DOE/WIPP 05-3320

Basic Data Report For Drillhole SNL-14 (C-3140) (Waste Isolation Pilot Plant)

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Basic Data Report
For Drillhole SNL-14 (C-3140)
(Waste Isolation Pilot Plant)

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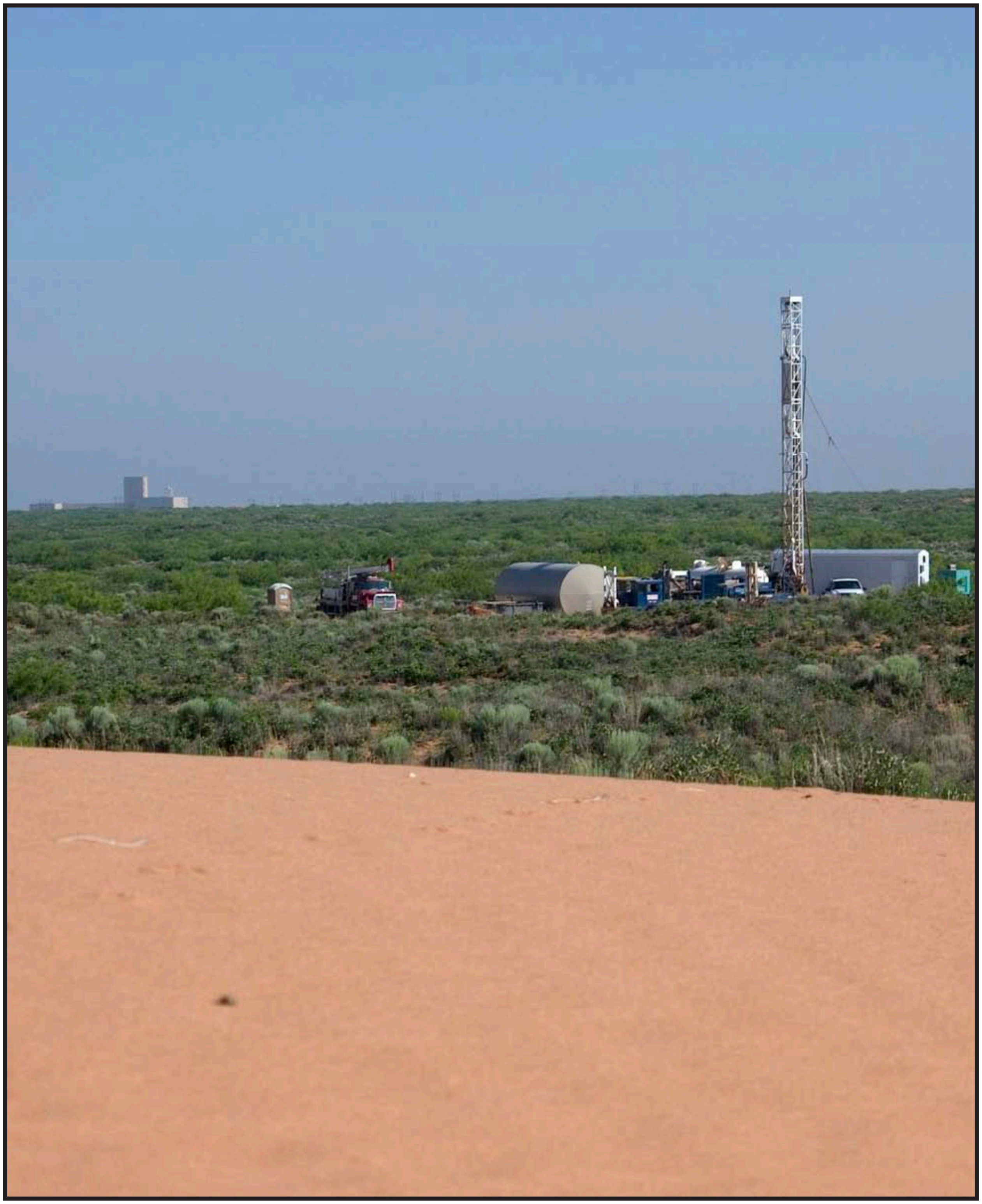
August 2008



West Texas Water Well Service rig #15 at SNL-14 location on May 20, 2005. The Waste Isolation PIlot Plant facilities are on the left horizon north-northeast of the well pad. The waste shaft is the tallest building. Photo by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-14 (permitted by the New Mexico State Engineer as C-3140) was drilled and completed in May 2005 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation in an area south of the Waste Isolation Pilot Plant (WIPP) site where Culebra transmissivity is expected to be high. SNL-14 is located in the southeast quarter of section 4, T23S, R31E, in eastern Eddy County, New Mexico. SNL-14 was drilled to a total depth of 718.5 ft below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-14 encountered the Mescalero caliche, Gatuña, Dewey Lake, and Rustler Formations. The Rustler was cored from the upper Magenta Dolomite Member into the upper Tamarisk Member and from the lower Tamarisk Member through the Culebra Dolomite and into the upper Los Medaños Member. Geophysical logs were acquired from the open hole to a depth of ~713 ft. Significant water flowed into the drillhole from the Dewey Lake, and the remainder of the hole was drilled with circulating fresh water with soap and polymer additives.

The upper part of the Los Medaños has normal lithology, thickness, and stratigraphic sequence for areas immediately south of WIPP. The upper part of the lower clastic-halite unit of the Los Medaños (M-1/H-1) at SNL-14 was well preserved in cores, and the unit was dominated by halite, consistent with expectations based on previous drilling in this area. The halite is medium-to-coarse crystalline, generally white, and is bedded and interbedded with thin mudstone layers. The halite displays displacive growth. A thin anhydrite with halite in the basal and uppermost parts was deposited in the upper part of M-1/H-1, and it likely converges with the basal A-1 to the west and north. A-1 is predominantly anhydrite with a thin reddish zone that may be correlative with polyhalitic zones in drillholes farther east. Bottom growth gypsum crystals near the base of A-1 have been pseudomorphed by halite. There is no halite in the mudstone (M-2/H-2) unit at the top of the Los Medaños. M-2 preserves siltstone and mudstone intraclasts, bedding, and the typical color change from reddish brown to dark gray upward. The contact zone with the overlying Culebra was recovered and does not indicate significant deformation.

Core recovery from the Culebra was variable, as is common in this general area. Much of the lower Culebra was recovered as elongated blocks up to ~3 inches, and it is estimated that 4 ft of core may not have been recovered. Vuggy porosity is moderate in intact core segments. The middle two hydrogeologic units (CU-3 and CU-2) are not well represented by core. There is a short zone in the lower part of CU-1 with a few vugs filled with gypsum. Some subhorizontal bedding occurs throughout the core, and there are concentrated laminae in the upper 1.5 ft with probable organic (algal) laminae. The recovered Culebra core materials total ~22.7 ft thick, while the Culebra is 27 ft thick as interpreted by geophysical logs. This is normal for the WIPP site. There are few distinct fractures in the intact core segments. Given the lack of gypsum fill in porosity and fractures, the Culebra should have high transmissivity compared to most wells tested at WIPP.

The Tamarisk has a normal stratigraphic sequence for the area south of WIPP and thickness similar to other drillholes around the WIPP site where halite does not occur. The lower sulfate unit (A-2), mudstone unit (M-3/H-3), and a few feet at the base of the upper sulfate unit (A-3) were cored; recovery was excellent. A-2 has a sharp basal contact with the Culebra, although some carbonate laminae were deposited in the lower A-2. A thin, gray, argillaceous zone in the upper part of A-2 is persistent across the WIPP area. At SNL-14, M-3 is conglomeratic, with intraclasts of both reddish brown and gray claystone and possible fining upwards. The upper gray zone of

M-3 also shows thin bedding that is not deformed. The transition to the overlying sulfate (A-3) shows some deformation within ~1 ft of the contact and intraclasts of anhydrite cemented by translucent anhydrite. Above that, A-3 bedding appears little disturbed; there are some short fractures with very little displacement. Cores from the upper 6.3 ft of A-3 show bedding, with some carbonate outlining bedding. A thin nodular zone appears to be present. The upper contact displays several inches of relief overlain by algal laminae of the basal Magenta. A-3 is 60 ft thick, consistent with other encounters in the area.

The Magenta Dolomite is ~28 ft thick, based on geophysical logs. The cored thickness of Magenta was 24 ft, indicating that as much as 4 ft of the upper Magenta were drilled before coring began. Core recovery was excellent. Bedding is thin to laminar and generally wavy, with amplitudes lessening from the base upward to a zone of small gypsum nodules. Three high-angle fractures were intercepted; one was filled with gypsum. Core and logs indicated higher porosity through a zone ~10 ft thick in the upper middle part of the member generally consistent with findings at other drillholes in the area. There were no indications of groundwater inflow while the interval was cored and reamed with circulating fluid.

The Forty-niner is represented by a sequence of sulfate–halite and mudstone–sulfate. The basal sulfate (A-4) is ~14 ft thick and shows both anhydrite and gypsum. There is no halite in M-4/H-4 indicated by geophysical logs or the limited cuttings recovered from the interval. The upper anhydrite and gypsum (A-5) of the Forty-niner is 28 ft thick, and the contact with the overlying Dewey Lake appears sharp on the logs.

The Dewey Lake is 456 ft thick at SNL-14, similar to nearby drillholes. Cuttings showed more gypsum and probable sulfate cement below 305 ft, and resistivity increased modestly below that point. Irregular neutron and slight reduction in resistivity from 170-295 ft are consistent with finding groundwater in the Dewey Lake in this zone. In the southern part of the WIPP site area, water has been encountered in the Dewey Lake in a similar stratigraphic position above sulfatic zones. Field measurements of the water indicated a specific gravity of 1.0255.

The Santa Rosa Formation has been eroded at SNL-14.

The Gatuña at SNL-14 is mainly fine sandstone and claystone that is calcareous. Some reworked clasts of Dewey Lake are also preserved.

The Mescalero caliche is moderately indurated at SNL-14, but cuttings were insufficient to determine the stage of development.

SNL-14 was drilled (and reamed through cored intervals) with a diameter of 11 inches to 686 ft for completion. Fiberglass reinforced plastic (FRP) tubing (4.85 inches inside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 676.0–649.5 ft below the top of the conductor casing. Approximately 2.5 ft of FRP casing was left above the connector. The annulus was filled with 4/10 gravel from the reamed depth of 686 ft to 645 ft, above the Culebra. HolePlug® (bentonite) was placed from 645–640 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface.

SNL-14 was completed May 25, 2005. The well was developed May 27, 2005, by jetting with fresh water and bailing 640 gallons. On June 1, 2007, the well was further developed by pumping an additional 4,500 gallons. SNL (Sandia National Laboratories) installed a miniTroll in May 2005 to monitor pressure changes in response to testing at other wells and recovery after drilling. The first water level recorded by Washington Regulatory and Environmental Services (WRES) was measured June 20, 2005; water was 371.16 ft below the top of the casing.

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List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-14 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)

Tracks of unidentified animal (tortoise?) at Los Medaños. Photo taken May 20, 2005, by Dennis W. Powers

1.0 INTRODUCTION

SNL-14 was drilled in the northeast quarter of Section 4, T23S, R31E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 3,306 ft from the north line (fnl) and 1,388 ft from the east line (fel) of the section (Fig. 1-2). This location places the drillhole south of the WIPP site and between drillholes H-17 and P-17. SNL-14 was begun and completed in May 2005. SNL-14 will be used to test hydraulic properties and to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for WIPP.

SNL-14 was permitted by the New Mexico State Engineer as C-3140. 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 New Mexico Environment Department. WIPP is located about 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 below ground level (bgl).

1.2 Purpose of SNL-14

SNL-14 was not designated as a drilling location in the integrated hydrology program for WIPP (Sandia National Laboratories, 2003). The location was selected in response to interactions with the EPA regarding travel paths and times southward from the site. Memoranda about the site selection and characteristics for SNL-14 are reproduced in Appendix A. Among the objectives of the integrated hydrology program, SNL-14 is expected to 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 (Sandia National Laboratories, 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 Culebra model used in the Compliance Recertification Application (CRA; U.S. DOE, 2004) submitted to the EPA was based on these factors.

SNL-14 was located to test Culebra hydraulic properties in an area south of WIPP where modeling suggests a zone of higher transmissivity. Previous studies indicated that the halite margin in the Tamarisk Member (above the Culebra) was between H-17 and P-17; halite was present at H-17 and absent at P-17. SNL-14 was located midway between the two, as there were no other data available to pinpoint the halite margin. It was preferable that SNL-14

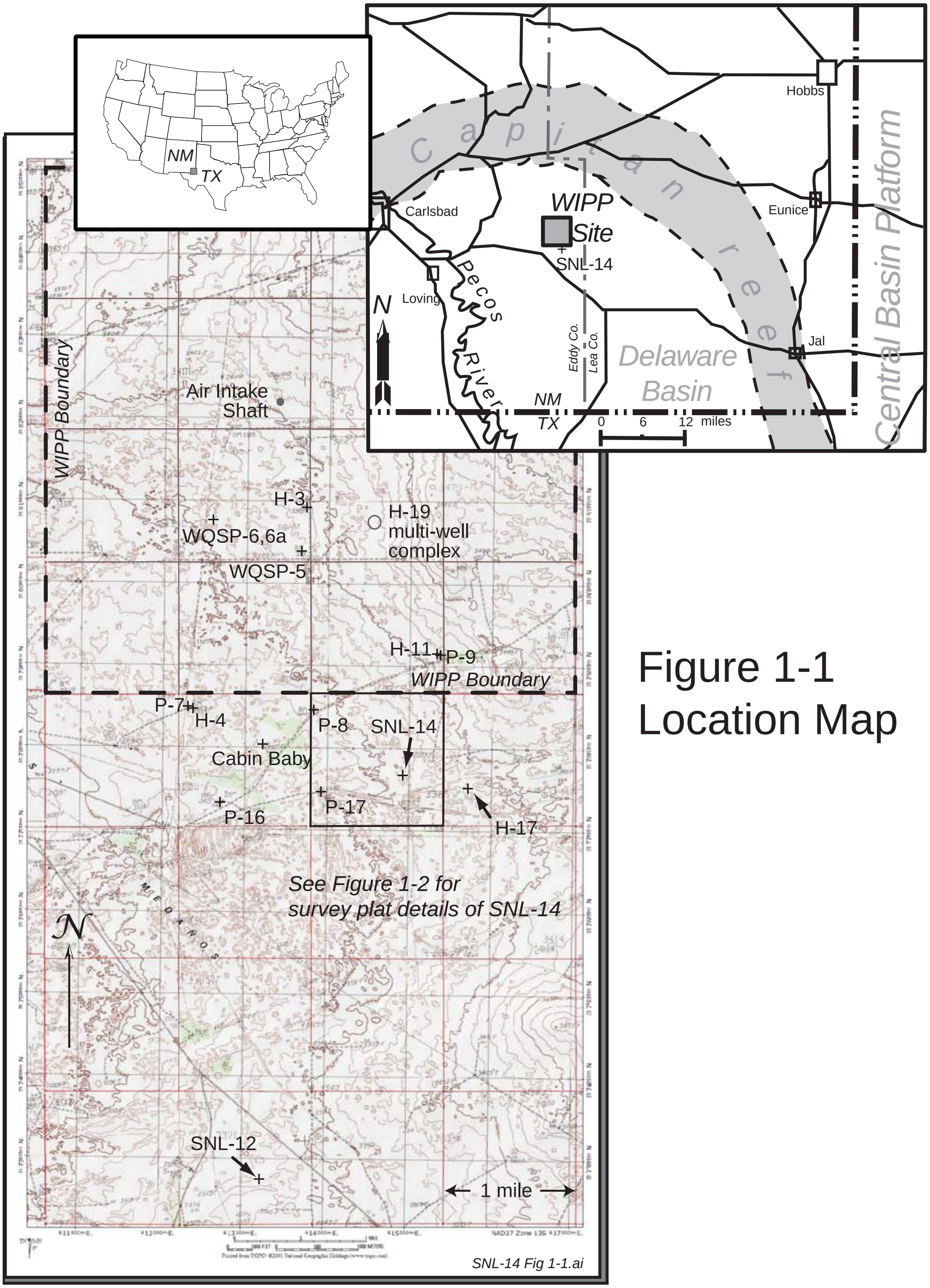


Figure 1-1
Location Map

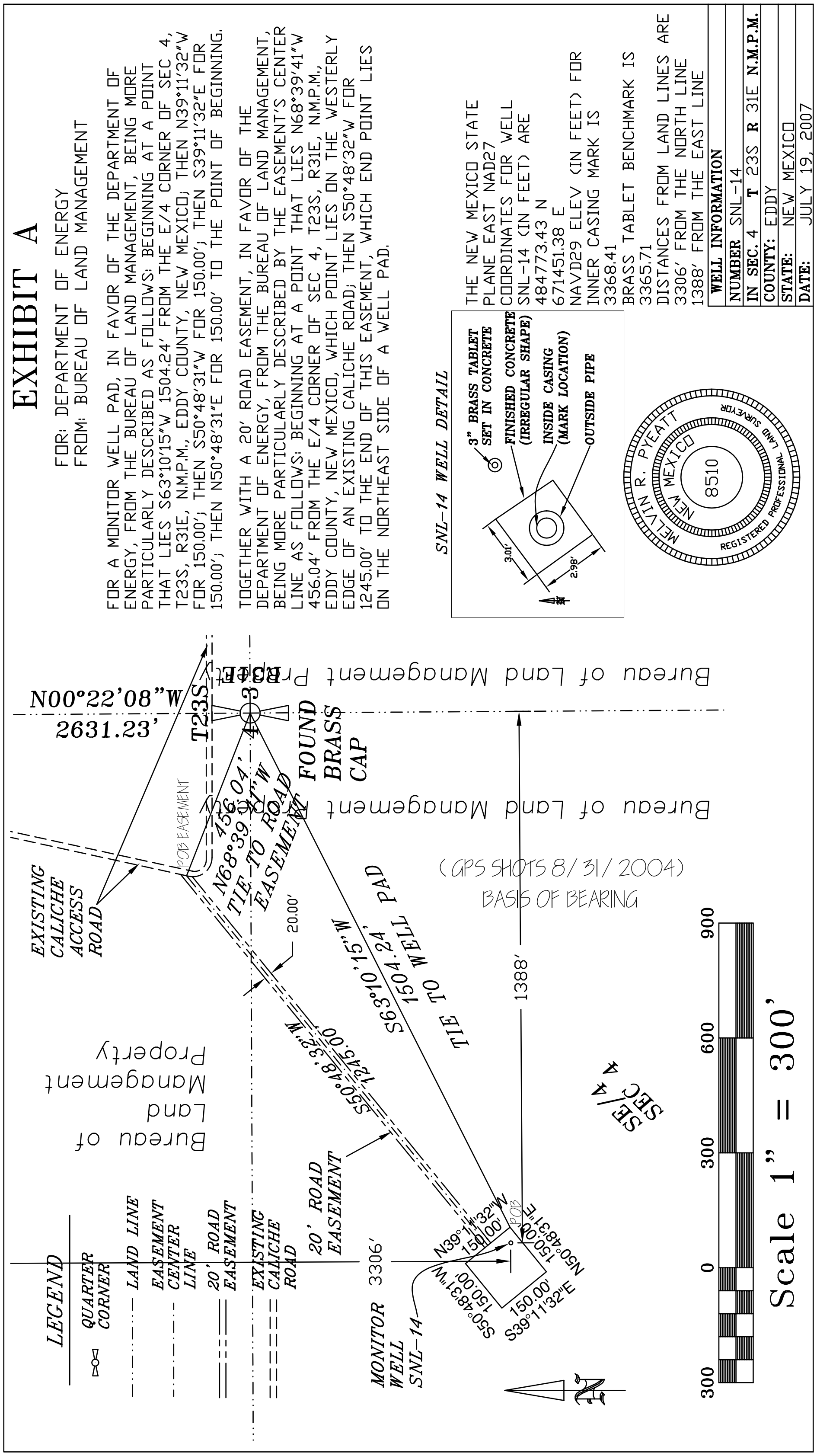


Figure 1-2 Survey Plat for SNL-14

be beyond the halite margin (in the mudflat facies), especially if there is a zone where halite has been dissolved adjacent to the current halite margin. Optimization modeling (McKenna, 2004) indicated that modest improvement in our understanding of Culebra transmissivity and hydraulic head would be provided by a drillhole located in this general area.

1.3 SNL-14 Drilling and Completion

The basic information about drilling and completion of SNL-14 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-14 was rotary drilled and cored to a total depth of 718.5 ft bgl (Fig. 1-3) as measured during drilling and coring. Geophysical logging tools did not reach total drilled depth, but stratigraphic contacts inferred from the logs are similar to those determined while drilling and coring. Figures are based on geophysical logs, but the total depth is being reported at 718.5 ft. The upper part of SNL-14 was drilled using compressed air (two compressors) with a small added volume of water and Quik–Foam® to improve cuttings returns. After significant water was encountered while drilling the Dewey Lake Formation, the hole was drilled from 304 ft using circulating water with polymer to increase viscosity. Cuttings were fine and less useful after drilling was continued with circulating water.

Core recovery was good; recovered lengths equalled or, for one run, slightly exceeded the cored interval as measured during drilling (Table 1-1; Appendix C). Core recovery through the Culebra was good to poor, as is common (e.g., Powers, 2002b; Mercer and others, 1998).

In keeping with recent practice at WIPP, SNL-14 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 similar to SNL-14 (Sandia National Laboratories, 2003).

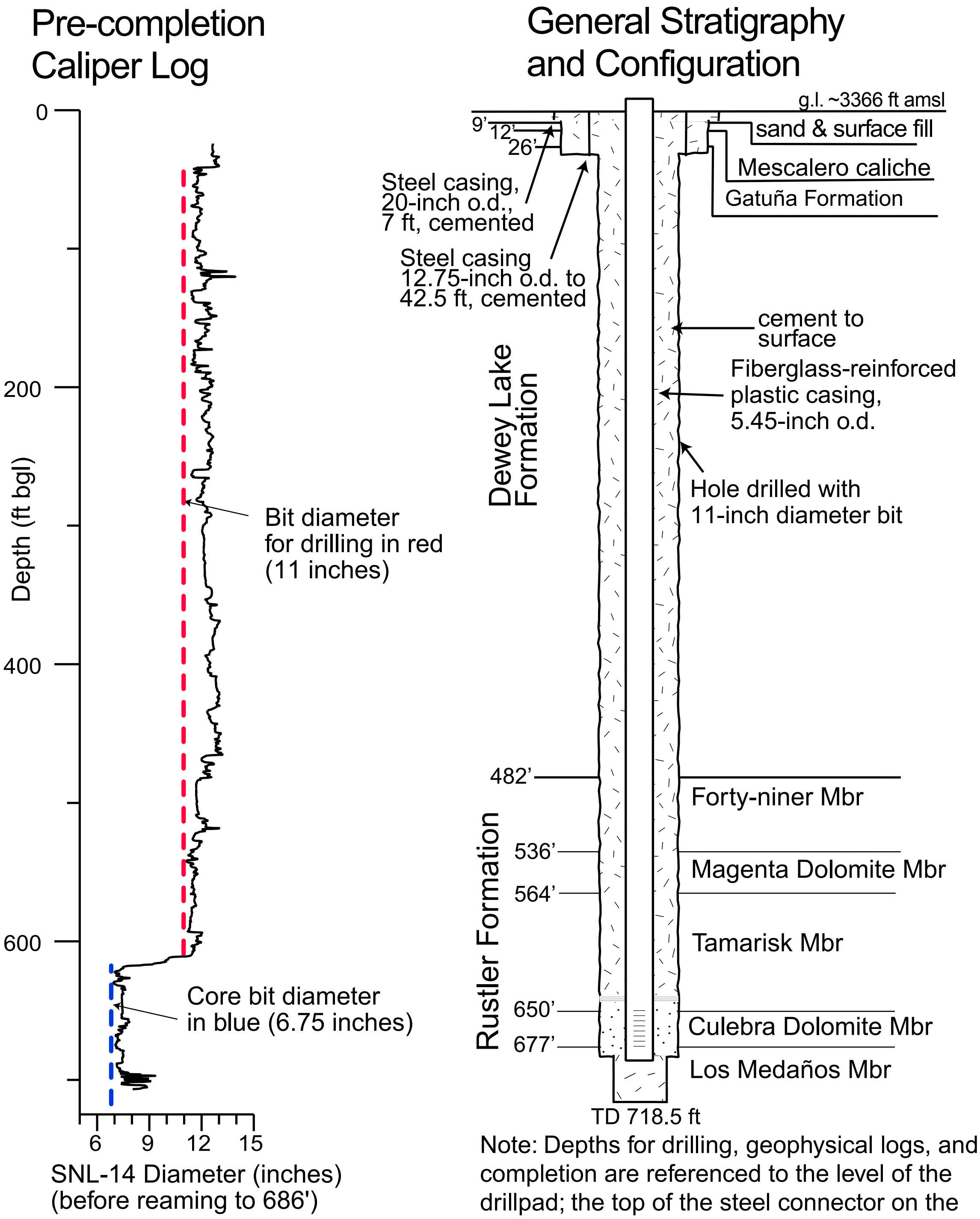
SNL-14 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4) (Appendix D). With a single completion interval, some difficulties with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water level 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. If warranted, additional wells can be completed on the SNL-14 wellpad to other intervals, such as the Dewey Lake Formation, where significant fresh water was encountered.

Geophysical logs, especially the natural gamma, density, and caliper logs, were used to make the final decisions regarding completion of SNL-14 (Fig. 1-4) (Appendix D). The drillhole penetrated the upper part of the lower Rustler, and the lower part of the corehole was cemented to prevent circulation into that interval (Fig. 1-4) from the Culebra. The bottom of the Culebra screen interval was placed at 676 ft to remain above the claystone below the Culebra and avoid possible plugging of the lowermost slots (Fig. 1-4). The top of the screen at 649.5 ft is above the top of the Culebra. The top of the gravel pack (4/10) at 645 ft is below the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (HolePlug®) was placed to 640 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) before the drillhole was reamed to 686 ft shows the drillhole enlarged by ~2 inches through the Dewey Lake.

The surface configuration (Fig. 1-5) provides stability, security, and ready access to the casing for measurements, sampling, or other testing. The surface benchmark is an accessible reference point for future measurements.

Reference points for measurements at SNL-14 varied slightly during the initial drilling

Figure 1-3
SNL-14 As-Built Diagram



See Figures 1-4 and 1-5 for additional details

Note: Depths for drilling, geophysical logs, and completion are referenced to the level of the drillpad; the top of the steel connector on the 12.75" surface conductor casing is 0.5 ft above the surface of the drilling pad.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-14 (C-3140)

LOCATION: Southeast ¼, Section 4, Township 23 South (T23S), Range 31 East (R31E)

SURFACE COORDINATES: The well is located 3,306 ft from the north line (fnl) and 1,388 ft from the east line (fel) of Section 4. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 484773.43 North, 671451.38 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-14 using Corpscon for Windows (v. 6): 614989.68 East, 3577651.97 North. Figure 1-1 shows UTM coordinates on a 1,000-m grid.

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 (bgl), which is taken as 3,366 ft above mean sea level (amsl), the rounded up value for the brass tablet benchmark (3,365.71 ft amsl; punched benchmark shows 3,365.70 ft) adjacent to the cement well pad. The primary datum for the completed well is 3,368.41 ft amsl (NGVD 29) for a mark on the top 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-14.

DRILLING RECORD:

Dates: Began drilling May 2, 2005; drillhole reached total depth (718.5 ft) on May 19, 2005. Geophysical logging was conducted on May 20, 2005. Drillhole was reamed to 686 ft on May 24, and it was cased and cemented May 25, 2005. SNL-14 well development began by jetting with 100 barrels (4200 gallons) of fresh water and bailing 640 gallons on May 27, 2005. On June 1, 2005, 4,500 gallons of water were pumped during final development.

Circulation Fluid: SNL-14 was drilled to 208 ft bgl with circulating air. Water flowing into the hole became a problem, and fresh water and Quik-Foam® were used to drill from 208 ft to 304 ft, discharging cuttings into a lined portable steel container. Water inflow continued heavy, and the surface conductor casing was cemented to 42.5 ft. SNL-14 was drilled from 304 ft and cored to total depth of 718.5 ft bgl (driller's depth) and reamed (using an 11-inch bit) to 686 ft following coring using circulating fresh water with a polymer (Poly-Bore®), Quik-Foam®, and a small amount of soda ash added.

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

538.0–570.0 ft bgl: upper Magenta Dolomite, and upper Tamarisk Members
619.0–718.5 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-14 (C-3140), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
Not determined	0	>7
17.5	0	42.5
11	42.5	686
6.75	686	718.5

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
~20	Not determined	52.78	0	7
12.75	12.25	33.41 steel	-0.5	42.5
5.45	4.85	4.40 FRP** blank	-2.5	649.50
5.45	4.85	4.40 FRP screen	649.5	676.0
5.45	4.85	4.40 FRP blank	676.0	684.0

*Top of the casing connector is ~ 0.5 ft above pad level. The reference for depth denoted bgl is the pad level because the casing was installed after drilling was well under way. The FRP extends ~2 ft above the steel casing connector.

