DOE/WIPP 03-3295

Basic Data Report
For Drillhole SNL-12 (C-2954)
(Waste Isolation Pilot Plant)

April 2004

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

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For Drillhole SNL-12 (C-2954)
(Waste Isolation Pilot Plant - WIPP)

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April 2004

West Texas Water Well Service Rig #15 at drillhole SNL-12, dawn, July 11, 2003.

EXECUTIVE SUMMARY

SNL-12 (permitted by the New Mexico State Engineer as C-2954) was drilled to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation near the margin of dissolution of halite in the upper part of the Salado south of the Waste Isolation Pilot Plant (WIPP). SNL-12 is located in the southeast quarter of section 20, T23S, R31E, in eastern Eddy County, New Mexico. SNL-12 was drilled to a total depth of 905 ft below the ground level. Below surface dune sand and the Berino soil, SNL-12 encountered, in order, the Mescalero caliche, Gatuña, Dewey Lake, Rustler, and uppermost Salado Formations. Two intervals 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-12, the uppermost Salado cores display displacive halite crystals in clastic-rich units below an amalgamated sulfate at the top of the formation. There is no indication of thinning of the upper Salado due to postdepositional dissolution, and this is consistent with predrilling expectations. The Los Medaños has a thickness and stratigraphic sequence very similar to that found at the center of the WIPP site. The basal Los Medaños beds are laminar and show no signs of postdepositional dissolution of upper Salado halite. Higher clastic beds of the Los Medaños do not indicate postdepositional dissolution of halite either.

The Culebra Dolomite is above average in thickness (40 ft), and core recovery from the unit was very good. Recovered cores show a zone of probable öolites accounting for much of the greater than normal thickness. Bedding and porosity are generally similar to that across much of the WIPP site. Hydrostratigraphic units CU-3 and CU-2, normally the most transmissive parts of the Culebra, have been extended to include the öolite zone. Although these hydrostratigraphic zones are thicker than at the WIPP site, vugs and fracturing may be less extensive than in other drillholes.

The Tamarisk has a normal stratigraphic sequence and thickness, and the mudstone unit shows typical reddish-brown claystone overlain by gray and reddish-brown claystone. Some intraclasts of claystone are preserved. There is no indication of postdepositional dissolution of halite from the mudstone unit.

The Magenta Dolomite is about 28 ft thick and shows typical laminar to wavy bedding, some ripples, minor algal stromatolites, and possible öolites. Only one fracture was observed, and there was little macroscopic evidence of porosity. Microresistivity indicates about 12 ft of higher porosity in the upper part of the Magenta, which is consistent with other cores of the Magenta.

The Forty-niner is represented by a typical sulfate–mudstone–sulfate sequence. Cuttings indicate a typical color and lithologic sequence for the mudstone in the member.

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 180 ft below ground level at SNL-12, which is lower stratigraphically than the cement boundary is near the center of the WIPP site. A saturated zone with good quality water was encountered above this depth, and it is suggested that it is perched on the sulfate-cemented zone.

Most of the open drillhole below the Culebra was cemented before reaming.The drillhole was reamed to a diameter of 12.25 inches through the Culebra. Fiberglass reinforced plastic casing (4.83 inches o.d.) 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 August 2003, with several pumping and surge periods and with pumping rates ranging from about 16 to 26.5 gallons per minute. The fluid density of water from the Culebra was measured in the field as 1.02 grams per cubic centimeter (g/cc). The water level, measured March 8, 2004, was 2997.03 ft above mean sea level. On April 5, 2004, the screen interval was cleaned by jetting, and the well was pumped for nearly 3 hours. The fluid density measured in the field was 1.004 g/cc. The measured water level on April 13, 2004, was 2998.94 ft above mean sea level.

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List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-12 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)

West Texas Water Well Service rig #15 at SNL-2 in a view toward north showing relationship to WIPP site (on horizon, below arrow). The oil well visible behind the rig is Pure Gold “B” Federal #6.

1.0 INTRODUCTION

SNL-12 was drilled in the southeast quarter of section 20, T23S, R31E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 1711 ft from the south line (fsl) and 2137 ft from the east line (fel) of the section (Fig. 1-2). This location places the drillhole near the southeast arm of Nash Draw among oil wells of the Sand Dunes field. SNL-12 will be used to test hydraulic properties and to monitor ground water levels of the Culebra Dolomite Member of the Permian Rustler Formation.

SNL-12 was permitted by the New Mexico State Engineer as C-2954. [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-12 is also co-designated WTS-10 because the location also satisfies needs for long-term monitoring of water levels and flow rate and direction in the Culebra Dolomite for Resource Conservation and Recovery Act permit compliance; 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 about 25 miles east of Carlsbad, New Mexico, in eastern Eddy County (Fig. 1-1). Disposal panels are being excavated in the Permian Salado Formation at a depth of about 2,150 ft below ground level (bgl)

1.2 Purpose of SNL-12

SNL-12 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-12 will help "… resolve questions related to observed water-level changes around the WIPP site, provide data needed for comprehensive modeling of WIPP groundwater hydrology, [and] construct a groundwater monitoring network that can be maintained throughout the operational period of WIPP …" (p. 1).

Culebra water levels in many of the wells monitored for WIPP have been rising in recent years, contrasting with the conditions used to calibrate models of the Culebra across the site area (Sandia National Laboratories, 2003) for the Compliance Certification Application (CCA; U.S. Department of Energy, 1996). Hydraulic properties of the Culebra vary spatially, and three factors (overburden, upper Salado dissolution, and Rustler halite distribution) appear to explain most of the variability in transmissivity (Holt and Yarbrough, 2002; Powers and others, 2003). SNL-12 was located to test Culebra hydraulic properties near the upper Salado dissolution margin as well as confirming the geological conditions used to estimate Culebra hydraulic properties (Sandia National Laboratories, 2003; Powers, 2002a, 2003a; Powers and others, 2003).

The drillhole is to (Sandia National Laboratories, 2003, p. 40; see also Appendix A):

1. Confirm that the high transmissivity south of the site indicated by our models exists;
2. Determine if dissolution of the upper Salado has occurred in this area;

