on these factors.

SNL-10 was located west of the WIPP site center between areas of higher and lower Culebra transmissivity and near the margin of the Rustler halite unit H-1 (SNL, 2003). Geologic data obtained from the drillhole would help confirm the effects of Rustler halite on Culebra hydraulic properties. SNL-10 was included in the program plan (SNL, 2003), and it was co-located at the site designated WTS-5. From the program plan (SNL, 2003), SNL-10 is to:

1. Provide transmissivity data in an area of the Culebra model domain where data are currently lacking;


NM
TX
Capitan reef
SNL-3 +
Carlsbad
Eunice
WIPP Site
Loving
Pecos River
N
Eddy Co.
Lea Co.
Delaware Basin
Jal
Central Basin Platfo
NM
TX
0 6 12 miles
Figure 1-1
Location Map
SNL-1
WIPP 30
SNL-3
SNL-5
SNL-2
P-13
WIPP Boundary
P-21
H-6
H-5
WIPP 33
WIPP 12
SNL-9
P-14
N
SNL-10
X
30
See Figure 1-2 for survey plat details of SNL-10
WIPP Boundary
1 mile
SNL-1 Fig 2-1.ai

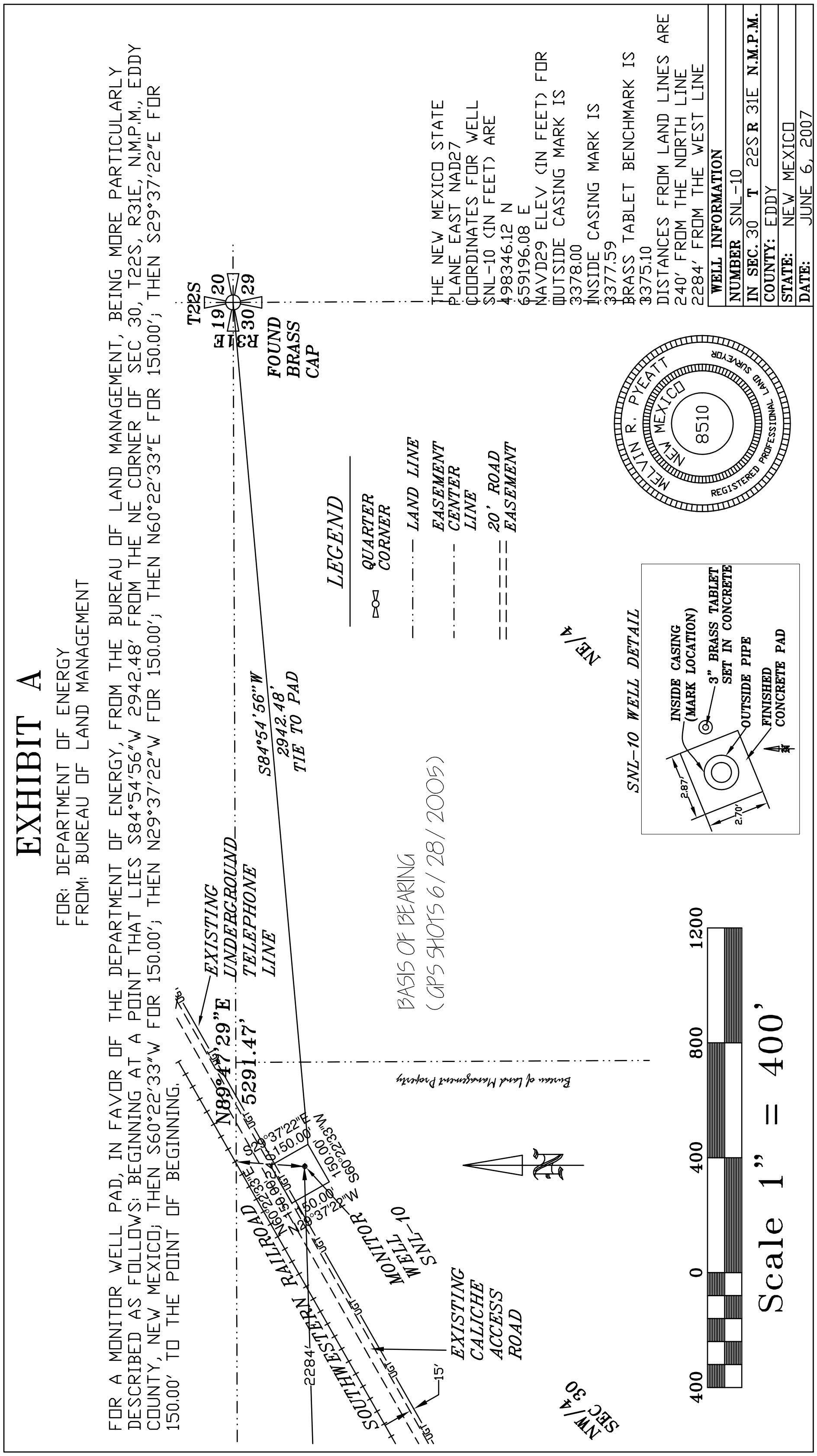


Figure 1-2
Survey Plat
for SNL-10

2. Provide data to define better the location of the M-1/H-1 halite margin and its effect on Culebra transmissivity; and
3. Provide a monitoring location for a large-scale (multipad) pumping test (centered at SNL-9) to provide transient data for calibration of the Culebra model on the west side of the WIPP site.

This location provides information to help define the direction and rate of groundwater flow across WIPP for reporting to the NM Environment Department.

1.3 SNL-10 Drilling and Completion

The basic information about drilling and completion of SNL-10 is presented here in tabular form (Table 1-1) and graphics (Figs. 1-3, 1-4, and 1-5) for ease of reference. Appendix B includes details based on daily drilling logs.

SNL-10 was rotary drilled and cored to a total depth of 651 ft bgl (Fig. 1-3) as measured during drilling. Coring recovery was excellent (Table 1-1), with the fitted, measured, and marked core 0.6 ft more than intervals measured during coring. The total depth of the drillhole as measured during drilling is 651 ft. The bottom marked core is 652 ft. For practical purposes, 651 ft is taken as the total depth. The bottom of SNL-10 was plugged back to ~631 ft with Aquagel® before reaming the cored interval to 630 ft and logging for completion. Geophysical logging indicated the drillhole was open to 630 ft. SNL-10 was drilled to 595 ft using compressed air only (two compressors); compressed air with mist was used to complete drilling and coring. Cuttings from SNL-10 were of useful size because of these methods.

Core recovery was complete or nearly complete through the Culebra (Table 1-1; Appendix C). The difference (0.5 ft) between cored interval and recovery is likely loss in the underlying mudstone. Complete core recovery is rare through the Culebra (e.g., Powers, 2002b; Mercer and others, 1998).

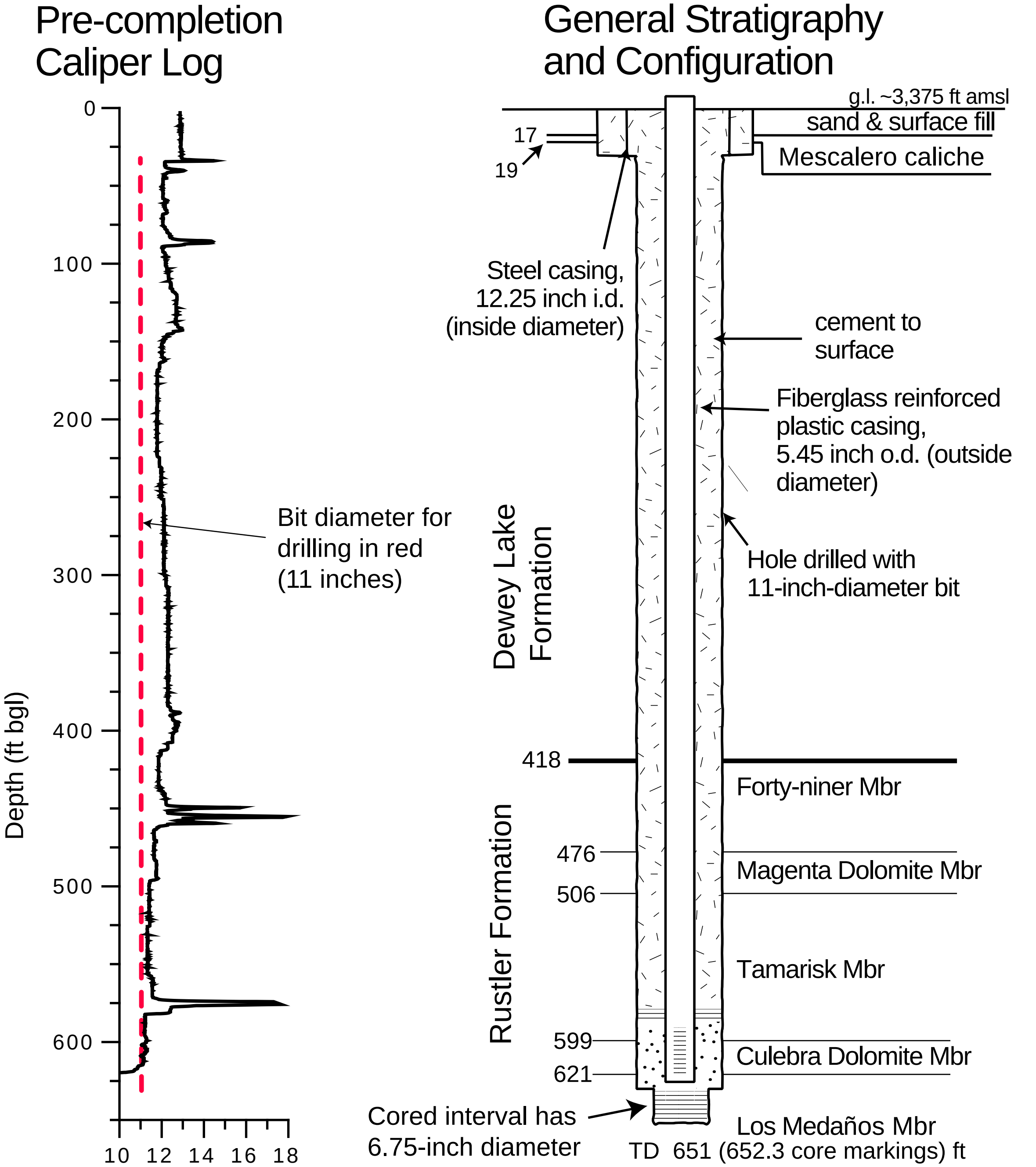
In keeping with recent practice at WIPP, SNL-10 was cased with FRP casing rather than steel to provide longer utility of the well for monitoring and testing. Steel-cased wells at WIPP are expected to be plugged and abandoned and, where necessary, replaced with wells completed with FRP casing (SNL, 2003).

SNL-10 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water-level data when packers fail; mixing of waters of differing qualities when packers fail; and the increased complexity of testing in a well completed to multiple intervals. No wells to other intervals have been proposed for the SNL-10 wellpad (SNL, 2003).

Geophysical logs, especially the natural gamma and caliper logs, were used to make the final decisions regarding completion of SNL-10 (Fig. 1-4) (Appendix D). The drillhole penetrated the uppermost part of the lower Rustler, and Aquagel® was put into SNL-10 to prevent circulation into that interval (Fig. 1-4). The bottom of the Culebra screen interval was placed at 620 ft, above the claystone below the Culebra. The top of the screen, at 593.3 ft, is above the top of the Culebra. The top of the gravel pack (4/10 silica gravel) at 589 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (Aquagel®) was placed to 584 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) after the drillhole was reamed to 630 ft at a diameter of 11 inches and before the casing was placed shows drillhole enlargement in the Forty-niner and Tamarisk mudstones.

The surface configuration (Fig. 1-5) provides stability, security, and ready access to the casing for measurements, sampling, or other testing. The

Figure 1-3
SNL-10 As-Built Diagram (6/14/06)



SNL-10 Diameter (inches)
(after drilling and reaming to
11 inches to 630 ft)
See Figures 1-4 and 1-5 for
additional details

Note: Depths for drilling, geophysical logs, and completion are referenced to the top of the steel connector on the surface conductor casing, which is at the surface of the drilling pad at SNL-10 and is taken as 3,375 ft amsl.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-10 (C-3221)

LOCATION: Northwest ¼, Section 30, Township 22 South (T22S), Range 31 East (R31E)

SURFACE COORDINATES: The well is located 240 ft from the north line and 2,284 ft from the west line of Section 30. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 498346.12 North, 659196.08 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters (m) were calculated for SNL-10 using Corpscon for Windows (v. 6): 611229.25 East, 3581764.84 North. Figure 1-1 shows 1,000-m UTM gridlines.

ELEVATION: All depths from geological and geophysical data used for completion were measured from the surface conductor casing just above the level of the drillpad surface (Fig. 1-5). Depths are reported as below ground level, which is taken as 3,375 ft above mean sea level (amsl), the rounded value for the brass tablet benchmark (3,375.10 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,377.59 ft amsl (NGVD 29) for a mark on the inside of the fiberglass reinforced plastic casing inside the protective well pipe. Figures 1-3, 1-4, and 1-5 show the as-built configuration of SNL-10.

DRILLING RECORD:

Dates: Began drilling May 30, 2006; drillhole reached total depth (651 ft, driller's measurement) on June 5, 2006. Drillhole was reamed to 630 ft on June 13. Geophysical logging was conducted on June 14, 2006. SNL-10 was cased and cemented June 14, 2006. SNL-10 was jetted from 621-590 ft on June 21 and 160 barrels of water were pumped from the well. Low-flow pumping was conducted on June 22, 2006.

Circulation Fluid: SNL-10 was drilled to 595 ft bgl with circulating air. Moist cuttings at 595 ft resulted in using additional fresh water and Quik-Foam® to drill from 595 ft to total depth, discharging cuttings into a lined portable steel container.

Cored Intervals: 4.0-inch core was taken through these intervals (depths from drilling data):

470.0–510.0 ft bgl: basal Forty-niner, Magenta Dolomite, and uppermost Tamarisk Members

565.0–651.0 ft bgl: lower Tamarisk, Culebra Dolomite, and upper Los Medaños Members

Rig and Drilling Contractor: Gardner-Denver 1500; West Texas Water Well Service, Odessa, Texas

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-10 (C-3221), continued

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
17.5	0	35
11	35	630
6.75	630	651

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
12.75	12.25	33.41 steel	-3	35
5.45	4.85	4.40 FRP** blank	-2.5	593.3
5.45	4.85	4.40 FRP screen (0.070")	593.3	620.0
5.45	4.85	4.40 FRP blank	620.0	626.4

*Top of the casing connector is ~ pad level. The reference for depth denoted below ground level (bgl) is the pad level. The FRP extends ~2.5 ft (-2.5) above the steel casing connector. Above the connector, 3 ft of steel casing were added for security.

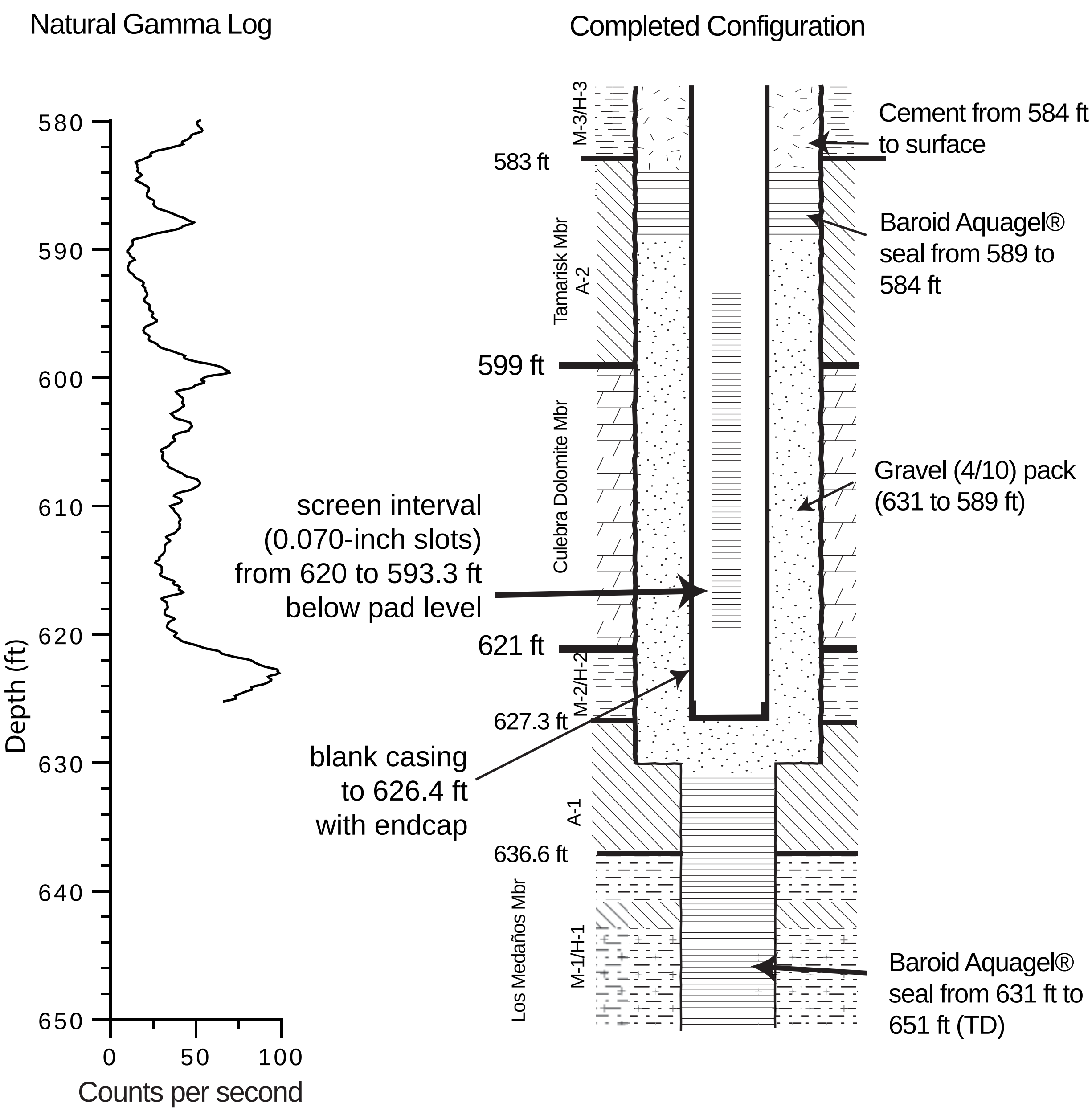
**FRP: fiberglass reinforced plastic

Coring Record:

Core Run No.	Depth Interval (ft) From	Depth Interval (ft) To	Interval (ft) Cored	Interval (ft) Recovered	Recovered %
1	470	500	30	29.6	98.67%
2	500	510	10	10.5	105.00%
3	565	595	30	30	100.00%
4	595	625	30	29.5	98.33%
5	625	651	26	27	103.85%
		Totals	126	126.6	100.48%

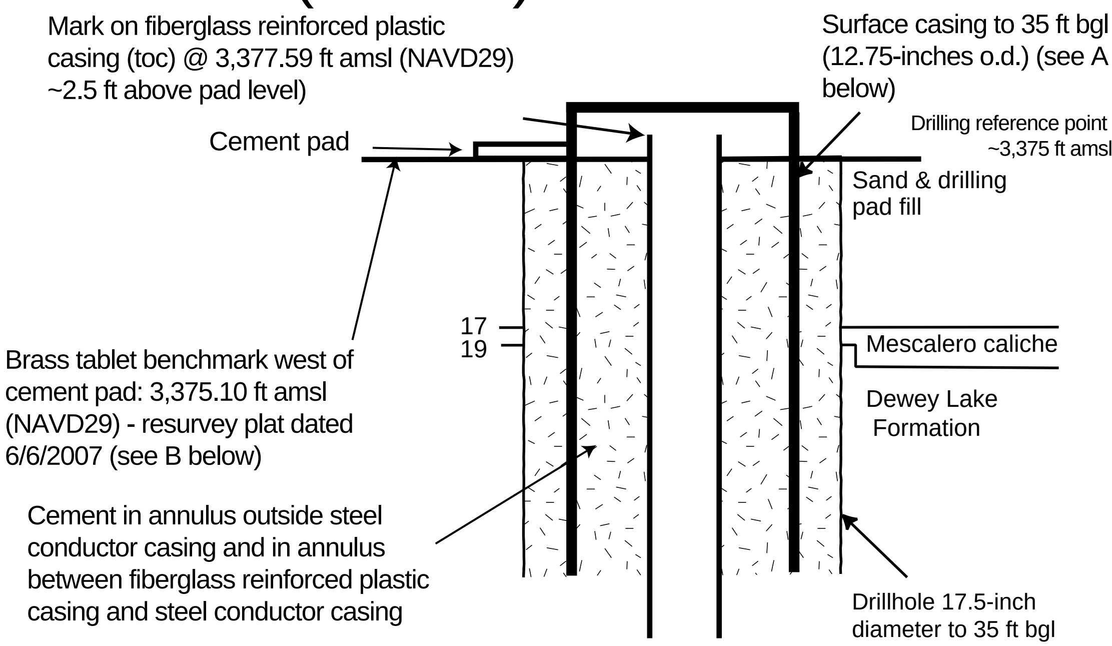
Note: The interval measured on recovered core may exceed the length measured during coring because core doesn't fit together precisely, some core from a previous run may be subsequently recovered, or depth measured during coring varies slightly.

Figure 1-4
SNL-10 Completion and Monitoring Configuration (6/14/06)

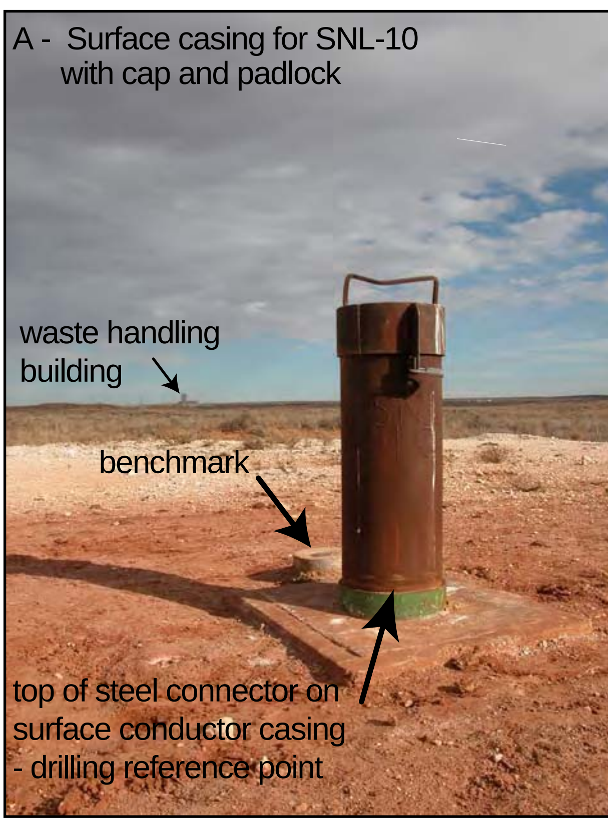


Note: Lithologic contacts below logged area are based on coring depths.