**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	538	556	18	18	100.00%
2	556	570	14	14.3	102.14%
3	619	634	15	13	86.67%
4	634	662.5	28.5	28.5	100.00%
5	662.5	669.5	7	7	100.00%
6	669.5	674.5	5	4	80.00%
7	674.5	688.5	14	12	85.71%
8	688.5	718.5	30	29	96.67%
		Totals	131.5	125.8	95.67%

Figure 1-4
SNL-14 Completion and Monitoring Configuration (5/25/05)

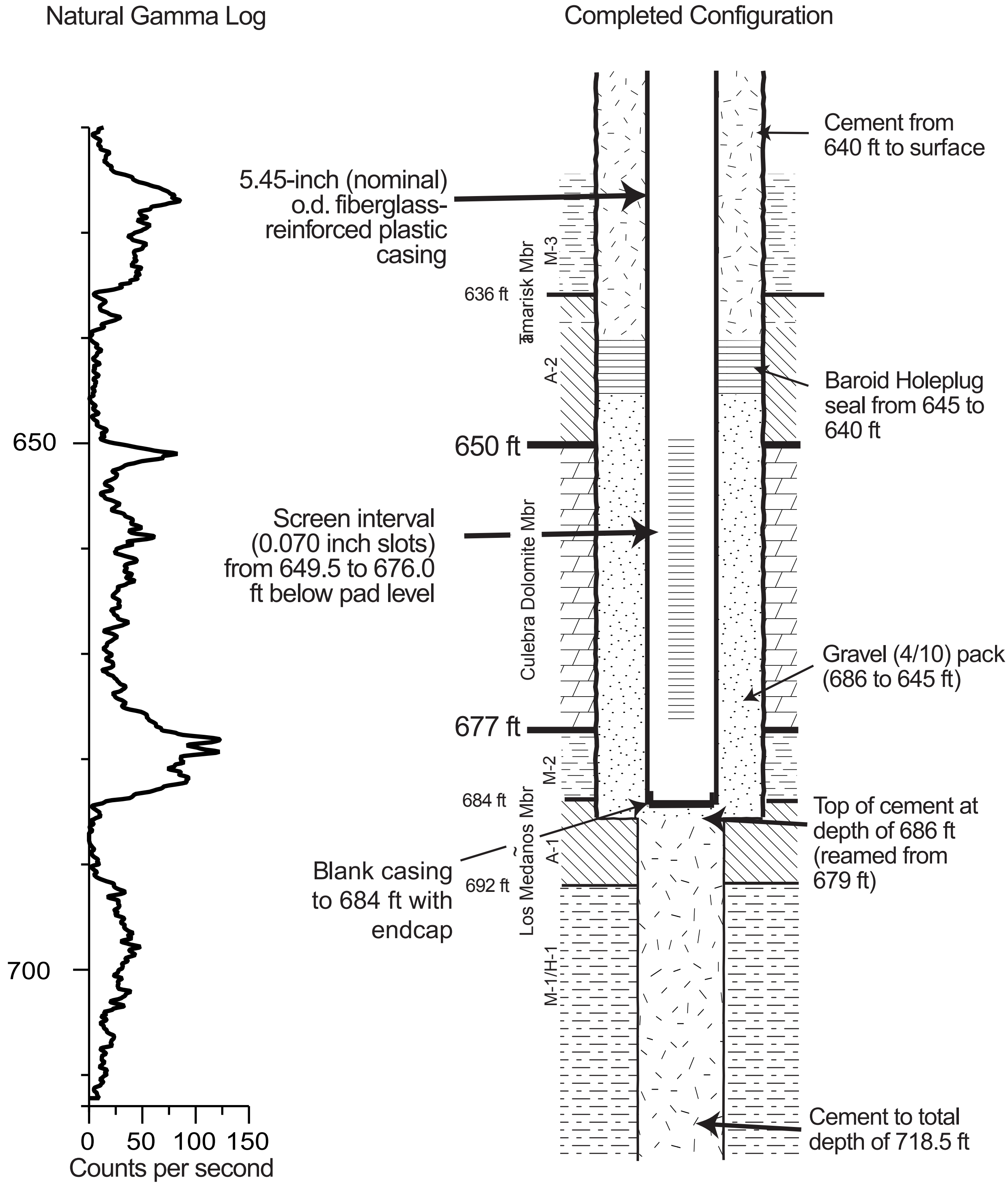
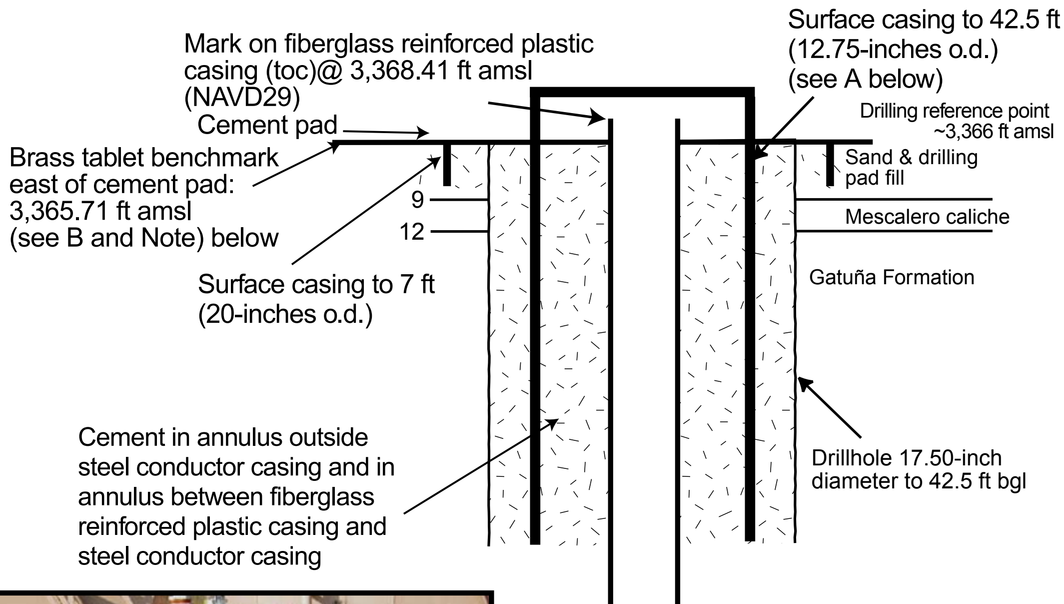


Figure 1-5
SNL-14 Surface Configuration and Elevations (9/10/05, rev 7/24/07)



Note: Depths of shallow units are based on cuttings and observations during drilling.

Note: Benchmark shows punched elevation 3,365.70 ft amsl instead of survey plat elevation (Fig. 1-2) of 3,365.71 ft amsl.

A - Surface casing at SNL-14 set up for monitoring

B - Detail of brass tablet benchmark on east side of SNL-14 cement pad.
Elevation 3,365.71 ft amsl (Fig. 1-2)

of the well before a longer (42 ft) surface casing was placed. Pad level was used as a reference before this and there are only a few inches difference between early and later reference points. The hole was drilled to a depth of 208 ft with a temporary diverter in place to direct airflow and cuttings. The surface around the diverter was unstable, and a 20-inch casing was cemented to 7 ft. After drilling to 304 ft, water production from the Dewey Lake increased to the point that a steel surface conductor casing (12.75-inch outside diameter) was cemented in place to a depth of 42 ft below the surface, and the top of the steel connector on the conductor casing was used 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 3,366 ft amsl, based on the predrilling survey of the pad level. The benchmark next to the completed well has an elevation of 3,365.71 ft amsl [the benchmark shows an elevation of 3,365.70 ft amsl; Fig. 1-5]. *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 ~3,366 ft amsl (Figs. 1-3, 1-4, and 1-5)*. Geological and geophysical data collected during this investigation for completing the well are reasonably represented by this proxy reference point and elevation for the drill pad.The geophysical log paper copies were printed with an elevation of 3,366.69 ft amsl. The FRP casing projects ~2 ft above the steel connector on top of the conductor casing. This FRP casing point has a surveyed reference elevation (3,368.41 ft amsl) for monitoring water levels (Fig. 1-5). [An earlier survey indicated a reference elevation of 3,368.38 ft amsl, which has been used elsewhere.]

1.4 Other Background

SNL-14 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, TX, 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, TX. 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 (WTWWS). Geological support was provided by Dennis W. Powers under contract to WTS. Mike Stapleton of the New Mexico Office of the State Engineer witnessed hole completion activities (Appendix D). Well drilling wastes (cuttings and mud) were removed from SNL-14 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-14 were photographed with a digital camera, and a photo log is included in Appendix F. Electronic images can be requested from WTS. Geophysical log information and a larger format figure are provided in Appendix G.

1.5 Acknowledgements

Drafts of this document were reviewed by Rick Salness, Steve Travis, and Joel Siegel (all WRES), and by Rick Beauheim and Patricia Johnson (both SNL). Mark Crawley (WRES) provided field support and information on well development. Doug Lynn (WRES) obtained permits and provided permitting and regulatory information. Ronnie Keith and Luis Armendariz (WTWWS) provided drilling data and daily drilling records. WTWWS personnel provided access for sampling during drilling. Al Henderson (Jet West) provided print and electronic files of geophysical logs. Vivian Allen (L&M) provided editorial guidance.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been investigated intensively since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is certainly the Compliance Certification Application (CCA) 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-14.

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 to have been subject mainly 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-14

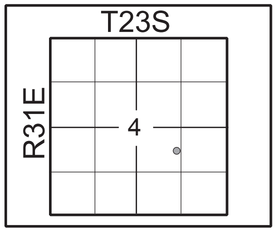
SNL-14 encountered a normal stratigraphic sequence from ground level to total depth for this location south of the WIPP site area, (Fig. 2-1; Table 2-1). Units encountered ranged from unconsolidated surficial alluvium to the upper part of the Los Medaños Member of the Permian Rustler Formation. Structural, 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. The Dewey Lake Formation yielded considerable water during drilling, resulting in changes to drilling techniques.

The geologic units encountered in SNL-14 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 logs and drilling depths is generally slight. The largest differences between depths determined by geophysical logging and core markings based on depths measured during drilling is approximately 3 ft through lower units in SNL-14. 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.

Figure 2-1
Well Record SNL-14 (C-3140)

Company: Washington TRU Solutions LLC
Well: SNL-14 (C-3140)
Section: 4 Twp: T23S Rge: R31E
Location: 3,306 ft from north line (fnl)
1,388 ft from east line (fel)



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

Elevation
KB:
DF:
GL: 3,366 ft amsl
(benchmark: 3,365.71)

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 2, 2005
Completion date: May 25, 2005
Total depth (TD): 718.5 ft bgl (driller log)

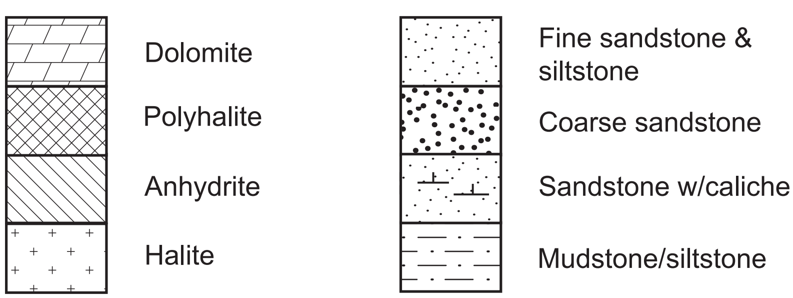
Casing Record
Conductor: 42.5 ft
12.25 inch steel i.d.
Casing: 4.85 inch i.d.
FRP to TD
Screened interval:
649.5-676.0 ft

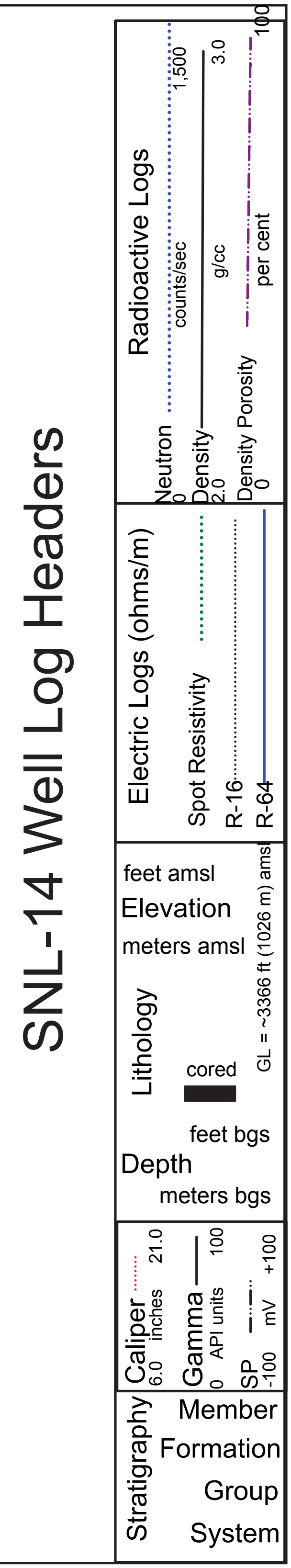
Geophysical Logs Date: May 20, 2005

Micro/Laterolog/SP:	0-712 ft
Gamma/Fluid:	0-712 ft
Caliper:	0-712 ft
Density/Neutron:	0-712 ft

Type fluid in hole: water
Res mud: n.d.
Res mud filtrate: n.d.

General Lithologic Symbols Used





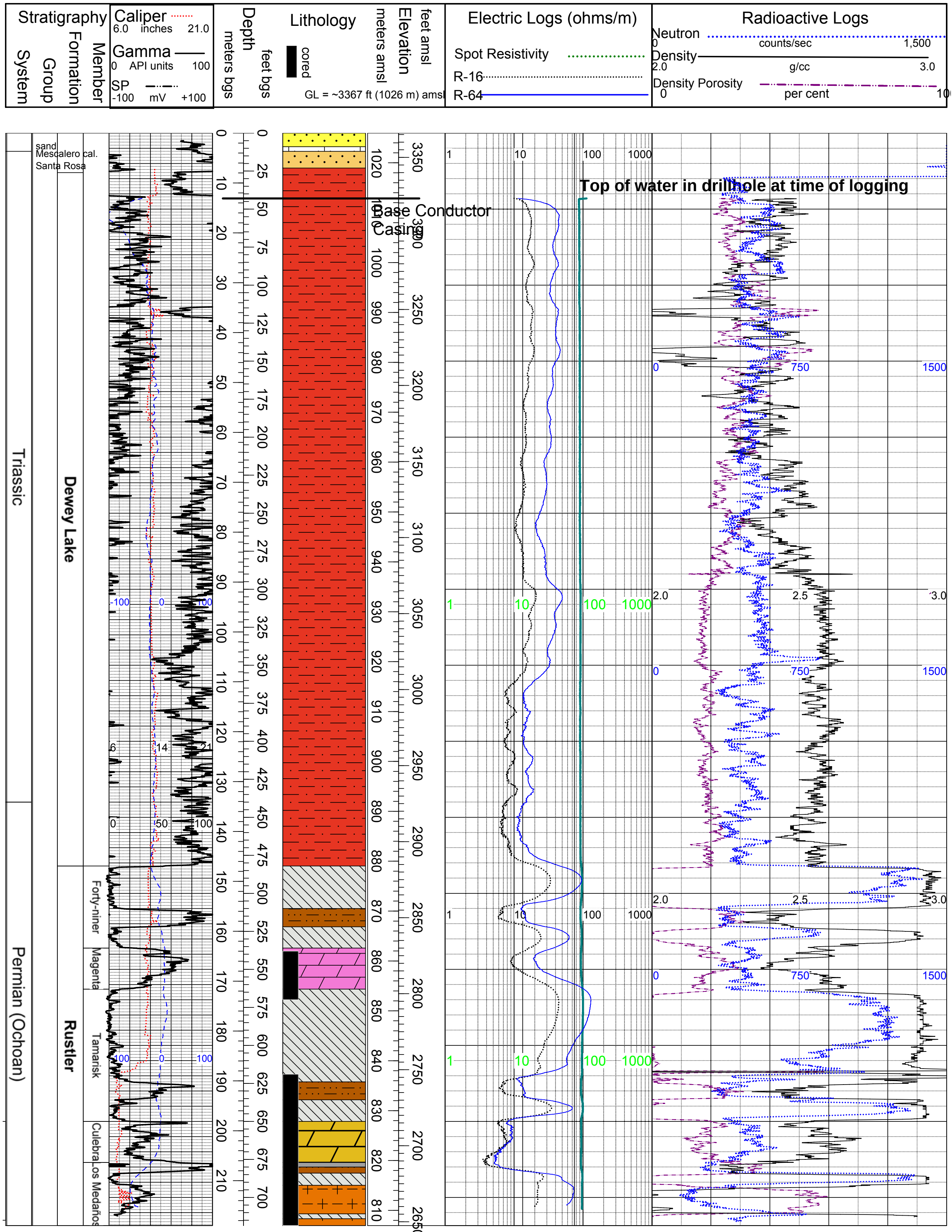


Figure 2-1, continued. (see Appendix G for larger format log.

Table 2-1
Geology at Drillhole SNL-14

System/	**Period**/Epoch	**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface dune sand and pad fill		0 - 9 ft
	Pleistocene	Mescalero caliche		9 - 12 ft
	Miocene-Pleistocene	Gatuña		12 ft - 26 ft
Mesozoic	**Triassic**	Santa Rosa[2]		eroded
		Dewey Lake[3]		26 ft - 482 ft
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	482 ft - 536 ft *482 ft - 510 ft* *510 ft - 522 ft* *522 ft - 536 ft*
			Magenta Dolomite	536 ft - 564 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	564 ft - 650 ft *564 ft - 624 ft* *624 ft - 636 ft* *636 ft - 650 ft*
			Culebra Dolomite	650 ft - 677 ft
			Los Medaños[4] *M-2/H-2* *A-1* *M-1/H-1*	677 - 718.5 (T.D.) *677 - 684 ft* *684 - 692 ft* *692 - 718.5 ft*

[1]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data to total depth (TD) of 718.0 ft bgl by driller's log and 718.5 ft as marked on core. 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 3,366 ft amsl; it is near the elevation of the surface benchmark adjacent to SNL-14. 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, mainly in the lower part of SNL-14.

[2]The Santa Rosa Formation, part of the Dockum Group or undifferentiated Triassic, is not present at SNL-14; it commonly is eroded west of the center of the WIPP site.

[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.

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 482 ft (Fig. 2-1), and 236.5 ft of the Rustler were penetrated at SNL-14 (Table 2-1).

2.2.1.1 Los Medaños Member

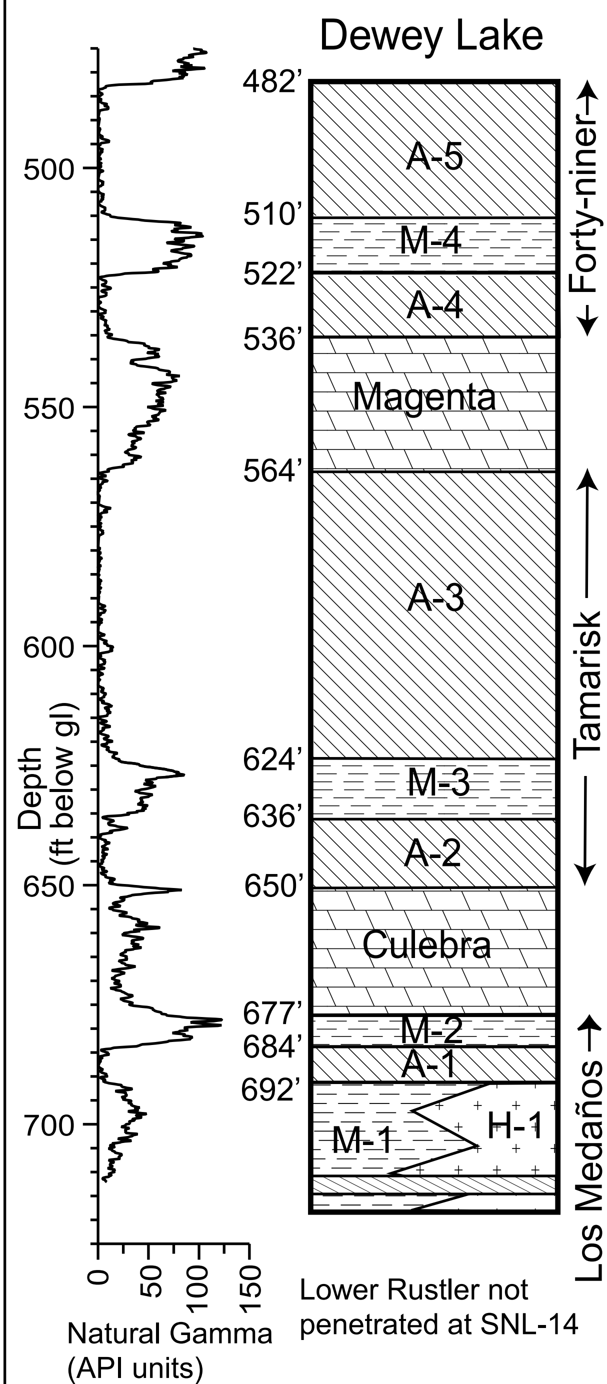
The Los Medaños was named by Powers and Holt (1999) based on the rocks described in shafts at the WIPP site. For the area around WIPP, studies of the Rustler have commonly referred to this interval from the base of the Culebra Dolomite Member to the top of the Salado Formation as the unnamed lower member 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 marked core from the upper part of the Los Medaños totals 39.5 ft in SNL-14, penetrating through A-1 and into the upper M-1/H-1 (Table 1-1).

The informal unit *mudstone-halite 1* (M-1/H-1; Fig. 2-2) was encountered from 718.5–693.1 ft (core markings). Fill in the drillhole prevented geophysical logging to TD. The depth to the top of M-1/H-1 measured on geophysical logs is 692 ft (Table 2-1). Halite is present below 694 ft in M-1/H-1.

The lower 4.4 ft (below 714.1 ft) is a light reddish-brown halite-cemented siltstone with an upper thin zone (0.1 ft) of reddish-brown siltstone with small clasts of darker siltstone

Figure 2-2
Rustler Units at SNL-14



Formal and informal Rustler Formation units and depths at SNL-14 based on natural gamma log in combination with coring that helps identify halite interval.

(Fig. 2-3). The halite is in small, irregular crystals as well as crystal masses. The halite crystals have been corroded by dissolution during drilling with fresh water; it is not clear without slabbing and more detailed examination whether the crystals have been subjected to natural dissolution. The siltstone shows color and textural evidence of bedding, but the surface is somewhat smeared.

A thin bed of gray anhydrite and white gypsum is present from 714.1–710.8 ft (core markings). The bed is wavy bedded to laminar. Thin, subhorizontal zones parallel to bedding in the lower 0.5 ft are filled with halite cement. Near the top of this thin sulfate, bedding is somewhat inclined, and a wedge of siltstone occurs within the bedded zone (Fig. 2-4). Some halite also cements porosity near the top of the sulfate, and the siltstone is likely associated with some early exposure and infiltration or deposition on an exposure surface rather than late infiltration after dissolution.

Figure 2-3. Reddish-Brown Siltstone With Clasts Between Halite and Gypsum (714.1-714.2 ft)

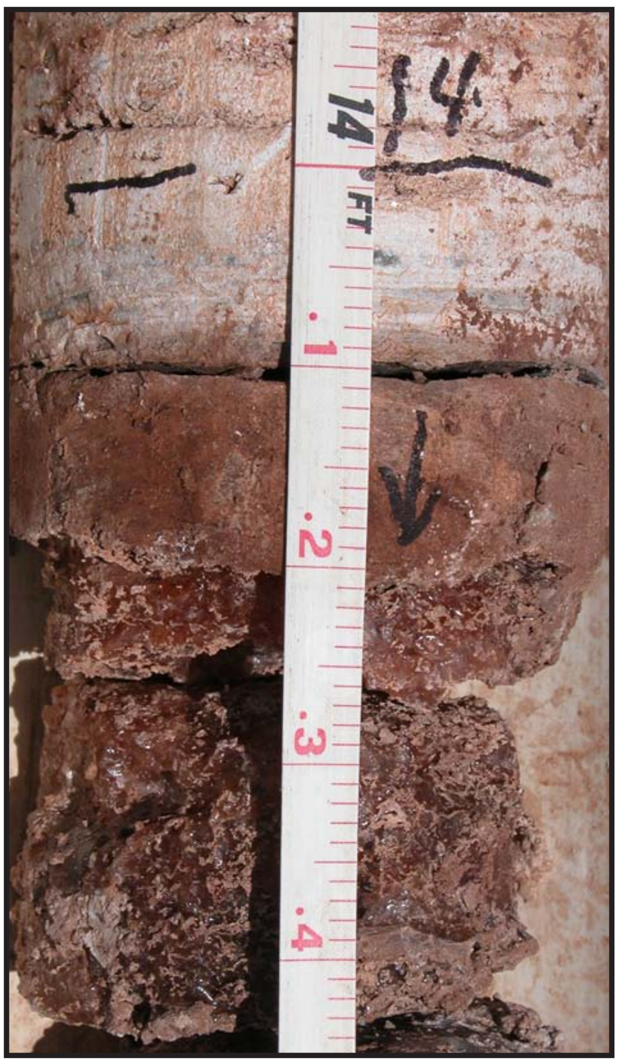


Figure 2-4. Siltstone Wedge (711 ft) in Gypsum With Halite in Overlying and Underlying Beds

Above this thin sulfate, the uppermost H-1 is composed of reddish-brown silty halite and halitic siltstone. Zones with more siltstone exhibit more bedding. The halite in the lower part is less silty, and the halite is coarsely crystalline. Upward, halite in silty zones is generally coarse and displacive, with mainly planar boundaries (Fig. 2-5). As siltstone becomes more abundant upward, the halite tends to smaller crystal sizes, and the crystal boundaries are more corroded. Little or no halite is present in the upper 1 ft of this interval, and bedding is observable as texture and color changes. Gray siltstone clasts are included. The transitional zone (694–693.1 ft) to A-1 is gypsum and siltstone, with angular gypsum clasts and corroded halite (Fig. 2-6). The contact is sharp and undisturbed, and the overlying thin basal beds of A-1 are undeformed, indicating that the clasts are part of the depositional system.

Figure 2-5. Displacive Halite and Planar Surfaces After Halite Dissolved During Drilling

Figure 2-6. Gypsum and Siltstone Clasts With Corroded Halite Below Contact with A-1

The informal unit *anhydrite 1* (A-1; Fig. 2-2) was encountered from 693.1–685.0 ft (driller's depth) (692–684 ft on geophysical logs). The thickness of A-1 at SNL-14 is slightly less than is common farther north. At SNL-2, for example, A-1 comprises three units: two sulfates and a thin siltstone (Powers and Richardson, 2004). It appears that the lower thin sulfate and siltstone of A-1 at SNL-2 are equivalent to the halitic zone and thin sulfate from 693.1–714.1 ft at SNL-14. This shows the difference between the mudflat facies (e.g., SNL-2) and the area closer to the depositional center (e.g., SNL-14) where a halite pan persisted through the depositional history of upper M-1/H-1.

A-1 at SNL-14 is mainly brownish gray anhydrite with thin beds and fine laminae. Displacive halite in gypsum near the base of A-1 is overlain by a 1-ft-thick zone of gypsum with some halite pseudomorphs after bottom-growth gypsum. A thin zone with reddish color is present ~1 ft below the top of A-1.

M-2, the mudstone facies of informal unit *mudstone-halite 2* (M-2/H-2; Fig. 2-2) was encountered from 685–679 ft bgl, based on coring depths, and recovery was good. The natural gamma log shows the top of M-2 at 677 ft (Fig. 2-1). The basal contact with A-1 is transitional over ~0.1 ft, with small claystone clasts above the contact. The contact between M-2 and Culebra was recovered as blocky core, but the uppermost recovered M-2 does not appear deformed.

The lower 4.7 ft of core from M-2 is reddish brown claystone and silty claystone with some reduction spots or mottles. Smeared intraclasts (Powers and Holt, 2000) occur from 683.7–684.3 ft (core markings). The upper part of this mudstone interval displays some thin interbedded stilstone and gypsum. Diagonal fractures are slickensided and filled with fibrous gypsum.

The upper 2.3 ft of M-2 consist of gray silty claystone with small (<0.25 inch) gypsum clasts and probable siltstone clasts. The basal 1 ft of the gray silty claystone shows some bedding as well as smeared intraclasts.

2.2.1.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-14, the Culebra extends from 677–650.0 ft bgl, a thickness of 27 ft (Fig. 2-1). Based on drilling depths available at the time, the recovered Culebra core was marked from 679–653.3 ft bgl (as used in information in Appendices C and E). Recovered Culebra core (Fig. 2-7) totals ~22.7 ft, and this represents most of the unit, with apparent core loss in the lower half of the Culebra.

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 because of the porosity of that zone.

The dolomite recovered in core from SNL-14 is generally brown (10YR6/3) with dark brown (10YR5/2) in the upper 1.5 ft. Bedding is horizontal to slightly inclined. The upper 1 ft has fine laminae. Vugs occur in zones through much of the recovered Culebra core (Appendix C). Most of the vugs or pores in the Culebra at SNL-14 are less than ~0.25–0.50 inches; a thin zone from 659–660.4 ft displays oblate vugs up to ~1 inch wide and 0.5 inch high. These vugs appear to range from open to silt-filled to gypsum-filled (654.4–658 ft). Few fractures were observed on intact core segments. They are uncemented in the lower few feet. Some coarse gypsum fills a fracture in the zone with some gypsum-filled vugs. From ~661–668.5 ft, recovered core material tends to form blocks with surfaces that may represent short fracture segments without cement or observable filling.

The basal hydrostratigraphic unit (CU-4) proposed for the Culebra by Holt (1997) is represented in part by the blocky core recovered in the lower 2 ft of the unit. Core loss interpreted between 677 and 673 ft obscures interpreting the upper zone, although the core loss may be indicating CU-3.

From 673–669.5 ft, the Culebra shows larger fracture blocks (compared to the interval above it), small vugs (<0.125 inch) with some silty dolomite filling, and few larger vugs. There is no preserved gypsum from this interval. This interval is tentatively correlated with CU-3 (Holt, 1997).

From 669.5–661 ft, the dolomite is bedded and includes some thin organic laminae from 664.3–663.5 ft. There are zones of smaller vugs parallel to bedding through the rest of the interval. Much of the zone comprises blocks from 0.25–3 inches, and most of the fractures are stained dark brown to black. There is no gypsum in this interval, which is tentatively assigned to CU-2 (Holt, 1997).

From 661–653.3 ft, the dolomite is fine-grained, with horizontal to slightly inclined thin beds to laminae. Organic-rich laminae are present near the top of the interval. Vugs are more commonly small (~0.25 inch) and arranged in zones parallel to bedding. The zone of oblate, larger vugs is near the base of this interval. Gypsum fills some of the vugs and fractures from ~658–654.4 ft, in the lower part of the interval. A high-angle fracture with no filling was intercepted from 659.8–659.0 ft. This interval corresponds to CU-1 (Holt, 1997).

The geophysical logs (Fig. 2-1) of the Culebra provide few additional details of the unit. The natural gamma is relatively high at the top of the unit, corresponding to the laminar zone at the top that appears algal. An 8–10 ft zone below this, corresponding to CU-1, has lower gamma, and higher gamma below that generally corresponds to unit CU-2, with fractures and staining. The caliper through CU-2 (Fig. 2-1; Appendix G) after coring was complete shows some modest enlargement. Neutron counts and density are somewhat lower in the lower third of the Culebra than in the rest of the unit. Resistivity shows slight changes through the unit. Overall, there is not a great contrast in geophysical log properties through the Culebra, and the Culebra is likely to have similar hydraulic properties through much of CU-2 and CU-3, with some indications of water (low neutron) and porosity (low density and poor core recovery) into CU-4.

2.2.1.3 Tamarisk Member

The natural gamma log of SNL-14 shows that the Tamarisk occurs from 650–564 ft bgl. The Tamarisk comprises three basic subunits: a lower anhydrite, a middle mudstone to halite, and an upper anhydrite; all three are clearly shown by geophysical logs and were recorded by cuttings during drilling. 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-14 is located in the mudflat or M-3 facies of these beds. The basal 19.3 ft and upper 6.0 ft of the Tamarisk were cored; 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 14 ft thick (650–636 ft) based on the geophysical logs. Core retained from A-2 was marked from 653.3–637.7 ft, an interval thickness of 15.6 ft. A-2 is predominantly gray gypsum, with some anhydrite as well as thin claystone interbeds.

The basal contact with the Culebra (Fig. 2-7) is sharp, although some probably organic (algal layering) persists into the sulfate bed. The upper contact is also sharp, with some sulfate laminae in the overlying mudstone. Bedding is horizontal through A-2. Gray siltstone and clay, with gypsum-filled horizontal separations, occurs from 640.8–640.1 ft.

Figure 2-7 Culebra Dolomite Member of the Rustler Formation at SNL-14

Note: due to cropping, each photograph varies slightly in scale.

