DOE/WIPP 03-3291

Basic Data Report
For Drillhole SNL-9 (C-2950)
(Waste Isolation Pilot Plant)

December 2003

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Basic Data Report
For Drillhole SNL-9 (C-2950)
(Waste Isolation Pilot Plant)

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December 2003

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EXECUTIVE SUMMARY

SNL-9 (permitted by the State Engineer as C-2950) was drilled during 2003 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation within a proposed reentrant of the margin of halite dissolved from the upper part of the Permian Salado Formation near Livingston Ridge. SNL-9 is located in the southeast quarter of section 23, T22S, R30E, in eastern Eddy County, New Mexico. SNL-9 was drilled to a total depth of 845 ft below ground level (bgl). Below surface dune sand and the Berino soil, SNL-9 encountered, in order, the Mescalero caliche, Gatuña, Dewey Lake, Rustler, and uppermost Salado Formations. Two intervals of the Rustler were cored: (1) from the lower Forty-niner Member through the Magenta Dolomite and into the upper Tamarisk Member; and (2) from the lower Tamarisk Member through the Culebra Dolomite and Los Medaños Members and into the uppermost Salado Formation. Geophysical logs were acquired from the open hole to total depth, and the drillhole was successfully completed with a screened interval open across the Culebra.

At SNL-9, the uppermost Salado cores display depositional cycles as well as displacive halite crystals in clastic-rich units near the top. The upper Salado at SNL-9 is thinner than it is in some surrounding areas; this is consistent with predrilling expectations that the upper Salado had been dissolved at this location. A sharp contact between uppermost halite and siliciclastics at 676 ft is believed to mark the lower boundary of dissolution. Thicker gypsum beds at the Rustler-Salado contact are somewhat tilted and may have been amalgamated by dissolving halite. The Los Medaños has a thickness and stratigraphic sequence very similar to that found at the center of the WIPP (Waste Isolation Pilot Plant) site. There is no halite in the lower Los Medaños, and fractures are commonly not cemented. The Culebra Dolomite is about average in thickness (23 ft) for this area, and recovered core shows bedding and porosity similar to that across much of the western part of the WIPP site. Core was lost from part of the lower-middle Culebra, which is usually the most porous and transmissive part of the unit. The Tamarisk has a normal stratigraphic sequence and thickness, and the mudstone unit shows typical reddish-brown sandy claystone overlain by gray and reddish-brown claystone. Intraclasts of claystone are preserved, as are angular clasts or fragments of gypsum in the claystone. The Magenta Dolomite is about 27 ft thick and shows typical laminar to wavy bedding, some ripples, and algal stromatolites. The Forty-niner is represented by a typical sulfate–mudstone–sulfate sequence. The Dewey Lake was partially eroded, and the Santa Rosa completely removed, prior to deposition of the Gatuña. Cuttings and geophysical logs indicate that the sulfate–carbonate cement transition in the Dewey Lake is about 116 ft bgl at SNL-9, which is lower stratigraphically than the cement boundary near the center of the WIPP site. The Gatuña is about 40 ft thick at SNL-9; the thickness is consistent with observed Gatuña outcrops at nearby Livingston Ridge.

No water was encountered in the Gatuña or Dewey Lake; there was, however, a slight indication of moisture from the open hole from the Forty-niner mudstone to the surface after being left overnight. Overnight water level rises in the hole (open from the surface through the Magenta) indicated less than 0.2 gallons per minute (gpm). Water flowed into the hole from the Culebra during drilling and water levels from the open hole prior to reaming and casing rose well into the Dewey Lake. There was no indication of fluid inflow at the Rustler–Salado contact during drilling or from cores.

Most of the open drillhole below the Culebra was cemented before reaming the upper part of the drillhole.The drillhole was reamed to 15.75 inches in diameter through the Culebra. Fiberglass casing (9.32 inches outside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite. The annulus was filled with 8/16 Brady

sand to just above the Culebra, and bentonite was placed on the sand to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface. The well was developed in late June 2003 with partial success. After bailing to remove sediment and water from SNL-9 early in September 2003, the well was developed by pumping at relatively high rates (up to 21.1 gpm), which is consistent with the expectation that the Culebra would have high transmissivity at this location. Water levels in SNL-9 have consistently risen since the well was completed and developed, and the November 2003 measured water level is 3,042.80 ft above mean sea level (amsl). A preliminary measurement of fluid density was 1.034 g/cc (grams/cubic centimeter).

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In keeping with practice at the WIPP site, the basic data for SNL-9 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)

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1.0 INTRODUCTION

SNL-9 was drilled in the southeast quarter of section 23, T22S, R30E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 1,197 ft from the south line (fsl) and 627 ft from the east line (fel) of the section (Fig. 1-2). This location places the drillhole slightly more than 1 mile west of the west boundary of the WIPP site and well east of the Livingston Ridge escarpment. SNL-9 will be used to test hydraulic properties and to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation.

SNL-9 was permitted by the New Mexico State Engineer as C-2950. (Official correspondence regarding permitting and regulatory information must reference this permit number.) In the plan describing the integrated groundwater hydrology program (Sandia National Laboratories, 2003), SNL-9 is co-designated WTS-2 because the location also satisfies needs for long-term monitoring of water levels and flow rate and direction in the Culebra Dolomite for RCRA (Resource Conservation and Recover Act) permitting; this program is under the management of Washington TRU Solutions LLC (WTS).

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

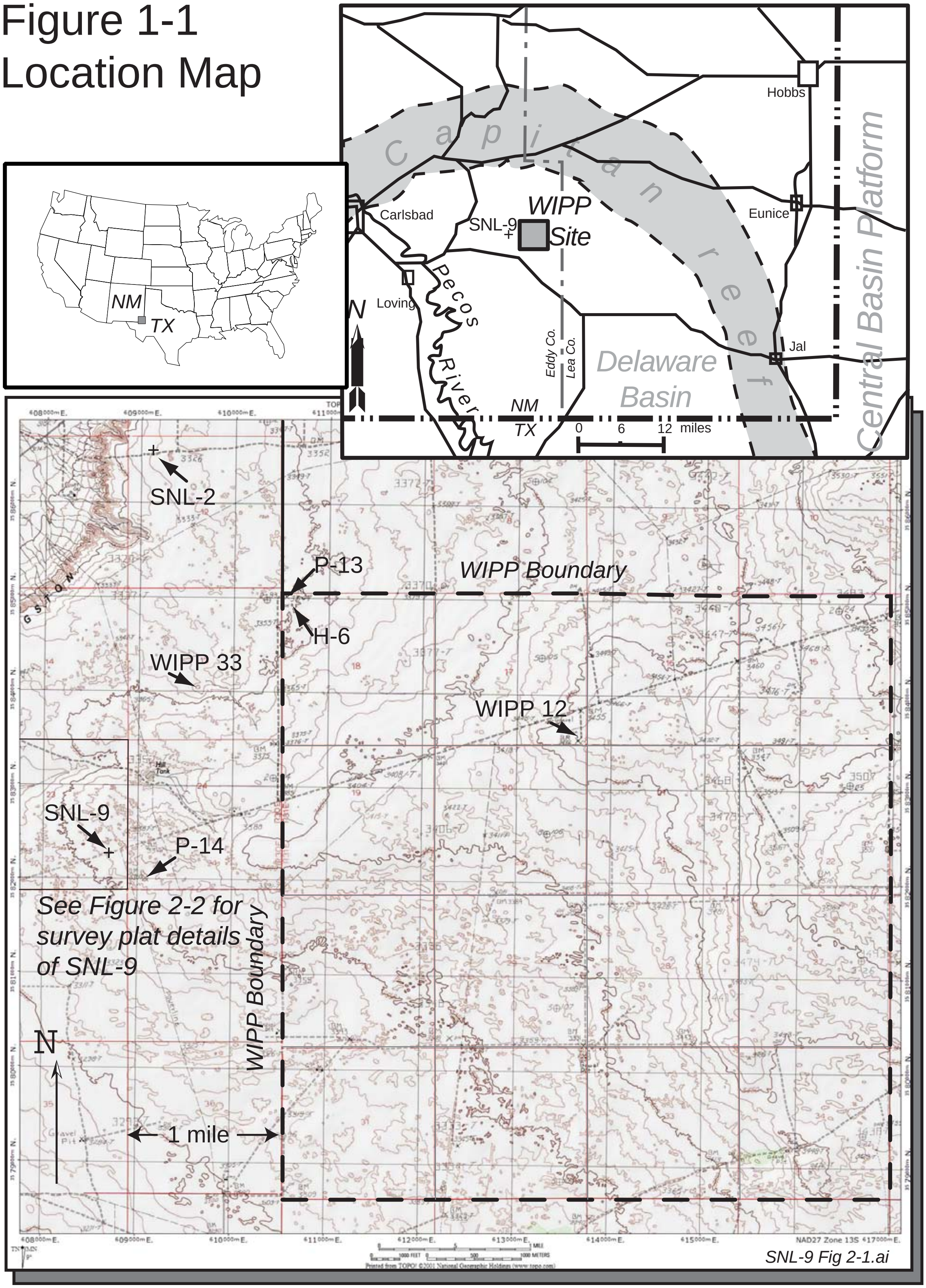
WIPP is a U.S. Department of Energy (DOE) facility disposing of transuranic and mixed waste, byproducts of U.S. defense programs, as certified by the U.S. Environmental Protection Agency (EPA) and under a permit issued by the New Mexico Environment Department. WIPP is located ~25 miles east of Carlsbad,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

1.2 Purpose of SNL-9

SNL-9 was designed and located to provide information for the integrated hydrology program for WIPP (Sandia National Laboratories, 2003). Among the objectives of the integrated hydrology program, SNL-9 will help "… resolve questions related to observed water-level changes around the WIPP site, provide data needed for comprehensive modeling of WIPP groundwater hydrology, [and] construct a groundwater monitoring network that can be maintained throughout the operational period of WIPP …" (*op. cit.*, 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 estimate the transmissivity ("T") of the Culebra across the site area for the Compliance Certification Application (CCA) (see Sandia National Laboratories, 2003). 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 T (Holt and Yarbrough, 2002; Powers and others, 2003). SNL-9 was located to test Culebra hydraulic properties in a possible reentrant of the upper Salado dissolution margin extending eastward from Livingston Ridge. SNL-9 is in the vicinity of drillhole P-14, where Culebra T was significantly higher than in some other drillholes in the vicinity of WIPP (Beauheim and Ruskauff, 1998). The drillhole is also intended to confirm the geological conditions used to estimate Culebra hydraulic properties (Sandia National Laboratories, 2003; Powers, 2002a; Powers and others, 2003).

Figure 1-1
Location Map



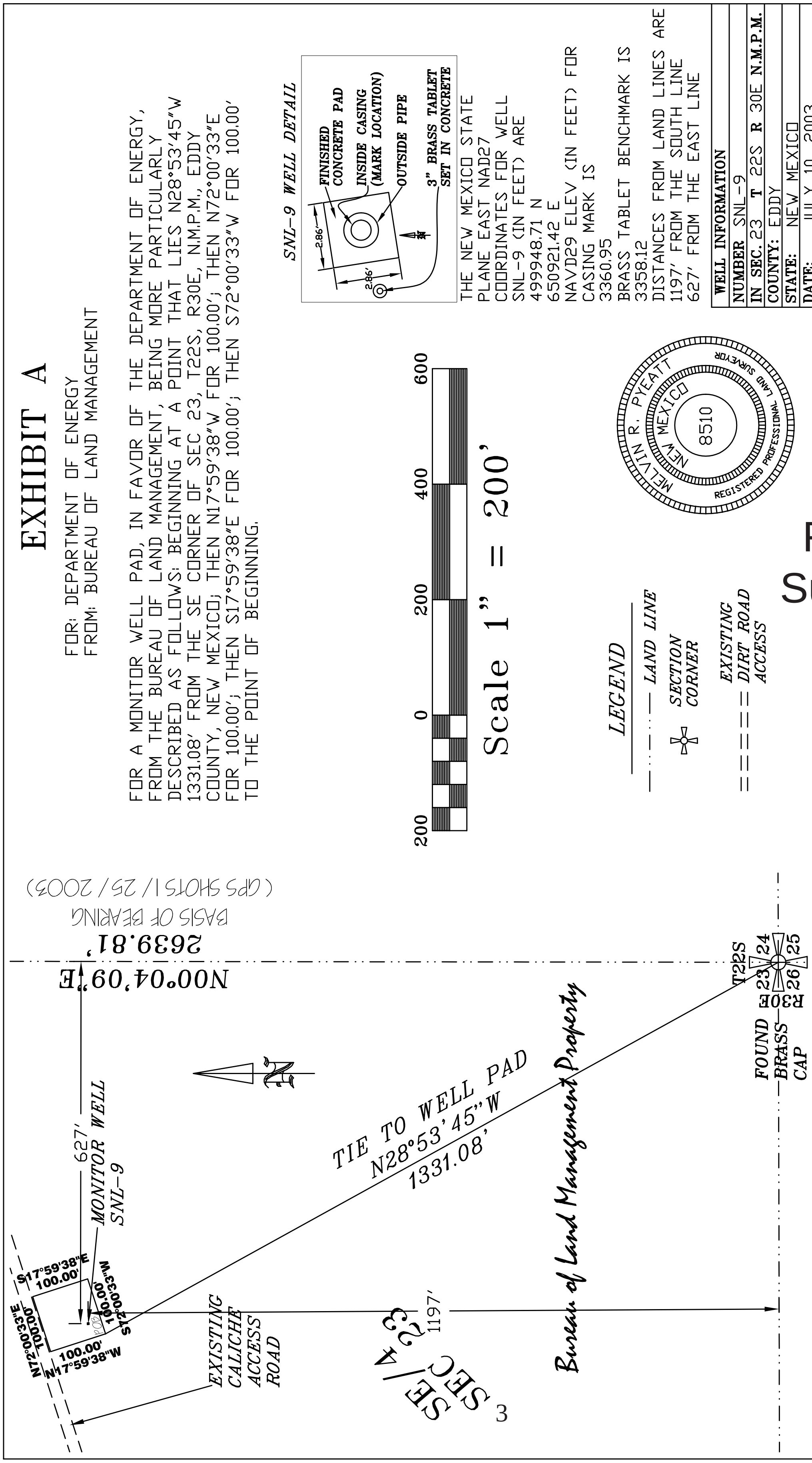


Figure 1-2
Survey Plat
for SNL-9

The drillhole is to (Sandia National Laboratories, 2003, p. 45; see also Appendix A):

1. Confirm that dissolution of the upper Salado has in fact occurred at this location;
2. Confirm that the high transmissivity measured at P-14 is characteristic of the Culebra within this dissolution reentrant;
3. Determine if the flow dimension inferred from a pumping test is consistent with a bounded, linear feature, or indicates connection with a larger volume of the Culebra;
4. Determine how well-connected the Culebra and Magenta are within this dissolution reentrant;
5. Determine the direction of flow at this location; and
6. Provide a pumping location for a large-scale (multipad) test to provide transient data for calibration of the Culebra model on the west side of the WIPP site.

"In addition, a well at the SNL 9 location will provide needed information to help define the direction and rate of Culebra groundwater flow across the WIPP site, which is required for annual HWFP [Hazardous Waste Facility Permit] reporting to NMED [New Mexico Environment Department] (hence the parallel designation WTS2)" (*op. cit.*, p. 45).

1.3 SNL-9 Drilling and Completion

The basic information about drilling and completion of SNL-9 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. *Note that depths during drilling, geophysical logging, and completion activities have a reference point at the top of a connector on the conductor casing that is close to the benchmark later placed adjacent to the well pad. Groundwater level readings have a reference point on top of the casing that stands above ground level (Fig. 1-5).*

SNL-9 was rotary drilled and cored to a total depth of 845 ft bgl (Fig. 1-3). As the drillhole progressed, circulating fluids were successively changed from air to fresh-water mist with foam to brine with foam to brine with surfactant. The changes reflect needs for maintaining drillhole stability as well as for determining geological and hydrological conditions in the drillhole.

Core recovery ranged from excellent to poor; this experience is common in these intervals (e.g., Powers, 2002b; Mercer and others, 1998) (Appendix C).

In keeping with recent practice at WIPP, SNL-9 was cased with fiberglass reinforced plastic (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-9 (Sandia National Laboratories, 2003).

The location for SNL-9 was selected on geohydrological factors suggesting that the Culebra would have higher T than in many other locations. As a consequence, the casing (9.83-inch outside diameter [o.d.]) installed was larger than at SNL-2 and other wells to allow larger pumps and higher pumping rates. The drillhole was reamed to a diameter of 15.75 inches before casing was installed.

SNL-9 was completed with a screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water level data when packers fail; mixing of waters of differing qualities when packers fail; and the increased complexity of testing in a well completed to multiple intervals. If warranted, additional wells can be completed to other intervals, such as the Magenta Dolomite, on the SNL-9 wellpad (Sandia National Laboratories, 2003).

Geophysical logs (Appendix D), especially the natural gamma and caliper logs, were used to make the final decisions regarding completion of SNL-9 (Fig. 1-4) (Appendix E). The drillhole was cemented back to a level below the Culebra to

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-9 (C-2950)

LOCATION: Southeast ¼, section 23, Township 22 South (T22S), Range 30 East (R30E)

SURFACE COORDINATES: The well is located 1,197 ft from the south line (fsl) and 627 ft from the east line (fel) of Section 23. The NM State Plane (NAD 27) horizontal coordinates are 499948.71 N., 650921.42 E. (Fig. 1-2 shows the survey plat). UTM horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-9 using Corpscon for Windows (v. 5.11.08): 608704.61 E., 3582237.50 N. Figure 1-1 shows UTM coordinates on a 1000-m grid.

ELEVATION: All depths used in geological and geophysical data here are reported bgl, which is taken as 3,358 ft amsl (above mean sea level), the rounded value for the brass tablet benchmark (3,358.12 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,360.95 ft amsl (NAVD 29) for a mark on the top of the casing inside the protective well pipe. Figures 1-3 and 1-4 show the as-built configuration of SNL-9. For more precise calibration of geophysical logs taken after reaming, the zero point used was the top of the collar of the conductor casing before the surface protective length was added. This zero point is approximately benchmark ground level.

DRILLING RECORD:

Dates: Began drilling May 17, 2003; drillhole reamed to completion depth (587 ft) on June 18, 2003. Final geophysical logging was conducted on June 19, 2003. Drillhole prepared for casing, cased, and cemented June 20, 2003. Rig was moved off the drillpad June 23, 2003. SNL-9 was initially developed June 26, 2003. On September 2, 2003, about 1560 gallons of water and solids from drilling fluids were bailed from SNL-9. On September 4, 2003, a total of about 1722 gallons of water was pumped from SNL-9 at rates from 14.5–21.1 gallons per minute (gpm). Water levels are being monitored monthly by WRES.

Circulation Fluid: SNL-9 was rotary drilled to 430 ft bgl with circulating air with a temporary surface conductor casing. SNL-9 was cored and drilled from 430 ft bgl (Forty-niner Member) to 582 ft bgl (which is below Culebra Dolomite Member) using Baroid Quik-Foam® and fresh water mist driven by compressed air. From 582 ft bgl to total depth (845 ft bgl), the drillhole was cored and drilled using circulating brine with Flowzan® biopolymer (MSDS# 463650) in a portable mud pit. SNL-9 was reamed to a final diameter (15.75 inches) to 587 ft using circulating brine with Flowzan® biopolymer in a portable mud pit.

Cored Intervals: 4.0-inch core was taken from the following intervals (depths according to drilling data):

- 430.0-470.3 ft bgl: lower Forty-niner, Magenta Dolomite, and upper Tamarisk Members of the Rustler Formation
- 520.0-692.0 ft bgl: lower Tamarisk, Culebra Dolomite, and Los Medaños Members of the Rustler Formation; and upper Salado Formation

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-9 (C-2950), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
22	0	30
15.75	30	587
7.875	587	845

Note: The lower part of the drillhole was cemented back to 590 ft bgl.

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
18.63	18.13	47.44 steel	0	30
9.32	8.42	11.25 FRP** blank	-2	545.0
9.32	8.42	11.25 FRP screen	545.0	572.0
9.32	8.42	11.25 FRP blank	572.0	584.0

*Top of the casing connector is the reference for depth denoted below ground level (bgl). The FRP extends 2 ft (-2) above the connector on the steel conductor casing.
**FRP: fiberglass reinforced plastic

Coring Record:

Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered*	Recovered %
1	430	460.5	30.5	29.9	98.03
2	460.5	470.5	10	10.4	104.00
3	520	550	30	30	100.00
4	550	567.3	17.3	16.6	95.95
5	567.3	582.3	15	5.7	38.00
6	582.3	612.3	30	27.5	91.67
7	612.3	640.3	28	15.5	55.36
8	640.3	645.3	5	3.9	78.00
9	645.3	660.3	15	10.7	71.33
10	660.3	667.3	7	4.5	64.29
11	667.3	692.3	25	27.3	109.20
		Totals	212.8	182	85.53

Note: Marked core depths (e.g., Appendix C) vary slightly from core interval depths partly due to differing recoveries and estimates of lost core intervals.
*Recovered core length exceeds the cored interval for some runs because some or all of the core not extracted from the bottom of the drillhole during a run was collected during the next run.

Figure 1-3
SNL-9 As-Built Diagram

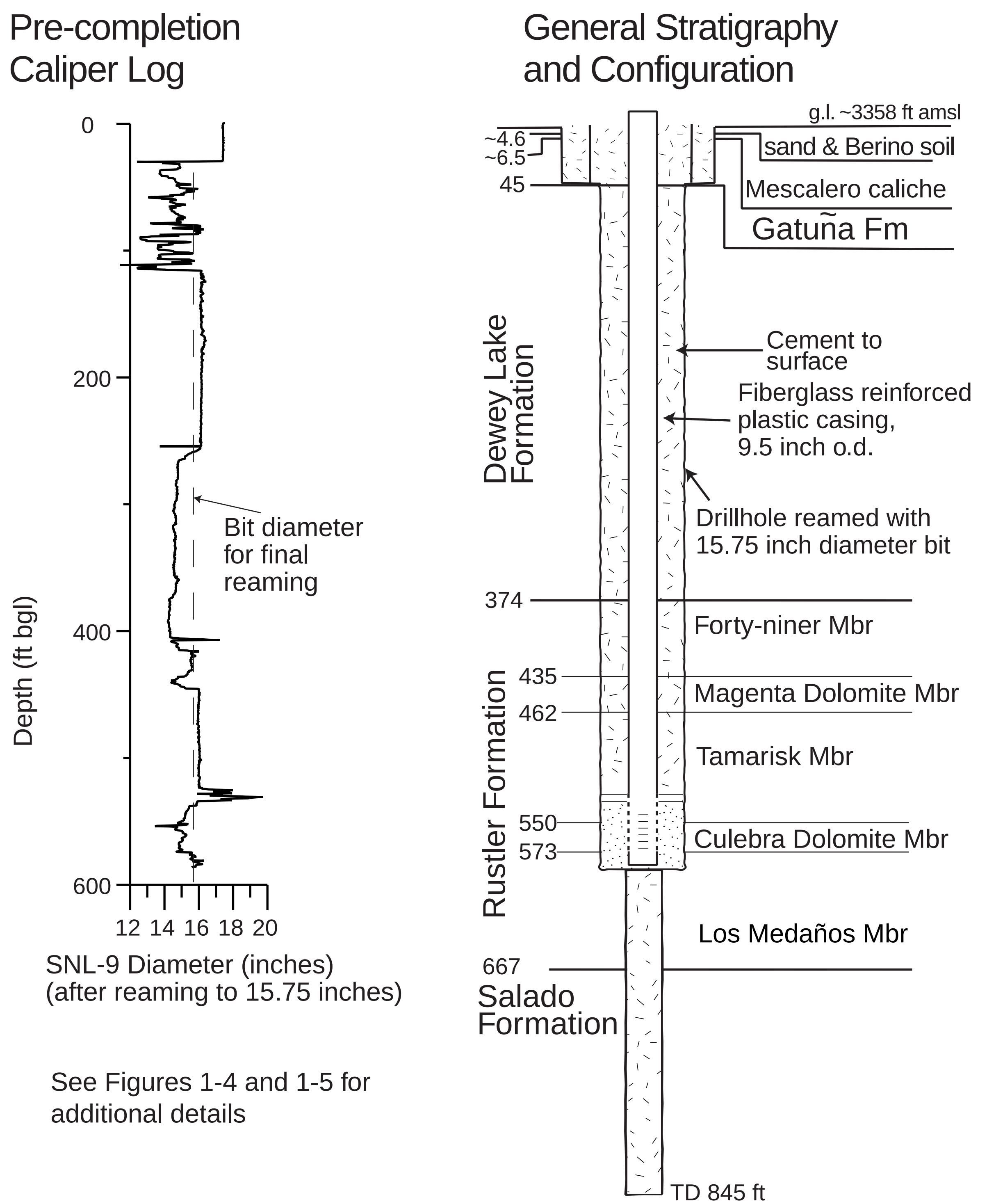


Figure 1-4
SNL-9 Completion and Monitoring Configuration (6/20/03)

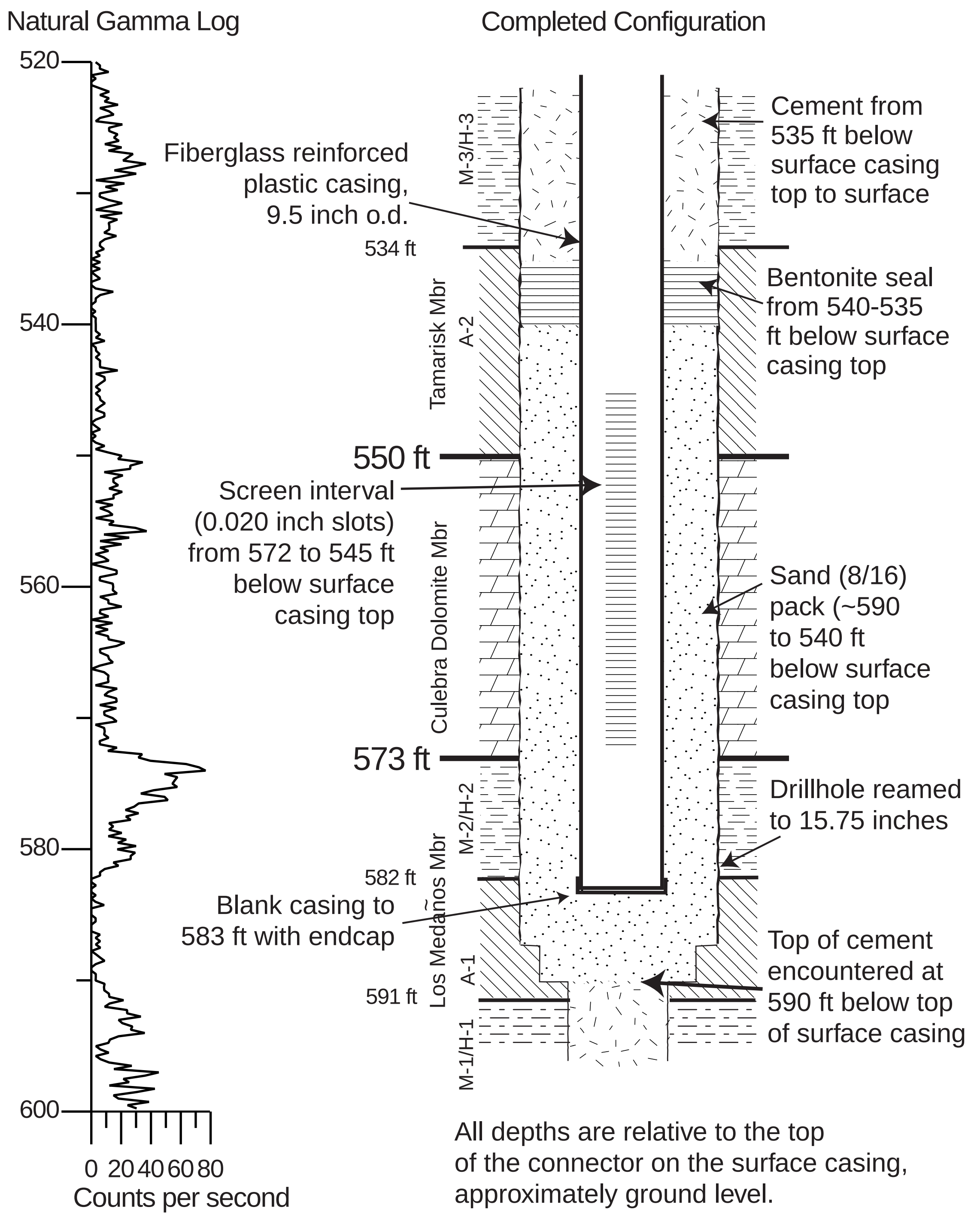
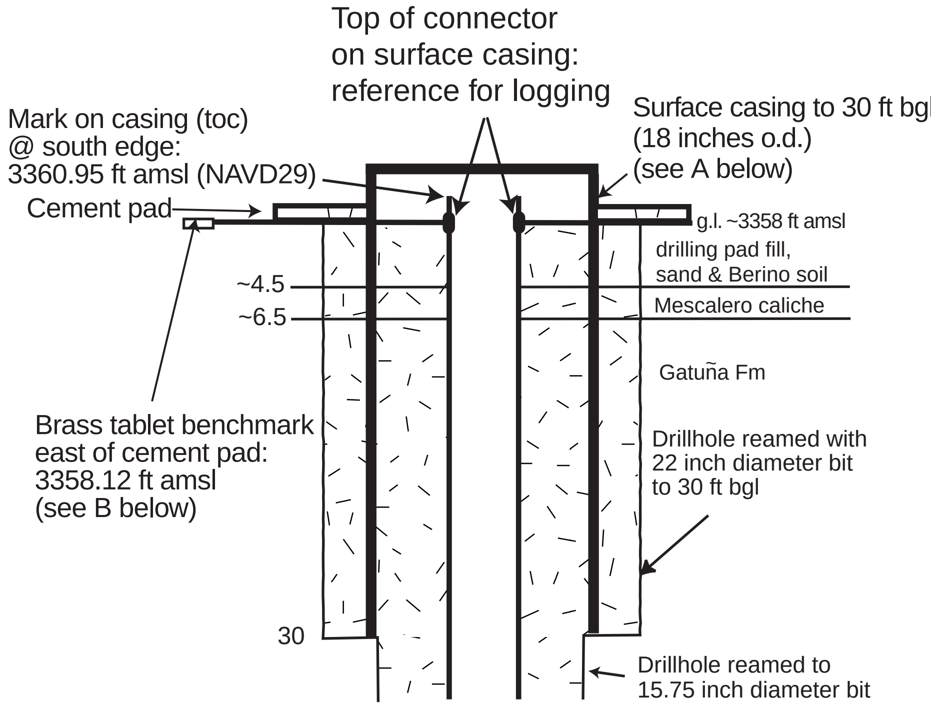
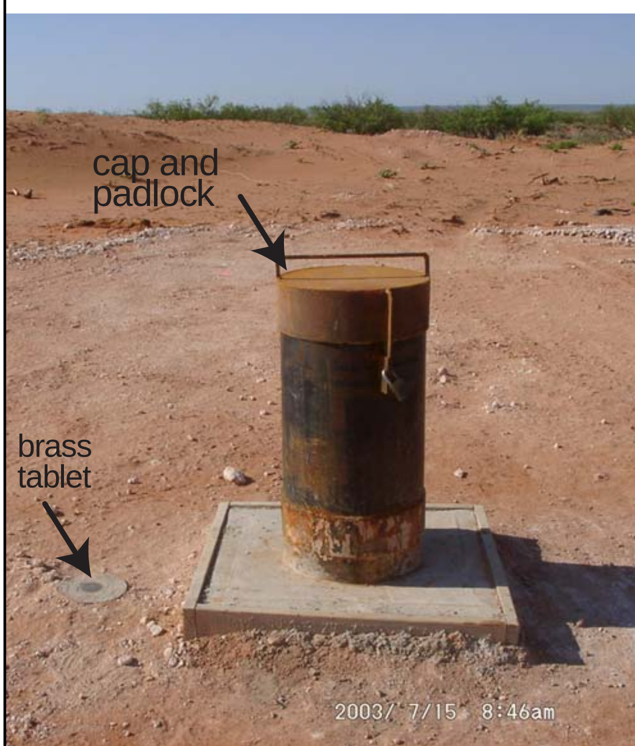


Figure 1-5
SNL-9 Surface Configuration and Elevations (7/15/03)





A - Surface casing for SNL-9 with cap and padlock. View to south.