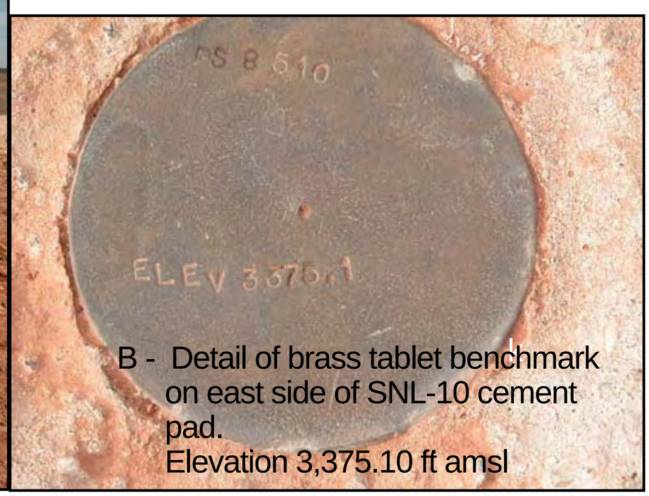
Figure 1-5
SNL-10 Surface Configuration and Elevation (9/20/07)



Note: Drawing is not to scale.



A - Surface casing for SNL-10 with cap and padlock



B - Detail of brass tablet benchmark on east side of SNL-10 cement pad.
Elevation 3,375.10 ft amsl

surface benchmark is an accessible reference point for future measurements if the well configuration is changed.

A steel surface conductor casing was cemented in place to a depth of 35 ft below the surface, with the top of the cutoff conductor casing ~6 inches above the pad level (Fig. 1-5) serving as a common reference point for drilling; geophysical logging; and placing the screened interval, sand pack, bentonite seal, and cement. The top of the steel connector was estimated to have an elevation of 3,373 ft amsl, based on a pre-drilling survey of the well pad. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,375.10 ft amsl (survey plat dated June 6, 2007) and is very close to the elevation of the connector on the casing. *Other than water-level monitoring, depths are stated as bgl, and the top of the steel connector on the surface conductor casing is taken as a proxy reference point for ground level with an elevation of ~3,375 ft amsl (Figs. 1-3, 1-4, and 1-5).* The FRP casing projects ~2.5 ft above the steel connector on top of the conductor casing. This FRP casing point is surveyed (Fig. 1-5), and it provides the reference point and reference elevation (3,377.59 ft amsl) for monitoring water levels.

1.4 Other Background

SNL-10 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, Texas, under contract from Washington TRU Solutions LLC (WTS). Coring was done by Billy Pon, Diamond Oil Well Drilling Co., Inc., P.O. Box 7843, Midland, Texas. Geophysical logging was conducted by Al Henderson, Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, under contract to West Texas Water Well Service. Geological support was provided by Dennis W. Powers under contract to WTS. Well drilling wastes (cuttings) were removed from SNL-10 and disposed of at the Lea Land, Inc., landfill north of WIPP. Archeological clearances obtained from the U.S. Bureau of Land Management were based on field work and reports by Mesa Field Services, Carlsbad, NM (Appendix E). Cores from SNL-10 were photographed with a digital camera, and a photo log is included in Appendix F. Electronic images can be requested from WTS.

Formal color designations (e.g., weak red: 5YR5/4) included in the text and Appendix C are based on the 1971 edition of the Munsell Soil Color Charts. The names may differ from the general color observed; the rocks are compared when dry unless otherwise specifically noted.

1.5 Acknowledgements

Drafts of this document were reviewed by Rick Salness, Joel Siegel, and Rick Beauheim, and their comments improved the final report. Ron Richardson (Washington Regulatory and Environmental Services - WRES) and Ed Bielecki (Washington Group International) provided field support during drilling. Mark Crawley (WRES) provided field support and information on well development. Larry Keith and Luis Armendariz (West Texas Water Well Service) provided drilling data and daily drilling records. West Texas Water Well Service personnel were very helpful in providing access for sampling during drilling. Al Henderson (Jet West Geophysical Services) provided the printed and electronic files that were used to develop Figure 2-1. Vivian Allen (L&M) provided useful editorial guidance and management of the review process.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been intensively investigated since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is certainly the Compliance Certification Application submitted in 1996 by the DOE to the EPA (U.S. DOE, 1996). Some salient features of the broader geological history, as well as more recent work on the geohydrology of the Rustler (e.g., Holt and Yarbrough, 2002; Powers, 2002a, 2003a; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-10.

The Delaware Basin (Fig. 1-1) was a large structural feature that controlled deposition through much of the Paleozoic. By late Permian, the basin connection to the open ocean was restricted, and evaporite minerals were precipitated in abundance to fill the basin. Near the end of the Permian, circulation with the ocean improved, and some of the Rustler Formation, for example, was deposited in saline water rather than brine. As the Permian ended and Triassic began, significant redbeds were deposited in non-marine environments. Although surrounding areas accumulated variable thicknesses of later Mesozoic and Cenozoic age sediments, the WIPP area appears mainly to have been subject to erosion during an extended period. Some basin tilting from middle to late Cenozoic time exposed the evaporite beds to faster solution and erosion, and weathered material began to accumulate. The Pecos River drainage became integrated through the region during this period, and more recent deposits reflect such a sedimentary environment as well as sources of sediment from outside the local area. Although the region continues to be subject to some dissolution of evaporites and erosion, large areas have remained geologically stable for about the last half million years, resulting in the formation and preservation of pedogenic calcrete (caliche) deposits.

2.2 Geological Data From SNL-10

SNL-10 encountered a normal stratigraphic sequence from ground level to total depth for this location in the west-central part of the WIPP site, (Fig. 2-1; Table 2-1). Units encountered ranged from unconsolidated surface sand to the upper part of the Los Medaños Member of the Permian Rustler Formation. Structural, sedimentological, and diagenetic features were examined during investigation using cuttings, cores, and geophysical logs. Details of the sedimentology of the Rustler will extend understanding of that unit. Moist cuttings were encountered just above the Culebra and drilling was modified to use mist.

The geologic units encountered in SNL-10 are described from total depth to the surface, in the order in which they were deposited rather than in the order in which they were encountered in the drillhole. Cores and cuttings were described in the field using mainly drilling depths for depth control. Geologic logs detailing field observations of cuttings and cores are included in Appendix C. The difference between geophysical log and drilling depth is generally slight. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix G).

Note that the descriptions that follow use depths that correspond to core markings, with basic stratigraphic intervals provided by geophysical logs, as indicated.

2.2.1 Permian Rustler Formation

The Rustler was drilled and cored into the upper Los Medaños Member. The contact between the Rustler and the overlying Dewey Lake Formation is at 418 ft (Fig. 2-2; Table 2-1), and 233 ft of the Rustler were penetrated at SNL-10 (Table 2-1).

2.2.1.1 Los Medaños Member

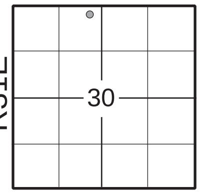
The Los Medaños was named by Powers and Holt (1999) based on the rocks described in shafts at the WIPP site. For the area around WIPP, studies of the Rustler have commonly referred to

Figure 2-1
Well Record SNL-10 (C-3221)

Company: Washington TRU Solutions LLC
Well: SNL-10 (C-3221)
Section: 30 Twp: T22S Rge: R31E
Location: 240 ft from north line (fnl)
2,284 ft from west line (fwl)

T22S

R31E



Reference point
Log measured from: top of connector on conductor casing (gl)
Drilling measured from: gl
Permanent Datum: benchmark

Elevation
KB:
DF:
GL: 3,375 ft amsl
(benchmark: 3,375.10)

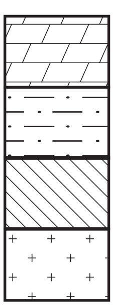
Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: May 30, 2006
Completion date: June 14, 2006
Total depth (TD): 651 ft bgl (driller log)

Casing Record
Conductor: 35 ft
12.75 inch o.d. steel
Casing: 5.45 inch o.d. fiberglass reinforced plastic to 626.4 ft bgl
Screened interval: 593.3-620 ft bgl

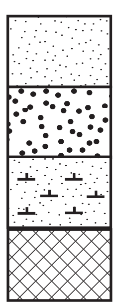
Geophysical Logs Date: June 14, 2006	
Micro/Laterolog/SP:	530-630 ft
Gamma	0-625 ft
Caliper:	0-620 ft
Density/Neutron:	0-629 ft

Type fluid in hole: water from drillhole to 532 ft
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.: not recorded

General Lithologic Symbols Used



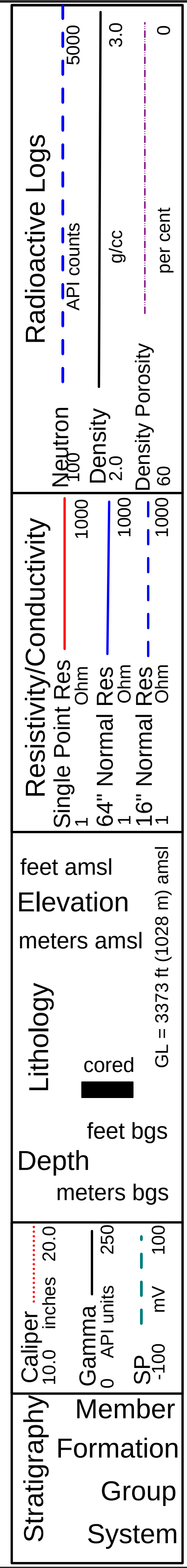
Dolomite
Mudstone/siltstone
Anhydrite
Halite

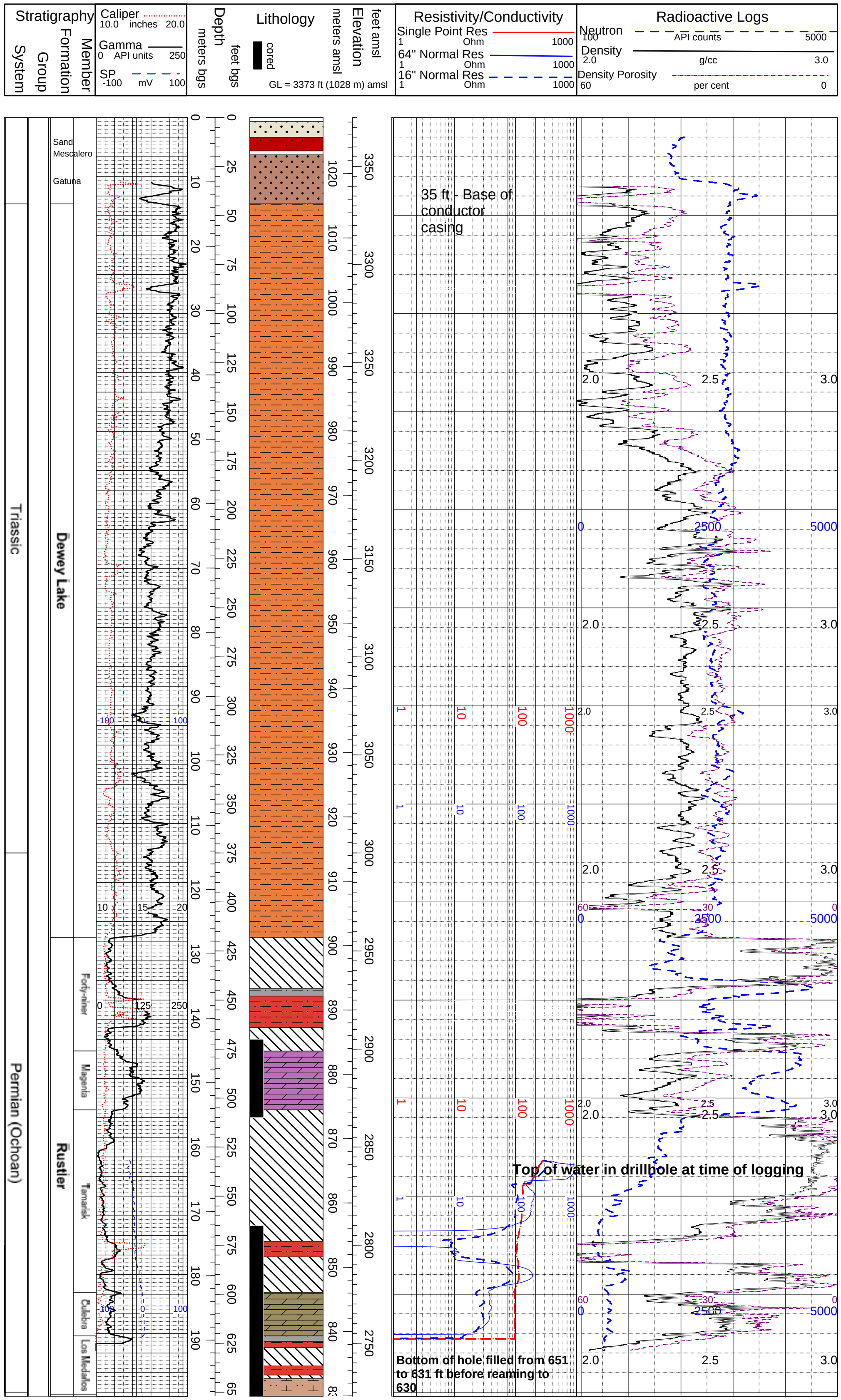


Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Figure 2-1 Log Title & Header page.ai

SNL-10 Well Log Headers





See end of Appendix G for larger format pdf version

Table 2-1
Geology at Drillhole SNL-10

System/ **Period**/Epoch		Formation or unit	Member *Informal units*	Depth below surface (ft)[1] *log depths*	*core marks*
Cenozoic	Holocene	surface dune sand and pad fill		0 - 17 ft	
Cenozoic	Pleistocene	Mescalero caliche		17 ft - 19 ft	
Cenozoic	Miocene-Pleistocene	Gatuña		19 ft - 44 ft	
Mesozoic	**Triassic**	Santa Rosa[2]		eroded	
Mesozoic	**Triassic**	Dewey Lake[3]		44 ft - 418 ft	
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	418 ft - 476 ft *418 ft - 444 ft* *444 ft - 464 ft* *464 ft - 476 ft*	
Paleozoic	**Permian**	Rustler	Magenta Dolomite	476 ft - 506 ft	478.7 ft - 504.7 ft
Paleozoic	**Permian**	Rustler	Tamarisk *A-3* *M-3/H-3* *A-2*	506 ft - 599 ft *506 ft - 573 ft* *573 ft - 583 ft* *583 ft - 599 ft*	504.7 ft - 598.2 ft *573.1 ft - 581.4 ft* *581.4 ft - 598.2 ft*
Paleozoic	**Permian**	Rustler	Culebra Dolomite	599 ft - 621 ft	598.2 ft - 621.3 ft
Paleozoic	**Permian**	Rustler	Los Medaños[4] *M-2/H-2* *A-1* *M-1/H-1*	top at 621 ft	621.3 ft - 652.2 ft[1,5] *621.3 ft - 627.3 ft* *627.3 ft - 636.6 ft* *636.6 ft - 652.2 ft*

[1]Depths are based mainly on measurements by geophysical logging; drilling and coring provided supplemental data to total depth (TD) of 651 ft bgl by driller's log and 652.2 ft as marked on core. All depths below Culebra Dolomite are based on core depth marks. Geophysical logs and drilling/coring depths begin at the top of the connector on the surface steel conductor casing. This reference point is taken as 3,375 ft amsl; it is near the elevation of the surface benchmark adjacent to SNL-10. Water level depths will be measured and reported relative to the surveyed point on the top of the fiberglass reinforced plastic casing (Fig. 1-5). Geological logs based on field descriptions (Appendix C) and markings on cores (Appendix G) vary modestly from log depths.

[2]The Santa Rosa has been removed by erosion in this area.

[3]The Dewey Lake Formation has been considered part of the Permian System in the past. Recent work (Renne and others, 1996, 2001) indicates that lithologically equivalent rocks in Texas are mostly Lower Triassic, with some Upper Permian at the base.

[4]The Los Medaños Member was named by Powers and Holt (1999) to replace the informal unit "unnamed lower member" of the Rustler Formation. Depths are based on core markings.

[5]The total depth by drilling is 651 ft. The mark on the recovered core is 652.3 ft at the bottom.

this interval from the base of the Culebra Dolomite Member to the top of the Salado Formation as the unnamed lower member of the Rustler. Holt and Powers (1988) and Powers and Holt (1999) also informally subdivided the Los Medaños into five units (Fig. 2-2): a bioturbated clastic interval at the base, a sandy transition zone, a lower mudstone-halite 1 (M-1/H-1), anhydrite 1 (A-1), and an upper mudstone-halite 2 (M-2/H-2). Halite margins for the Los Medaños below A-1 have been treated as a single composite unit (Powers, 2002a), called M-1/H-1 (Fig. 2-2), because halite below A-1 is not restricted to the thinner zone designated M-1/H-1 in these earlier publications.

The upper part of the Los Medaños was cored (30 ft) in SNL-10, penetrating through M-2, A-1, and into halite facies (H-1) of M-1/H-1.

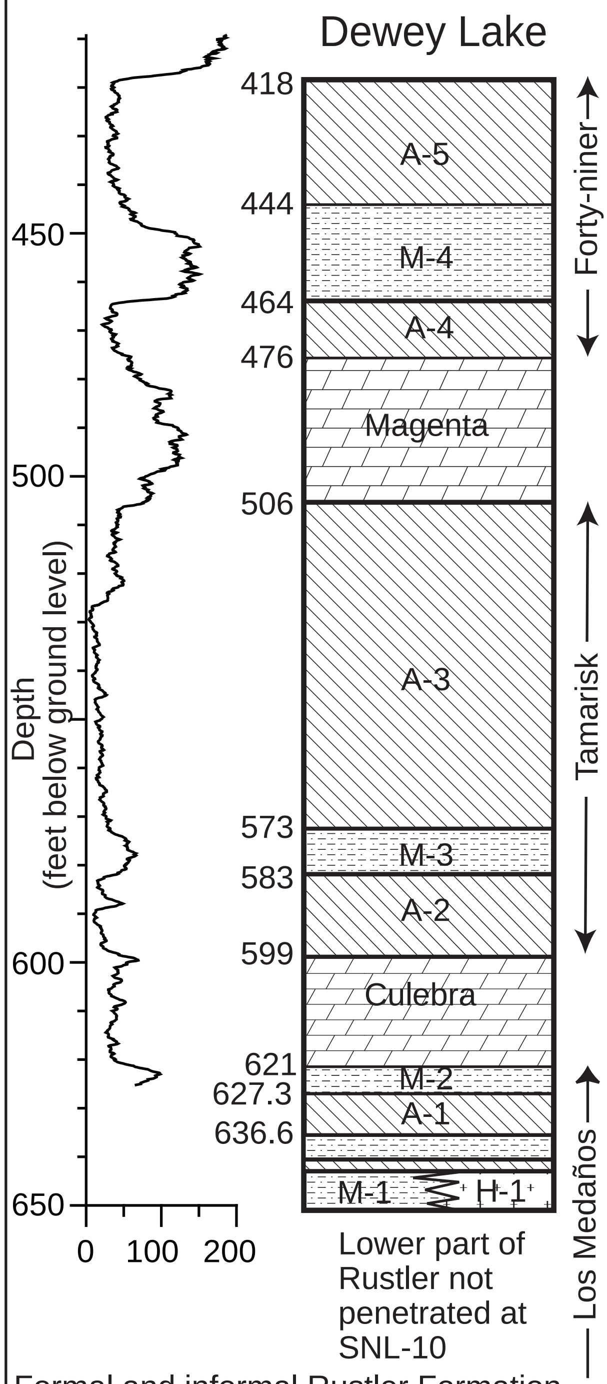
The informal unit *mudstone-halite 1* (H-1; Fig. 2-2) was encountered from 651–636.6 ft bgl, based on coring depths, and recovery was complete. Geophysical logs were not run on this interval, as it was filled with Aquagel® before reaming the cored interval to 630 ft.

The cored H-1 interval consists of halite and slightly sandy siltstone, a thin anhydrite, and an upper thin silty claystone. The siltstone ranges from horizontal beds or stringers to more dispersed siltstone blebs or boundary material around halite. The halite is fine to coarse and ranges from poorly bedded to displacive. There are two crudely defined intervals or depositional cycles that display some or all of these characteristics: lower coarse halite with less siltstone and some larger fluid inclusions, increasing siltstone content upward, more displacive halite upward, more corroded halite margins upward, and more bedded and concentrated siltstone near the top (e.g., Fig. 2-3). No well-developed exposure surfaces were identified.

The 1.9-ft anhydrite segment is interlaminated with thin siltstone beds in the lower half and some displacive halite near the base.

The 4.6-ft silty claystone at the top is dark reddish brown (2.5YR3/4) matrix with clasts of

Figure 2-2
Rustler Units at SNL-10



Formal and informal Rustler Formation units and depths at SNL-10 based on natural gamma log; below the gamma log, drilling depths correspond to core markings.

sandy siltstone that are weak red (2.5YR5/2) to light gray (5Y7/1). Subhorizontal fabric or bedding is more apparent upward. Sulfatic zones occur near the top, and mottled greenish gray siltstone underlies the overlying anhydrite.

The informal unit *anhydrite 1* (A-1; Fig. 2-2) was encountered from 636.6–627.3 ft based on core data. A-1 is light gray anhydrite and gypsum. It is thinly bedded near the base, with bedding less distinct upward. A-1 appears possibly nodular upward, and it is more fractured upward. A pinkish zone from 629.5–629 ft overlies a sharp contact and underlies the fractured zone.

The informal unit *mudstone-halite 2* (M-2; Fig. 2-2) was encountered from 627.3–621.3 ft bgl, based on coring depths, and recovery was apparently complete. The natural gamma log did not go deep enough to show M-2 (Fig. 2-2). The contact between M-2 and Culebra was recovered, and the contact bedding is undeformed (Fig. 2-4).

From 627.3–624.1 ft, the core is dark red (2.5YR3/6) silty claystone with two thin zones of gray laminar siltstone and claystone. Fibrous gypsum occurs along some bedding separations.

From 624.1–621.3 ft, the core is dark gray silty claystone with thin (0.125 inch), parallel, horizontal to near horizontal thin laminae. Sulfate at 623 ft may be nodular.

2.2.1.2 Culebra Dolomite Member

Based on drilling depths available at the time, the recovered Culebra core from SNL-10 was marked from 621.3–598.2 ft bgl (as used in information in Appendices C and F). The natural gamma log shows Culebra from 599–621 ft bgl (Fig. 2-2). Recovered Culebra core (Fig. 2-5) totals 23.1 ft thick, and this represents all of the unit.

Figure 2-3. Upper halite and bedded siltstone at top of M-1/H-1 interval. Upper surface of halite at 643.1 ft appears corroded.

Holt and Powers (1988) found a range of 20–30 ft thickness in Culebra cores described from the WIPP Project, and a regional thickness exceeding 40 ft, based on geophysical log data. Significant core loss in the middle of the Culebra is common. Complete recovery of core at SNL-10 is likely due to modest porosity with gypsum or silt fillings. Drilling using compressed air and mist may also have contributed to complete recovery.

The dolomite recovered in core from SNL-10 is generally light to dark brown sandy dolomite with argillaceous zones. The Culebra at SNL-10 is thin bedded to laminar (Fig. 2-5) in the lower half, with less visible bedding upward. Small vugs are more common, filled with silt or gypsum, but a few larger vugs are also present.