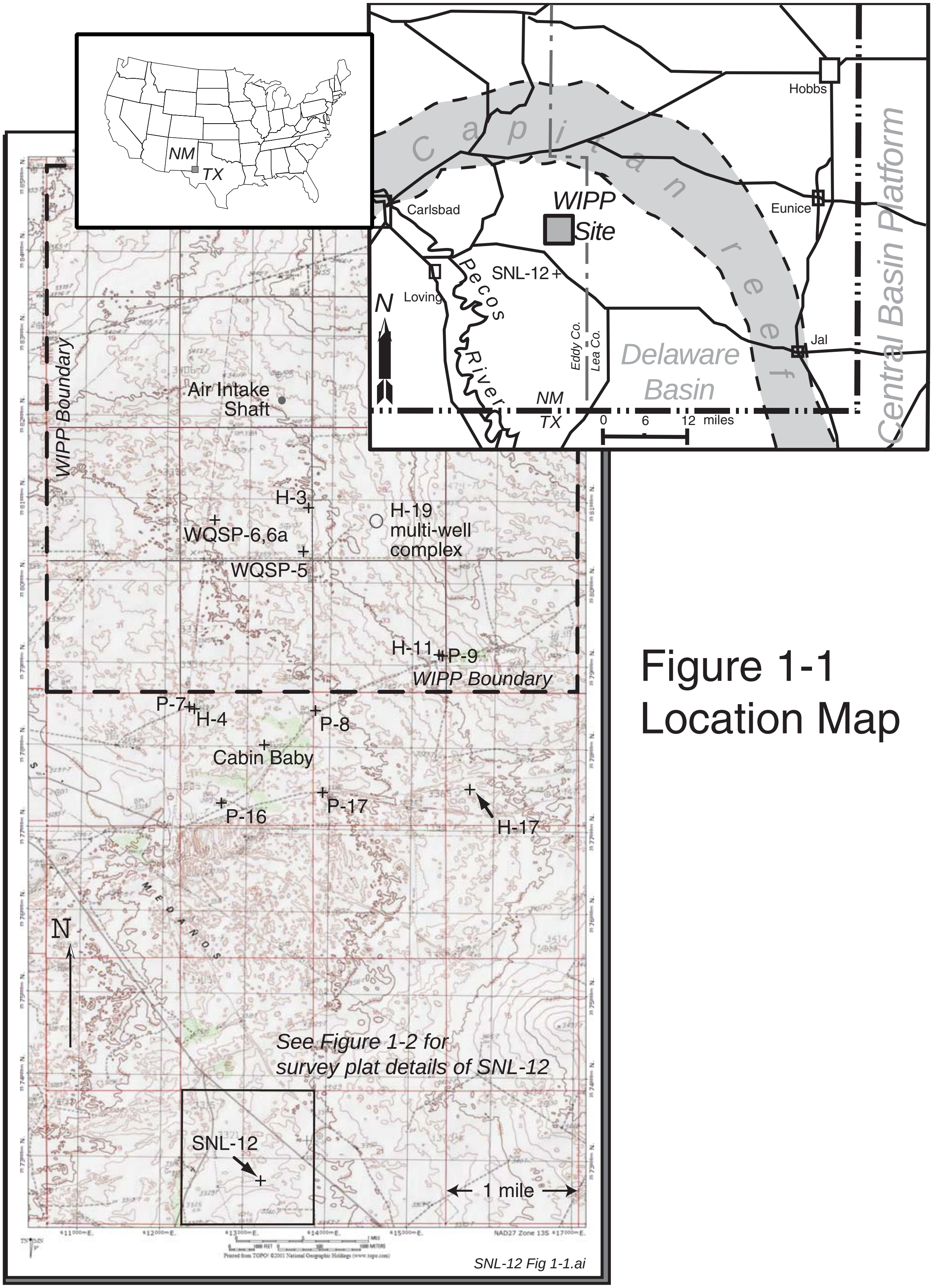


Figure 1-1
Location Map

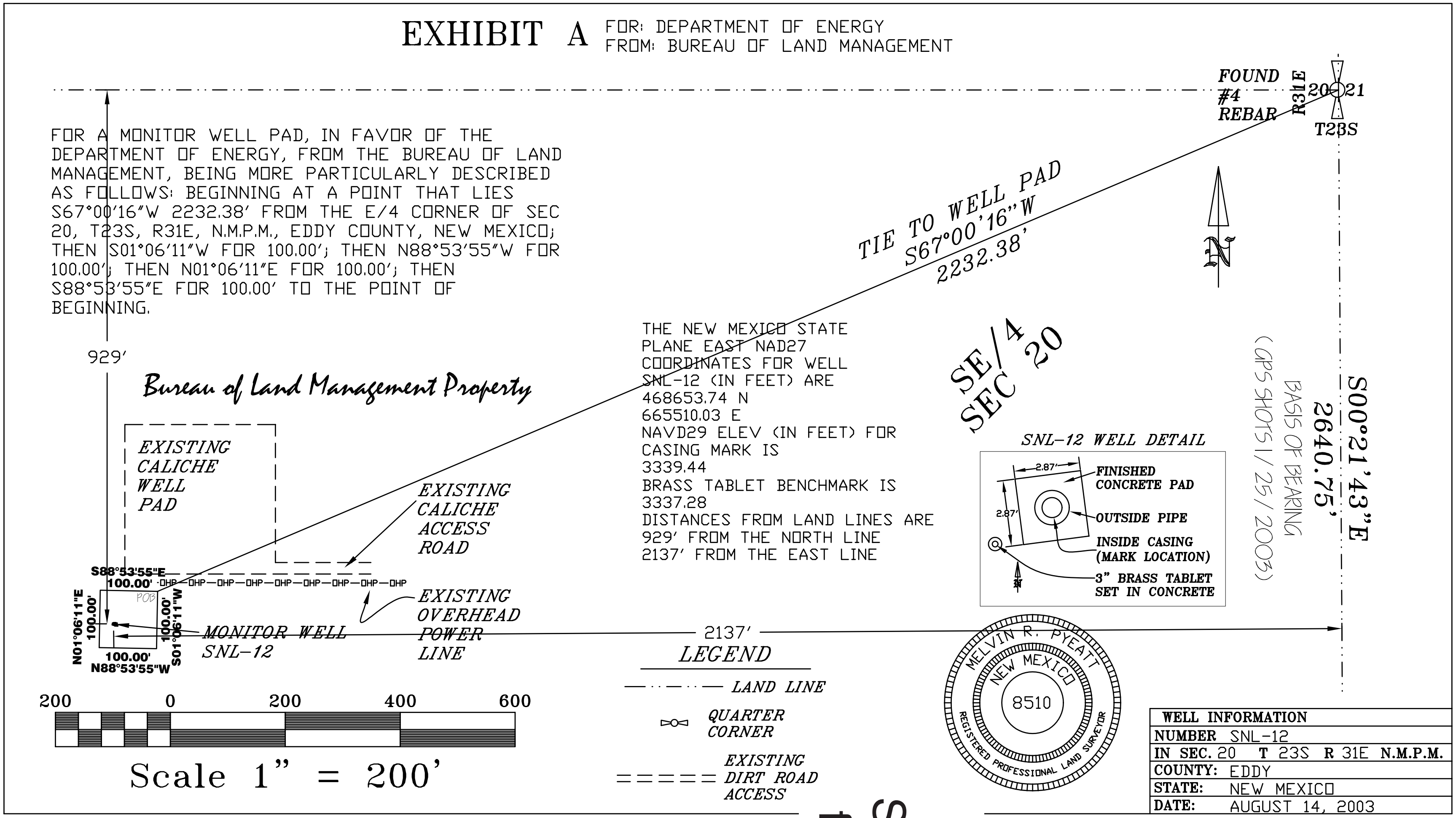


EXHIBIT A FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT

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 S67°00′16″W 2232.38′ FROM THE E/4 CORNER OF SEC 20, T23S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN S01°06′11″W FOR 100.00′; THEN N88°53′55″W FOR 100.00′; THEN N01°06′11″E FOR 100.00′; THEN S88°53′55″E FOR 100.00′ TO THE POINT OF BEGINNING.

THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-12 (IN FEET) ARE
468653.74 N
665510.03 E
NAVD29 ELEV (IN FEET) FOR CASING MARK IS
3339.44
BRASS TABLET BENCHMARK IS
3337.28
DISTANCES FROM LAND LINES ARE
929′ FROM THE NORTH LINE
2137′ FROM THE EAST LINE

WELL INFORMATION
NUMBER SNL-12
IN SEC. 20 T 23S R 31E N.M.P.M.
COUNTY: EDDY
STATE: NEW MEXICO
DATE: AUGUST 14, 2003

Figure 1-2
Survey Plat
for SNL-12

3. Determine if the dimensionality of flow (inferred from a pumping test) indicates that the high transmissivity is channelized (focused) or is widely distributed (diffuse);
4. Provide another monitoring point to help determine the source and/or cause of the water-level changes regularly observed at H-9;
5. Provide information on Culebra heads in an area with many nearby oil and gas wells; and
6. Provide a pumping location for a large-scale (multipad) test to provide transient data for calibration of the Culebra model south of the WIPP site.

1.3 SNL-12 Drilling and Completion

The basic information about drilling and completion of SNL-12 is presented here in tabular form (Table 1-1) and graphics (Figs. 1-3, 1-4, and 1-5) for ease of reference. Appendix B includes details based on daily drilling logs.

SNL-12 was rotary drilled and cored to a total depth of 905 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 determining geological and hydrological conditions in the drillhole as well as maintaining control of drillhole conditions.

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

In keeping with recent practice at WIPP, SNL-12 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-12 (Sandia National Laboratories, 2003).

SNL-12 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water level data when packers fail; mixing of waters of differing qualities when packers fail; and the increased complexity of testing in a well completed to multiple intervals. Although units other than the Culebra bear water at SNL-12, including the Dewey Lake Formation, the program plan does not refer to additional monitor or pump wells on the SNL-12 wellpad (Sandia National Laboratories, 2003).

Geophysical logs, especially the natural gamma and caliper logs, were used to make the final decisions regarding completion of SNL-12 (Fig. 1-4) (Appendices D and E). The drillhole was cemented back to a level below the Culebra to protect the lower Rustler from circulation of Culebra water (Fig. 1-4). The bottom of the Culebra screen interval was placed at 584 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 546 ft, is above the top of the Culebra. The top of the sand/gravel pack (8/16 silica sand) at 540 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Baroid Holeplug from 540–535 ft also prevents circulation between the Culebra and the Tamarisk mudstone. The annulus above the seal at 535 ft was cemented to the surface.

A final caliper log (Fig. 1-3), obtained after the drillhole was reamed to 12.25 inches and before the casing was placed, shows drillhole enlargement in the Forty-niner and Tamarisk mudstones, and also at the contact between the Dewey Lake and Rustler Formations. The caliper log (Fig. 1-3) also shows that the drillhole diameter decreased through the Culebra, similar to the experience at drillhole C-2737 (Powers, 2002b). Above 180 ft, the drillhole diameter is somewhat irregular and diminished from the nominal reaming diameter; this zone corresponds to the upper Dewey Lake where sulfate cements are not present (see section 2.0).

The surface configuration (Fig. 1-5) provides stability, security, and ready access to the casing for measurements, sampling, or other testing. The surface benchmark is an accessible reference point for future measurements if the well configuration is changed. Geophysical logs and depths for FRP casing, screen, and fill in the annulus are measured from the top of the connector on the steel surface conductor casing. The top of FRP casing was cut off 2 ft above this point before the outer protective steel casing was threaded to the connector on the steel surface conductor casing. The cement pad was poured around the surface conductor casing and connector.

1.4 Other Background

SNL-12 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. Geophysical logging was conducted by Raymond Federwisch, Geophysical Logging Services, 6250 Michele Lane, Prescott, Arizona, under contract to West Texas Water Well Service. Geological support was provided by Dennis W. Powers under contract to WTS. Mike Stapleton of the New Mexico Office of the State Engineer witnessed hole completion activities (Appendix E). Archeological clearances obtained from the U.S. Bureau of Land Management were based on field work and reports by Mesa Field Services, P.O. Box 3072, Carlsbad, New Mexico (Appendix F). Cores from SNL-12 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, Wayne Stensrud, Rick Salness, Joel Siegel, 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. West Texas Water Well Service personnel were very helpful in providing access for sampling during drilling. Raymond 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) provided useful editorial and formatting guidance.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-12 (C-2954)

LOCATION: Southeast ¼, section 20, Township 23 South (T23S), Range 31 East (R31E)

SURFACE COORDINATES: The well is located 1,171 ft from the south line (fsl) and 2,137 ft from the east line (fel) of section 20. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 468653.74 North, 665510.03 East (Figure 1-2 shows the survey plat). UTM horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-12 using Corpscon for Windows (v. 5.11.08): 3572728.40 North, 613209.67 East. Figure 1-1 shows UTM coordinates on a 1000-m grid.

ELEVATION: All depths used in geological and geophysical data here were measured from the top of the connector on the steel surface conductor casing, at about ground level. Depths are reported bgl, which is taken as 3,337 ft above mean sea level (amsl), the rounded value for the brass tablet benchmark (3,337.28 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,339.44 ft amsl (NAVD 29) for a mark on the top of the FRP casing inside the protective well pipe. Figures 1-3, 1-4, and 1-5 show the as-built configuration of SNL-12.

DRILLING RECORD:

Dates: Began drilling June 25, 2003; drillhole reamed to completion depth (600 ft) on July 24, 2003. Final geophysical logging was conducted on July 24, 2003. Drillhole was prepared for casing, and was cased and cemented July 29, 2003. Rig was taken down July 30,2003. SNL-12 well was developed by pumping on August 4, 2003, and April 5, 2004.

Circulation Fluid: The surface conductor casing pilot hole was drilled to 30 ft bgl with circulating air and was then reamed to 18-inch diameter with Baroid Quik-Foam® and fresh water mist driven by compressed air. SNL-12 was drilled to 175 ft bgl with circulating air. The saturated zone in the Dewey Lake Formation caused cuttings to cake in the drillhole, and Baroid Quik-Foam® and fresh water mist driven by compressed air were used to drill and core to 577 ft bgl, partially through the Culebra Dolomite. From 577 ft bgl to total depth (905 ft bgl), the drillhole was cored and drilled using circulating brine with Flowzan® biopolymer (MSDS# 463650) in a portable mud pit. After geophysical logging and plugging the lower part of the drillhole, SNL-12 was reamed to a final diameter (12.25 inches) to 600 ft using circulating brine with Flowzan® biopolymer (MSDS# 463650) in a portable mud pit.

Cored Intervals: 4.0-inch core was taken through these intervals (depths from drilling data):
425.0-470.5 ft bgl: lower Forty-niner, Magenta Dolomite, and upper Tamarisk Members
520.0-720.0 ft bgl: lower Tamarisk, Culebra Dolomite, and Los Medaños Members; and upper Salado Formation

Rig and Drilling Contractor: Gardner-Denver 1500, Rig #15; West Texas Water Well Service, Odessa, Texas

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-12 (C-2954), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
18	0	30
12.25	30	600
7.875	600	905

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
13.38	12.72	48 steel	0	30
4.83	4.33	3.20 FRP** blank	-2	546.0
4.83	4.33	3.20 FRP screen	546.0	584.0
4.83	4.33	3.20 FRP blank	584.0	595.0

*Reference point for logging and completion is the top of the connector on the surface conductor casing, which is ~ ground level. The blank FRP extends ~2 ft above this connector.