B - Detail of brass tablet benchmark on east side of SNL-9 cement pad. Elevation is 3358.12 ft amsl (NAVD29)

protect the lower Rustler from circulation of Culebra water (Fig. 1-4). The bottom of the Culebra screen interval was placed at 572 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 545 ft bgl is above the top of the Culebra. The top of the sand pack (8/16 silica sand) is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. The annulus above the sand/gravel pack was cemented to the surface. A final caliper log (Fig. 1-3) after the drillhole was reamed to 15.75 inches and before the casing was placed shows only modest drillhole enlargement in the Tamarisk mudstone. The final caliper also indicates that, from conductor casing to ~115 ft bgl, some of the upper Dewey Lake and Gatuña slightly squeezed into the drillhole.

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

Geophysical logs, casing and screen depths, and depths for materials placed in the annulus to complete SNL-9 use the top of a connector on the steel surface conductor casing as a reference point. The FRP casing was cut off 2 ft above the top of this connector. Depths as recorded by the geophysical logs and used for completing the well would therefore be 2 ft greater if the top of the FRP casing is the reference point.

1.4 Other Background

SNL-9 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, Texas, under contract from WTS. Coring was done by John W. Wood, Diamond Oil Well Drilling Co., Inc., P.O. Box 7843, Midland, Texas. Geological support was provided by Dennis W. Powers under contract to WTS (Appendix C). Geophysical logging was conducted by Raymond Federwisch, Geophysical Logging Services, 6250 Michele Lane, Prescott, Arizona, under contract to West Texas Water Well Service (Appendix D). Mike Stapleton of the New Mexico Office of the State Engineer witnessed hole completion activities (Appendix E). Archeological clearances obtained from the U.S. Bureau of Land Management were based on field work and reports by Mesa Field Services, Carlsbad, New Mexico (Appendix F). Cores from SNL-9 were photographed with digital cameras, and a photo log is included in Appendix G. Electronic images can be requested from WTS.

1.5 Acknowledgements

Drafts of this document were reviewed by Mark Crawley, Rick Salness, Joel Siegel, Wayne Stensrud, and Rick Beauheim, and their comments improved the final report. Mark Crawley (Washington Regulatory and Environmental Services - WRES) provided field support and information on well development. Doug Lynn (WRES) obtained permits and provided permitting and regulatory information included in appendix material. Ronnie Keith and Rodney Dutton (West Texas Water Well Service) provided drilling data and daily drilling records. Ray Federwisch (Geophysical Logging Services) provided the printed and electronic files that were used to develop Figure 2-1. Chris Mahoney checked certain files and figures and provided data files for sections. Vivian Allen (L&M Technologies) helped guide us through necessary editing changes.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been intensively investigated since 1975; the data and interpretations have been reported in numerous documents. The most thorough compilation is the CCA submitted in 1996 by the DOE to the EPA. 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; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-9.

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. The basin filled with sediments, and it no longer significantly limited the area of sedimentation. 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, continental environments prevailed, and significant redbeds were deposited. Although surrounding areas accumulated variable thicknesses of later Mesozoic and Cenozoic age sediments, the WIPP area appears to have mainly been subject to erosion during an extended period. Some basin tilting from middle-to-late Cenozoic exposed the evaporite beds to faster solution and erosion, and weathered material began to accumulate. The Pecos River drainage became integrated throughout the region during this period. 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 approximately the last half million years, and pedogenic calcrete (caliche) has formed and been preserved.

2.2 Geological Data From SNL-9

SNL-9 encountered a normal stratigraphic sequence for the area between Livingston Ridge and the WIPP site area, from ground level to total depth (Table 2-1; Fig. 2-1). Units encountered ranged from unconsolidated surficial sands to the upper part of the Permian Salado Formation. No unusual structural, sedimentological, or diagenetic features were found during investigation using cuttings, cores, and geophysical logs, although details of the sedimentology of the Rustler will extend understanding of that unit. Units above the Rustler did not yield noticeable water during drilling.

The geologic units encountered in SNL-9 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. The difference between geophysical logs and drilling depths is generally slight. The largest differences commonly resulted from depths and core markings through intervals of partial core recovery when compared to later geophysical logs. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix D). Geologic logs detailing field observations of cuttings and cores are included in Appendix C.

The following descriptions use depths that correspond to core depths. Intervals or depths based on geophysical logs are also indicated.

2.2.1 Permian Salado Formation

The upper Salado was cored and drilled in SNL-9, providing a record of the transition from Salado to Rustler Formation and any dissolution that may have affected the upper Salado or basal Rustler. Core was obtained from the upper 25 ft (667–692 ft), and the hole was then drilled an additional 153 ft (845 ft total depth) to obtain stratigraphic evidence through known marker beds of the upper Salado.

The program plan (Sandia National Laboratories, 2003) outlined a potential drilling target of a marker bed (possibly MB103) in the upper Salado. Predrilling work estimated that this location had been affected by dissolution of upper Salado halite extending southeastward from Livingston Ridge (Powers, 2002a), based on the thickness of the interval between the Culebra and the Vaca Triste Sandstone Member of the Salado Formation in an exploration hole (P-14) drilled by WIPP to determine potash resources (Fig. 1-1). The core provides direct stratigraphic and textural evidence to investigate any dissolution at the top of the Salado. Drilling beyond the uppermost Salado to an identifiable marker bed (MB103) is expected to help in relating thickness changes of the larger stratigraphic interval to dissolution, if any, of upper Salado halite.

The upper Salado at SNL-9 is dominated by coarse halite ranging in color from white to orange or reddish-brown from included accessory minerals. Four intervals are dominated by anhydrite and polyhalite and are believed to represent known marker beds of the upper Salado. From ~804–835 ft bgl, cuttings and geophysical logs indicate a thick anhydrite bed with polyhalite in the upper ~ 4 ft and possibly in the basal 3 ft. This unit is underlain by claystone that is ~1 ft thick. This thick sulfate corresponds to a similar interval in nearby drillhole P-14, which appears to include ~7 ft of halite between anhydrite and the upper polyhalite (Jones, 1978). Geophysical logs from drillhole ERDA 9 (Sandia National Laboratories and U.S. Geological Survey, 1983), near the center of the WIPP site (Fig. 1-1), and mapping of the air intake shaft at WIPP (Holt and Powers, 1990a) suggest that this interval includes both MB103 and MB102. MB103 is typically anhydrite in this area, and MB102 is typically polyhalite. Cuttings for SNL-9 are indeterminate with regard to halite between the two MB. Drilling rates, cuttings, and geophysical logs indicate likely intervals for the MB (Table 2-1). Somewhat faster penetration for the upper part of the combined interval also suggests halite may be present. The total thickness of the interval is consistent with the combined interval thickness for MB103, MB102, and the intervening halite at both ERDA 9 and the air intake shaft at WIPP.

The polyhalite and anhydrite unit from ~771–776 ft in SNL-9 is consistent with MB101, as found in other drillholes in the area.

The polyhalitic halite unit inferred from 750–756 ft may represent MB100, but its depth is not well-established; drilling rates were not greatly affected, and cuttings are significantly delayed in appearing at the surface from that depth.

The cored interval at the top of the Salado displays depositional cycles (both Type 1 and Type 2, Lowenstein, 1988) (Fig. 2-2), with sequences similar to those described by Holt and Powers (1990a,b). The cycle in the lowest cored interval shows coarse halite with few disseminated impurities overlain by silty halite to sandy siltstone. Surfaces that may indicate synsedimentary dissolution are present at 675–675.8 and at 678.4 ft, within cycles dominated by halite and clastics. These cycles include displacive halite (Fig. 2-3) as well as halite crystals with corroded margins. Some probable smeared intraclasts (Fig. 2-3) (Powers and Holt, 2000) indicate synsedimentary or very early dissolution. Coarse, orange halite in the interval from 670.6–674.3 ft appears to be part of a Type 2 cycle, unaffected by postdepositional dissolution. The irregular surface at 670.6 ft, where coarse halite is overlain by claystone (Fig. 2-4), is sharp and likely represents the lower boundary of postdepositional dissolution of upper Salado halite at SNL-9.

The claystone and gypsum from 668.1–670.6 ft overlying the dissolution boundary have distorted bedding and mud clasts. The sharp basal contact with coarse halite should be more closely examined because it also appears macroscopically consistent with being an erosional contact, in contrast with an origin as a dissolution surface.

The gypsum from 666.4–668.1 ft has contorted bedding. It ranges from white to gray to reddish brown. The unit has aspects of bedding and coloration that suggest it was amalgamated from several units as a residue after more soluble halite was removed from the zone at the top of the Salado.

Table 2-1
Geology at Drillhole SNL-9

<table>
<tr><th colspan="2">System/
Period/Epoch</th><th>Formation or unit</th><th>Member
(or informal marker bed - MB)</th><th>Depth below surface (ft)[1]</th></tr>
<tr><td rowspan="3">Cenozoic</td><td>Holocene</td><td>surface dune sand and Berino soil[2]</td><td></td><td>0 - 4.5 ft</td></tr>
<tr><td>Pleistocene</td><td>Mescalero caliche</td><td></td><td>4.5 - 6.5 ft</td></tr>
<tr><td>Miocene-Pleistocene</td><td>Gatuña</td><td></td><td>6.5 ft - 46 ft</td></tr>
<tr><td rowspan="2">Mesozoic</td><td rowspan="2">Triassic</td><td>Santa Rosa[3]</td><td></td><td>eroded</td></tr>
<tr><td>Dewey Lake[4]</td><td></td><td>46 ft - 374 ft</td></tr>
<tr><td rowspan="9">Paleozoic</td><td rowspan="9">Permian</td><td rowspan="5">Rustler
(374-667 ft)</td><td>Forty-niner</td><td>374 ft - 435 ft</td></tr>
<tr><td>Magenta Dolomite</td><td>435 - 462 ft</td></tr>
<tr><td>Tamarisk</td><td>462- 550 ft</td></tr>
<tr><td>Culebra Dolomite</td><td>550 - 573 ft</td></tr>
<tr><td>Los Medaños[5]</td><td>573 - 667 ft</td></tr>
<tr><td rowspan="4">Salado[6]
(667-845 ft
total depth)</td><td>MB100?</td><td>750-756</td></tr>
<tr><td>MB101</td><td>771-776 ft</td></tr>
<tr><td>MB102</td><td>804-810?</td></tr>
<tr><td>MB103</td><td>820?-835</td></tr>
</table>

[1]Depths are mainly based on measurements by geophysical logging; drilling and coring provided data to total depth (TD) of 845 ft bgl. Geological logs based on field descriptions (Appendix C) and markings on cores (Appendix F) vary modestly because of incomplete recovery and lesser precision using cuttings. The zero depth point for the geophysical logs is the top of the collar on the permanent conductor casing; for most purposes, this level is taken as the ground elevation.

[2]Drillpad construction disturbed surficial materials. Units and depths are based on cuttings and exposures in the wall of the mud pit adjacent to the drillhole.

[3]The Santa Rosa Formation, part of the Dockum Group or undifferentiated Triassic, is apparently completely eroded at SNL-9.

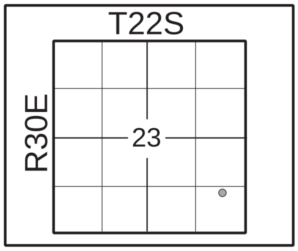
[4]The Dewey Lake Formation has been considered part of the Permian System in the past. Recent work (Renne and others, 1996, 2001) indicates that lithologically equivalent rocks in Texas are mostly Lower Triassic, with some Upper Permian at the base.

[5]The Los Medaños Member was named by Powers and Holt (1999) to replace the informal unit "unnamed lower member" of the Rustler Formation.

[6]The marker beds in the upper Salado are interpreted from a combination of cuttings, changes in drilling rates observed during drilling, and geophysical logs. The natural gamma commonly shows the argillaceous bed immediately underlying many marker beds.

Figure 2-1
Well Record SNL-9 (C-2950)

Company: Washington TRU Solutions LLC
Well: SNL-9 (C-2950)
Section: 23 Twp: T22S Rge: R30E
Location: 1,197 ft from south line (fsl)
627 ft from east line (fel)



Reference point
Log measured from: ground level (gl)
Drilling measured from: gl
Permanent Datum: gl

Elevation
KB:
DF:
GL: 3,358 ft amsl
(benchmark: 3,358.12)

Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Raymond Federwisch
Geophysical Logging Services (AZ)
Geologist: Dennis W. Powers
Spud date: May 17, 2003
Completion date: June 20, 2003
Total depth (TD): 845 ft bgl (driller log)

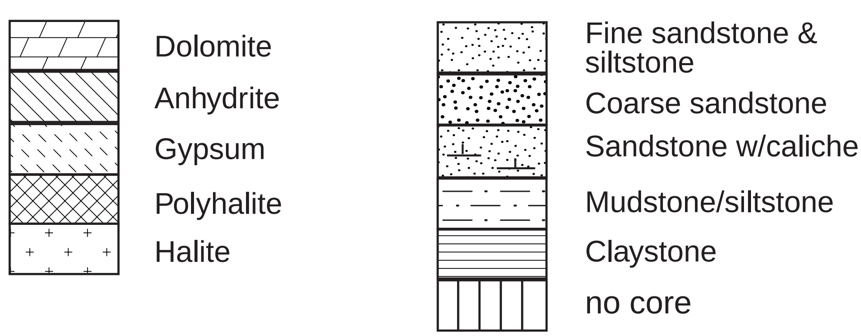
Casing Record
Conductor: 30 ft
18.0 inch steel
Casing: 9.5 inch o.d.
fiberglass to 584 ft
Screened interval:
572.0-545.0 ft

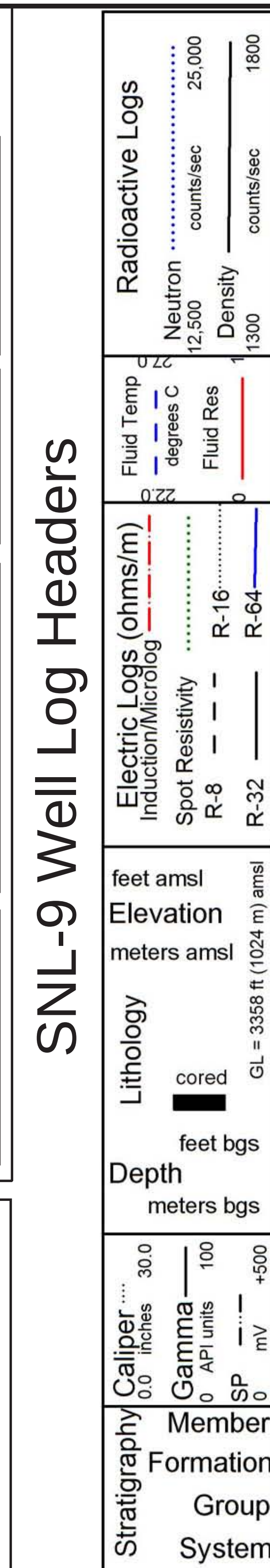
Geophysical Logs Date: June 19, 2003

Micro/Laterolog/Induction/SP:	0-~842 ft
Gamma/Fluid:	0-840 ft
Caliper:	0-844 ft
Density/Neutron:	0-845 ft
Fluid resistivity & temperature:	0-844 ft

Type fluid in hole: Brine
Res mud: 0.1 ohm-m.
Res mud filtrate:
9.3 ohm-m.
Max. Rec. Temp.:
27.0^{o}C

General Lithologic Symbols Used





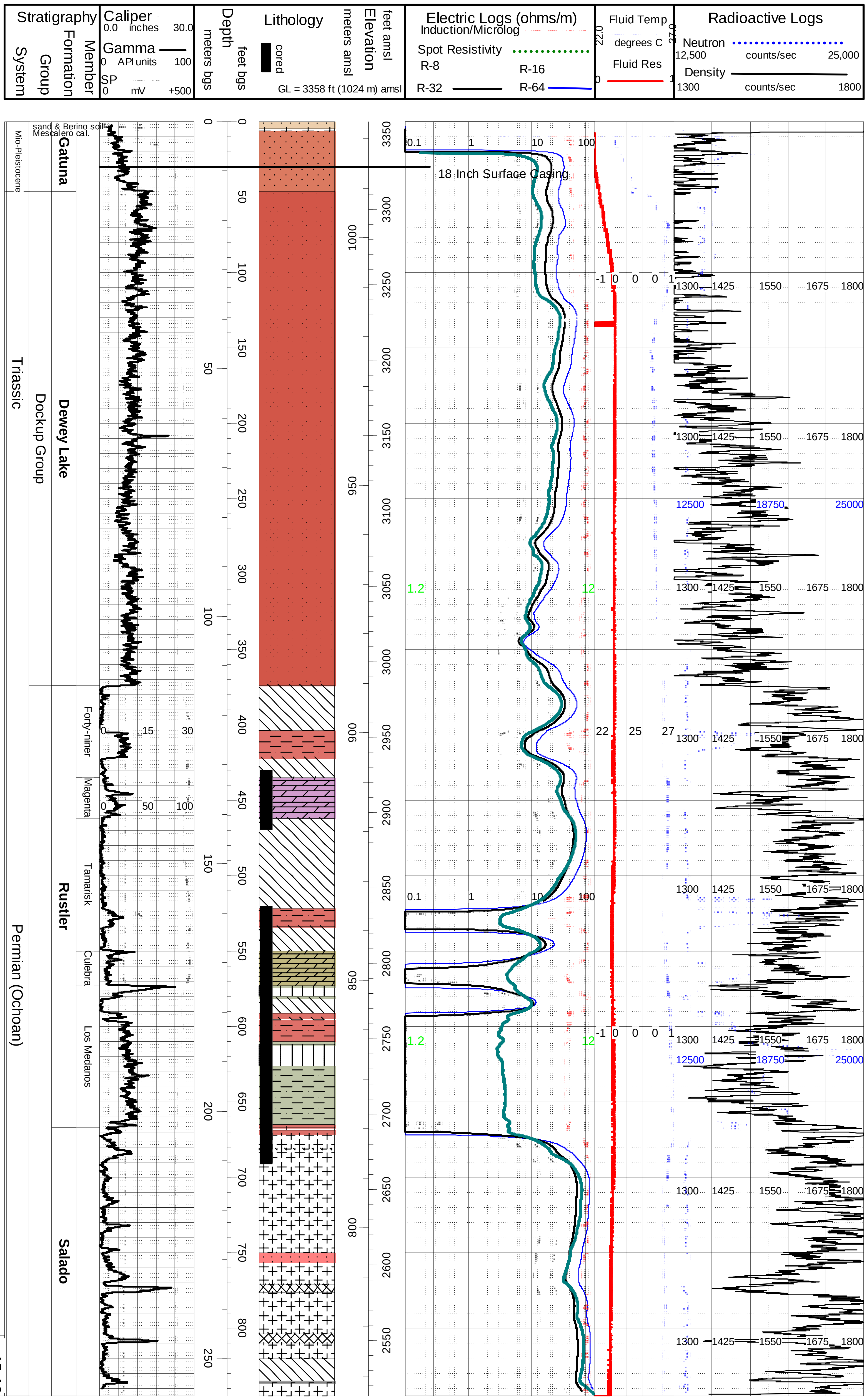
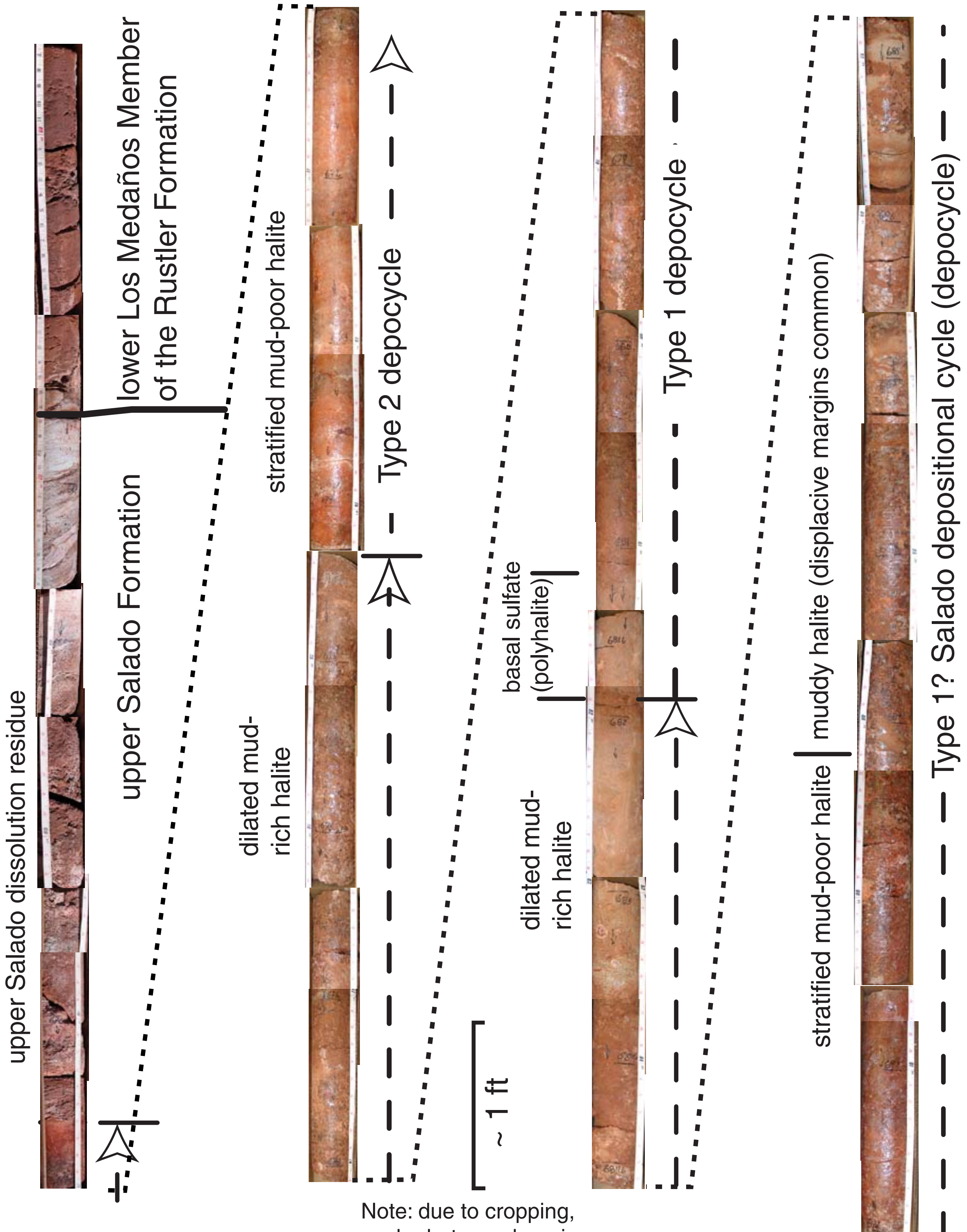

Stratigraphy
System
Group
Formation
Member
Caliper
0.0 inches 30.0
Gamma
0 API units 100
SP
0 mV +500
Depth
meters bgs
feet bgs
Lithology
cored
GL = 3358 ft (1024 m) amsl
Elevation
meters amsl
feet amsl
Electric Logs (ohms/m)
Induction/Micrologs
Spot Resistivity
R-8
R-16
R-32
R-64
Fluid Temp
degrees C
Fluid Res
Radioactive Logs
Neutron
12,500 counts/sec 25,000
Density
1300 counts/sec 1800
sand & Berino soil
Mescalero cal.
Mio-Pleistocene
Gatuna
Triassic
Dockup Group
Dewey Lake
Permian (Ochoan)
Rustler
Forty-niner
Magenta
Tamarisk
Culebra
Los Medanos
Salado
18 Inch Surface Casing

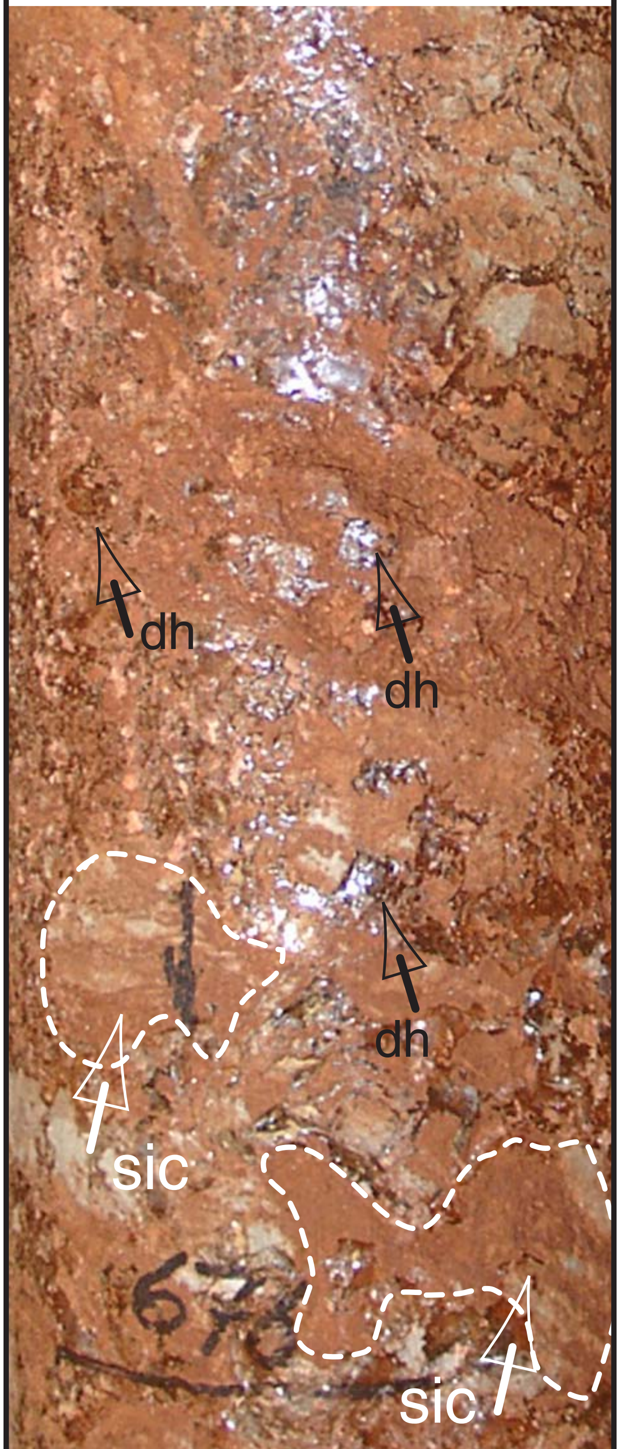
Figure 2-2 Core Features for the Upper Salado and Basal Rustler Formations at SNL-9



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

Figure 2-3

Salado Displacive Halite (dh), Smeared Intraclasts (sic) at SNL-9



2.2.2 Permian Rustler Formation

The Rustler Formation was completely drilled. The contact with the underlying Salado is at 666.4 ft, as marked on the core, and 667 ft based on geophysical logs. The contact between the Rustler and the overlying Dewey Lake Formation is at 374 ft, based on geophysical logs, and the total Rustler thickness at SNL-9 is 293 ft.