From ~611.5–602 ft, near-vertical, complex fractures occur, and they are filled more commonly with coarse, rather than fibrous, gypsum (e.g., Fig. 2-6); some possibly have silt filling. These fractures appear to have resulted from collapsing porosity.

The hydrostratigraphic units proposed for the Culebra by Holt (1997) are reasonably represented in SNL-10. Depths are based on core markings.

The most likely equivalent to the basal CU-4 hydrostratigraphic unit occurs from 621.3–619.6 ft. It has bedding, is fine-grained, is light brownish gray, and exhibits limited filled pores. The basal contact is undeformed. In the WIPP site area, this zone shows some fracturing, and the basal contact is usually slightly deformed by fracturing.

From 619.6–614.3 ft, the Culebra shows thin laminar zones and bedding at 0.5–3 inches. Smaller pores (~0.125 inch) are abundant, and they are partially filled with dolomite silt and some gypsum. Larger pores or vugs are rare. This

Figure 2-4. Undisturbed laminated gray claystone at the top of M-2 and in basal Culebra dolomite.

Figure 2-5 Culebra Dolomite Member of the Rustler Formation at SNL-10

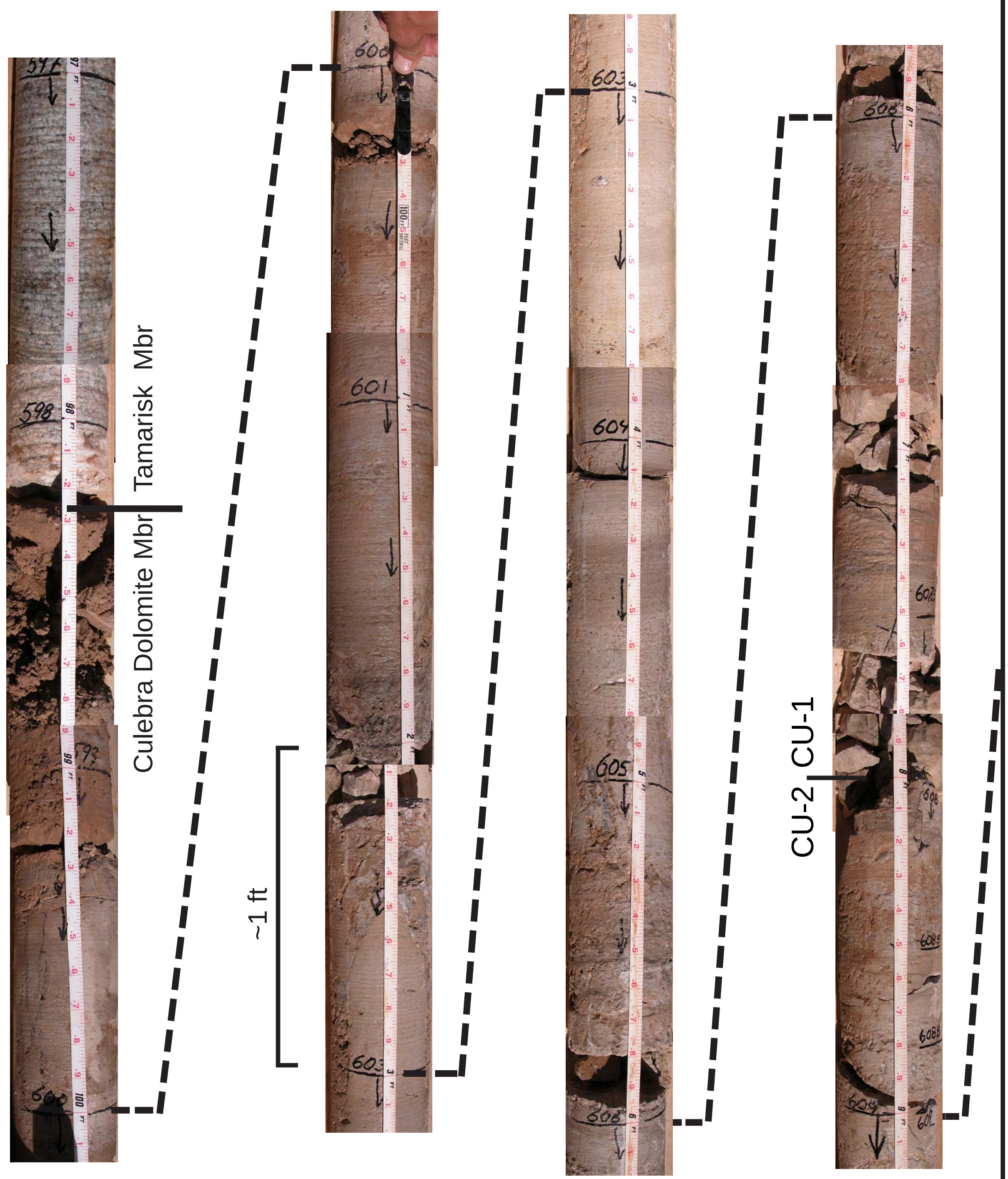
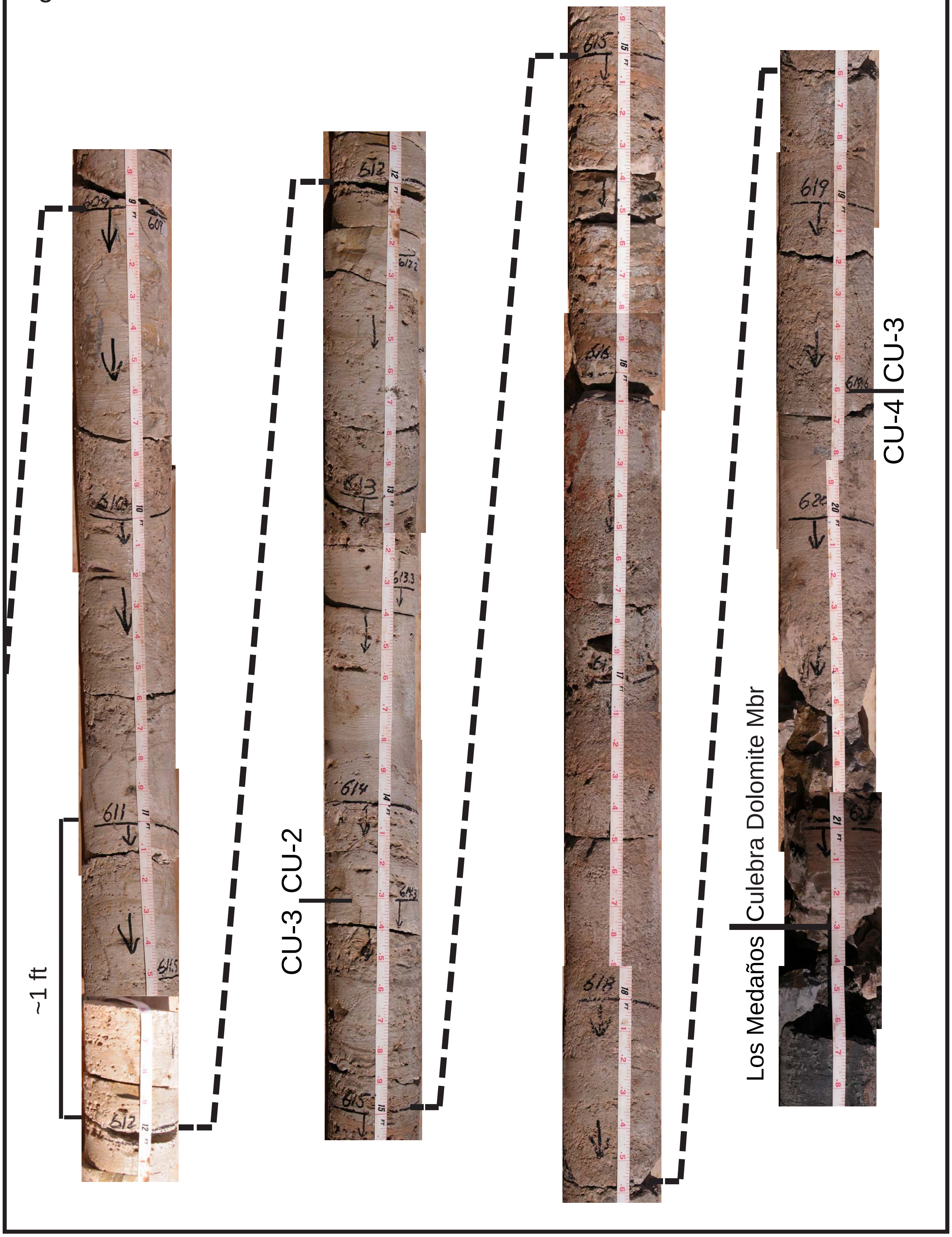
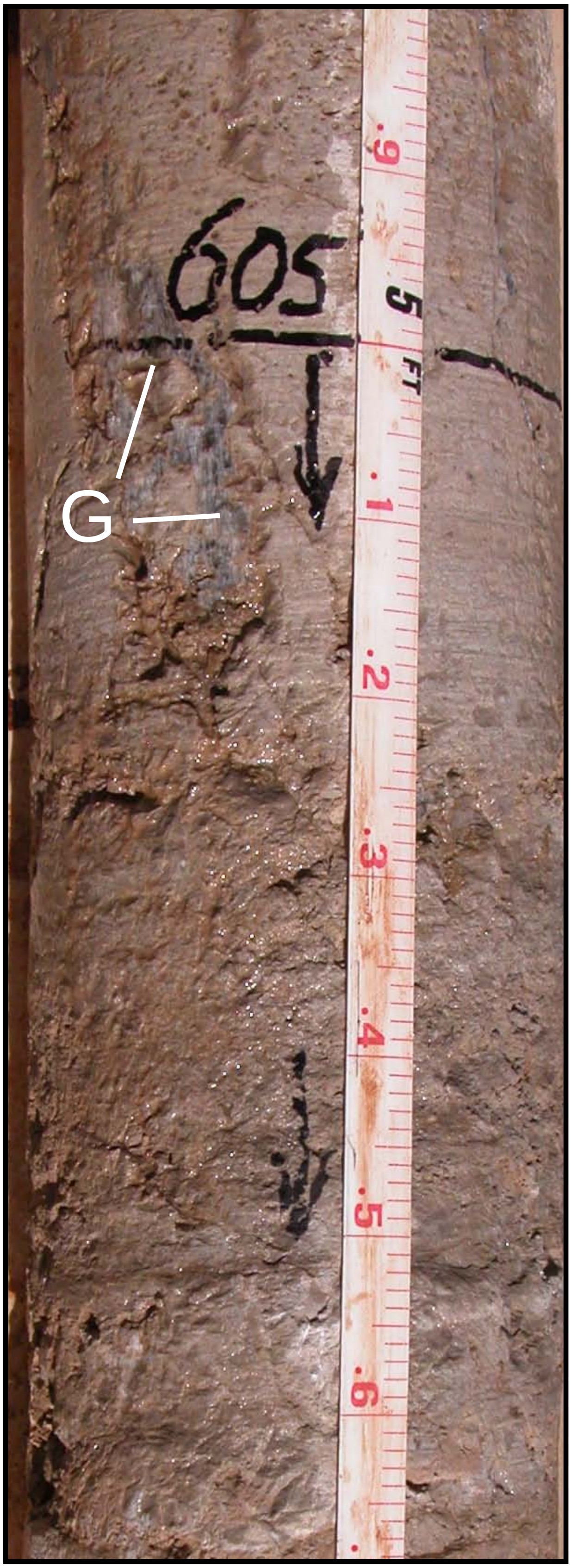


Figure 2-5 continued





interval also shows indications in the lower part of considerable collapse of small porosity with silty dolomite fill rather than gypsum. The upper few feet show few signs of collapse, with porosity and bedding still visible. The interval from 619.6–614.3 ft is tentatively correlated with CU-3 (Holt, 1997).

From 614.3–608 ft, the dolomite displays more laminar bedding and few silt interbeds. Vugs, filled with silt or gypsum, are still visible in the lower part. The upper few feet show more complex high-angle fracturing and probable porosity collapse. Fractures and some of the porosity are more commonly filled with coarse crystalline gypsum rather than fibrous gypsum. There are a few, larger sulfate-filled vugs. The entire interval is tentatively assigned to CU-2 (Holt, 1997).

From 608–598.2 ft, the dolomite is fine-grained, sandy, and bedded, with an organic-rich zone near the top. Scattered vugs to 0.5 inch are filled with coarse gypsum. A few sub-vertical fractures show coarse gypsum (Fig. 2-6) and some collapse. This interval tentatively corresponds to CU-1 (Holt, 1997).

The geophysical logs (Fig. 2-1) of the Culebra provide a few additional details of the unit. Resistivity remains generally low through the Culebra and increases in the lower anhydrite of the Tamarisk. Neutron is low through the Culebra. The density log shows lower values in the lower and upper part of the formation with an increase at the CU-2–CU-1 boundary. The core observations of vugs and gypsum are generally consistent with log properties. Overall, there is not a great contrast in log properties through the Culebra, and the Culebra is likely to have moderately low transmissivity based on field observations.

Figure 2-6. Coarse gypsum (G) fills some fractures and porosity in Culebra dolomite. The lower portion of the core photo shows collapse of porosity.

2.2.1.3 Tamarisk Member

The natural gamma log of SNL-10 shows that the Tamarisk occurs from 599–506 ft bgl (core markings 598.2–504.7 ft). The Tamarisk comprises three basic subunits: a lower anhydrite, a middle halite and/or mudstone, and an upper anhydrite; all three are clearly shown by geophysical logs and were recorded by cores. Powers and Holt (2000) labeled these A-2, M-3/H-3, and A-3, respectively, and showed that the lateral gradation from mudstone M-3 to halite H-3 generally reflects lateral changes in deposition. SNL-10 is located in the M-3 facies (mudflats or saline mudflats) of these beds, ~3 miles west of the current H-3 margin (see Section 4.0). The upper 5 ft and basal 8 ft of A-3 were cored in addition to all of M-3 and A-2; the remainder of the unit is described on the basis of cuttings and geophysical logs.

The informal unit *anhydrite 2* (A-2; Fig. 2-2) at the base of the Tamarisk is 16 ft thick (599–583 ft) based on the geophysical logs (core depths marked 598.2–581.4 ft). The cored interval from 598.2–587.6 ft is predominantly dark gray anhydrite with some gypsum. It is generally fine to medium grained, with prominant laminae near the base that are less pronounced upward. A few beds of interlaminated carbonate and anhydrite in the upper part of this interval are somewhat wavy and may be stromatolitic. Some bedded-nodular texture may be present in the middle. There are high-angle gypsum-filled fractures with very slight vertical displacement near the top.

A-2 is divided here, as in most locations, by a dark gray siltstone (587.6–586.8 ft). The sharp basal contact with the lower part of A-2 appears to parallel bedding. The upper boundary is slightly gradational. This siltstone shows fine laminae (~0.06–0.25 inch), probable displacive gypsum growth, and some gypsum-filled fractures. This clastic unit within A-2 is commonly indicated in natural gamma logs with a small spike in counts.

The upper part of A-2, from 586.8–581.4 ft, is also fine, gray anhydrite at the base to mostly gypsum near the top with horizontal to sub-horizontal bedding up to ~1 inch. The bedding near base and top both show some deformed to wavy or inclined bedding and fine laminae that also may indicate stromatolites and ridge-like growth of gypsum. The middle of this anhydrite segment also shows possible nodular textures.

The informal Tamarisk unit *mudstone 3* (M-3; Fig. 2-2) at SNL-10 is 10 ft thick (583–573 ft bgl), based on the natural gamma log, and is 8.3 ft thick based on core markings (581.4–573.1 ft). Clay in the overlying basal anhydrite contributes to the difference in thickness between log signature and core depths.

The geophysical log (Fig. 2-1) for M-3 shows common characteristics of the mudstone facies: an increase in natural gamma with low neutron and low density. The caliper log, density log and, to a lesser extent, the gamma log all display differences between the lower and upper part (divided at 578 ft) that are consistent with core evidence.

M-3 is mainly silty claystone that is reddish brown (2.5YR3/4). The basal contact is sharp and parallels inclined bedding of the underlying A-2. Bedding is most observable on core surfaces at 578 ft, where small clasts of gypsum occur in grayish siltstone. Within M-3, intraclasts or peds(?) are common and are observable by somewhat lighter color. Some gypsum has grown displacively in the claystone, mainly above 578 ft. A few fractures show gypsum, and parting surfaces (up to ~ 30°) have slickensides of variable orientations.

The informal Tamarisk unit *anhydrite 3* (A-3; Fig. 2-2) at SNL-10 is 67 ft thick (573–506 ft bgl) based on geophysical logs and is 68.4 ft thick based on core markings (573.1–504.7 ft).

A-3 is represented by mainly dark to light gray anhydrite and gypsum, with laminar bedding (probably including dolomite) near the base and some gypsum and laminar dolomite near the top.

Basal A-3 was cored and shows bedding dipping variably with some fibrous gypsum on bedding separations. Some of the gypsum bedding may be nodular. From 571.5–572.0 ft, gray siltstone is present with deformed or wavy laminae and some gypsum.

The uppermost A-3 shows some nodules developed along bedding as well as laminar bedding of carbonate that may be initial stages of algal growth that appears in the lower Magenta. The contact with the Magenta, as marked, is sharp. The contact could have been placed as deep as 506.6 ft because of the carbonate present, but it was placed higher where the carbonate dominates.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-10 is 30 ft thick (506–476 ft), while core thickness is 27.5 ft (504.7-477.2 ft). This is a normal thickness for the member. The difference in log and core thicknesses is due to additional carbonate (and natural gamma) within the dominantly sulfate beds below and above the boundaries assigned by core examination.

The Magenta is a gypsum and dolomite bed of light gray (10YR7/2) to grayish brown (10YR5/2) above 486 ft and more greenish (5Y8/2 to 5Y7/2; white to light gray) below 486 ft. The Magenta is well-bedded, showing a variety of forms from the base to top (Fig. 2-7). Near the base, wavy laminae (~1 inch thick) with amplitudes of 1 inch are stacked and are consistent with algal bedding found elsewhere in this zone. At 504 ft, relief on the algal laminae is ~0.2 ft, with white gypsum filling the low between thin laminae. Amplitudes lessen upward and become ~horizontal at 501 ft. From 501–485.8 ft, laminae increase modestly upward in amplitude, with thin (~0.05 ft) ripple or laminae sets and slight erosional bases. A few may represent starved ripples. From 485.8–482.7 ft, ripples and beds thicken, with slightly greater amplitude. From 482.7–481.3 ft, thinner bedding and relief is similar to beds below 482.7 ft, and from 481.3–480.4 ft, beds thicken and amplitudes increase, with a gypsiferous zone from 480.6–480.2 ft. The gypsum appears to have some small nodules. Above 480.4 ft, bedding is nearly flat and shows minor evidence of erosional bases. Another gypsum zone occurs from 478.5–478.0 ft, and it shows very thin laminae of dolomite.

Grains are generally silt-sized, with somewhat coarser grain sizes near the top.

Gypsum along bedding planes, including wavy bedding, is present, but not abundant, in the Magenta with the exception of the zone from ~485.6–480.6 ft.

Some near-vertical, bed-scale fractures were preserved from 502–501 ft. They are filled with fibrous gypsum and terminate at bedding planes. A fracture from 493.4–493.0 ft, at ~45°, has an aperture of ~0.06 inch and is filled with fibrous gypsum. Irregular, near-vertical fractures from bed to bed also are present in the upper 3 ft of the Magenta. They are filled with fibrous gypsum.

Geophysical log data from the Magenta show zones of varying density. The neutron log decreases from ~502–488 ft. This is the interval of core with apparent greatest porosity. Resistivity was not obtained through the Magenta, as fluid level was below Magenta at time of logging.

2.2.1.5 Forty-niner Member

Based on geophysical logs, the Forty-niner at SNL-10 is 58 ft thick (476–418 ft). The Forty-niner is described mainly on the basis of cuttings and geophysical logs; only the lower 7 ft was cored. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that is a mudstone at SNL-10. Powers and Holt (2000) informally designated these units as A-4, M-4/H-4, and A-5, from bottom to top. They attributed the lateral relationship between clastic beds (M-4) and halite (H-4) to depositional facies of mudflat–saline mudflat–saltpan environments.

The lower unit, *anhydrite 4* (A-4; Fig. 2-2), is mainly gray gypsum. A-4 is 12 ft thick (476–464 ft), based on geophysical logs, and

13.2 ft thick as marked on core at the base. The basal core shows mainly gray gypsum with anhydrite. Carbonate laminae in the sulfate are 0.01–0.02 ft thick, and they show disruptions that may be due to gypsum crystals that grew vertically from the sediment/water interface. Some nodular to bedded nodular textures are present near the top of the cored interval. A purplish zone exists from 472.5–472.2 ft, but the origin of the coloration is unknown. A high-angle fracture from 476.4–473.5 ft has some fibrous gypsum fill and stained surfaces.

Mudstone-halite 4 (M-4/H-4; Fig. 2-2) is ~20 ft thick (464–444 ft), based on the natural gamma and density log as well as the drilling record. Cuttings and geophysical log data indicate that only M-4 is present. From 464–448 ft, cuttings indicate reddish brown argillaceous siltstone that has some laminae. Gray siltstone was encountered from 448–444 ft.

The upper sulfate unit, *anhydrite 5* (A-5), is gray to white gypsum that is 26 ft thick (444–418 ft bgl) at SNL-10 based on geophysical logs. Drilling rates changed at ~416 ft bgl. Cuttings were limited. The upper contact with the Dewey Lake Formation appears sharp.

2.2.2 Permo-Triassic Dewey Lake Formation

The Dewey Lake Formation has most commonly been assigned to the Permian System (e.g., Hills and Kottlowski, 1983), although there is no direct evidence, either paleontological or radiometric, of age in the vicinity of WIPP. More recently, Renne and others (1996, 2001) obtained radiometric (Ar-Ar) ages from ash beds near the base of lithologically equivalent red beds (Quartermaster Formation) in the Texas panhandle. These ages show that the basal Quartermaster is Permian, but most of the formation is early Triassic in age. Although lithologic contacts are not inherently isochronous, the particular relationships of evaporites to red beds suggest that the Dewey Lake is mainly Triassic in age (e.g., Schiel, 1988, 1994; Powers and Holt, 1999). Lucas and Anderson (1993) have asserted that the Quartermaster, and Dewey Lake, are Permian in age, but more recent direct evidence supersedes their discussion.