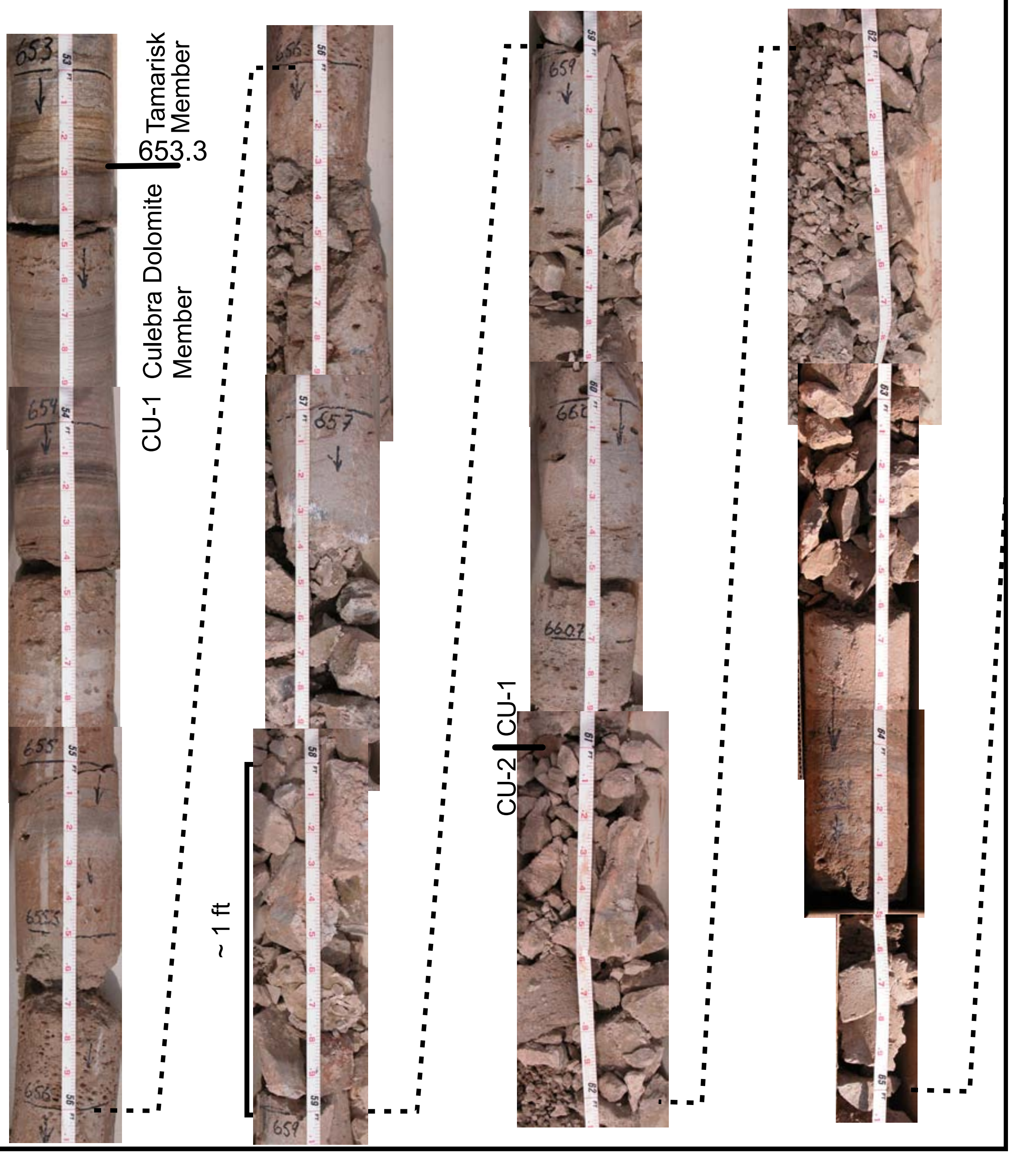
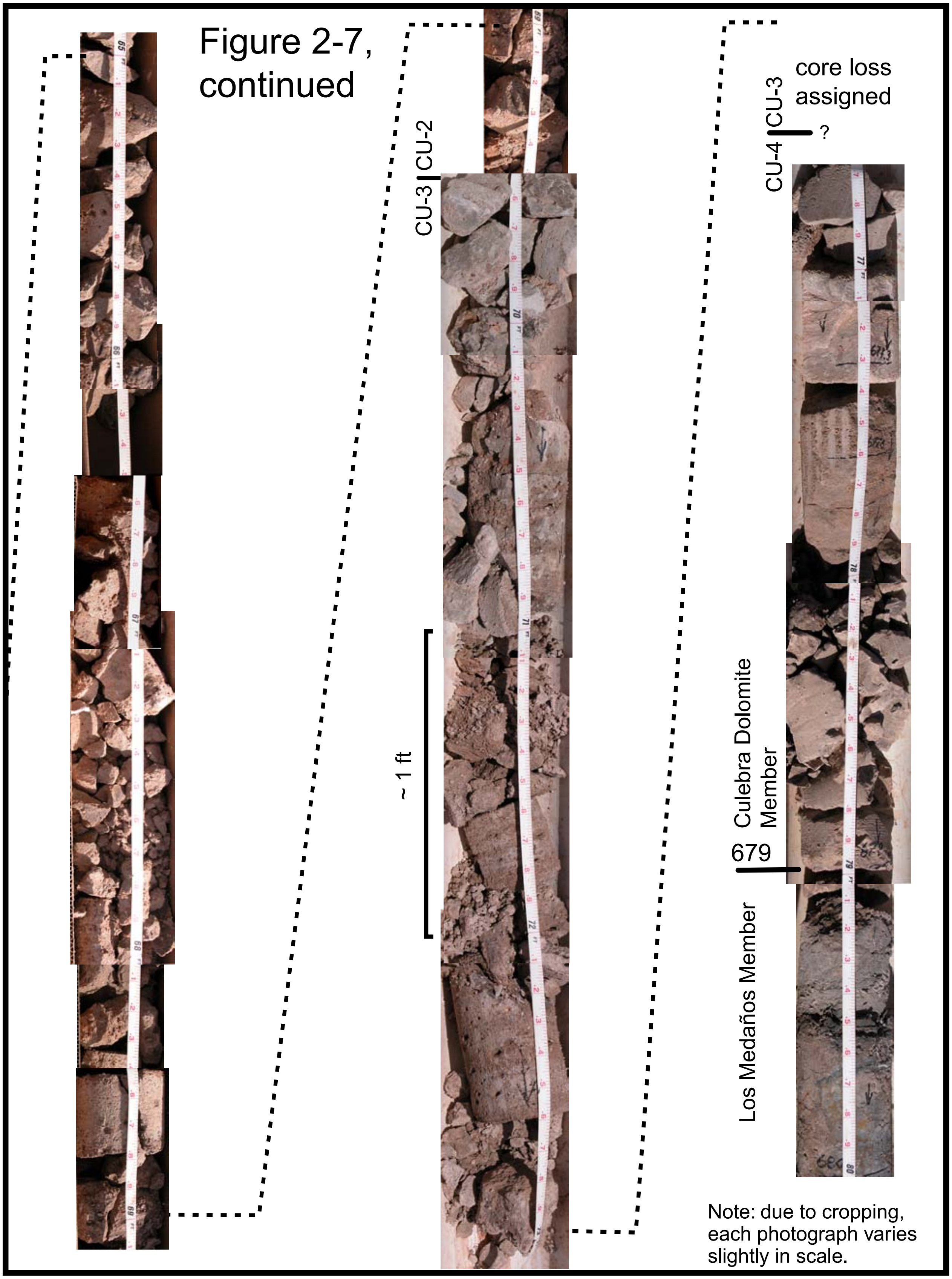


Figure 2-7, continued



Note: due to cropping, each photograph varies slightly in scale.

Thin beds and fine laminae are clear near the base of A-2, showing some carbonate to organic deposition persisted above the Culebra, although the contact between dolomite and sulfate is sharp. A thin, more laminar zone also occurs from 644.6–644.3 ft. Bedding becomes thicker and less distinct upward, with a bedded-nodular fabric dominating most of A-2. From 642–641.2 ft, just below the gray claystone interval, A-2 shows nodular fabric that is better developed.

The claystone bed within A-2 indicates exposure across much of the area, as it is persistent in most cores and geophysical logs.

The upper sulfate of A-2 generally reveals thicker bedding with an interval of carbonate and possible algal laminae from 639.1–639.0 ft.

M-3, the mudstone facies of informal Tamarisk unit *mudstone-halite 3* (M-3/H-3; Fig. 2-2) is 12 ft thick (636–624 ft bgl) at SNL-14, based on the natural gamma log. M-3 was completely cored, as marked from 637.3–625.7 ft. Approximately 2 ft of missing core were assigned to the interval 634–632 ft, at the base of core run #3. No halite (H-3) is present at SNL-14. The recovered core from the base of M-3 reveals a conglomeratic argillaceous siltstone and silty claystone comprising white sulfate clasts as well as intraclasts of gray (2.5YRN5/) and dark reddish-brown (2.5YR3/6) mudstone (Fig. 2-8). These clasts appear to form two or three vague cycles with modest upward fining. Some slickensiding is displayed within the core when it is separated. From 632-627.8 ft, dark reddish brown (2.5YR3/4) silty claystone is interbedded with light gray (10YR7/1) sandy siltstone. The zone is somewhat calcareous, and the bedded intervals appear somewhat deformed. From 627.8–625.7 ft, M-3 is capped by gray (7.5YR4/N) claystone that is laminar to thin-bedded, silty at the base, and that displays more prominent bedding upward. The contact shows deformed bedded sulfate and gray clay.

The informal unit *anhydrite 3* (A-3; Fig. 2-2) occurs from 624–564 ft bgl on geophysical logs, a thickness of 60 ft, which is similar to many drillholes around the WIPP site. Core from the top of A-3 has a contact marked at 564 ft, implying a thickness of 61.7 ft. The main part of A-3 was drilled.

The basal part of A-3 (13.2 ft) was cored, and this part of the unit is dark to light gray anhydrite and gypsum. Basal A-3 is laminar, with very thin (< 1 mm) laminae near the contact with M-3. Laminae dip <5° and are slightly more irregular or deformed near the contact with M-3. Possible nodular zones are present at 619.5–619.7 ft and 620.4–621.0 ft. Intraclasts of brown, fine-grained anhydrite are cemented by translucent anhydrite from 620.1–620.4 ft.

Figure 2-8. Claystone and Siltstone Intraclasts on Core Interior Surface with Slickensides in M-3

Short, high-angle fractures are present in the cored interval, and those at the top of the core were stained and separated after coring.

The upper 6.3 ft of A-3 were cored and show laminar to thin-bedded, dark gray, gypsum and anhydrite. Thin (~1 mm) gray organic to carbonate laminae outline bedding. Bedding is convoluted and also shows some depositional relief. There are some nodular features from 566.5-567.0 ft. High amplitude bedding at 568.5 ft is from algal or sulfate ridge growth. Fibrous gypsum separates some bedding. The transition to the Magenta is sharp in core, with about 0.2 ft relief.

Most of A-3 was not cored. The cuttings from drilling were generally fine slurry and stratigraphically unusable. A thin zone of faster drilling rates was encountered from ~602–603 ft that correlates with a slight spike in natural gamma. Geophysical logs for A-3 show typical low natural gamma signature and high density. The caliper log indicates some enlargement in part of the lower A-3. Through this same interval, the neutron log is reduced, and the shallow and deep resistivity logs indicate lower resistivity as well. The density log shows slight differences through A-3. These log responses are similar in many drillholes through A-3.

The Tamarisk stratigraphy and thickness are generally consistent with other drillholes and shafts in the area (Holt and Powers, 1988).

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-14 is 28 ft thick (564–536 ft). Core from the Magenta is marked from 564.0–538.0 ft, a recovered thickness of 24.0 ft (Fig. 2-9). Recovery was complete, but as much as 4 ft of the upper Magenta may not have been cored.

The Magenta consists of gypsiferous dolomite and gypsum, and it is light olive gray (5YR6/2) to white (5YR8/2) with some thin grayish brown (10YR5/2) interbeds. The reddish-purple color for which the Magenta is named occurs in outcrop and apparently is a consequence of weathering. The dominant characteristic of the Magenta in cores from SNL-14, like outcrops and shaft exposures of the Magenta, is strong wavy to laminar bedding.

From 564.0–561.0 ft, wavy laminae and thin beds have higher amplitudes indicating algal growth (Fig. 2-9). Laminae are darker near the base of the Magenta. The relief on the algal layers is ~2.5 inches at 563 ft. From 561–557.0 ft, bedding is nearly flat. Beds are thicker (~ 1 inch) from 559.1-561 ft than above or below this interval. Low-angle cross-cutting relationships and ripples with cross-laminae are preserved from 556–557 ft, followed upward by very thin wavy and lenticular bedding. Some reddish brown laminae and interbeds beds above ~546 ft occur below a higher relief surface at 544.3 ft. A thin zone of very small gypsum nodules occurs from 541.3–541.0 ft. Bedding thickens in the upper few feet of the core, with higher angle cross-cutting relationships.

Gypsum-filled separations occur in the lower 4 and upper 5 ft of the cored interval. High-angle fractures (>45°) were encountered at 563 ft, 557 ft, and 553.2 ft. The fracture at 557 ft was filled with gypsum, and the upper fracture surface was covered with some unidentified gray material.

The dolomite appears most porous in core from 552–542.9 ft, and there is little evidence of sulfate through this interval. This zone is stratigraphically similar to more porous zones in other drillholes. Geophysical logs indicate reduced resistivity through this interval.

The Magenta is typical in thickness, composition, and sedimentary features. The more porous zone in the upper Magenta is consistent in stratigraphic position with porous zones in many other Magenta cores. Fractures in the Magenta are in the lower half of the unit, and only one, near the lower end of the reduced zone of resistivity, appears not to be filled with gypsum.

Figure 2-9 Magenta Dolomite Member of the Rustler Formation at SNL-14

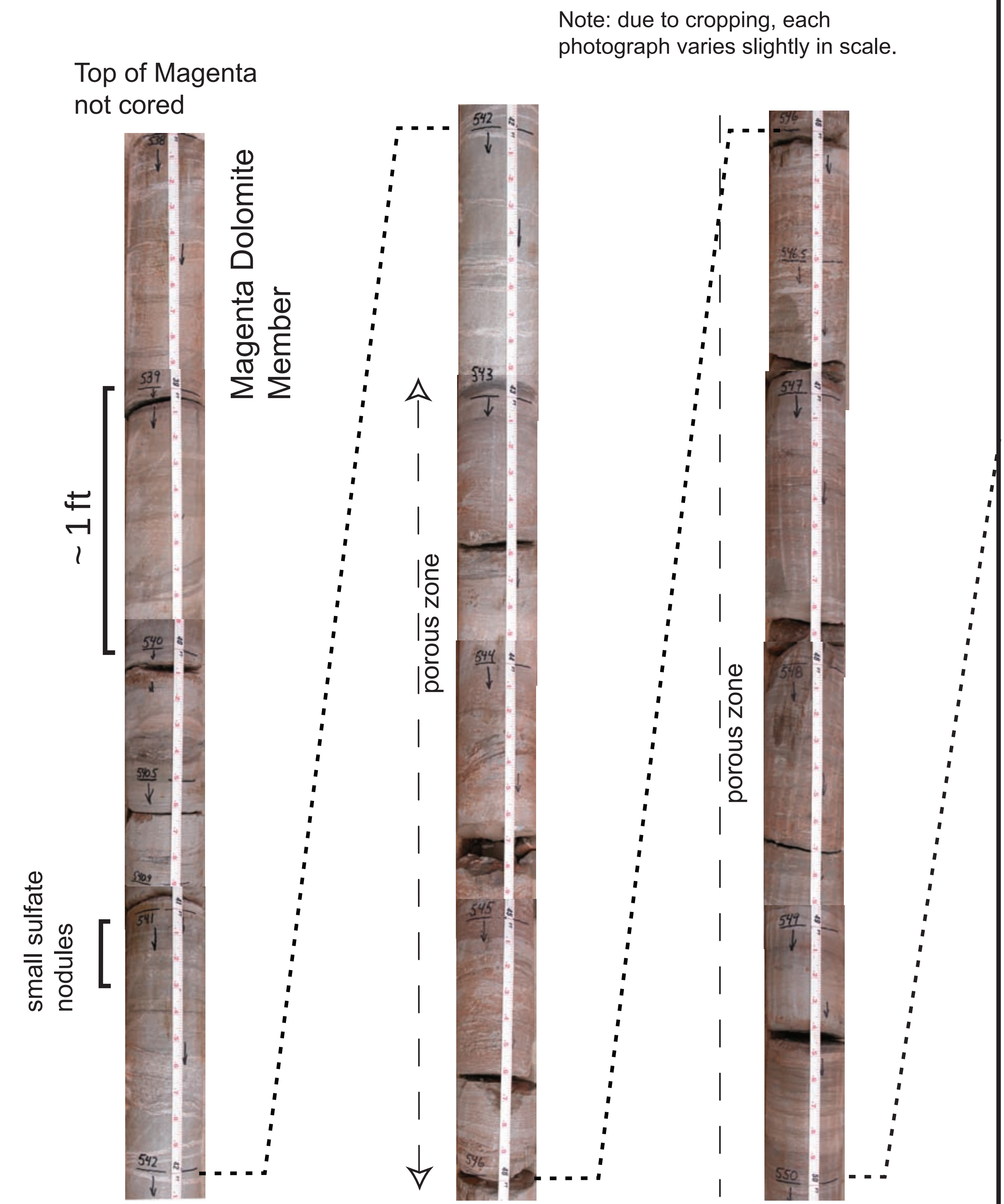
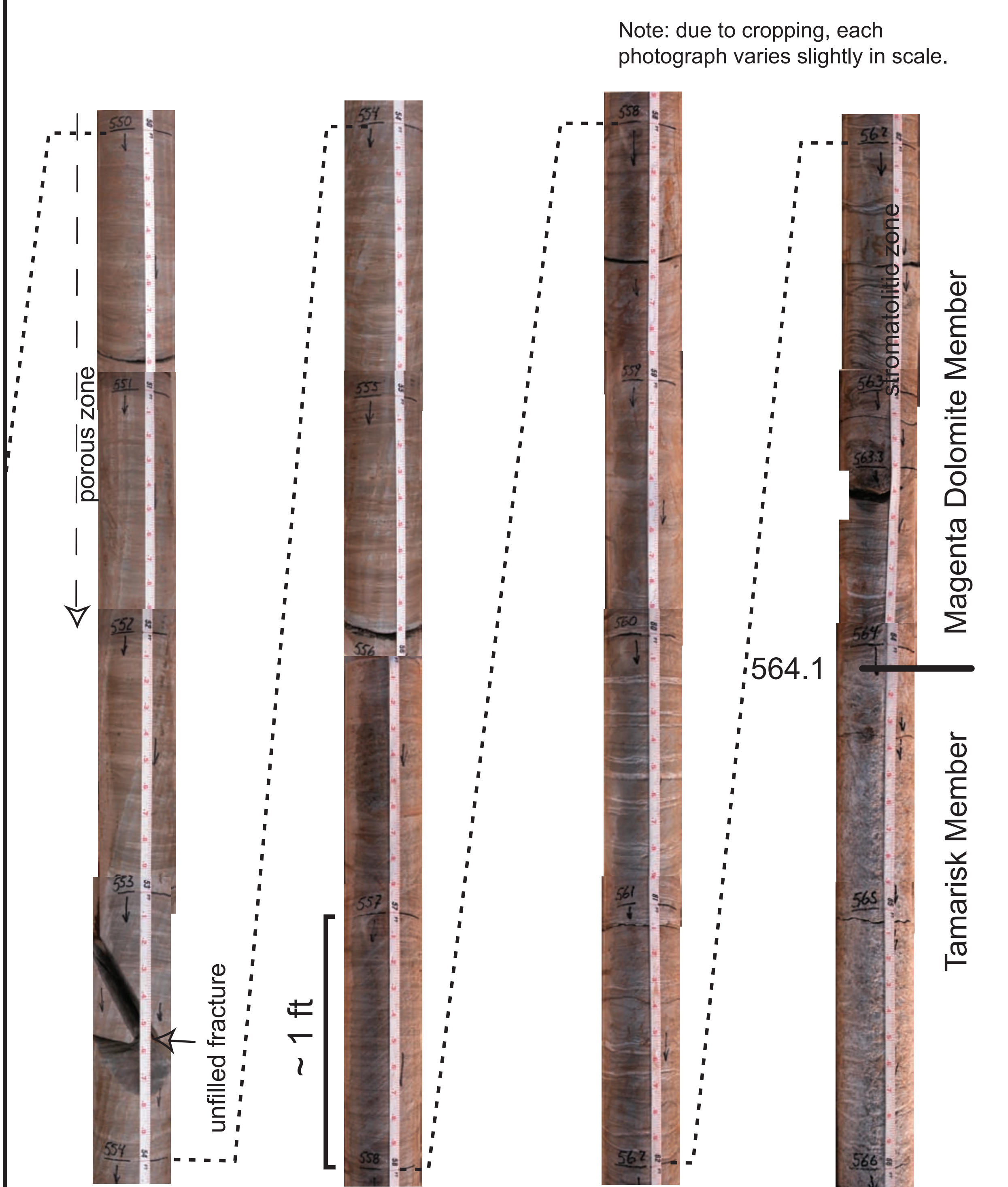


Figure 2-9, continued



2.2.1.5 Forty-niner Member

The Forty-niner at SNL-14 is 54 ft thick (536–482 ft), based on geophysical logs. A change in drilling rates was noted at 484 ft, consistent with the logging depths for the top of the Forty-niner. The Forty-niner is described on the basis of limited cuttings and geophysical logs. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that ranges from claystone at SNL-14 to halite east of the WIPP site area. 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 white to gray, coarse to fine anhydrite and gypsum. A-4 is 14 ft thick (536–522 ft), based on geophysical logs. The change in drilling rate indicated that the top of A-4 is at 525 ft. Neither drilling rate nor cuttings was sufficient to indicate the A-4 to Magenta contact, and coring did not include any sulfate from A-4. Cuttings from the unit consisted mainly of gypsum mud created during drilling. Some gray, fine crystalline anhydrite was also recovered.

M-4, the mudstone facies of informal unit *mudstone-halite 4* (M-4/H-4; Fig. 2-2), is ~15 ft thick (522–510 ft), based on the natural gamma log. Cuttings and drilling rates indicating clastics from ~525–513 ft are consistent with the geophysical log. Cuttings from M-4 showed grayish brown siltstone and claystone with no diagnostic features.

The upper sulfate unit, *anhydrite 5* (A-5), is gray (5YR6/1) gypsum and anhydrite composed of fine to medium crystals. Cuttings were mostly gypsum mud. A-5 is 28 ft thick (510–482 ft bgl) at SNL-14.

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-14, the Dewey Lake is 456 ft thick (482–26 ft bgl) and is composed mainly of dark reddish brown (2.5YR3/4; damp) to red (2.5YR4/6; damp) interbedded claystone, sandy siltstone, argillaceous siltstone, and fine-grained sandstone. These reddish brown hues become somewhat less intense upward. Small gray (10YR6/1) reduction spots and zones are a common characteristic elsewhere and at SNL-14. The Dewey Lake is calcareous from 23 ft–~220 ft. Below 305 ft, cuttings from the Dewey Lake included gypsum. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-14 can be interpreted to indicate different basic sedimentary regimes as well as some 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, 2004).

Only the lower two of three general depositional regimes for the Dewey Lake Formation can be clearly distinguished on natural gamma logs of SNL-14. The lowermost part of the third may be preserved.

The interval from 482–386 ft bgl in SNL-14 displays the natural gamma features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003b). The natural gamma fluctuates around a similar value (~70 cps in this case) over this vertical interval. There are zones of lower gamma, but there are no apparent trends over the entire interval. The resistivity and density logs tend to fluctuate slightly on a coarse vertical scale of tens of feet. The fluctuations are too coarse to correlate with other boreholes as is possible in some logs. The patterns are consistent with broadscale bedding, and the interval corresponds to a bedded section clearly exposed in the air intake shaft (Holt and Powers, 1988).

The interval from 386–~70 ft bgl (315 ft thick) is marked by generally upward-increasing gamma above thinner low gamma units. These 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 a sandstone unit from 386–379 ft. Near the center of the site, this interval is also more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b).

The natural gamma log through the fining-upward cycles shows a marked decrease over an interval from 122–114 ft, corresponding to very fine to medium-grained sandstones found across the site area (Powers, 2003b). The sand grains from the lower unit are typically subangular to well-rounded and include few opaque grains. This unit corresponds to sandstone 1 (*ss1*), a persistent sandstone in this stratigraphic interval (Powers, 2003b).

Natural gamma decreases above 70 ft. The thin interval from 70 ft to 26 ft is tentatively attributed to the third sequence, a slight coarsening-upward cycle at the top of the Dewey Lake in drillholes to the east of this area. [The casing and cement to ~42 ft create an interval of artificially low natural gamma.]

The broad sedimentological units definable by natural gamma logs for the Dewey Lake are present, and the lower two are generally representative of occurrences in other drillholes in the area of SNL-14.

Cuttings from the upper Dewey Lake were calcareous to a depth of 220 ft. From 220–305 ft, neither gypsum nor calcite was observed in cuttings. Fibrous gypsum observed below 305 ft is consistent with very modest increases in the density log and resistivity logs below 295–300 ft. Slightly lowered resistivity and irregular lower neutron from 170–295 ft are consistent with the saturated zone encountered in the Dewey Lake but are not very diagnostic.

The boundary between carbonate (above) and sulfate (below) at ~305 ft is stratigraphically lower in the Dewey Lake compared to observations near the center of the WIPP site (e.g., Holt and Powers, 1988). This position is similar to observed lower cement changes in some other drillholes in the southern part of the WIPP site and along Livingston Ridge (Powers, 2002b, 2003b).

On the basis of the resistivity log (Fig. 2-1) and by comparison with other similar situations, the Dewey Lake is likely to be more transmissive above ~305 ft, at or near the carbonate–sulfate boundary.

2.2.3 Miocene-Pleistocene Gatuña Formation

The Gatuña at SNL-14 is about 14 ft thick (26–12 ft). It is mainly fine sandstone and claystone that is very calcareous and weak red (10R4/3). The claystone is laminar and has some reduction spots. The Gatuña here includes slightly reworked clasts of Dewey Lake, which is similar to some other findings in broader studies of the Gatuña (Powers and Holt, 1993).

2.2.4 Pleistocene Mescalero Caliche

The Mescalero is an informal soil stratigraphic unit defined by Bachman (1973). It is widespread in southeastern New Mexico, 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 southwest of SNL-1 along Livingston Ridge (Izett and Wilcox, 1982).

At SNL-14, the Mescalero is ~3 ft thick (12–9 ft). The Mescalero is a white, very calcareous sandstone to sandy limestone.

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-14.

2.2.4 Surficial Deposits

Dune sand above the Mescalero is covered by thin construction fill. The sand is pale brown (10YR6/3) and becomes more reddish, moist, and argillaceous with depth. The Berino soil (Chugg and others, 1971) overlies the Mescalero.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-14

SNL-14 was drilled specifically to monitor water levels and water quality from the Culebra Dolomite Member of the Rustler Formation, to serve as a location for observations during pumping tests, and as a possible pumping well for a multi-well test south of the WIPP site.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

Damp cuttings above the Mescalero caliche are attributed to the thick sand cover area at SNL-14 and rainfall over the previous year.

The upper Dewey Lake, from a depth of about 100 ft, returned cuttings that were just moist enough to clump if compressed. The drillhole reached a depth of 125 ft at the end of drilling on May 2, 2005. On the morning of May 3, the Solinst probe was run inside the drillpipe to 119 ft without detecting water. No fluid was returned to the surface when compressed air was introduced to begin drilling.

The amount of moisture was observed to increase as drilling reached 170 ft. At a depth of 208 ft on May 3, drilling was halted because the water and compressed air were eroding the sand around the short, temporary surface casing. After the drilling pipe and bit had been removed from the drillhole, a water level was measured by Solinst at 176.6 ft below pad level. A water sample was collected with a field specific gravity of 1.0255 and temperature of 17.3°C.

Water was produced more abundantly as drilling progressed on May 4 from 208 ft using mist and QuickFoam®. Drilling was stopped at 304 ft because of the difficulty in getting cuttings returns and the potential for hole erosion using compressed air with the produced water (memo, Appendix E, dated May 5, 2005, from Powers to Beauheim and Richardson). A depth to water was not obtained with the Solinst probe due to the buildup of foam in the hole. A miniTroll was installed in the hole at a depth of 250 ft for overnight observations.

The miniTroll was removed from the drillhole on the morning of May 5. Depth to water was 167.9 ft below pad level at 0955 MDT. A water sample was obtained for analysis. Field-measured specific gravity was 1.0025 g/cc and the water had a temperature of 19.6°C. Although the hole was being drilled with compressed air and some water with Quik-Foam®, no new water was being added to the compressed air by the time drilling had reached 304 ft.

3.2 Initial Results From the Magenta Dolomite

Circulating fresh water and PolyBore® were used to core SNL-14 through the Magenta and upper Tamarisk (570.3–556 ft) on May 14, 2005. There were no direct observations of fluid inflow through this interval. Because drilling fluid was being used and drill pipe and tools were being left in the upper part of SNL-14 overnight, no observations were acquired on fluid inflow or drilling fluid levels while the Magenta was open to the drillhole.

3.3 Initial Results From the Culebra Dolomite

The upper Culebra was cored to a depth of 669.5 ft on May 18. On the morning of May 19, the drilling fluid level in the drillhole was at 34 ft bgl. At that time, the entire drillhole below 40 ft was open. On May 19, coring continued through the Culebra and into the upper Los Medaños. The fluid level had dropped to near the base of the surface casing (~40 ft) by the time logging was complete on May 20. The bottom of SNL-14 was cemented May 20, and the drillhole was subsequently reamed using circulating fluid to a diameter of 11 inches. No data on Culebra inflow were obtained during drilling.

On May 25, the FRP casing was placed in the hole, and the well was completed for Culebra testing and monitoring.

After the well was completed, the Culebra was developed to prepare it for future testing and monitoring. On May 27, 2005, 100 barrels (4,200 gallons) of water from the WIPP water line were used to jet the FRP casing at SNL-14 to clean out the casing and screen. The well was then bailed, with 640 gallons of water removed from the well. On May 31, 2005, a pump was installed in SNL-14. The pump was run for just under 4 hours at rates from 12.5–11.5 gpm. After backwashing briefly, the pump was run for 2 hours at 12.2–12.0 gpm. The specific gravity after this pumping was 1.056. This pumping produced 4,500 gallons of water from SNL-14.

Static water levels for the Culebra in SNL-14 are now being measured. The initial measurement on June 20, 2005, was a depth of 371.16 ft (U.S. DOE, 2006).