2.2.2.1 Los Medaños Member

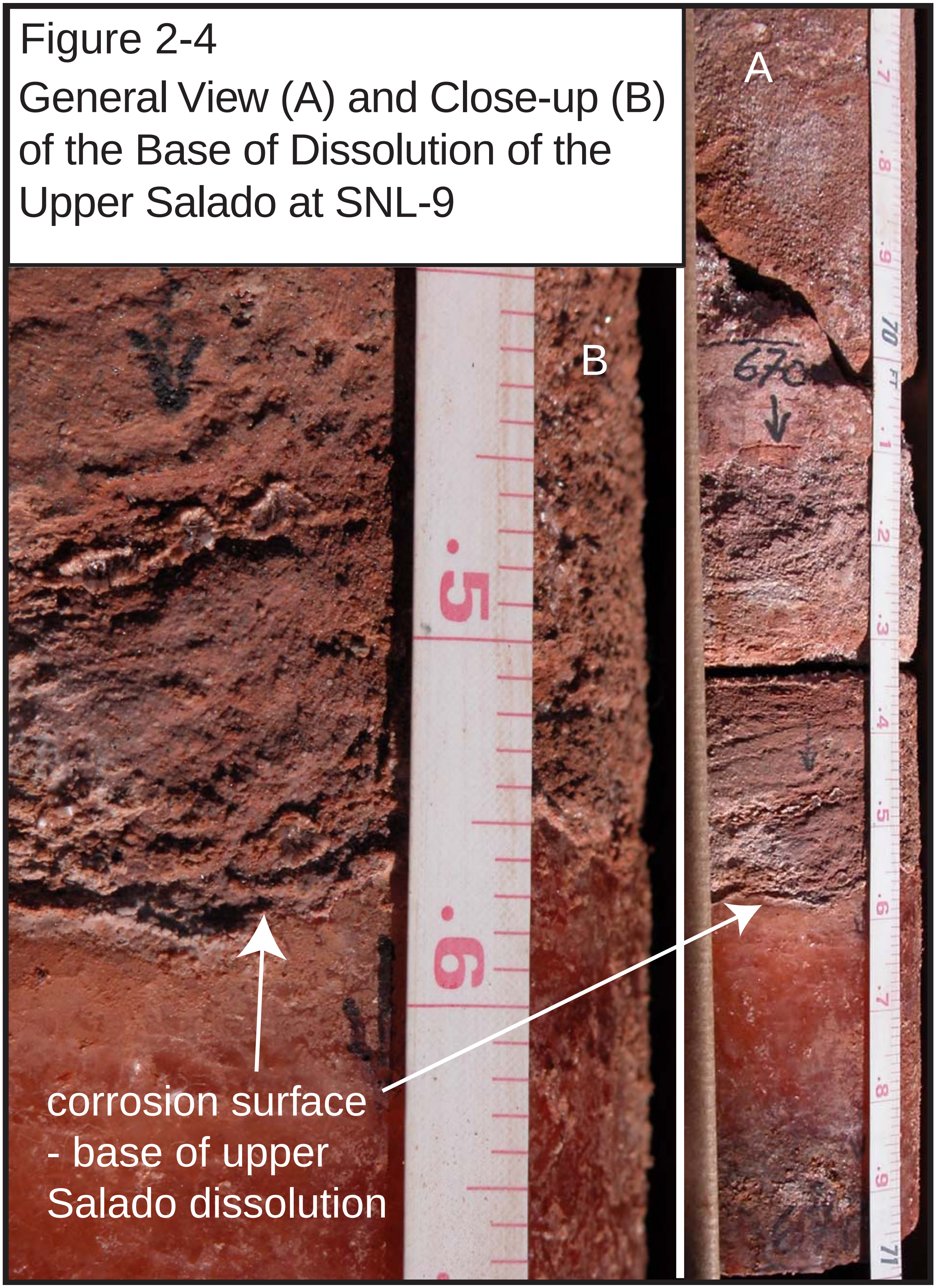
The Los Medaños Member of the Rustler was named by Powers and Holt (1999) based on the rocks described in shafts at WIPP. For the area around WIPP, studies of the Rustler have commonly referred to this interval from the base of the Culebra to the top of the Salado as the unnamed lower member of the Rustler. Holt and Powers (1988) and Powers and Holt (1999) also informally subdivided the Los Medaños into five units: 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. 2-5), because halite below A-1 is not restricted to the thinner zone designated M-1/H-1 in these earlier publications.

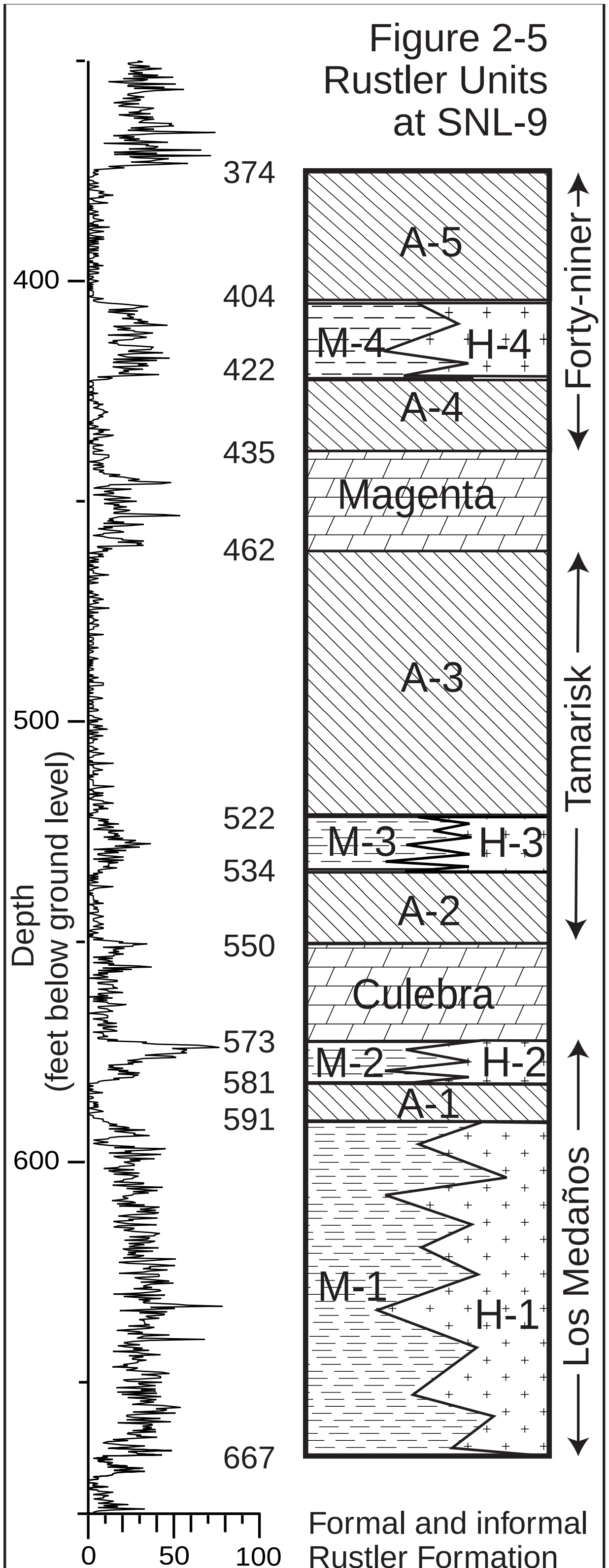
Based on geophysical logs, the Los Medaños at SNL-9 is 94 ft thick (667–573 ft). The entire member was cored in SNL-9, although portions of the upper part were only partially recovered.

The informal unit *mudstone-halite 1* (M-1/H-1, see Fig. 2-5; Holt and Powers, 1988) has several important characteristics at SNL-9. It occurs from 667-591 ft, a thickness of 76 ft.

At the base of M-1/H-1, 2.1 ft of reddish brown siltstone or very fine sandstone overlies the gypsum considered the top of Salado (Fig. 2-2). The siltstone is bedded, and the bedding is inclined to deformed. Small sulfate clasts are included in the top of the unit. There is no clear erosional surface near the base of this unit, in contrast to many other drillholes and shafts.

Figure 2-4
General View (A) and Close-up (B) of the Base of Dissolution of the Upper Salado at SNL-9





Formal and informal Rustler Formation units and depths at SNL-9 based on natural gamma log

Much of the lower M-1/H-1 cored from 610–664.3 ft is dark gray (2.5YRN/4; Munsell Soil Color Chart, 1971 edition), very fine sandstone that is little cemented and moderately lithified. Laminae generally are low-angle planar to slightly wavy (Fig. 2-6), and cross-cutting relationships are common. Probable subhorizontal burrows occur from ~654–655 ft as well as near 650 ft (Fig. 2-6), and some core surface pockmarks may also be evidence of bioturbation. Some laminae display soft sediment deformation (Fig. 2-6). The basal part of the dark gray sandstone includes anhydrite and gypsum clasts and inclined bedding (~30°).

Most fractures through this interval are near vertical. Fractures range from filled with gypsum to unfilled. Samples retrieved during coring of this interval tended to be blocky because of fractures and bedding.

Samples from ~610–599.9 ft display three graded sequences of very fine sandstone to siltstone upward with colors from reddish brown (5YR5/3) to very dusky red (7.5YR2.5/2). The middle sandstone has an erosional base at 607.9 ft. The sandstones include sets of thin beds, and bedding becomes wavy to very thin laminae upward in the siltstones. Sulfate is more common in the siltstones at the top of each sequence. There is also some soft sediment deformation in the siltstones. A nearly vertical fracture from 610 ft downward shows sandstone fill and some possible gypsum.

A thin anhydrite from 598.3–599.9 ft is white and fine-grained, and it includes reddish-brown laminae near the base. This anhydrite is distinct from A-1 at SNL-9 (see below). Shaft mapping (e.g., Holt and Powers, 1990a) also showed a thin anhydrite below A-1, but it appears to be lower in the stratigraphic sequence than in SNL-9 and may not be exactly correlative. This thin anhydrite is similar in stratigraphic position to a thin anhydrite included in A-1 in drillhole SNL-2 (Powers and Richardson, in review). Because the intervening clastic unit was thinner (see next paragraph) at SNL-2, the units were combined. Detailed stratigraphic correlation will likely be examined in later interpretive reports.

Another fining upward sequence (very fine sandstone to sandy claystone) lies at the top of M-1/H-1. It ranges from reddish brown (5YR4/4) at the base to dark reddish brown (5YR3/2) upward. Smeared intraclast textures (Powers and Holt, 2000) may be present in the lower part of the unit. Gypsum is present in the upper part, ranging from fracture fill to stellate (displacive?) forms.

Coring was moderately successful through M-1/H-1. The unit is not well-cemented and is fractured into blocks. It is likely that ~20 ft of the unit was lost during coring.

The informal unit *anhydrite 1* (A-1; see Fig. 2-5; Holt and Powers, 1988) was encountered from 581–591ft, based on the natural gamma log from SNL-9. Considering the drilling records and apparent loss of core from the unit above A-1, the core of A-1 was attributed to the interval from 585–594.9 ft and was accordingly marked. The core has not been re-marked. The features of A-1 are discussed according to core depth markings.

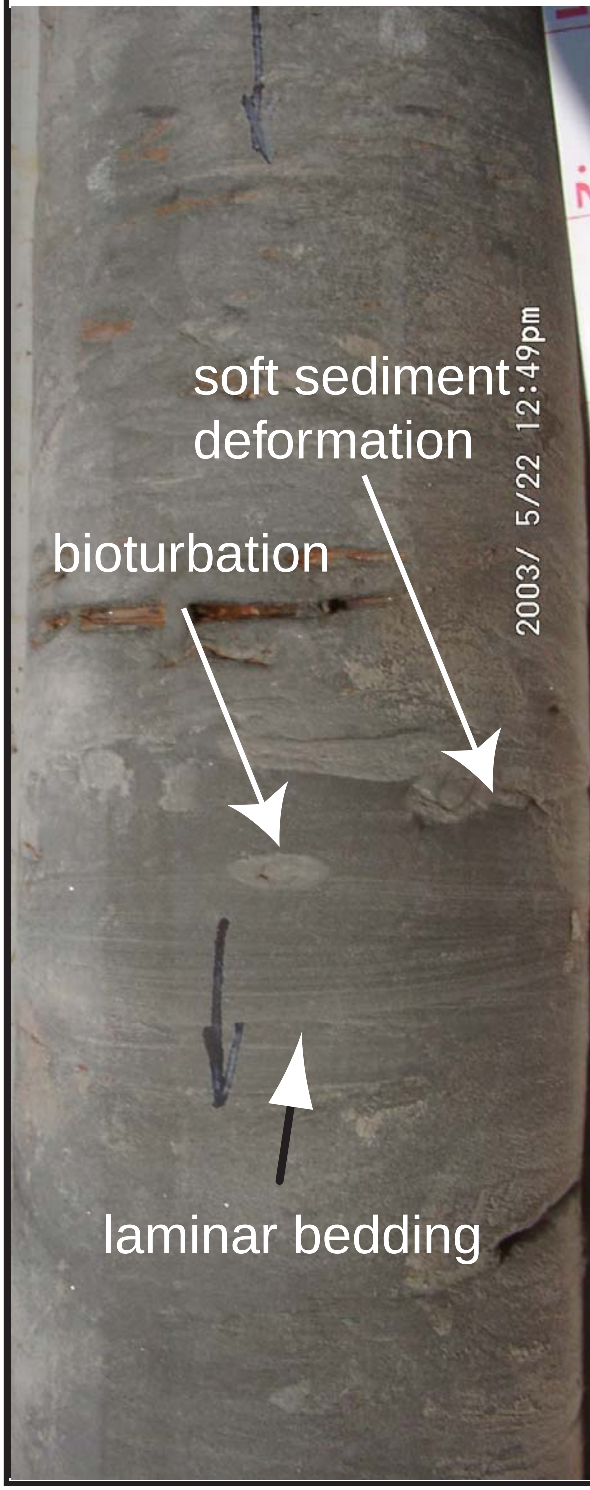
A-1 at SNL-9 is gray, fine-grained anhydrite with thin laminae. The unit is reddish from ~586.7–587.2 ft, which can indicate the presence of polyhalite. The geophysical log does not show elevated natural gamma from potassium through this zone. A similar zone in A-1 is polyhalitic in some drillholes farther to the southeast (Holt and Powers, 1988).The surface of the core also displays features that may indicate anhydrite pseudomorphs after vertically oriented gypsum crystals.

The informal unit *mudstone-halite 2* (M-2/H-2; see Fig. 2-5; Holt and Powers, 1988) was encountered from 573–591 ft, based on the natural gamma log from SNL-9. Only small core sections at the bottom and top of the unit were recovered, and they were marked according to the drilling depth at the time of recovery.

Approximately 0.3 ft of core recovered from the base of M-2/H-2 consisted of gray and green calcareous claystone. Approximately 0.1 ft of black, sticky claystone was recovered from the top of M-2/H-2, and it appears to have a sharp contact with the overlying Culebra.

Figure 2-6

Los Medaños Sedimentary Features (650.1-650.9 ft) at SNL-9



2.2.2.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-9, the Culebra extends from 550–573 ft, a thickness of 23 ft (Fig. 2-1). Based on drilling depths available at the time, the recovered Culebra core was marked from 552.9–581.9 ft (as used in information in Appendices B, C, and G). Less core was lost from the Culebra than was believed at the time of coring. Recovered Culebra core (Fig. 2-7) totals 19 ft thick, indicating a core loss of ~4 ft from this unit. Based on the drilling activity and recovery of adjacent units, the core loss was attributed to the middle of the Culebra (Appendix C, sheet 6).

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 Culebra is a pale brown (10YR6/3) to brown (10YR5/3) silty dolomite at SNL-9. A thin, brown, argillaceous, organic-rich zone occurs at the top of the Culebra. In the cores from SNL-9, the dolomite is fine-grained and poorly bedded, and it displays zones of characteristic pores that range from open to filled with gypsum. This is similar to other Culebra cores (e.g., Holt and Powers, 1988; Powers and Holt, 1990; Holt, 1997).

The basal dolomite marked at 581.9 ft overlies the black claystone of the Los Medaños as a continuous unit. From 581.9–576.6 ft, however, the retrieved Culebra core is very crumbly and vuggy. Most vugs are open, with little silt filling. Vertical fractures connect porosity, and the fractures show some color staining. It is not clear whether this material represents the basal Culebra adequately or is part of the lower middle Culebra. It is not like the basal hydrostratigraphic unit (CU-4) defined from studies of cores elsewhere at WIPP (Holt, 1997). Although CU-4 is commonly brecciated, it is cemented and relatively well-lithified elsewhere. The recovered core material through this zone appears mostly to represent hydrostratigraphic unit CU-3.

The middle Culebra recovered from the base of core run 4, from 567.3–562.3 ft, also shows vertical fractures with stains. These fractures are common and connect porosity. The vugs are mostly open, with little silt filling. The core from this interval is crumbly. This core interval is most like hydrostratigraphic unit CU-3 (Holt, 1997).

The dolomite from 562.3–558.3 ft is very porous, with vugs to ~1 inch diameter. Most vugs in this interval are small (0.04–0.08-inch diameter), and they are organized in horizontal beds or zones. Near-horizontal laminae are common. Fractures are scattered though this zone and are near-vertical. This zone corresponds best to CU-2 (Holt, 1997).

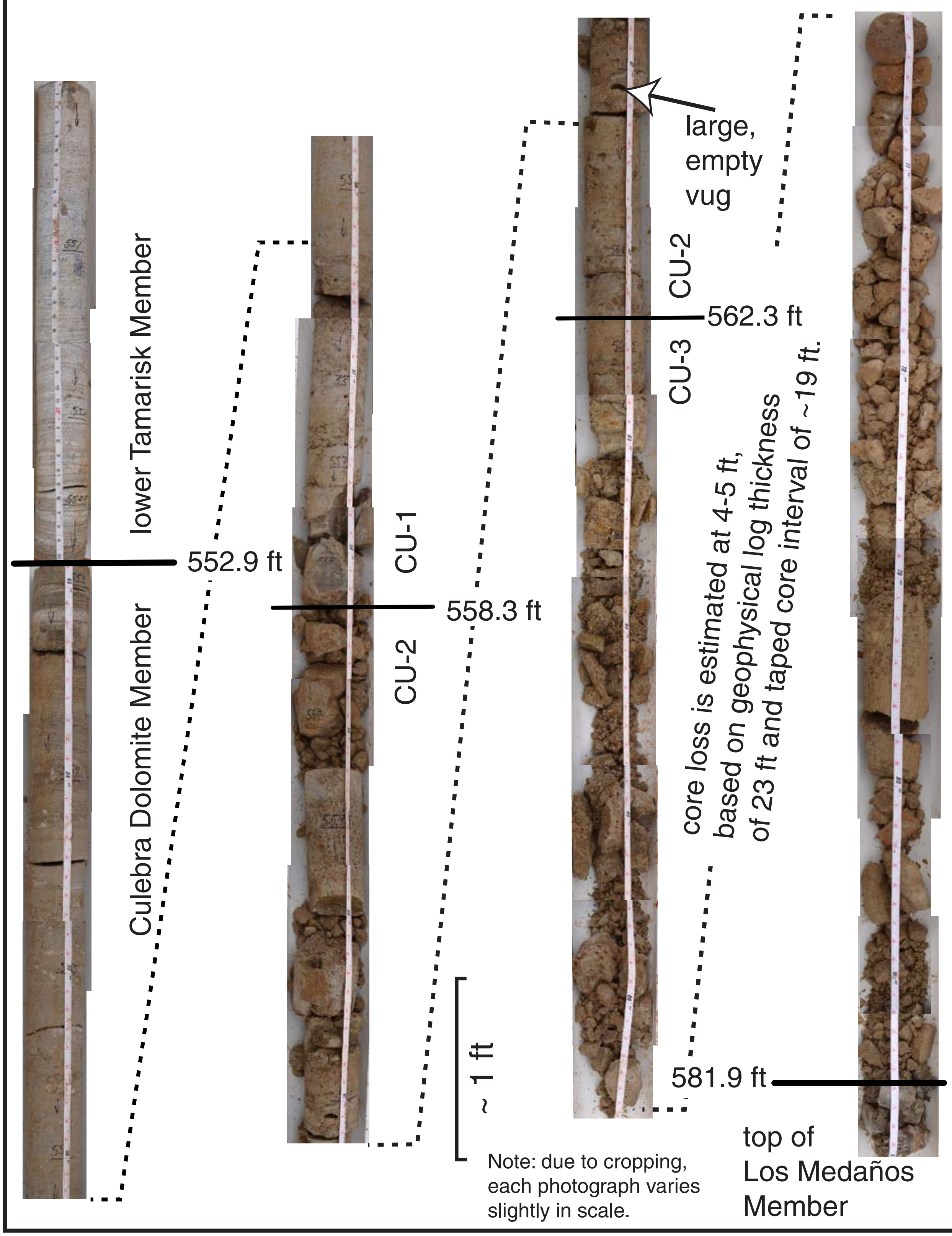
The upper Culebra, from 558.3–552.9 ft, is bedded and shows less porosity. Vugs in this zone are generally filled with gypsum. This interval is equivalent to CU-1 (Holt, 1997).

The geophysical logs of the Culebra provide some additional details of the unit. The natural gamma drops to a relatively low value near the base of the unit and is generally low to the top. A small spike ~5 ft below the top of the Culebra may coincide with the general boundary between CU-1 and CU-2. The natural gamma spike at the top of the Culebra is consistent with the argillaceous, organic-rich zone at this horizon throughout much of the basin. The resistivity logs (Fig. 2-1) show a distinctive, lower resistivity zone from 559–573 ft, indicating that this is probably the most transmissive part of the Culebra.

2.2.2.3 Tamarisk Member

The natural gamma log of SNL-9 shows that the Tamarisk Member occurs from 462–550 ft. The Tamarisk comprises three basic subunits: a lower anhydrite, a middle mudstone to halite, and an upper anhydrite (Fig. 2-5). All three are clearly shown by geophysical logs and were recorded by cuttings and cores during drilling. Powers and Holt (2000) labeled these A-2, M-3/H-3, and A-3, from base to top, respectively, and they showed that the lateral gradation from mudstone M-3 to halite H-3 reflects lateral changes in deposition. SNL-9 is located in the mudflat or M-3 facies of these beds.

Figure 2-7 Culebra Dolomite Member of the Rustler Formation at SNL-9



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

The basal 22.9 ft and upper 8.6 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* (Fig. 2-5; A-2 of Holt and Powers, 1988) at the base of the Tamarisk is 16 ft thick (534–550 ft) on the geophysical logs. Core retained from the interval was marked from 536.5–552.9 ft, an interval thickness of 16.4 ft. A-2 is predominantly gray gypsum. A-2 is bedded, and the middle portion of the unit is laminar. Some possible bedded nodular textures were noted on the core surface, and there are possible algal textures from 543–546.1 ft. In contrast to some other cores and shafts, there is little evidence of an argillaceous zone in core or from increased natural gamma in the geophysical log. The upper boundary of A-2 with the overlying claystone is sharp.

The informal Tamarisk unit *mudstone-halite 3* (Fig. 2-5; M-3/H-3 of Holt and Powers, 1988) is 12 ft thick (522–534 ft) at SNL-9, based on the geophysical logs. The cored interval marked from 525.9–536.5 ft corresponds to the logged interval, and the thicknesses are consistent within the limits of interpreting the logs.

From 536.5–529.2 ft, M-3/H-3 is reddish brown claystone and mudstone, with gray claystone clasts from 534–532.8 ft. A high-angle fracture from 534.5–533.6 ft is filled with gypsum.

From 529.2–525.9 ft, M-3/H-3 is gray claystone with large gypsum clasts. Stratification is thick at the base and laminar toward the top of this interval.

Resistivity decreases greatly through M-3/H-3, indicating there may be significant porosity and fluid within the unit, including invasion during drilling.

Geophysical logs indicate the informal unit *anhydrite 3* (A-3) (Fig. 2-5; Holt and Powers, 1988) occurs from 522–462 ft, a thickness of 60 ft. Core markings for the base and top, respectively, for this unit are 525.9 ft and 461.9 ft, for a thickness of ~64 ft. The upper and lower contacts were cored, and the main part of the unit was drilled.

Approximately 5.9 ft of the basal A-3 was cored, and this part of the unit is mainly bedded gray gypsum. The gypsum is well indurated, with very coarse crystals. A gray siltstone and claystone, 0.1 ft thick, occurs at 523.2 ft. Fractures near the base create some breccia.

Cuttings from the drilled interval of A-3 were rare. The geophysical logs do not indicate any unusual lithology for this interval.

The upper part of A-3 was cored from 470.5–461.9 ft, a thickness of 8.6 ft. The core consists of white to dark gray, bedded anhydrite and gypsum (Fig. 2-8). Thin organic and carbonate layers, possibly algal in origin, were encountered at 465 and 467 ft. Some bedded nodules may be present.

The upper contact with the Magenta is transitional over an interval of ~0.5 ft; it has been placed at the base of the transition zone.

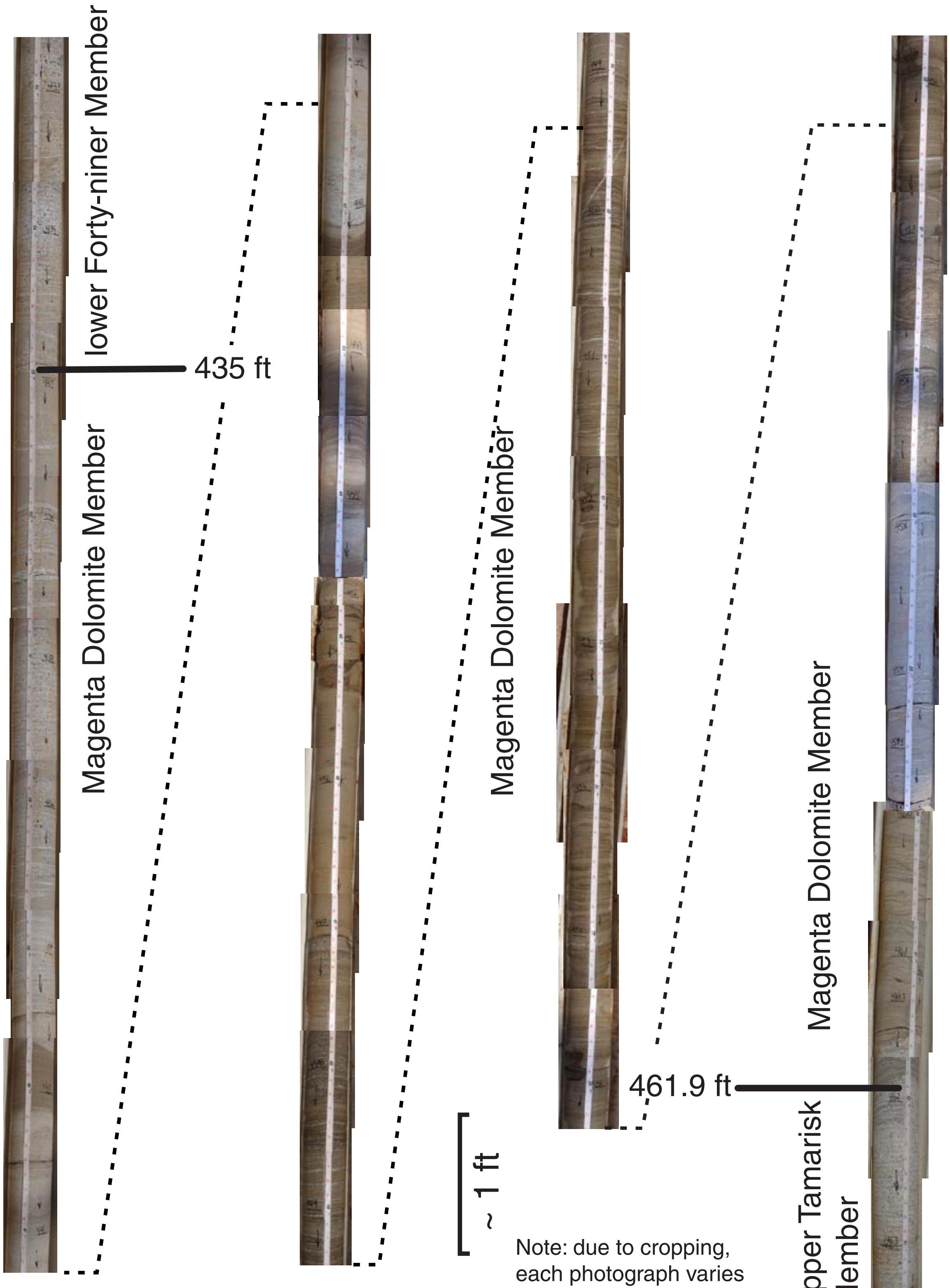
The Tamarisk stratigraphy and thickness are consistent with other drillholes and shafts in the area (Holt and Powers, 1988). Differences are consistent with depositional variations and do not suggest unusual conditions.