At SNL-10, the Dewey Lake is 374 ft thick (418–44 ft bgl) and is composed mainly of reddish-brown (2.5YR4/4) to dark red (2.5YR3/6) interbedded sandy siltstone, argillaceous siltstone, and fine-grained sandstone. Small white (5Y5/1) reduction spots and zones are a common characteristic of the Dewey Lake and are recorded by the cuttings at SNL-10. The Dewey Lake is generally moderately well indurated. It is slightly calcareous near the top but shows no evidence of carbonate below 90 ft. Below 100 ft, Dewey Lake cuttings include gypsum, mainly represented by fibrous gypsum. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

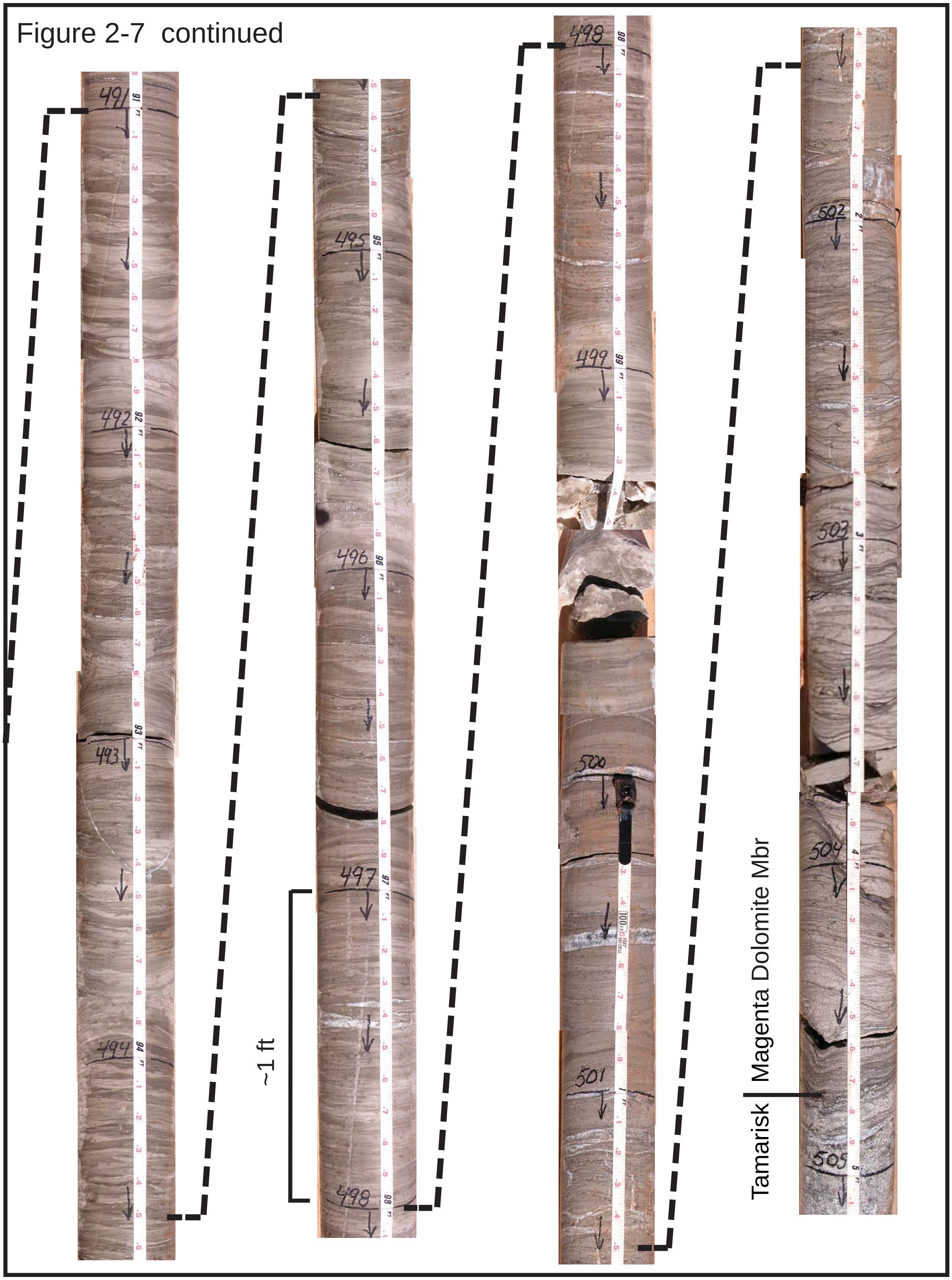
Geophysical logs from SNL-10 can be partially interpreted to indicate different basic sedimentary regimes as well as porosity conditions (e.g., Doveton, 1986). The following information follows the basic template developed for a study of the Dewey Lake hydrogeology (Powers, 2003b) and applied to other drillholes such as C-2737 (Powers, 2002b) and SNL-2 (Powers and Richardson, 2003).

Two of three general depositional regimes for the Dewey Lake can be more readily distinguished on natural gamma logs of SNL-10; the upper regime has been eroded.

The interval from 418–309 ft bgl in SNL-10 displays the natural gamma features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003b). Natural gamma fluctuates around a similar value (~125–150 API units) over this vertical interval. A low in natural gamma indicates the top of the zone. The density log shows thin lower density intervals, but these density lows do not correspond to probable sandstones as well as in some other drillholes.

Figure 2-7 Magenta Dolomite Member of the Rustler Formation at SNL-10

Figure 2-7 continued



The interval from 309–44 ft bgl (265 ft) is marked by generally upward-increasing gamma above thinner low-gamma units. The highest gamma reading is at 45 ft. These features are interpreted as an interval of *fining-upward cycles* because increasing natural gamma is frequently an indicator of finer clastic grain sizes (Doveton, 1986; Powers, 2003b). The base of this interval is defined by sandstone from ~309–300 ft. Near the center of the site, this interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). Part of the interval of upper fining-upward cycles has been eroded.

The contact with the Gatuña at 44 ft is placed where interbedded sandstones and siltstones begin to dominate and a sharp decrease in gamma occurs. The uppermost, coarsening upward depositional cycle has entirely been eroded at SNL-10.

The natural gamma log through the fining-upward cycles shows a zone of decreased intensity over an interval from 90–84 ft, likely corresponding to one of the very fine to medium-grained sandstones found across the site area (Powers, 2003b). The sand grains in cuttings consistent with this log signature are subround to round and slightly calcareous. This unit likely corresponds to sandstone 1 (*ss1*), a persistent sandstone in this stratigraphic interval (Powers, 2003b).

There is a decrease in density above 170 ft that coincides with a change in drilling rates (slower drilling below 170 ft) and an apparent increase in sulfate in cuttings. At SNL-10, it is likely that sulfate cement begins below ~170 ft depth (~250 ft above the base of the Dewey Lake) and that fibrous gypsum extends above this depth. Thin sections have not been taken or analyzed to confirm this inference.

By comparison with other drillholes, the Dewey Lake is likely to be more transmissive above ~100 ft, but there were no indications of water during drilling of the Dewey Lake.

2.2.3 Miocene-Pleistocene Gatuña Formation

The Gatuña is ~25 ft thick (44–19 ft). It is noncalcareous, reddish brown (5YR5/6) sandy, laminar siltstone.

2.2.4 Pleistocene Mescalero Caliche

The Mescalero is an informal soil stratigraphic unit defined by Bachman (1973). It is widespread in southeastern NM, and it is a continuous stratigraphic unit at the WIPP site. Uranium-disequilibrium ages indicate the Mescalero formed as a pedogenic unit between ~570,000 (± 100,000) and about 420,000 (±60,000) years ago (Rosholt and McKinney, 1980). The age is further bounded by the Lava Creek B ash, about 600,000 years old, which underlies the Mescalero along Livingston Ridge (Izett and Wilcox, 1982).

At SNL-10, the Mescalero is 2 ft thick (19–17 ft) based on cuttings. It is a white, sandy limestone at SNL-10, and it is thin.

Bachman and Machette (1977) classified six useful stages of pedogenic calcrete development, ranging from I as the least developed to VI morphologies showing multiple generations of calcrete development. ("Pedogenic calcrete" is preferred by many geologists and pedologists over the term "caliche" because of the wide variation in use of the latter term.) The Mescalero could not be classified at SNL-10.

2.2.6 Surficial Deposits

Construction fill (2 ft) and sand up to 15 ft thick were encountered at the drillhole location. From 17–10 ft, the sand is fine, red (2.5YR4/6), well-rounded, and moderately sorted. It shows ~1% opaque grains and some lithification.This interval is considered the Berino soil (Chugg and others, 1971). From 10–2 ft, the sand is fine to very fine, yellowish red (5YR5/6), rounded, and well-sorted. This interval is the loose surface dune sand.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-10

SNL-10 was drilled specifically to monitor water levels from the Culebra Dolomite Member of the Rustler Formation and to serve as a location for observations during a pumping test.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

The hole was drilled with compressed air to 595 ft. No moisture was observed in the drillhole after overnight halts through the formations overlying the Rustler. Slightly moist cuttings were returned at 130 ft, but no inflow was detected then or later.

3.2 Initial Results From the Magenta Dolomite

The Magenta was cored and reamed with compressed air, and an overnight halt between coring and reaming did not result in any observed inflow.

3.3 Initial Results From the Culebra Dolomite

At 595 ft, cuttings and air were moist at the end of the cored interval. The core barrel was returned to surface, and a Solinst water-level sounder was run to near total depth detected moisture. Coring resumed using mist.

The Culebra and intervals below were cored in one day, and the decision was made to plug the lowermost drillhole with Aquagel® and start reaming. Rig repairs and maintenance delayed completion for more than one week. No further observations of water levels were made during the period from end of coring through well completion.

SNL-10 was completed with FRP casing with 0.070-inch slots and isolated using Aquagel® (Figs. 3-1, 3-2, 3-3).

The well was jet cleaned on June 21, 2006. Before further development on June 22, 2006, the water level was 266.65 ft below top of FRP.

WRES began monthly water-level monitoring of the Culebra on September 14, 2006; the initial depth to water was 323.24 ft below the top of casing (US DOE, 2007).

Figure 3-1. Blank FRP casing and glued end cap. It was placed below screened interval in SNL-10. Centralizers used are also shown. Photo by Dennis W. Powers.

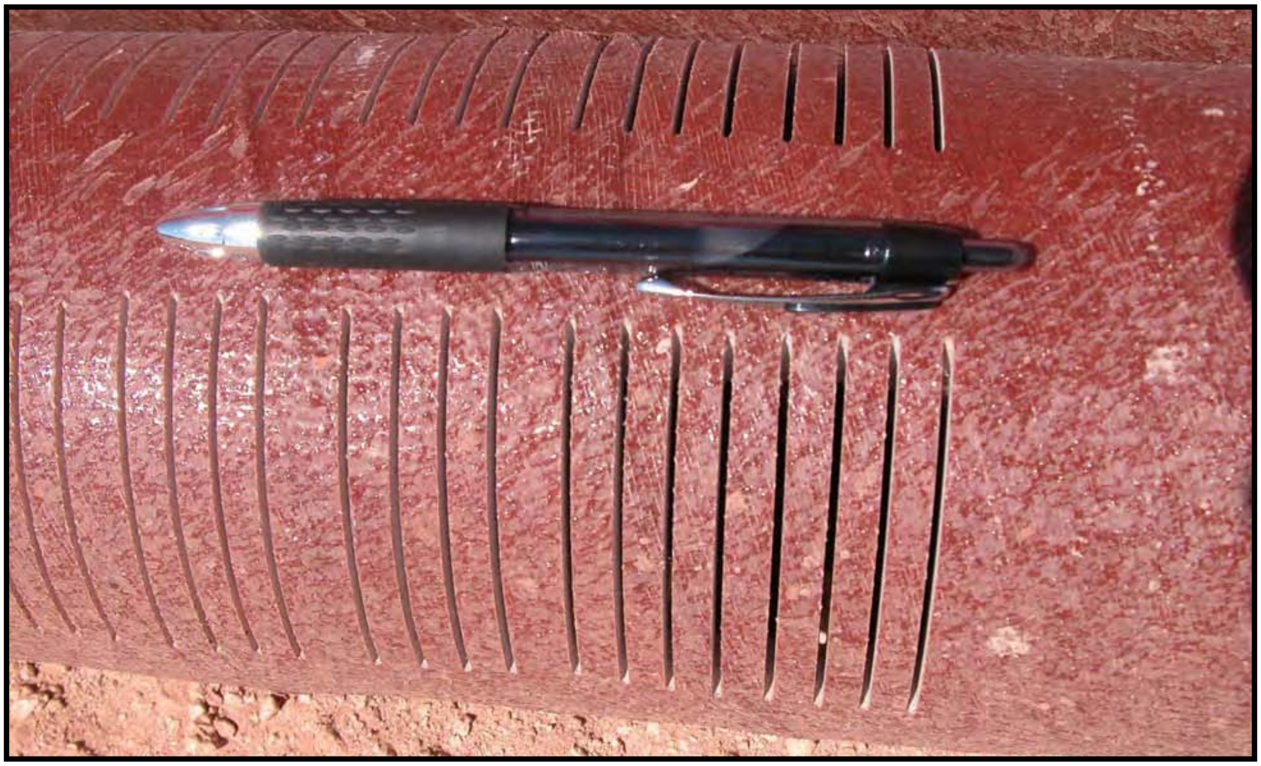


Figure 3-2. Screen used in SNL-10 with 0.070-inch slots (above). Photo by Dennis W. Powers.

Figure 3-3. Bentonite used in SNL-10 to plug bottom of hole and above gravel pack (below). Photo by Dennis W. Powers.

4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-10 are expected to be stable over a lengthy monitoring period, in contrast to steel casing in monitoring wells drilled before 1995. Newer monitoring wells provide construction experience for groundwater surveillance wells that may be drilled in the future.

The lower Rustler and upper Salado were not penetrated at SNL-10. Previous studies of thickness changes between the Culebra and Vaca Triste Sandstone Member of the Salado (Powers, 2002a, 2003a, 2007; Powers and others, 2003, 2006) indicated that SNL-10 was located east of the upper Salado halite dissolution margin and is in the area where no upper Salado halite has been dissolved. SNL-10 was also located considerably west of the margin of halite in the three upper M/H units of the Rustler (Fig. 4-1), and it was particularly located to evaluate the M-1/H-1 margin. It is generally comparable to the location for SNL-2 with respect to the M-1/H-1 margin (Powers and Richardson, 2003).

Halite was encountered in the M-1/H-1 interval below anhydrite beds. The halite did not form thicker, purer beds, but is primarily displacive halite in the clastic material. The upper part of the interval, just below A-1, shows siltstone clasts and evidence that the halite pan had diminished and mudflats prevailed in this location. The overlying A-1 was not fractured to indicate any post-lithification dissolution.

No halite was recovered from cores through M-2/H-2, as expected. The contact with the overlying Culebra showed continuous deposition and no deformation of fine laminae in the claystone immediately underlying the dolomite or in the basal Culebra. Halite has not been removed from this interval since the Culebra was lithified. The core from SNL-10 is consistent with the proposal by Holt and Powers (1988) that Culebra was deposited across the depositional center and surrounding mudflats without a hiatus.

Culebra core recovery was complete. One reason may be the lack of porosity at SNL-10 because of less vug/nodule preservation. Many of the fractures appear to indicate that porosity has collapsed, with silt and gypsum fill (see also Holt and others, 2005). In addition, the drilling used compressed air and foam, and this may also have contributed to the success in core recovery. The Culebra overall will likely have low transmissivity at SNL-10.

No halite was present in H-3/M-3 at SNL-10, as expected. M-3 included intraclasts and possible peds developed on a mudflat.

The lower part of A-3 in core showed no fracturing or block rotation that would indicate subsidence and deformation due to dissolution of halite in the underlying M-3 interval. Powers and others (2006) explored the distribution of halite in the Culebra and other Rustler units, including at SNL-14, -15, and -8. No halite in H-3 was removed at the SNL-10 location after A-3 was lithified. This is similar to SNL-14, even though SNL-14 is located much nearer the halite margin but also in the mudflat tract of the M-3/H-3 facies (Powers and Richardson, 2008).

The Magenta was completely recovered during coring. It showed little porosity development or open fractures.

The Forty-niner also intercepted mudstone of the M-4/H-4 facies, showing a position within the mudflat environment where most WIPP drillholes are located.

Cuttings returned fibrous gypsum from 100 ft depth, while drilling rates and density logs suggest that sulfate cements of the Dewey Lake occur below ~170 ft bgl. The position of sulfate cement is lower stratigraphically than at the center of the WIPP site (Powers, 2003b). The broad trend for this boundary is to be stratigraphically low west and south of the WIPP site center and stratigraphically higher in the center and eastern part of the site (Powers, 2003b). There does not appear to be a saturated zone at this boundary in SNL-10, or in any other part of the Dewey Lake.

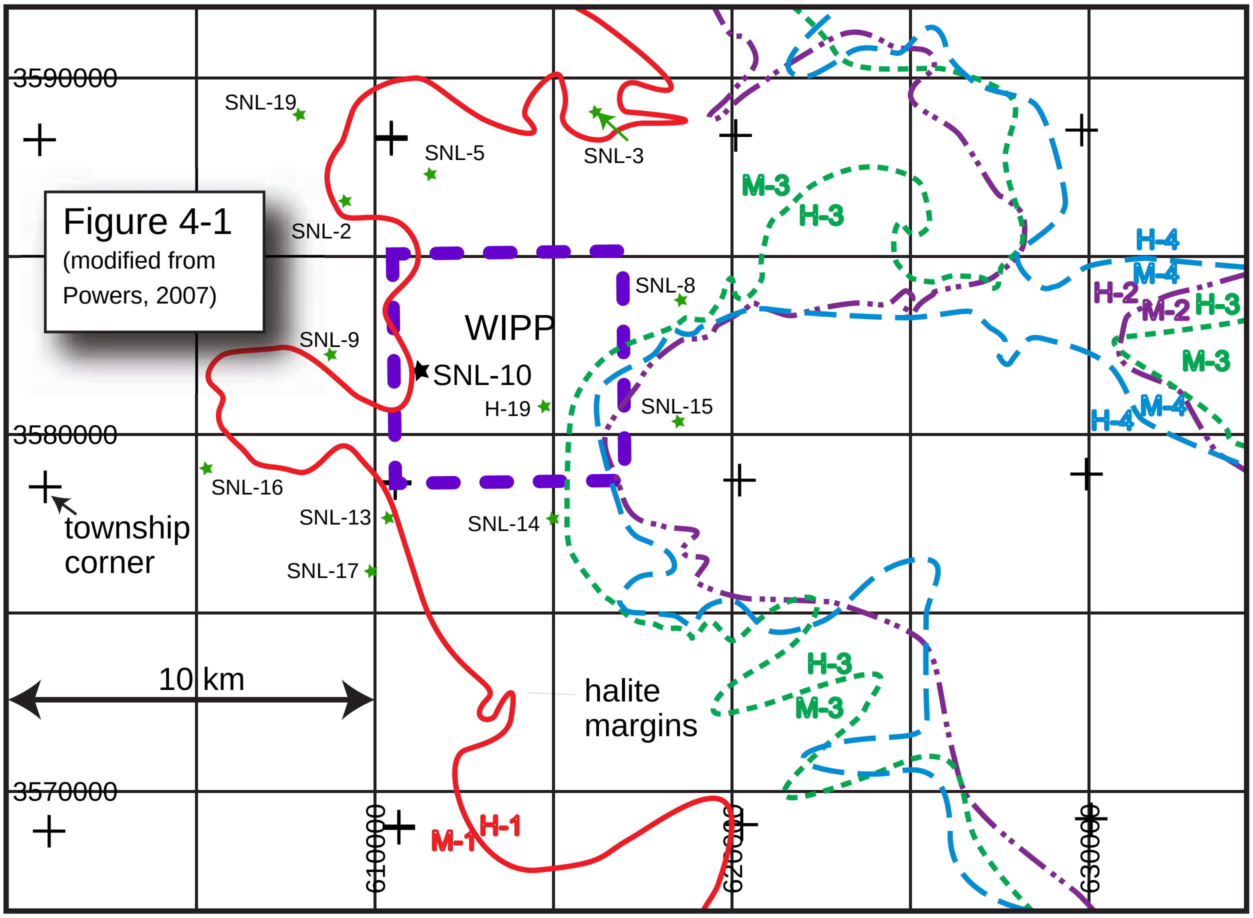


Figure 4-1. Location of SNL-10 relative to H-1 margin. SNL-10 is located west of other halite margins. The H-1 margin at the SNL-10 location was only generally located prior to drilling and was moved west based on the encounter of H-1. Several other wells drilled recently are shown for reference. Modified from Powers (2007).

The Santa Rosa has been eroded at SNL-10, similar to most areas in the southwest part of WIPP.

The Gatuña is ~25 ft thick at SNL-10. The formation tends to thicken from east to west across WIPP toward Nash Draw (e.g., Powers and Holt, 1993). SNL-10 is also located on the southern side of a ridge trending ~E-W through WIPP, and the Gatuña is thinner or absent toward the top of the ridge.

During drilling, no water was encountered in SNL-10 until near the top of Culebra. No water samples were taken or water level measurements made during drilling.

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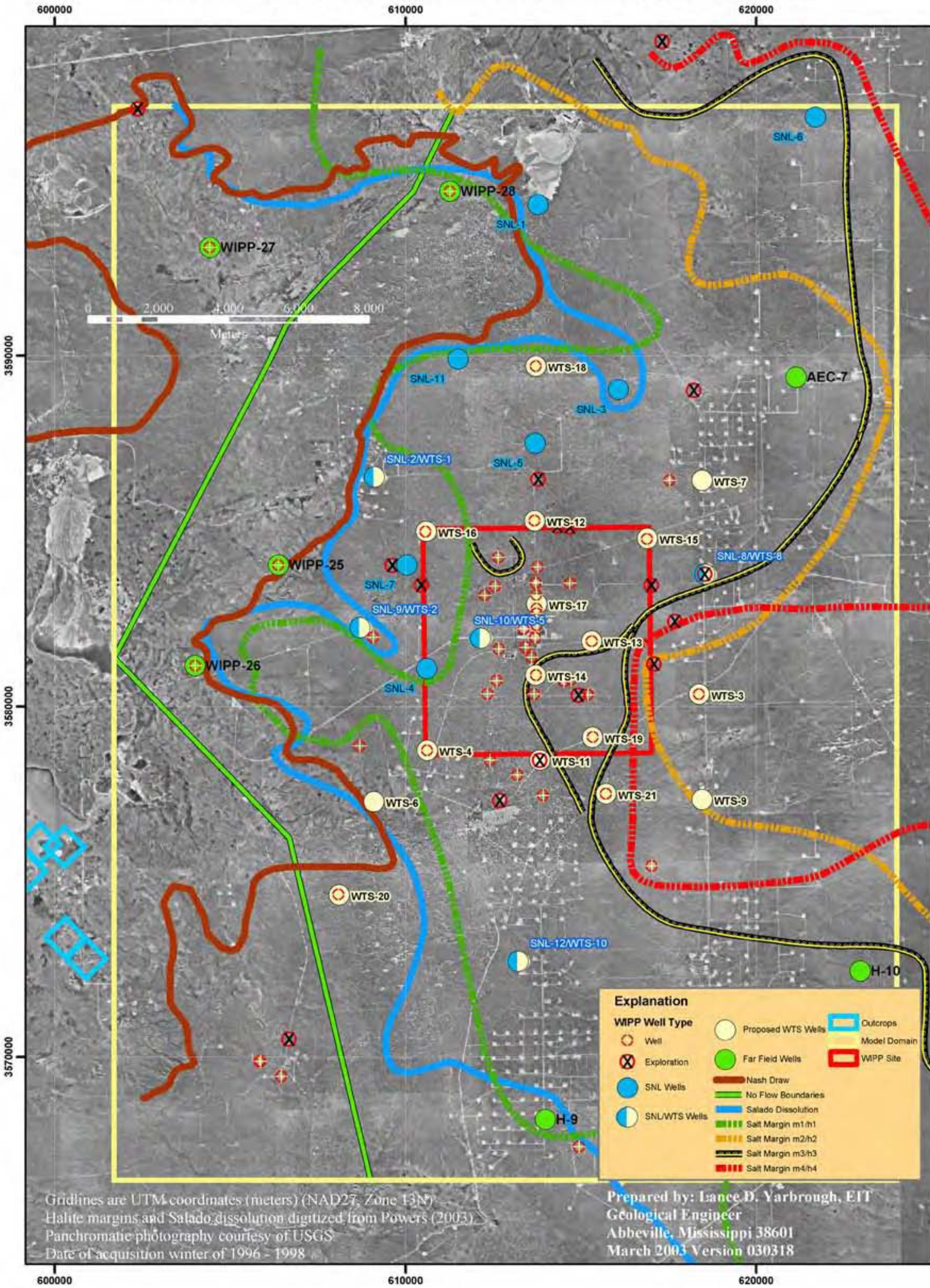
Appendix A
Drillhole Objectives

The basic document providing the basis for the drillhole and operations is the Program Plan WIPP Integrated Groundwater Hydrology Program, FY03-09 (Revision 0; Sandia National Laboratories, 2003). The main objectives are to resolve questions about water-level changes, provide data for modeling groundwater hydrology, and construct a network of wells to monitor groundwater through the WIPP operational period. Sections of this document relevant to this drillhole have been reproduced on the following pages, with the page number of the section preceding the extract and an ellipsis (…) following the end of the extracted section. A few figures have been included, but references and most figures are not included. The original document (Sandia National Laboratories, 2003) should be consulted for complete details and context for the program. Acronyms in the extracted text may not have a definition included in the extracted text.