4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-14 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-14. Previous studies of thickness changes between the Culebra and Vaca Triste Sandstone Member of the Salado Formation (Powers, 2002a, 2003a; Powers and others, 2003) indicated that SNL-14 was located considerably east of the margin where upper Salado halite has been dissolved (Fig. 4-1). SNL-14 was located east of the margin of halite in M-1/H-1, where halite was expected in this part of the lower part of the Los Medaños (Fig. 2-2). Halite was recovered from cores in the upper M-1/H-1 interval, as expected. Halite pseudomorphs after bottom-grown gypsum were revealed in the lower part of A-1, similar to those reported for well H-17 (Mercer and Snyder, 1990) to the east of SNL-14. Interpolated Culebra elevations in the area of SNL-14 will be revised by the data from the drillhole (Fig. 4-1).

The uppermost Los Medaños (M-2/H-2) does not include halite at SNL-14. This is consistent with halite margins (Fig. 4-1) as previously estimated for this unit (Powers, 2002a, 2003a) and a depositional origin for mudstone-halite facies. Nearest wells, including H-17 to the east (Mercer and Snyder, 1990), do not include halite in this interval. Although the contact with the overlying Culebra was not recovered as intact core, the upper part of M-2 did not display much soft deformation. The uppermost M-2 includes clasts of gypsum and siltstone and some apparent smeared intraclasts ~2 ft below the contact.

Culebra core recovery appeared to be good in the upper 14–16 ft. In the lower few feet of the Culebra, some core was not recovered. Much of the recovered Culebra below ~658 ft, however, was fractured into small, separated blocks and short core segments. Fracturing appears somewhat more intense in the lower few feet, especially where gypsum is not present. At SNL-14, pores or vugs are abundant, as in many cores from the Culebra south of the WIPP site center. Fracturing was common through the Culebra, and the unit overall will likely have high transmissivity.

The Tamarisk mudstone samples do not include halite, in contrast to H-17 (Mercer and Snyder, 1990). SNL-14 was located to be near the estimated halite margin of M-3/H-3, in the area where the possible effects of dissolution of halite from this interval could be evaluated further (Fig. 4-1). M-3 includes clasts of siltstone and mudstone, as well as gypsum, but bedding in the upper mudstone indicates little deformation due to post-depositional dissolution of halite. In addition, the overlying sulfate (A-3) shows bedding disturbed at the contact with M-3 and then is overlain within 1-2 ft by laminar to thin-bedded gypsum that is essentially horizontal. A fracture above the contact indicates no significant displacement. The location at SNL-14 does not indicate post-depositional dissolution of halite in the manner of H-19, for example (Mercer et al., 1998), and the proposed original margin of halite deposition (Fig. 4-1; black dashed line) should be moved east.

The Magenta core showed some slight porosity through an interval in the upper part of the Magenta. Resistivity through this interval is reduced as well. The drillhole was open to higher sources of inflow and the hole was being drilled with circulating fluid; there was no discernible indication during drilling of water inflow from the Magenta.

Cuttings and resistivity changes suggest that the change in natural mineral cements of the Dewey Lake is ~305 ft bgl. This position is lower stratigraphically compared to its position 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 is a saturated zone above this boundary in SNL-14; no testing was done to determine if the zone below 305 ft bgl in the Dewey Lake would also yield significant inflow. Changes in resistivity are small in the lower Dewey Lake, and the lower 120 ft are similar in resistivity to the higher zone that does yield water.

The Gatuña is relatively thin at SNL-14, indicating that the drillhole is near the eastern extent of the formation. To the east, at H-17, the unit is not reported, a thin portion of Santa Rosa Formation remains, and the Dewey Lake is ~450 ft thick (Mercer and Snyder, 1990). All of the Santa Rosa has been eroded at SNL-14, but the thickness of the Dewey Lake is nearly identical to H-17. The Gatuña includes some little-altered clasts of Dewey Lake, and the source and edge of erosion is likely near this location.

The top of Culebra at SNL-14, at an elevation of ~2,716 ft amsl, is consistent with data for the Culebra in the vicinity of SNL-14.

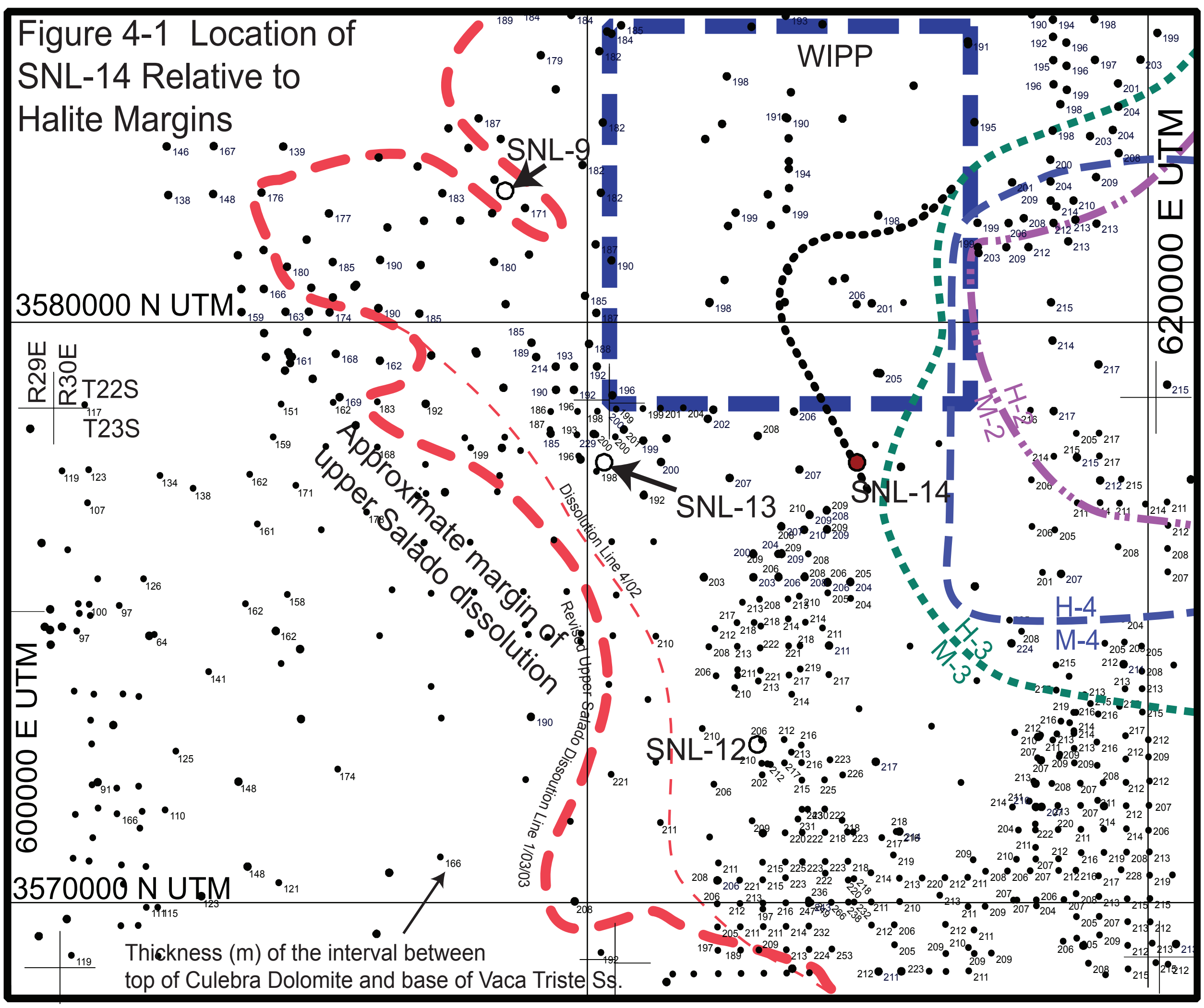


Figure 4-1 Location of SNL-14 Relative to Halite Margins

5.0 REFERENCES CITED

Bachman, G.O., 1973, Surficial Features and Late Cenozoic History in Southeastern New Mexico: U.S. Geological Survey Open-file Report USGS-4339-8, 32 p.

Bachman, G.O., 1985, Assessment of Near-Surface Dissolution at and near the Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico: SAND84-7178, Sandia National Laboratories, Albuquerque, NM.

Bachman, G.O., and Machette, M.N., 1977, Calcic Soils and Calcretes in the Southwestern United States: U.S. Geological Survey Open-file Report 77-794, 163 p.

Chugg, J.C., Anderson, G.W., Kink, D.L., and Jones, L.H., 1971, Soil Survey of Eddy Area, New Mexico: U.S. Department of Agriculture, 82 p plus figures.

Doveton, J.H., 1986, Log Analysis of Subsurface Geology: John Wiley & Sons, New York, NY, 273 p.

Hills, J.M., and Kottlowski, F.E. (coordinators), 1983, Southwest/Southwest Mid-Continent Region: American Association of Petroleum Geologists, Correlation Chart Series.

Holt, R.M., 1997, Conceptual Model for Transport Processes in the Culebra Dolomite Member, Rustler Formation: SAND97-0194, Sandia National Laboratories, Albuquerque, NM.

Holt, R.M., and Powers, D.W., 1988, Facies Variability and Post-Depositional Alteration Within the Rustler Formation in the Vicinity of the Waste Isolation Pilot Plant, Southeastern New Mexico: WIPP DOE 88-004, U.S. Department of Energy, Carlsbad, NM, 88221

Holt, R.M., and Powers, D.W., 2002, Impact of Salt Dissolution on the Transmissivity of the Culebra Dolomite Member of the Rustler Formation, Delaware Basin, Southeastern New Mexico: Abstracts with Programs, Geological Society of America, v. 34, no. 6, p. 203.

Holt, R.M., and Yarbrough, L., 2002, Analysis Report, Task 2 of AP-088, Estimating Base Transmissivity Fields. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 523889.

Izett, G.A., and Wilcox, R.E., 1982, Map Showing Localities and Inferred Distribution of the Huckleberry Ridge, Mesa Falls and Lava Creek Ash Beds in the Western United States and Southern Canada: U.S. Geological Survey, Miscellaneous Investigations Map I-1325, Scale 1:4,000,000.

Lucas, S.G., and Anderson, O.J., 1993, Stratigraphy of the Permian-Triassic Boundary in Southeastern New Mexico and West Texas, *in* Hawley, J.W., and others, eds., Geology of the Carlsbad Region, New Mexico and West Texas: 44th NMGS Fall Field Conference Guidebook, New Mexico Geological Society, Socorro, NM, p. 219-230.

Mercer, J.W., and Snyder, R.P., 1990, Basic data report for drillholes H-17 and H-18 (Waste Isolation PIlot Plant - WIPP): SAND89-0204, Sandia National Laboratories, Albuquerque, NM.

Mercer, J.W., Cole, D.L., and Holt, R.M., 1998, Basic Data Report for Drillholes on the H-19 Hydropad (Waste Isolation Pilot Plant–WIPP): SAND98-0071, Sandia National Laboratories, Albuquerque, NM.

Powers, D.W., 2002a, Analysis Report, Task 1 of AP-088, Construction of Geologic Contour Maps. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 522085.

Powers, D.W., 2002b, Basic Data Report for Drillhole C-2737 (Waste Isolation Pilot Plant – WIPP): DOE/WIPP 01-3210, U.S. Department of Energy, Carlsbad, NM, 88221.

Powers, D.W., 2003a, Addendum 2 to Analysis Report Task 1 of AP-088, Construction of Geologic Contour Maps. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 522085.

Powers, D.W., 2003b, 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.

Powers, D.W., and Holt, R.M., 1993, The Upper Cenozoic Gatuña Formation of Southeastern New Mexico, *in* Hawley, J.W., and others, eds., Geology of the Carlsbad Region, New Mexico and West Texas: 44th NMGS Fall Field Conference Guidebook, New Mexico Geological Society, Socorro, NM, p. 271-282.

Powers, D.W., and Holt, R.M., 1999, The Los Medaños Member of the Permian Rustler Formation: *New Mexico Geology*, v. 21, no. 4, p. 97-103.

Powers, D.W., and Holt, R.M., 2000, The Salt That Wasn't There: Mudflat Facies Equivalents to Halite of the Permian Rustler Formation, Southeastern New Mexico: *Journal of Sedimentary Research*, v. 70, no. 1, p. 29-36.

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

Powers, D.W., and Richardson, R.G., 2004, Basic Data Report for Drillhole SNL-2 (C-2948) (Waste Isolation Pilot Plant): DOE/WIPP 03-3290, U.S. Department of Energy, Carlsbad, NM.

Renne, P.R., Steiner, M.B., Sharp, W.D., Ludwig, K.R., and Fanning, C.M., 1996, $^{40}Ar/^{39}Ar$ and U/Pb SHRIMP Dating of Latest Permian Tephras in the Midland Basin, Texas: *EOS*, Transactions, American Geophysical Union, v. 77, p. 794.

Renne, P.R., Sharp, W.D., Montañez, I.P., Becker, T.A., and Zierenberg, R.A., 2001, $^{40}Ar/^{39}Ar$ Dating of Later Permian Evaporites, Southeastern New Mexico, USA: *Earth and Planetary Science Letters*, v. 193, p. 539-547.

Rosholt, J.N., and McKinney, C.R., 1980, Uranium Series Disequilibrium Investigations Related to the WIPP Site, New Mexico, Part II: Uranium Trend Dating of Surficial Deposits and Gypsum Spring Deposit near WIPP Site, New Mexico: U.S. Geological Survey Open-file Report 80-879, p. 7-16.

Sandia National Laboratories, 2003, Program Plan, WIPP Integrated Groundwater Hydrology Program, FY03-09, Revision 0. March 14, 2003. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 526671.

Schiel, K.A., 1988, The Dewey Lake Formation: End Stage Deposit of a Peripheral Foreland Basin [unpublished M.S. Thesis]: El Paso, TX, University of Texas at El Paso, 181 p.

Schiel, K.A., 1994, A New Look at the Age, Depositional Environment and Paleogeographic Setting of the Dewey Lake Formation (Late Permian?): *West Texas Geological Society Bulletin*, v. 33, no. 9, p. 5-13.

U.S. Department of Energy, 1996, Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant: DOE/CAO-1996-2184, U.S. Department of Energy, Carlsbad, NM.

U.S. Department of Energy, 2004, Title 40 CFR Part 191 Subparts B and C Compliance Recertification Application for the Waste Isolation Pilot Plant: DOE/WIPP 04-3231, U.S. Department of Energy, Carlsbad, NM.

U.S. Department of Energy, 2006, Waste Isolation Pilot Plant Annual Site Environmental Report for 2005: DOE/WIPP 06-2225, U.S. Department of Energy, Carlsbad, NM.

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-14 was not designated as a location in the original groundwater hydrology program (Sandia National Laboratories, 2003). Within the program, the nearest designated wells were WTS-21 (replacement for H-17) and WTS-11 (centered on the southern boundary of the WIPP site and also considered a replacement for P-17). Neither of these locations precisely reflects the reasons for locating SNL-14, as noted in the memoranda included in this appendix. Short portions of McKenna (2004) have been included to illustrate optimization of the network relative to the SNL-14 location, and this work influenced the location of SNL-14. Note that some pages reproduced here have been reduced in scale to fit the report page format.

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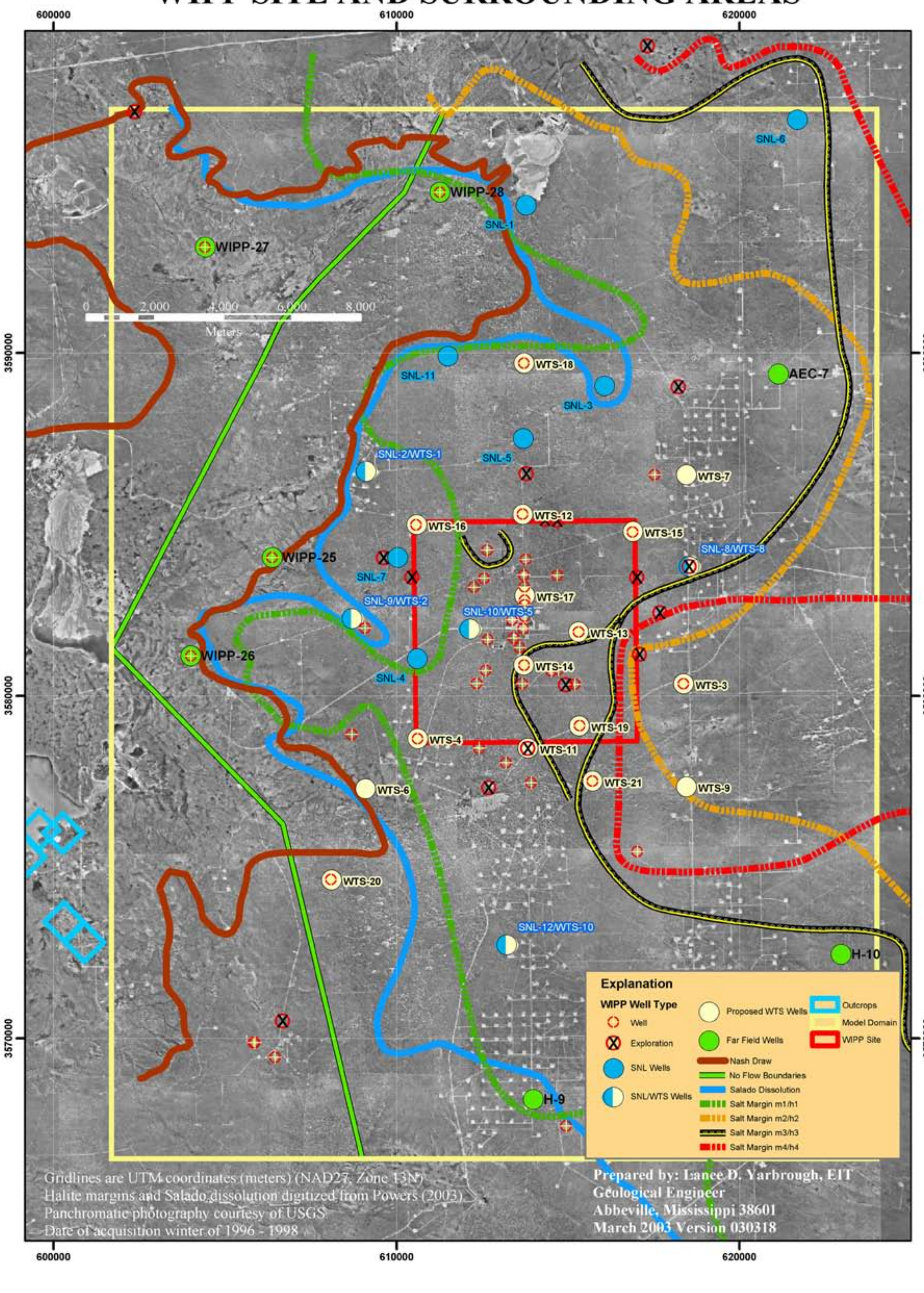
WIPP SITE AND SURROUNDING AREAS



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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.

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Dear Rick and Ron:

By request from Rick Beauheim, I have re-examined geologic data in the vicinity of the following potential locations for drillholes to provide recommendations on whether the locations are appropriate, considering the objectives of the drillholes.

Drillhole Name	General Location	Hydrologic Objectives	Geologic Information
SNL-6	500’ fnl & fel, 7-21-32	Model boundary conditions; conceptual model: low T in area with H-2 and M-3	Better logs show H-3 present; move south ~ 1 mi
SNL-8	@ P-20; 800’ fsl, 100’ fel, 14-22-31	Confirm assumed low T east of WIPP, located in area of possible dissolution of halite from H-3; provide info on Culebra heads in area with many O&G wells	Logs re-examined confirm M-3 and indicate possible thicker M-3 adjacent to inferred halite margin at P-20 and adjacent O&G wells
SNL-13	SE ¼, 1-23-30	Replace WTS-4, provide monitor well in area off SW corner of WIPP where some models show flow is forced	No halite in H-2, -3, or -4; probable H-1 halite cements in most drillholes
SNL-14	SE ¼, 4-23-31	Examine area between P-17 and H-17 for possible high T zone indicated in CCA	No drillhole or other data helps define the mudstone-halite boundaries in M-2/H-2, M-3/H-3, and M-4/H-4
SNL-15	@P-10; 2300 fnl, 340’ fwl, 26-22-31	Confirm T values in area with halite in all Rustler units along eastern boundary of WIPP	Drillhole data confirm halite present in P-10 and nearby oil and gas drillholes

Locations for SNL-6 and SNL-14 provide some challenges. From preliminary analysis, additional logs near the northeast corner of the hydrology domain indicate that halite is present farther west than was indicated in the original analysis (Powers, 2002). Although it is desirable to locate SNL-6 in an area without H-3, determining Culebra hydraulic properties near the boundary of the hydrologic domain is more important. SNL-6 would have to be located at considerable distance from this corner of the domain to assure not encountering H-3. Because SNL-14 is intended to test for the presence of a high T zone in the Culebra between H-17 and

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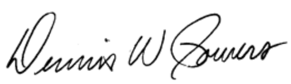
P-17, the drillhole should be located where H-3 is not present to minimize effects it may have on Culebra T values. Nevertheless, there are no drillholes between H-17 and P-17 to help delineate this margin. SNL-14 was therefore located approximately midway between the drillholes.

The coordinates for the drilling pads for each hole are:

Drillhole Name	UTM X (m) (NAD27)	UTM Y (m) (NAD27)	T,R Approximate Location (estimated)
SNL-6	621294	3595390	7-21-32, 1825 fsl, 1250 fel
SNL-8	618522	3583793	14-22-31, 900 fsl, 125 fel
SNL-13	610406	3577599	1-23-30, 1750 fsl, 400 fel
SNL-14	614871	3577302	4-23-31, 800 fsl, 1475 fel
SNL-15	617137	3581276	26-22-31, 2100 fnl, 500 fwl

Map locations, aerial photos with locations, and some site figures for each drill hole are included in the following pages.

Sincerely,

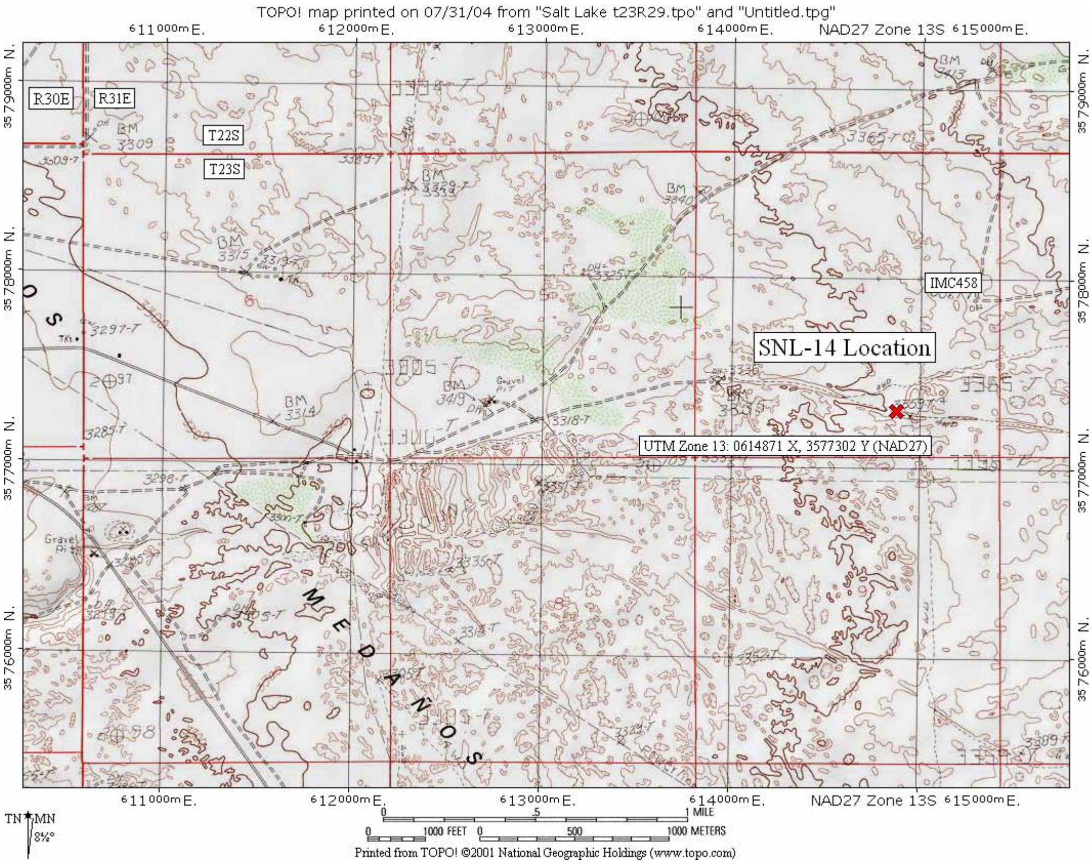


Dennis W. Powers

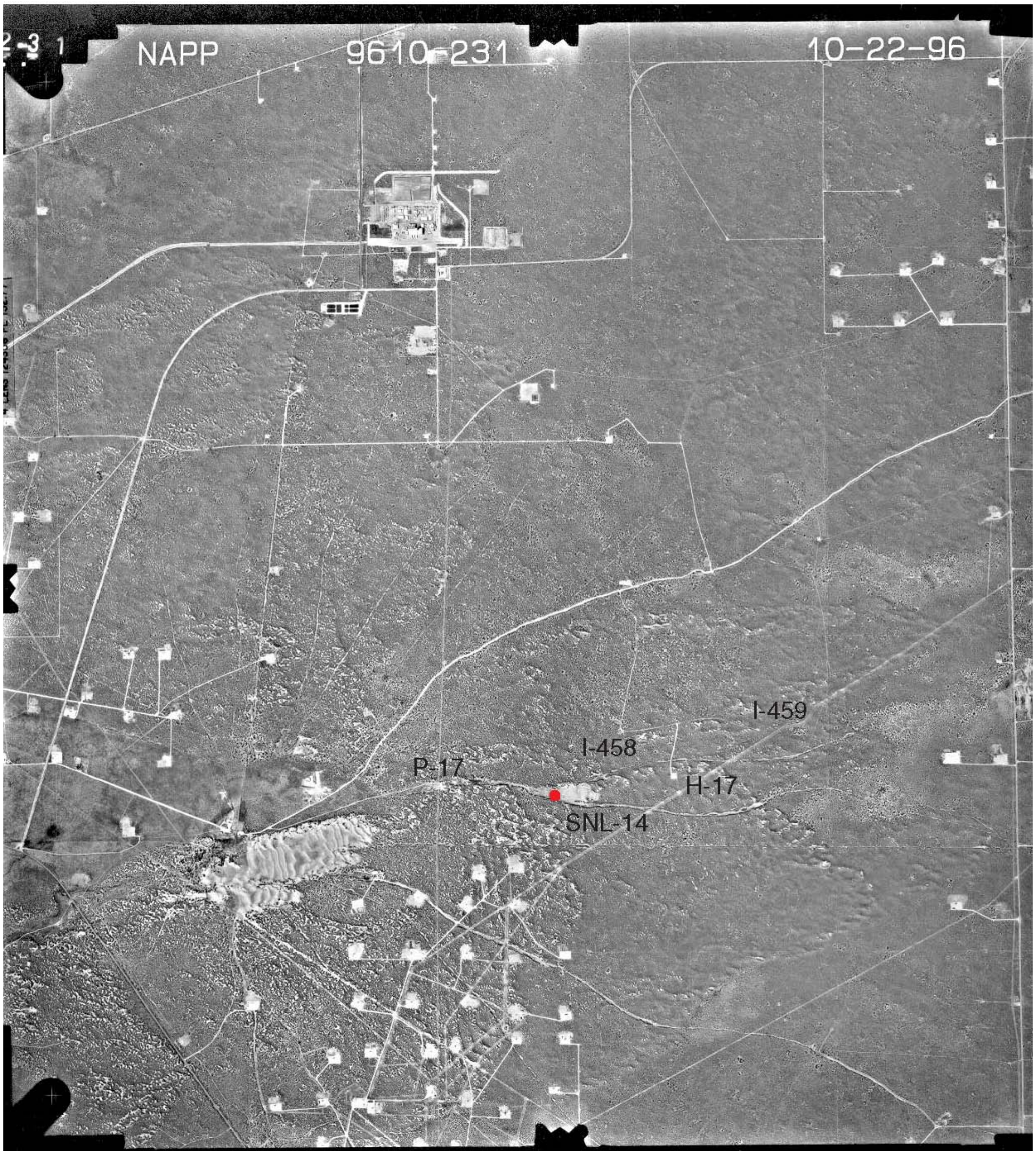
Note: several pages of this memorandum have been omitted here as not relevant to SNL-14.

Dennis W. Powers, Ph. D.
Consulting Geologist

Assessing FY05 Drillhole Locations
August 1, 2004



Topographic map showing location of SNL-14. Bottom left shows local sand at location. Bottom right shows relationship to higher dunes and track at right for access.



Aerial photograph showing location of SNL-14 relative to surface features and nearby drillholes. WIPP is near the top center of the photograph.

Dennis W. Powers, Ph. D.
Consulting Geologist

March 6, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Drilling Estimates and Revisions for New Hydrology Wells FY2005

Because of limits to the budget for drilling in 2005, I have revised the expectations for drillholes SNL-6, SNL-8, SNL-13, SNL-14, and SNL-15 (see accompanying Excel workbook). Here I also describe the differences with respect to the hydrology plan and also initial points about these drillholes (notes adjacent to initial Excel worksheet). In reassigning coring intervals and drilling depths, I have made an attempt to maximize the information for higher priority items. That does not mean that I think the earlier objectives were unnecessary or inappropriate. At the end of the summary, I provide some additional priorities for decision-making based on incremental costs as they accrue. For easy reference, a generalized diagram of the stratigraphy of each hole and the the intervals to be cored under this revision is included at the end of the drillhole summaries.

Note: portions of this document not related to SNL-14 have been omitted.

SNL-14

Prior Expectations for SNL-14

No drillhole designated SNL-14 was included in the original hydrological program plan. SNL-14 is located south of the southern boundary of the WIPP site, about midway between drillholes P-17 and H-17, where the Culebra has been tested and monitored. SNL-14 is about centered in an area that was designated the “high-T zone” for the Culebra in many earlier reports. The nearest equivalent well in the existing hydrology program plan was designated WTS-11, and it was originally located nearer the southern WIPP boundary, at the drillpad for P-8. WTS-11 was intended to be a replacement for P-17. WTS-11 was to provide monitoring information as well as Culebra transmissivity data. WTS-11 was scheduled to be drilled in FY05. The location of SNL-14 likely will provide information about the direction and rate of groundwater flow across the WIPP for annual reporting to the NMED.

The hydrology plan generically indicated that wells such as WTS-11 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to below the Culebra (~70 ft) for a total of about 100 ft.

My initial forecast called for coring the Forty-niner mudstone and through the Magenta and from above the Tamarisk mudstone into the upper Salado, a total of up to 350 ft. This plan was based on the lack of detail for the mudstone/halite facies in all units in this area and the import of SNL-14 as an indicator of the “high-T zone” that is not as prominent in recent modeling based on the Culebra geohydrological conceptual model. Nearby drillholes (P-17 and H-17) bracket the presence and absence of halite in the units above and below the Culebra, and this location is important as a test of the extension of a possible dissolution zone in M-3/H-3. The upper Salado is not likely to be dissolved at this location, but drilling and coring was projected into the upper Salado to thoroughly test the any relationship between high Culebra transmissivity and upper Salado dissolution. Coring above and beyond the hydrology plan included more of the lower Tamarisk and a longer interval in the upper Salado.