2.2.2.4 Magenta Dolomite Member

The Magenta Dolomite Member at SNL-9 is 27 ft thick (435–462 ft) based on geophysical logs. Core from the Magenta is marked from 435–461.9 ft, a thickness of ~26.9 ft (Fig. 2-8). The entire unit was cored, and core recovery was very good.

The Magenta consists of dolomite and gypsum and is commonly white (10YR8/2) to light grayish brown (10Y6/2) at SNL-9. 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-9, as in outcrops and shaft exposures, is well-developed laminar, wavy, and lenticular bedding, along with zones of algal stromatolites in the lower Magenta (below 455 ft). A few small ripples were observed. Wave amplitudes commonly decrease upward from the base toward the middle of the unit and then increase slightly upward toward the upper contact. In the lower Magenta, amplitudes range from ~0.1–0.2 ft

Figure 2-8 Magenta Dolomite Member of the Rustler Formation at SNL-9



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

(Fig. 2-8). Bedding amplitude is more commonly ~0.25–0.5 inch in the middle and upper part of the Magenta. Near the base of the Magenta at SNL-9, the wavy bedding includes very thin, dark laminae draping the high points. These are interpreted as stromatolites, consistent with well-exposed algal features in the air intake shaft (Holt and Powers, 1990a; Powers and Holt, 1990). Both the base and top of the Magenta show environment transitions over time; the upper part of the Magenta displays interbedded zones dominated by gypsum or anhydrite.

Fibrous gypsum fills bedding-plane separations that are common in much of the Magenta, except for the interval from ~447–439 ft. The core from this same interval remained damp after the rest of the core had dried and is likely more porous. High-angle to vertical fractures are sparse through the Magenta at SNL-9. They are filled with gypsum, show little or no vertical offset, and have widths up to 0.1 inch. Three are obvious: from 460.9–459+ ft, from 450.0–449.4 ft, and from ~445–444+ ft. The last fracture is the only apparent high-angle fracture within the more porous zone of the Magenta.

The standard resistivity logs through the Magenta display slight vertical variability. The microresistivity reveals lower resistivity from 436–455 ft, with a minimum at ~444–445 ft, similar to the position for the high-angle fracture observed in the core. The neutron log shows a slight increase from ~436–455 ft, which corresponds to the zones without macroscopic evidence of gypsum. The density log indicates a decrease from ~444–456 ft.

The upper contact of the Magenta with the overlying Forty-niner Member, as placed on the core, is sharp but continuous. Some gypsum or gypsiferous units are included in the upper part of the Magenta at SNL-9. This contrasts somewhat with the situation at SNL-2 (Powers and Richardson, in review) where intermittent dolomite was included in the lower Forty-niner.

The Magenta is typical in thickness, composition, and sedimentary features. Fractures are limited, and this is consistent with much of the findings around WIPP. The zone with gypsum in the upper Magenta at SNL-9 has lower natural gamma than is typical of the upper Magenta, but this is consistent with the gypsum present.

2.2.2.5 Forty-niner Member

The Forty-niner Member at SNL-9 is 61 ft thick (435–374 ft), based on geophysical logs. The Forty-niner is described on the basis of cuttings and geophysical logs through the upper part of the member to the coring depth beginning at 430 ft. All Forty-niner cores were recovered from the lower sulfate beds of the member. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that ranges from siltstone and claystone at SNL-9 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 (Fig. 2-5), and 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), is gray to white gypsum and anhydrite ranging from very coarse gypsum and finer anhydrite. A-4 is 13 ft thick (from 422–435 ft), based on geophysical logs as well as drilling. The recovered core of A-4 (Fig. 2-8) displays some laminar to wavy bedding that may be algal in dolomitic beds. The gypsum is bedded, may be nodular, and may include some swallowtail gypsum. The environmental transition from the Magenta was not sharp, and there appear to have been oscillations between dolomite and gypsum deposition for a period before gypsum became predominant.

A-4 reveals numerous thin (generally < 0.2 inch) gypsum veinlets, with vertical fibers, along bedding separations.

Mudstone-halite 4 (M-4/H-4) is ~18 ft thick (404–422 ft), based on the natural gamma log. Cuttings from M-4 provided siltstone and claystone that was weak red (7.5YR5/2) and non-calcareous at the top and bottom of the unit. The middle part of M-4 at SNL-9 returned cuttings of reddish brown (2.5YR5/4) sandstone that was friable and non-calcareous.

The upper sulfate unit, *anhydrite-5* (A-5), is white (10YR8/1), and it is ~30 ft thick (374–404 ft) at SNL-9. Cuttings from the interval in SNL-9 were mainly powder.

2.2.3 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 et al. (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 evaporite to redbed 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-9, the Dewey Lake is 328 ft thick (374–46 ft) and is composed mainly of dark red (2.5YR3/6) interbedded silty claystone, siltstone, sandy siltstone, and fine-grained sandstone. Small (< 0.04 inch) grayish-green reduction spots are a common characteristic of the Dewey Lake at SNL-9 and elsewhere. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical logs (e.g., Doveton, 1986).

Geophysical logs from SNL-9 indicate different basic sedimentary regimes as well as porosity conditions. The following information follows the basic template developed for a study of the Dewey Lake hydrogeology (Powers, 2003) and applied to other drillholes such as C-2737 (Powers, 2002b).

Only the lower two of three general depositional regimes for the Dewey Lake Formation can be distinguished on natural gamma logs of SNL-9, and the second (middle) is likely only partially preserved.

The interval from 374–295 ft in SNL-9 displays the natural gamma and resistivity features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003). The natural gamma fluctuates around a similar value (~30 cps in this case) over this vertical interval, and there are no apparent trends over the entire interval. The resistivity tends to fluctuate as well, on a vertical scale of ~4–15 ft. The fluctuations appear to correlate across boreholes, suggesting broad-scale bedding, and the interval corresponds to a bedded section exposed clearly in the air intake shaft (Holt and Powers, 1990).

The interval from 295–46 ft (249 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 (Powers, 2003). A sandstone unit from ~295–288 ft is at the base of this interval.

The interval of fining upward cycles may be somewhat truncated at SNL-9 by erosion by the Gatuña. Near the center of the site, this interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). Erosion has removed more than 50 ft of this unit at the location of SNL-9.

The *upper coarsening interval* was eroded at SNL-9.

The Dewey Lake is not full thickness here because of erosion before the Gatuña was deposited. The sedimentological units definable by natural gamma logs for the lower Dewey Lake are present and are generally representative below the erosional surface.

Cuttings from the upper Dewey Lake were calcareous to very calcareous to a depth ~116 ft. Below this point, cuttings included some gypsum and very little carbonate. All resistivity logs show an increase below 116 ft. The neutron flux decreased slightly below this point, reflecting the significant presence of gypsum below ~116 ft. The precompletion caliper log (Fig. 2-3) shows an irregular hole diameter above 116 ft and a very regular diameter from 116–260 ft, which is likely the most heavily cemented zone. The carbonate-sulfate cement boundary is interpreted as 116 ft.

This cement change is observable in other cores from the area (Powers, 2003), and it was reported in the air intake shaft (Holt and Powers, 1990a).

The likely carbonate-sulfate cement boundary in the range of 116 ft is stratigraphically lower than at the middle of the WIPP site. At C-2737, the cement change is 303 ft above the Dewey Lake–Rustler contact (Powers, 2002b); at SNL-9, the cement change is 258 ft above the contact. This change is consistent with the boundary dropping stratigraphically while the Dewey Lake was exposed to more erosion and weathering (Powers, 2003).

On the basis of the resistivity logs (Fig. 2-1), the Dewey Lake is likely to be more transmissive above ~116 ft, which is the possible lower limit of the carbonate-sulfate boundary. The resistivity is relatively high and uniform from 116–275 ft, which is consistent with the high resistivity, lower porosity unit hypothesized by Powers (2003) for the sulfate-cemented zone of the Dewey Lake.

2.2.4 Miocene–Pleistocene Gatuña Formation

Based on the cuttings from drilling and geophysical logs, the Gatuña occurs from 46–6.5 ft. The Gatuña at SNL-9 is primarily reddish brown (2.5YR4/4) sandy claystone interbedded with siltstone and fine sandstone.

The Gatuña is variably calcareous, with calcite increasing in the upper portion where pedogenic calcrete has infiltrated the unit. It is also very calcareous from ~40–43 ft, just above the top of the Dewey Lake. MnO_2 stains some of the cuttings, probably from pedogenic processes. The formation is porous and mottled due to pedogenic processes.

The Gatuña generally increases in thickness to the west, and the depositional edge of the formation at WIPP is in the same area where the Santa Rosa pinches out because of erosion that preceded Gatuña deposition (Powers and Holt, 1993). The Gatuña is moderately thick at SNL-9. To the west of SNL-9, along the Livingston Ridge escarpment, the formation is considerably thicker and is exposed in an arroyo described by Powers and Holt (1993).

The Gatuña ranges in age from at least 13.5 to ~0.5 million years old (Powers and Holt, 1993). From general relationships along Livingston Ridge, the Gatuña at SNL-9 most likely represents younger portions of the unit range.

2.2.5 Pleistocene Mescalero Caliche

The pedogenic Mescalero caliche 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. Ages obtained using uranium-disequilibrium methods indicate the Mescalero formed between ~570,000 (± 100,000) and ~420,000 (± 60,000) years ago (Rosholt and McKinney, 1980). The Lava Creek B ash, ~600,000 years old, underlies the Mescalero less than 2 miles north of SNL-9 along Livingston Ridge (Izett and Wilcox, 1982). It provides an approximate indicator of the age of the uppermost Gatuña, as well as a lower limit for the Mescalero.

At SNL-9, the Mescalero is less than 2 ft thick (4.6-6.5 ft). From exposures in the area of WIPP, the Mescalero shows evidence of pedogenic processes such as nodule, ped, and laminae development. Not only is the unit strongly calcareous, the upper portion of the unit is locally plugged and subhorizontal laminae are partially developed at the upper surface. 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 because of the wide variation in use of the term "caliche.") The Mescalero is generally at stage V in the vicinity of WIPP. At SNL-9, the stage of development is less certain because cuttings were powder and the mud pit did not sufficiently expose the Mescalero.

2.2.6 Pleistocene Berino Soil and Surficial Sands

The Berino is a yellowish-red (2.5YR5/6) sandstone that is friable and argillaceous. Sand grains are very fine to medium. The Berino soil is not a geologic unit; it is a pedogenic unit defined in the area by soil scientists (Chugg et al., 1971). From SNL-9 to the Livingston Ridge escarpment, the Berino is commonly present below dune sand. The Berino is known also to fill "flowerpots" in this area, which are breaks in the Mescalero created by root zones around bushes such as mesquite.

Grayish brown dune sand, stabilized by vegetation, and thin surficial colluvium and eolian silt overlie the Mescalero where it has not been completely exposed. These materials, with imported Mescalero caliche, were used to construct the pad, forming 4.6 ft of fill over the surface of the Mescalero.

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3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-9

SNL-9 was drilled specifically to monitor water levels and water quality from the Culebra Dolomite Member of the Rustler Formation and to serve as a location for a pumping test and observations during pumping tests.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

No groundwater zone was observed in the Dewey Lake or Gatuña Formations, which were drilled with compressed air in one day.

The drillhole was drilled with compressed air to a depth of 430 ft, into the lower anhydrite (A-4) of the Forty-niner Member, and it was left overnight before continuing coring from that depth. An electric probe was run into the drillhole to total depth, and it showed a response at the bottom of the drillhole. The drilling pipe was run into the hole and compressed air was used to blow the hole dry. The driller estimated there may have been up to 5 ft of water, but the drillhole did not produce additional water while blowing compressed air. It is undetermined where in the stratigraphic section this water may have entered or if it represents mainly condensation overnight.

3.2 Initial Results from the Magenta Dolomite

During drilling of SNL-9, some general evidence of water inflow and rates for the Magenta was obtained.

The Magenta was cored on May 19, 2003, using air and mist (Baroid QuickFoam). After the Magenta and upper Tamarisk were cored to 470 ft, the cored interval was reamed to 7.875 inches diameter to a depth of 468 ft. At that point, the drillhole appeared to be producing ~1/2 gallon per minute (gpm) from the compressed air and mist return. The hole was deepened to 520 ft in preparation for additional coring, and it remained open overnight.

On May 20, 2003, an electric probe was used to determine that the water level was at 458 ft, 4 ft above the base of the Magenta. The most likely producing interval is the Magenta.

The apparent water level rise was 62 ft (520–458 ft) in a 7.875-inch diameter drillhole. This is equivalent to 157 gallons. The compressed air was turned off by 1530 MDT on May 19, 2003, and the water level was measured at about 0630 MDT on May 20, 2003, a period of ~15 hours, or 900 minutes. The estimated inflow during this period is therefore ~0.17 gpm. The Magenta is 27 ft thick in SNL-9. Core observations suggested a more porous zone ~8 ft thick, while geophysical logs recorded resistivity changes over 19 ft.

There were no other observations in the drillhole regarding potential Magenta hydraulic properties or water levels. The water was not sampled.

3.3 Initial Results From the Culebra Dolomite

The Culebra was cored on May 20, 2003, and the drillhole was observed producing some water at a total depth of 582 ft at the end of drilling (~1400 MDT). The water level was 275 ft in SNL-9 at about 0630 MDT on May 21, 2003. No samples were taken, and no testing was conducted.

On June 26, 2003, a pump was placed in the casing to develop the Culebra hydraulically and remove drilling fluids. Pumping was cycled on and off at relatively high pumping rates (up to 187 gpm) for shorter periods early in the development. Longer pumping periods were at lower rates, starting from ~50 gpm and reduced to ~25 gpm by the end of the development period. The total removed from the well on June 26 was 91 barrels. A preliminary fluid density of 1.060 g/cc was obtained near the end of this initial development.

On September 2, 2003, SNL-9 was bailed because of apparent infill in the casing. Thirty bailer volumes (~780 gallons) were removed from the well, along with reddish mud from the bottom of the well. Fourteen feet of fill is estimated to have been removed from the well by bailing. This allowed a pump to be placed near the base of the screen in the well.

On September 4, 2003, SNL-9 was further developed by pumping at relatively steady rates (14.5 gpm initial, 21.1 gpm at end) over a period of 2 hours, 50 minutes. The total volume pumped was 41 barrels. Fluid density was measured in the field at 1.036 and 1.034 g/cc.

Beginning in July 2003, static water levels for the Culebra in SNL-9 were regularly measured (Siegel, 2003). The casing reference elevation is 3,360.95 ft amsl (Fig. 2-3), and the water level elevations are provided (Table 3-1) and plotted (Fig. 3-1) both as measured and corrected for fluid density to a fresh-water-equivalent (FWE) elevation. Changes in FWE (Fig. 3-1) partially reflect differing fluid density measurements.

3.4 Observations About the Rustler–Salado Contact

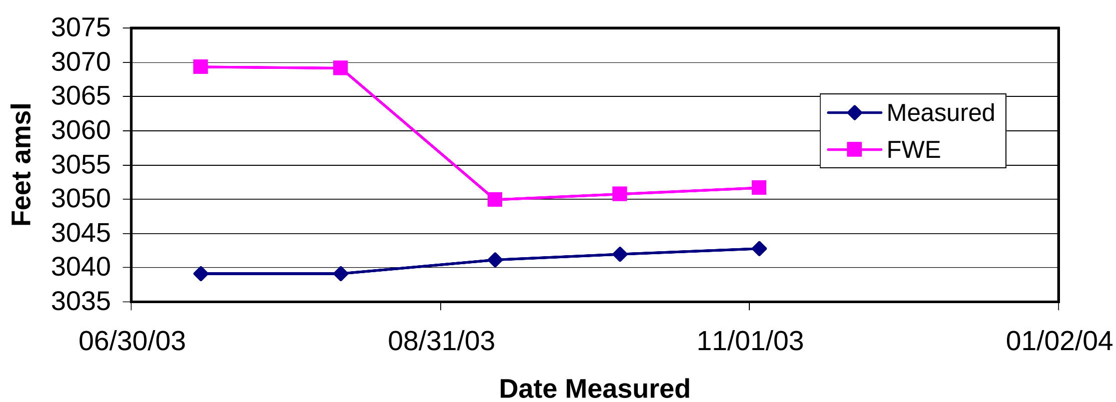
The interval was cored with good recovery. There was no indication during drilling of changes in drilling fluid or of flow into the drillhole from this zone affecting the drilling fluid returns. Cores across the Rustler–Salado contact appear to include residues after postdepositional dissolution of halite from the upper Salado.

Table 3-1
Water Levels and Elevations In SNL-9

Date	Time (MD/ST)	Depth (ft) to Water Level	Water Elevation (ft amsl)	FWE Water Elevation (ft amsl)
07/14/03	10:43	321.82	3039.13	3069.34
08/11/03	10:09	321.81	3039.14	3069.18
09/11/03	7:30	319.86	3041.09	3049.89
10/06/03	11:11	319.00	3041.95	3050.78
11/03/03	10:18	318.15	3042.80	3051.66

Source: Siegel, 2003;
Note that times are U.S Mountain Zone, either Daylight (D) or Standard (S), based on the season

Figure 3-1
Water Elevation at SNL-9



4.0 SIGNIFICANCE/DISCUSSION

Drillhole SNL-9 provides a groundwater monitoring point west of the WIPP site that extends geological and hydrological information about higher T areas of the Culebra originally found in P-14, a drillhole now plugged and abandoned. SNL-9 is in a location that should provide excellent monitoring and testing of the hydraulic regime along the western side of WIPP (Appendix A). The materials used in completing SNL-9 are expected to be stable over a lengthy monitoring period, in contrast to steel casing in monitoring wells drilled before 1995.

The lower Rustler and uppermost Salado were cored to obtain direct evidence of dissolution of halite in the uppermost Salado in this vicinity. P-14 showed evidence of dissolution of the upper Salado and high T in the Culebra. Powers (2002a) reported that several potash industry drillholes west and north of P-14 encountered significant water flows from depths corresponding approximately to the Culebra. Powers (2002a) and Holt and Powers (2002) proposed that the upper Salado had been dissolved along a fairly narrow reentrant from Livingston Ridge (Fig. 4-1). The reentrant corresponds to the dissolution at P-14, encounters of significant Culebra water in potash-industry drillholes, a thick outcrop of Gatuña at Livingston Ridge (Powers and Holt, 1993), and some surface drainage. Preliminary examination of SNL-9 cores and interval thicknesses indicate that there has likely been dissolution of the upper Salado halite. Nevertheless, comparable intervals from the lower Rustler to upper Salado in SNL-9 and P-14 show that these intervals are slightly (11–17 ft) thicker at SNL-9. If there is a dissolution reentrant from Livingston Ridge toward P-14, as proposed in Powers (2002a) and elsewhere, SNL-9 may not be located along the main axis. Cores are expected to be further analyzed, and the relationship between Culebra T, as yet undetermined for SNL-9, and upper Salado dissolution will be reexamined.

Macroscopic features of cores across the boundary reveal depositional cycles in the uppermost Salado. More clastic-rich beds near the boundary with the Rustler preserve displacive halite crystals as additional evidence of primary sedimentation. These observations limit the stratigraphic zone that has been dissolved, or might be undergoing dissolution, at the top of the Salado.

Sulfate at the Rustler/Salado boundary is thicker than in drillholes and shafts further to the east, possibly indicating an amalgamated unit after dissolution of some upper Salado halite. Beds near the boundary are somewhat distorted and tilted, which is also likely due to dissolution of some upper Salado halite. In contrast, the overlying lower Rustler does not appear brecciated, as would be expected after greater dissolution at this boundary.

The premise is that Culebra hydraulic properties at SNL-9 are related to overburden thickness and upper Salado dissolution, based on existing Culebra well tests (Holt and Yarbrough, 2002).

Much of the lower Los Medaños in M-1/H-1 is fractured and only moderately lithified. Gypsum fills some of the fractures. There is no evidence of halite beds or halite cement in M-1/H-1 at SNL-9 from preliminary examination of the cores. More detailed study of samples or slabbed cores may help determine if halite cement was once present, similar to SNL-2 (Powers and Richardson, in review). In contrast, some cores from southeast of WIPP show thickening of the upper part of M-1/H-1, with discrete halite beds and dissolution surfaces marking the fresh water/brine interface at the time.

The uppermost Los Medaños (M-2/H-2) was cored, but very little core was recovered. There is no evidence in core or geophysical logs of halite in this unit at SNL-9. This is consistent with previous halite margins determined for this unit and a depositional origin for mudstone-halite facies. The short casing blank placed below the Culebra screen interval was not cemented because there was no evidence of halite in the unit.

Culebra core recovery was poor to good, with some loss through the zones generally believed to be more transmissive. The original field assessment of the Culebra interval suggested more substantial core loss through the lower Culebra, but the geophysical logs showed that the Culebra base is ~9 ft higher than is marked on the core. At least

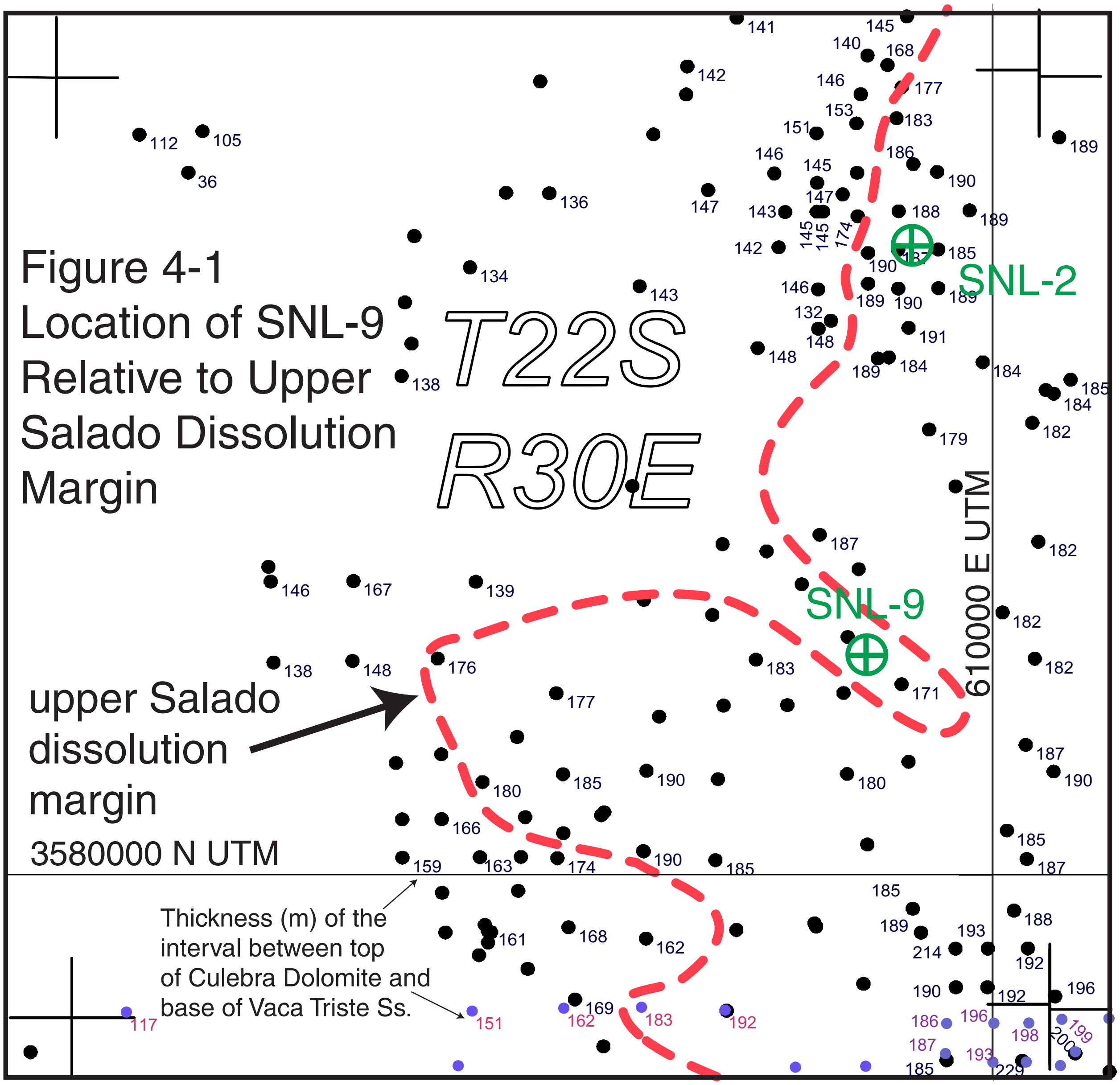


Figure 4-1 Location of SNL-9 Relative to Upper Salado Dissolution Margin

three of the hydrostratigraphic units proposed by Holt (1997) were observable in SNL-9 cores.

The Magenta core showed some surface indications of greater porosity through an 8-ft-thick zone in the upper part of the unit. Electric logs indicated a thicker zone (up to 19 ft) of reduced resistivity that indicates increased porosity. Nevertheless, low discharge rates for the Magenta estimated from water-level rises and the core and log observations are all consistent with relatively low T for the unit.

Cuttings and resistivity changes suggest that the change in natural mineral cements of the Dewey Lake occurs at 116 ft. This boundary is stratigraphically higher in the center and eastern part of the WIPP site and is lower to the south and west (e.g., Holt and Powers, 1990a; Powers, 1997, 2002b, 2003). SNL-9 is consistent with this trend. In the southern part of the site, Powers (1997, 2003) hypothesized that this cement boundary provides a perching horizon for natural groundwater.

At SNL-9, neither geophysical logs nor observations during drilling suggest that the Dewey Lake, either above, below, or at the cement boundary, will yield significant water in a drillhole.