SNL-10 was designated as a location in the original groundwater hydrology program (Sandia National Laboratories, 2003); it was co-designated WTS-5. The material selected here for SNL-10/WTS-5 represents objectives for SNL-10 excerpted from Sandia National Laboratories (2003). In addition, some material from one or more letter reports regarding the locations and characteristics of wells drilled during FY05 has been excerpted where it is germane to SNL-10. Note that some pages reproduced here have been reduced in scale to fit the report page format.

p. 27

WIPP SITE AND SURROUNDING AREAS



p. 39:

5. Description of Field Activities

A variety of field activities are planned to address the issues discussed in Section 3 and provide data needed for the modeling activities discussed in Section 4. To the extent possible, the activities represent an integrated approach to addressing all of the issues simultaneously, rather than a piecemeal approach that addresses each issue individually. The principal components of the field activities are drilling and logging of new and replacement wells, testing in individual wells, large-scale testing involving many wells, recompletion of existing wells, and plugging and abandonment of old wells. In addition, we anticipate that various ancillary activities will be necessary to collect information to support scenario evaluation and conceptual model development. The planned schedule for the field activities, as well as for the modeling activities, is described in Section 6. The activities described below represent our best current estimate of the work that will be needed. Clearly, the activities conducted in FY04 and later years are necessarily contingent on the results of previous years' field and modeling activities. As described in Section 11, a meeting of all parties involved in the hydrology program will be held annually to evaluate progress to date and develop final plans for the coming year.

5.1 New and Replacement Wells

Twelve locations have been identified where data from new wells are needed. These locations are designated with "SNL-#" labels in this document. Some of these wells are expected to provide information directly relevant to the scenarios under consideration, while others will provide information needed to support our conceptual and numerical models. In addition, a long-term Culebra monitoring network consisting of fiberglass-cased wells at potentially 21 locations has been designed to provide the data needed for compliance with the requirements of the WIPP HWFP. These wells will replace the existing network of steel-cased wells that are deteriorating and in need of plugging and abandonment. The 21 locations for the long-term monitoring network are designated with "WTS-#" labels. Well locations have been optimized so that five wells can serve as both SNL and WTS wells, reducing the total to 28 locations. Preliminary locations for the wells are shown in Figure 8. However, the final number and locations of the WTS wells will be optimized based on the modeling described in Section 4. Seven other existing well locations outside the extent of the HWFP network have been identified that will likely require replacement wells in the future to continue to provide data needed for Culebra modeling. New Magenta wells will be installed at six of the SNL- and WTS-designated locations to provide data needed for scenario evaluation and modeling. Five Dewey Lake wells are planned for locations north of the WIPP site where Dewey Lake water is encountered while drilling the Culebra wells. The justifications for the 12 SNL locations are given below, followed by the justifications for the WTS locations and the "far-field" replacement locations. Table 1 shows the roles to be played by each of the wells. The sequencing of drilling and testing in the new wells is described and explained in Section 6.

p. 41

Table 1. Roles Served by Planned Wells.

Well	Addresses leakage from tailings pile	Addresses high-T conduits	Addresses leaking boreholes	Addresses Salado dissolution	Provides model boundary condition information	Provides other information needed for modeling	Provides information supporting conceptual model	Provides information on flow across WIPP site
SNL-10/ WTS-5						X	X	X

p. 45-46

SNL-10/WTS-5: A Culebra well will be installed at this location in the west-central portion of the WIPP site near the m1/h1 halite margin (see Figure 8). The effect, if any, of this halite margin on Culebra transmissivities is unclear. A well in this location will help define the boundary between the high Culebra transmissivities at wells such as P-14 and WQSP-1 and the low transmissivities at wells such as H-2 and H-14. A well at the SNL-10 location will serve the following purposes:

1. provide transmissivity data in an area of the Culebra model domain where data are currently lacking;
2. provide data to define better the location of the m1/h1 halite margin and its effect on Culebra transmissivity; and
3. provide a monitoring location for a large-scale (multipad) pumping test (centered at SNL-9) to provide transient data for calibration of the Culebra model on the west side of the WIPP site.

In addition, a well at the SNL-10 location will provide needed information to help define the direction and rate of Culebra groundwater flow across the WIPP site, which is required for annual HWFP reporting to NMED (hence the parallel designation WTS-5). Putting a well at this location obviates the need to install a replacement well on the H-2 hydropad when the last Culebra well there has to be plugged and abandoned.

p. 48

WTS-5/SNL-10: This well coincides with SNL-10 and will be installed one mile west of the center of the WIPP site. Putting a well at this location obviates the need to install a replacement well on the H-2 hydropad when the last Culebra well there has to be plugged and abandoned.

p. 56

Table 2. Testing to Be Performed in New/Replacement Wells.

Well	4-day Pumping Test	Slug Tests	Multipad Pumping Test	Scanning Colloidal Borescope Logging	Testing Not Needed—Replacement Well
SNL-10/WTS-5	C?	C?			

C=Culebra well
M=Magenta well
DL=Dewey Lake well

p. 58

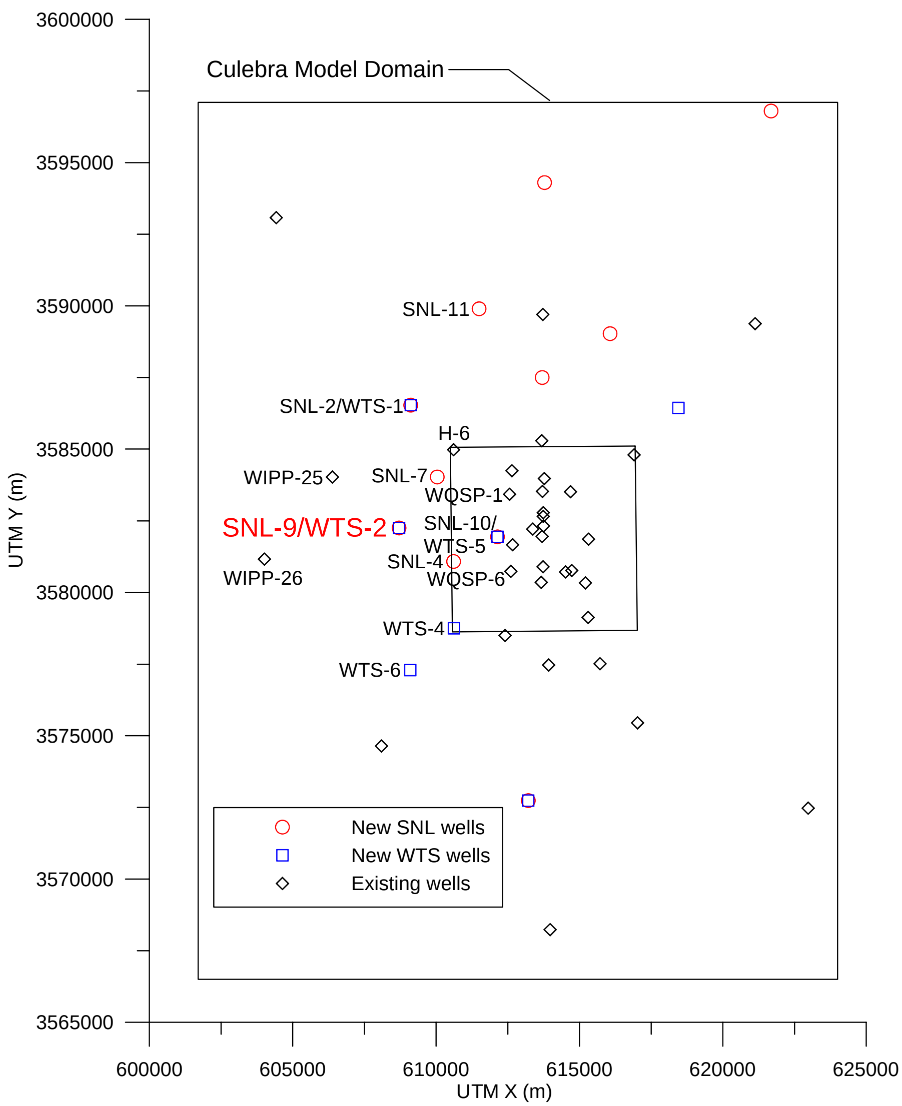


Figure 18. Pumping well and principal observation wells for western multipad pumping test.

p. 70

Table 4. Expectations and Contingent Actions for New Wells.

Well	Expectations	Possible Actions if Expectations Not Met
SNL-10/ WTS-5	• few—generally a characterization hole • Culebra T could be low to moderately high	If T is high: • characterize connectivity with H-2, WQSP-1, and WQSP-6 • consider need for new well to define eastern limit of high T

p. 72

Table 5. Anticipated Total Depths of Proposed Wells.

Location	Culebra Well Depth (ft)	Magenta Well Depth (ft)	Dewey Lake Well Depth (ft)
SNL-10/WTS-5	695		

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July 7, 2005

Ron Richardson
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Initial Locations of Three New Drillholes for FY2006

Five drillholes are expected to be drilled during FY2006 to develop information in support of studies of the hydrogeology of the Waste Isolation Pilot Plant (WIPP). These studies provide information for modeling the hydrologic regime near WIPP and understanding processes behind continuing rises in hydraulic head for the Culebra around WIPP. Summary information and results are provided to EPA as part of periodic mandated recertification of WIPP by EPA (Sandia National Laboratories, 2003).

Here I summarize background information and justification for three of these drillhole locations so permitting and supporting activities can proceed. Although these wells are first to be located specifically for FY2006, that does not imply that the locations will be drilled in this order.

SNL-10

No well number has been assigned by the Office of the State Engineer (OSE) (New Mexico) for this well because there has not been a previous permit application.

Location

SNL-10 is located within the land withdrawal area of WIPP, west of the site center (Figure 1). Field UTM coordinates (NAD27, Zone 13) for this location were obtained 6/6/05: 611217 m Easting, 3581777 m Northing. SNL-10 is adjacent to the railroad grade near the western boundary of the WIPP land withdrawal area. This location for SNL-10 is somewhat west of the original location proposed in the Hydrology Plan (Sandia National Laboratories, 2003).

Background for SNL-10

SNL-10 is located over the estimated boundary for halite in M-1/H-1 in the lower Rustler. Halite is not anticipated in M-2/H-2, just below the Culebra, or in either M-3/H-3 or M-4/H-4.

The Magenta Dolomite hydraulic properties are not known in the vicinity of SNL-10.

There is not expected to be significant water in the Dewey Lake Formation at SNL-10 based on general knowledge of the extent of the saturated zone in this unit (Powers, 2003a).

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Drillhole Locations for FY2006
July 7, 2005

Justification for, and Scope of, SNL-10

The justification for this well remains as provided in the hydrology plan (Sandia National Laboratories, 2003, p. 45-46):

> A well in this location will help define the boundary between the high Culebra transmissivities at wells such as P-14 [C-2637] and WQSP-1 [C-2413] and the low transmissivities at wells such as H-2 [H-2b1 is C-2758] and H-14 [C-2766]. A well at the SNL-10 location will serve the following purposes:
>
> 1. provide transmissivity data in an area of the Culebra model domain where data are currently lacking;
> 2. provide data to define better the location of the m1/h1 halite margin and its effect on Culebra transmissivity; and
> 3. provide a monitoring location for a large-scale (multipad) pumping test (centered at SNL-9 [C-2950]) to provide transient data for calibration of the Culebra model on the west side of the WIPP site.
>
> In addition, a well at the SNL-10 location will provide needed information to help define the direction and rate of Culebra groundwater flow across the WIPP site, which is required for annual HWFP reporting to NMED (hence the parallel designation WTS-5). Putting a well at this location obviates the need to install a replacement well on the H-2 hydropad when the last Culebra well there has to be plugged and abandoned.

The general scope of the well is similar to recent wells for investigating hydraulic properties of the Culebra. As the well proceeds, the Dewey Lake will be checked for fluid inflow; it will be monitored for a short period (typically overnight) and sampled, if appropriate. The Magenta Dolomite will be cored (~30 ft), water levels will be monitored for a short period, and water will be sampled if appropriate. The lower Tamarisk through Culebra and into upper-mid M-1/H-1 will be cored (~140 ft) to define halite margins or cements. Culebra water may be sampled if conditions are appropriate, but this is more commonly done after the well has been developed. It is not anticipated that the lower Rustler and Salado contact will be drilled or cored. The hole will likely be about 650-675 ft deep, based on P-6 [no OSE designation], about ½ mile southwest of SNL-10. The lowermost part of the hole will be plugged back to a point 10-20 ft below the Culebra. The well will be completed with a single screened interval open to the Culebra at a depth to be determined based on drilling and logging; in the absence of a surveyed surface elevation at the proposed location, the estimated base of the ~ 26-ft screen interval is about 600 ft below ground level.

Note: Many of the remaining pages of the memorandum have been omitted because they are not directly relevant to SNL-10.

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Drillhole Locations for FY2006
July 7, 2005

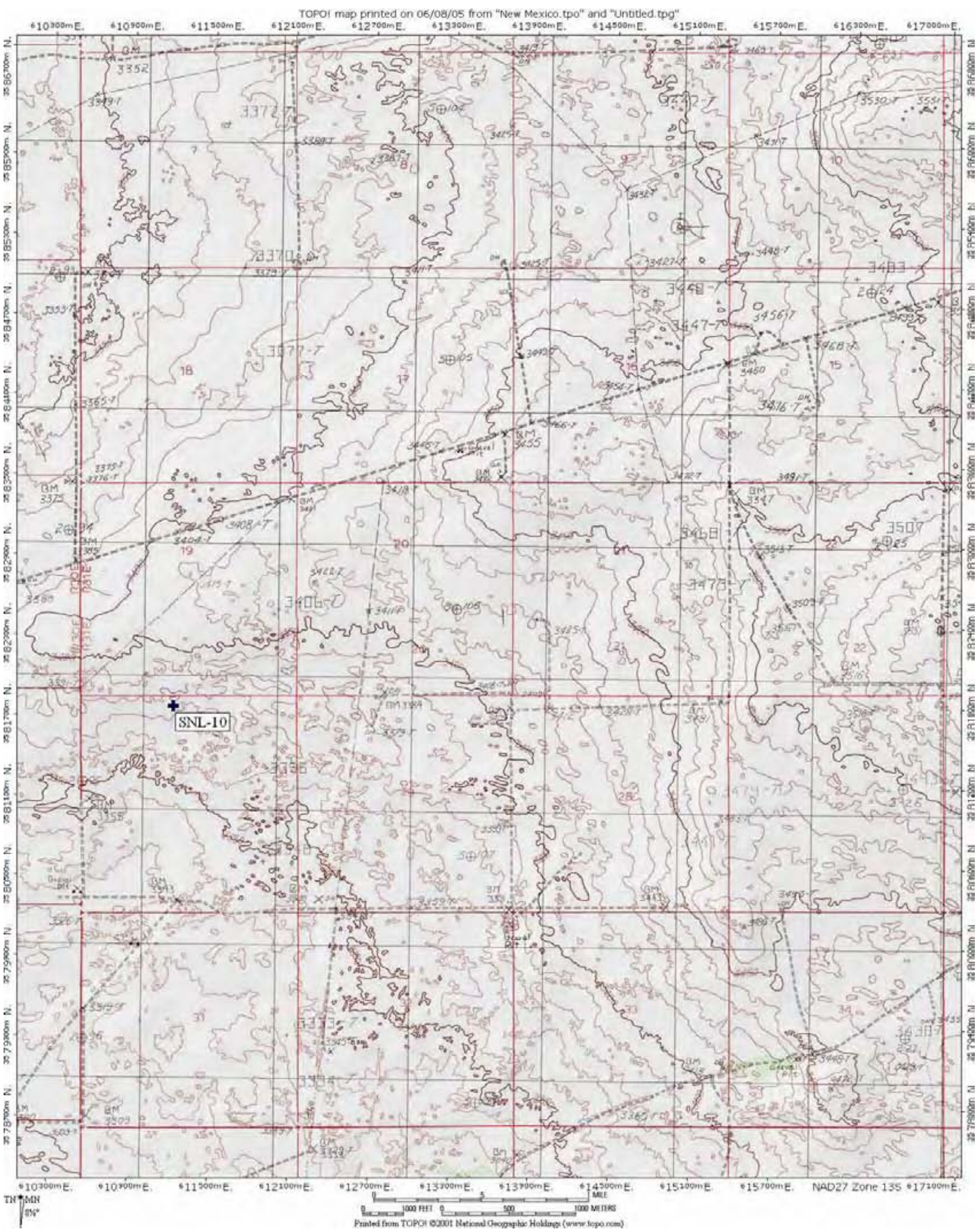

Figure 1. Location of SNL-10, a little more than 1.5 miles west of the center of the WIPP site land withdrawal area.

Dennis W. Powers, Ph. D.
Consulting Geologist

Drillhole Locations for FY2006
July 7, 2005

Note: Many of the previous pages of the memorandum have been omitted because they are not directly relevant to SNL-10.

Summary Comments on Drillholes

These three locations for drillholes to be completed during FY06 are part of the overall program to address two of the principal components of the hydrology program (Sandia National Laboratories, 2003):

- Resolution of water-level changes
- Enhancement of groundwater models

The locations focus more heavily on possible effects on the hydraulic system of the Culebra in the southwestern area of the site, including part of Nash Draw. Surface hydrology and geohydrology factors from this area are being integrated into modeling, and they are explicit parts of the process of selecting these locations. Nevertheless, the location of either SNL-16 or SNL-17 may need to be modified if modeling results are available with sufficient lead time and warrant a significant change.

I have limited some of the coring and drilling projections for these drillholes as a compromise between prioritizing objectives and the likelihood of budget limitations to pursue some of the lesser priorities.

As a last point, these three locations, out of five anticipated for FY2006, are easier to evaluate than potential locations in the northern to northeastern part of Nash Draw to help resolve Culebra water level rises. Permitting processes for these three locations can proceed to ensure a more orderly contracting and drilling schedule. As potential locations for additional drillholes for FY2006 are evaluated and determined over the next few weeks, they may be drilled before one or more of these three locations because of the priority assigned to the information.

Sincerely,

Dennis W. Powers

Dennis W. Powers, Ph. D.
Consulting Geologist

Drillhole Locations for FY2006
July 7, 2005

References cited:

Beauheim, R.L., and Ruskauff, G.J., 1998, Analysis of Hydraulic Tests of the Culebra and Magenta Dolomites and Dewey Lake Redbeds Conducted at the Waste Isolation Pilot Plant Site: SAND98-0049, Sandia National Laboratories, Albuquerque, NM.

Powers, D.W., 2003a, TEST PLAN, TP 02-05 Geohydrological Conceptual Model for the Dewey Lake Formation in the Vicinity of the Waste Isolation Pilot Plant (WIPP): Sandia National Laboratories.

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Powers, D.W., Holt, R.M., Beauheim, R.L., and McKenna, S.A., 2003, Geological factors related to the transmissivity of the Culebra Dolomite Member, Permian Rustler Formation, Delaware Basin, Southeastern New Mexico, *in* Johnson, K.S., and Neal, J.T., eds., Evaporite karst and engineering/environmental problems in the United States: Oklahoma Geological Survey Circular 109, p. 211-218.

Sandia National Laboratories, 2003, Program Plan WIPP Integrated Groundwater Hydrology Program, FY03-09, Revision 0: Sandia National Laboratories, March 14, 2003.

Unidentified cactus (hedgehog?) in the vicinity of the location of SNL-10. Photo taken June 9, 2005, by Dennis W. Powers

Appendix B
Abridged Borehole History

The abridged borehole history has been prepared by compiling information from driller's reports by West Texas Water Well Service (WTWWS) personnel, on-site reporting by Washington Regulatory and Environmental Services (WRES) personnel, and geologic logs by Dennis W. Powers. The main information is from WTWWS reports, which are reported as Central Daylight time. For consistency, all information in the abridged borehole history has been converted to Central Daylight time, regardless of source. Original files are maintained by WRES in the Environmental Monitoring and Hydrology Section.

Note: The abridged drillhole history provided here has been compiled mainly from the daily records produced by personnel of West Texas Water Well Service (WTWWS) and provided to Ron Richardson (Washington Regulatory and Environmental Services). The information has been reformatted and has been modestly edited. *Additions to the record from notes by Dennis Powers or other personnel are in italics.* All times reported in the abridged drillhole history are in CDT (Central Daylight Time) as recorded by WTWWS because they operate from Odessa, TX. Any additional notes included here (*in italics*) with times recorded in MDT (Mountain Daylight Time) at the site have been converted to CDT. Geologic logs (main body of text) have times as MDT, and times in the geologic logs commonly vary slightly from driller's log after allowing for the hour time difference.

5-29-06 WTWWS crew moved equipment from SNL-19 to SNL-10 site.

5-30-06 Picked up lumber for surface pad construction. Arrived on location at 10:00 (schedule restrictions because of designated prairie chicken habitat). Held safety meeting. *Constructors dug pit for drilling. Rolloff delivered.* Completed rigging up to drill shallow hole for conductor casing by 12:15. Drilled 7.875" pilot hole to 35' by 14:00. Rigged up with 17.5" bit and drilled with air to 35' by 17:00. Set 35' of 12.75" steel surface casing and cemented with 2 cubic yards of cement by 18:30. Unloaded compressor and shut down site by 18:50.

5-31-06 WTWWS crew arrived on SNL-10 site at 10:00 and held safety meeting. *Office trailer was hauled to well pad and set up.* Rigged up to drill 11" hole from 35'; began drilling at 11:40 with air. Stopped at 67'; put on diverter and hooked up hose to direct cuttings to rolloff. Drilled to ~185' from 14:50 to 17:28. Tripped out part of drilling string and shut down operations due to storm with lightning moving into site vicinity. *Secured site and departed at 18:30.*

6-1-06 WTWWS crew arrived on SNL-10 site at 10:00 and held safety meeting. Tripped into hole and began to drill 11" hole from 185' at 10:30 using air. *No fill or water in hole.* Shut down at 11:15 at 202' because of wind change blowing dust into compressors. Resumed drilling at 12:15; no change in wind direction. *Tripod on site at 17:30 with empty rolloff and removed rolloff with cuttings. Set up empty rolloff with hose for cuttings.* Stopped drilling at 306' at 19:00. Tripped part way out of hole and departed site at 19:30.