Dennis W. Powers, Ph. D.
Consulting Geologist

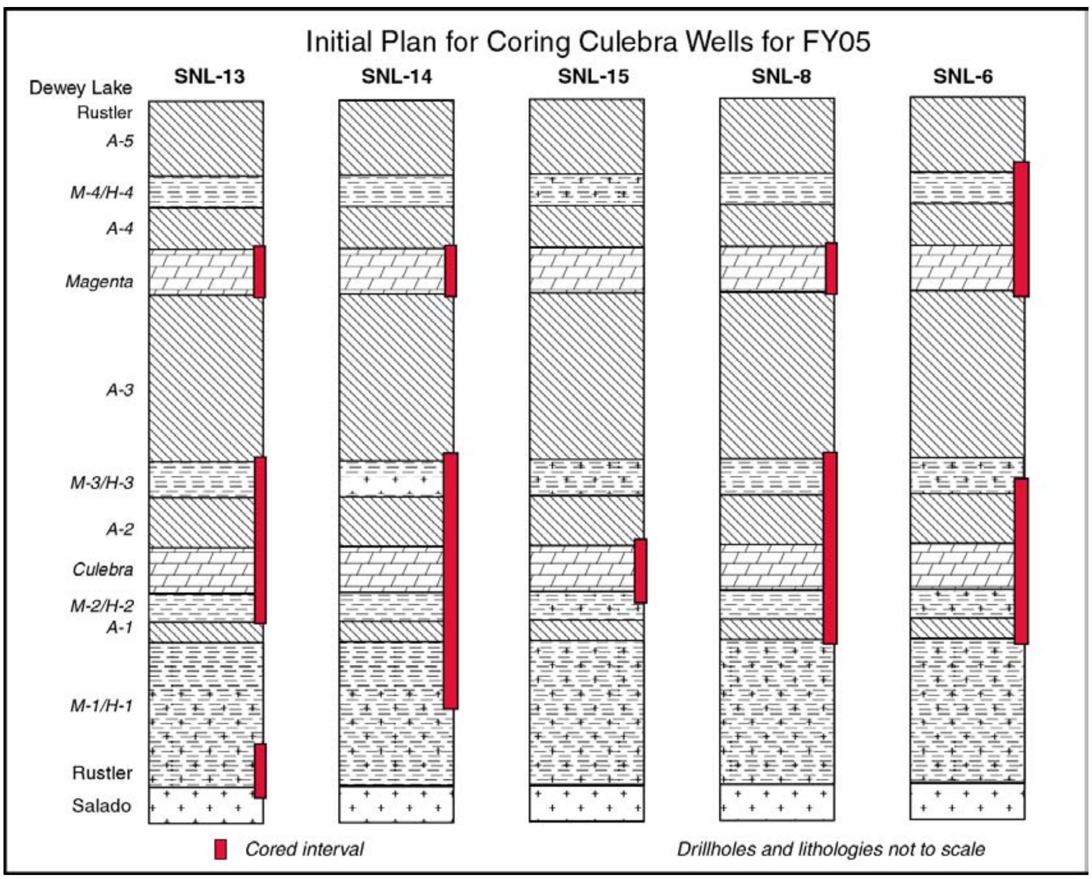
Drilling Estimates and Revisions FY2005
March 6, 2005

Current Plan for SNL-14

Since it was first proposed, the location for SNL-14 has been moved somewhat to mitigate impacts from construction near the Los Medaños, but it is still located along a general midline between H-17 and P-17. There are no changes in the estimates of the geological setting for this drillhole from the original plan for SNL-14. Although SNL-14 is south of the intended location for WTS-11, the geology is expected to be similar.

The revised drilling estimate is to a depth about 50 ft below the Culebra, the depth necessary to check reasonably for halite in the underlying M-2/H-2 and M-1/H-1. The revised core interval includes the Magenta, although there is no plan to locate a Magenta well in this area. The interval including Tamarisk mudstone (M-3/H-3) through Culebra and into the middle of the Los Medaños is cored under this plan. This provides a test of the halite in the Tamarisk mudstone as well as an attempt to intercept the upper halite of the lower Rustler (M-1/H-1).

This revised plan eliminates coring of the Forty-niner mudstone to examine the M-4/H-4 halite margin, and it eliminates coring and drilling of the lowermost Rustler and Salado. Direct drillhole and textural evidence from these zones will not be obtained.



Dennis W. Powers, Ph. D.
Consulting Geologist

Drilling Estimates and Revisions FY2005
March 6, 2005

Summary Comments on Revisions

The initial program of drilling and coring I recommended was aggressive, and I intended it to provide a solid base of physical evidence bearing on the geohydrological factors that contribute to the understanding of the spatial variation in the hydraulic properties of the Culebra Dolomite as well as the Magenta Dolomite. A hydrogeological conceptual model of the Culebra has been put forward, and these drillholes provide additional means of testing that model. Although a similar conceptual model of the Magenta has not yet been established, the spacing and distribution of these drillholes potentially add much to the existing coverage, as the eastern sector of the WIPP hydrologic modeling domain is not well represented by cores. Although Salado dissolution is not expected to be a significant factor in any of these five locations except possibly SNL-13, the distribution of halite and other Rustler facies, along with depth, are expected to be significant for the Culebra. The general distribution of halite in the Rustler is believed to be well known, but the margins are still poorly sampled to determine the potential for dissolution to have affected local halite distribution and hydraulic properties of these units.

With budget limitations in mind, I have attempted my version of *triage* – to sort or allocate on the basis of need for or likely benefit from ….

I have eliminated all drilling and coring of the basal Rustler and upper Salado except for SNL-13, which is located in part to test the potential effects of upper Salado dissolution. Data from other drillholes will supplement the estimate of upper Salado dissolution at SNL-13 and the amount of coring and depth has been greatly reduced. Drilling of the basal Rustler and upper Salado in the remaining holes, without core, would not significantly improve knowledge, although a specific data point on the contact might be provided by a geophysical log. I have eliminated coring of any units significantly above or below the Culebra in SNL-15 because there is little doubt about the presence of halite in all mudstone/halite units. I have also eliminated coring of some mudstone/halite units in different holes to focus on the greatest priority, the Culebra Dolomite.

Thirty years of experience at WIPP indicate to me that the cost of not having information and the cost of later providing equivalent information is more expensive than the savings of the moment. Nevertheless, I provide here a basis for choosing drillhole depths and core intervals from the five wells to be drilled and completed in FY04 with these limitations in mind. I will work with you on priorities as the drilling unfolds to do my best to balance the technical needs and budgetary limitations.

Sincerely,

Dennis W. Powers

p. 9, McKenna (2004)

1.0 Introduction

This document presents the methods, supporting data, and results of calculations done in support of Culebra head and hydraulic gradient network monitoring design. Three different approaches to monitoring network design are examined and results for the Culebra are obtained for each. These results include optimal locations for additional monitoring wells and identification of wells in the current monitoring network that could be removed with minimal effect on meeting the monitoring objectives. The three different sets of results are then combined into a final set of maps indicating areas for the installation of new monitoring wells. Additionally, several wells in the existing network could be removed with minimal effect on the ability of the monitoring network to predict heads at unmonitored locations and to detect changes in the hydraulic gradient.

p. 100, McKenna (2004)

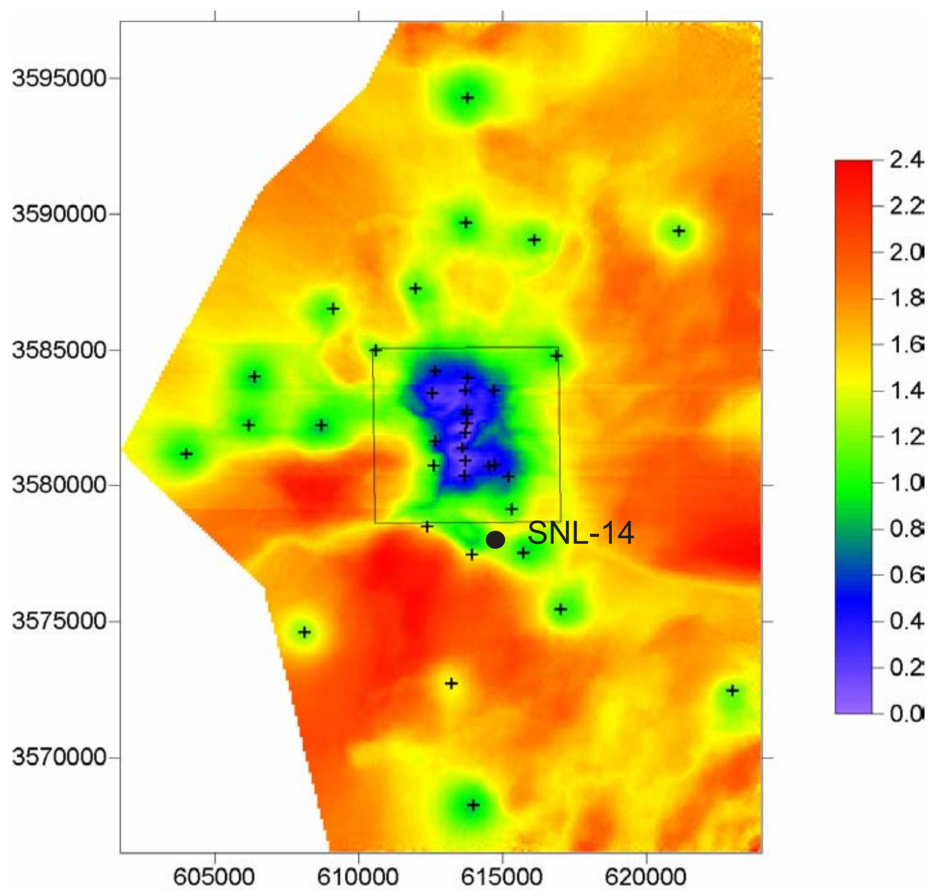


Figure 38. Combined score values map including estimation variance, number of three-point estimators and sensitivity of travel time to head. The wells in the expanded monitoring network are shown as plus signs.

Note that the identifier and dot showing the approximate location of SNL-14 have been added to this figure and are not part of McKenna (2004).

p. 102, McKenna (2004)

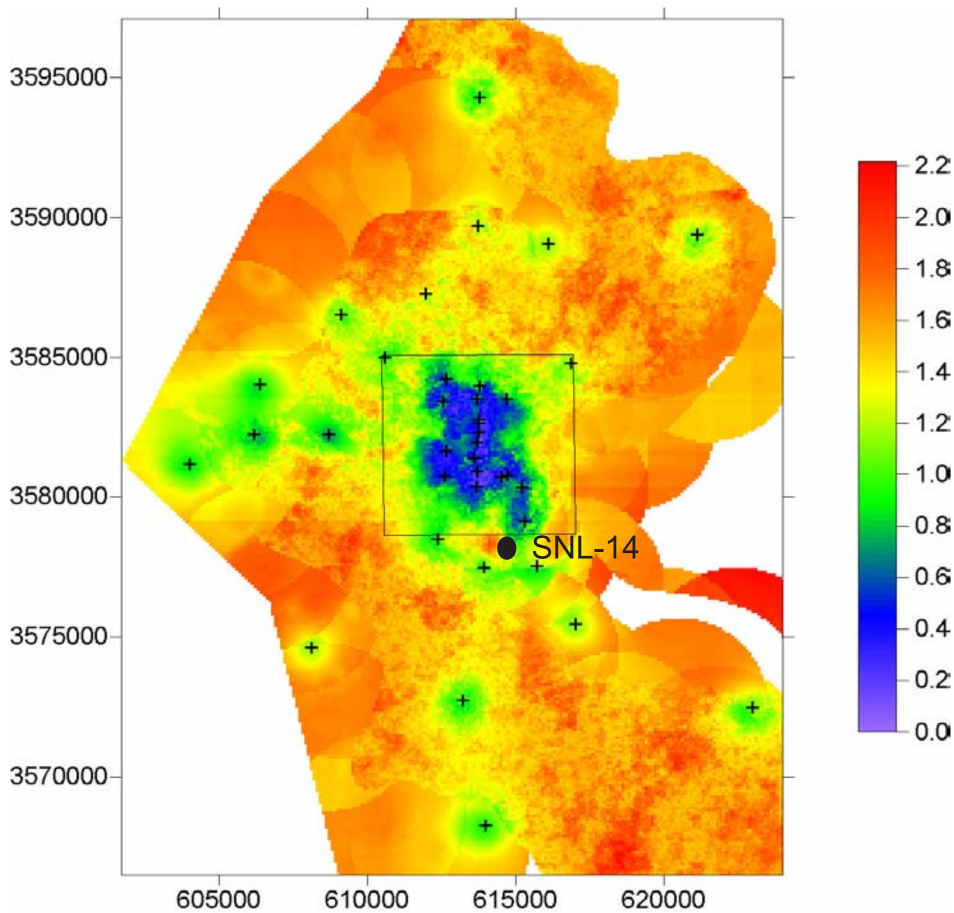


Figure 39. Combined score values map including estimation variance, number of three-point estimators and sensitivity of travel time to transmissivity. The wells in the expanded monitoring network are shown as plus signs.

Note that the identifier and dot showing the approximate location of SNL-14 have been added to this figure and are not part of McKenna (2004).

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. Note that daily activities began after 10:00 CDT due to restrictions regarding drilling in prairie chicken habitats.

5-2-05 Left Odessa at 09:20 and arrived on site at 10:50. Held safety meeting. Unloaded drill collars and drill pipe on rack. Began drilling 11" hole at 14:02. Reached 37' at 14:33. Put diverter on drillhole and moved roll-off container. Began drilling 11" hole from 37' at 16:26. Reached 125' at 18:15. Removed drill pipe from hole. Secured site and left for evening at 18:25.

5-3-05 Arrived on site at 10:04. Held safety meeting. *Ran Solinst meter in hole to 119'; no water detected*. No water blown from hole. Drilled 11" hole from 125 ft, starting at 10:25. Reached 208' at 11:40. *Water being produced by hole.* Compressed air blew out around base of temporary casing and cement. Tripped out of hole. *Used Solinst meter to measure water level at about 190' below pad level at 12:54. Measured about 188' below pad level at 12:58. Measured water level at 188.4' below pad level at 13:10. Obtained water samples at 15:00 (labelled 13:00 MST); water temperature 17.3°C, and specific gravity 1.0255. Obtained water level at 176.6' below pad level at 1515.* Waited on 20" casing from Odessa. Casing arrived 15:30; welded 7' of casing together. LaFarge on site at 16:55 and poured 2 yards cement behind 20" casing. Shut down at 17:20 to wait on cement.

5-4-05 Arrived on site at 10:05. Held safety meeting. Tripped into hole to begin drilling and tagged fill at 117'. Started at 117' at 10:20; cleaned out hole to 208' at 13:30. Began drilling 11" hole from 208' at 13:30. Used mist and 3 gallons of Quik-Foam®. Reached 304' at 15:40. Driller estimated hole makes 30 gallons per minute water. Water is produced too fast to continue drilling on air. Finished tripping out of well at 16:55. *Made decision to place longer surface casing and change to drilling with water and polymer. Ran electric probe into hole but foam in hole prevented a reliable measurement. Installed miniTroll at 250' below pad level.* Secured and left site at 17:58.

5-5-05 *Arrived on site at 10:00.* WTWWS crew arrived 10:15. Held safety meeting. *Removed miniTroll from hole at 10:40. Measured depth to water of 167.9' at 10:55. Obtained bailer samples of water for analysis by Sandia National Laboratories. Field measured specific gravity 1.0025, and field temperature of 19.6°C. Downloaded miniTroll data for checking; miniTroll slipped 0.25' into hole overnight.* Pumped fluid out of roll-off container. Set up to ream 17.5" and began to ream at 12:00. Cleaned up site and left at 16:30.

5-6-05 Arrived on site from Odessa at 12:00. Held safety meeting. Moved portable pit system onto drill pad. Left site at 16:00 for Odessa.

5-09-05 Stand by for shipment of Poly-Bore®. Left Odessa at 09:00 and arrived on site at 10:30 to deliver auxiliary mud pump. Departed site at 15:00 for Odessa.

5-10-05 Left Odessa at 09:00 and arrived on site at 10:25. Held safety meeting. Rigged up generator and moved drill pipe onto rack. Ran line into hole and tagged fill at 226' at 11:30. *Ran Solinst meter probe into drillhole and found top of water at 166.7 ft below pad level at 11:35.* Ran collars and drillpipe into hole with 11" bit to clean out hole. Hauled 180 barrels of fresh drilling water *from WIPP water line*. Mixed 35 pounds of Poly-Bore®, 2 bags of soda ash, and 3 gallons of EZ-Mud® *with 90 barrels of fresh drilling water*. Worked on mud pit. Tripped into hole at 14:45; fill at 226'. Began cleaning out fill at 16:03. Worked on shaker screen to allow fluids to pass through. Reached 304' at 19:30. Drilled hole from 304' to 305' at 19:35. Tripped out drilling pipe, *left collars and reamer in hole*. Shut down rig, secured site, and departed site at 19:55.

5-11-05 Arrived on site at 10:00. Held safety meeting. *Fluid level was 47.7' below pad level at 10:50.* Pumped fluid from roll-off container to pit system. Tripped in at 10:30 and began to circulate at 11:05. Began drilling from 305' at 11:17. Reached 434' at 18:37. Circulated on bottom to 18:55, and tripped out drilling pipe by 19:20. *Some areas of middle part of hole had squeezed in.* Added 90 barrels of water, 70 pounds of Poly-Bore®, 40 pounds (1 bag) of soda ash, and 4 gallons of EZ-Mud® during day. Hauled 90 barrels of fresh water. Topped up drillhole with drilling fluid. Shut down rig, secured site, and departed at 19:30.

5-12-05 Arrived on site at 10:00. Held safety meeting. *Fluid level was 45.5' below pad level at 10:30.* Reamed back into hole from 10:45 to 12:00. Began to drill 11" hole from 434' at 12:02. Drilled to 498' by 17:40. Added 10 gallons of EZ-Mud® during drilling. Circulated on bottom. Pulled drill pipe by 18:20. Topped up drilling fluid in hole. Shut down rig, secured site, and departed at 18:25.

5-13-05 Arrived on site at 08:30. Held safety meeting. *WTWWS supervisor requested permission to perform rig maintenance without startup prior to 10:00. Richardson called Lynn to request concurrence; Lynn attempted to contact BLM without success. Lynn approved work as long as heavy equipment not started before 10:00.* Cleaned mud pits. Tripped into the hole from 11:40 to 12:10. Worked on desander. Began to drill from 498' at 13:00. Reached coring point at 538' at 18:08. Circulated on bottom until 18:33. Tripped out of hole. Used 10 gallons of EZ-Mud® and hauled 60 barrels of fresh water. Secured site and left at 19:15.

5-14-05 Arrived on site at 10:10. Held safety meeting. Billy Pon (DOWDCO) arrived on site with core barrel at 10:20, unloaded and rigged up to core. Measured fluid level at 24.6' below pad level at 10:40. Tripped into hole and circulated from 12:10 to 12:15. Began coring at 538' at 12:15. Reached 556' at 14:30. Core jammed. Circulated on bottom until 14:45 and tripped out of hole with core barrel. Laid core down; recovered 18' from 18' of drilling. Tripped back into hole at 16:28 and began coring from 556'. Reached 570' at 18:25. Circulated on bottom until 18:35. Tripped out of hole with core barrel at 19:05. Laid down core by 19:24. Ran 11" bit, reamer, and 3 collars in hole and shut down. *Cut 14' of core and recovered 14.3'*. Used 5 gallons of EZ-Mud®. Secured site and left at 20:00.

5-15-05 *Arrived on site at 09:00. Rain and lightning in area that looked like it would persist. Richardson decided there is too much lightning in the area for safe drilling and decided to resume drilling on 5/16/05.*

5-16-05 *Richardson on site at 09:30. Measured fluid level at 63.3' below pad level at 11:30.* WTWWS arrived on site at 11:45 with extra mud pit. Held safety meeting. Began tripping into hole with 11" bit at 11:55. Began reaming cored interval from 538' at 12:19. Reamed out to 570' at 16:48 and began drilling new hole. Reached 587' at 19:43. Circulated on bottom until 20:00 and tripped out drilling pipe. Used 12 gallons of EZ-Mud®. Secured site and left at 20:30.

5-17-05 Arrived on site at 09:55. Conducted safety meeting. Changed fuel filter on rig. Started tripping into hole at 10:15 and began drilling from 587' at 10:46. *Billy Pon (DOWDCO) arrives on site at 15:50.* Reach coring point at 619' at 16:25. Tripped out of hole by 16:45 and rigged up to core. Tripped into hole starting 17:25 and began coring from 619' at 18:10. Cored to 634' by 19:55. Circulated on bottom to 20:05. Tripped out of hole by 20:40. *Will lay core down in morning.*

5-18-05 Arrived on site at 09:55. Conducted safety meeting. Laid core down; recovered 13'. Put core barrel together and tripped into drillhole. Began coring from 634' at 11:32. Reached 662.5' at 14:00. Circulated on bottom. Tripped out of hole by 14:40 and laid down core with 100% recovery. Put core barrel together and began to trip in at 15:06. Began coring from 662.5' at 15:43. Reached 669.5' at 16:35 and circulated on bottom for 10 minutes. Tripped out by 17:20 and laid down core. Recovered 7' . Tripped core barrel and one drill collar into drillhole by 17:30 and shut down for night. Used 5 gallons of EZ-Mud®.

5-19-05 *Powers, Pon, Ronnie Keith arrive on site from 09:20 to 09:35. J. Siegel (WRES) and Paul Hoffman (IS) arrive on site 09:55, inspect fork lift, find modified tine requiring load test or replacement or certificate of load test.* WTWWS crew arrives on site; held safety briefing. Measured fluid level in drillhole at 34' below pad level at 09:20. *Siegel and Hoffman depart site.* Tripped into hole by 11:00 and began to core from 669.5'. Reached 674.5' at 11:45; core jammed. Tripped out of hole by 12:20 and laid down core. Recovered 4'. *Powers transferred core to R. Carrasco and assisted in moving it to storage. J. Siegel and Gene Valett visited site at 13:00 and Valett returned to drill site at 13:25.* Tripped in by 13:40 and began coring from 674.5' at 13:40. Reached 688.5' at 15:38. Core jammed. Tripped out and laid down core by 16:15. Recovered 12'. Tripped into hole by 17:30 and cored to 718.5' by 18:50. Circulated on bottom. Tripped out of hole by 19:35 and laid part of core down. *Observed halite in lower core, indicating coring was complete. Will lay rest of core down on following morning. Secured site and departed at 20:15.*

5-20-05 Arrive on site; held safety briefing. Laid down remaining core; recovered 29'. *JetWest logger arrives on site at 10:32.* Broke down core barrel and loaded onto trailer. Billy Pon left by 11:40. Jet West rigged up to log starting at 11:25 and logged well from 11:45 to 14:55. Tripped into hole with tremmie line at 15:05 and cemented back to 690' with 0.25 cubic yard of cement by 16:28. Tripped out of hole by 17:05 and cleaned up pipe. Departed site at 17:25.

5-23-05 *Richardson arrived on site at 10:00 with Wes Nance (WIPP maintenance) to inspect fork lift and returned to WIPP by 10:30.* WTWWS arrives on site from Odessa and held safety meeting. Began to trip in drill pipe at 11:45 and tagged cement at 679'. Went for load of water. Tripped into hole with 11" bit to 619' and began reaming at 15:00. Took fork lift for load testing. Completed reaming to 643' at 19:00. Circulated for 10 minutes and tripped out of hole. Shut down rig and depart site at 19:45. Used 8 gallons of EZ-Mud®.

5-24-05 WTWWS arrived on site at 10:00 and held safety meeting. Tripped into hole with 11" bit to 643' and began reaming at 10:50. Completed reaming to 686' at 15:15. Circulated until 16:00 and tripped out of hole. Shut down rig and depart site at 16:45. Used 6 gallons of EZ-Mud®.

5-25-05 WTWWS arrived on site at 10:10 and held safety meeting. Tripped into hole with 11" bit and circulated hole for 30 minutes. Tripped out of hole and ran tremmie pipe into hole by 13:00. Ran casing into the hole by 15:45. *Mike Stapleton (OSE) arrived on site at 16:35.* Cut casing off and displaced fluid in hole with fresh water. Placed gravel pack (686-645') from 17:40-18:10. Pumped 3 bags of Hole Plug® (645-640'). Let Hole Plug® set for 20 minutes. Pumped first load of cement from 18:40 to 19:05. Pulled 9 joints of tremmie pipe. Second load of cement arrived at 19:55. Pumped cement with returns to surface. *Mike Stapleton (OSE) departed site at 20:13.* Pulled 9 joints of tremmie pipe by 20:35 and shut down for night.

5-27-05 *Arrived at PortaCamp to get pipe at 09:00. On-site at SNL-14 at 10:30; prepare to install jet tool. Pipe joints #1 to #12 total 386.5'. Screen = 649.5'-676.0' + 8' sump = 684' to bottom of well. Need 297.5' more to target depth. Use next 9 joints to get total of 292.8' + 7' for tool = 299.8'. Tubing lengths did not match initial calculations; will need to recalculate after pullout. Ready for jetting at 12:10. Crew leaves site to get new pressure hose. Crew returns at 12:35 and we start setting up for jetting using 100 bbls of fresh water from WIPP water line (Double Eagle - City of Carlsbad water line). Start jetting at 13:00. First return of water is tan, silty, very milky. Water very dirty at 13:10, brown and muddy. Water still fairly dirty brown at 13:20. Water varies from muddy brown to fairly clear at times by 13:30. Water still fairly dirty brown and not really clearing up at 13:40. Water appears to be clearing up; much light color by 13:50. Water appears to be cleaning up with sporadic cloudiness at 14:00. Water has been clear for last three passes at 14:10. Water clear at 14:20; completed jetting and preparing to trip out of hole. Completed tripping out of hole by 15:20, rigging up to bail. Water level 305' below top of casing at 15:50. Started bailing well at 15:55. Eighth bailer empty at 16:25. Collected 5 gallon bucket sample at 17:30; water still muddy after settling out and showed some fines in* *bottom of bucket. Bailed ~ 1 wellbore volume to 17:55; water clearing but still cloudy. Stoppped bailing at 18:55. Bailed 67 bailers (640 gallons) of water. Well bore volume is 374 gallons. Shut down rig.*

5-31-05 *Arrived at PortaCamp at 09:30. WBS crew arrives at 10:30 and picks up pipe. Arrive on site at 10:50. Pump target depth is 665'; actual set depth is 667'. Used 20 joints, pump, and 10' shorty. Rig showed up at 12:05. Generator showed at 12:10. Start setting pump at 12:25. Pump set at 13:30; started plumbing discharge line. Pump stopped working at 14:00; Problem appears to be a short in motor. Pulled pump to replace pump motor. Pump out at 15:45; could not find short. Will go back down hole with all new wire. Back down hole at 16:10. Pump set to depth and ready to test at 17:15. Everything works fine. Water very silty. Pumped 5 gallons and then turned off. Finished replumbing discharge line at 17:50. Returned to site at 18:00.*

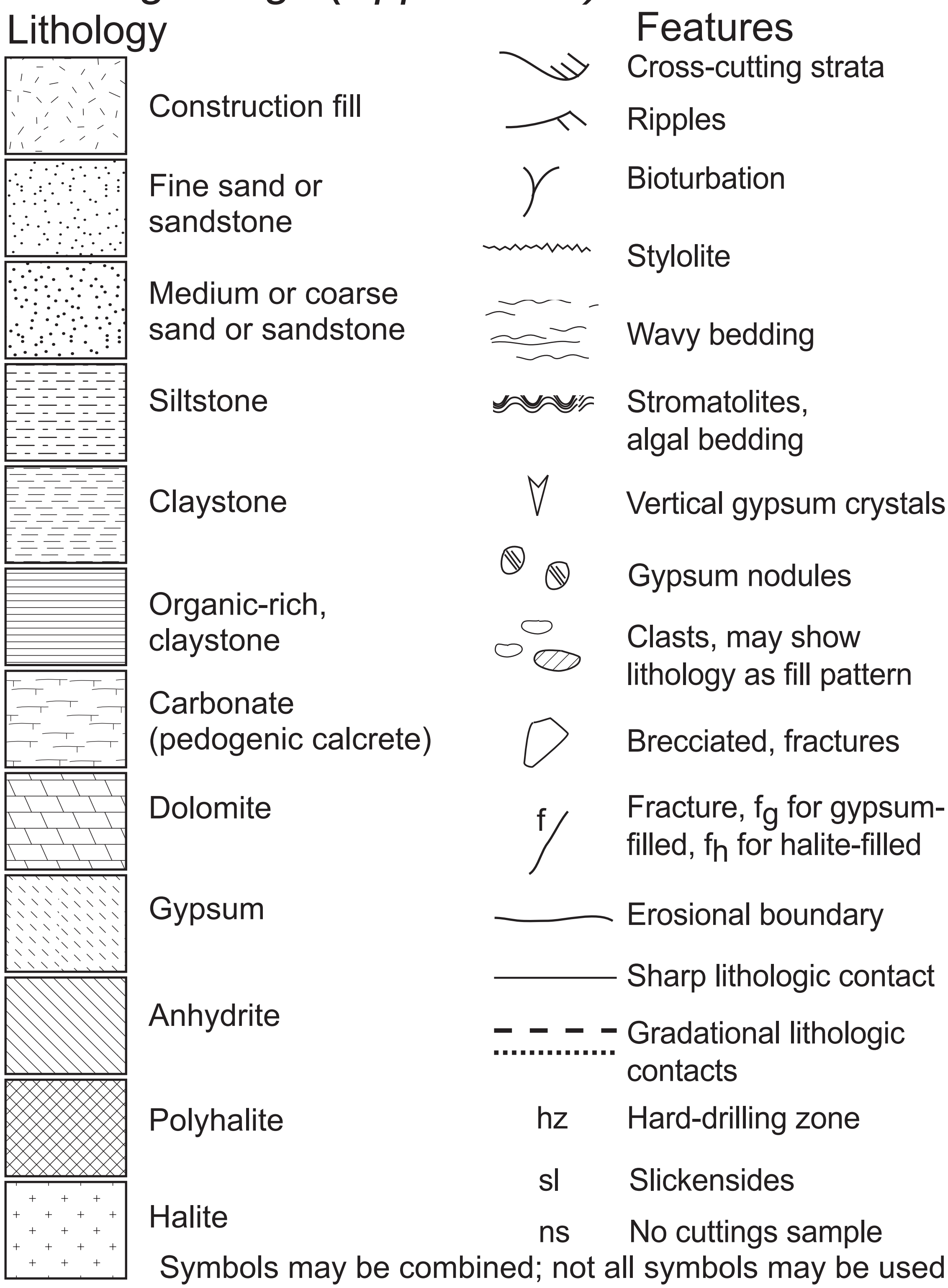
6-01-05 *Arrived on site at 09:30; wait for crew. WBS crew arrives at 10:12. Pump started wide open at 10:15 with flow at 12.5 gpm. Water very silty and tan. Flow rate 12.0 gpm at 11:00. Water is clearer. Specific gravity 1.05, temperature 23.7 degrees C. Flow 12 gpm at 12:00; water very clear with specific gravity at 1.054. Flow 11.8 gpm at 13:00; water is clear with specific gravity 1.055. Flow 11.5 gpm at 14:00; water is clear with specific gravity 1.055. Stopped pump at 14:10 to backwash for 10 minutes. Pump back on at 14:25 with flow at 12.2 gpm; water still clear. Flow 12 gpm at 15:00. Flow 12.0 gpm at 14:15; specific gravity 1.056. Pump off at 16:25. Started disassembly at 16:30; pull pump. Pump removed by 18:00. Return to PortaCamp. Pipe trailer dropped off at Portacamp. Go back to SNL-14 to get rig and generator. Total water pumped is 4,500 gallons + 640 gallons = 5,140 gallons.*

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 7

Hole ID: SNL-14	Location: SE 1/4, section 4, T23S, R31 E
Drill Date: 5/2/04	Drill Method: Rotary, with air
Drill Crew: WTWWS; Luis Armendariz; Ronny Keith	Hole Diameter: 11 inches
	Hole Depth:
	Hole Orient: vertical down
Drill Make/Model: Gardner-Denver 1500	Barrel Specs: 4" i.d.; 6.75" o.d.
Drill Fluid: variable	Core Preserv: as recovered, in boxes
Logged by: Dennis W. Powers, Ph.D., consulting geologist	Date: 5/2/05
Scale: variable	

	Northing	Easting	Elevation
Survey Coordinate: (Ft)			

Comments: NM State Engineer designation is C-3140 for this well.