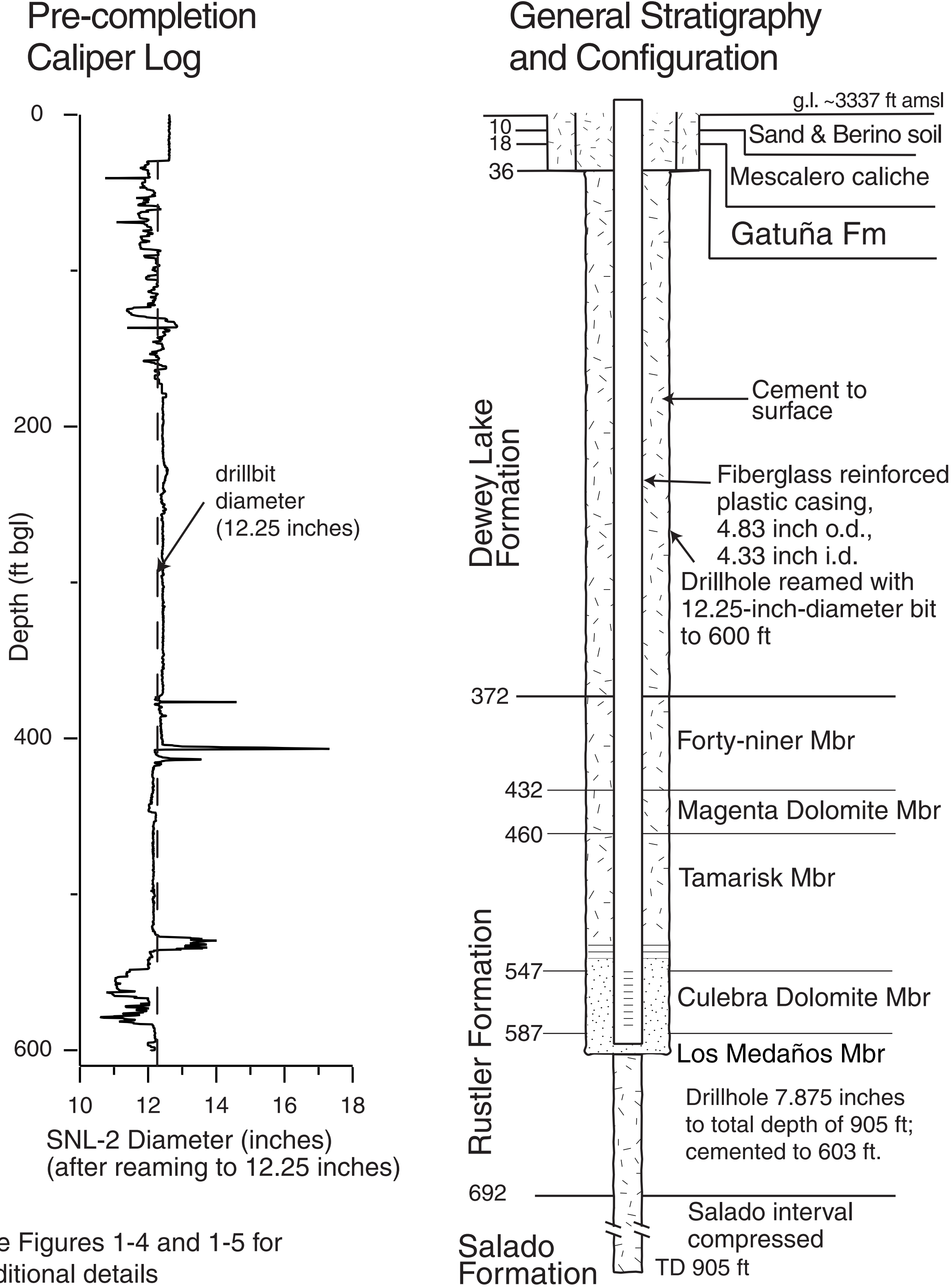
**FRP = fiberglass reinforced plastic

Coring Record:

Core Run No.	**Depth Interval (ft)**		**Interval (ft)**		**Recovered %**
	From	**To**	**Cored**	**Recovered**	
1	425	454	29	29	100.00%
2	454	470	16	16.5	103.13%
3	520	548	28	28.3	101.07%
4	548.3	577.3	29	29	100.00%
5	577.3	600	22.7	22.7	100.00%
6	600	610	10	10	100.00%
7	610	638	28	18	64.29%
8	638	666	28	20	71.43%
9	666	690.5	24.5	17.8	72.65%
10	690.5	720	29.5	30	101.69%
		Totals	244.7	221.3	90.44%

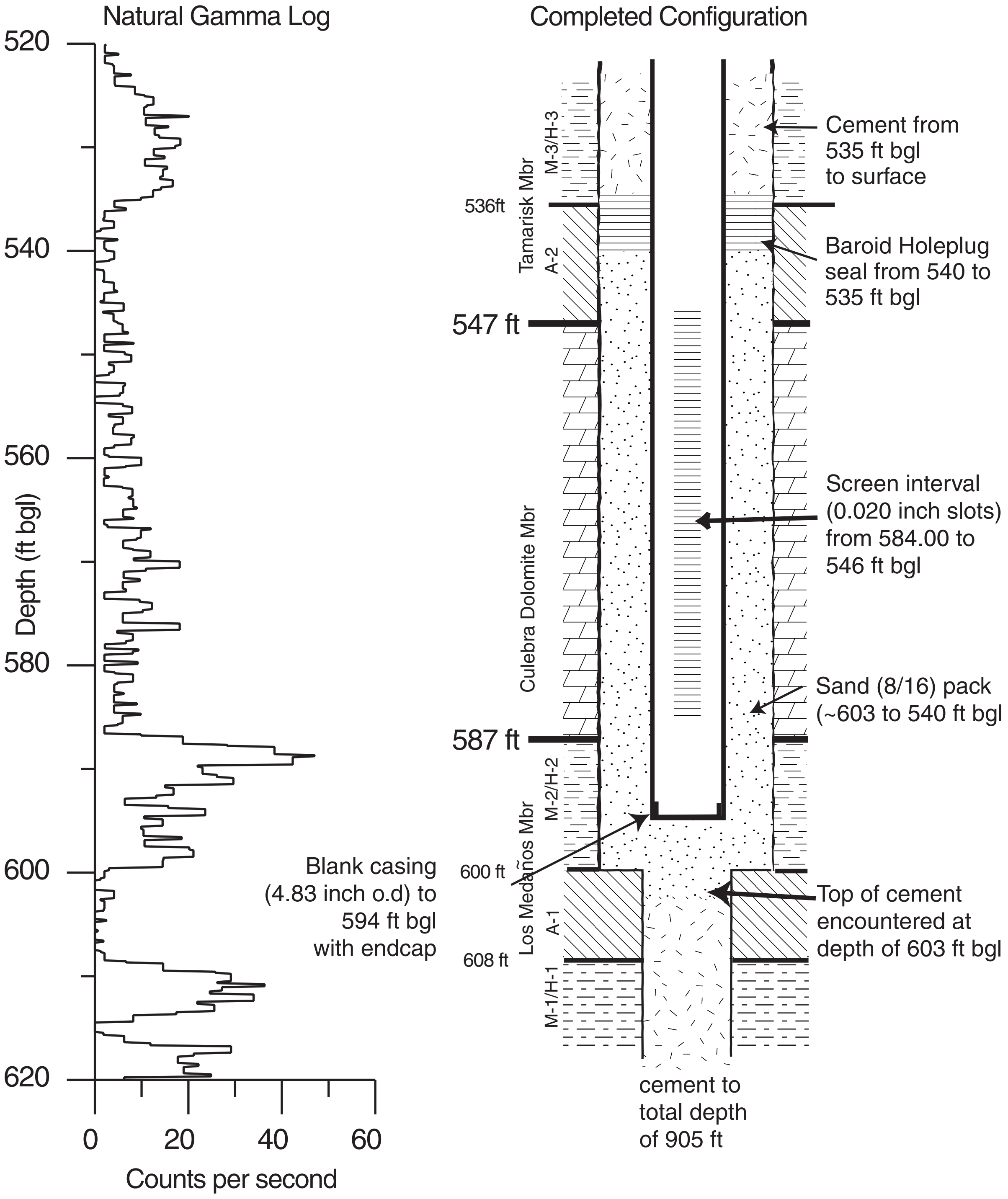
Note: Marked core depths (e.g., Appendix C) vary slightly from core interval depths partly due to differing recoveries and estimates of lost core intervals. Recovery >100% results from recovery of core left in the drillhole on a previous run, from measurement discrepancies, or from core not fitting together precisely when laid out for marking.

Figure 1-3
SNL-12 As-Built Diagram



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

Figure 1-4
SNL-12 Completion and Monitoring Configuration (7/29/03)