6-02-06 *Arrived on site at 09:50*; WTWWS crew arrived at 10:00. Held safety meeting. Blew dust from filters for compressors and rig. Tripped back into hole with drilling pipe; no fill and no water. Began drilling from 306' at 11:25 with air. *Ed and Annie Schaub on site at 14:30 to deliver longer mini-Troll and wire rope to Dennis Powers. Billy Pon (Diamond Oil Well Drilling Company) arrived on site at 16:15 with core barrel and equipment. Queen Oil and Gas arrived at 1640 and delivered diesel for WTWWS.* Stopped drilling at 470' at 16:45. Tripped pipe and bit out of hole and set up to start coring from 470'. Departed site at 18:45.

6-03-06 WTWWS arrived on site at 10:00. Blew air filters out on both compressors and rig. Picked up core barrel and set up for coring. Began tripping into hole at 11:05. Core barrel on bottom at 11:45, with no fill in hole. Circulated hole with air. Began coring from 470' at 12:20.

Stopped coring at 500' at 13:00. Tripped out of hole from 14:10 to 14:45 and laid down 29.5' of 4" diameter core. Tripped back into hole from 14:45 to 15:25 to core additional 10'. Cut core to 510' by 15:45. Tripped out of hole by 16:20 and retrieved 10.5 ft of core. Removed diverter and began rigging up to ream and drill with 11" bit. Left site at 18:00.

6-04-06 Arrived on site and began operations at 10:00; conducted safety briefing. Tripped into the hole at 10:15 to start reaming from 470'. Started reaming at 11:05. Bill Pon arrives on site at 11:06. Finished reaming hole to 510' at 12:13 and began drilling. Reached 565' at 15:20 and began tripping out of hole to set up for coring. Set up for coring and tripped core barrel and collars into drillhole. Mario from Constructors was on site from 16:05 to 16:10 to discuss road work with Luis. Shut down rig at 17:15 and departed site at 17:30.

6-05-06 Arrived at 09:45. Began operations at 10:00. Tripped into the hole at 565' and circulated on bottom 10:30 to 10:45. Completed some rig maintenance. Began coring at 10:45 and finished core run at 595' at 11:20. Tripped out of hole by 12:00 and laid down 30' of recovered core. Ran Solinst into drillhole at 12:25 to check for fluid in hole at a depth of 599.6' from top of outer core barrel (approximately 5.6' above pad level). Faint signal may indicate little moisture (less than 1') at bottom of drillhole. Ran into drillhole with core barrel and began cutting core at 14:14 with air. Finished cutting 30' at 14:44. Tripped out of hole by 15:45. Recovered 29.5' of core. Began tripping back into hole at 16:00. Performed some rig maintenance. Completed tripping into hole at 17:50. Cut 26' of core (to 651') and tripped out of drillhole. Left core in core barrel overnight. Left site at 18:25.

6-06-06 Arrived on site at 09:15. Safety meeting at 10:00. Laid down core and retrieved 27', including halite in the lower part of the hole. Drilling is complete. *Because the geophysical logger is not available, the decisions was made to plug the lower part of the hole and begin reaming the cored interval for completion. Decision was made to use Baroid Aquagel® to seal the bottom of the hole, and 8 bags were added at 11:55 to plug back to about 631'.* Core barrel was rigged down and loaded. Billy Pon (DOWDCO) left site at 12:00. Rigged up for reaming 11" hole from 565' to about 630'. Tripped into hole and started reaming at 13:30. At 588', drillers discovered bolts shearing in diverter bushing. Stopped drilling and tripped drillpipe out of the hole by 15:40. Removed diverter bushing for repair in Odessa. WTWWS crew left site at 16:10. *Completed core descriptions, secured generator and trailer, and left site at 18:20.*

6-07-06 *WTWWS crew arrived at site from Odessa at 11:20 with repaired diverter bushing. Repaired rig and began tripping into the hole at 11:55. Started reaming at 12:45. Derrick crown broke at 12:50, and the rig was shut down. Bearings are broken and damage will require taking rig to Odessa, TX, for shop repairs.* WHB pulling unit arrived on site at 15:00, pulled out 100' of drill pipe. Secured drill pipe in hole, rigged down, and left site at 18:30 with Rig #15 for repairs.

6-13-06 WTWWS arrived at site with Rig #15 and air compressor at 10:15. Unloaded compressor and set up rig over SNL-10 drillhole. Began to trip into hole at 11:10. Started reaming from 588' at 11:55 and reached 630' at 14:10. Tripped out of hole by 15:05. Laid down drilling collars and moved drill pipe. Left site at 15:30.

6-14-06 WTWWS arrived at site at 10:00 and held safety meeting. JetWest personnel arrived on site at 10:10 to log well. JetWest started logging hole at 10:45 and completed at 13:45. Began running tremmie pipe in hole at 13:45 and completed by 15:15. Started running 5.5" fiberglass reinforced plastic casing into the hole at 15:15 and finished at 17:35. Set bottom of casing at 626.4' and screen interval from 620' to 593.3'. Pumped sand to 589' from 18:08 to 18:45. Added 3 bags of Aquagel® to 584'. South East RediMix arrived at 19:20 with 8 cubic yards of cement. Finished pumping cement at 21:30 without returns to surface. Cleaned up grout pump and departed site at 22:00.

6-15-06 WTWWS arrived at site at 10:00 and held safety meeting. Cement was tagged, and more cement was ordered to fill annulus to surface. Started loading trucks with equipment at 10:20. Cement arrived at 12:00. Poured 1 cubic yard to cement to surface. Continued vehicle and equipment move from SNL-10 to SNL-18 from 13:00 to 18:00. Departed at 18:00 for Carlsbad.

6-21-06 *Arrived at Portacamp at 07:30, wait for WTWWS. Moved equipment to SNL-10 pad and set up by 08:40. Started down hole at 08:45 with tool to jet interval 590' to 621'. At bottom at 09:55; set up discharge line. TFH Trucking arrives on site at 10:46 with 100 bbls from Hobbs city water supply. First returns at 11:10 are fairly clear; quickly turned dirty. After 15 bbls at 11:25, water very foamy and muddy. At 11:35, water clearing up and foam all gone. Water very clear at 11:47; top foot or two of screen still a little dirty. Pumped 67 bbls by 12:02; water very clear. Added short pipe to allow better jetting of upper 3' of screen. Started jetting again at 12:08. Stopped jetting at 12:30 after pumping 95 bbls. Water clear up and down screen. Began pulling pipe at 12:40 to set pump. Pump installed at bottom of screen and wired by 16:00. Plumbing completed, generator tested, and pump working at 16:30. Leave site at 16:50.*

6-22-06 *Arrived on site at 07:45. Water level 266.65' below top of plastic pipe. Pump started and set to ~2 gpm (as recorded in field notes) after starting at full open. Actual flow 20.5 gpm, adjusted to 25 gpm. Pressure climbed, continued to adjust valve setting. Flowed 15 gpm; water fairly clear. Shut down pump at 08:46 because of bad pressure gauge. Sample field specific gravity 0.998. New gauge on at 09:47 and pump on. Adjusted pressure to 90 psi, flow 9 gpm. Drawdown to pump intake at 09:58; turned pump off. Measured water level 529.00' at 10:08. Water level at 516.6' at 10:36. Water level 504.6' at 10:55. Water level 502.7' at 11:00. Pump turned back on and flow adjusted to 2.75 gpm. Adjusted flow again to 1.9 gpm at 11:05. Pressure is 138 psi. Flow 2.0 gpm at 11:20. Drawdown to pump at 11:22. Flow 0.3 gpm at 11:28; pressure slightly increasing. Flow 0.4 gpm at 11:42; pressure increasing slightly. Flow 0.525 gpm at 11:50; specific gravity 0.995. Flow to 0.9 to 1.2 gpm, variable at 12:35. Pressure started to drop at 12:40; pumped all way down. Pumping very low with recovery. Flow back to 0.5 gpm at 12:55. Steady flow at 0.6 gpm at 13:10. Flow 0.6 gpm and pressure 50 psi at 13:45. Drawdown to 0 pressure at 14:20; pump off. Pump back on at 14:55 with 0.9 gpm and 145 psi. Flow 0.9 gpm at 15:10. Flow 0.5 gpm at 15:40. Pump off at 16:18. Load generator and clean up site. Leave 16:25.*

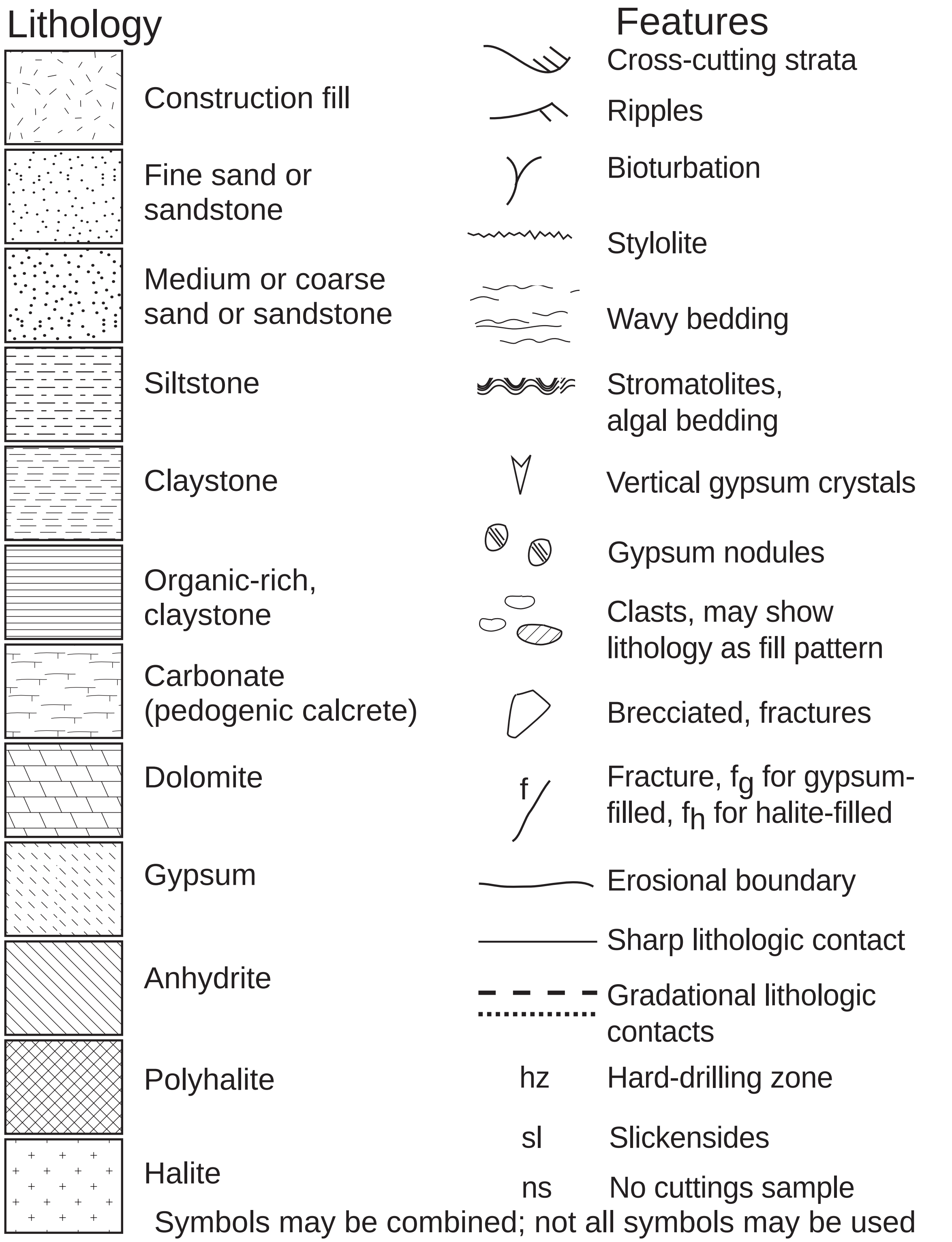
7-6-06 *Arrived on site at 08:30. Dissassembled discharge line and removed pump from well by 10:15. End of development. Left site at 10:30.*

Appendix C
Geologic Logs

Note: The original field descriptions and graphic logs were prepared at differing scales, and the graphic logs for publication were generally produced at 10 or 20 vertical ft per inch, as indicated in the header for the log.

The field descriptions were related to depth based on drilling information and core recovery as best determined in the field. Core and sample footages are marked accordingly and can vary somewhat from depths determined for stratigraphic units based on geophysical logs (see Table 2-1 of text). Core depth markings have not been revised to reflect later geophysical log data. Depths used for completing the well are based on geophysical logs.

Explanation of Symbols Used in Lithologic Logs (Appendix C)



Symbols may be combined; not all symbols may be used

CORE LOG

Sheet 1 of 9

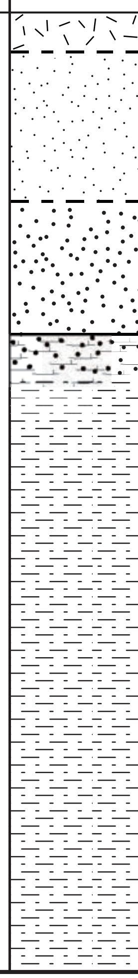
Hole ID: SNL-10	Location: NE 1/4 NW 1/4, section 30, T22S, R31E, Eddy Co, NM

Drill Date: 5/30/2006	Drill Method: Rotary with air	Drill Make/Model: Gardner-Denver 1500
Drill Crew: West Texas Water Well	Hole Diameter: initial 11 inches	Barrel Specs: 6 in o.d., 4 in. core
	Hole Depth:	Drill Fluid: air
	Hole Orient: vertical downward	Core Preserv: box as is

Logged by: Dennis W. Powers, Ph.D., consulting geologist	Date: 5/30/2006	Scale: variable

UTM NAD27	Northing	Easting	Elevation (ft amsl)
Survey Coordinate: m	3581772	611229	3373' (pad)

Comments: elevation and coordinates pre-survey

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	0					drilling with air
N/A		N/A C-1	N/A	 2'	Construction fill 2-10' Fine to very fine sand, reddish-brown, well-sorted; surface dune sand, loose (5YR5/6; yellowish-red)	
	10	C-2		10'	10-17' Sand, fine (coarser than above), red (2.5YR4/6), well-rounded, moderately sorted, shows some lithification. ~1% opaque grains, (Berino soil sand dune base).	
				17' ~19'	17-19' Sandy limestone, thin (Mescalero caliche) Siltstone, reddish-brown (5YR5/6), sandy; chips are platy, show fine laminae (<1/16"); non-calcareous, well indurated.	
	20	C-3				
	30	C-4			Siltstone, sandy, weak red (2.5YR5/2), well lithified, non-calcareous; laminae are thin (1/8-1/16") to thick.	end drilling 5/30/2006 at 35'; install 12.75" surface casing. begin 5/31/06 at 35'
	40	C-5			As above, rare small gray reduction spots.	
	50	C-6			Siltstone, sandy, dark red (2.5YR3/6), feels slightly damp, with greenish-gray sandy zones. More sandy than 40'	

Hole ID: SNL-10 | CORE LOG (cont. sheet) | Sheet 2 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 5/31/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks drilling with air
N/A	50	N/A	N/A			
	60	C-7			Similar to above, more sandy; well lithified, non-calcareous	install diverter begin 67' at 1400 MDT
	70	C-8			as above, more abundant greenish reduction spots, slightly calcareous	
	80	C-9			less sand, slightly moist	
					~86-90 sandstone', white to dark brown (2.5YR4.4, reddish brown); fine to medium, well rounded, slightly calcareous.	
	90	C-10			Siltstone, sandy, similar to 80'	add jt. 94'
	100	C-11			as above, possible fine crystalline gypsum in some porosity	
	110	C-12			as above	
	120	C-13			as above, fine crystalline gypsum increasing slightly	add jt. 122'
					as above, less gypsum, slightly damp cuttings	
	130	C-14				

Hole ID: SNL-10			CORE LOG (cont. sheet)		Sheet 3 of 9
Logged by: Dennis W. Powers, Ph.D.				Date: 5/31/06 - 6/01/2006	

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks drilling with air
N/A	130	N/A	N/A			
					as above, less gypsum or none, slightly damp	
	140	C-15				
	150	C-16			as above	
	160	C-17			as above, dry	
	170	C-18			siltstone as above, slightly sandy; white fibrous gypsum. Still 2.5YR4/6	
	180	C-19			sandy siltstone, harder, reddish-brown (2.5YR4/4); gypsum on fracture surfaces	stopped at 182' at 1628 MDT because of lightning 5/31/06
						6/1/06 begin 182' no fill, no water
	190	C-20			as 170' above, fibrous gypsum increasing, larger chips of greenish gray within red (2.5YR4/6) laminar siltstone	
	200	C-21			similar to 180', more purple hue (2.5YR4/4; reddish brown); less gypsum; harder drilling	
					similar to 200'	
	210	C-22				

Hole ID: SNL-10				CORE LOG (cont. sheet)	Sheet 4 of 9
Logged by: Dennis W. Powers, Ph.D.				Date: 6/1/2006	
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks drilling with air
N/A	210	N/A	N/A		Dewey Lake Formation, continued	
	220	C-23			as above	
	230	C-24			as above	
	240	C-25			as above	
	250	C-26			as above	
	260	C-27			as above	
	270	C-28			as above	
	280	C-29			as above	
					as above	
	290	C-30				

Hole ID: SNL-10 | CORE LOG (cont. sheet) | Sheet 5 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/1/06 - 6/2/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
						drilling with air
N/A	290	N/A	N/A		Dewey Lake Formation, continued	
	300	C-31			as above	end drilling at 306' 6/1/06
						begin 6/2/06 at 306' - no fill, no water; drilling with air
	310	C-32			as above	
	320	C-33			as above	
	330	C-34			as above	
	340	C-35			as above	
	350	C-36			as above	
	360	C-37			sandy siltstone, more argillaceous and reddish-brown than above, softer, more fibrous gypsum	
	370	C-38				

Hole ID: SNL-10 | CORE LOG (cont. sheet) | Sheet 6 of 9

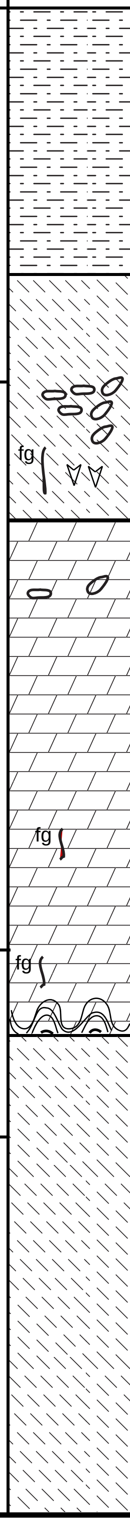
Logged by: Dennis W. Powers, Ph.D. | Date: 6/2/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks drilling with air
N/A	370	N/A	N/A			
	380	C-39			as above	
	390	C-40			as above	
	400	C-41			as above	
	410	C-42			as above	
				416’	base of Dewey Lake Top of Rustler Gypsum, gray to white, few cuttings	
	420	C-43				
	430	ns			as above	
	440	C-44			as above	
				444’	444’- gray siltstone	
					448’ - reddish-brown siltstone, argillaceous, platy cuttings	
	450	C-45				

Hole ID: SNL-10 | CORE LOG (cont. sheet) | Sheet 7 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/2/06 - 6/3/06

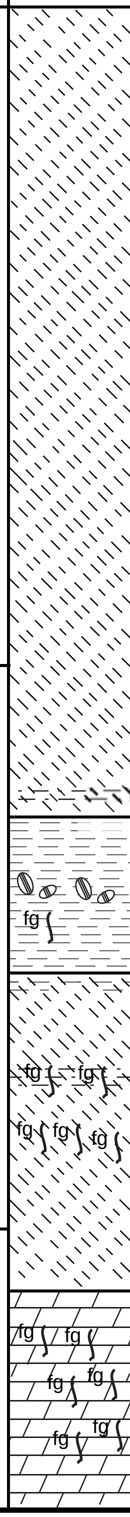
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)		Description	Remarks
N/A	450–470	N/A; C-46 (460); C-47	N/A			450-464' Reddish-brown argillaceous siltstone, platy to soft	
					464'	464' Gypsum, dark gray. Thin laminae to thin bedded, slightly wavy; nodular to bedded nodular textures ~470-472', more laminar deeper. Laminae from ~475-477' show sharp disruptions as possible vertical gypsum growth. Gypsum-filled fracture from 473.5-476.4'. Near vertical gypsum in lower part is fibrous; gray stained, possible carbonate crystals above 475'. Purplish fine laminae at 472.2-472.5'	end drilling at 470' 6/2/06
1	470–500	cut 30', recovered 29.6'	0.4' in segments <4"; RQD =98.6		477.2'	Forty-niner Member Magenta Dolomite Member. Dolomite, light gray (10YR7/2) to grayish-brown (10YR5/2) above 486' and more greenish below (5Y8/2 to 5Y7/2), sandy. Gypsum-filled fracture 493.0-493.4', 1/16", fibrous gypsum. 478.7-480.4' Laminar, nearly flat, gypsum on bedding plane separations. 480.4-481.3' Thicker bedding, higher amplitude; more gypsum, slightly nodular. 481.3-482.7' Low-angle bedding similar to 501-485.8', with less erosional relief. 482.7-485.8' Ripple cross laminae that are thicker (up to ~1.5") with distinct very fine laminae dipping up to ~20 degrees and erosional relief up to ~1/2"; little or no gypsum. Gypsum-filled fracture 501.0-502.0' near vertical, irregular 485.8-501.0' Thin laminae (generally <3/4") with erosional bases, slight dip to very fine laminae with longer laminae; gypsum on bedding plane separations, more abundant downward 501.0-503.0' Amplitude decreasing to mainly horizontal separations with erosional surfaces 503.0-504.7' Very wavy, fine laminae on relief to 0.4' truncated and eroded bedding (algal). Trapped intraclasts at 503.2'	begin coring at 470'; hole dry
2	500–510	cut 10', recovered 10.5'	0.5' in segments <4"; RQD = 95.2		504.7'	Magenta Dolomite Member Tamarisk Member Gypsum and anhydrite, gray, laminar to poorly bedded; with some carbonate (especially 506.1-506.6') Indistinct nodular-like fabric. Some vertical fibrous gypsum along horizontal bedding plane separation.	6/3/06 end coring at 510', set up to drill
N/A	510–530	N/A; C-48 (520); C-49 (530)	N/A				6/4/06 Reamed 470-510'; drill