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	0	N/A	N/A		0-9': fill; dune sand, generally pale brown (10YR6/3), becoming more reddish with depth; more argillaceous and moist with depth (Berino soil).	Begin drilling with air from 3.5' @ 1302 MDT, 5/2/05
		C-1			9-12': Sandstone, calcareous, white, to sandy limestone; Mescalero caliche; no data on stage of development	
		C-2			12-23': Sandstone, fine-grained, and claystone; weak red (10R4/3); claystone has very fine laminae (0.02") and gray and green spots. Similar to Santa Rosa; interpreted as Gatuña Formation from resedimented Santa Rosa.	
	20	C-3				10' at 1306 MDT make temporary diverter
		C-4			23-484': Interbedded siltstone, fine sandstone, and claystone; generally reddish brown (5YR4/4) to red (2.5YR4/8); small greenish-gray reduction spots are common within unit; variably calcareous to about 350', sulfatic below 350'; Dewey Lake Formation	
		C-5				15' @ 1311 MDT
	40	C-6				20' @ 1314 MDT
					42-43': gray zone, fast drilling 47': hz 50': small greenish-gray spots	
		C-7			55': generally hard drilling, calcareous (10R4/4 with 10R6/2)	25' @ 1316 MDT
	60	C-8				30' @ 1322 MDT
		C-9			72-82': faster drilling	35' @ 1331 MDT
	80	C-10			82': hz	37' @ 1333 MDT set up regular diverter 40' @ 1531 MDT 45' @ 1535 MDT
	100	C-11				

Hole ID: SNL-14 — CORE LOG (cont. sheet) — Sheet 2 of 7

Logged by: Dennis W. Powers, Ph.D. — Date: 5/2-4/05

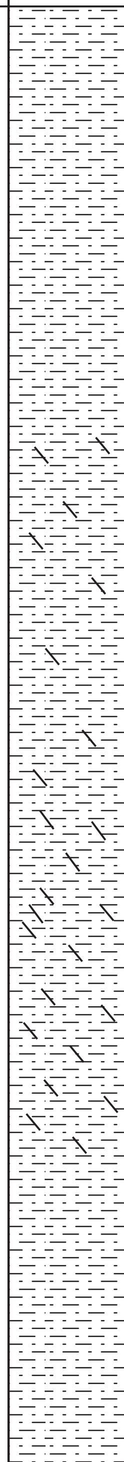
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	100	N/A	N/A		100'+: cuttings begin clumping slightly, powdered, no chips ~115': sand, very fine; siltstone; easy drilling	105' @1703 MDT 110' @ 1705 115' @ 1707
	120	C-12				120' @ 1709
		C-13			125': poorly indurated, 2.5YR4/4 fresh powdery cuttings 5/3/05 0921MDT ran Solinst inside pipe to 119' and detected no moisture; blew dusty cuttings from hole at beginning of drilling	125' @ 1712, end 5/2/05; begin 0925 MDT 5/3/05 130' @ 0931 135' @ 0935
	140	C-14			140': calcareous, moderately indurated, 1/8" gray spots; laminated; 2.5YR4/6 fresh cuttings	140' @ 0937
		C-15			150': cuttings clump slightly; fine sandstone and siltstone, poorly indurated, very calcareous; 10R4/6 fresh	145' @ 0939 150' @ 0941 153' @0942, add jt begin 0954
	160	C-16			170': moisture increasing in cuttings	155' @ 0956 160' @ 1000 165' @ 1003
		C-17				170' @ 1007
	180	C-18			180': moist cuttings	175' @ 1009 180' @ 1012
		C-19			190': drilling rate slows	185' @ 1014, add jt begin 1025 190' @ 1030
	200	C-20			Collected Dewey Lake water sample for SNL at 1400 MDT, 5/3/05; water level 176.6' below pad level at 1415 MDT; field sample 17.3^{o}C, s.g. 1.0255.	200' @ 1036
		C-21				205' @ 1039 208' @ 1041, stop drilling, encountered water. End 5/3/05 Begin 1131 MDT 5/4/05 with mist, reach 208' @1230
	220	C-22			220': not calcareous; sandstone, very fine, and siltstone; dark reddish brown (2.5YR3/4) to red (2.5YR4/6) when damp; numberous gray (10YR6/1) spots and thin intervals. Well indurated. Harder drilling from 225'.	210' @ 1232 215' @1236, add jt begin 1245 220' @ 1248
		C-23				225' @ 1252 230' @ 1256
	240	C-24				235' @ 1300 240' @ 1305
		C-25				256' @ 1312, add jt begin 1322 250' @ 1325 255' @ 1328
		C-26			260': sandstone, very fine, light red (2.5YR6/6)	260' @ 1330
	260					

Hole ID: SNL-14 CORE LOG (cont. sheet) Sheet 3 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 5/4/05; 5/10-11/05

Run Number	Depth (ft)	% Recovered	RQD
N/A	260	N/A	N/A
		C-27	
	280	C-28	
		C-29	
	300	C-30	
		C-31	
	320	C-32	
		C-33	
	340	C-34	
		C-35	
	360	C-36	
		C-37	
	380	C-38	
		C-39	
	400	C-40	
		C-41	
	420	C-42	

Profile (Rock Type)



Description

Tried to measure water in hole 5/4/05; encountered foam. Placed mini-Troll @ 250.0' below pad level on 5/4/05. Removed mini-Troll @ 0940 MDT 5/5/05. Slipped 0.25' overnight. Water level @ 167.9' below pad at 0955 MDT. Collected Dewey Lake water sample @ 1020 MDT. Field samples 19.6^{o}C, s.g. 1.0025. Water level 166.7' below pad 10:35 MDT 5/10/05.
310': clay, fine, reddish-brown; includes some gray clay; slightly calcareous; fibrous gypsum

340': less calcareous below this point

346': harder drilling
350': gypsum more abundant

390': slower drilling, less gypsum

Remarks

265' @ 1333 MDT
270' @ 1335
275' @ 1338
279' @ 1340; add jt begin 1416
280' @1417
285' @1421
290' @ 1425
300' @ 1431
304' @ 1435; stopped drilling because of water; change to mud
5/10/05 drilled 304-305' with water and polymer.
Begin 5/11/05 mud level 47.7', 305' @ 1017 MDT
309' @ 1032 MDT, add jt; begin 1042
310' @1044
315' @ 1056
320' @ 1108
325' @ 1120
330' @ 1134
335" @ 1147
340' @ 1158
341' @ 1201; add jt begin 1214
345' @ 1228
350' @ 1243
355' @ 1255
360' @ 1306
365' @ 1320
370' @ 1328
371' @ 1331; add jt begin 1355
375' @ 1403
380' @ 1414
stop 1421-1427
385' @ 1435
390' @ 1451
391' @ 1455, stop, begin 1502
395' @ 1508
400' @ 1523
402' @ 1529; add jt begin 1600
405' @ 1607
410' @ 1618, stop, begin 1625
415' @ 1638
420' @ 1651

Hole ID: SNL-14 CORE LOG (cont. sheet) Sheet 4 of 7

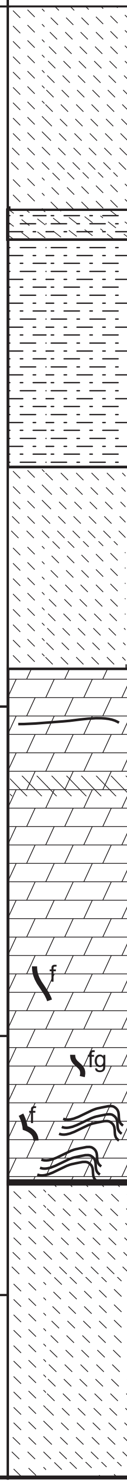
Logged by: Dennis W. Powers, Ph.D. Date: 5/11-13/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description (Note scale change)	Remarks
N/A	420	N/A	N/A		430'+: cuttings show reddish-brown claystone and siltstone with some greenish-gray spots and 1-2% small chips of clear to translucent gypsum.	425' @ 1712; stop 1714, begin 1718
	430	C-43				430' @ 1725 434'@ 1737; end drilling 5/11/05; left full of drilling mud 5/12/05 begin @ 434' @ 1102 MDT, water level 45.5' below pad level 435' @ 1106
	440	C-44				440' @ 1121, circulate to 1126 445' @ 1137
	450	C-45				450' @ 1148, circulate to 1155 455' @ 1207
	460	C-46				460' @ 1216 465' @ 1225 466' @ 1227; add jt; begin 1252
	470	C-47				470' @ 1302 475' @ 1315, circulate to 1320
	480	C-48			Base of Dewey Lake Formation 484' Top of Rustler Formation Gypsum, white, soft cuttings ground up by drilling; some gray fine to medium crystalline gypsum and anhydrite	480' @ 1332 484' @ 1342 485' @ 1353
	490	C-49				490' @ 1451 495' @ 1602 498' @ 1640, circulate, pull drill pipe; end 5/12/05 begin 1007 MDT 5/13/05; mud @
	500	C-50				

Hole ID: SNL-14 | CORE LOG (cont. sheet) | Sheet 5 of 7

Logged by: Dennis W. Powers, Ph.D. | Date: 5/13-16/05

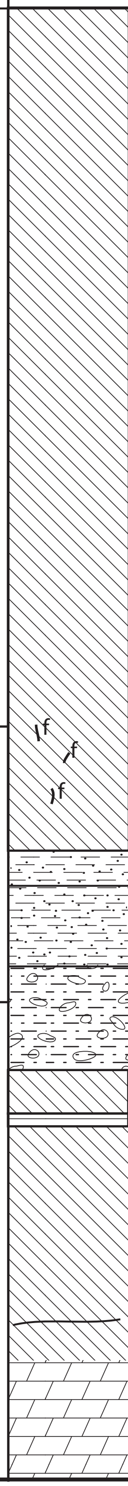
Note scale change

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	500	N/A	N/A		A-5 Gypsum, white, soft cutting; ground up by drilling; some gray fine to medium crystalline gypsum and anhydrite	500' @ 1200 MDT 505' @ 1337 MDT
	510	C-51			Change of drilling rates @ 511' 513' base of A-5/top M-4? M-4 Siltstone and claystone, grayish brown	510' @ 1423 MDT removed cuttings 511' @ 1536 MDT 515' @ 1451 MDT; circulate to remove cuttings; begin 1454 MDT
	520	C-52				520' @ 1504 MDT; circulate
					525' A-4 Anhydrite, gray, fine crystalline, and white gypsum mud from drilling/grinding	525' @ 1525 MDT
	530	C-53			536' Base of Forty-niner Member Top of Magenta Dolomite Member	530' @ 1602 MDT; circulate; begin 1617 MDT 535' @ 1650 MDT 538' @ 1708 MDT; circulate, trip out; end drilling 5/13/05 5/14/05 begin coring @ 538'
1	540 550	cut 18'; recovered 18' (100%)	0.2' in segments < 4" (RQD=98.89)		Dolomite, light olive gray (5YR6/2) to white (5Y8/2); some gypsum and some thin grayish brown (10RY5/2) interbeds. 564-562': thin beds - laminae; algal, 5" basal relief, 2.5" relief upward and decreasing 562-549': thin beds; slight cross-cutting, ripples, <0.5" relief 549-542.9': thin beds - laminae; cross-cutting, 1" amplitude; reddish-brown silty interbeds; no gypsum; more porous; thin brown laminae at top 542.9-541.8': dolomite and gypsum; thicker beds; subhorizontal separations with gypsum 541.8-538': thicker dolomite beds with thin brown laminae, especially at 539'; erosional relief increasing upward; small gypsum nodules 541.3-541' f: 553.7-553.2; 50° from horizontal; gray material on surface f_g: 557.95-557.4'; 65° from horizontal; gypsum-filled f: 562.4-561.8'; 65° from horizontal	
2	560	cut 14'; recovered 14.3' (102%)	all segments > 4" (RQD=100)		564' Base of Magenta Dolomite Member Top of Tamarisk Member Gypsum and anhydrite, dark gray; laminar to thin beds with convolution and relief. Very thin organic laminae (<0.06") outline bedding. Some possible nodules 567-566.6'. High amplitude bedding 568.5' from algal or ridge growth. Separations parallel to bedding are filled with fibrous gypsum	end coring 5/14/05 no drilling 5/15/05 due to storm
	570 580	C-54				5/16/05 ream 11" to 570' at 1548 MDT; begin drilling new hole 575' @ 1635 MDT 580' @ 1726 MDT

Hole ID: SNL-14 | CORE LOG (cont. sheet) | Sheet 6 of 7

Logged by: Dennis W. Powers, Ph.D. | Date: 5/16-18/05

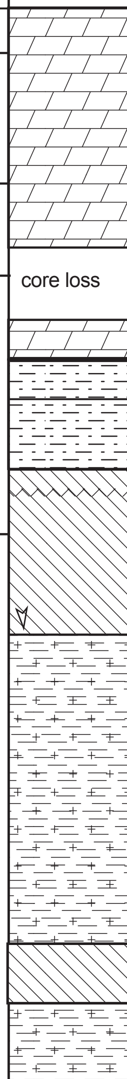
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	580	N/A	N/A			585' @ 1824 MDT 587' @ 1843 MDT, end drilling 5/16/05 Begin @ 587' at 0946 MDT 5/17/05
	590	C-55			A-3	590' @ 1015 MDT 594' @ 1045 MDT, add jt; begin 1105
	600	C-56			faster drilling rates @ 602-603'	600' @ 1208 MDT 605' @ 1302 MDT
	610	C-57			Anhydrite and gypsum; dark to light gray; laminar and thinly bedded; nodular(?) 619.7-619.5', 621-620.4'; cemented intraclasts of brown, fine-grained anhydrite in translucent anhydrite @620.4-620.1'. Laminae are slightly inclined (<5°). Gray brown laminae near base are very thin (0.06") and more convoluted f: high angle, 619.5-619.1', 621.8-621.3', 623.6-622.7'	610' @ 1353 MDT; circulate 615' @ 1441 MDT 619' @ 1525; circulate, prep for coring; begin coring 1710 MDT
3	620 630	cut 15'; recovered 13' (86.67%)	~1.3' in segments < 4" (RQD=90.00)	f	625.7' — 627.8-625.7': Claystone, gray (7.5YR4/N), sandy at base; bedding unclear at base, more laminae and bedding observed upward; deformed clast of bedded gypsum @ 626.5-626.0' in laminar, slickensided silty claystone. Gypsum-filled fracture in clast and claystone. M-4 632-627.8': Claystone, silty, dark reddish brown (2.5YR3/4); slightly calcareous; interbedded with sandy siltstone, light gray (10YR7/1), bedded to deformed, slightly calcareous; upper 2' general fining upward and color gradation; base of zone deformed into underlying bed. 637.7' — 637.7-632': Siltstone, argillaceous, and claystone, silty, dark reddish brown (2.5YR3/4); conglomeratic, dark red (2.5YR3/6) and gray (2.5YRN5/) mudstone intraclasts; larger sulfate clast @635.1'; some fining upward in 2 or 3 cycles; slickensides; sharp basal contact, 20° dip.	End coring @ 634' 5/17/05; begin coring @ 634' 5/18/05
4	640 650 660	cut 28.5'; recovered 28.5' (100%)	~3.5' in segments , 4", all Culebra (RQD=87.72)		A-2 Gypsum and anhydrite, gray, finely laminar to thin beds, horizontal to inclined several degrees, wavy to crenulated; some small bedded nodular textures ~643'; gray claystone 640.8-640.1' includes fibrous gypsum in horizontal separation; carbonate (algal?) laminae at 639.1-639'; erosional surface 651.8' with 0.5" relief. 653.3' Base of Tamarisk MemberTop of Culebra Dolomite Member	



Hole ID: SNL-14 | CORE LOG (cont. sheet) | Sheet 7 of 7

Logged by: Dennis W. Powers, Ph.D. | Date: 5/18-19/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
5	660	cut 7'; recovered 7' (100%)	~0.8' in segments > 4" (RQD=11.4)		Dolomite, brown to dark brown (10YR6/3; 10YR5/6 in upper 1.5'); fine laminae (algal) upper 1', horizontal bedding in intact cores (to ~661'); vugs .2-.3" @ 653.6-653.5', 655-654.5', 657-655.3'; vugs .5-1.0" 660.5-659'; vugs .2" 661-660.4; vugs < .5" from 673-665' in blocky fragments; rare .5" vugs 679-678'; recovered 1-3" blocky fragments 663-661" and 670-665'; blocks commonly have darker stained surfaces. Brown silty zone 673-671'. fg: low angle, platy gypsum fill, 657.3' f: 660-659', no fill, vertical, curved. f: 669.1-668.5', near vertical, curved, no fill. Gypsum from ~657-656' in some f and vugs	End coring @ 669.5' 5/18/05 Begin coring @ 669.5' 5/19/05
6	670	cut 5'; recovered 4'; (80%)	~1.2' in seg's < 4" (RQD=70)	core loss		
7	680	cut 14'; recovered 12' (85.7%)	~3' in segments < 4" (RQD=75.00)		**Base of Culebra Dolomite Member** / **Top of Los Medaños Member** — 679' M-2: Claystone, silty; gray 681.3-679', with gypsum (<0.25") and siltstone clasts, bedded, smeared intraclasts basal 1.0'; dark reddish brown 685-681.3', some siltstone and gypsum beds near top, smeared intraclasts @ 684.3-683.7', bedding in basal 0.7', some gray reduction spots or clasts, slickensided surfaces @ 45°; basal transition shows probable claystone clasts over gypsum. 685' A-1: Anhydrite; brownish gray, with reddish zone (polyhalitic?) 686.5-686.1' over erosional surface; laminar, horizontal to slightly wavy bedding; small (<0.5" high) halite pseudomorphs after bottom growth gypsum 693.1-692'; displacive halite 693.5-693.1'.	Core run #7 marked from base up; assumed core loss in Culebra
8	690 / 700 / 710	cut 30'; recovered 29' (96.67%)	~0.6' in segments < 4" (RQD=98)		694' M-1/H-1: 710.8-694': Halite, clear, and siltstone, reddish brown (5YR5/4 in lower part, 5YR4/3 in upper part; siltstone generally increases upward to thin siltstone at top; narrow f_h from 696-695' 696-694.5': less halite, more corroded margins 708.2-696': large displacive halite, some laminar mudstone 698.5-698' 710.8-708.2': 5-10% siltstone; coarse halite to 1" with displacive margins; halite to halite mosaic common. 714.1-710.8': Anhydrite, gray, and gypsum, white; bedded, wavy; salt crystals fill porosity near base and top. 718.5-714.1': Siltstone, reddish brown (5YR3/3) to light reddish brown (5YR6/3), with halite in small, irregular crystals and crystal masses; ~.1" darker siltstone clasts at top. 718.5'	
	720 / 730 / 740					



Sensitive briar(?) (*Mimosa rupertiana)* flowering in Los Medaños south of SNL-14. Photo taken May 16, 2005, by Dennis Powers.

Appendix D
Permitting and Completion Information

A case file for SNL-14 (C-3140) 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-3140.

Information on management of well-drilling wastes for SNL-14 is not included; at the time of basic data report preparation, these wastes were still being characterized for disposal.

Dennis W. Powers, Ph. D.

Consulting Geologist

May 6, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Drilling Decision on SNL-14

Here is a brief summary of the first three days of drilling at SNL-14 that provide background to a decision to change drilling methods at this time. The methods are not unusual or extraordinary; documenting the change is helpful for the historical record of the drillhole.

- On May 2, SNL-14 was drilled with air to 125 ft. Cuttings from the upper Dewey Lake were damp, but no water accumulated in the hole overnight.
- On May 3, SNL-14 was drilled to a depth of 208 ft, in the upper part of the middle Dewey Lake. Water was encountered, and drilling was stopped to reconfigure the temporary surface conductor pipe. A sample was taken for analysis; the field specific gravity was 1.0255 g/cc. At 1415 MDT, the water level was 176.6 ft below pad level.
- After the temporary surface casing was reconfigured, SNL-14 was bridged ~117 ft below the pad level. On the morning of May 4, no water was encountered above this bridge. The drillhole was re-entered, cleaned out, and drilling resumed from 208 ft. As drilling continued to 304 ft, in the lower part of the middle Dewey Lake, water production increased; Ronnie Keith halted drilling to consider drilling options. I was unsuccessful measuring water level in the drillhole with a Solinst probe because of foam in the hole. I installed a mini-Troll at 250 ft below pad level for overnight observations of inflow.
- On May 5, I obtained the pressure and temperature data from the drillhole and removed the mini-Troll. The water level is estimated to be about 167.9 ft below the pad level, based on the Solinst measurements. A sample of the water was taken for analysis. The field specific gravity was 1.0025 g/cc and the temperature was 19.6 °C.

Our original approach was to drill with air (with mist and soap assist as needed). We anticipated that we might encounter water in the Dewey Lake. I expected, consistent with basic Dewey lake hydrogeological concepts expressed in TP 02-05 (Powers, 2003), that water in the Dewey Lake in this area would be perched on a less permeable zone cemented with sulfate minerals, although the depth of this zone was unknown at the SNL-14 location. If a water-bearing zone in the Dewey Lake could be drilled through at a reasonable depth, a surface conductor casing could be installed into this cemented zone to isolate a producing zone. Then, drilling with air/mist could resume, with the intent of completing the hole without resorting to drilling with water and polymer. We recognize that the Culebra may be productive enough at SNL-14 that air/mist drilling will not be practical after the Culebra is penetrated. Dewey Lake hydrogeological concepts have not been altered; the depth to a cement change, if any, at SNL-14 is unknown and appears deep enough to warrant changes in methods.

Several factors led to the original drilling approach:

- Drilling with air is faster, and we have had better Culebra core recovery with air/mist.
- Drilling through the Dewey Lake with water and polymer produces a viscous mud that seems to be more difficult to remove from the Culebra during well development.
- Isolating the Dewey Lake with a casing could lessen the need for fluid storage and disposal, saving costs.

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Dennis W. Powers, Ph. D.
Consulting Geologist

I collected cuttings regularly and observed drilling rates to establish if the middle and lower Dewey Lake is adequately cemented with sulfate to enable us to reasonably case off the producing zone and resume drilling with air/mist. Cuttings from the lower part of the hole, below about 220 ft, were not very calcareous. I did not, however, see macroscopic evidence of sulfate cements or fracture fillings. In addition, cuttings continued to show chips of fine sand or siltstone that appeared somewhat porous, and water was produced more abundantly with depth. With the information available, I am unable to reliably estimate a depth at which we may encounter a change in vertical permeability that could be used as a casing point to isolate Dewey Lake water with a surface conductor casing. It is possible that the upper Rustler anhydrite/gypsum bed, at an estimated 455 ft depth, would be the first unit that could be used with confidence. It is also possible that we are near a cement change that would inhibit vertical infiltration.

The first decision is to switch to drilling with circulating water. This will reduce the production of fluids that need to be stored, tested, and disposed of, and it will protect drillhole integrity. Large volumes of circulating air with significant fluid production are likely to enlarge the drillhole through some of the poorly indurated Dewey Lake siltstone/sandstone encountered higher in the drillhole. For general security of the hole and operation, a switch to drilling with circulating water and polymer is necessary. To accommodate this method, a permanent surface conductor casing to about 43 ft depth was placed and cemented yesterday (05/05/05).

One alternative considered and discarded was to make necessary changes to continue drilling to a cement change or top of Rustler to case off the Dewey Lake inflow and return to drilling with air. This approach has been discarded because of

- the significant increase in costs of casing and cementing to much deeper unit than was planned,
- the delay in obtaining and placing a larger surface conductor casing to accommodate casing to top of Rustler, and
- the possibility that, even after those measures, drilling the Culebra and deeper Rustler would still require drilling with circulating water.

Effects of drilling with circulating water on the hydraulic properties of the Culebra are still of concern. As drilling proceeds, mitigating methods will be considered. One likely approach is to circulate out much of the drilling fluid before completing the well. The gravel pack and wider screen slots being used will assist in developing the well after completion.

I believe this letter summarizes our discussions and presents the hydrological and drilling background for deciding to change methods for drilling SNL-14.

Sincerely,

Dennis W. Powers

Powers, D.W., 2003b, 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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Dennis W. Powers, Ph. D.
Consulting Geologist

May 24, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-14

The information regarding the Culebra Dolomite Member in SNL-14 indicates that the best interval to screen is from 676–649.5 ft below the drilling pad level. This decision is based on geophysical logs completed on April 25, 2005 (see attached figure) and cores from SNL-14.

These are factors considered in this decision for SNL-14:

- The Culebra interval, based on the natural gamma geophysical log, is from 677–650 ft. This interval is 27 ft thick, about average around the WIPP site.
- Core across the transition from Culebra to Los Medaños was recovered reasonably intact. The gray claystone below the Culebra was more indurated and less plastic than in some drillholes. The base of the screen will be placed at 676 ft, about 1 ft above this contact, to prevent squeezing of the claystone into the screen.
- The screened or slotted section of the casing joint is 26.5 ft long. This will provide a screened interval that can incorporate all of the Culebra above the basal 1 ft (see above). The top of the screened interval will be at 649.5 ft.
- The laminated claystone and mudstone (M-2/H-2) below the Culebra was well sampled. No salt was detected in this section, and it does not need to be cemented.
- Cores below A-1 sampled halite to the final drilled depth of 718.5 ft. The drillhole was cemented back, and the top of cement was tagged at 679 ft, which is just below the Culebra. This uppermost cement will be drilled out when the well is reamed for casing. SNL-14 should be reamed to a depth of ~684–686 ft, a maximum of 2 ft into the anhydrite (A-1) below the Culebra.
- Geophysical logs and core above the Culebra indicate the anhydrite/gypsum unit (A-2) is intact and separates the Culebra from the Tamarisk Member mudstone (M-3) by 14 ft. The base of M-3 is at 636 ft. There is a thin siltstone in the upper part of A-2 (638-639.5 ft on logs) that should also be isolated from the Culebra screen interval.
- The sand/gravel pack should be placed from the base of the reamed drillhole to a depth of about 645 ft, just above the upper screen. The bentonite seal will be placed from about 645 to about 640 ft, and the annulus will be cemented from the top of the HolePlug® ft to the surface. This should prevent circulation into the Tamarisk mudstone (M-3).

To provide sump space below the screen interval, 5+ ft of blank casing with an end cap will be added below the screen. The length will be determined when the reaming is complete.

I believe this letter summarizes the hydrological and geological justification for setting the screened interval and preparing SNL-14 for completion.

Sincerely,

Dennis W Powers

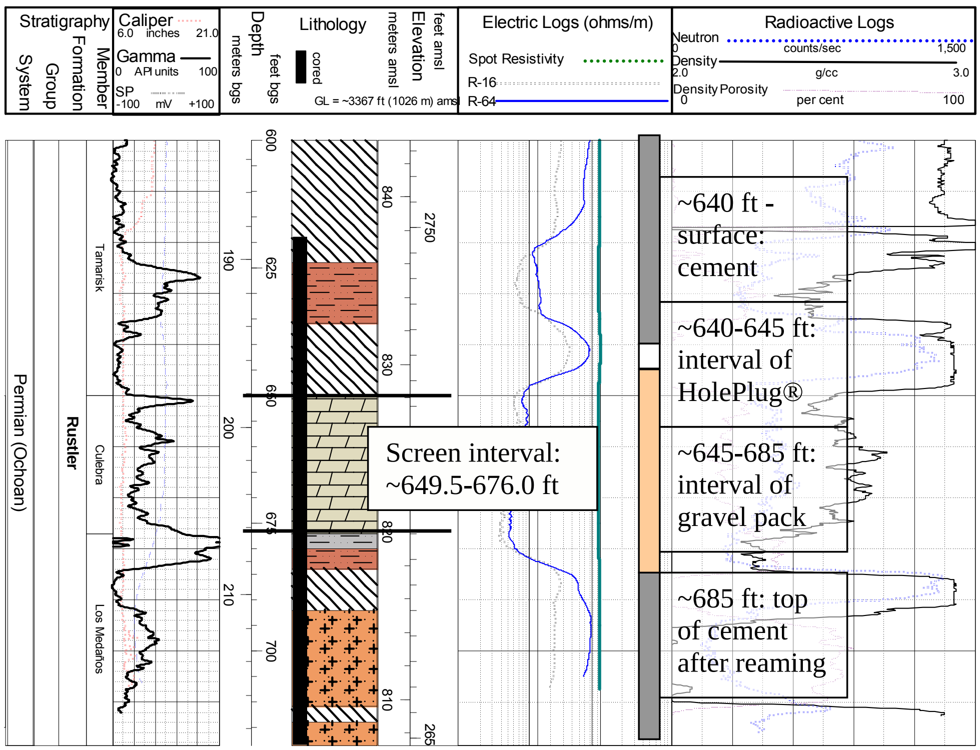
Dennis W. Powers

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

May 24, 2005

Partial Geophysical Log of SNL-14
Showing Completion Intervals



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

August 23, 2005

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-14

Background

Cores and cutting samples have been collected from drillhole SNL-14 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-14 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-14 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-14 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.

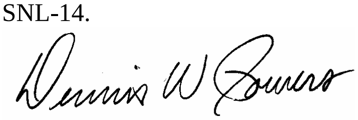
Core and Cuttings Retention Periods

It is recommended that cores obtained from SNL-14 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. The cuttings are commonly very fine in shallow sections and add little to the geologic record from initial observations as well as geophysical logs. 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-14.