Cement from 535 ft bgl to surface

Baroid Holeplug seal from 540 to 535 ft bgl

Screen interval (0.020 inch slots) from 584.00 to 546 ft bgl

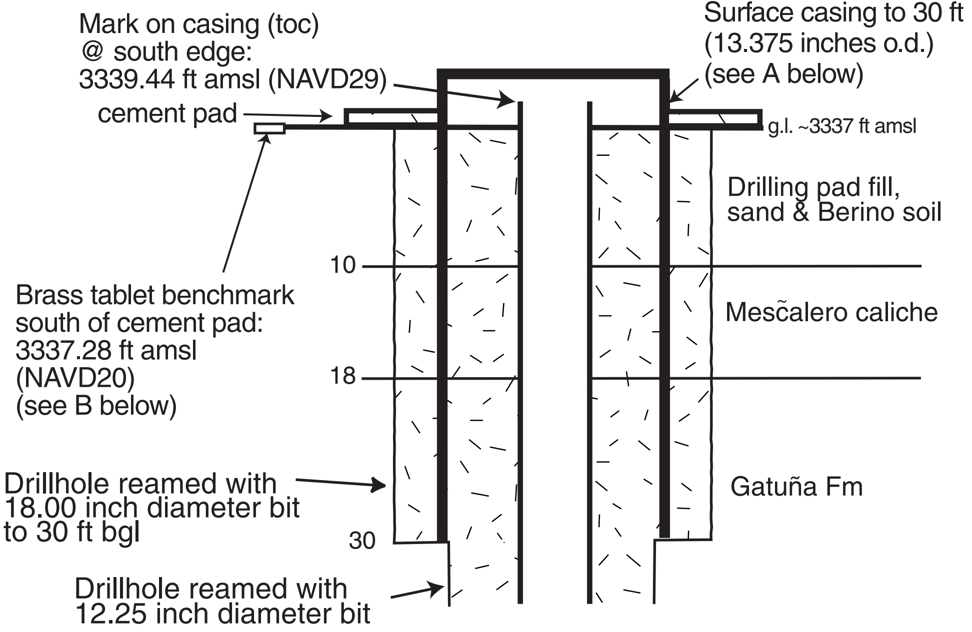
Sand (8/16) pack (~603 to 540 ft bgl

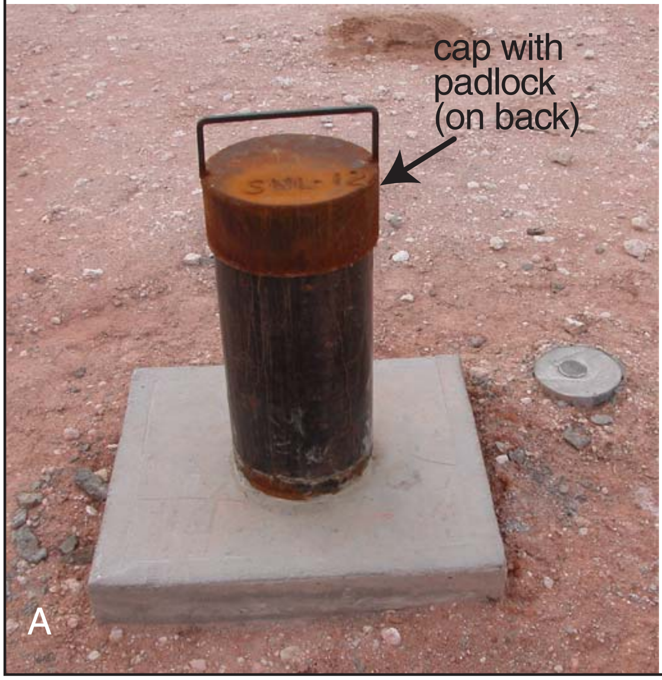
Blank casing (4.83 inch o.d) to 594 ft bgl with endcap

Top of cement encountered at depth of 603 ft bgl

cement to total depth of 905 ft

Figure 1-5
SNL-12 Surface Configuration
and Elevations (7/29/03)





A - Surface casing for SNL-12 with cap and padlock.

B - Detail of brass tablet benchmark on southwest side of SNL-12 cement pad.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been intensively investigated since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is certainly the Compliance Certification Application (CCA) submitted in 1996 by the DOE to the EPA (U.S. Department of Energy, 1996). Some salient features of the broader geological history, as well as more recent work on the geohydrology of the Rustler (e.g., Holt and Yarbrough, 2002; Powers, 2002a; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-12.

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 affected 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 mid-to-late Cenozoic exposed the evaporite beds to faster solution and erosion, and weathered material began to accumulate. The Pecos River drainage became integrated through the region during this period, and more recent deposits reflect such a sedimentary environment as well as sources of sediment from outside the local area. Although the region continues to be subject to some dissolution of evaporites and erosion, large areas have remained geologically stable for approximately the last half million years, resulting in the formation and preservation of pedogenic calcrete (caliche) deposits.

2.2 Geological Data From SNL-12

SNL-12 encountered a normal stratigraphic sequence for the area south of the WIPP site and adjacent to the southeast arm of Nash Draw, 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. Groundwater was encountered in the Dewey Lake Formation during drilling.

The geologic units encountered in SNL-12 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.

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

2.2.1 Permian Salado Formation

Approximately 28 ft of the uppermost Salado were cored in SNL-12, and an additional 185 ft

Table 2-1
Geology at Drillhole SNL-12

System/ **Period/**Epoch		**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface dune sand and Berino soil		0 - 10 ft
	Pleistocene	Mescalero caliche		10 - 18 ft
	Miocene-Pleistocene	Gatuña		18 ft - 36 ft
Mesozoic	**Triassic**	Santa Rosa[2]		eroded
		Dewey Lake[3]		36 ft - 372 ft
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	372 ft - 432 ft *372 ft - 403 ft* *403 ft - 418 ft* *418 ft - 432 ft*
			Magenta Dolomite	432 ft - 460 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	460 ft - 547 ft *460 ft - 524 ft* *524 ft - 536 ft* *536 ft - 547 ft*
			Culebra Dolomite	547 ft - 587 ft
			Los Medaños[4] *M-2/H-2* *A-1* *M-1/H-1*	587 ft - 692 ft *587 ft - 600 ft* *600 ft - 608 ft* *608 ft - 692 ft*
		Salado	 *?Marker Bed 100* *Marker Bed 101* *Marker Bed 102* *Marker Bed 103*	692 - total depth (905 ft) *? - 785? ft* *822 ft - 825 ft* *845 ft - 850 ft?* *879 ft - 894 ft*

[1] Depths are based on measurements by geophysical logging supplemented by drilling data.Geological logs based on field descriptions (Appendix C) and markings on cores (Appendix G) vary modestly because of incomplete recovery and lesser precision using cuttings.

[2] The Santa Rosa Formation, part of the Dockum Group or undifferentiated Triassic, is completely eroded at SNL-12.

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

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

were drilled and logged with geophysical tools. The core provides a record of the transition from the Salado to the Rustler and any dissolution that may have affected the upper Salado or basal Rustler.

The program plan (Sandia National Laboratories, 2003) outlined a potential drilling target of a marker bed (MB) in the upper Salado. Powers (2002a, 2003a) estimated before drilling that this location had not been affected by dissolution of upper Salado halite, based on the thickness of the interval between the Culebra and the Vaca Triste Sandstone Member of the Salado in surrounding industry drillholes. 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 (possibly MB103) was expected to help in relating thickness changes of the larger stratigraphic interval to dissolution, if any, of upper Salado halite.

The upper Salado is dominated by coarse halite ranging in color from white to orangish or reddish-brown from included accessory minerals. SNL-12 also intercepted anhydrite to polyhalite [$K_2Ca(SO_4)_2 \cdot 2H_2O$] marker beds in the upper Salado and thin argillaceous beds.

A white anhydrite, ~15 ft thick, is estimated to occur from ~879–894 ft, based on changes in drilling rates and cuttings returned at the surface. This bed is considered to be MB103; it is similar in thickness and stratigraphic position to MB103 in other drillholes in the area (Powers, 2002a).

A polyhalite and halite unit from ~845–850 ft is believed to be MB 102. This unit is widespread, but it is not as thick or uniform as MB 103. The identification, based mainly on cuttings, is tentative.

Based on limited data from cuttings and geophysical logs, MB 101 is inferred from ~770–778 ft. Resistivity and density logs indicate lithologies generally consistent with this marker bed. Black claystone cuttings (returned to the surface after the drillhole had reached ~785 ft) are consistent with high natural gamma from ~778–782 ft, which is a likely position for an underclay for this unit. This inferred location for MB101 is not sufficiently reliable to use as an indicator of thickness changes across the Salado–Rustler contact due to local or regional dissolution.

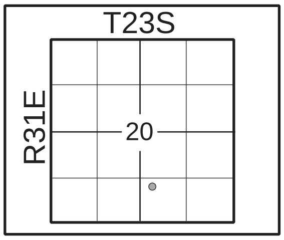
Several depositional cycles (both Type 1 and Type 2, Lowenstein, 1988) are represented in the cores from the uppermost Salado (Fig. 2-2), with sequences similar to those described by Holt and Powers (1990a,b). The basal halite beds of the depositional cycle are commonly coarse halite with few disseminated impurities, some thin bedding (2–8 inches), and some discontinuous thin sulfate laminae along bedding (stratified mud-poor halite – smph; Fig. 2-2). Above this basal part of the cycle, the halite crystals tend to become smaller vertically, and clay (and sometimes polyhalite) content increases upward (muddy halite–mh, possibly podular; Fig. 2-2). Halitic mudstone or claystone generally marks the upper part of a cycle.

At the top of the cycle at 712 ft, some claystone accumulated before the next depositional cycle began with sulfate, which was later converted to polyhalite. Sandy siltstone accumulated at the top of the Type 1 cycle at 703.4 ft. Halite crystals grew displacively in the clastic material included in the intervals from 711.7–703.4 ft and 703.3–694.7 ft. Bedding is generally poorly displayed within the clastic-rich parts of the depositional cycles. Syndepositional solution surfaces are likely at 715.3 ft, 714.3 ft, and 713.5 ft. Reddish-orange polyhalite, ~0.3 ft thick, at 712 ft may not be the beginning of a Type 1 cycle; the upper surface is undulatory, appears corroded by dissolution, and displays small features that are possible halite-filled desiccation cracks.

From 694.7–692.1 ft, thin bedded gypsum and reddish brown siltstone and sandstone mark the uppermost Salado Formation (Fig. 3-3). The beds are modestly disrupted, and appear to have been amalgamated as a unit. Whether this is by syndepositional dissolution of some halite or by local facies variations is undetermined from macroscopic evidence. The overlying beds are not disturbed.

Figure 2-1
Well Record SNL-12 (C-2954)

Company: Washington TRU Solutions LLC
Well: SNL-12 (C-2954)
Section: 20 Twp: T23S Rge: R31E
Location: 1711 ft from south line (fsl)
2137 ft from east line (fel)



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

Elevation
KB:
DF:
GL: 3337 ft amsl
(benchmark: 3337.28)

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: June 25, 2003
Completion date: July 29, 2003
Total depth (TD): 905 ft bgl (driller log)

Casing Record
Conductor: 30 ft
13.375 inch steel
Casing: 4.83 inch o.d.
fiberglass to TD
Screened interval:
584.0-546.0 ft

Geophysical Logs Date: July 14, 2003	
Micro/Laterolog/Induction/SP:	0-905 ft
Gamma/Fluid:	0-905 ft
Caliper:	0-905 ft
Density/Neutron:	0-905 ft
Geophysical Logs Date: July 24, 2003	
Caliper:	0-600 ft

Type fluid in hole: Brine
Res mud: 0.2 ohm-m.
Res mud filtrate:
4 ohm-m.
Max. Rec. Temp.:
28.2^{o}C

General Lithologic Symbols Used

▨	Dolomite	⁘	Fine sandstone & siltstone
▩	Polyhalite	●	Coarse sandstone
▧	Anhydrite	⊥	Sandstone w/caliche
+	Halite	☰	Mudstone/siltstone