Hole ID: SNL-10 CORE LOG (cont. sheet) Sheet 8 of 9

Logged by: Dennis W. Powers, Ph.D. Date: 6/4/06 - 6/5/06

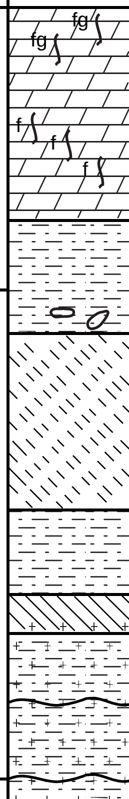
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	530 540 550 560	N/A	N/A		Gypsum and anhydrite, cuttings sparse Gray gypsum and anhydrite, very fine laminae to thin bedding, near horizontal, with local wavy black laminae (algal?); gray siltstone 571.5-571.7'. Fibrous gypsum on some bedding separations.	drilling with air; foam from 595' end of drilling at 565' 6/4/06
3	570 580 590	cut 30', recovered 30'	All segments came from core barrel >4" RQD = 100.0		Claystone, silty, dark reddish-brown (2.5YR3/4), gray mottling (gleyed?), with common intraclasts or peds of similar material, slightly lighter color; gypsum as clasts (white) and displacive crystals (clear). Fibrous gypsum on some gypsum-filled fractures. Parting surfaces at ~30 degrees dip with slickensides of varying orientation. Gypsum clasts increasing upward. 573.1' 581.2-581.4' Siltstone, gray, some reddish-brown; with small (<1/8") white gypsum clasts, well rounded. 581.4' 581.4-583.3' Anhydrite, gray, fine laminae at base, to gypsum and siltstone above 582.4'. Corroded upper surface. 583.3-586.8' Gypsum, very coarse, mosaic; no apparent bedding 586.8-587.6' Dark gray (N4/) finely laminar (1/16-1/4") siltstone; gypsum-filled fracture from near-vertical and wide at ~45 degrees to ~horizontal. Bedding plane separations. Sharp base; upper contact gradational; bedding plane separations probably oldest - cut by 45-degree gypsum-filled fracture. 587.6-598.2' Anhydrite, dark gray (N4/) with some gypsum; thin bedded to very fine laminae of darker gray - lighter gray (organic dark gray?); some carbonaceous laminae. Some healed fractures in upper part.	begin coring at 565' 6/5/06 - no water blown from hole; some moist cuttings at beginning
4	600 610	cut 30', recovered 29.5'			Base of Tamarisk Member Top of Culebra 598.2' Dolomite, sandy, brown. 598.3-599.3' - argillaceous, organic? 599.3-600' - fine grained, low porosity 600-601.3' - argillaceous, darker brown 601.3-606.2' - fine grained, light brown, some small (<1/32") vugs increasing downward. 606.2-608.6' - darker brown, silty, few vugs 608.6-614.3' - light brown, small to larger vugs	ran Solinst in hole to 599.6' (below top of core barrel) - detected moisture. Began using foam from 595'



Hole ID: SNL-10 CORE LOG (cont. sheet) Sheet 9 of 9

Logged by: Dennis W. Powers, Ph.D. Date: 6/5/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
4	610–625				614.3-616.0' - darker brown with 1/2" silty dolomite beds 616.0-620.2' - mostly small vugs (1/8") along bedding, few larger vugs to 1". 620.2-621.3' - fine grained, not vuggy. 602-611.5' - fracture system, complex high angles, some brecciation, silt fill in zones. Gypsum is coarse, not fibrous. Fractures with silt or no fill, narrow apertures. Sharp basal contact but continuous. 621.3' Base of Culebra Dolomite Member Top of Los Medaños Member 621.3-624.1' Claystone, gray, silty, fine horizontal laminae (1/8"); nodular(?) sulfate at 623'; reddish-brown at 624'	624.1-621.3' Gray (2.5YRN6/) siltstone at base to dark gray (N4/) silty claystone at top.
5	625–651	cut 26', recovered 27'	5' in segments <4"; RQD =81.5		624.1-627.3' Claystone, silty, dark red (2.5YR3/6) with thin (0.1') gray (2.5YRN6/) siltstone and clay at 624.4' and 626.0', respectively. Fibrous gypsum in bedding plane separations and very low angle separations across bedding. 627.3' 627.3-636.6' Anhydrite, light gray, and gypsum; fine crystalline; laminae (<1/2") to dark (carbonaceous?) and light couplets in lower 2', less distinct upward. Pink zone 629.5-629.0' over sharp basal contact includes argillaceous or gypsiferous gray subzone. Possibly nodular, somewhat fractured in upper half. 636.6' 636.6-641.2' Claystone, silty, dark reddish-brown (2.5YR3/4) as matrix with clasts of sandy siltstone from weak red (2.5YR5/2) to light gray (5Y7/1); subhorizontal fabric or bedding more apparent upward. Sulfatic zone from 636.7-636.9'; greenish-gray mottled siltstone on top. 641.2' 641.2-643.1' Anhydrite, gray, with gypsum, interlaminated reddish-brown siltstone in lower half; displacive halite at base; gypsum clasts(?) near base. Undulatory corrosion surface at top. 643.1' Halite, muddy, with mudstone or siltstone interbeds and interbedded halitic mudstone. 643.1-643.3' Halite, coarse, mosaic. 643.3-647.2' Mudstone, halitic, mosaic and small is predominant, some larger isolated halite; margins commonly corroded. 646.9' 647.2-647.4' Bedded mudstone, slumped; halite-filled fracture (fibrous) 647.4-649.4' interbedded mosaic and displacive halite, slumping, halite-filled fracture 649.4-649.5' isolated displacive halite to 1/4" 649.5-650.0' mosaic halite, small, corroded 650.0-650.9' Distinct bedding sulfate laminae; isolated to mosaic halite, little corrosion 650.8' 650.9-651.2' Larger displacive halite to 1/8", isolated 651.2-652.2' Mosaic halite with corroded margins, generally small crystals in siltstone matrix. Reddish-brown (2.5YR4/4)	end coring 6/5/06
	660–690					



Male desert cardinal or pyrrhuloxia in mesquite along the WIPP railroad grade. Photo taken June 1, 2006, by Dennis W. Powers.

Appendix D
Permitting and Completion Information

A case file for SNL-10 (C-3221) containing official documents is maintained by the land management coordinator, Environmental Monitoring and Hydrology Section of Washington Regulatory and Environmental Services for the WIPP Project. Selected documents are reproduced here for ease of access. Originals have been reduced to fit page formats.

As noted in the text, all official correspondence concerning permitting and regulatory matters should refer to the New Mexico State Engineer permit number C-3221.

Dennis W. Powers, Ph. D.

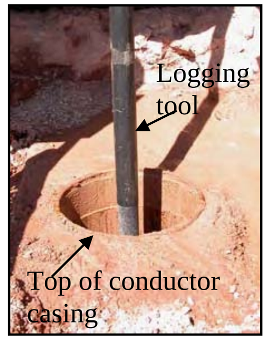
Consulting Geologist

June 15, 2006

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-10



Geophysical logging June 14, 2006, indicates that the best interval to screen the Culebra in SNL-10 is from 620.0–593.3 ft below the top of the surface conductor casing (see adjacent photo and log next page).

These are factors considered in this decision for SNL-10:

- The Culebra interval, based on the natural gamma log, is from 621–599 ft. The Culebra is 22 ft thick, slightly less than average around WIPP. Core recovery from the Culebra was excellent, and these log depths correspond well to the core depths.
- The gray silty claystone (upper M-2) below the Culebra was cored, and the upward transition into the Culebra shows no significant deformation. The samples show good induration in general and modest plasticity. The caliper log did not reach this interval.
- The main part of A-1 was cored through depths of 627-3–636.6 ft. Reddish brown claystone was cored from 636.6–641.2 ft, and a thinner anhydrite was recovered from 641.2–643.1 ft. Halite crystals were found at the base of the thinner anhydrite, and mudstone-halite lithologies were recovered to the total depth of 652 ft.
- At 595 ft depth (lower Tamarisk Member), drilling was changed from air to air-mist to enhance cuttings recovery during coring. There were no tool drops during drilling or coring of SNL-10. Electric logs indicate the fluid level during logging was at about 542 ft, the middle of A-3 in the Tamarisk Member. Culebra flow appears low at SNL-10.
- The base of the screen interval is placed 1 ft above the base of the Culebra to minimize any potential for M-2 to squeeze into the screen interval. The upper end of the screen interval is below the argillaceous zone of A-2. The screened or slotted section of the casing joint is 26.7 ft long. The screened interval will incorporate nearly all of the Culebra as well as lower A-2. Lower A-2 does not appear fractured.
- After coring was completed, the lower part of the drillhole was filled from total depth to about 630 ft with 8 bags of HolePlug® to isolate the deeper halite-bearing beds. The drillhole was then reamed to 11-inch diameter to 630 ft in preparation for completion. The 4/10 sand/gravel pack is recommended to fill from 630–589 ft, just below the siltstone in A-2. HolePlug® is to be added from the top of the gravel pack to ~584 ft. The annulus is to be cemented from the top of the bentonite seal to the surface.

I believe this letter summarizes the hydrological and geological justification for setting the screened interval and preparing SNL-10 for completion.

Sincerely,

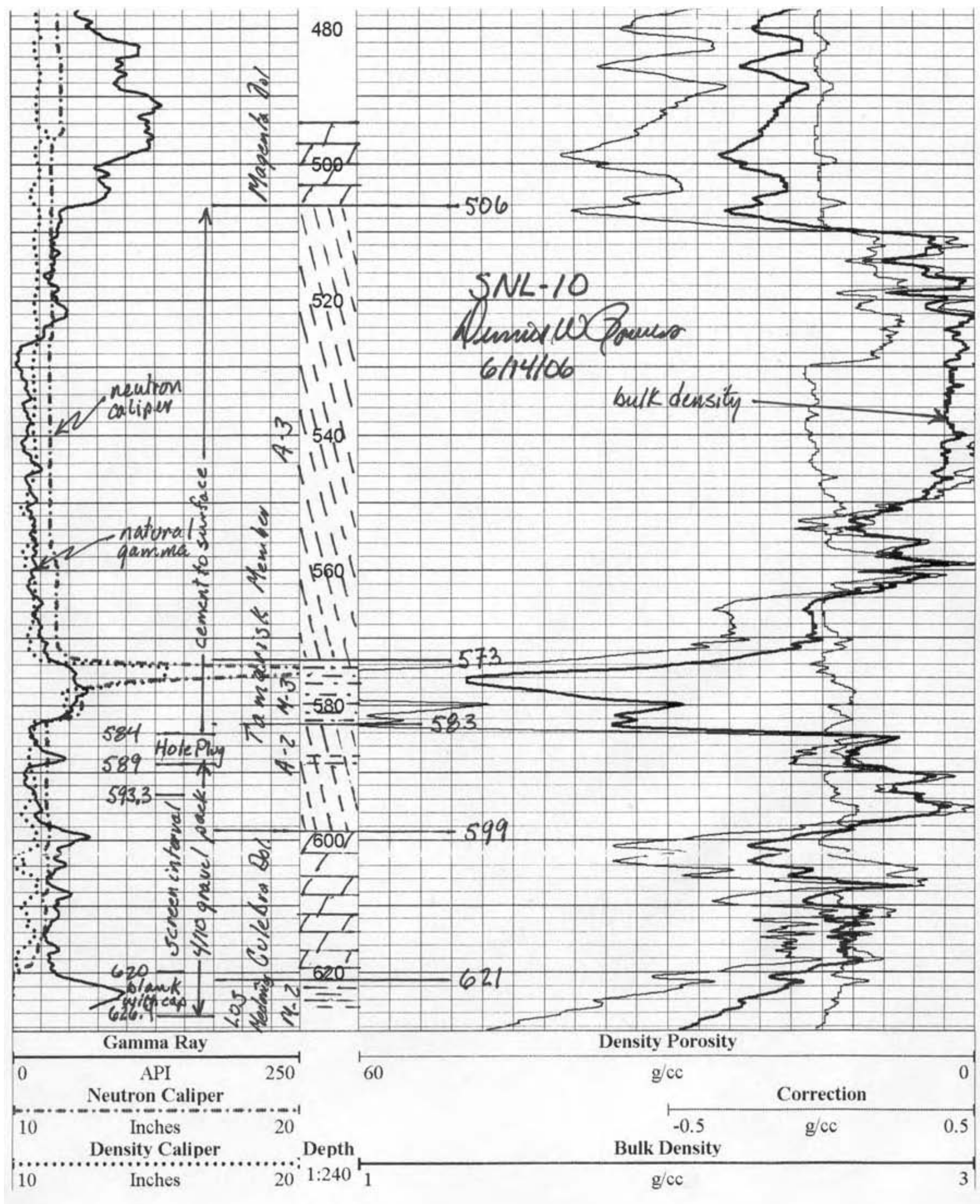
Dennis W. Powers

140 Hemley Road, Anthony, TX 79821
Telephone: (915) 877-3929 E-mail: dwpowers@evaporites.com *CELL: (915) 588-7901*

Dennis W. Powers, Ph. D.
Consulting Geologist

June 15, 2006

Partial Geophysical Log of SNL-10
Showing Completion Intervals
(scanned copy of marked field-log)



140 Hemley Road, Anthony, TX 79821
Telephone: (915) 877-3929 E-mail: dwpowers@evaporites.com *CELL: (915) 588-7901*

Dennis W. Powers, Ph. D.
Consulting Geologist

June 13, 2006

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-10

Background

Cores and cutting samples have been collected from drillhole SNL-10 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me or WRES personnel. SNL-10 is being drilled, completed, and tested under WTS contract provisions and under provisions in the hydrology program plan (SNL. 2003. Program Plan, WIPP Integrated Groundwater Hydrology Program, FY03-09, Revision 0. March 14, 2003. ERMS 526671).

Core and Cuttings Storage Conditions

There is no sample or core testing planned for SNL-10 requiring abnormal handling, preservation conditions, or immediate action to obtain test information. As a consequence, these samples and cores can be maintained in your current core storage facilities. Many of the cores obtained from SNL-10 are likely to be accessed in the next few months for further geologic studies to establish more details of stratigraphic, sedimentologic, and diagenetic conditions and events. These studies, if carried out, will be carried out under a formal plan, most likely developed under QA requirements of Sandia National Laboratories.

Core and Cuttings Retention Periods

It is recommended that cores obtained from SNL-10 be maintained indefinitely under normal storage conditions because of their relevance to hydrology and monitoring programs. The cores can be accessed for observations, and they can be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

It is recommended that cuttings samples be retained under normal storage conditions through the approval by EPA of the second CRA. Cuttings may be accessed for observation, and they may be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

Supplemental Information

Descriptive core logs and digital photographs of cores with a photograph log will be provided to you on CD-ROM format in accessible formats when the content has been reviewed for the basic data report for SNL-10.

Dennis W Powers

Dennis W. Powers

Copy to:
Ron Richardson, *Environmental Monitoring*, WRES
Richard L. Beauheim, *Hydrology Lead*, Sandia National Laboratories

140 Hemley Road, Anthony, TX 79821
Telephone: (915) 877-3929 E-mail: dwpowers@evaporites.com *FAX: (915) 877-5071*

John R. D Antonio, Jr., P.E.
State Engineer

COPY

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 337501
File Nbr: C 03221

Jul. 26, 2005

SNL-10

HAROLD JOHNSON
U.S. DEPARTMENT OF ENERGY
CARLSBAD FIELD OFFICE - WIPP
P.O. BOX 3090
CARLSBAD, NM 88221

Greetings:

Enclosed is your copy of the Exploratory / Monitoring Permit which has been approved. Your attention is called to the Specific and General Conditions of Approval of this permit.

In accordance with General Condition C, a well record shall be filed in this office ten days after completion of drilling. The well record is proof of completion of well. IT IS YOUR RESPONSIBILITY TO ASSURE THAT THE WELL LOG BE FILED WITHIN 10 DAYS OF DRILLING OF THE WELL.

This permit will expire on or before 07/31/07, unless the well has been drilled and the well log filed in this office.

Sincerely,

Mike Stapleton
Mike Stapleton
(505)622-6521

Enclosure

cc: Santa Fe Office

explore

UNIQUE #	DOE CFO	DATE REC'VD	ADDRESSEES
5502669	548710	JUL 28 2005	H Johnson w/orign J. Plum

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

SPECIFIC CONDITIONS OF APPROVAL

2 The well shall be constructed to artesian well specifications and the State Engineer shall be notified before casing is landed or cemented

4 No water shall be appropriated and beneficially used under this permit.

B The well shall be drilled by a driller licensed in the State of New Mexico in accordance with Section 72-12-12 New Mexico Statutes Annotated.

C Driller's well record must be filed with the State Engineer within 10 days after the well is drilled or driven. Well record forms will be provided by the State Engineer upon request.

C1 A complete and properly executed Well Record on the form provided by the State Engineer shall be filed not later than ten (10) days after completion of the well.
Test data shall be filed not later than ten (10) days after completion of the test(s).

LOG The Point of Diversion C 03221 EXPLORE must be completed and the Well Log filed on or before 07/31/2006.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd: Date Rcvd. Corrected:
Formal Application Rcvd: 07/25/2005 Pub. of Notice Ordered:
Date Returned - Correction: Affidavit of Pub. Filed:

This application is approved provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare of the state; and further subject to the specific conditions listed previously.

Witness my hand and seal this 26 day of Jul A.D., 2005

John R. D Antonio, Jr., P.E. , State Engineer

By:
Art Mason

Desc: C 03221 MONITORING WELL

File Number: C 03221
Trn Number: 337501

page: 1

IMPORTANT - READ INSTRUCTIONS ON BACK BEFORE FILLING OUT THIS FORM

APPLICATION FOR PERMIT

To appropriate (explore & monitor) the Underground Waters of the State of New Mexico

Date Received 7/25/05 File No. C-3221 Explore

1. Name of applicant U.S. Department of Energy, Carlsbad Field Office, WIPP
   Mailing address P.O. Box 3090, Carlsbad, New Mexico 88221-3090
   City and State Carlsbad, New Mexico, 88221

2. Source of water supply Artesian - Culebra/Dolomite (Artesian or shallow water aquifer), located in Carlsbad, (Name of underground basin)

3. The well is to be located in the NW 1/4 ne 1/4 nw 1/4 Section 30 Township 22 South Range 31 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Carlsbad, District, on land owned by U.S. Department of Energy, Waste Isolation Pilot Plant

4. Description of well: name of driller West Texas Water Well Service,
   Outside Diameter of casing <7 inches; Approximate depth to be drilled 650 feet;

5. Quantity of water to be appropriated and beneficially used N/A acre feet, (Consumptive use, diversion)
   for N/A purposes.

6. Acreage to be irrigated or place of use N/A acres.

Subdivision	Section	Township	Range	Acres	Owner

7. Additional statements or explanations The intent of this application is to provide authorization to configure a well to access the Culebra Dolomite member of the Rustler Formation (~650' bgs) for monitoring purposes only. This well will be configured with 5.5" fiberglass casing and a well screen (@ ~600' ft. bgs). See attached justification (well bore entitled SNL 10).

ACTION OF STATE ENGINEER

Alter notice pursuant to statute and by authority vested in me, this application is approvedprovided it is not exercised to the detriment of any others having existing rights; further provided that all rules and regulations of the State Engineer pertaining to the drilling of __________ wells be complied with; and further subject to the following conditions:

see attached conditions of approval

Proof of completion of well shall be filed on or before N/A

Proof of application of water to beneficial use shall be filed on or before N/A

Witness my hand and seal this 26th day of July, A.D., 2005

John R. D'Antonio, Jr., P.E., State Engineer

By: ______________________

Art Mason, District II Supervisor

INSTRUCTIONS

This form shall be executed, preferably typewritten, in triplicate and shall be accompanied by a filing fee of $25.00. Each of triplicate copies must be properly signed and attested.

A separate application for permit must be filed for each well used.

Secs. 1-4 - Fill out all blanks fully and accurately.

Sec. 5 - Irrigation use shall be stated in acre feet of water per acre per annum to be applied on the land. If for municipal or other purposes, state total quantity in acre feet to be used

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well U.S. DEPARTMENT OF ENERGY - WIPP Owner's Well No. SNL-10
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C-3221 and is located in the:

a. NE ¼ NW ¼ ____ ¼ ____ ¼ of Section 30 Township 22 S Range 31 E N.M.P.M.

b. Tract No. ____ of Map No. ____ of the CARLSBAD DISTRICT

c. Lot No. ____ of Block No. ____ of the ____
Subdivision, recorded in EDDY County.

d. X= ____ feet, Y= ____ feet, N.M. Coordinate System ____ Zone in the ____ Grant.

(B) Drilling Contractor WEST TEXAS WATER WELL SERVICE License No. WD1184

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 05-30-06 Completed 06-16-06 Type tools AIR ROTARY Size of hole 11 in.

Elevation of land surface or ____ at well is 3373 ft. Total depth of well 651 ft.

Completed well is ☐ shallow ☒ artesian. Depth to water upon completion of well ____ ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
599	621	22	DOLOMITE (CULEBRA)	

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
12-3/4	35		3' AGL	35	38			
5-1/2	4.4	4	2.5' AGL	626.4	628.9		620	593.3

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
0	35	17-1/2		54 CU. FT.	S.E.R.M. TRIMIE
0 584	584 589	11 11	3 BGS BENT. HOLE PLUG	405 CU. FT.	S.E.R.M. - TRIMIE
631	651	6-3/4	8 BGS BENT. HOLE PLUG		

Section 5. PLUGGING RECORD

Plugging Contractor ____
Address ____
Plugging Method ____
Date Well Plugged ____
Plugging approved by:

____
State Engineer Representative

No.	Depth in Feet Top	Depth in Feet Bottom	Cubic Feet of Cement
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad ____ FWL ____ FSL ____

File No. ____ Use ____ Location No. ____

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	2	2	CONSTRUCTION FILL
2	17	15	BROWN FINE-GRAINED SAND, LOOSE (DUNE SAND), WITH BASAL REDDISH BROWN BERINO SOIL
17	19	2	WHITE SANDY LIMESTONE AND CALCAREOUS SANDSTONE, (MESCALERO CALICHE)
19	44	25	REDDISH BROWN CALCAREOUS SILTSTONE (GATUNA FORMATION)
44	418	374	REDDISH BROWN SILTSTONE WITH SMALL GRAY REDUCTION SPOTS; CALCAREOUS TO GYPSIFEROUS AND WELL-INDURATED (DEWEY LAKE FORMATION)
418	476	58	GYPSUM, GRAY TO WHITE, WITH INTERMEDIATE REDDISH BROWN SILTSTONE FROM 448-464 FT. (FORTY-NINER MEMBER OF RUSTLER FORMATION)
476	506	30	LIGHT GRAY TO GRAYISH BROWN GYPSIFEROUS DOLOMITE WITH LAMINAR TO WAVY BEDDING (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
506	599	93	GRAY TO WHITE GYPSUM, BEDDED, WITH INTERMEDIATE REDDISH-BROWN MUDSTONE FROM 573-583 FT. (TAMARISK MEMBER OF THE RUSTLER FORMATION)
599	621	22	LIGHT TO DARK BROWN DOLOMITE (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
621	627	6	DARK GRAY CLAYSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
627	643	16	GYPSUM & ANHYDRITE WITH CLAYSTONE FROM 636.7-641.2 FT. (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
643	651	8	HALITE WITH MUDSTONE & HALITIC MUDSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)

Section 7. REMARKS AND ADDITIONAL INFORMATION

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Larry Keith
Driller

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the appropriate district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1(a) and Section 5 need be completed.