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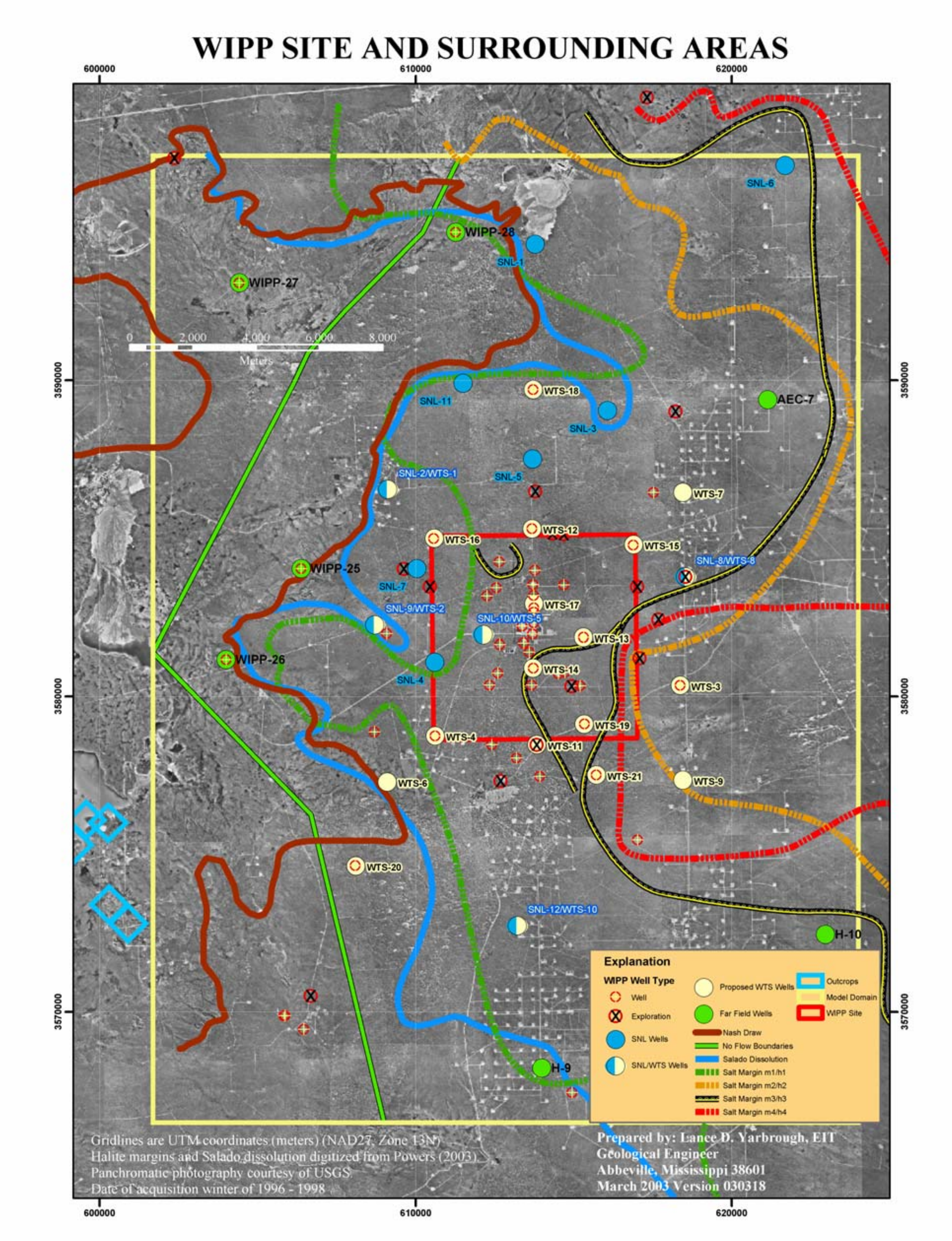
Appendix A
Drillhole Objectives

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


WIPP SITE AND SURROUNDING AREAS
600000
610000
620000
3590000
3580000
3570000
WIPP-28
WIPP-27
WIPP-25
WIPP-26
SNL-1
SNL-6
SNL-11
SNL-3
SNL-5
AEC-7
SNL-2/WTS-1
WTS-18
WTS-7
WTS-12
WTS-16
WTS-15
SNL-8/WTS-8
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SNL-10/WTS-5
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WTS-21
WTS-9
WTS-20
SNL-12/WTS-10
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Meters
Explanation
WIPP Well Type
Well
Exploration
SNL Wells
SNL/WTS Wells
Proposed WTS Wells
Far Field Wells
Outcrops
Model Domain
WIPP Site
Nash Draw
No Flow Boundaries
Salado Dissolution
Salt Margin m1/h1
Salt Margin m2/h2
Salt Margin m3/h3
Salt Margin m4/h4
Gridlines are UTM coordinates (meters) (NAD27, Zone 13N)
Halite margins and Salado dissolution digitized from Powers (2003)
Panchromatic photography courtesy of USGS
Date of acquisition winter of 1996 - 1998
Prepared by: Lance D. Yarbrough, EIT
Geological Engineer
Abbeville, Mississippi 38601
March 2003 Version 030318

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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.

5.1.1 SNL Well Justifications

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Table 1. Roles Served by Planned Wells.

Well	Addresses leakage from tailings pile	Addresses high-T conduits	Addresses leaking boreholes	Addresses Salado dissolution	Provides model boundary condition information	Provides other information needed for modeling	Provides information supporting conceptual model	Provides information on flow across WIPP site
SNL-9/ WTS-2		**X**		**X**		**X**		

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SNL-9/WTS-2: Both Culebra and Magenta (and possibly Dewey Lake) wells will be installed at this location in the southern re-entrant of inferred dissolution extending to the southeast from Nash Draw (see Figure 8), approximately one mile west of the western WIPP site boundary near the location of the old P-14 monitoring well, which had to be plugged and abandoned. If present, this dissolution re-entrant may allow anthropogenically induced changes in the flow regime in Nash Draw to affect the Culebra and Magenta at the WIPP site. Wells at the SNL-9 location will serve six primary purposes:

1. confirm that dissolution of the upper Salado has in fact occurred at this location;
2. confirm that the high transmissivity measured at P-14 is characteristic of the Culebra within this dissolution re-entrant;
3. determine if the flow dimension inferred from a pumping test is consistent with a bounded, linear feature, or indicates connection with a larger volume of the Culebra;
4. determine how well-connected the Culebra and Magenta are within this dissolution re-entrant;
5. determine the direction of flow at this location; and
6. provide a pumping location for a large-scale (multipad) test to provide transient data for calibration of the Culebra model on the west side of the WIPP site.

In addition, a well at the SNL-9 location will provide needed information to help define the direction and rate of Culebra groundwater flow across the WIPP site, which is required for annual HWFP reporting to NMED (hence the parallel designation WTS-2).

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

Well	4-day Pumping Test	Slug Tests	Multipad Pumping Test	Scanning Colloidal Borescope Logging	Testing Not Needed—Replacement Well
SNL-9/WTS-2	M?, DL?	M?	C	C	

C=Culebra well

M=Magenta well

DL=Dewey Lake well

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5.3.2 Multipad Pumping Tests

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Well SNL-9/WTS-2 will be the pumping well for the western multipad test, with observation wells as shown in Figure 18. Provided that it is able to produce at least approximately 5 gpm, SNL-5 will be the pumping well for the northern multipad test, with observation wells as shown in Figure 19. If SNL-5 does not have the needed pumping capacity, SNL-11, SNL-3, and WTS-12 (in that order) will be considered as potential fallback pumping wells for the test. The pumping well for the southern multipad test will prospectively be SNL-12/WTS-10, with observation wells as shown in Figure 20. Should SNL-12/WTS-10 not have the required pumping capacity, WTS-11 and WTS-6 (in that order) will be considered as fallback pumping locations.

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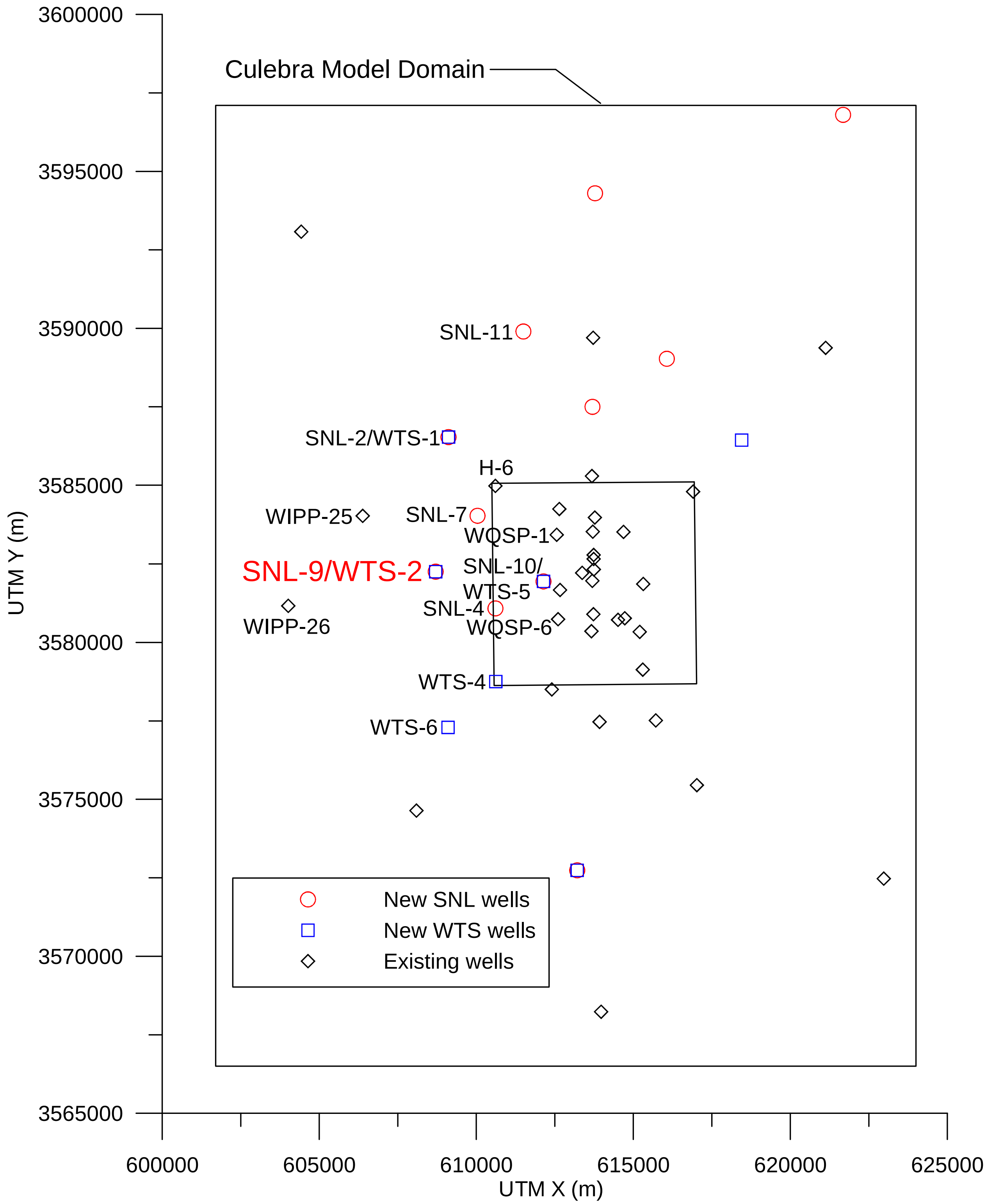

Figure 18. Pumping well and principal observation wells for western multipad pumping test.

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5.3.3 Scanning Colloidal Borescope Logging

Direct measurement of the direction of groundwater flow is needed in the inferred Salado dissolution re-entrants, near the Mississippi East tailings pile, and on the edge of Nash Draw. Therefore, after SNL-1, 2, 3, 7, 9, and 11 have recovered from well development or pumping tests, the screened intervals of both the Culebra and Magenta (if present) wells will be logged using the scanning colloidal borescope. The scanning colloidal borescope images colloidal-size particles moving with the water through the wellbore, and tracks their motion to determine the direction and velocity of groundwater flow. In SNL-3 and 9, this will provide direct indications of whether the dissolution re-entrants serve as sources of fluid to the WIPP site, or as sinks for fluids coming from the east and north. In all cases, the information will be useful in flow model calibration.

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Table 4. Expectations and Contingent Actions for New Wells.

Well	Expectations	Possible Actions if Expectations Not Met
SNL-9/ WTS-2	• upper Salado dissolution • high Culebra T similar to that at P-14 • subradial flow dimension • flow direction parallel to dissolution re-entrant	• revise conceptual model • consider additional well

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Table 5. Anticipated Total Depths of Proposed Wells.

Location	Culebra Well Depth (ft)	Magenta Well Depth (ft)	Dewey Lake Well Depth (ft)
SNL-9/WTS-2	860*	500	175

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Dissolution of the upper Salado Formation will be studied in up to eight drilling locations: SNL-2, 3, 4, 7, 9, and 12 and WTS-4 and 6. At these selected locations, the boreholes that will become the Culebra wells will be cored from the lower part of the upper Tamarisk anhydrite to the halite beds of the upper Salado (approximately 175 ft), and then will be rotary drilled through Marker Bed (MB) 103. If MB100, 101, or 102 are well defined, the on-site geologist together with the Lead Hydrologist and Field Operations Lead may terminate drilling at any one of these marker beds. If MB103 is disturbed by deeper dissolution, the borehole may need to be deepened by an estimated additional 100 ft by rotary drilling through MB109 or other suitable stratigraphic marker bed as determined by the on-site geologist in consultation with the Lead Hydrologist and Field Operations Lead. This decision is most likely for four holes (SNL-2, SNL-3, SNL-11, and SNL-12) where the uppermost Salado may have been dissolved to greater depths, obscuring the upper Salado stratigraphic record. After all desired core and geophysical logs have been collected from the upper Salado, the holes will be plugged with cement back to a depth approximately 20 ft below the base of the Culebra before the upper part of the hole is reamed to its final diameter.

Available information is adequate to justify coring the upper Salado in holes SNL-2, SNL-3, and SNL-9. WTS-4 will provide reference data from a location where dissolution of the upper Salado is not believed to have occurred. With respect to SNL-4 and SNL-7, however, decisions to continue the holes beyond the Culebra will depend on information obtained as this program progresses. Because the purpose of coring the upper Salado in SNL-4 would be to determine if the dissolution found in SNL-9 extended to the SNL-4 location, that coring will occur only if dissolution of the upper Salado is conclusively found at SNL-9. The purpose of SNL-7 is to determine whether or not the cavernous porosity found in the Rustler at WIPP-33 continues to the east. If cavernous porosity is found at SNL-7, and if (unlike WIPP-33) it extends as deep as the Culebra, the hole will be continued through MB103 to determine if any dissolution of the upper Salado has occurred. Similarly, if conditions encountered while drilling any other borehole for this program (outside of Nash Draw) indicate the potential for dissolution of the upper Salado, drilling will continue through MB103.
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7.3 Logging

Open-hole geophysical logging will be performed after each Culebra hole is drilled to total depth and reamed, but before the casing and well screen are installed. Wells drilled into the upper Salado will be logged prior to reaming, and caliper logging will be repeated after reaming. The suite of logs to be run in all wells includes: natural gamma, resistivity (induction if the well is not fluid-filled), neutron, density, and caliper. These logs will be used to confirm stratigraphic contact depths determined from core, and will aid in selecting final casing and screening depths. In addition, a high-resolution microresistivity log (e.g., FMI, FMS, EMI) will be run in the SNL-2 Culebra well to determine its effectiveness at identifying fractures and their orientations. If successful, a microresistivity log may be run in other holes. In the Magenta and Dewey Lake wells, only natural gamma and caliper logs are planned, although resistivity (or induction) and neutron logs could be required in Dewey Lake wells to resolve uncertainty about the zone of saturation. After well completion, an acoustic cement-bond log may be run to provide a baseline of cement conditions behind the well casing. The logger must provide all logs in both paper and digital form.

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Appendix B
Abridged Borehole History

The abridged borehole history has been prepared by compiling information from drillers' reports by West Texas Water Well Services (WTWWS) personnel, on-site reporting by 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 group.

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

5-17-03 Arrived on site from SNL-2 site at 10:30. Lined pits. Rigged up at 12:30. Set 4' of temporary surface casing. Left site at 17:30.

5-18-03 Arrived on site at 07:15. Held safety meeting on blowing dust from well. *Began rigging up to drill at 07:25.* Began drilling 7.875" hole on air at 07:40. *Collected samples at 07:53: C-1 (10' to 11'), C-2 (20'), and C-3 (30' to 31'). Drilled into a cemented zone in the Gatuña at 08:10. Hard drilling at approximately 42'. Returned to smooth drilling at approximately 50' by 08:14. Drilled to approximately 64' by 08:20. Entered top of Dewey Lake at approximately 48'. Collected samples: C-4 (40' to 41'), C-5 (50' to 51'), and C-6 (60' to 61'). Drilled to approximately 92' by 09:05. Collected samples: C-7 (70' to 71'), C-8 (80' to 81'), and C-9 (90' to 91'). Drilled to depth of approximately 119' by 09:30. Began collecting samples at 20' intervals beginning at 100'; collected C-10 (100' to 101'). Drilled to depth of approximately 151' by 10:15. Collected samples: C-11 (119'), C-12 (120' to 121'), and C-13 (140' to 141'). Drilled to depth of approximately 182' by 10:38. Collected samples: C-14 (160' to 161') and C-15 (180' to 181'). Drilled to depth of approximately 214' by 11:13. Collected sample C-16 (200' to 201'). Drilled to depth of approximately 245'. Collected samples: C-17 (220' to 221') and C-18 (240' to 241'). Drilled to depth of approximately 261' by 12:02. Averaged ± 1'/minute. Collected sample C-19 (260' to 261').* Drilled to approximate depth of 310' by 12:55. *Collected samples: C-20 (280' to 281') and C-21 (300' to 301').* Stopped for lunch. Resumed drilling 7.875 " hole at 13:30. *Drilled to depth of approximately 341' by 13:51. Collected samples: C-22 (320' to 321') and C-23 (340' to 341'). Drilled to depth of approximately 372' by 14:21. Collected sample C-24 (360' to 361'). Drilled to depth of approximately 402' by 15:00. Collected samples: C-25 (380' to 381') and C-26 (400' to 401').* Drilled to 430' by 15:40. Tripped drill pipe out of hole. Left site at 16:00.

5-19-03 Arrived on site at 07:15. Held safety meeting regarding heat stress. *Rigged up to clean hole. Checked for fluid in hole at 07:40. Some moisture at bottom of hole.* Tripped into hole to clear out 5' water in bottom of hole. *No fill in hole, blew hole dry.* Tripped out of hole at 08:00. Standing for John Wood at 08:25. Rigged up core tool at 08:40. Tripped core tool into hole at 09:30. Began core run #1 at 10:15. *Coring was started with air/mist due to moisture in the hole.* Cored 30' from 430' to 460' by 11:00. Tripped out of hole. Retrieved core at 11:30. *Retained 29.9'*. Tripped into hole at 11:45. Began core run #2 at 12:25. Cut 10' core from 460' to 470' by 13:40. Tripped out of hole. *Recovered 10.4' core.* Broke for lunch at 14:00. Tripped back into hole to drill approximately 50' before coring again at 14:37. Reamed cored section to 7.875" from 430' to 468' *using foam (Baroid QuikFoam®). Blew hole with air from 15:05-15:12. Produced approximately ½ gal/min. Added* *joint and reamed from 468' with air mist.* Resumed drilling at 15:14. Drilled from 470' to 520' by 16:12. Cleaned cuttings out of hole. Tripped pipe out of hole from 16:16-17:15. Cleaned up location at 17:15. Left site at 17:45.

5-20-03 Arrived on site at 07:15. Held safety meeting. Water level at 458' below ground level.Tripped into hole to clear out at 07:25. Began core run #3 at 08:20. Cored 30' from 520' to 550'. Tripped out of hole from 09:20-10:12. Laid out core in core trough. Retained 100%. Tripped core barrel into hole at 10:12. Began core run #4 at 10:57. Cored 17.4' before core barrel jammed at 11:25. Tripped core barrel out of hole. Laid core in trough. Retained 16'. Broke for lunch at 12:35. Tripped core barrel back into hole at 13:25. Began core run #5 at 14:14. Cut 15' core at 14:48. Retained 5.7'. Observed well producing some water. Tripped out of hole. Ordered 2 loads of brine for tomorrow. Prepared core barrel for more coring tomorrow at 15:30. Rigged up portable mud system. Left site at 17:45.

5-21-03 Arrived on site at 07:15. Held safety meeting. IW Transports on location with 2 loads of brine at 07:25. Rigged up portable pit system. Water level at 255'. Tripped core tool into hole at 08:01. Began circulating hole at 08:45. Fifty feet of fill; mixed Flowzan to clean out. Began core run #6 at 10:26. *Drilling slowed down by anhydrite at 10:40.* Cored 30' from 582' to 612'. Tripped core out of hole at 12:09. Retained 27.5'. Stopped for lunch at 13:03. Tripped core tool back into hole at 13:40. *Cleaned hole.* Began core run #7 at 14:30. Cored 28' before core barrel jammed at 15:40. Circulated hole until 15:48. Tripped core out of hole at 15:48. Laid core out in trough at 16:15. Retained 15.5'. Put core tool back together. Secured site for evening and left site at 17:15.

5-22-03 Arrived on site at 07:15. Held safety meeting regarding properly grounding equipment. Tripped core barrel into hole at 07:25. *Fluid level was at surface with all drill pipe in hole at 07:45*. Circulated hole from 07:55-08:15 to clear 3' fill. Began core run #8 at 08:15. Cored 5' from 640' to 645' before core barrel jammed at 08:40. Circulated hole. Tripped core tool out of hole at 08:49. Laid core in trough at 09:30. Retained 4'. Tripped core tool back into hole at 09:49. Began core run #9 at 10:30. Cored 15' *from 645' to 660'* before core barrel jammed at 12:05. Broke for lunch. Tripped core out of hole at 12:26. Laid core out in trough. Retained 10.6'. Tripped core tool back into hole. Began core run #10 at 14:06. Cored 7' from 660' to 667' before core barrel jammed at 14:58. Circulated hole. Tripped core barrel out of hole at 15:07. Laid core out in trough at 15:46. Retained 4.7'. Assembled core tool and tripped core tool into hole. Circulated hole at 16:30. Began core run #11 at 16:34. Cut 25' from 667' to 692'. Circulated hole at 17:41. Tripped core tool out of hole at 17:46. Laid out core in trough. Full recovery, plus 2.3' from last core. Loaded Dowdco equipment at 18:46, secured site for evening and left for Carlsbad.

5-27-03 Arrived on site at 08:00. Worked on mud pit at 08:15. Tripped into hole at 08:50. Reamed hole starting at 520' to 692' from 6¾" to 7.875" at 09:40. Began drilling at 692' at 13:45. *Drilled to 759' by 15:33; drilled at rate of approximately 1' per minute. Drilled to 790' by 16:30; drilled at rate of approximately 0.5' per minute.* Hit MB 103 at 804' *based on drilling rates and geologist report*. *Drilled to 823' by 17:15; approximately 20' to logging depth.* Out of MB 103 at 833' *based on drilling rates and geologist report*. Drilled to 845' at 18:20. Circulated hole. Tripped out of hole at 18:50. Secured site and left at 19:35.

5-28-03 Arrived on site at 06:50. Held safety meeting. Began logging well at 07:00. *Completed caliper log at 08:15. Ran gamma and resistivity logs. Reviewed completion of well at 09:52. Reviewed and kept marked-up logs at 10:16. Pulling out of hole after running neutron, induction, and conductivity logs at 10:47.* Reviewed completed logs at 11:15. Stopped for lunch at 12:00. Representative of State Engineer's Office (*Mike Stapleton*) inspected *and approved* casing. Rigged up equipment to cement bottom at 12:20. Tripped drill pipe into hole. Pumped 76 sacks of cement (Portland) from 845' (TD) to 580'. *Placed 27 sacks into hole by 14:09. Placed 26 sacks into hole by 14:36. Placed another 23 sacks into hole by 15:03.* Washed equipment and flushed drill pipe at 15:01. Tripped drill pipe out of hole at 15:56. Cleaned and secured. Left site at 17:15.

5-29-03 Arrived on site at 07:45. Held safety meeting. Fluid at 50′. Tripped drill pipe into hole at 08:00. Tagged cement plug at 590' at 08:45. Tripped drill pipe out of hole. Performed maintenance on equipment at 09:20. Changed out U-joint on rotary table. Obtained load of fresh water. Stopped for lunch at 11:20. Finished maintenance (replacing U-joint, greasing rig) at 14:00. Circulated mud in pits at 14:20. Put on 18" bit and began first pass on surface casing. Began second pass on surface with 22" bit at 15:48. *Completed reaming 22" hole to 30' at 16:45.* Prepared surface casing of 30'4" in length (18.63" outside diameter, 0.25-inch wall, 47.39#/ft.). Circulated hole. Secured site for evening at 17:00. Left site at 17:15.

5-30-03 Arrived on site at 07:45. Held safety meeting. Ran 30' of 18" surface casing at 08:00. *Set Tremmie pipe at 08:30. Mixed cement at 08:56. Began cementing casing at 09:20.* Cemented casing in place with 27 sacks (Portland). *Cemented to surface. Pulled Tremmie pipe from hole at 09: 25. Cleaned equipment.* Secured site for weekend. Left site at 09:40.

6-02-03 Arrived on site at 08:30. Held safety meeting. Serviced rig at 08:45. Worked on mud pit system at 09:10. Began reaming hole to 12 ¼" diameter at 30' *at 11:04. Reamed to 120' by 14:35. Reamed to 170' by 17:30.* Tripped out of hole. Left site at 17:45.

6-03-03 Arrived on site at 06:45. Held safety meeting. Changed mill tooth bit to a button bit at 07:00. *Fluid level in hole at 55'.* Reamed back top 170' at 07:30. Reamed from 170' to 310' from 08:10 to 17:45. Worked on auxillary mud pump from 09:30 to 17:00. IW Transport brought 110 barrels of brine. Circulated hole at 17:45. Tripped out of hole at 17:55. Left site at 18:08.

6-04-03 Arrived on site at 07:00. Held safety meeting. Rigged up for reaming 12¼" diameter. Tripped into hole at 07:15. Water level at 38'. Began reaming at 310' at 07:35. *Reamed to 340' by 09:00. Reamed to 437' by 15:30.* Reamed to 467' by 17:15. Circulated hole. Tripped out out of hole at 17:30. Left site at 17:50.

6-05-03 Arrived on site at 07:00. Held safety meeting. Water level at 38'. Tripped into hole to clean out 20' of fill at 07:15. *Began reaming 12 ¼" at 467' at 08:00. Light rain began to fall at 08:25. Reamed to 500' by 11:00. Rain stopped.* IW Transport brought 110 barrels of brine. *Reamed to 532' by 13:31. Reamed to 562' by 15:30.* Reamed to 586' (T.D.) by 17:15. Circulated hole. Began tripping out of hole at 17:30. Drill pipe stuck at 467'. *Bit hung up in hole at approximately 420'. Began washing over bit at 18:00. Pushed bit down hole and rotated while washing. Bit still hung in hole at 18:30. Continued washing over bit. Freed bit and got one joint out at 19:00. Next joint* *hung up at approximately 400'. Second joint came loose and and was removed from hole at 19:25. Third joint removed without difficulty.* Tripped all of drill pipe out at 19:30. Left site at 20:00.

6-06-03 Arrived on site at 07:00. Held safety meeting. *Fluid level in hole at 35' at 07:30.* Took 12 ¼” bit off. Rigged up 15 ¾” bit to act as hole opener. Began reaming 15 ¾” at 30' at 09:00. *Reamed to 60' by 10:20. Reamed to approximately 90' by 11:20. Reamed to approximately 184' by 15:00. Notified State Engineer’s Office that casing was scheduled to be set on Monday morning. Reamed to 215' by 16:20*. Circulated hole at 16:40. Tripped out at 16:55. Left site.

6-07-03 Arrived on site at 07:30. Held safety meeting. Water level at 40'. Tripped into hole at 07:45. Thin mud down. IW Transport brought 110 barrels of brine. *Cleaned hole.* Began reaming 15 ¾” hole at 215' at 08:20. Reamed to 258'. Auxillary mud pump went down at 10:35. Tripped out of hole. Left site at 11:20.

6-09-03 Arrived on site at 14:00. Held safety meeting. Began setting up replacement auxillary mud pump 14:15. Left site at 18:00.

6-10-03 Arrived on site at 07:00. Held safety meeting. Water level at 68'. Tripped into hole at 07:15. Reamed top 120'. Began reaming 15 ¾” at 258' at 08:25. Rig down for repairs at 09:55. *Loosened the jammed kelly block with new harness. Stuck at 270'. Began pulling out all drilling pipe with block and tackle gear.* Broke bushing on pull down chain. Tripped out of hole. Waited on spare parts. Began servicing rig at 14:30. Left site at 17:30.

6-12-03 Arrived on site at 17:00. Held safety meeting. Installed pull down chain and rigged up at 17:15. Left site at 18:15.

6-13-03 Arrived on site at 07:00. Held safety meeting. Water level at 62'. Tripped in at 07:15. Began reaming 15¾” at 283' at 08:30. *Reamed to 315' by 09:45. Reamed to 343' by 11:25. Reamed to 400' by 16:15.* Reamed to 425' by 17:25. Circulated hole. Tripped out of hole at 17:40. Left site at 18:10.

6-14-03 Arrived on site at 07:00. Held safety meeting. Water level at 31'. Tripped in at 07:15. Began reaming 15¾” at 425' at 08:00. *Reamed to 475' by 14:00. U-joint on rotary table vibrated loose at 15:45. Made repairs.* Reamed to 494' by 16:45. Circulated hole. Tripped out at 17:00. Left site at 17:25.

6-16-03 Arrived on site at 08:00. Held safety meeting. After cleaning bit, cracks were found. R. Keith took bit to Odessa for repairs at 09:00. Hands did rig maintenance from 09:00-11:00 and left site.

6-17-03 Arrived on site at 07:00. Held safety meeting. Back into hole reaming to 494' to 09:25. Ream 15¾” from 494-554' from 09:25-17:30. Circulated hole from 17:30-17:45. Tripped out of hole from 17:45. Crew cleaned up bit and found one cone missing. Phoned Odessa yard for fishing tool. Left site.