SNL-12 Well Log Headers

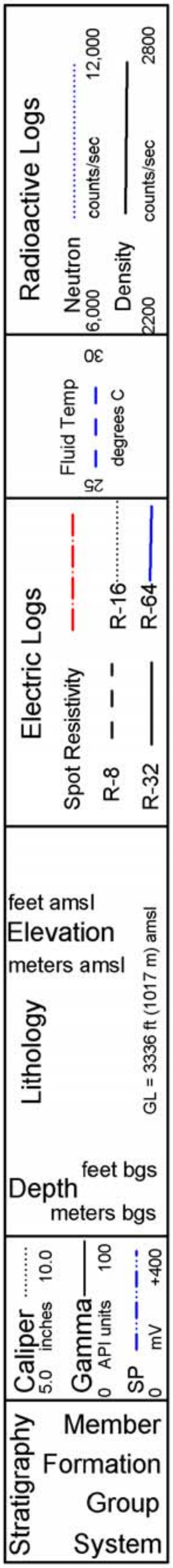
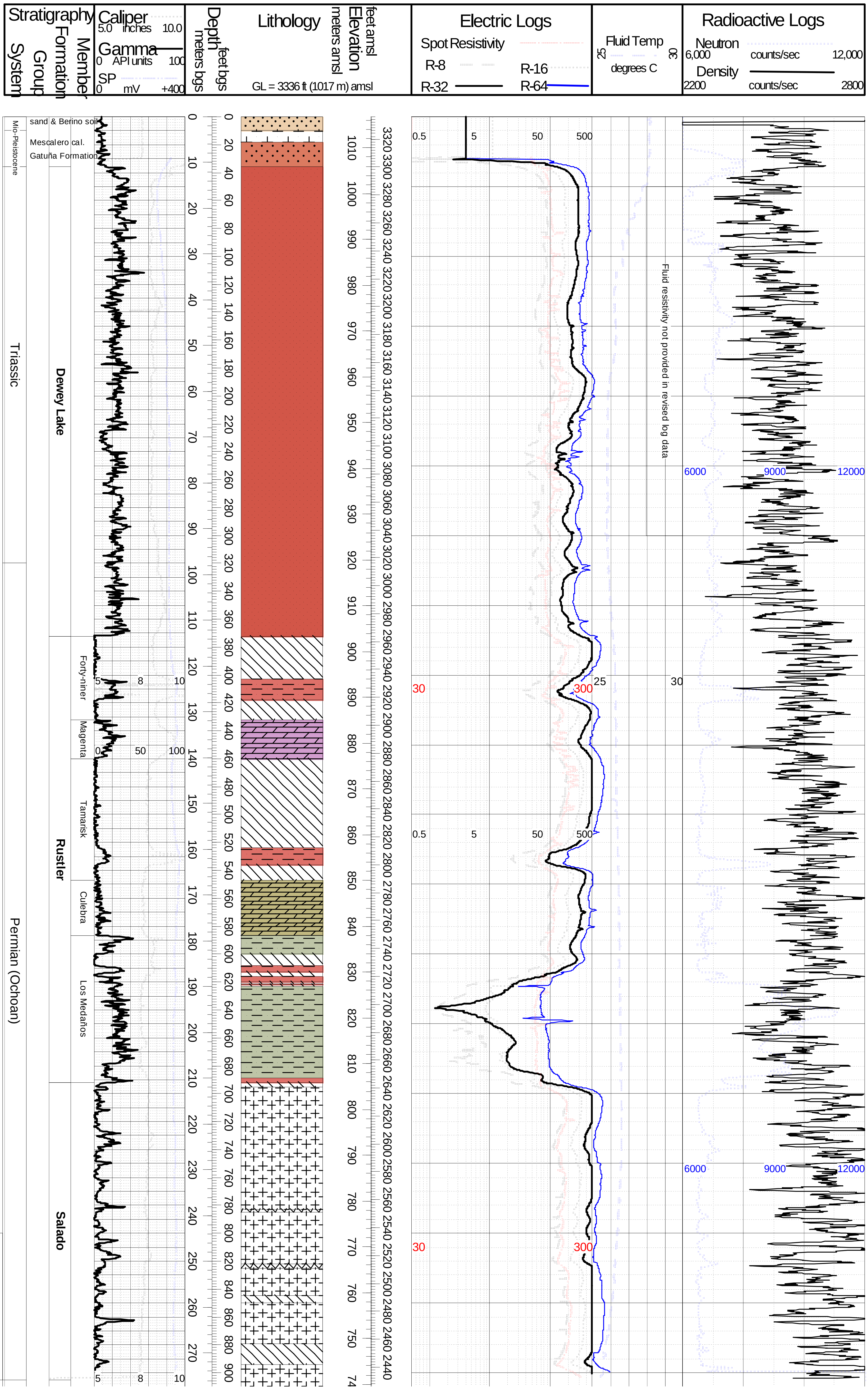


Figure 2-1 Log Title & Header page.ai


Stratigraphy
System
Group
Formation
Member
Caliper
5.0 inches 10.0
Gamma
0 API units 100
SP
0 mV +400
Depth
feet bgs
meters bgs
Lithology
GL = 3336 ft (1017 m) amsl
Elevation
feet amsl
meters amsl
Electric Logs
Spot Resistivity
R-8
R-16
R-32
R-64
Fluid Temp
25 30
degrees C
Radioactive Logs
Neutron
6,000 counts/sec 12,000
Density
2200 counts/sec 2800
Mio-Pleistocene
Triassic
Permian (Ochoan)
sand & Berino soil
Mescalero cal.
Gatuña Formation
Dewey Lake
Rustler
Salado
Forty-niner
Magenta
Tamarisk
Culebra
Los Medaños
5 8 10
0 50 100
0.5 5 50 500
30 300
25 30
6000 9000 12000
Fluid resistivity not provided in revised log data

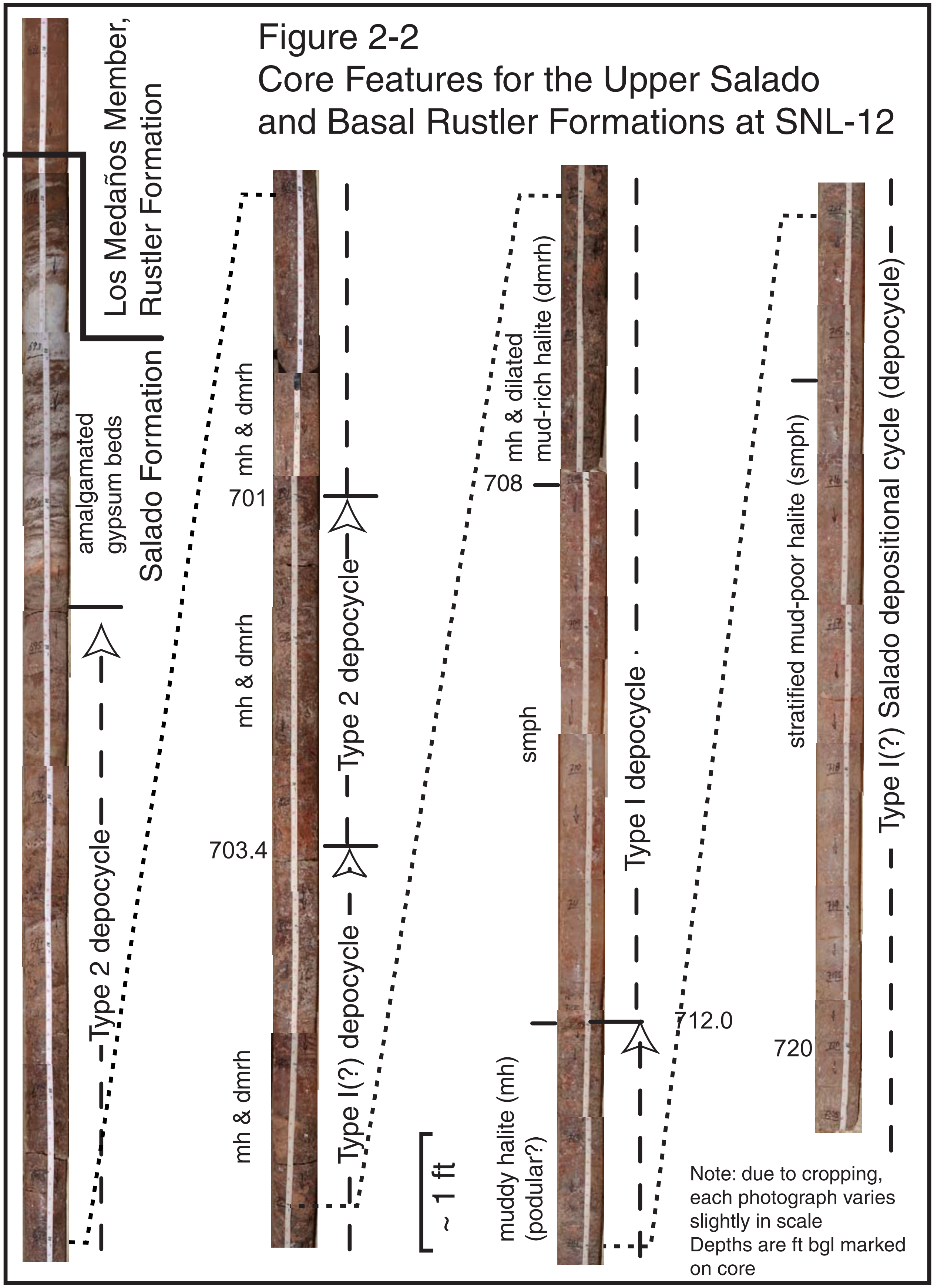


Figure 2-2
Core Features for the Upper Salado and Basal Rustler Formations at SNL-12

Note: due to cropping, each photograph varies slightly in scale
Depths are ft bgl marked on core

Figure 2-3
Upper Salado Displacive Halite at SNL-12

The muddy halite below the Salado–Rustler contact at SNL-12 reveals a variety of sedimentary textures relevant to interpreting whether dissolution has affected the upper Salado. Displacive halite margins are commonly visible (e.g., Fig. 2-3; ~ 696.2–696.3 ft) in some beds. Some of the halite appears to have corroded margins. A thin siltstone bed (Fig. 2-3) may have both displacive and corroded halite margins at its base. The siltstone also shows narrow vertical separations that may be due to desiccation.

2.2.2 Permian Rustler Formation

The Rustler was completely drilled. The contact with the underlying Salado Formation is at 692 ft, based on geophysical logs; the boundary marked on the core is at 692.1 ft. The contact between the Rustler and the overlying Dewey Lake Formation is at 372 ft, based on geophysical logs, and the total Rustler thickness at SNL-12 is 320 ft.

2.2.2.1 Los Medaños Member

The Los Medaños Member of the Rustler Formation was named by Powers and Holt (1999) based on the rocks described in shafts at the WIPP site. For the area around WIPP, studies of the Rustler have commonly referred to this interval from the base of the Culebra Dolomite Member to the top of the Salado Formation as the unnamed lower member of the Rustler. Holt and Powers (1988) and Powers and Holt (1999) also informally subdivided the Los Medaños into five units: 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. 2-4), because halite below A-1 is not restricted to the thinner zone designated M-1/H-1 in these earlier publications.