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*

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 03140 must be completed and the Well Log filed on or before 12/31/2005.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd:	Date Rcvd. Corrected:
Formal Application Rcvd: 12/09/2004	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 17 day of Dec A.D., 2004

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

By: [signature]
Art Mason

Trn Desc: C 03140 MONITORING WELL

File Number: C 03140
Trn Number: 318422

page: 1

United States Department of the Interior

Bureau of Land Management
Carlsbad Field Office
620 E. Greene Street
Carlsbad, NM 88220
www.nm.blm.gov

IN REPLY REFER TO:
NM-108365
2805(080)owl

U. S. Dept. of Energy, Carlsbad Field Office
P. O. Box 3090
Carlsbad, NM 88221-3090

JAN 25 2005

RIGHT-OF-WAY RESERVATION AMENDMENT

KNOW ALL MEN BY THESE PRESENTS, that in accordance with section 507 of the Federal Land Policy and Management Act of 1976 (90 Stat. 2781, 43 U.S.C. 1767) that the United States of America acting by and through the U. S. Department of the Interior, Bureau of Land Management, does hereby issue and reserve to the U. S. Department of Energy, Carlsbad Field Office, Waste Isolation Pilot Plant (WIPP), a right-of-way amendment for two additional wellbores, and access roads for the expressed purpose of conducting groundwater investigations in support of the WIPP, over the following described real property situated in the County of Eddy, State of New Mexico to wit:

T. 23 S., R. 30 E., NMPM
Sec. 01: NE¼SE¼;
Sec. 04: SE¼NE¼,N½SE¼.

The well site locations contain approximately 1.034 acres (approximately 150′ X 150′) and the road contains approximately 1529.52 feet length, 30 feet width, for 2.087 acres. The combined acreage of the site locations and roads are 2.087 acres.

A plat showing the right-of-way described above is attached hereto as Exhibit A and made a part hereof.

The right-of-way herein granted and reserved is for the full use of the above described property by the U. S. Department of the Energy, Carlsbad Field Office, WIPP, subject to reasonable rules and regulations of the Secretary of the Interior, and to the following terms and conditions:

1. The facility will be constructed, operated, and maintained in accordance with the details specified in the application submitted January 6, 2005.

2. The Bureau of Land Management retains the right to occupy and use the right-of-way, provided such occupancy and use will not unreasonably interfere with the rights granted herein. The Bureau of Land Management may, if the Department of Energy, Carlsbad Field Office, WIPP concurs, grant rights and privileges for the use of the right-of-way to other compatible users including members of the public and other Government Departments and Agencies, States, and local subdivisions thereof.

3. Department of Energy, Carlsbad Field Office, WIPP, will be responsible for the security and day-to-day operation of the facility.

4. Any resources on lands within the right-of-way shall remain under the jurisdiction of the Bureau of Land Management and may be severed or extracted or disposed of only in accordance with applicable law and regulation of the Secretary of the Interior. The extraction, severance, and disposal of any such resources shall be subject to such stipulations, if any, that the Bureau of Land Management and Department of Energy, Carlsbad Field Office, WIPP, agree are needed to avoid unreasonable interference with the use of the land.

5. When and if the Department of Energy, Carlsbad Field Office, WIPP, no longer needs this amended reservation, if jurisdiction is not transferred to another entity, the Department of Energy, Carlsbad Field Office, WIPP, will rehabilitate the land according to the following specifications.

A. All structures, improvements, debris, etc., will be removed.

B. The land will be returned to the original contour.

C. All disturbed surfaces will be reseeded with a seed mixture conducive with Lesser Prairie Chicken habitat.

D. Attached are Special Stipulations for Site/Road Reclamation along with special stipulations for plugging and abandonment procedures.

6. The reservation being amended has a 30-year term, commencing on August 30, 2002.

Maria Lekelson

for Tony J. Herrell, Field Manager
Carlsbad Field Office, BLM

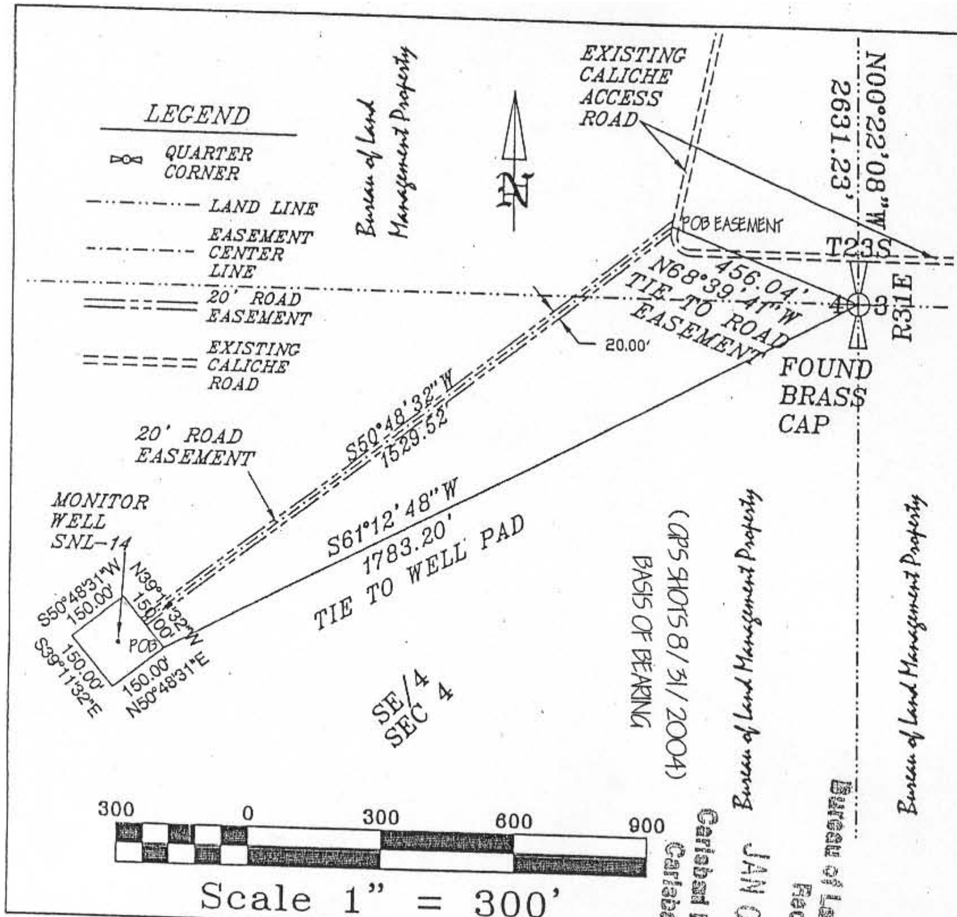
1-25-2005
Date

EXHIBIT A

FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT

FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES S61°12'48"W 1783.20' FROM THE E/4 CORNER OF SEC 4, T23S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N39°11'32"W FOR 150.00'; THEN S50°48'31"W FOR 150.00'; THEN S39°11'32"E FOR 150.00'; THEN N50°48'31"E FOR 150.00' TO THE POINT OF BEGINNING.

TOGETHER WITH A 20' ROAD EASEMENT, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED BY THE EASEMENT'S CENTER LINE AS FOLLOWS: BEGINNING AT A POINT THAT LIES N68°39'41"W 456.04' FROM THE E/4 CORNER OF SEC 4, T23S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO, WHICH POINT LIES ON THE WESTERLY EDGE OF AN EXISTING CALICHE ROAD; THEN S50°48'32"W FOR 1529.52' TO THE END OF THIS EASEMENT, WHICH END POINT LIES ON THE NORTHEAST SIDE OF A WELL PAD.

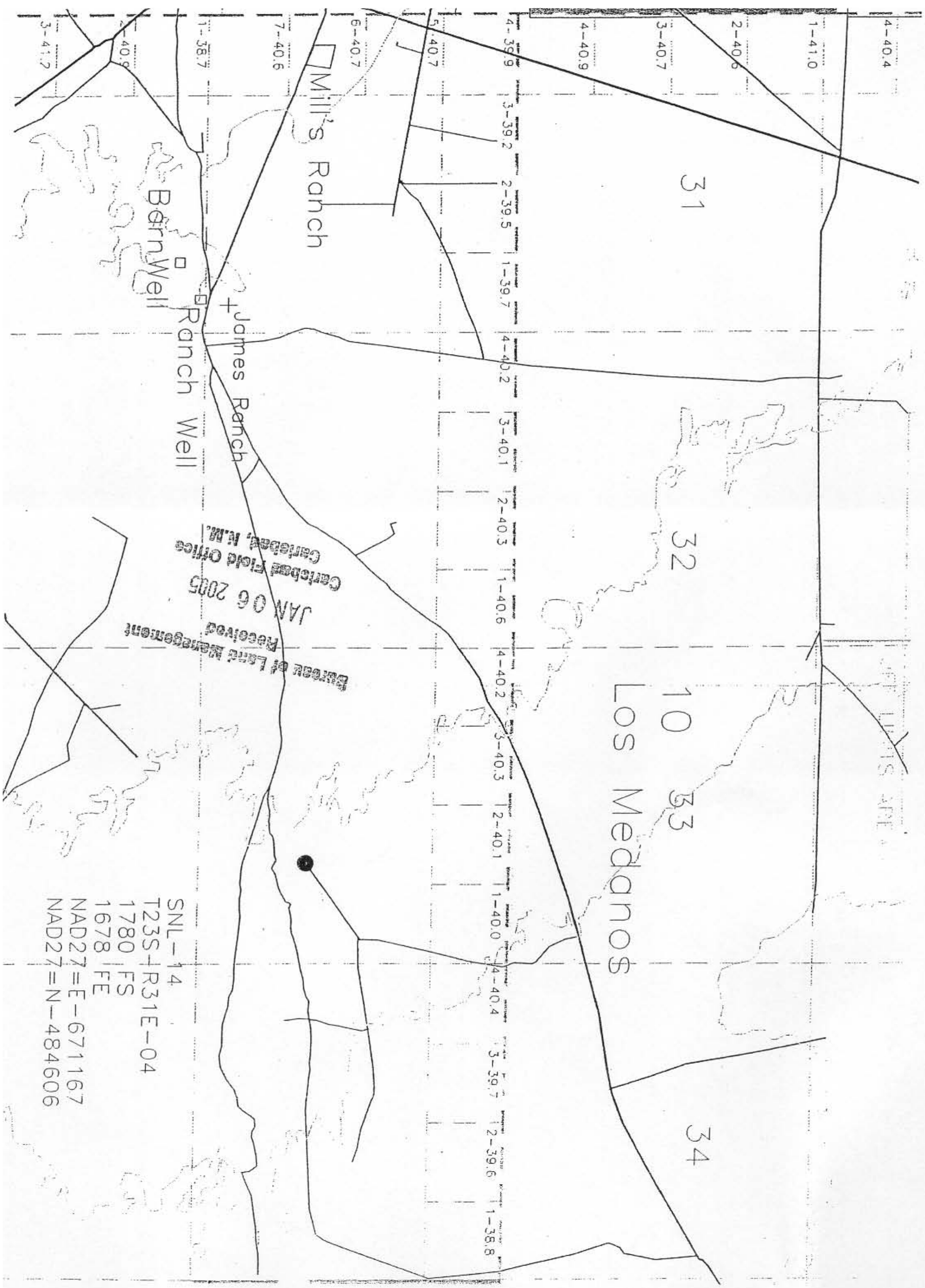


Bureau of Land Management
Received
JAN 06 2005
Carlsbad Field Office
Carlsbad, N.M.

THE NEW MEXICO
STATE PLANE EAST NAD27
COORDINATES FOR WELL
SNL-14
484606.02 N*
671166.22 E*
ELEV-3366.69*
(*SUBJECT TO CHANGE)

MELVIN R. PYEATT
NEW MEXICO
8510
REGISTERED PROFESSIONAL LAND SURVEYOR

WELL INFORMATION		
NUMBER SNL-14		
IN SEC. 4	T 23S	R 31E
COUNTY: EDDY		
STATE: NEW MEXICO		
DATE: SEPTEMBER 8, 2004		


Mill's Ranch
Barn Well
James Ranch
Ranch Well
31
32
33
34
10
Los Medanos
SNL-14
T23S-R31E-04
1780 FS
1678 FE
NAD27=E-671167
NAD27=N-484606
Received
Bureau of Land Management
JAN 06 2005
Carlsbad Field Office
Carlsbad, N.M.

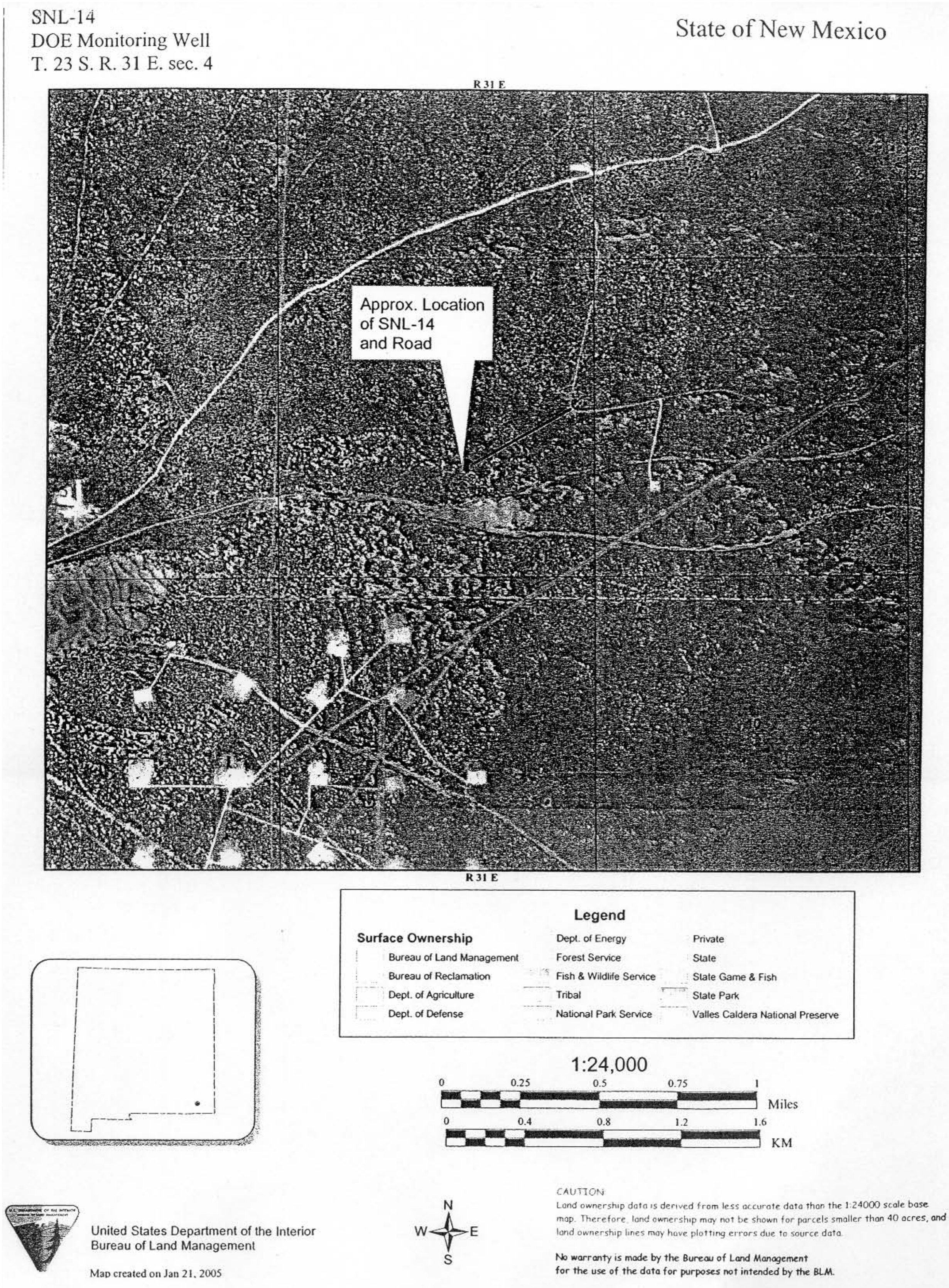

SNL-14
DOE Monitoring Well
T. 23 S. R. 31 E. sec. 4
State of New Mexico
R 31 E
Approx. Location of SNL-14 and Road
R 31 E
Legend
Surface Ownership
Bureau of Land Management
Bureau of Reclamation
Dept. of Agriculture
Dept. of Defense
Dept. of Energy
Forest Service
Fish & Wildlife Service
Tribal
National Park Service
Private
State
State Game & Fish
State Park
Valles Caldera National Preserve
1:24,000
0 0.25 0.5 0.75 1 Miles
0 0.4 0.8 1.2 1.6 KM
N W E S
CAUTION
Land ownership data is derived from less accurate data than the 1:24000 scale base map. Therefore, land ownership may not be shown for parcels smaller than 40 acres, and land ownership lines may have plotting errors due to source data.
No warranty is made by the Bureau of Land Management for the use of the data for purposes not intended by the BLM.
United States Department of the Interior
Bureau of Land Management
Map created on Jan 21, 2005

EXHIBIT B
January 21, 2005
NM-108365

STIPULATIONS FOR FLPMA SITES

1. The holder shall indemnify the United States against any liability for damage to life or property arising from the occupancy or use of public lands under this right-of-way.

2. The holder shall comply with all applicable Federal laws and regulations existing or hereafter enacted or promulgated. In any event, the holder shall comply with the Toxic Substances Control Act of 1976, as amended (15 U.S.C. 2601, *et. seq.*) with regard to any toxic substances that are used, generated by or stored on the right-of-way or on facilities authorized by this grant. (See 40 CFR, Part 702-799 and especially, provisions on polychlorinated biphenyls, 40 CFR 761.1-761.193.) Additionally, any release of toxic substances (leaks, spills, *etc.*) in excess of the reportable quantity established by 40 CFR, Part 117 shall be reported as required by the Comprehensive Environmental Response, Compensation and Liability Act, Section 102b. A copy of any report required or requested by any Federal agency or State government as a result of a reportable release or spill of any toxic substances shall be furnished to the Authorized Officer concurrent with the filing of the reports to the involved Federal agency or State government.

3. The holder agrees to indemnify the United States against any liability arising from the release of any hazardous substance or hazardous waste (as these terms are defined in the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C. 9601, *et. seq.* or the Resource Conservation and Recovery Act, 42 U.S.C. 6901, *et. seq.*) on the right-of-way (unless the release or threatened release is wholly unrelated to the right-of-way holder's activity on the right-of-way). This agreement applies without regard to whether a release is caused by the holder, its agent, or unrelated third parties.

4. If, during any phase of the construction, operation, maintenance, or termination of the site any pollutant should be discharged from site facilities, or from containers, or vehicles impacting public lands, the control and total removal, disposal, and cleanup of such pollutant, wherever found, shall be the responsibility of the holder, regardless of fault. Upon failure of the holder to control, dispose of, or clean up such discharge on or affecting public lands, or to repair all damages to public lands resulting therefrom, the Authorized Officer may take such measures as deemed necessary to control and cleanup the discharge and restore the area, including, where appropriate, the aquatic environment and fish and wildlife habitats, at the full expense of the holder. Such action by the Authorized Officer shall not relieve the holder of any liability or responsibility.

5. Sites shall be maintained in an orderly, sanitary condition at all times. Waste materials, both liquid and solid, shall be disposed of promptly at an appropriate, authorized waste disposal facility in accordance with all applicable State and Federal laws. "Waste" means all discarded matter including, but not limited to, human waste, trash, garbage, and equipment.

6. All above-ground structures not subject to safety requirements shall be painted by the holder to blend with the natural color of the landscape. The paint used shall be a color which simulates "Standard Environmental Colors" designated by the Rocky Mountain Five-State Interagency Committee. The color selected for this project is Shale Green, Munsell Soil Color Chart Number 5Y 4/2.

NM-108365
January 21, 2005
Page 2 of 2

7. The holder shall post a sign designating the BLM serial number assigned to this right-of-way grant in a permanent, conspicuous location on the site where the sign will be visible from the entry to the site. This sign will be maintained in a legible condition for the term of the right-of-way.

8. Any cultural and/or paleontological resource (historic or prehistoric site or object) discovered by the holder, or any person working on the holder's behalf, on public or Federal land shall be immediately reported to the Authorized Officer. The holder shall suspend all operations in the immediate area of such discovery until written authorization to proceed is issued by the Authorized Officer. An evaluation of the discovery will be made by the Authorized Officer to determine appropriate actions to prevent the loss of significant cultural or scientific values. The holder will be responsible for the cost of evaluation and any decision as to the proper mitigation measures will be made by the Authorized Officer after consulting with the holder.

9. Should the holder require a base of mineral material, a sales contract for removal of mineral material (caliche, sand, gravel, fill dirt) from an authorized pit, site, or on location must be obtained from the BLM prior to commencing construction. There are several options available for purchasing mineral material: contact the BLM office.

10. The area will be kept free of the following plant species: Malta starthistle, African rue, Scotch thistle, and saltcedar.

Special Stipulations:

The Authorized Officer will be contacted for the well pads and access road restoration instructions when the wells are ready for final abandonment procedures. AT that time fill restoration of the sites (150' X 150') will be addressed.

EXHIBIT C

BLM Serial No.: NM-108365
Company Reference:

Seed Mixture for LPC Sand/Shinnery Sites

The holder shall seed all disturbed areas with the seed mixture listed below. The seed mixture shall be planted in the amounts specified in pounds of pure live seed (PLS)* per acre. There shall be no primary or secondary noxious weeds in the seed mixture. Seed will be tested and the viability testing of seed will be done in accordance with State law(s) and within nine (9) months prior to purchase. Commercial seed will be either certified or registered seed. The seed container will be tagged in accordance with State law(s) and available for inspection by the authorized officer.

Seed will be planted using a drill equipped with a depth regulator to ensure proper depth of planting where drilling is possible. The seed mixture will be evenly and uniformly planted over the disturbed area (smaller/heavier seeds have a tendency to drop the bottom of the drill and are planted first). The holder shall take appropriate measures to ensure this does not occur. Where drilling is not possible, seed will be broadcast and the area shall be raked or chained to cover the seed. When broadcasting the seed, the pounds per acre are to be doubled. The seeding will be repeated until a satisfactory stand is established as determined by the authorized officer. Evaluation of growth will not be made before completion of at least one full growing season after seeding.

Species to be planted in pounds of pure live seed* per acre:

Species	lb/acre
Plains Bristlegrass	5lbs/A
Sand Bluestem	5lbs/A
Little Bluestem	3lbs/A
Big Bluestem	6lbs/A
Plains Coreopsis	2lbs/A
Sand Dropseed	1lbs/A
**Four-winged Saltbush	5lbs/A

* This can be used around well pads and other areas where caliche cannot be removed.

*Pounds of pure live seed:

Pounds of seed **x** percent purity **x** percent germination = pounds pure live seed

SPECIAL STIPULATIONS

RIGHT-OF-WAY RESERVATION
NM-108365

Casing / Plugging & Abandonment Requirements

(1) Casing Program

(a) A salt protection string of new or used casing in good condition shall be set in any well which has reached the salt section. Well depth permitting, the casing shall be set not less than one hundred (100) feet below the base of the salt section. If the well does not extend to a depth of at least one hundred (100) feet below the base of the salt section, the casing shall be set at total depth.

(b) The salt protection string shall be cemented with sufficient cement to fill the annular space back of the pipe from the casing seat to the surface or to the bottom of the cellar.

(c) If the cement fails to reach the surface or the bottom of the cellar, the top of the cement shall be located by a temperature, gamma ray or other survey and additional cementing shall be done until the cement is brought to the point required.

(d) The fluid used to mix the cement shall be saturated with the salts common to the zones penetrated and with suitable proportions but not less than one (1) percent of calcium chloride by weight of cement.

(e) Cement shall be allowed to stand a minimum of twelve (12) hours under pressure and a total of twenty-four (24) hours before drilling the plug or initiating tests.

(f) Casing tests shall be made both before and after drilling the plug and below the casing seat. The mud shall be displaced with water and a hydraulic pressure of one thousand (1000) pounds per square inch shall be applied. If a drop of one hundred (100) pounds per square inch should occur within thirty (30) minutes, corrective measures shall be applied.

(g) The Bureau of Land Management may require the use of centralizers on the salt protection string when in their judgement the use of such centralizers would offer further protection to the salt section.

(2) Plugging and Abandonment

(a) The wells shall be plugged in a manner and in accordance with rules established by the Bureau of Land Management that will provide a solid cement plug from total depth to the surface.

(b) The fluid used to mix the cement shall be saturated with the salts common to the salt section penetrated and with suitable proportions but not more than three (3) percent of calcium chloride by weight of cement being considered the desired mixture whenever possible.

BLM Serial Number: NM-108365
Company Reference:
Well No. & Name: SNL-13 & SNL-14

STANDARD STIPULATIONS FOR PERMANENT RESOURCE ROADS
CARLSBAD FIELD OFFICE

A copy of the reservation and attachments, including stipulations and map, will be on location during construction. BLM personnel may request to view a copy of your permit during construction to ensure compliance with all stipulations.

The holder/grantee/permittee shall hereafter be identified as the holder in these stipulations. The Authorized Officer is the person who approves the Application for Permit to Drill (APD) and/or Right-of-Way (ROW).

GENERAL REQUIREMENTS

A. The holder shall indemnify the United States against any liability for damage to life or property arising from the occupancy or use of public lands under this grant.

B. The holder shall comply with all applicable Federal laws and regulations existing or hereafter enacted or promulgated. In any event, the holder shall comply with the Toxic Substances Control Act of 1976, as amended (15 U.S.C. 2601, *et. seq.*) with regard to any toxic substances that are used, generated by or stored on the right-of-way or on facilities authorized by this grant. (See 40 CFR, Part 702-799 and especially, provisions on polychlorinated biphenyls, 40 CFR 761.1-761.193.) Additionally, any release of toxic substances (leaks, spills, etc.) in excess of the reportable quantity established by 40 CFR, Part 117 shall be reported as required by the Comprehensive Environmental Response, Compensation and Liability Act, Section 102b. A copy of any report required or requested by any Federal agency or State government as a result of a reportable release or spill of any toxic substances shall be furnished to the Authorized Officer concurrent with the filing of the reports to the involved Federal agency or State government.

C. The holder agrees to indemnify the United States against any liability arising from the release of any hazardous substance or hazardous waste (as these terms are defined in the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C. 9601, *et. seq.* or the Resource Conservation and Recovery Act, 42 U.S.C. 6901, *et. seq.*) on the right-of-way (unless the release or threatened release is wholly unrelated to the right-of-way holder's activity on the right-of-way). This agreement applies without regard to whether a release is caused by the holder, its agent, or unrelated third parties.

D. If, during any phase of the construction, operation, maintenance, or termination of the road, any oil or other pollutant should be discharged, impacting Federal lands, the control and total removal, disposal, and cleaning up of such oil of other pollutant, wherever found, shall be the responsibility of the holder, regardless of fault. Upon failure of the holder to control, dispose of, or clean up such discharge on or affecting Federal lands, or to repair all damages to Federal lands resulting therefrom, the Authorized

Officer may take such measures as deemed necessary to control and cleanup the discharge and restore the area, including, where appropriate, the aquatic environment and fish and wildlife habitats, at the full expense of the holder. Such action by the Authorized Officer shall not relieve the holder of any liability or responsibility.

E. The holder shall minimize disturbance to existing fences and other improvements on public domain surface. The holder is required to promptly repair improvements to at least their former state. Functional use of these improvements will be maintained at all times.

The holder will make a documented good-faith effort to contact the owner of any improvements prior to disturbing them. When necessary to pass through a fence line, the fence shall be braced on both sides of the passageway prior to cutting of the fence.

F. The Holder shall ensure that the entire right-of-way, including the driving surface, ditching and drainage control structures, road verges and any construction sites or zones, will be kept free of the following plant species: Malta starthistle, African rue, Scotch thistle and salt cedar.

Holder agrees to comply with the following stipulations:

1. ROAD WIDTH AND GRADE

The road will have a driving surface of 14 feet (all roads shall have a minimum driving surface of 12 feet, unless local conditions dictate a different width). The maximum grade is 10 percent unless the box below is checked. Maximum width of surface disturbance from construction will be 30 feet.

/__/ Those segments of road where grade is in excess of 10% for more than 300 feet shall be designed by a professional engineer.

2. CROWNING AND DITCHING

Crowning with materials on site and ditching on one side of the road on the uphill side will be required. The road cross-section will conform to the cross section diagrams in Figure 1. If conditions dictate, ditching may be required for both sides of the road; if local conditions permit, a flat-bladed road may be considered (if these conditions exist, check the appropriate box below). The crown shall have a grade of approximately 2% (i.e., 1" crown on a 12' wide road).

/__/ Ditching will be required on both sides of the roadway as shown on the attached map or as staked in the field.

/__/ Flat-blading is authorized on segment(s) delineated on the attached map.

2

3. DRAINAGE

Drainage control shall be ensured over the entire road through the use of borrow ditches, outsloping, insloping, natural rolling topography, lead-off (turnout) ditches, culverts, and/or drainage dips.

A. All lead-off ditches shall be graded to drain water with a 1 percent minimum to 3 percent maximum ditch slope. The spacing interval for lead-off ditches shall be determined according to the following table, but may be amended depending upon existing soil types and centerline road slope (in %):

SPACING INTERVAL FOR TURNOUT DITCHES

Percent slope	Spacing interval
0% - 4%	400' - 150'
4% - 6%	250' - 125'
6% - 8%	200' - 100'
8% - 10%	150' - 75'

A typical lead-off ditch has a minimum depth of 1 foot below and a berm 6 inches above natural ground level. The berm will be on the down-slope side of the lead-off ditch. The ditch end will tie into vegetation whenever possible.

For this road the spacing interval for lead-off ditches shall be at

/_x_/ 400 foot intervals.

/__/ ____ foot intervals.

/__/ locations staked in the field as per spacing intervals above.

/__/ locations delineated on the attached map.

B. Culvert pipes shall be used for cross drains where drainage dips or low water crossings are not feasible. The minimum culvert diameter must be 18 inches. Any culvert pipe installed shall be of sufficient diameter to pass the anticipated flow of water. Culvert location and required diameter are shown on the attached map (Further details can be obtained from the Roswell District Office or the appropriate Resource Area Office).

C. On road slopes exceeding 2%, drainage dips shall drain water into an adjacent lead-off ditch. Drainage dip location and spacing shall be determined by the formula:

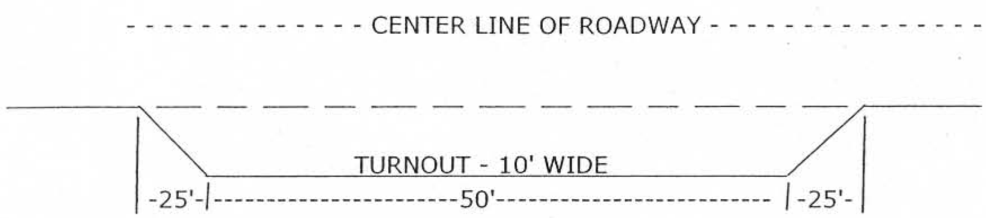
$$\text{spacing interval} = \frac{400'}{\text{road slope in \%}} + 100'$$

Example: 4% slope: $\text{spacing interval} = \frac{400}{4} + 100 = 200 \text{ feet}$

3

4. TURNOUTS

Unless otherwise approved by the Authorized Officer, vehicle turnouts will be required. Turnouts will be located at 2000-foot intervals, or the turnouts will be intervisible, whichever is less. Turnouts will conform to the following diagram:



STANDARD TURNOUT - PLAN VIEW

5. SURFACING

Surfacing of the road or those portions identified on the attached map may, at the direction of the Authorized Officer, be required, if necessary, to maintain traffic within the right-of-way with caliche, gravel, or other surfacing material which shall be approved by the Authorized Officer. When surfacing is required, surfacing materials will be compacted to a minimum thickness of six inches with caliche material. The width of surfacing shall be no less

than the driving surface. Prior to using any mineral materials from an existing or proposed Federal source, authorization must be obtained from the Authorized Officer.