6-18-03 Arrived site 07:00. Held safety meeting. Water level at 18'. Removed 15¾" bit from drill string. Attached magnet, started in hole at 07:45. On bottom at 08:30; 4' fill, circulated hole. Tripped out of hole from 09:00-09:30. No fish (metal) recovered. Tripped back in by 10:10, rotated on bottom and circulated fluid. Tripped out of hole from 10:35-11:15, did not recover any materials. Attached new 15¾" bit; started in drillhole at 12:15, reaming while tripping. Began drilling at 13:30 *with the goal of pushing the cone to the bottom* and completed well to total depth (587') at 16;15. Circulated hole for 30 minutes and tripped out of hole by 17:30. Shut down and left site *at 18:30*.

6-19-03 Arrived on site at 09:45 and conducted safety meeting. Raymond Federwisch ran final caliper log and final gamma log from 0-587' from 10:00-12:00. Crew did rig service from 12:00-13:00.

6-20-03 Arrived at site at 07:00, and conducted safety meeting. Static fluid level at 51'. Ran into hole with 15¾" bit to ream hole. Tagged bottom at 09:06, and circulated hole until 10:00. Tripped out of hole from 10:00 to 10:45. Run tremmie line in hole from 10:45-11:40; broke for lunch. State Engineer rep (Mike Stapleton) on site. Run casing in hole from 12:05 to 16:40. Received one load of brine from IW Transport. Unloaded brine and rigged up to thin fluid in hole from 17:10 to 17:35. Light tower arrived. Placed 3600 pounds gravel pack to 540' from 17:35 to 18:45. Pumped bentonite hole plug from 540-535' from 18:45-19:05. Cement arrived on location at 18:50. Pumped 16 yards of cement from 19:15-21:05. Cleaned up equipment *and left site at 21:15*.

6-21-03 Arrived at site at 09:45. Held safety meeting. Cleaned out steel pits from 10:00-11:00. Tripped in hole from 11:00-11:35. Flushed hole out with clear water from 11:35-12:20. Tripped out of hole from 12:20-13:00 and shut down.

6-23-03 Arrived at site at 11:20. Held safety meeting. Began shutting rig down and moving equipment from SNL-9 to SNL-12 at 11:35. Began shutting down both sites at 17:10 (due to bad lightning storm). Left SNL-9 site at 18:00.

6-24-03 Arrived at SNL-12 site at 07:00. Held safety meeting. Finished moving equipment, cleaning up, and pouring slab on SNL-9 by 11:30. Hauled one load of fresh water and brought Ron's generator from WIPP site by 12:30. Stopped for lunch. Brought mobile home from WIPP site to SNL-12 site by 14:00. Rigged up on SNL-12. Left SNL-12 site at 17:30.

6/26/03 *Arrived on site at 09:15 with generator. Hooked up generator and flow meter; wired pump to generator at 09:15. Started pump at 10:00. Major producer pumped 7 barrels. Stopped pumping to recover at10:05. Resumed pumping at 187 gpm flow at 10:06. Pumped 5 barrels (total of 12 barrels). Reduced flow to 113 gpm. Stopped pumping to recover at 10:09. Pumped 2 barrels (total of 14 barrels). Cleaned up very nicely at 10:11. Water only slightly murky red/grey. Resumed pumping at 10:12. Surged on and off to clean filter pack at 10:15. Purged mud/silt. Water very salty. Returned to producing at 10:17. Water muddy. Large flow of 150 gpm. Pumped well to bottom. Stopped pumping to recover. Returned to surging at 10:25. Pumped 13 barrels (total of 27 barrels). Stopped pumping to recover. Resumed pumping at 120 gpm at 10:45. Pumped 4 barrels (total of 31 barrels). Continued surging to develop at 10:50. Water remained dirty red. Stopped pumping to recover. Attempted to pump at consistent 50 gpm for a steady discharge rate at 11:15. Pumped 7 barrels (total of 34 barrels). Maintained steady 37-gpm* *flow at 11:26. Water remained murky. Water level dropped to near pump intake at 11:30. Pumped 10 barrels (total of 44 barrels). Stopped pumping. Returned to surging at 11:40. Pumped 6 barrels (total of 50 barrels). Stopped pumping to recover at 11:45. Resumed pumping at 31 gpm steady flow at 12:00. Water appeared clearer. Pumped 10 barrels (total of 60 barrels). Flow dropped to 26 gpm at 12:18. Flow dropped to 18 gpm at 12:26. Water continued to clear, but retained reddish/clay appearance. Pumped 3 barrels (total of 63 barrels). Stopped pumping at 12:33 to recover. Resumed pumping at 12:36. Pumped 7 barrels (total of 70 barrels). Stopped pumping to recover at 12:50. Water appeared cleaner. Resumed pumping at 30 gpm at 13:10. Water appeared much cleaner. Measured density at 1.060 g/cc. Pumped 10 barrels by 13:30 (total of 80 barrels). Water appeared increasingly clear, but slight pinkish clay remained. Continued pumping well at approximately 25 gpm at 13:45. Pumped 11 barrels (total of 91 barrels). Cycled pump on and off several times. Ceased pumping for the day at 14:40. In need of smaller pump.*

9-2-03 *Arrive on site at 10:00 to start bailing well. Began bailing well at 10:30. Screened interval is 545-572', and sump is 572-583' with total depth 583'. Red gumbo clay in bottom of well stuck to bailer. Water has foul oder and is very murky or muddy looking. Pulled 10 bailers by 11:10 totalling about 300 gallons. Stopped bailing to allow well to recover. Back to bailing at 11:20. TD has increased about 2'. Water is very muddy and thick. Making hole deeper with every pass—now over 8' deeper at bottom. Water still very muddy at 12:15; not cleaning up. Have collected about 25-30 bailers full. Pulled 35 or 36 bailers by 12:35. Water starting to get lighter color and thinner. Started to bring up some of gravel pack (?) at 12:45. Pulled 45 bailers full by 13:00; bailed 50 bailers full. Measured total increase in depth at bottom of casing as 14' at 13:40. By 14:40, recovered 60 total bailers. Bailer is 5.5" diameter and contains about 26 gallons. Left site at 15:30 for portacamp.*

9-4-03 *Arrive at portacamp at 08:40. Arrive on site (SNL-9) at 10:10 with pipe and pump. Pump will be set at 570.24' below top of casing (10:20). Start setting pump at 10:25. Flowmeter is Halliburton Services 3" flowmeter model MC-II FlowAnalyzer wsw 10-2. Pump installed and meter on at 11:40; ready to go. Start pumping at 12:00 at 14.5 gpm. Water flow started at 12:05; water clear. Valve wide open at 12:11 pumping 20.3 gpm (665 bpd). Holding steady at 12:20 at 19 gpm (618 bpd); total pumped is 5 barrels. Holding very steady at 12:30 at 19 gpm (618 bpd); total pumped is 9 barrels. Holding steady at 12:41 at 19 gpm (618 bpd); total pumped is 14 barrels. Appears like no more drawdown at 19 gpm. Flow increased slightly at 12:50 to 20.3 gpm (665 bpd); total pumped is 19 barrels. Water is clear. Density measured at 13:00 is 1.036 g/cc; decreased from previous measurement. Flow up to 21.1 gpm (691 bpd) at 13:15; total pumped is 30 barrels. Well is in very good shape now. Nicely developed with drilling brine being removed from formation. Density measured at 13:35 is 1.034 g/cc. Total production is 40 barrels. Final total pumped is 41 barrels. Removed flow meter at 14:50 and returned it to West Texas Water Well Service.*

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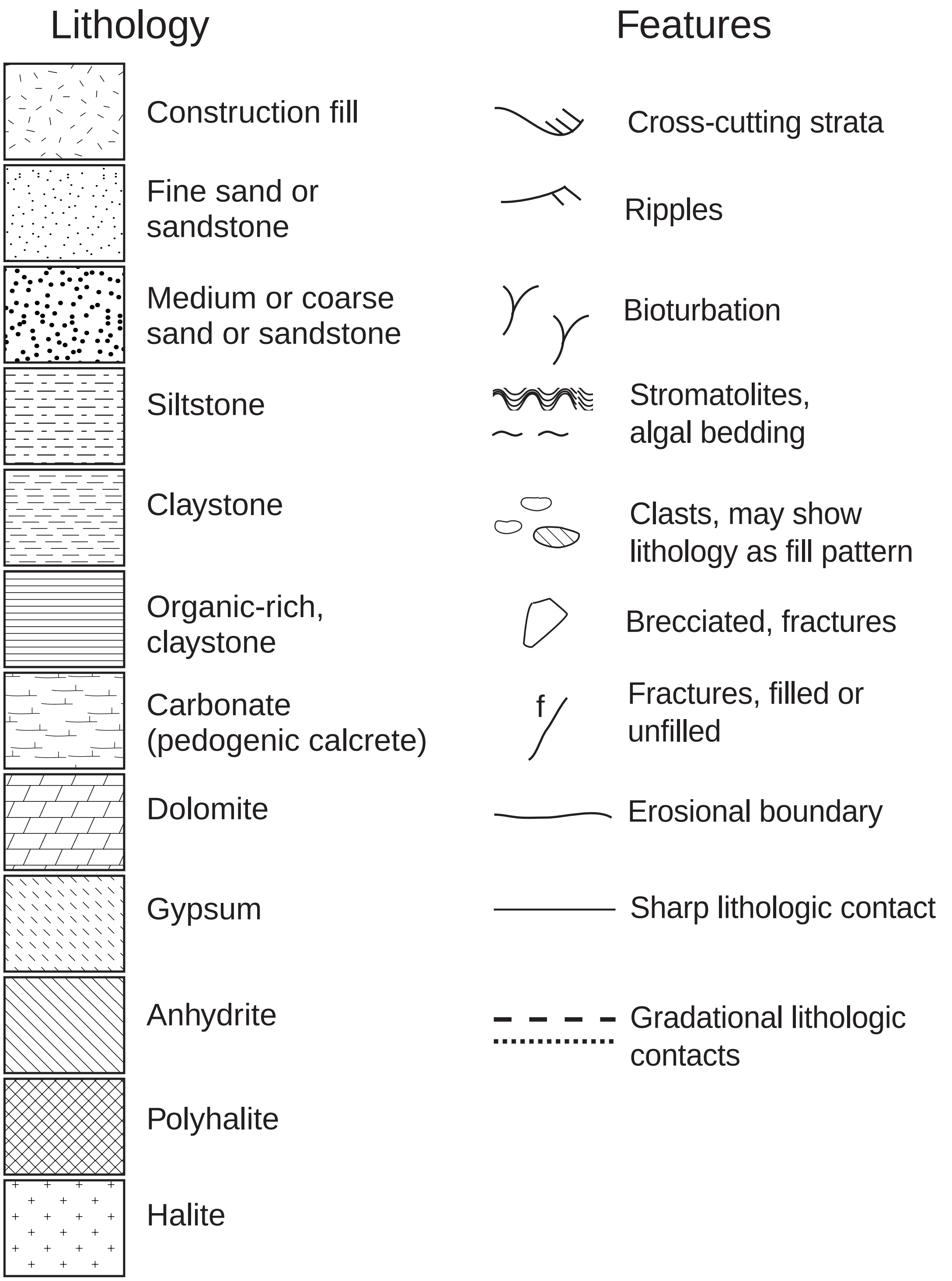
Appendix C
Geologic Logs

Note: The original field descriptions and graphic logs were prepared at somewhat variable scales, and the graphic logs for publication were generally produced at 10 or 20 vertical feet per inch, indicated in the header for the log. For publication purposes, the figures were reduced from the original size, and the scale indicated will be incorrect. The vertical footage log is reduced proportionally and will still be correct.

Explanation of Symbols Used in Lithologic Logs (Appendix C)



Symbols may be combined

CORE LOG — Sheet 1 of 9

Hole ID: SNL-9	Location: about 1197 ft fsl, about 627 ft fel, sec. 23, T22S, R30E	
Drill Date: 5/17/03-5/27/03	Drill Method: rotary	Drill Make/Model: Gardner-Denver 1500
	Hole Diameter: initial 7.875 inches	Barrel Specs: 6 in o.d., 4 in core
Drill Crew: West Texas Water Well Service (Ronnie Keith, driller)	Hole Depth: TD 845 ft	Drill Fluid: air; foam, brine
	Hole Orient: vertical downward	Core Preserv: box as is
Logged by: Dennis W. Powers, Ph.D., Consulting Geologist	Date: 5/18/03	Scale: 1":10'; 1":20'

	Northing	Easting	Elevation
Survey Coordinate: (Ft)	499948.71 NM SP (NAD27)	650921.42 NM SP (NAD27)	3358.12 ft amsl (brass cap)

Comments: The State Engineer assigned the number C-2950 for this well, and official records reflect this number. Within program documents, the well is also known as WTS-2. The reference point for coring and drilling is the top of conductor casing collar, which is approximately ground level. Differences in stratigraphic intervals compared to geophysical logs derive mainly from uncertainties during drilling and from core recovery. Core depth marks were based on best estimate of recovered depths.

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	0	N/A	N/A		Construction fill (caliche) and dune sand to ~ 4.6 ft	Drill to 4.6' on 5/17/03; place temporary surface casing
					Mescalero caliche (4.6-6.5 ft bgl) 4.6-6.5: caliche, powdery, white, no cuttings caught	Begin @ 4.6' at 0630 MDT 5/18/03 drilling with air
					Top of Gatuña Formation (6.5-46 ft bgl)	
	10	10-11			6.5-19 ft: Sandstone, light reddish brown, fine to medium grained, very calcareous at top, decreasing downward; with mixed claystone and siltstone	10 ft @ 0633 MDT
	20	20-21 (cutting sample depths)			19-46 ft: Claystone, reddish brown (2.5YR4/4), sandy, porous; interbedded with siltstone and fine sandstone; variably calcareous, with carbonate decreasing downward in general; some MnO_2 stains.	20 ft @ 0639 MDT
	30	30-31				30 ft @ 0647 MDT add jt (0650-0702)
	40	40-41			40-43 ft: very calcareous	40 ft @ 0704 MDT
					Top of Dewey Lake Formation (46-374 ft bgl)	stop 0709-0712 MDT
	50	50-51			46-116 ft: Siltstone, sandy, and silty claystone, with interbedded fine grained, silty sandstone; dark red (2.5YR3/6) with very small gray-green reduction spots; calcareous to very calcareous.	50 ft @ 0712 MDT
	60	60-61				60 ft @ 0720 MDT add jt (0724-0746)

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

Logged by: Dennis W. Powers, Ph.D., consulting geologist | Date: 5/18/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	60	N/A (cutting sample depths)	N/A		46-116 ft: Siltstone, sandy, and silty claystone, with interbedded fine grained, silty sandstone; dark red (2.5YR3/6) with very small gray-green reduction spots; calcareous to very calcareous.	
	70	70-71				70 ft @ 0749 MDT
	80	80-81				80 ft @ 0755 MDT
	90	90-91				90 ft @ 0801 MDT add jt (0802-0813)
	100	100-101				100 ft @ 0817 MDT
	110					110 ft @ 0822 MDT
					116 ft: begin sulfatic zone of Dewey Lake (resistivity log); cuttings at 117 ft begin to show sulfate.	
					117-122 ft: sandstone, reddish brown (2.5YR5/4), fine to very fine grained, cemented by sulfate, some white fibrous gypsum in cuttings.	
	120	119 120-121				119 ft @ 0829 MDT add jt, begin drilling 0836 MDT 120 ft @ 0837 MDT
					122 ft +: interbedded siltstone, claystone, with some sandstone, similar to zone above 116 ft; slightly calcareous; gypsiferous, thin zones with coarse gypsum.	
	130					130 ft @ 0845MDT
					133 ft: coarse clear crystalline gypsum in cuttings	
	140	140-141				140 ft @ 0856 MDT

Hole ID: SNL-9

CORE LOG
(cont. sheet)

Sheet 3 of 9

Logged by: Dennis W. Powers, Ph.D., consulting geologist

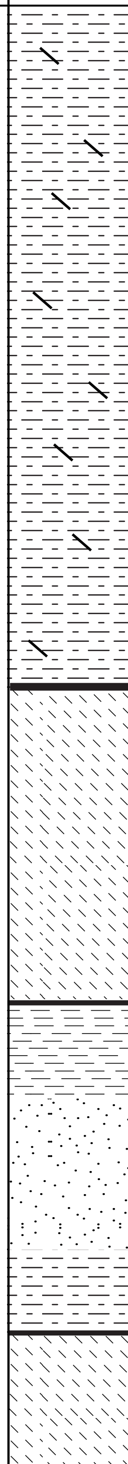
Date: 5/18/03

Note scale change

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	140	N/A	N/A		Dewey Lake Formation, cont.	
		cutting sample depths			122 ft +: interbedded siltstone, claystone, with some sandstone, similar to zone above 116 ft; slightly calcareous; gypsiferous, thin zones with coarse gypsum.	150 ft @ 0905 MDT; add jt @ 152 ft (0906-0913)
	160	160-161				160 ft @ 0920 MDT
					gypsum increases, drilling rate increases from about 170 ft	170 ft @ 0928 MDT
	180	180-181				180 ft @ 0933 MDT add jt @ 182 ft (0935-0944)
						190 ft @ 0949 MDT
	200	200-201				200 ft @ 0958 MDT
						210 ft @ 1018 MDT; add jt @ 214 (1012-1019)
	220	220-221				220 ft @ 1023 MDT
						230 ft @ 1036 MDT
	240	240-241				240 ft @ 1039 MDT add jt @ 245 (1044-1050)
					thin gypsum @ 255 ft	250 ft @ 1054 MDT
	260	260-261				260 ft @ 1102 MDT
						270 ft @ 1110 MDT add jt @ 277 ft (1117)
	280	280-281				280 ft @ 1130 MDT
						290 ft @ 1136 MDT
	300	300-301				300 ft @ 1144 MDT

Hole ID: SNL-9 | CORE LOG (cont. sheet) | Sheet 4 of 9

Logged by: Dennis W. Powers, Ph.D., consulting geologist | Date: 5/18/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	300	N/A	N/A		Note scale change at 400 ft **Dewey Lake Formation, cont.** 122 ft +: interbedded siltstone, claystone, with some sandstone, similar to zone above 116 ft; slightly calcareous; gypsiferous, thin zones with coarse gypsum.	310 ft @ 1154 MDT; add jt (1154-1226)
	320	320-321				320 ft @ 1234 MDT
						330 ft @ 1240 MDT
	340	340-341				340 ft @ 1247 MDT; add jt @ 341 (1249-1256)
						350 ft @ 1301 MDT
	360	360-361				360 ft @ 1309 MDT
		cutting sample depths			base of Dewey Lake Formation 374 ft top of Rustler Formation (374-666.4 ft) Forty-niner Member Anhydrite and gypsum; cuttings mostly white powder A-5	370 ft @ 1318 MDT; add jt @ 372 (1320-1327)
	380	380-381				380 ft @ 1334 MDT
						390 ft @ 1345 MDT
	400	400-401			Scale change at 400 ft 404 ft (log)	400 ft @ 1356 MDT; add jt @ 402 ft (1359-1404))
		408			Claystone and siltstone, weak red (7.5YR5/2) at top, bottom; sandstone in middle, reddish brown (2.5YR5/4), friable, non-calcareous. M-3/(H-3)	
	410	413				410 ft @ 1409 MDT
	420	420			422 ft (log) Anhydrite and gypsum, white (see description of core on next sheet) A-4	420 ft @ 1415 MDT
		425				425 ft @ 1421 MDT
	430	430				430 ft @ 1426 MDT; stop rotary drilling, end for 5/18/03

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

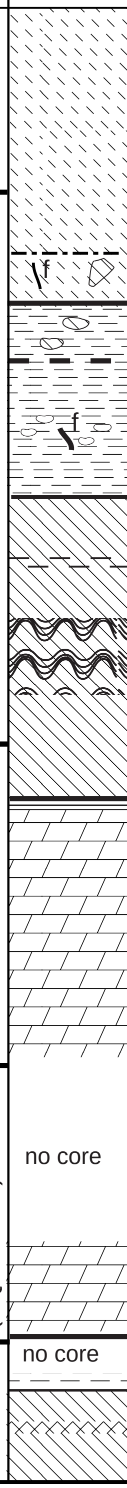
Logged by: Dennis W. Powers, Ph.D., consulting geologist | Date: 5/19/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
1	430 440 450 460	cut 30.5 ft, recovered 29.9 ft (98.03%)	0.4 ft of 29.9 ft in segments < 4 inches long (RQD = 98.7) 460.5	A-4	430-435 ft: Anhydrite and gypsum, gray to white, with some dolomite; laminar to wavy dolomite from 430-432 ft in gypsum, possible algal laminae. Bedded and possibly nodular and swallowtail gypsum. **435 ft: base Forty-niner Member, top Magenta Dolomite Member (435-461.9 ft)** 435-461.9 ft: Dolomite, white (10YR8/2) to light grayish brown (10YR6/2) where dry. Laminar to thin bedding, wavy to lenticular; rare ripples. Algal features are more significant below 455 ft to the base; may be associated with thin beds with gypsum clasts ~0.04 inch diameter. Core remains damp, may be more porous from 439.7-440.1 ft and 442.1 to 447.1 ft, and is not gypsiferous. Gypsum is interbedded near top and is common in the rest of the Magenta core, along bedding with fibers perpendicular to bedding. It fills separations generally 0.01-0.02 inches high, with a few 0.03-0.04 inches high. Fracture from 449.43-450.04 ft has no vertical offset. Fracture from 460.9-459+ is about 0.01 inch wide.	begin coring @ 430 ft @ 0915 MDT with mist (fresh water and QuickFoam)
2	470	cut 10.0 ft, recovered 10.4 ft (104%)	no segments < 4 inches (RQD 100) 470.5		**461.9 ft: base of Magenta Dolomite Member, top of Tamarisk Member (per core markings)** 461.9-520 ft: Gypsum and anhydrite, white to dark gray; bedded, with some small nodules indicating "bedded nodular" fabric; organic/carbonate layers occur at about 465 and 467 ft.	begin rotary drilling @1419 MDT from 470.5 ft after reaming 430-470.5 ft
N/A	480 490 500 510	N/A cuttings consisted mainly of powder through this interval	N/A	A-3		480 ft @ 1428 MDT 500 ft @ 1428 MDT; add jt (1448-1458) 510 ft @ 1506 MDT

Hole ID: SNL-9	CORE LOG (cont. sheet)	Sheet 6 of 9
Logged by: Dennis W. Powers, Ph.D., consulting geologist		Date: 5/19-21/03

Run Number	Depth ( )	% Recovered	RQD
	510–520		
3	520–550	cut 30 ft, recovered 30 ft (100%)	~0.2 ft of 30 ft in segments < 4 inches long (RQD = 99.3)
4	550–567.3	cut 17.3 ft, recovered 16.6 ft (95.95%)	~7 ft of 16.6 ft in segments < 4 in. long (RQD = 54.5)
5	567.3–582.3	cut 15.0 ft, recovered 5.7 ft (38.0%)	~5.0 ft of 5.7 ft in segments < 4 in. long (RQD = 12.3)
6	582.3–590		

Profile (Rock Type):



Description

A-3

few cuttings @ 520 ft. Gray gypsum and anhydrite.

Gypsum, gray, coarse, with bedding; fractured zones and very coarse gypsum. Gray siltstone and claystone 0.1 ft @ 523.2 ft.

525.9

M-3/H-3

525.9-529.2 ft: Claystone, gray, thin laminae at top, thicker bedding below; large angular gypsum clasts.
529.2-536.5 ft: Claystone & mudstone, reddish brown, with gray claystone clasts 534-532.8 ft; fracture 533.6-534.5, filled with gypsum, 70^{o} from horizontal.

536.5

A-2

536.5-552.9 ft: Gypsum, white to dark gray, bedded, with laminar zones, possible algal textures 543-546.1 ft; argillaceous zone 539.8-540.3 ft; possible bedded nodular texture; bedded 546.1-552.9 ft.

552.9 ft: base of Tamarisk Mbr and top of Culebra Dolomite Mbr (552.9-581.9

552.9

CU-1

Dolomite, silty, pale brown (10YR6/3) to brown (10YR5/3); argillaceous, organic-rich zone @ top of unit. Bedded, low porosity 558.3-552.9 ft, gypsum-filled vugs (CU-1).

CU-2

Very porous vugs to ~ 1 inch diameter from 558.3-562.3 ft; most vugs 0.04-0.08 inch in beds or zones. Near horizontal laminar bedding, scattered fractures ~ vertical (CU-2).

CU-3

Below 562.3 ft, vertical fractures with stains are common and connect porosity; core becomes crumbly. Most vugs open, with little silt filling (CU-3).

Dolomite, as above; very vuggy and crumbly (CU-3?).

581.9 ft: base of Culebra Dol. Mbr and top of Los Medaños Mbr (581.9-666.4 ft)

581.9 (core mark)

M-2/H-2

581.9-582.3 ft: Claystone, black, sticky.
584.7-585 ft: Claystone, gray and green, calcareous.

A-1

585-594.9 ft: Anhydrite, gray, fine grained; thin laminae, small vertical gypsum (anhydrite pseudomorphs); [cont. next p.]

Remarks

520 ft @ 1514 MDT; end drilling 5/19/03; begin coring 5/20/03 water level @ 458 ft bgl @ 0630 MDT 5/20/03

Core was marked assuming lowest core recovered was at base of cored interval; loss attributed to lower Culebra is exaggerated.

loss of core mostly M-2/H-2; base of Culebra at 573 ft in geophysical logs.