The Los Medaños occurs from 692–587 ft at SNL-12. The entire thickness (105 ft) of the Los Medaños was cored, although portions of the upper part were only partially recovered.

The informal unit *mudstone-halite 1* unit (M-1/H-1; Fig. 2-4) (Holt and Powers, 1988) is considered here to extend from the top of the Salado at 692 ft to 608 ft (based on geophysical logs), and it includes the bioturbated clastic interval and sandy transition without separation. Approximately 10 ft of core were lost from core run 7 (610–638 ft). It was assumed during drilling that the loss occurred from ~610–620 ft, and the uppermost core from this interval was therefore marked as 620 ft (Appendix C, sheet 7). The gray anhydrite marked from 624.8–627.9 ft is now believed to correspond to the diminished natural gamma from 613–616 ft. Nearly five ft of core above the anhydrite also correspond to the five ft thick geophysical log interval between the base of anhydrite 1 (at 608 ft; see below) and the top of this additional anhydrite. The core loss from run 7 more likely occurs at the base of the recovered core. Nevertheless, the core is not being remarked.

At the base of M-1/H-1 at SNL-12, ~2.6 ft (692.1–689.5 ft) of reddish brown (2.5YR4/4; Munsell Soil Color Chart, 1971 edition; colors are from dry samples unless noted as wet) fine sandstone overlies the anhydrite considered the top of Salado (Figs. 2-2, 2-5). The sandstone has well-preserved thin beds and laminae (Fig. 2-5) that appear to be undisturbed by fracturing or tilting. Probable claystone intraclasts are preserved in the middle of the unit, but there is no obvious erosional contact like that found slightly above the base of the Rustler in other cores (e.g., Powers and Richardson, in review) and shafts (Holt and Powers, 1990a,b; Powers and Holt, 1999). This sandstone appears to be fining upward, and bedding becomes more wavy upward. This reddish brown section also appears to be partially cemented by gypsum.

From ~689.5–679 ft, M-1/H-1is dominated by grayish brown (2.5Y5/2), silty, argillaceous sandstone. Bedding ranges from faint to thin laminae, with some low-angle cross-bedding or ripples near the base and top of the unit. Small holes near the top indicate possible bioturbation; and there are possible small pelecypod molds at ~681–681 ft.

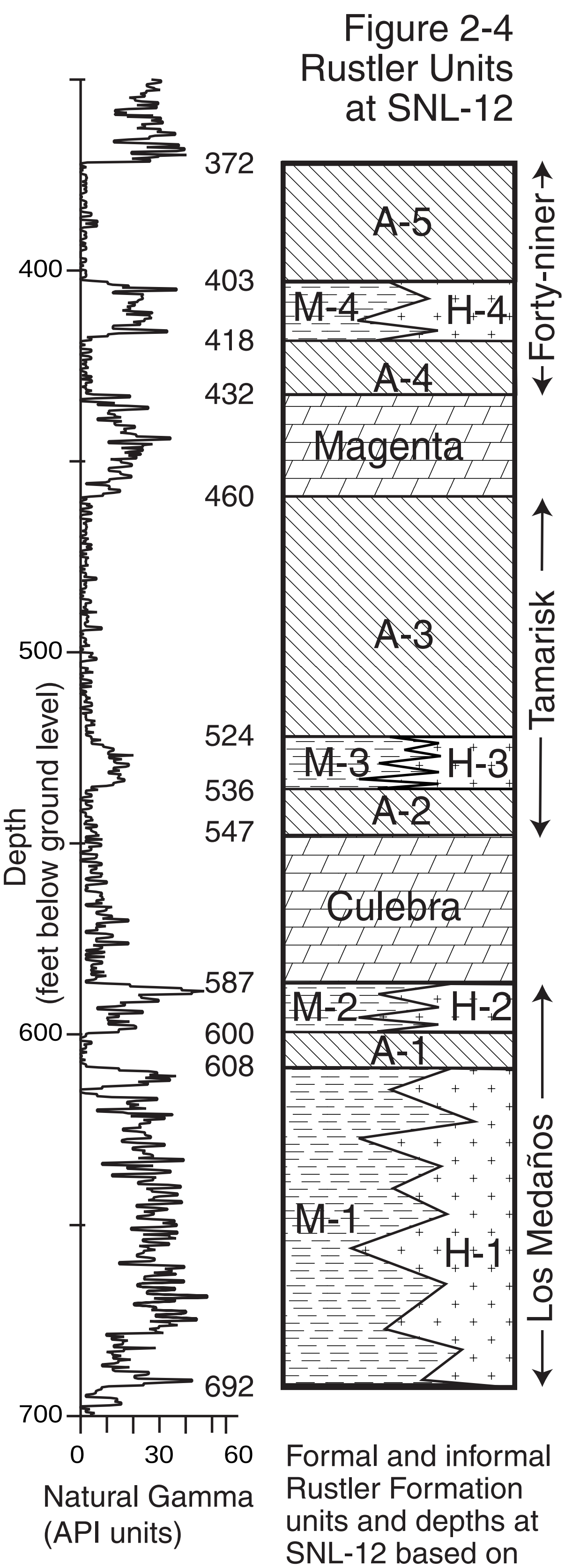


Figure 2-4
Rustler Units
at SNL-12

Formal and informal Rustler Formation units and depths at SNL-12 based on natural gamma log

Figure 2-5 Unfractured Thin Beds at the Base of the Rustler Formation at SNL-12

The unit is moderately indurated, and is likely cemented by gypsum near the base. Near-vertical fractures occur in the interval from 684–682 ft; some horizontal washouts parallel bedding, but they may also indicate horizontal separations. Holt and Powers (1988) and Powers and Holt (1999) also informally described this portion of the Los Medaños as the bioturbated clastic interval.

The interval from ~679–673 ft is dark gray (5Y4/1), very fine sandstone that is silty and argillaceous. Bedding is faint in thin zones (2–4 inches thick), and other thin beds (2–4 inches) included very thin laminae and some cross-bedding. This interval has poor to moderate induration. Fractures are approximately vertical and unfilled. Small pores (<0.5 inches diameter) are washed out, and they may indicate bioturbation. Some bedding planes are also partially washed out.

The core from 673–658 ft is believed to have been lost as the lower part of core run 8 and upper part of core run 9. The area of core loss is uncertain.

The interval from 658–644 ft is gray to dark gray (5Y5/1–4/1) argillaceous siltstone that is also slightly calcareous. Laminae are common, ~0.04–0.08 inch thick, some in sets to 0.2 ft thick, and as low angle near-planar crossbedding (see 650.2–650 ft). From ~657–652 ft, unfilled fractures range from nearly vertical to 45^o from vertical. There are short washout sections with similar orientations. Small nodules of gypsum (0.125–0.25 inch) are scattered throughout, and there are irregular vugs to ~ 1 inch diameter.

Dark grayish brown (2.5YR4/2), sandy siltstone from 644–638 ft is not calcareous. It includes thin laminae (~ 0.04 inch) and some slight mottling in zones with poor bedding, possibly indicating bioturbation. This interval probably correlates with the transitional zone as assigned in Holt and Powers (1988); all of the lower Rustler here is included in M-1/H-1 when trying to compare thickness changes in the WIPP area due to dissolution of halite in the lower Rustler.

A thin, anhydrite-cemented, gray sandstone from 638–637.1 ft caps this section of clastic beds.

A thin, light brown sandy anhydrite occurs from 637.1–636.2 ft. This bed would be consistent with the upper part of the transition zone, as generally indicated by color changes, but it also correlates with sulfatic zones in the middle of the transition zone.

From 636.2–634.3 ft, a dark reddish brown (5YR3/4), silty, argillaceous sandstone includes possible claystone clasts, some poorly defined beds, and laminae at the top.

An anhydrite-cemented sandstone, from 634.3–633.7 ft, is somewhat similar to the sandy anhydrite from 637.1–636.2 ft.

A dark reddish brown (5YR3/4) argillaceous, silty sandstone from 633.7–627.9 ft generally has poorly defined bedding, some possible claystone clasts, and laminae at the top of the bed.

The gray (5Y5/1) anhydrite from 627.9–624.8 ft is recognizable in cores, shafts, and many geophysical logs across the WIPP site area (e.g., Powers and Richardson, in review). The anhydrite displays thin laminae, possible tiny vertically oriented (swallowtail) gypsum in the lower part, a probable growth ridge created by expansive gypsum crystal growth while the unit was subaerially exposed, and possible nodules in the upper part of the bed. The upper contact is irregular.

The reddish brown (5YR4/4), silty, argillaceous sandstone and dark reddish brown (5YR3/4), silty, sandy claystone from 624.8–620 ft likely represent the interval immediately below A-1, although it was assigned below a core loss interval based on best field observations. Geophysical logs show that the anhydrite from 627.9–624.8 ft is approximately 5 ft below A-1 (Fig. 2-1). The claystone at the base displays subhorizontal mottled zones and gray layers. It includes probable smeared intraclast textures (Powers and Holt, 2000). The overlying sandstone exhibits thin laminae, some slight cross-cutting bedding, and deformation. It is sulfatic, but it is poorly indurated. A very thin claystone was included at the base of core run 6, just below A-1, from 610–609.8 ft.

M-1/H-1 is generally not well-cemented, and there was significant core loss. There is some probable gypsum cement near the base, overlying the Salado. Some sulfate cements are indicated in the zone with anhydrite beds, from 638–633.7 ft. The only zone with indications of carbonate cement is from 658–644 ft. No halite was observed anwhere in the lower Rustler. No fractures were observed to have a crystalline filling.

The informal unit *anhydrite 1* (A-1; Fig. 2-4) (Holt and Powers, 1988) was encountered from 609–600 ft, based on the natural gamma and caliper logs from SNL-12 (Figs. 2-4, 3-1). Based on the drilling records, the core of A-1 was marked from 609.8–599.3 ft. The sedimentology of A-1 is discussed according to core depth markings.

A-1 at SNL-12 is expressed as three subunits: an anhydrite, a thin claystone, and a thin upper gypsum.

The anhydrite from 609.8–601 ft is gray, with a slightly pink area at 609 ft. The pinkish color may indicate an earlier polyhalite or polyhalitic zone that has been diagenetically alterred. Vertical-growth gypsum occurs near the base, and the unit overall displays interbedded laminae and nodular beds on a scale of ~0.5–1 ft.

The claystone from 600.5–600 ft is silty, mainly reddish brown, and has some blebs of gypsum in the lower part.

At the top of A-1, white, nodular gypsum from 600–599.3 ft includes claystone that has infiltrated the unit from the overlying bed.