Appendix E
Archeological Clearance Report

The report from Mesa Field Services on the following three pages was converted from an original Word document to an Acrobat (pdf) file and reduced in size slightly to fit page formats. The original signed document is maintained by the land management coordinator, Washington Regulatory and Environmental Services, for the WIPP Project.

TITLE PAGE/ABSTRACT/
NEGATIVE SITE REPORT
CFO/RFO

1/03

1. BLM Report No.

2. Reviewer's Initials/Date________
ACCEPTED ( ) REJECTED ( )

3. NMCRIS No.: 94962

4. Type of Report: Negative (X) Positive ( )

5. Title of Report:
Class III archaeological survey of a pad for monitor well SNL-10.

Author(s): Ann Boone

6. Fieldwork Date(s):
from 13 Sept. 2005 to

7. Report Date: 14 Sept 2005

8. Consultant Name & Address:
Boone Archaeological Services
2030 North Canal, Carlsbad, NM 88220
Direct Charge: Danny Boone
Field Personnel Names: Danny Boone
Phone: (505) 885-1352

9. Cultural Resource Permit No.:
BLM: 190-2920-05-G
STATE: NM 05-157

10. Consultant Report No.
BAS 08-05-77

11. Customer Name: Washington TRU Solutions, LLC
Responsible Individual: Ron Richardson
Address: P.O. Box 2078
Carlsbad, NM 88221
Phone: (505) 234-8395

12. Customer Project No.:
SNL-10

13. Land Status:	BLM	STATE	PRIVATE	OTHER	TOTAL
a. Area Surveyed (acres)	1.01 (+/-)	0	0	0	1.01 (+/-)
b. Area of Effect (acres)	0.52 (+/-)	0	0	0	0.52 (+/-)

14. a. Linear: Length; N/A Width; N/A
b. Block: 150' x 150' [Survey,210' x 210'] See. 16 b.

15. Location: (Maps Attached if Negative Survey)
a. State: New Mexico
b. County: Eddy
c. BLM Office: Carlsbad
d. Nearest City or Town: Carlsbad, NM
e. Legal Location: T 22S, R 31E, Sec. 30, NE¼ NW¼.
f. Well Pad Footages: N/A
g. USGS 7.5 Map Name(s) and Code Number(s): Los Medanos, NM (Prov. Ed. 1985) 32103-C7

16. Project Data:

a. Records Search: Date(s) of BLM File Review: 12 Sept. 2005 Name of Reviewer (s): Danny Boone

Date(s) of ARMS Data Review: 12 Sept. 2005 Name of Reviewer (s): Ann Boone

Findings (see Field Office requirements to determine area to be reviewed during records search):

LA 47661, 54364, 14308, 35004, 98816, 99597, 103180, 141662 are within 1.00 mile

b. Description of Undertaking:

This project is staked as a 150 by 150 feet square. One addational transect around the outer perimeter was added for the 1.0 acre minimum. Access will be from an existing caliche capped road (parallels the south side of a railroad track) that is the northern boundary of the survey area. A plat for the project is attached to this report.

c. Environmental Setting (NRCS soil designation; vegetative community; etc.):

Topography: Dunal plain with deflation basins ranging in size up to 15 meters in diameter and 1 meter deep.

Vegetation: Overall groundcover is approximately 35% consisting primarily of shinoak, mesquite, sage brush, assorted grasses and other flora.

NRCS: Kermit-Berino association: Sandy, deep soils from wind-worked mixed sand deposits.

d. Field Methods: (transect intervals; crew size; time in field, etc.):

Transects: A parallel grid spaced 15 meters or less apart.

Crew Size: One

Time in Field: 1.0 hour.

e. Artifacts Collected (?): None

17. Cultural Resource Findings:

a. Identification and description: None

b. Evaluation of significance of Each Resource: None

18. Management Summary (Recommendations):

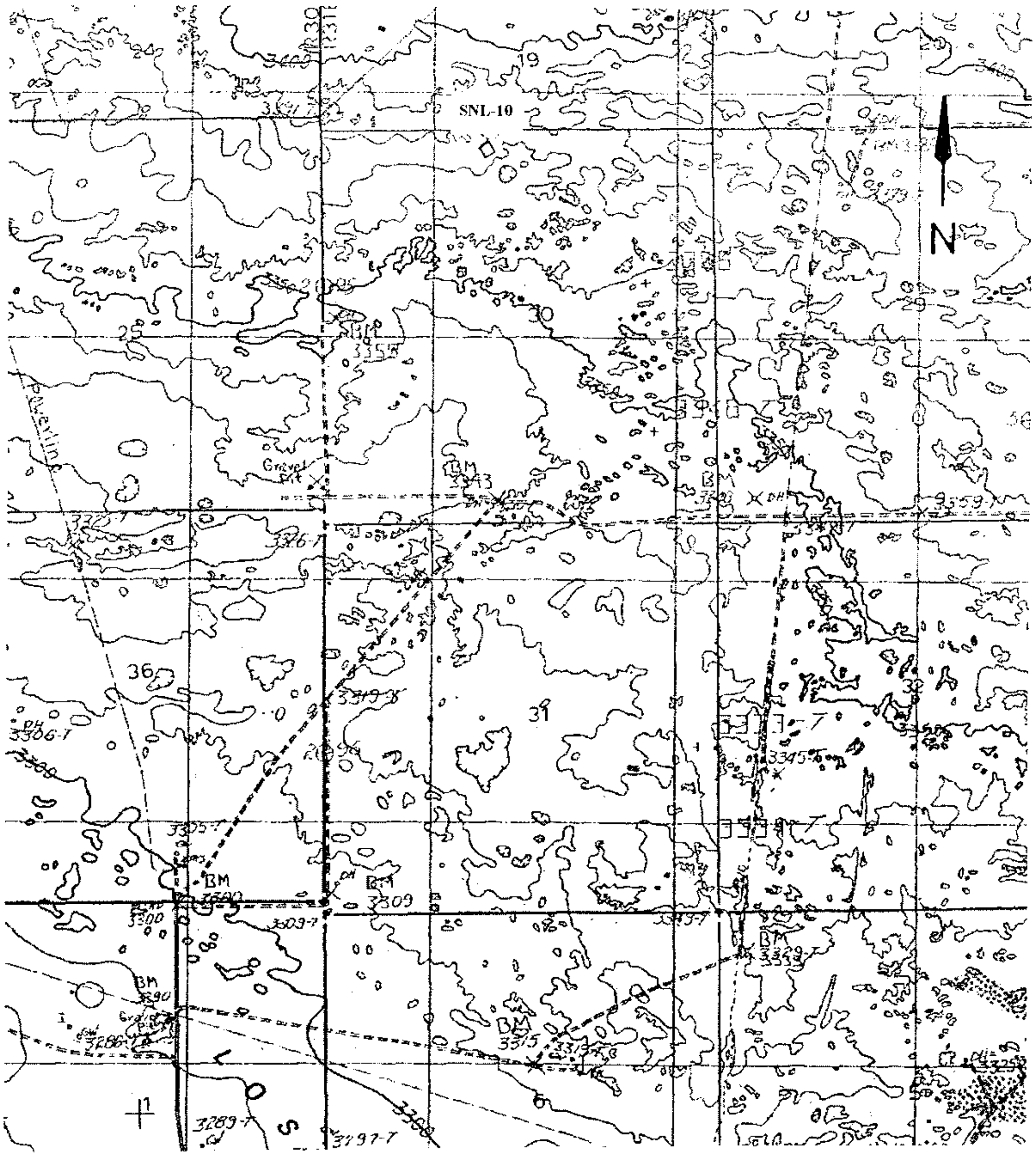
Archaeological clearance of a pad for monitor well SNL-10 for Washington TRU Solutions, LLC as presently staked is recommended. If cultural resources are encountered at any time all activity should cease and the BLM Archaeologist notified immediately.

19.

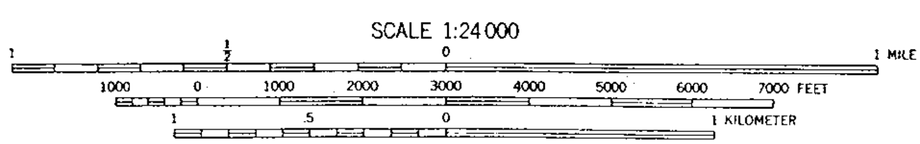
I certify that the information provided above is correct and accurate and meets all appreciable BLM standards.

Responsible Archaeologist Dany Boone 14 September, 2005

Signature Date



Location Map of a pad for monitor well SNL-10 for Washington TRU Solutions LLC in Section 30, T 22S, R 31E, NMPM, Eddy County, NM.
Map Reference: USGS 7.5' Series; Los Medanos, NM (Prov. Ed. 1985) 32103-C7



Appendix F
Photograph Logs

Digital photographs were taken of the cores from SNL-10. A listing has been compiled of consecutive photos beginning with the uppermost core (Magenta Dolomite Member of the Rustler Formation) and ending with the lowermost (upper Los Medaños Member of the Rustler Formation). The photographs were taken in the field shortly after recovery. A CD-ROM with these images (jpeg format) is being archived, and a copy with photographic log is maintained by Geotechnical Engineering (Washington TRU Solutions LLC) with records of the cores stored for WIPP.

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core001.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 470.0 - 471.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core002.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 470.9 - 472.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core003.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 471.9 - 473.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core004.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 472.9 - 474.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core005.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 473.9 - 475.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core006.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 474.9 - 476.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core007.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 475.9 - 477.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core008.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner Mbr core, 476.9 - 478.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core009.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Forty-niner and Magenta Dolomite Mbr core, 477.9 - 479.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core010.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 478.9 - 480.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core011.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Doloimite Mbr core, 479.9 - 481.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core012.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 480.8 - 482.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core013.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 481.9 - 483.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core014.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 482.9 - 484.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core015.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 483.9 - 485.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core016.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 484.9 - 485.6 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 1 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core017.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 485.6 - 486.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core018.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 485.9 - 487.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core019.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 486.9 - 488.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core020.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 487.9 - 489.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core021.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 488.9 - 490.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core022.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 489.9 - 491.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core023.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 490.9 - 492.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core024.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 491.8 - 493.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core025.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 492.8 - 494.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core026.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 493.9 - 495.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core027.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite/ Tamarisk Mbrs core, 494.8 - 496.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core028.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 495.9 - 497.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core029.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 496.9 - 498.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core030.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 497.9 - 499.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core031.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 498.9 - 499.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core032.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 499.5 - 500.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

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File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core033.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite core, 499.9 - 501.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core034.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 500.9 - 502.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core035.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 501.9 - 503.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core036.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite Mbr core, 502.9 - 504.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core037.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Magenta Dolomite and Tamarisk Mbr core, 503.9 - 505.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core038.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 504.8 - 506.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core039.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 505.8 - 507.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core040.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 506.8 - 508.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core041.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 507.8 - 509.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core042.jpg	6/3/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 508.9 - 510.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core043.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 565.0 - 566.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core044.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 565.9 - 567.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core045.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 566.9 - 568.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core046.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 567.9 - 569.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core047.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 568.9 - 570.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core048.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 569.9 - 571.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 3 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core049.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 570.9 - 572.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core050.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 571.9 - 573.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core051.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 572.9 - 574.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core052.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 573.9 - 575.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core053.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 574.9 - 576.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core054.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 575.9 - 577.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core055.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 576.9 - 578.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core056.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 577.9 - 579.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core057.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 578.9 - 580.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core058.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 579.9 - 580.8 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core059.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 580.8 - 582.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core060.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 581.9 - 583.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core061.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 582.8 - 584.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core062.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 583.8 - 585.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core063.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 584.8 - 586.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core064.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 585.8 - 587.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 4 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core065.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 586.8 - 588.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core066.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 587.8 - 589.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core067.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 588.8 - 590.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core068.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 589.8 - 591.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-10_Core069.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 590.8 - 592.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core070.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 591.8 - 593.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core071.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 592.8 - 594.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core072.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 593.8 - 595.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core073.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 595.2 - 596.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core074.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 595.9 - 597.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core075.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk Mbr core, 596.9 - 598.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core076.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Tamarisk & Culebra Dolomite Mbrs core, 597.9 - 599.1 with markings, scale	DW Powers Consultant to WTS
SNL-10_Core077.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 598.9 - 600.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core078.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 599.9 - 601.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core079.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 600.9 - 602.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core080.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 601.9 - 603.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 5 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core081.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 602.8 - 604.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core082.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 603.9 - 605.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core083.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 604.9 - 606.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core084.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 605.8 - 607.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core085.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 606.9 - 608.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core086.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 607.9 - 609.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core087.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 608.9 - 610.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core088.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 609.9 - 611.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core089.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 610.9 - 611.6 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core090.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 611.6 - 612.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core091.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 611.9 - 613.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core092.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 612.9 - 614.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core093.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 613.8 - 615.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core094.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 614.9 - 616.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core095.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 615.9 - 617.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core096.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 616.9 - 618.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 6 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core097.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 617.9 - 619.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core098.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite Mbr core, 618.9 - 620.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core099.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite and Los Medaños Mbr core, 619.9 - 621.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core100.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Culebra Dolomite and Los Medaños Mbr core, 620.9 - 621.6 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core101.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 621.4 - 622.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core102.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 621.9 - 622.6 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core103.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 622.4 - 623.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core104.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 623.9 - 624.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core105.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 624.9 - 624.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core106.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 624.5 - 625.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core107.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 625.9 - 627.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core108.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 626.9 - 628.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core109.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 627.9 - 629.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core110.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 628.9 - 630.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core111.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 629.9 - 631.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core112.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 630.9 - 632.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 7 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core113.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 631.9 - 633.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core114.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 632.9 - 634.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core115.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 633.9 - 635.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core116.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 634.9 - 636.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core117.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 635.9 - 637.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core118.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 636.9 - 637.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core119.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 637.4 - 638.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core120.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 637.9 - 639.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core121.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 638.9 - 640.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core122.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 639.9 - 641.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core123.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 640.9 - 642.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core124.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 641.9 - 643.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core125.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 642.9 - 644.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core126.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 643.9 - 645.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core127.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 644.9 - 646.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core128.jpg	6/6/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 645.9 - 647.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 8 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-10_Core129.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 646.8 - 648.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core130.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 647.9 - 649.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core131.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 648.9 - 650.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core132.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 649.8 - 651.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-10_Core133.jpg	6/5/06	SNL-10 drillpad; T22S, R31E, sec 30	Close-up photo of Los Medaños Mbr core, 650.9 - 652.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

Appendix G
Geophysical Logs

Geophysical logging of SNL-10 was conducted by Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, on June 14, 2006. The operator was Al Henderson. Copies of the logs are maintained by Washington Regulatory and Environmental Services, Environmental Monitoring and Hydrology Section, for the WIPP project. A CD-ROM is being retained that includes:

1) Electronic copies of the logs produced by Jet West Geophysical Logging Services using WellCAD v. 4.0,
2) WellCAD Reader to open the electronic logs, and
3) Electronic data files in both .txt and .las formats.

The following geophysical logs were obtained:

- •Caliper (neutron and density)
- •Natural gamma
- •Density-porosity
- •Resistivity
- •Spontaneous potential

SNL-10 had been cored and drilled to about 652 ft, plugged from 630 ft to total depth, and reamed to 11-inches diameter to 630 ft at the time of logging. Maximum depth reached during logging was 630 ft. A conductor casing had been placed to a depth of 35 ft bgl. SNL-10 was drilled with air and foam, and the apparent water level varied between 430 and 540 ft bgl during logging.

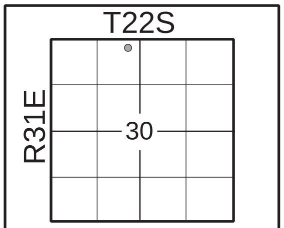
The caliper log was used for estimating material volume to be placed in the annulus between fiberglass reinforced plastic casing and the drillhole wall.

The reference point (0 ft depth) for geophysical logging was the top of the connector on the surface conductor casing (see photo, next page). This point was assigned an elevation of 3,373.41 ft amsl on the logs, based on the pre-drilling pad survey. A benchmark placed near the drillhole after completion has an elevation of 3,375.10 ft amsl (see Fig. 1-5 and Table 1-1 in the main text). The rounded elevation of 3,375 ft amsl for the reference point is appropriate for the measurements and elevations of units for later studies.

Geophysical logging tool at reference point at top of connector on conductor casing at SNL-10 on June 14, 2006. Photo by Dennis W. Powers.

Figure 2-1
Well Record SNL-10 (C-3221)

Company: Washington TRU Solutions LLC
Well: SNL-10 (C-3221)
Section: 30 Twp: T22S Rge: R31E
Location: 240 ft from north line (fnl)
2,284 ft from west line (fwl)



Reference point
Log measured from: top of connector on conductor casing (gl)
Drilling measured from: gl
Permanent Datum: benchmark

Elevation
KB:
DF:
GL: 3,375 ft amsl
(benchmark: 3,375.10)

Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: May 30, 2006
Completion date: June 14, 2006
Total depth (TD): 651 ft bgl (driller log)

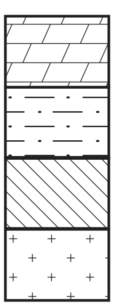
Casing Record
Conductor: 35 ft
12.75 inch o.d. steel
Casing: 5.45 inch o.d.
fiberglass reinforced
plastic to 626.4 ft bgl
Screened interval:
593.3-620 ft bgl

Geophysical Logs Date: June 14, 2006

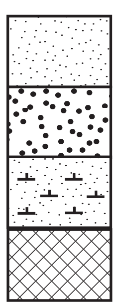
Micro/Laterolog/SP:	530-630 ft
Gamma	0-625 ft
Caliper:	0-620 ft
Density/Neutron:	0-629 ft

Type fluid in hole: water
from drillhole to 532 ft
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.:
not recorded

General Lithologic Symbols Used



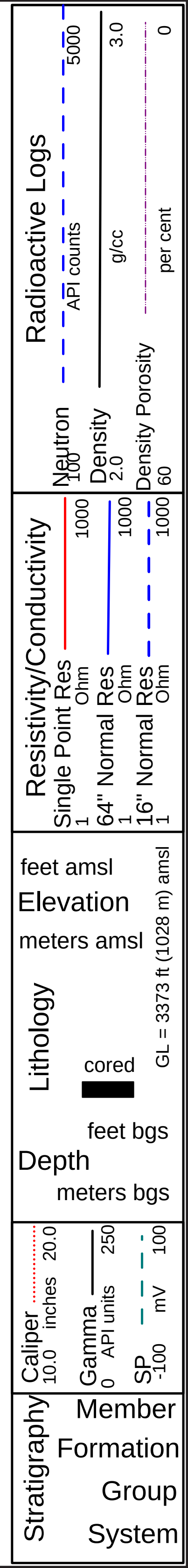
Dolomite
Mudstone/siltstone
Anhydrite
Halite

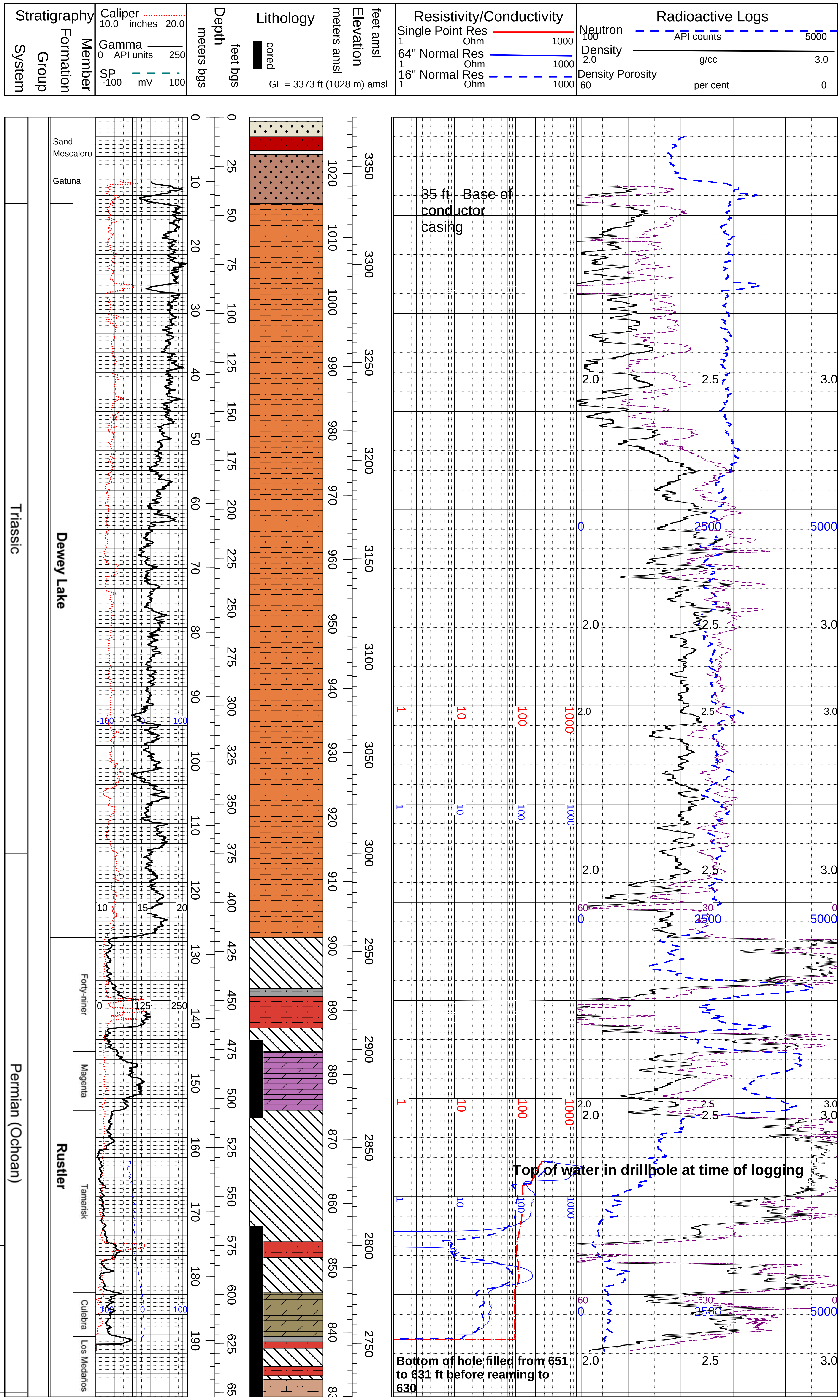


Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Figure 2-1 Log Title & Header page.ai

SNL-10 Well Log Headers




Stratigraphy
System
Group
Formation
Member
Caliper
10.0 inches 20.0
Gamma
0 API units 250
SP
-100 mV 100
Depth
meters bgs
feet bgs
Lithology
cored
GL = 3373 ft (1028 m) amsl
Elevation
meters amsl
feet amsl
Resistivity/Conductivity
Single Point Res
1 Ohm 1000
64" Normal Res
1 Ohm 1000
16" Normal Res
1 Ohm 1000
Radioactive Logs
Neutron
100 API counts 5000
Density
2.0 g/cc 3.0
Density Porosity
60 per cent 0
Triassic
Permian (Ochoan)
Dewey Lake
Rustler
Sand
Mescalero
Gatuna
Forty-niner
Magenta
Tamarisk
Culebra
Los Medaños
35 ft - Base of conductor casing
Top of water in drillhole at time of logging
Bottom of hole filled from 651 to 631 ft before reaming to 630

p. 88-89