Hole ID: SNL-9

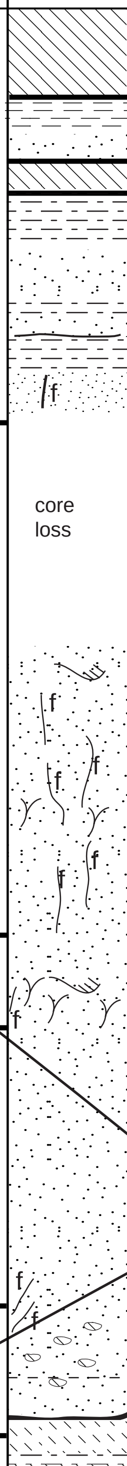
CORE LOG
(cont. sheet)

Sheet 7 of 9

Logged by: Dennis W. Powers, Ph.D., consulting geologist

Date: 5/21-22/03

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
6	590–612.3	cut 30 ft, recovered 27.5 ft (91.7%)	0.6 ft of 30 ft in segments < 4 inches long (RQD = 98.2)		585-594.9 ft, cont: polyhalitic? from 586.7-587.2 ft., algal? at 586.7 ft; gypsum-filled fracture 585-587 ft. 594.9 — 594.9-598.3 ft:Sandstone, very fine, to sandy claystone upward. Stellate gypsum and gypsum veins from 594.9-595.8; 0.5 inch horizontal gypsum-filled fracture @ 595.8 ft. Smeared intraclast textures 598.4-595.8 ft. Reddish brown (5YR4/4) from 598.3-597.4 ft; dark reddish brown (5YR3/2) from 597.4-594.9 ft. 598.3 — 598.3-599.9 ft: Anhydrite, fine grained, white, with reddish-brown laminae near base. 599.9 — 599.9-612 ft: Series of sequences of sandstone grading vertically to siltstone; color from reddish brown (5YR5/3) to very dusky red (7.5YR2.5/2) upward; sulfate near top of unit; erosional base at 607.9 ft; sandstones include some sets of small beds; wavy to very thin laminae upward in siltstones; soft sediment deformation; fracture from 610 ft down, near vertical, sandstone fill with possible gypsum. Color changes to dark olive gray (5Y3/2) from 610.3 ft downward.	
7	612.3–640.3	cut 28 ft, recovered 15.5 ft (55.4%)	10 ft of 15.5 ft in segments < 4 inches long (RQD = 35.5)	core loss	625.8-666.4 ft: Sandstone, very fine, dark gray (2.5YR N/4), poorly cemented, moderately lithified. Abundant low-angle planar to slightly wavy stratification, with common cross-cutting relationships. Some washouts along horizontal bedding and along fractures. High-angle fractures, some with gypsum fill, some unfilled, especially from ~632-640, producing blocky samples. Probable subhorizontal burrows ~ 654-655 ft. Small (0.08-0.16 in.) surface pockmarks may be eroded bioturbation; similar size gypsum crystals are sparsely distributed from ~632-625.5 ft, and holes may be after gypsum was dissolved. Some pores have square cross-section. Anhydrite/gypsum clasts from 661-664.5 ft in zone with inclined bedding (~30^{o}); inclined bedding from 664.5-666.4 ft.	core loss attributed to top of core run #7.
8	640.3–645.3	cut 5 ft, rec. 3.9 ft (78%)	1.2 ft of 3.9 ft in segments < 4 in. long (RQD = 69.2)			end coring 5/21/03; begin coring 5/22/03
9	645.3–660.3	cut 15 ft, recovered 10.7 ft (71.3%)	3 ft of 10.7 ft in segments < 4 in. long (RQD = 72)			
10	660.3–667.3	cut 7.0 ft, rec. 4.5 ft (64.3%)	~ 1 ft of 4.5 ft in segments < 4 in. long (RQD = 77.8)		**666.4 ft: base Rustler Formation, top of Salado Formation (666.4-total depth)** 664.3 ft — 664.3-666.4 ft: reddish brown; deformed ~ 664.4 ft 666.4 — 666.4-668.1 ft: gypsum, bedded, contorted, amalgamated unit. White to gray to reddish brown.	Core depths from 664.5-692 were initially mismarked in field; remarked and rephotographed 5/28/03.
11	667.3–670					



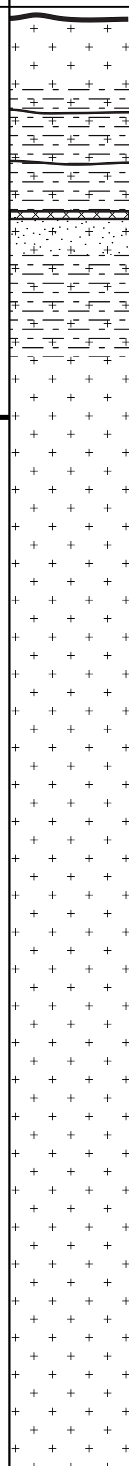
Hole ID: SNL-9

CORE LOG
(cont. sheet)

Sheet 8 of 9

Logged by: Dennis W. Powers, Ph.D., consulting geologist

Date: 5/22/03; 5/27/03

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
11	670–692.3	cut 25 ft, recovered 27.3 ft (109%)	all segments > 4 inches long (RQD = 100)		670.6 668.1-670.6 ft: Claystone with gypsum. Distorted bedding, mud clasts. Basal contact irregular, sharp from dissolution or possibly erosion. 670.6-674.3 ft: Halite, orange, coarse, slightly polyhalitic 674.3-681.2: Halite, with sandy siltstone; estimate ~ 30% clastics average, some displacive margins on halite; halite margins corroded near base. Some siltstone intraclasts with laminae. Corrosion surfaces @ 675.6-675.8, also 678.4 ft. 681.2-681.9 ft: Polyhalite, reddish brown, irregular upper surface. 681.9-689.2 ft: Halite, silty, slightly polyhalitic at base to halitic siltstone to sandy siltstone upward. Possible pseudomorphs after langbeinite at 683.2-683.5. Displacive halite margins common. Fine sandstone laminae at 685.9-685.8 ft. 689.2-692 ft: Halite, polyhalitic, slightly silty; coarse to very coarse, clear to orange; some displacive halite in polyhalite and siltstone.	end drilling 5/22/03 @ 692 ft; begin reaming to 7.875 in. from 520 on 5/27/03; drilling fluid level @ 95 ft with drilling string in hole. @ 695 ft @ 1255 MDT, circulate on bottom. Add jt and begin drilling from 695 ft @ 1315 MDT.
N/A	692.3–750	N/A cuttings sample depths noted 700-701 720-721 740-741	N/A		692-750 ft: Halite, coarse, clear.	720 ft @ 1343 MDT add jt 740 ft @ 1413 MDT

Depth scale: 670, 680, 690, 700, 710, 720, 730, 740, 750

Hole ID: SNL-9

CORE LOG
(cont. sheet)

Sheet 9 of 9

Logged by: Dennis W. Powers, Ph.D., consulting geologist

Date: 5/27/03

Note scale change

Run Number	Depth ( )	% Recovered	RQD	Description	Remarks
N/A	750	N/A	N/A	750-756 ft: Polyhalite or polyhalitic halite (MB100)	
		760-761		756-771 ft: Halite, coarse, clear.	add jt @ 759 ft; 760 ft @ 1445 MDT
	770			771-776 ft: Anhydrite and polyhalite (MB101)	
		780-781		776-804 ft: Halite, coarse, clear (cuttings delayed and include polyhalite mud)	780 ft @ 1514 MDT; add jt @ 791 ft
	790	cuttings sample depths noted			
		800-801			800 ft @ 1545 MDT
	810			804-835 ft: Polyhalite and anhydrite (MB 102-103), with underlying claystone to about 836 ft.	
		820-821			820 ft @ 1609 MDT; add jt @ 823 ft
	830				
		840-841		836-845 ft: Halite, coarse, clear.	840 ft @ 1714 MDT
					TD @ 845 ft @1721 MDT; circulate hole, pull drillpipe
	850				

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Appendix D
Geophysical Logs

Geophysical logging of SNL-9 was conducted by Geophysical Logging Services, 6250 Michele Lane, Prescott, AZ 86305 on May 28, 2003, and on June 19, 2003. The operator was Raymond Federwisch. Copies of the logs and electronic files are maintained by WRES, Environmental Monitoring and Hydrology group, for the WIPP Project. A CD-ROM is being retained by WRES that includes:

1) Electronic copies of the logs produced by Geophysical Logging Services using WellCAD vs 3.2,

2) WellCAD Reader to open the electronic logs, and

3) Electronic data files in both .txt and .las formats.

On May 28, 2003, the following geophysical logs were obtained:

- Caliper
- Natural gamma
- Neutron
- Density
- Formation resistivity (including induction and spot resistivity)
- Fluid resistivity
- Fluid temperature

The drillhole was open to about 845 ft bgl at the time of logging. A temporary conductor casing had been emplaced to a depth of about 4 ft bgl. The fluid level at the time of logging was kept near surface level. The drillhole diameter was approximately 7.875 inches to total depth based on the bit size.

On June 19, 2003, the following geophysical logs were obtained after the drillhole was reamed to a depth of about 587 ft bgl using a 15.75 inch diameter bit:

- Caliper (0-587 ft)
- Natural gamma (0-587 ft)

The drillhole was relogged to 587 with the natural gamma log because a permanent conductor casing was installed, to a depth of 30 ft, after the initial geophysical logging. The additional log was run to provide a permanent reference point for the placement of screens, gravel pack, and cement, even though the top of the connector on the permanent conductor casing is very near the level of the temporary casing.

Note that the zero point for all logs has been taken as the rounded value of the ground level benchmark placed next to the SNL-9 well pad. If more precision is desired, the top of the connector on the permanent casing, near ground level, can be surveyed relative to the benchmark. This is not warranted for the geological data obtained from logs, which should not be considered more precise than approximately 1 ft (vertical).

Photographs of SNL-9 logging May 28, 2003

Appendix E
Permitting and Completion Information

A case file for SNL-9 (C-2950) containing official documents is maintained by the land management section of WRES for WIPP. Selected documents are reproduced here for ease of access. Legal size 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, C-2950.

Information on management of well-drilling wastes for SNL-2 is included at the end of this appendix. Original files are maintained by WRES.

Dennis W. Powers, Ph. D.
Consulting Geologist

June 5, 2003

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-9

Our discussions regarding the Culebra Dolomite Member in SNL-9 indicate that the best interval to screen is from 572-545 ft below the top of the temporary conductor casing. This decision is based on geophysical logs completed on May 28, 2003 (see attached figure). I recommend we confirm this interval on geophysical logs completed after the permanent surface conductor casing has been placed and SNL-9 has been reamed to its final diameter. The best logs for this final decision would be caliper and natural gamma. The screen interval will not change greatly, but the top of the permanent casing may be slightly different from the temporary casing.

These are the factors we considered in this decision for SNL-9:

- The screened or slotted section of a single casing joint is 27 ft long.
- The Culebra interval, as indicated by the natural gamma geophysical log, is from 550-573 ft below the top of the temporary conductor casing.
- The core, although incomplete below the Culebra, indicated that the laminated claystone immediately underlying the Culebra behaves plastically, and the screened interval should be kept above this zone to prevent it from squeezing into the slots.
- Core and geophysical logs above the Culebra indicate the anhydrite/gypsum units are intact and separate the Culebra from the Tamarisk Member mudstone (M-3) by ~ 16 ft.
- There is no indication of halite in the mudstone unit (M-2) below the Culebra and above the anhydrite (A-1) about 9 ft below the Culebra.

By placing the bottom of the screened interval 572 ft below the top of the conductor, the mudstone below the Culebra should be isolated from squeezing into the screens. The top of the screened interval at 545 ft should be isolated from the Tamarisk Member mudstone. The top of the sand/gravel pack around the screen should not be higher than about 540 ft below the top of the temporary casing location to prevent circulation into M-3.

To provide adequate space below the screened interval for pumping, a minimum 10 ft long blank casing should be added below the 30 ft long screened pipe. The lower part of the hole, as it currently exists, should be cemented up into the anhydrite unit (A-1) with top of cement in the interval from 582-594 ft below the top of the conductor casing to minimize circulation into the lower Los Medaños Member, even though there is no evidence of halite in M-1/H-1 at SNL-9.

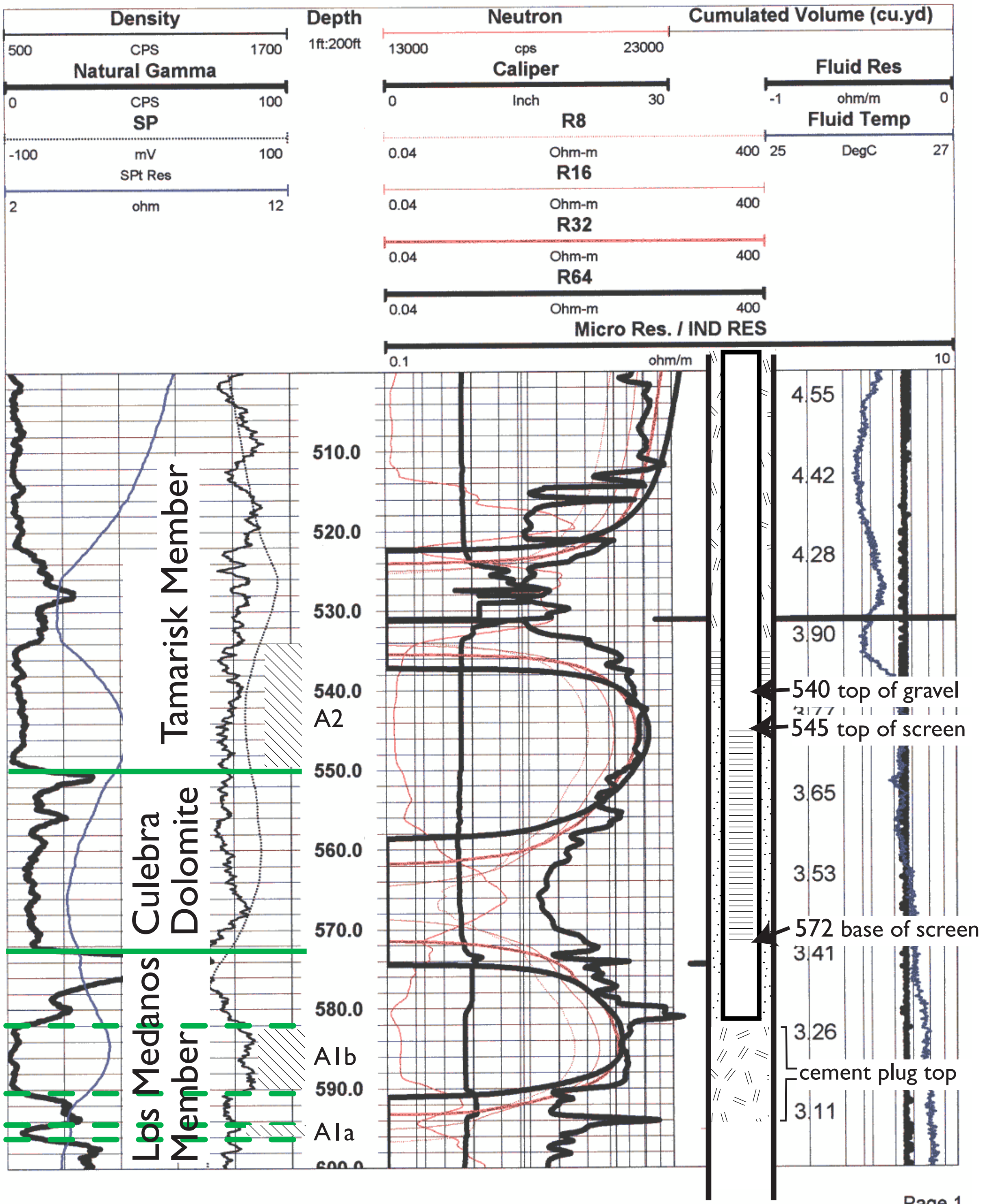
I believe this letter summarizes our discussions and presents the hydrological and geological justification for setting the screened interval and preparing SNL-9 for completion.

Sincerely,

Dennis W. Powers

Figure attached: Preliminary selection of screened interval, cement plug, and gravel pack interval for SNL-9 (SNL 9 Log.pdf)

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



Preliminary Selection of Screened Interval, Cement Plug, and Gravel Pack Interval for SNL-9

Dennis W. Powers, Ph. D.
Consulting Geologist

June 10, 2003

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-9

Background

Cores and cutting samples have been collected from drillhole SNL-9 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 Ron Richardson (WRES). SNL-9 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-9 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-9 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-9 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 approved for publication in the basic data report for SNL-9.

Dennis W. Powers

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

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

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

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

Trn Nbr: 258335
File Nbr: C 02950

Feb. 14, 2003

DOUG LYNN
US DEPT OF ENERGY CARLSBAD FIELD OFFICE, WIPP
PO BOX 3090
CARLSBAD, NM 88221-3090

Greetings:

Enclosed is your copy of the Exploratory Permit which has been approved. In accordance with the conditions of approval, the well can only be tested for 10 cumulative days, and the well is to be completed on or before 02/14/2004, unless a permit to use the water is acquired from this office.

Sincerely,

Mikeal Stapleton

Mikeal Stapleton
(505)622-6467

Enclosure

cc: Santa Fe Office

explore

Reissued due to metering requirement.

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

5A A totalizing meter shall be installed before the first branch of the discharge line from the well and the installation shall be acceptable to the State Engineer; the Engineer shall be advised of the make, model, serial number, date of installation, and initial reading of the meter prior to appropriation of water; pumping records shall be submitted to the District Supervisor for each calendar month on or before the 10th day of the following month.

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.

C2 No water shall be diverted from this well except for testing purposes which shall not exceed ten (10) cumulative days, and well shall be plugged or capped on or before , unless a permit to use water from this well is acquired from the Office of the State Engineer.

LOG The Point of Diversion C 02950 EXPL must be completed and the Well Log filed on or before 02/14/2004.

Trn Desc: C 02950 EXPL

File Number: C 02950
Trn Number: 258335

page: 1

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

ACTION OF STATE ENGINEER

Notice of Intention Rcvd: Date Rcvd. Corrected:
Formal Application Rcvd: 02/12/2003 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 14 day of Feb A.D., 2003

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

By: [signature]
for Art Mason

This is a reissue to include condition 5A, the metering requirement due to a larger casing size.

Trn Desc: C 02950 EXPL File Number: C 02950
Trn Number: 258335

page: 2

IMPORTANT - R... INSTRUCTIONS ON BACK BEFORE FIL... ..G OUT THIS FORM

APPLICATION FOR PERMIT

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

Date Received February 12, 2003 File No. C-2950 Expl.

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

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

3. The well is to be located in the s/e 1/4 n/e 1/4 s/e 1/4, Section 23 Township 22 South Range 30 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Carlsbad, District, on land owned by U.S. Department of Energy, Carlsbad Field Office, WIPP

4. Description of well: name of driller West Texas Water Well Service,
   Outside Diameter of casing 5.5" fiberglass inches; Approximate depth to be drilled 810' bgs feet;

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

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

Subdivision	Section	Township	Range	Acres	Owner

7. Additional statements or explanations This well is to be drilled as an exploration/monitoring well only. It will be drilled to a total depth of 810' bgs in order to acquire core samples from Marker Bed 103. After cores are taken, the well will be cemented back to the Culebra dolomite interval @ 558-605' bgs. Casing and cement inspections have been identified as hold points pending on site inspections by personnel from the New Mexico Office of the State Engineer. After the initial drilling, pump tests will be conducted to determine the production capacity of the Culebra. These will occur for approximately 96 hours @ 20 gallons per minute. After the completion of the initial pump test, this well will be used for routine monitoring purposes (e.g., water level measurements).

STATE ENGINEER OFFICE ROSWELL NEW MEXICO 2003 FEB 12 AM 7:37

I, Harold Johnson, affirm that the foregoing statements are true to the best of my knowledge and belief and that development shall not commence until approval of the permit has been obtained.

U.S. Dept. of Energy - Carlsbad Field Office, Permittee,

By: Harold Johnson

Subscribed and sworn to before me this 11th day of Feb., A.D., 2003

My commission expires Oct. 3, 2005 Sharon Warren-Briggs
Notary Public

Number of this permit C-2950

ACTION OF STATE ENGINEER

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

Proof of completion of well shall be filed on or before ______, 20____

Proof of application of water to beneficial use shall be filed on or before ______, 20____

Witness my hand and seal this 14th day of February, A.D., 2003

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

By: [signature]

Art Mason, District II Supervisor

INSTRUCTIONS

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

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

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

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

Sec. 6 - Describe only the lands to be irrigated or where water will be used. If on unsurveyed lands describe by legal subdivision "as projected" from the nearest government survey corners, or describe by metes and bounds and tie survey to some permanent, easily located natural object.

Sec. 7 - If lands are irrigated from any other source, explain in this section. Give any other data necessary to fully describe water right sought.

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-9
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C-2950 EXPL and is located in the:

a. S/E ¼ N/E ¼ S/E ¼ ____ ¼ of Section 23 Township 22 S Range 30 E N.M.P.M.

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

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

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

(B) Drilling Contractor WEST TEXAS WATER WELL SERVICE License No. WD-1184

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 5-18-03 Completed 6-21-03 Type tools MUD ROTARY Size of hole 15-3/4 in.

Elevation of land surface or ____ at well is 3358.91 ft. Total depth of well 587 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)
550	573	23	LIGHT BROWN DOLOMITE	15 G.P.M.

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
18	47.30	8	2.5' AGL	30'	32-1/2			
9-5/8 FIBERGLASS	11.25	4	2' AGL	583'	585	FIBERGLASS CAP ON BOTTOM	545	572 .020 SLOT

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
845	590	7-7/8		76	TRIMMIE
0	30	22" 18" CSG		27	TRIMMIE
0	535	15-3/4 9-5/8 CSG		432	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	4	4	CONSTRUCTION FILL & BROWN SAND
4	6	2	WHITE CALICHE (MESCALERO)
6	46	40	REDDISH BROWN CALCAREOUS SANDSTONE & CLAYSTONE (GATUNA)
46	116	70	REDDISH BROWN CALCAREOUS SANDY SILTSTONE & SILTY CLAYSTONE (UPPER DEWEY LAKE FORMATION)
116	374	258	REDDISH BROWN GYPSIFEROUS SANDY SILTSTONE & SILTY CLAYSTONE (LOWER DEWEY LAKE FORMATION)
374	440	66	WHITE GYPSUM BEDS W/INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE (FORTY-NINER MEMBER OF RUSTLER FORMATION)
440	462	22	WHITE TO GRAYISH BROWN GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
462	550	88	WHITE GYPSUM BEDS W/INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE (TAMARISK MEMBER OF THE RUSTLER FORMATION)
550	573	23	LIGHT BROWN DOLOMITE (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
573	583	10	DARK GRAY TO REDDISH BROWN GYPSIFEROUS CLAYSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
583	590	7	WHITE ANHYDRITE & GYPSUM (UPPER LOS MEDANOS MEMEBER OF THE RUSTLER FORMATION)
590	672	82	DARK GRAY TO REDDISH BROWN VERY FINE SANDTONE & SILTSTONE (LOWER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
672	845	173	CLEAR TO WHITE COARSE HALITE W/INTERBEDDED ANHYDRITE & POLYHALITE (UPPER SALADO 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 th[illegible] rm is used as a plugging record, only Sectior[illegible] and Section 5 need be completed.

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-109175
2805(080)whs.

RIGHT-OF-WAY RESERVATION

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 for 1 Ground Exploration/Monitoring well, for the expressed purpose of hydrological investigations for the U.S. Department of Energy's Waste Isolation Pilot Plant, over the following described real property situated in the County of Eddy, State of New Mexico to wit:

T. 22 S., R. 30 E., NMPM
Sec. 23: SE¼SE1/4.

The well site location contains approximately 0.230 acres (approximately 100' X 100').

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 March 6, 2003.

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, Waste Isolation Pilot Plant agrees, 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 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 according to Bureau of Land Management specifications. Attached are stipulations for reseeding. Exhibit A.

D. The well shall be properly plugged (See the attached Casing Program Plugging and Abandonment Requirements). Exhibit A-1.

E. Precautions will be taken for all arc and/or gas welding operations. Exhibit A-2.

6. This reservation shall be renewable and shall have a 30-year term, commencing on the date shown below.

Dated this 15th day of April, 2003.

Leslie A. Theiss

Leslie A. Theiss, Field Manager
Carlsbad Field Office, BLM

April 15, 2003

BLM Serial No.: NM-109175
Company Reference: SNL-9

Seed Mixture 2, for Sandy 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
Sand dropseed (*Sporobolus cryptandrus*)	1.0
Sand lovegrass (*Eragrostis trichodes*)	1.0
Plains bristlegrass (*Setaria macrostachya*)	2.0

*Pounds of pure live seed:

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

SPECIAL STIPULATIONS (exhibit A-1)

RIGHT-OF-WAY RESERVATION
NM-109175

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.

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.

NM-109175
Exhibit A-2

The following precautions will be taken for all arc and/or gas welding operations, and operations where oxy-acetylene cutting and brazing are done in a wildland fire environment.

1. At the work site, clear away all flammable vegetation down to mineral soil for a minimum radius of 6 feet around where the welding/cutting will take place. This includes grasses and other vegetative material.

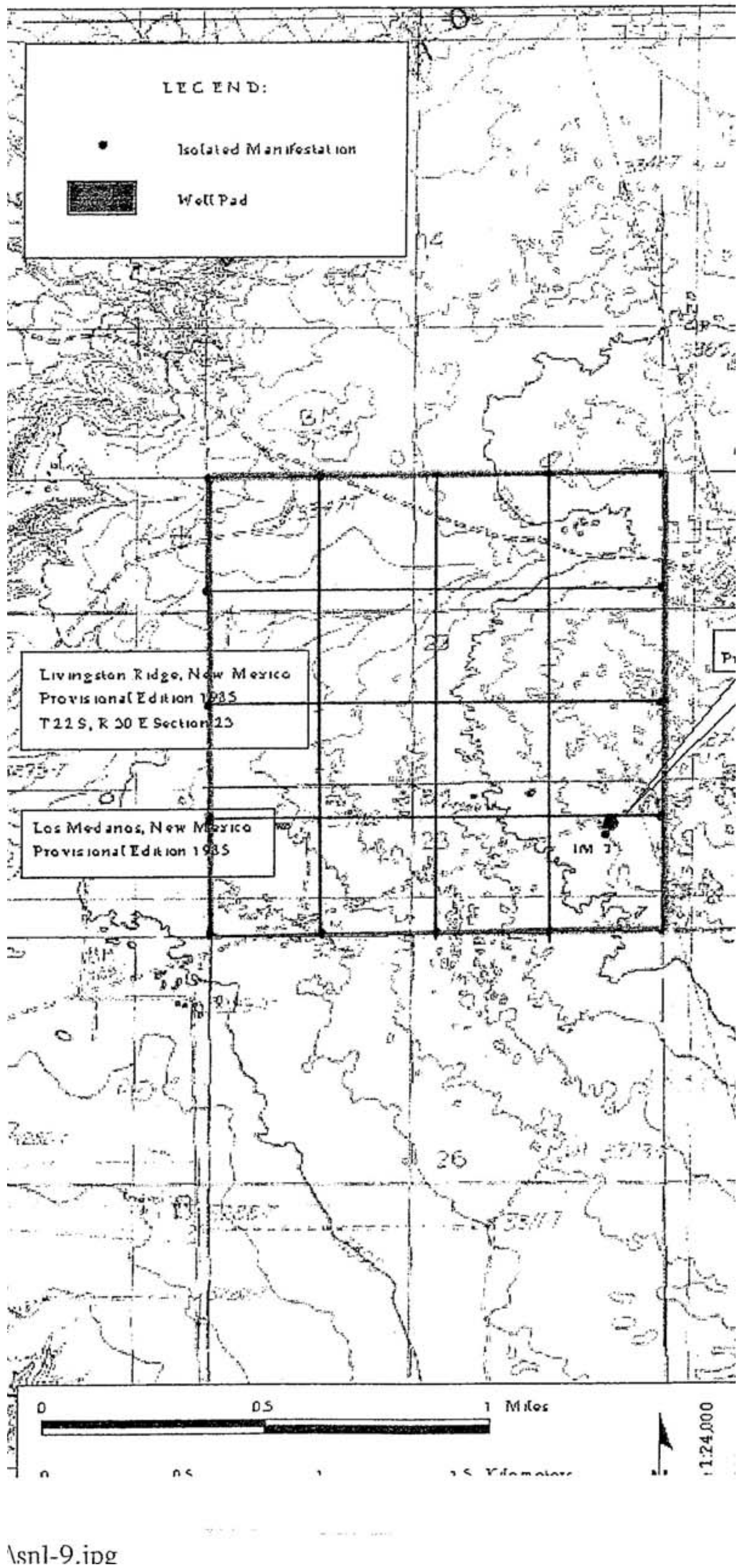
2. While conducting the welding/cutting operations, the operator will have within 25 feet of the welding/cutting site:

> Five (5) gallons of water and/or;
> A five (5) pound multi-purpose dry fire extinguisher and a round point shovel.

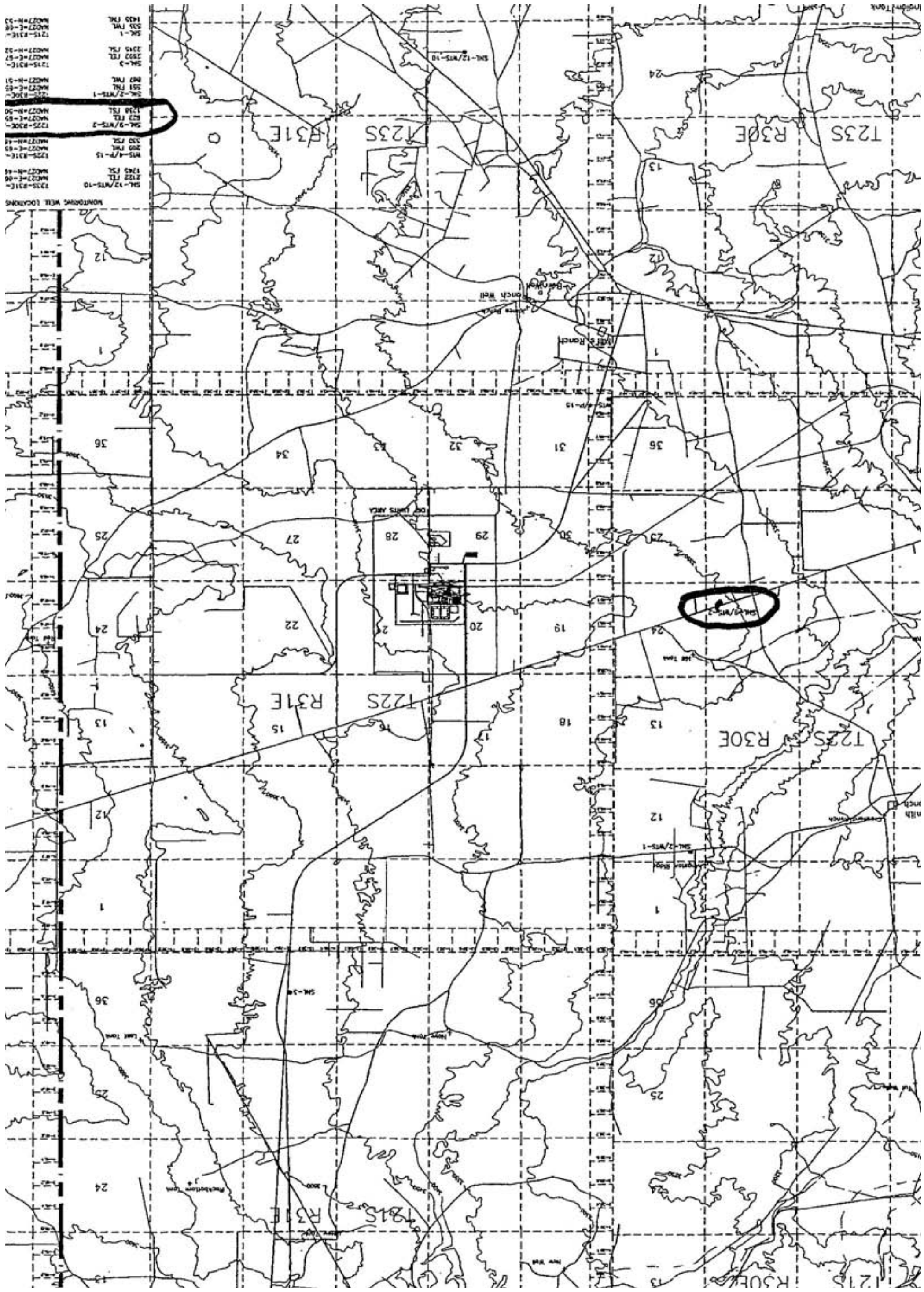
3. After welding/cutting activities are completed, a routine return to the site will be required within 1 hour after the completion of the activity to check for any potential hot material that may start a wildland fire.