A sales contract for the removal of mineral materials (caliche, sand, gravel, fill dirt, etc.) from an authorized pit, site, or on location must be obtained from the BLM prior to using any such mineral material from public lands. Contact the BLM solid minerals staff for the various options to purchase mineral material.

6. CATTLEGUARDS

Where used, all cattleguard grids and foundation designs and construction shall meet the American Association of State Highway and Transportation Officials (AASHTO) Load Rating H-20, although AASHTO U-80 rated grids shall be required where heavy loads (exceeding H-20 loading), are anticipated (See BLM standard drawings for cattleguards). Cattleguard grid length shall not be less than 8 feet and width of not less than 14 feet. A wire gate (16-foot minimum width) will be provided on one side of the cattleguard unless requested otherwise by the surface user.

7. MAINTENANCE

The holder shall maintain the road in a safe, usable condition. A maintenance program shall include, but not be limited to blading, ditching, culvert installation, culvert cleaning, drainage installation, cattleguard maintenance, and surfacing.

8. PUBLIC ACCESS

Public access along this road will not be restricted by the holder without specific written approval being granted by the Authorized Officer. Gates or cattleguards on public lands will not be locked or closed to public use unless closure is specifically determined to be necessary and is authorized in writing by the Authorized Officer.

9. CULTURAL RESOURCES

Any cultural and/or paleontological resource (historic or prehistoric site or object) discovered by the holder, or any person working on the holder's behalf, on public or Federal land shall be immediately reported to the authorized officer. The holder shall suspend all operations in the immediate area of such discovery until written authorization to proceed is issued by the authorized officer. An evaluation of the discovery will be made by the authorized officer to determine appropriate actions to prevent the loss of significant cultural or scientific values. The holder will be responsible for the cost of evaluation and any decision as to the proper mitigation measures will be made by the authorized officer after consulting with the holder.

10. SPECIAL STIPULATIONS:

The authorized officer will be contacted for the access road restoration instructions when the roads are ready for the final abandonment procedures. At that time full restoration of the roads will be addressed.

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-14
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NM 88221

Well was drilled under Permit No. C3140 and is located in the:

a. NW ¼ SE ¼ ___ ¼ ___ ¼ of Section 4 Township 23 S Range 31 E N.M.P.M.

b. Tract No. N/A of Map No. N/A of the ___

c. Lot No. ___ of Block No. ___ of the CARLSBAD DISTRICT 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. WD-1184

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 05-02-05 Completed 05-25-05 Type tools MUD ROTARY Size of hole 11" in.

Elevation of land surface or ___ at well is 3366.69 ft. Total depth of well 684 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)
650	677	27	BROWN 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
20"	52.78	N/A	0	7	7			
12-3/4	33.41	N/A	3' AGL	42-1/2	45-1/2			
5-1/2 IBERGLASS	4.4	4	2-1/2' AGL	684	686-1/2		649.5	.070 SCREEN 676

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
716	679	6-3/4		17	TRIMMIE
0	640	11" 5-1/2 CSG		378	TRIMMIE

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	9	7	PALE BROWN DUNE SAND & BASAL REDDISH-BROWN BERINO SOIL
9	12	3	WHITE CALICHE & CALCAREOUS SAND (MESCALERO)
12	26	14	WEAK RED SANDSTONE & LAMINATED CLAYSTONE (TRIASSIC SANTA ROSA FORMATION
26	482	456	RED TO REDDISH BROWN SANDY SILTSTONE, SILTY CLAYSTONE & FINE SANDSTONE (DEWEY LAKE FORMATION)
482	536	54	GRAY GYPSUM & ANHYDRITE BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE (FORTY-NINER MEMBER OF RUSTLER FORMATION)
536	564	28	LIGHT OLIVE GRAY TO WHITE GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
564	650	86	GRAY ANHYDRITE & GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE & SILTSTONE (TAMARISK MEMBER OF THE RUSTLER FORM.)
650	677	27	BROWN DOLOMITE WITH SOME GYPSUM (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
677	684	7	DARK GRAY TO REDDISH BROWN GYPSIFEROUS CLAYSTONE & SILTSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
684	692	8	GRAY ANHYDRITE & GYPSUM (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
692	718.5	26.5	REDDISH BROWN ARGILLACEOUS TO SILTY HALITE (MIDDLE 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.

Tommy 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.

1. (For BLM Use) **BLM Report No.**	**2. (For BLM Use)** **Reviewer's Initials/Date**_______ **Accepted ( ) Rejected ( )**	**3. NMCRIS Number:** 90928

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

5. Title of Report: A Cultural Resource Survey for the SNL-14 Monitor Well Pad **Author(s):** Theresa Straight	**6. Fieldwork Date(s):** November 22, 2004 **7. Report Date:** November 30, 2004
8. Consultant Name/Address: Mesa Field Services **Direct Charge:** Sean Simpson **Field Personnel Names:** Sean Simpson and Theresa Straight **Address:** P.O. Box 3072 Carlsbad, New Mexico 88221-3072 **Phone (**505**)** 628-8885	**9. Cultural Resource Permit No.:** 153-2920-03-N **10. Consultant Report No.:** MFS-1099
11. Customer Name: Westinghouse TRU Solutions, LLC **Responsible Individual:** Ron Richardson **Address:** P.O. Box 2078 Carlsbad, NM 88221 **Phone:** (505) 234-8395	**12. Customer Project No.:** P.O. No. 107596

13. Land Status	**BLM**	**State**	**Private**	**Other**	**Total**
a. Area Surveyed (acres)	5.58				5.58
b. Area of Effect (acres)	1.22				1.22

14. Linear **Length**__1,529.52____ **Width**__100 ft__
Block **Length**____350 ft____ **Width**__350 ft___

15. Location (Map[s] Attached):

a. State: New Mexico

b. County: Eddy County

c. BLM Office: Carlsbad Field Office

d. Nearest City or Town: Carlsbad, NM

e. Legal Description: T23S, R31E, Section 4: SE¼ NE¼, N½ SE¼

f. Well Pad Footages: approximately 1,750 ft FSL, 1,725 ft FEL

g. USGS 7.5' Map Name(s), Date(s), and Code(s): Los Medanos, New Mexico Provisional Edition 1985 (32103-C7)

16. Project Data:

a. Records Search: **Date(s) of BLM File Review:** November 16, 2004 **Name of Reviewer(s):** Theresa Straight
Date(s) of ARMS Data Review November 16, 2004 **Name of Reviewer(s):** Theresa Straight
Findings (see Field Office requirements to determine area to be reviewed during records search): No previously recorded cultural material is within the project area.

b. Description of Undertaking: Westinghouse TRU Solutions, LLC plans to build a monitor well. The well pad is located in Township 23 South, Range 31 East, Section 4. It will measure 150 ft square. The access road begins on an existing road and travels 1,529.52 ft southwest to the pad. The road will have a 20 ft wide easement. A 350 ft square was surveyed around the well pad and a 100 ft wide corridor was surveyed along the access road to protect cultural resources. A total of 5.58 acres was surveyed on land owned and administered by the BLM-CFO.

c. Environmental Setting (NRCS soil designation; vegetative community; elevation; etc.): The project area is located 13 miles east of Carlsbad, NM. The terrain slopes to the southwest at a grade of 1.7 percent. Soils were wind worked into dunes up to 2 m high and are of the Kermit-Berino association as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Local vegetation is typical of Chihuahuan Desert Scrub and includes mesquite, shin oak, grasses, forbs, prickly pear, and sand sage. Due to the vegetative cover, ground surface visibility ranged from 40 to 60 percent at the time of the survey.

Meteorological data was obtained for the Waste Isolation Pilot Plant (WIPP) from the Western Regional Climate Center online database. From 1986 to 2002, WIPP received an annual precipitation of 12.68 inches. June through August were the wettest months while January through March was the driest. During the same time, WIPP had an average annual high temperature of 80.1 degrees Fahrenheit and an average annual low temperature of 48.9 degrees Fahrenheit. December was the coldest month with an average high of 60.0 degrees Fahrenheit, while July was the warmest with an average high temperature of 98.0 degrees Fahrenheit.

d. Field Methods (transect intervals; crew size; time in field; etc.): A crew of two spent 1 hour surveying the project area. A 15 m wide transect was used.

e. Artifacts Collected?: None

17. Cultural Resource Findings: No cultural sites were encountered during the course of this project.

a. Location/Identification of Each Resource: N/A

b. Evaluation of Significance of Each Resource: N/A

18. Management Summary (Recommendations): Because no significant cultural material was encountered during the survey, archaeological clearance is recommended for the project as staked. If any additional cultural material is encountered during construction activities, work at that location should stop and archaeologists with the BLM-CFO should be notified.

19.

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

Responsible Archaeologist________________________________ ______________
Signature **Date**

THE ABOVE COMPLETES A NEGATIVE REPORT. IF ELIGIBLE OR POTENTIALLY ELIGIBLE PROPERTIES ARE INVOLEVED, THE ABOVE WILL BE THE TITLE PAGE AND ABSTRACT FOR A COMPLETE REPORT.

Survey for the SNL-14 Monitor Well

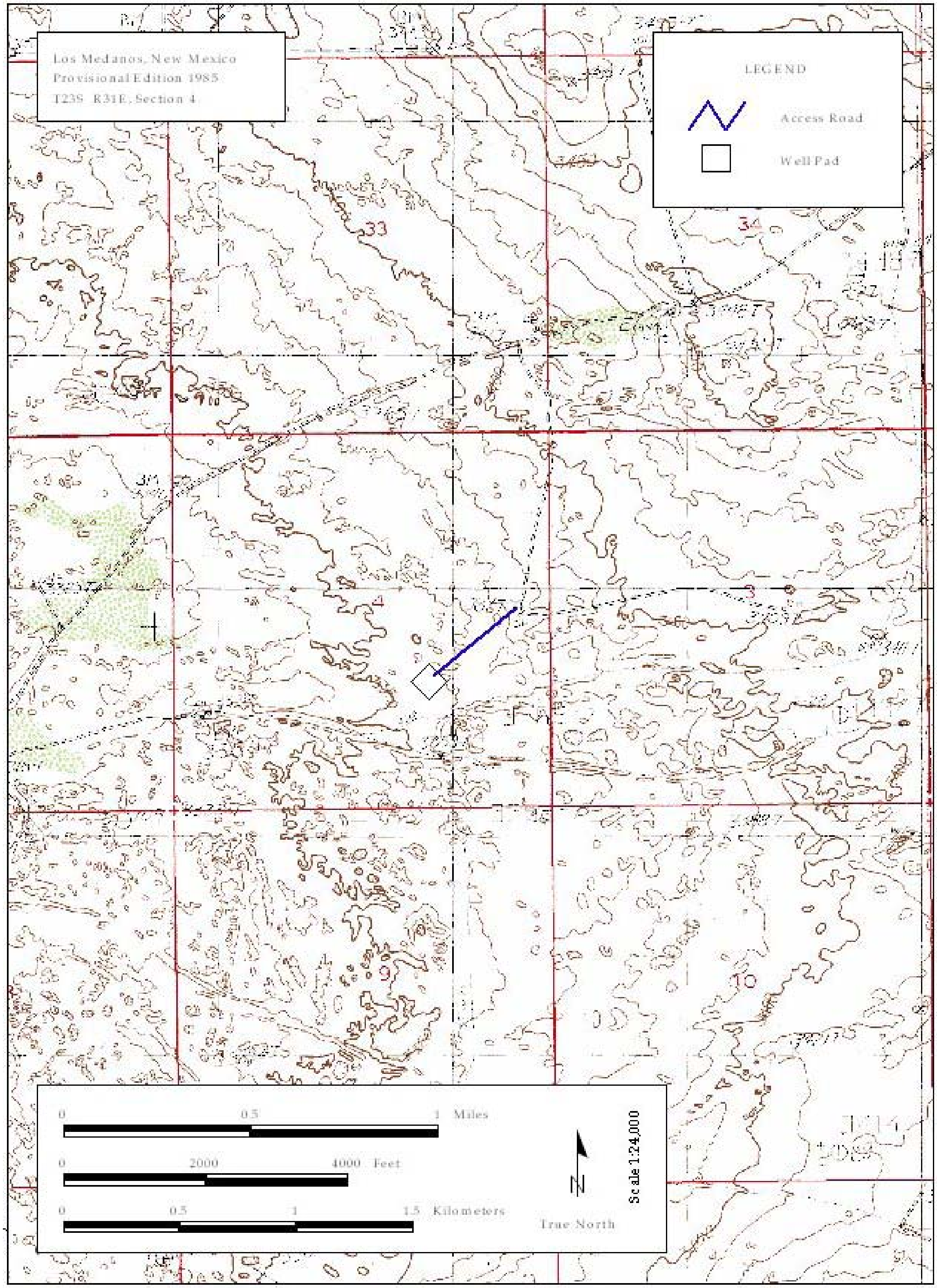


Figure 1. Project Area Map

Mesa Field Services

Appendix F
Photograph Logs

Digital photographs were taken of the cores from SNL-14. A listing 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), has been compiled and is included here in Appendix F. 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-14_Core001.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 538.0 - 539.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core002.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 538.9 - 540.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core003.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 539.9 - 541.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core004.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 540.9 - 542.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core005.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 541.9 - 543.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core006.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 542.9 - 544.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core007.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 543.9 - 545.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core008.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 544.9 - 546.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core009.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 545.9 - 547.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core010.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 546.9 - 548.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core011.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 547.9 - 549.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core012.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 548.9 - 550.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core013.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 549.9 - 551.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core014.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 550.9 - 552.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core015.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 551.9 - 553.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core016.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 552.9 - 554.1 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-14_Core017.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 553.9 - 555.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core018.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 554.9 - 556.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core019.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 556.0 - 557.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core020.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 556.9 - 558.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core021.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 557.9 - 559.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core022.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 558.9 - 560.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core023.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 559.9 - 561.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core024.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 560.9 - 562.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core025.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 561.9 - 563.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core026.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite Mbr core, 562.9 - 564.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core027.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Magenta Dolomite/ Tamarisk Mbrs core, 563.9 - 565.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core028.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 564.9 - 566.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core029.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 565.9 - 567.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core030.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 566.9 - 568.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core031.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 567.9 - 569.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core032.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 568.9 - 570.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 2 of 9

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-14_Core033.jpg	5/14/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 569.9 - 570.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core034.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 619 - 620.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core035.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 619.9 - 621.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core036.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 621.0 -622.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core037.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 622.0 - 623.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core038.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 622.9 - 624.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core039.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 624.0 - 625.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core040.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 624.9 - 626.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core041.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 625.9 - 627.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core042.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 626.9 - 628.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core043.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 627.9 - 629.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core044.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 628.9 - 630.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core045.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 629.9 - 631.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core046.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 630.9 - 632.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core047.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 634.0 - 635.1ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core048.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 635.0 - 636.0 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-14_Core049.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 636.0 - 637.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core050.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 636.9 - 638.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core051.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 638.0 - 639.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core052.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 639.0 - 640.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core053.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 640.0 - 641.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core054.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 641.0 - 642.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core055.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 642.0 - 643.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core056.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 642.9 - 644.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core057.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 643.9 - 645.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core058.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 644.9 - 646.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core059.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 645.9 - 646.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core060.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 646.5 - 647.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core061.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 646.9 - 648.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core062.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 647.9 - 649.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core063.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 649.0 - 650.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core064.jpg	5/18/06	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 649.9 - 651.1 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-14_Core065.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 650.9 - 652.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core066.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk Mbr core, 651.9 - 653.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core067.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Tamarisk/Culebra Dolomite Mbr score, 652.9 - 654.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core068.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 653.8 - 655.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core069.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 654.8 - 656.2 ft bgl, with scale	DW Powers Consultant to WTS
SNL-14_Core070.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 655.8 - 657.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core071.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 656.8 - 658.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core072.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core,657.8 - 659.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core073.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 658.9 - 660.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core074.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 659.9 - 661.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core075.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 660.9 - 662.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core076.jpg	5/18/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 661.9 - 662.5 ft bgl, with scale, no markings, broken core	DW Powers Consultant to WTS
SNL-14_Core077.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 662.5 - 663.1 ft bgl, with scale, no markings, broken core in box	DW Powers Consultant to WTS
SNL-14_Core078.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 662.9 - 664.1 ft bgl, with markings, scale, in box	DW Powers Consultant to WTS
SNL-14_Core079.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 663.9 - 664.5 ft bgl, with markings, scale, in box	DW Powers Consultant to WTS
SNL-14_Core080.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 664.5 - 665.3 ft bgl, with scale, broken core in box	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-14_Core081.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 665.0 - 666.1 ft bgl, with scale, broken core in box	DW Powers Consultant to WTS
SNL-14_Core082.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 666.0 - 666.5 ft bgl, with scale, broken coe in box	DW Powers Consultant to WTS
SNL-14_Core083.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 666.5 - 667.1 ft bgl, with scale, broken core in box	DW Powers Consultant to WTS
SNL-14_Core084.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 667.0 - 668.2 ft bgl, with scale, broken core in box	DW Powers Consultant to WTS
SNL-14_Core085.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 668.0 - 668.5 ft bgl, with scale, broken core in box	DW Powers Consultant to WTS
SNL-14_Core086.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 668.5 - 669.2 ft bgl, with scale, fractured core in box	DW Powers Consultant to WTS
SNL-14_Core087.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 669.0 - 669.5 ft bgl, with scale, broken core in box	DW Powers Consultant to WTS
SNL-14_Core088.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 669.5 - 670.1 ft bgl, with scale, broken core in tray	DW Powers Consultant to WTS
SNL-14_Core089.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 669.9 - 671.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core090.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 671.0 - 672.1 ft bgl, with scale, fractured core in tray	DW Powers Consultant to WTS
SNL-14_Core091.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 672.0 - 673.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core092.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 676.7 - 677.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core093.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 676.9 - 678.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core094.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite Mbr core, 677.9 - 679.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core095.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Culebra Dolomite/Los Medaños Mbrs core, 678.9 - 680.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core096.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 679.9 - 681.0 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-14_Core097.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 680.9 - 682.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core098.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 681.9 - 683.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core099.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 682.9 - 684.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core100.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 683.9 - 685.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core101.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 685.0 - 686.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core102.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 685.9 - 687.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core103.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 686.9 - 688.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core104.jpg	5/19/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 688.0 - 688.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core105.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 688.5 - 689.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core106.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 688.9 - 690.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core107.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 689.9 - 691.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core108.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 690.9 - 692.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core109.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 691.9 - 693.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core110.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 692.9 - 694.0 ft bgl, with scale	DW Powers Consultant to WTS
SNL-14_Core111.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 693.9 - 695.0 ft bgl, with scale	DW Powers Consultant to WTS
SNL-14_Core112.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 694.9 - 696.0 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-14_Core113.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 695.9 - 697.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core114.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 696.9 - 698.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core115.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 697.9 - 699.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core116.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 698.9 - 700.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core117.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 699.9 - 701.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core118.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 700.9 - 702.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core119.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 702.0 - 703.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core120.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 702.9 - 704.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core121.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 703.9 - 704.7 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core122.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 704.7 - 705.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core123.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 704.9 - 706.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core124.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 705.9 - 707.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core125.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 706.9 - 708.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core126.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 707.9 - 709.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core127.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 708.9 - 710.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core128.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 709.9 - 711.0 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-14_Core129.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 710.9 - 712.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core130.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 711.9 - 713.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core131.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 712.9 - 714.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core132.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 713.9 - 715.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core133.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 714.9 - 716.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core134.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 715.9 - 717.9 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-14_Core135.jpg	5/20/05	SNL-14 drillpad; T23S, R31E, sec 4	Close-up photo of Los Medaños Mbr core, 716.9 - 717.6 ft bgl, with markings, scale	DW Powers Consultant to WTS

Appendix G
Geophysical Logs

Geophysical logging of SNL-14 was conducted by Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, on May 20, 2005. 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 vs 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
- •Natural gamma
- •Density
- •Density-porosity
- •Density-porosity
- •Spontaneous potential (SP)
- •Resistivity
- •Neutron

SNL-14 had been cored and drilled to ~718.5 ft at the time of logging. A 20-inch casing was cemented to 7 ft to assist drilling with air. After significant water was encountered in the Dewey Lake Formation, a 43 ft conductor casing was placed and cemented, with a stickup of 0.5 ft. Fresh water with polymer was in the drillhole when logging was conducted. The caliper log was used for estimating material volume placed in the annulus between fiberglass reinforced plastic casing and the drillhole wall.

The reference point (0 ft depth) for geophysical logging is the drill pad level. This point was assigned an elevation of 3,366.99 ft amsl on the logs, based on the predrilling survey of the well pad (Appendix D). A benchmark placed near the drillhole after completion has been resurveyed since being initially placed and has an elevation of 3,365.71 ft amsl (see Fig. 1-5 and Table 1-1 in the main text). [The benchmark from an earlier survey has not been replaced.] A rounded elevation of 3,366 ft amsl for the reference point used in the text is appropriate for the measurements based on geophysical logs.

Jet West logging truck at SNL-14 (May 20, 2005) preparing to log (above). Al Henderson (Jet West) monitoring logging progress (right). Caliper tool inside well bore being checked for depth at well pad level ~ 0.5 ft below top of conductor casing (below).

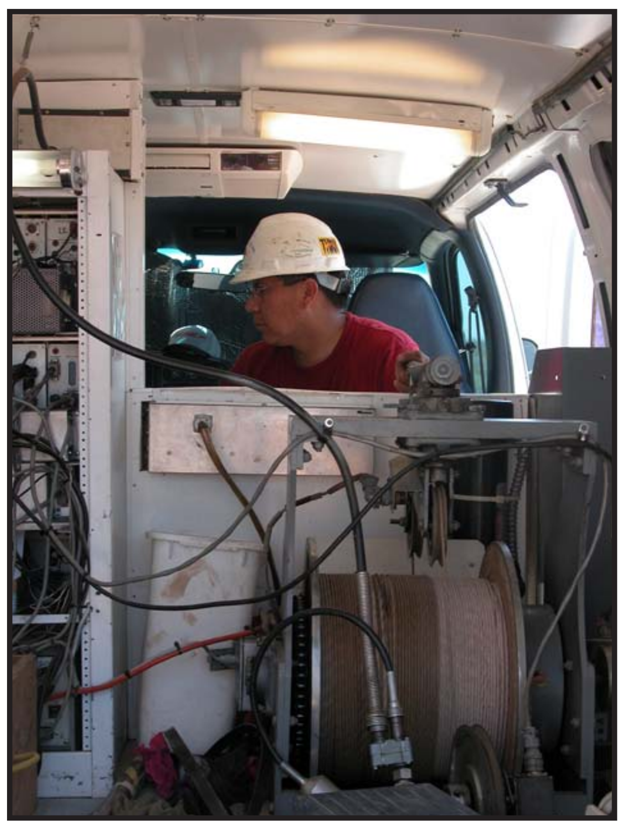
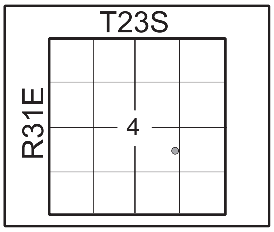


Figure 2-1
Well Record SNL-14 (C-3140)

Company: Washington TRU Solutions LLC
Well: SNL-14 (C-3140)
Section: 4 Twp: T23S Rge: R31E
Location: 3,306 ft from north line (fnl)
1,388 ft from east line (fel)



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

Elevation
KB:
DF:
GL: 3,366 ft amsl
(benchmark: 3,365.71)

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 2, 2005
Completion date: May 25, 2005
Total depth (TD): 718.5 ft bgl (driller log)

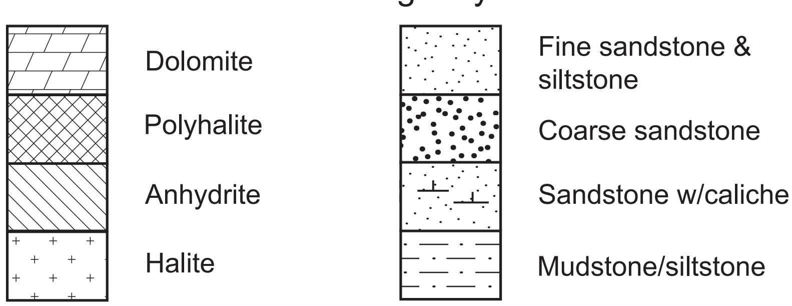
Casing Record
Conductor: 42.5 ft
12.25 inch steel i.d.
Casing: 4.85 inch i.d.
FRP to TD
Screened interval:
649.5-676.0 ft

Geophysical Logs Date: May 20, 2005

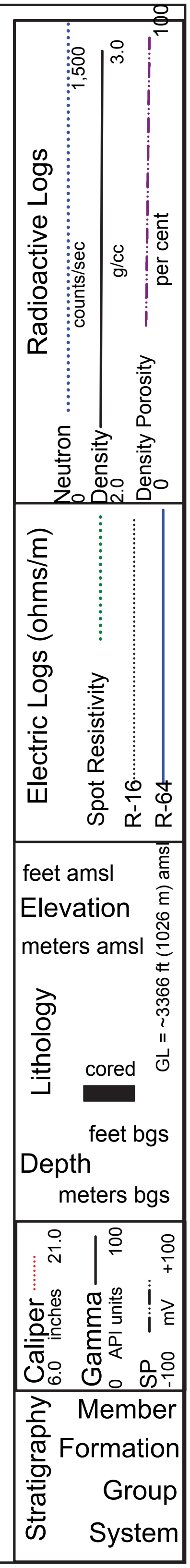
Micro/Laterolog/SP:	0-712 ft
Gamma/Fluid:	0-712 ft
Caliper:	0-712 ft
Density/Neutron:	0-712 ft

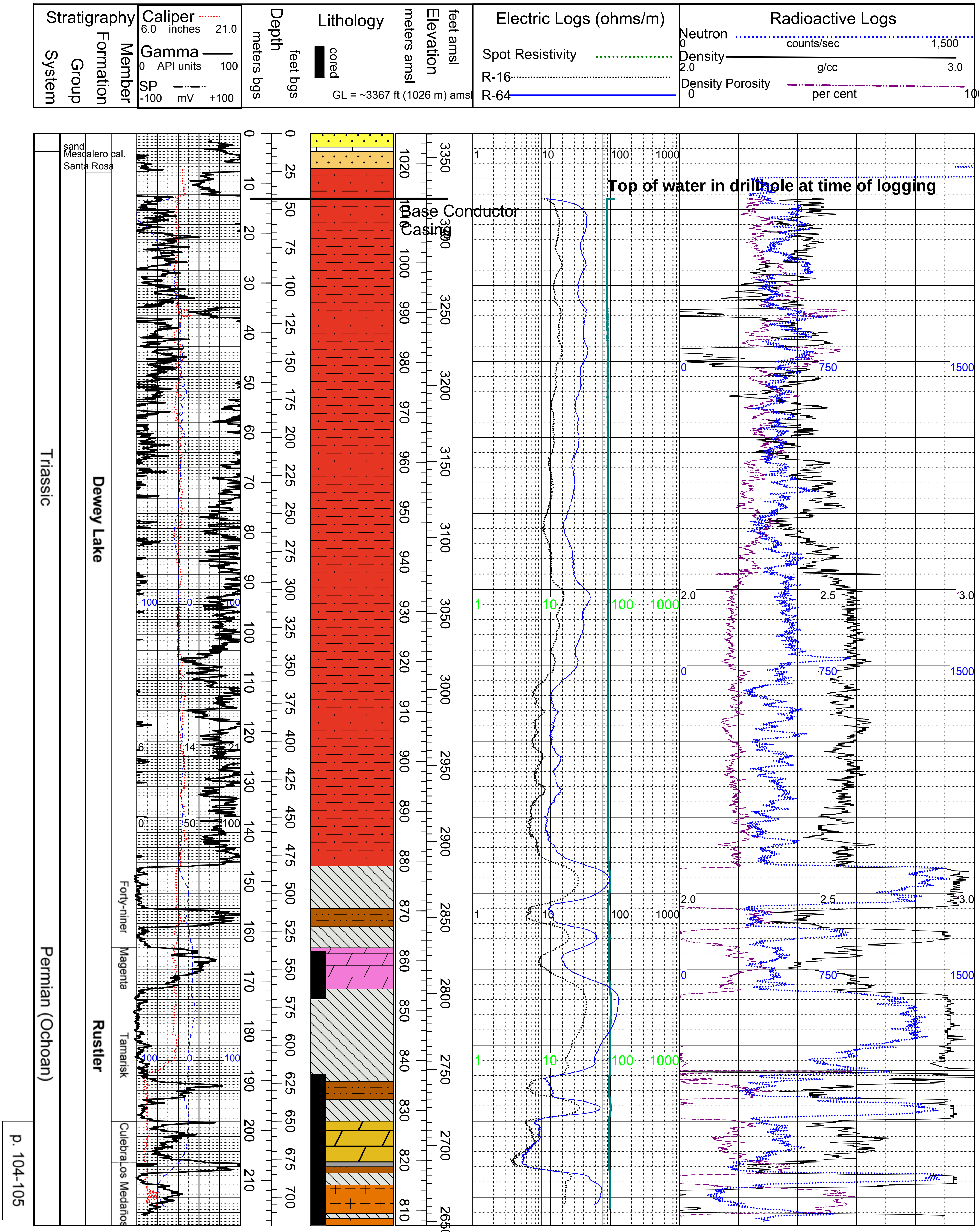
Type fluid in hole: water
Res mud: n.d.
Res mud filtrate: n.d.

General Lithologic Symbols Used



SNL-14 Well Log Headers





Stratigraphy
System
Group
Formation
Member
Caliper
6.0 inches 21.0
Gamma
0 API units 100
SP
-100 mV +100
Depth
meters bgs
feet bgs
Lithology
cored
Elevation
meters amsl
feet amsl
GL = ~3367 ft (1026 m) amsl
Electric Logs (ohms/m)
Spot Resistivity
R-16
R-64
Radioactive Logs
Neutron
0 counts/sec 1,500
Density
2.0 g/cc 3.0
Density Porosity
0 per cent 100
sand
Mescalero cal.
Santa Rosa
Triassic
Dewey Lake
Permian (Ochoan)
Rustler
Forty-niner
Magenta
Tamarisk
Culebra
Los Medaños
Top of water in drillhole at time of logging
Base Conductor Casing
p. 104-105