The informal unit *mudstone-halite 2* (M-2/H-2; Fig. 2-4) (Holt and Powers, 1988) was encountered from 600–587 ft, based on the natural gamma and caliper logs from SNL-12 (Figs. 2-4, 3-1). The core from M-2/H-2 was marked from 599.3–588.8 ft, according to the drilling data available. The unit was cored in one run, with all of the unit apparently recovered. The differences between core interval and log interval are not significant, with modest uncertainties for each. The unit is discussed according to core depth markings.

M-2/H-2 at SNL-2 is mainly argillaceous siltstone with a thin, silty, dark gray (2.5YRN4) claystone (marked 589.6–588.8 ft) at the top. Bedding is discernible but intermittent, ranging from laminae to thin beds. Bedding also can be horizontal (Fig. 2-6), as observed near the top of the M-2, mixed with zones showing some tilting of beds. M-2/H-2 is mainly gray from the claystone down to ~593.4 ft and is reddish brown below that point. There are gypsiferous zones and displacive gypsum in the reddish brown zone and a horizontal gypsum vein with vertical fibers separating the color zones. M-2/H-2 is blocky, and slickensides are common. The slickensides on different faces of block show differing directions. The upper contact with the overlying Culebra Dolomite Member appears sharp.

2.2.2.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-12, the Culebra extends from 587–547 ft, while the core has been marked from 588.8–548.1 ft. Recovered Culebra core (Fig. 2-7) totals ~40.7 ft thick, and it is believed that the Culebra coring was complete, although portions of the core were rocovered as small blocks. This contrasts with common loss of core from the more permeable middle and lower sections of the Culebra.

Holt and Powers (1988) found a range of 20–30-ft thickness in Culebra cores described from WIPP and a regional thickness exceeding 40 ft, based on geophysical log data. The Culebra at SNL-12 is near the maximum determined regionally.

At SNL-12, the lower Culebra (588.8–577 ft) is light gray (5YR7/1) to gray (5Y6/1) dolomite with numerous pores and some thin bedding and flat laminae. From 588.8–586.2 ft, the pores are few, small, and filled with gypsum. From 586.2–584.3 ft, the vugs are small to large and are mainly filled with gypsum. From 584.3–577 ft, porosity is estimated to be ~20%, pores are as large as ~ 0.5 inch, and ~1-2% are filled except in the zone from 582–579 ft. In that zone, an estimated 15–20% of the pores are filled. Horizontal fractures with black organic surfaces occur at 0.5–1 ft spacing from 584–577 ft.

The upper Culebra (577–548.1 ft) at SNL-12 generally ranges from very pale brown (10YR7/3) to pale brown (10YR6/3). It is silty dolomite, and may be gypsiferous. The upper Culebra includes scattered larger pores, to ~ 0.5 inch diameter, and vertical to subvertical fractures from 577–569.8 ft. From 569.8–569 ft, there are a few large pores. From 569–563.5 ft, pores are small, and some of the pores appear flattened. From 563.5–554.5 ft, the Culebra appears to have small öolites, large vugs, and rare subvertical fractures. From 553.5–551 ft, the Culebra has large pores. The uppermost Culebra is thin bedded to laminar, with stromatolites from 550–549.8 ft.

The Culebra core at SNL-12 differs from most of the other cores and shafts in thickness and presence of öolites. The macroscopic elements of the core indicate that the Culebra at SNL-12 corresponds generally to the hydrostratigraphic units, which are based on evidence from the cores at the H-19 multi-well complex (Holt, 1997).

The lowest hydrostratigraphic unit, CU-4, is assigned to the interval from 588.8–586.2 ft. This segment displays thin beds and laminae, and it has much less obvious porosity compared to overlying cores. It also is not a packbreccia, as is common in the vicinity of WIPP (e.g., Holt and Powers, 1988).

Hydrostratigraphic unit CU-3 is assigned to the interval from 586.2–569.8 ft. This interval is both fractured and very porous. It is expected to be the most permeable section of the Culebra at SNL-12.

Hydrostratigraphic unit CU-2 is the most problematic to assign because of the presence of öolites, which have not been identified near the WIPP site but have been reported from the Culebra elsewhere. In the absence of specific information about the hydraulic properties of the öolitic section, we assume that it has a permeability that is higher than the overlying, uppermost Culebra. The porous Culebra from 569.8–563.5 ft, and the öolitic segment from 563.5–553.5 ft, are both assigned to CU-2. Combined with CU-3, this section provides a thick interval (32.7 ft) that likely provides relatively high transmissivity.

Figure 2-6

Bedding in Upper M-2 at SNL-12

Hydrostratigraphic unit CU-1, with bedding and little conspicuous porosity, is assigned to the interval from 553.5–548.1 ft.

The geophysical logs of the Culebra from SNL-12 provide some additional details of the unit. The natural gamma log is low through the lower, gray-colored section of the Culebra below about 577 ft. The lower brown-colored dolomite from 577–563 ft shows variable natural gamma, with some higher zones consistent with more clay or organic matter. Above 563 ft, through the öolitic segment and overlying uppermost Culebra, natural gamma is low and decreases upward, indicating little clay or organic matter. The SNL-12 natural gamma log does not display features common to the Culebra nearer the WIPP site: a slight "spike" and upward sharp drop. The transition upward to gypsum of the Tamarisk was not as sharp or distinctive as in some other areas. The general low natural gamma through this interval is consistent with öolite deposition; öolites form in energetic shallow-water marine environments influenced by waves and tides that tend to remove fines. Some well logs in the vicinity of SNL-12 are similar, indicating öolitic beds are more widely distributed.

The microresistivity log shows three zones through the Culebra (Fig. 3-1). Resistivity is generally low, with a higher resistivity zone from 572–560 ft, corresponding to the brownish dolomite below the öolite zone. Given the evidence of porosity through this zone, the higher resistivity may be showing zonation to the fluid salinity, with lower salinity (higher resistivity) water through this zone. Resistivity measured deeper in the formation is similar in trend, but is not as distinctive.

The neutron log through the drillhole may not be reliable. It consistently shows signatures that indicate a 4-ft offset deeper than other log indicators. In addition, the neutron log shows neutron zones through the Culebra that correspond to the resistivity zone, if adjusted 4 ft upward. Nevertheless, there is little difference in neutron through the Culebra and little difference between Culebra and other units above and below.

Fluid resistivity shows slight variations through the Culebra. Fluid temperature does not vary significantly through the Culebra. Neither adds to the information available from other logs.

2.2.2.3 Tamarisk Member

The natural gamma log of SNL-12 shows that the Tamarisk Member occurs from 547–460 ft bgl. The Tamarisk comprises three basic subunits: a lower anhydrite, a middle mudstone to halite, and an upper anhydrite; all three are clearly shown by geophysical logs and were recorded by core and cuttings during drilling. Powers and Holt (2000) labeled these A-2, M-2/H-2, and A-3, respectively, and showed that the lateral gradation from mudstone M-2 to halite H-2 reflects lateral changes in deposition. SNL-12 is located in the mudflat or M-2 facies of these beds. The basal 28.1 ft and upper 10.2 ft of the Tamarisk were cored; the remainder of the unit is described on the basis of cuttings and geophysical logs.

The informal unit *anhydrite 2* (A-2; Fig. 2-4) (Holt and Powers, 1988) at the base of the Tamarisk is 11 ft thick (547–536 ft bgl) on the geophysical logs. Core retained from the interval was marked from 548.1–536.7 ft, an interval thickness of 11.4 ft. A-2 is predominantly gray gypsum, but some anhydrite is also present.

The contact between the Culebra and A-2 is transitional over about 0.2 ft. Above the contact with the Culebra (Fig. 2-7), A-2 has laminar bedding. Thin beds and laminae of carbonate are dispersed through much of the unit. Some of the bedding is crinkly, possibly from deposition over tiny vertically oriented gypsum crystals. A clay and organic layer occurs at about 540.4 ft. Possible nodules of gypsum occur between 539.5–537 ft. A stylolite is present at 545.3 ft. The upper boundary of A-2 with the overlying claystone is sharp.

The informal Tamarisk unit *mudstone-halite 3* (M-3/H-3; Fig. 2-4) (Holt and Powers, 1988) is 12 ft thick (536–524 ft bgl) at SNL-12, based on the geophysical logs. The cored interval marked from 536.7–525.6 ft corresponds to the logged

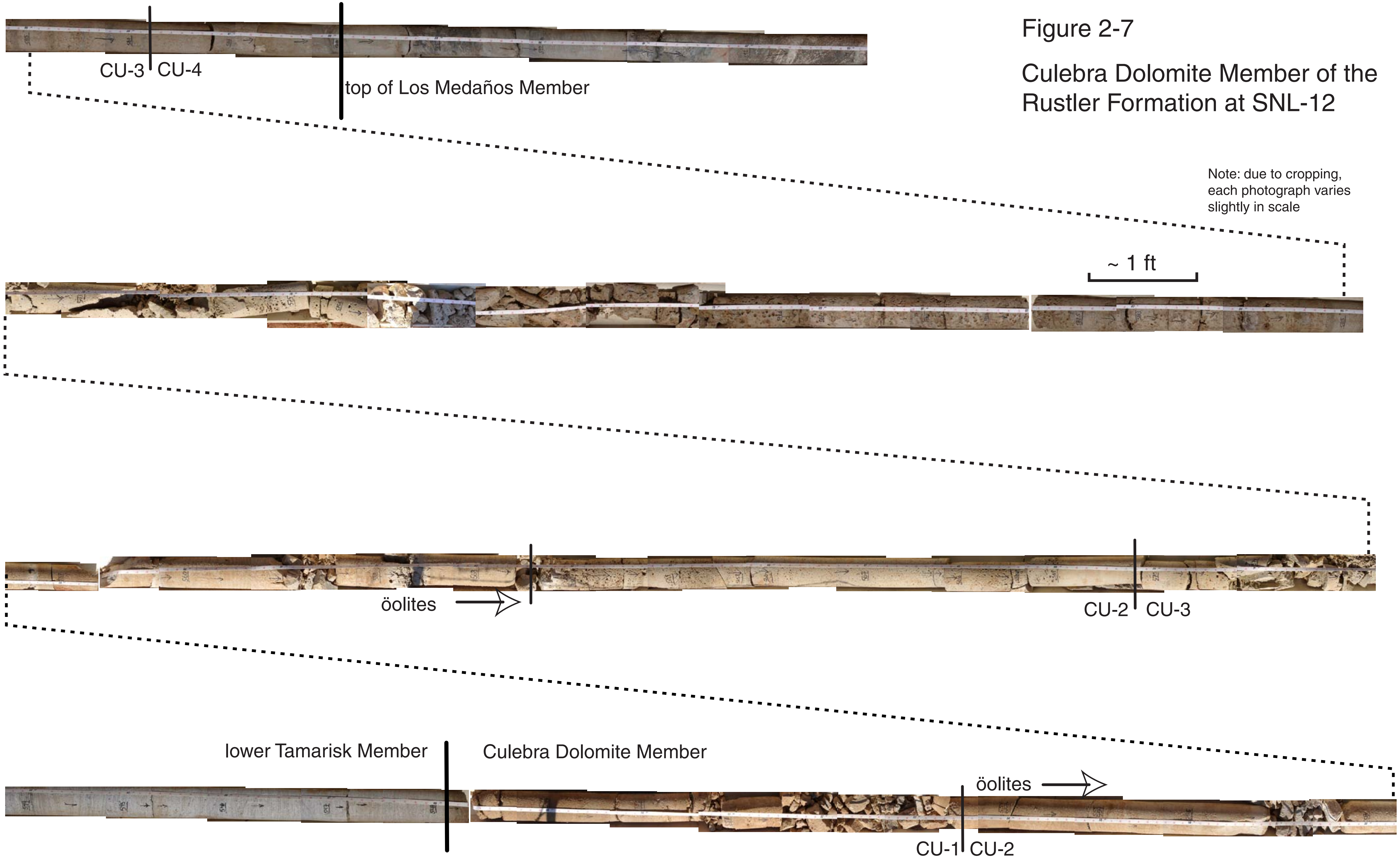


Figure 2-7

Culebra Dolomite Member of the Rustler Formation at SNL-12

Note: due to cropping, each photograph varies slightly in scale interval, and the thicknesses are consistent within the limits of interpreting the logs.