Operators and contractors are reminded that they may be held responsible for any wildland fire that starts from welding/cutting operations. This includes all cost for suppressing any wildland fire that starts from these activities.

Survey for the SNL-9/WTS-2 Water Mon



\snl-9.jpg



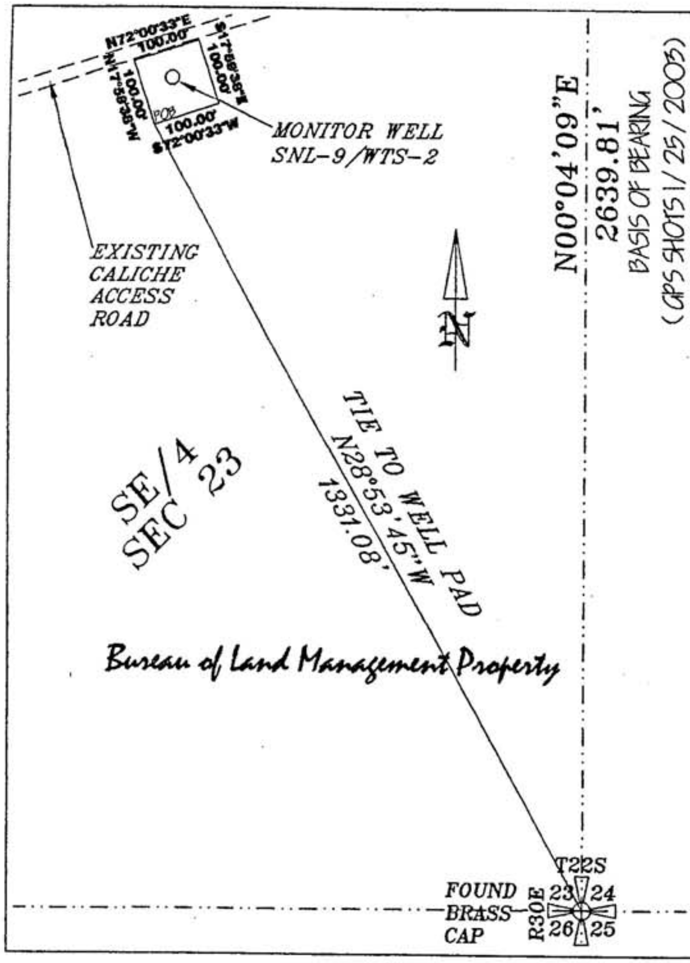


EXHIBIT A

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 N28°53'45"W 1331.08' FROM THE SE CORNER OF SEC 23, T22S, R30E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N17°59'38"W FOR 100.00'; THEN N72°00'33"E FOR 100.00'; THEN S17°59'38"E FOR 100.00'; THEN S72°00'33"W FOR 100.00' TO THE POINT OF BEGINNING.

200 0 200 400 600

Scale 1" = 200'

THE NEW MEXICO
STATE PLANE EAST NAD27
COORDINATES FOR WELL
SNL-9/WTS-2
499988.93 N*
650929.62 E*
ELEV-3357.30*
(*SUBJECT TO CHANGE)

LEGEND

—·—·— *LAND LINE*
SECTION CORNER
===== *EXISTING DIRT ROAD ACCESS*

MELVIN R. PYEATT
NEW MEXICO
8520
REGISTERED PROFESSIONAL LAND SURVEYOR

WELL INFORMATION		
NUMBER SNL-9/WTS-2		
IN SEC. 23	T 22S	R 30E
COUNTY: EDDY		
STATE: NEW MEXICO		
DATE: FEBRUARY 4, 2003		

FIGURE 12. SAMPLE NOS SUBMITTAL

NOTICE OF STAKING Not to be used in place of Application for Permit to Drill (Form 3160-3)	6. Lease Number N/A
1. Oil Well ____ Gas Well ____ Other (Specify) Groundwater Monitoring Well	7. If Indian, Allottee or Tribe Na N/A
2. Name of Operator: U.S. Department of Energy, Carlsbad Field Office, WIPP	8. Unit Agreement Name N/A
3. Name of Specific Contact Person: Mr. Harold Johnson	9. Farm or Lease Name N/A
4. Address & Phone No. of Operator or Agent: 4021 National Parks Highway, Carlsbad, NM. 88221 (505)234-7349	10. Well No. WIPP # = SNL9 NMOSE # = TBD
5. Surface Location of Well: SE/4, NE/4, SE/4, Section 23, T 22S, R 30E	11. Field or Wildcat Name N/A
Attach: a) Sketch showing road entry onto pad, pad dimensions, and roserve pit. b) Topographical or other acceptable map showing location, access road, and lease boundaries.	12. Sec., T., R., M., or Blk and Survey of Area Sec. 23, T22S, R30E See attached plat of surve

15. Formation Objective(s)	16. Estimated Well Depth	13. County, Parish, or Borough	14. Sta
Culebra w/TD @ Marker Bed (MB) 103 to be cemented back to Culebra	Culebra = 558'-605' bgs MB 103 = 810' bgs	Eddy	NM

17. Additional Information (as appropriate; shall include surface owner's name, address and, if k telephone number)
This well bore is intended for monitoring purposes only (e.g., water level measurements).

18. Signed Harold Johnson Title MCO Date 2/

Note: Upon receipt of this Notice, the Bureau of Land Management (BLM) will schedule the dat onsite predrill inspection and notify you accordingly. The location must be staked and acce must be flagged prior to the onsite.

Operators must consider the following prior to the onsite:
a) H2S Potential
b) Cultural Resources (Archeology)
c) Federal Right of Way or Special Use Permit

Original Version

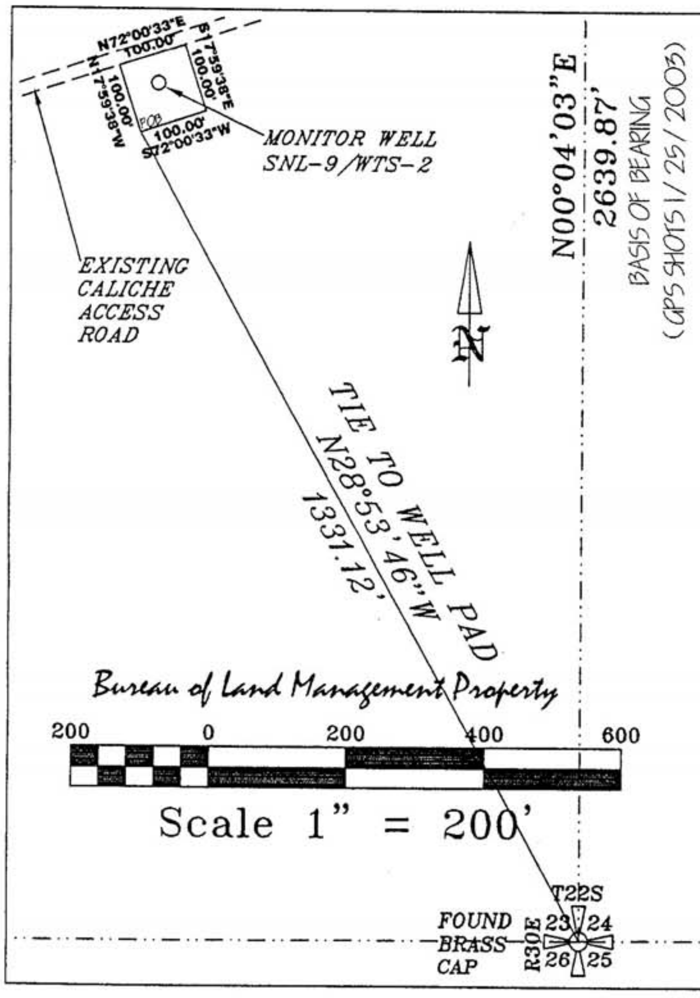


EXHIBIT A

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 N28°53'46"W 1331.12' FROM THE SE CORNER OF SEC 23, T22S, R30E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N17°59'38"W FOR 100.00'; THEN N72°00'33"E FOR 100.00'; THEN S17°59'38"E FOR 100.00'; THEN S72°00'33"W FOR 100.00' TO THE POINT OF BEGINNING.

THE NEW MEXICO
STATE PLANE EAST
COORDINATES FOR WELL
SNL-9/WTS-2
458870.42 N
692048.07 E
3358.91 ELEV
(SUBJECT TO CHANGE)

LEGEND

LAND LINE

SECTION CORNER

EXISTING DIRT ROAD ACCESS

WELL INFORMATION			
NUMBER	SNL-9/WTS-2		
IN SEC. 23	T 22S	R 30E	
COUNTY:	EDDY		
STATE:	NEW MEXICO		
DATE:	FEBRUARY 4, 2003		

CONTROLLED RECOVERY, INC.
P.O. Box 388 • Hobbs, New Mexico 88241-0388
(505) 393-1079

Bill to ______
Address ______

Company/Generator West Texas Water Well Service
Lease Name WIPP SL 9
Trucking Company ITW | Vehicle Number 1402 | Driver (Print) Tracy Lentz
Date 6 25 03 | Time 130 a.m. / p.m.

Type of Material

- ☐ Exempt
- ☐ Non-Exempt
- C138 ______
- ☐ Tank Bottoms
- C117 ______
- ☐ Soils
- ☐ Fluids
- ☒ Other Material
- List Description Below

NMED C

DESCRIPTION

Monitor Well Drill Cuttings / Water

Volume of Material ☒ Bbls. 15 ☐ Yard ______ ☒ Gallons 630

☐ Wash Out ☐ Call Out ☐ After Hours ☐ Debris Charge

This statement applicable to exempt waste only.
I represent and warrant that the wastes are: generated from oil and gas exploration and production operations: exempt from Resource Conservation and Recover Act (RCRA) Subtitle C Regulations, and not mixed with non-exempt wastes.

Agent ______ (Signature)

CRI Representative ______ (Signature)

TANK BOTTOMS

	Feet	Inches			
1st Gauge			BBLS Received		BS&W %
2nd Gauge			Free Water		
Received			Total Received		

White - CRI Canary - CRI Accounting Pink - CRI Plant Gold - Transporter

№ 47113

SUPERIOR PRINTING SERVICE, INC.

CONTROLLED RECOVERY, INC.

P.O. Box 388 • Hobbs, New Mexico 88241-0388
(505) 393-1079

Bill to ____________________

Address ____________________

Company/Generator: West Texas water well Service

Lease Name: WIPP SL #9

Trucking Company: I & W | Vehicle Number: 1402 | Driver (Print): Tracy

Date: 6-25-03 | Time: 10:50 a.m. / p.m.

Type of Material

- ☐ Exempt
- ☐ Non-Exempt
- C138 ____________
- ☐ Tank Bottoms
- C117 ____________
- ☐ Soils
- ☐ Fluids
- ☒ Other Material
  List Description Below

NMED C

DESCRIPTION

Monitor well Drill cuttings / water

Volume of Material ☒ ~~Bbls.~~ 120 | ☐ Yard ________ | ☒ Gallons 5040

☐ Wash Out | ☐ Call Out | ☐ After Hours | ☐ Debris Charge

This statement applicable to exempt waste only.
I represent and warrant that the wastes are: generated from oil and gas exploration and production operations: exempt from Resource Conservation and Recover Act (RCRA) Subtitle C Regulations; and not mixed with non-exempt wastes.

Agent ____________________
(Signature)

CRI Representative ____________________
(Signature)

TANK BOTTOMS

	Feet	Inches			
1st Gauge			BBLS Received		BS&W %
2nd Gauge			Free Water		
Received			Total Received		

№ 47097

White - CRI | Canary - CRI Accounting | Pink - CRI Plant | Gold - Transporter

Appendix F
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 WRES, land management section, for the WIPP Project.

TITLE PAGE/ABSTRACT/
NEGATIVE SITE REPORT
BLM/CFO **CARLSBAD FIELD OFFICE**

1. BLM Report No.:	**2. (ACCEPTED) (REJECTED)**	**3. NMCRIS No.:** 82094
4. Title of Report (Project Title): An Archaeological Survey for a the SNL-9/WTS-2 Water Monitoring Well		**5. Project Date(s):** January 30, 2003 **6. Report Date:** February 7, 2003
7. Consultant Name & Address **Direct Charge:** Sean Simpson **Name:** Mesa Field Services **Address:** P.O. Box 3072 Carlsbad, NM 88221-3072 **Author's Name:** Theresa Straight **Field Personnel Names:** Theresa Straight **Phone:** (505) 628-8885		**8. Permit No.:** 153-2920-02-L **9. Consultant Report No.:** MFS – 824
10. Sponsor Name and Address **Individual Responsible:** Ron Richardson **Name:** Westinghouse TRU Solutions, LLC **Address:** P.O. Box 2078 Carlsbad, NM 88221 **Phone:** (505) 234-8395		**11. For BLM use only** **12. Acreage** **Total acres surveyed:** 0.92 **Per Surface Ownership** **Federal:** 0.92 **State:** 0 **Private:** 0
13. Location & Area (maps attached if negative survey) **a. State:** New Mexico **b. County:** Eddy **c. BLM Field Office:** Carlsbad **d. Nearest City or town:** Carlsbad, NM **Location:** T 22S, R 30E, Section 23: NE¼ SE¼ SE¼ **Well Pad Footages:** N/A **f. 7.5' Map Name(s)and Code Number(s):** Los Medanos, NM Provisional Edition 1985 (32103-C7) **g. Area** **Block: Impact:** 100 ft by 100 ft **Surveyed:** 200 ft by 200 ft **Linear: Impact:** N/A **Surveyed:** N/A		
14. a. Records Search **Location:** Bureau of Land Management – Carlsbad Field Office and the Archaeological Records Management System (ARMS) via modem **Date:** January 29, 2003 by Natalie Allen **List by LA # all sites within .25 miles of the project (those sites within 500' are to be shown on the project**		

map): Three previously recorded sites (LA 98797, LA 98798, and LA 100333) are within 0.25 miles of the project area but further than 500 ft.

b. Description of Undertaking (client's activities): Westinghouse TRU Solutions, LLC plans on drilling a water monitoring well. The pad for the well will be 100 ft by 100 ft, yet an additional 50 ft on each side, totaling a 200 ft by 200 ft area was surveyed to ensure the protection of cultural resources. The project area totaled 0.92 acres, all of which is on land owned and administered by the BLM-CFO. An existing caliche capped road that runs along the north boundary of the well pad will serve as access.

c. Environmental Setting (NRCS soil designation, vegetative community, etc.): The project is located within a dune field. The soil is a reddish brown sand with caliche nodules and sandstone gravels. The soil has been wind worked into dunes up to 2 m high. It is of the Kermit-Berino soil association as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Project elevations average 3,360 ft above mean sea level. Local vegetation is characteristic of Chihuahuan Desert Scrub and includes mesquite, shin oak, yucca, bunch grasses, and snakeweed. Due to this vegetative cover, ground surface visibility ranged from 60 percent to 100 percent.

d. Field Methods

Transect Intervals: 15 m
Crew Size: 1
Time in Field: 1 hour
Collections: None

15. Cultural Resource Findings: One isolated manifestation was encountered and recorded during the survey.
Identification and Description (location shown on project map): IM 1 consists of a white chert flake with a flat platform and 10 percent dorsal cortex, size 2 (Zone 13: E 608687/ N 3582203).

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

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

Responsible Archaeologist:
Signature_______________________________________**Date**____________________

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

Survey for the SNL-9/WTS-2 Water Monitoring Well

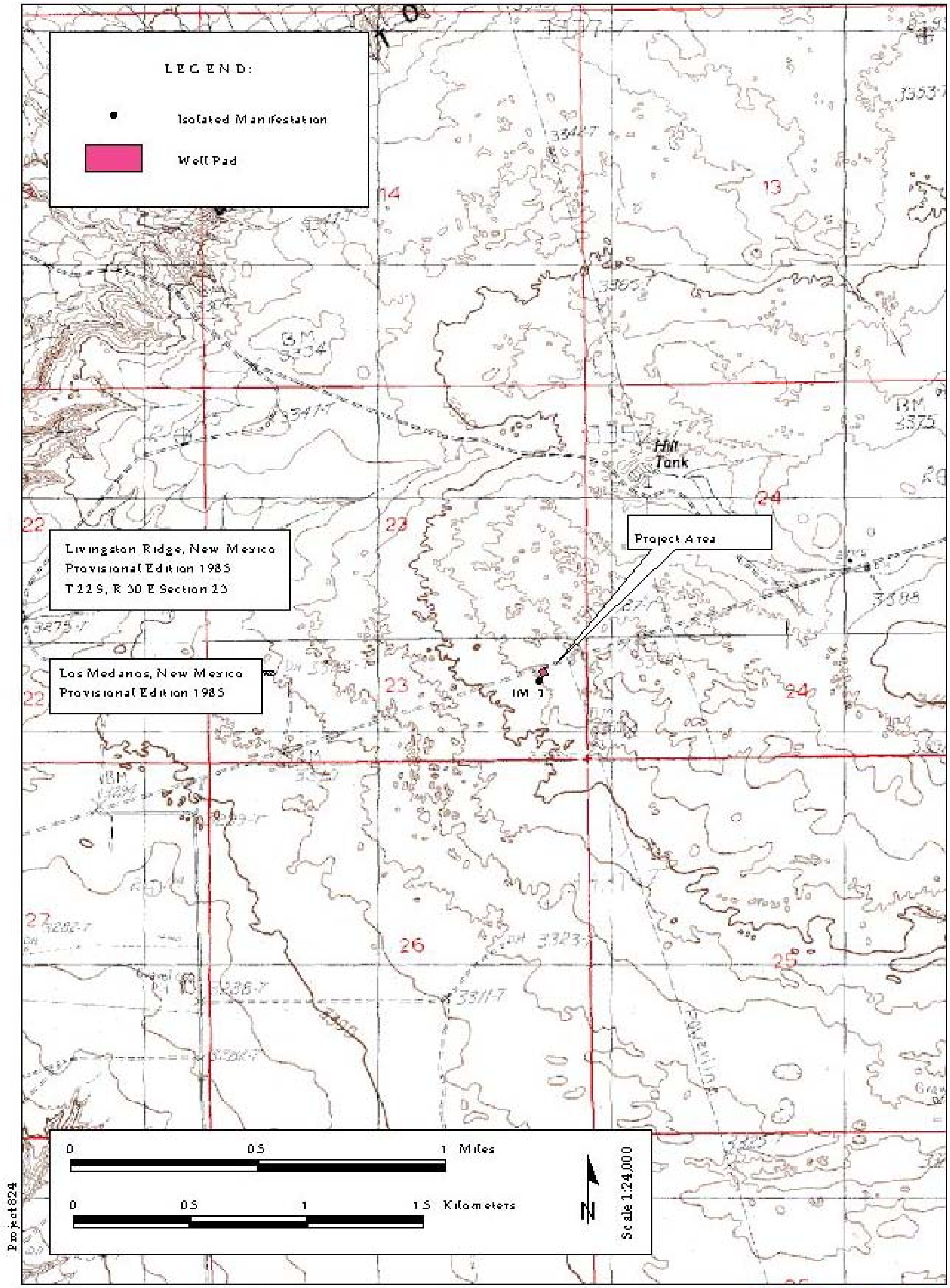


Figure 1. Project Area Map

Mesa Field Services

Appendix G
Photograph Logs

Digital photographs were taken of the cores from SNL-9. These photographs have been compiled into a listing of consecutive photos beginning with the uppermost core (lower Forty-niner Member of the Rustler Formation) and ending with the lowermost (upper Salado Formation). Most of the photographs were taken in the field shortly after recovery. Some images that were of lesser quality were retaken later. 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.

Original digital images were taken using the Casio camera indicated in the log footer. Replacement images taken October 1 2003 were taken with a Nikon Coolpix 5700.

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core001.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Forty-niner Mbr core, 430.0 - 431.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core002.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Forty-niner Mbr core, 430.7 - 432.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core003.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Forty-niner Mbr core, 431.6 - 433.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core004.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Forty-niner Mbr core, 432.6 - 434.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core005.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Forty-niner/Magenta Dolomite Mbrs core, 433.7 - 435.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core006.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Forty-niner/Magenta Dolomite Mbrs core, 434.6 - 436.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core007.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 435.7 - 437.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core008.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 436.7 - 438.3 ft bgl (mismarked 436.3), with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core009.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 437.7 - 439.3 ft bgl (438 mismarked 436), with markings, scale, and time-date	DW Powers Consultant to WTS
SNL-9_Core010.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 438.7 - 440.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core011.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 439.7 - 441.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core012.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 440.8 - 442.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core013.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 441.9 - 443.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core014.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 442.7 - 444.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core015.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 443.4 - 444.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core016.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 444.6 - 445.7 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page 1 of 12**

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core017.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 444.8 - 446.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core018.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 445.8 - 447.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core019.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 446.8 - 448.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core020.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 447.8 - 449.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core021.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 448.8 - 450.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core022.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 449.8 - 451.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core023.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 450.6 - 452.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core024.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 451.7 - 453.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core025.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 452.7 - 454.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core026.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 453.7 - 455.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core027.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 454.7 - 456.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core028.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 455.7 - 457.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core029.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 456.8 - 458.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core030.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 457.7 - 459.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core031.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 458.6 - 459.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core032.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 459.9 - 461.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page** 2 **of 12**

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core033.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 458.6 - 459.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core034.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 458.7 - 459.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core035.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite Mbr core, 459.9 - 461.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core036.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Magenta Dolomite/ Tamarisk Mbrs core, 460.8 - 462.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core037.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 462.7 - 464.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core038.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 463.8 - 465.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core039.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 464.9 - 466.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core040.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 465.8 - 467.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core041.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 466.7 - 468.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core042.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 467.7 - 469.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core043.jpg	5-19-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 468.6 - 470.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core044.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 520.0 - 521.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core045.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 520.6 - 522.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core046.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 521.6 - 523.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core047.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 522.5 - 524.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core048.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 523.6 - 525.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core049.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 526.7 - 528.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core050.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 527.8 - 529.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core051.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 528.8 - 530.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core052.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 529.7 - 531.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core053.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 530.8 - 532.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core054.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 531.2 - 532.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core055.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 532.3 - 533.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core056.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 532.5 - 534.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core057.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 533.6 - 535.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core058.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 534.6 - 536.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core059.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 535.8 - 537.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core060.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 536.7 - 538.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core061.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 537.6 - 539.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core062.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 538.7 - 540.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core063.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 539.7 - 541.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core064.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 540.7 - 542.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core065.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 541.7 - 543.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core066.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 542.8 - 544.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core067.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 543.7 - 545.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core068.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 544.7 - 546.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core069.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 545.8 - 547.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core070.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 546.8 - 548.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core071.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 547.8 - 549.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core072.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 548.7 - 550.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core073.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 550.0 - 551.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core074.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 550.7 - 552.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core075.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Tamarisk Mbr core, 551.6 - 552.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core076.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 552.9 - 554.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core077.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 553.7 - 555.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core078.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 554.8 - 556.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core079.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 555.7 - 557.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core080.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 556.7 - 558.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core081.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 555.7 - 557.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core082.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 556.7 - 558.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core083.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 557.8 - 559.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core084.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 558.7 - 560.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core085.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 559.8 - 561.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core086.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 560.8 - 562.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core087.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 561.8 - 563.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core088.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 562.8 - 564.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core089.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 563.8 - 565.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core090.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 564.8 - 566.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core091.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 565.5 - 566.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core092.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 576.2 - 577.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core093.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 576.8 - 578.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core094.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 577.9 - 579.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core095.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 578.9 - 580.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core096.jpg	5-20-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Culebra Dolomite Mbr core, 579.8 - 581.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core097.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 584.7 - 586.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core098.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 585.8 - 587.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core099.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 586.7 - 588.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core100.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 587.8 - 589.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core101.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 588.8 - 590.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core102.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 589.6 - 591.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core103.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 590.7 - 592.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core104.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 591.8 - 593.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core105.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 592.7 - 594.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core106.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 593.3 - 594.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core107.jpg	10-1-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 594.3-595.1 ft bgl, with markings, scale, no time-date stamp	DW Powers Consultant to WTS
SNL-9_Core108.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 594.7 - 596.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core109.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 595.8 - 597.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core110.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 596.7 - 598.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core111.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 597.7 - 599.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core112.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 598.7 - 600.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core113.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 599.9 - 601.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core114.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 600.9 - 602.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core115.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 601.9 - 603.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core116.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 602.9 - 604.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core117.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 603.9 - 605.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core118.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 604.9 - 606.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core119.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 605.9 - 607.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core120.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 606.8- 608.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core121.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 607.9 - 609.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core122.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 608.9 - 610.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core123.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 609.9 - 611.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core124.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 610.7 - 612.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core125.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 624.7 - 626.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core126.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 625.7 - 627.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core127.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 626.8 - 628.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core128.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 627.8 - 629.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core129.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 628.8 - 630.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core130.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 629.8 - 631.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core131.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 630.9 - 632.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core132.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 631.8 - 633.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core133.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 632.8 - 634.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core134.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 633.9 - 635.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core135.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 634.8 - 636.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core136.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 635.7 - 637.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core137.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 636.7 - 638.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core138.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 637.7 - 639.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core139.jpg	5-21-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 638.7 - 640.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core140.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 641.2 - 642.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core141.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 641.8 - 643.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core142.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 642.9 - 644.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core143.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 643.7 - 645.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core144.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 644.1 - 645.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core145.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 649.3 - 650.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core146.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 649.8 - 651.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core147.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 650.7 - 652.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core148.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 651.8 - 653.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core149.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 652.7 - 654.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core150.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 653.7 - 655.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core151.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 654.7 - 656.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core152.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 655.8 - 657.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core153.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 656.7 - 658.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core154.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 657.7 - 659.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core155.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 658.7 - 660.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core156.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 660.0 - 661.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core157.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 660.7 - 662.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core158.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 661.8 - 663.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core159.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 662.9 - 664.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core160.jpg	5-22-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Los Medaños Mbr core, 663.5 - 664.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core161.jpg	10-1-03	SNL-9 drillpad; T22S, R30E, sec13	Close-up photo of Los Medaños Mbr core, 664.5 - 665.3 ft bgl, with markings, scale, no time-date stamp	DW Powers Consultant to WTS
SNL-9_Core162.jpg	10-1-03	SNL-9 drillpad; T22S, R30E, sec14	Close-up photo of Los Medaños Mbr core, 664.9 - 666.0 ft bgl, with markings, scale, no time-date stamp	DW Powers Consultant to WTS
SNL-9_Core163.jpg	10-1-03	SNL-9 drillpad; T22S, R30E, sec15	Close-up photo of Los Medaños Mbr/Salado core, 666.0 - 666.8 ft bgl, with markings, scale, no time-date stamp	DW Powers Consultant to WTS
SNL-9_Core164.jpg	10-1-03	SNL-9 drillpad; T22S, R30E, sec16	Close-up photo of Salado core, 666.7 - 667.7 ft bgl, with markings, scale, no time-date stamp	DW Powers Consultant to WTS
SNL-9_Core165.jpg	10-1-03	SNL-9 drillpad; T22S, R30E, sec17	Close-up photo of Salado core, 667.7 - 668.3 ft bgl, with markings, scale, no time-date stamp	DW Powers Consultant to WTS
SNL-9_Core166.jpg	10-1-03	SNL-9 drillpad; T22S, R30E, sec17	Close-up photo of Salado core, 667.9 - 669.1 ft bgl, with markings, scale, no time-date stamp	DW Powers Consultant to WTS
SNL-9_Core167.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 668.2 - 669.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core168.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 669.2 - 670.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core169.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 670.0 - 671.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core170.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 671.0 - 672.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core171.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 672.3 - 673.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core172.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 673.2 - 674.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core173.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 674.3 - 675.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core174.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 675.2 - 676.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core175.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 676.4 - 677.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core176.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 677.0 - 678.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-9_Core177.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 678.1 - 679.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core178.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 678.9 - 679.8 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core179.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 679.8 - 681.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core180.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 680.4 - 681.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core181.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 681.4 - 682.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core182.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 681.9 - 682.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core183.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 682.9 - 684.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core184.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 683.7 - 684.8 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core185.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 684.8 - 685.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core186.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 685.6 - 686.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core187.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 686.6 - 687.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core188.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 687.3 - 688.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core189.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 688.5 - 689.7 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core190.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 689.3 - 690.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core191.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 690.5 - 691.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-9_Core192.jpg	5-28-03	SNL-9 drillpad; T22S, R30E, sec12	Close-up photo of Salado Fm core, 690.7 - 692.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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