From 536.7–529 ft, M-2/H-2 is reddish brown (2.5YR4/4) claystone with a few gray zones. It is bedded in the lower 3.7 ft, and it includes possible smeared intraclast textures and some gypsum clasts. Above this zone, gypsum occurs boths as clasts and as fillings along bedding planes. From 529–525.6 ft, the claystone is mainly dark gray. The gray zone displays bedding that is disrupted in some zones. Gypsum decreases upward; it mainly occurs along bedding planes in the lower part and as clasts or intraclasts in the upper part.

The informal unit *anhydrite 3* (A-3; Fig. 2-4) (Holt and Powers, 1988) occurs from 524–460 ft on geophysical logs, a thickness of 64 ft. Core markings for the base and top, respectively, for this unit are 525.6 ft and 460.3 ft, for an inferred thickness of approximately 65.2 ft. The upper and lower contacts were cored. The main part of the unit was drilled, and cuttings were retained from some of the interval (Appendix C, sheet 5).

About 5.6 ft of the basal A-3 was cored, and this part of the unit is dark gray anhydrite and gypsum. The core is bedded and may include some small gypsum nodules. Crystal sizes range from fine to coarse.

The drilled portion of A-3 produced mostly very fine powder; some coarser cuttings showed gray gypsum and anhydrite. Geophysical logs indicate a normal stratigraphic section through the drilled portion.

About 10.2 ft of the uppermost A-3 was cored. From 470.5–461 ft, the core is gray gypsum and anhydrite that are fine to coarsely crystalline. The core displays poorly defined laminar bedding and possible small nodules through this interval. From 461–460.3 ft, A-3 consists of gray gypsum, fine to coarse crystals, and irregular thin laminae of brown carbonate that indicate algal growth (Fig. 2-7). This zone is attributed to the Tamarisk, but it is indicating the transition from sulfate to carbonate deposition leading to the Magenta Dolomite.

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

2.2.2.4 Magenta Dolomite Member

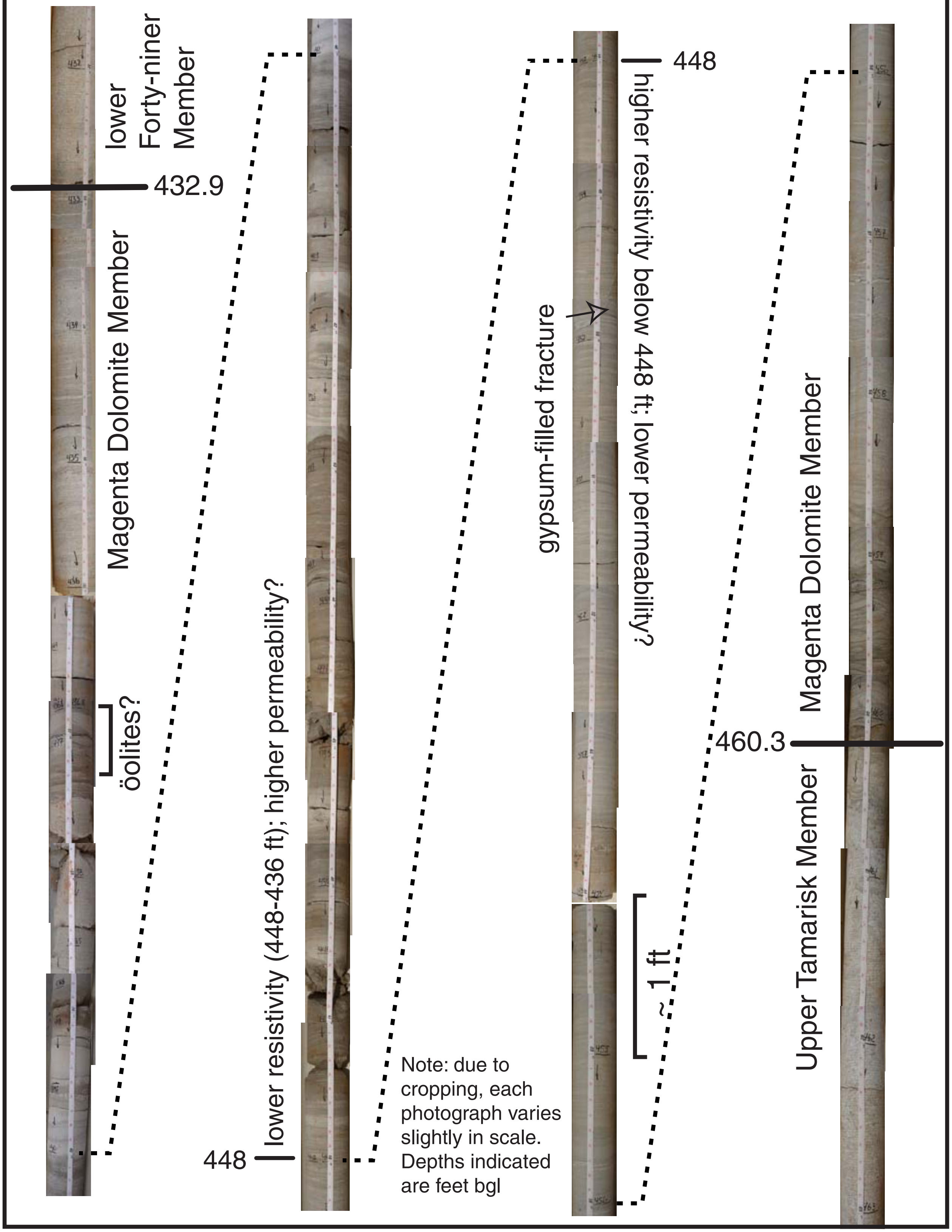
The Magenta Dolomite Member at SNL-12 is 28 ft thick (460–432 ft) based on geophysical logs. Core from the Magenta is marked from 460.3–432.9 ft, a thickness of about 27.4 ft (Fig. 2-7). The entire unit was cored; recovery was good, and the core quality was good.

The Magenta consists of sandy to granular dolomite and gypsum, and it is white (10Y8/2) to gray (10Y5/1) in core. 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-12, like outcrops and shaft exposures of the Magenta, is strong wavy to laminar bedding, with some ripples. Wave amplitudes commonly decrease upward from the base of the Magenta. In the lower Magenta, amplitudes range from about 0.1–0.2 ft (Figure 3-7). Bedding amplitude is more commonly about 0.25–0.5 inch in the middle and upper part of the Magenta. Some small ripple bedding is evident in the Magenta. Near the base of the Magenta at SNL-12, the wavy bedding and ripples are draped by very thin, dark laminae that are interpreted as stromatolitic. This is consistent with well-exposed algal features in the air intake shaft (Holt and Powers, 1990a; Powers and Holt, 1990), but there were no larger stromatolites in the core. In the zone from ~437.3–436.8 ft, some of the grains appear to be öolites, associated with ripples.

The Magenta shows little evidence of fracturing. A high-angle fracture from about 450–449 ft is filled with gypsum. Some bedding planes, even on wavy bedding, in the lower few ft of the Magenta core have fibrous gypsum filling slight separations.

The core of the Magenta from SNL-12 does not show surface evidence of open porosity or porosity zones. The microresistivity log shows lower resistivity through 448–435 ft, corresponding to the gray (brownish) zone of the Magenta that includes more granular and possible öolitic rock. The neutron

Figure 2-8 Magenta Dolomite Member of the Rustler Formation at SNL-12



Note: due to cropping, each photograph varies slightly in scale. Depths indicated are feet bgl log shows an increase through this zone, if a 4-ft offset is assumed as discussed regarding Culebra logs. The contrast for the resistivity log is with overlying gypsum and more gypsiferous zones below. These zones apparently have little porosity, increasing the resistivity. The neutron contrast (higher neutron in a more porous zone) would be consistent with low porosity, where the water content is volumetrically less than that in adjacent gypsum (increasing the relative neutron count).

The upper contact of the Magenta with the overlying Forty-niner Member, as placed on the core, is sharp. The depositional transition was not sharp, however, as gypsum is interbedded with dolomite through the upper 3 ft of the Magenta before dolomite becomes insignificant.

The Magenta is similar in thickness, composition, and bedding characteristics to most of the Magenta described around the WIPP site. Algal features are not as prominent as in some other cores, and ripples are better expressed. If öolites are confirmed to be present, they would be a new feature for the Magenta. The Magenta is little fractured at SNL-12, contrasting with some other cores (e.g., SNL-2; Powers and Richardson, in review). Based on the resistivity logs, the more porous part of the Magenta is ~12 ft thick and is located in the upper half of the Magenta. This is similar to findings from other recent drillholes (e.g., Powers, 2002b; Powers and Richardson, in review).

2.2.2.5 Forty-niner Member

The Forty-niner Member at SNL-12 is 60 ft thick (432–372 ft), based on geophysical logs. A change in drilling rates was noted at a depth of ~374 ft, consistent with the logging depths. 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 425 ft. All Forty-niner coring took place in 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-12 to halite east of the WIPP site area. Powers and Holt (2000) informally designated these units as A-4, M-4/H-4, and A-5, from bottom to top, 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; Fig. 2-4) (Holt and Powers, 1988), is gray to white gypsum and anhydrite ranging from very coarse gypsum to finer anhydrite. A-4 is 14 ft thick, based on geophysical logs; drilling and coring indicated a thickness of 14.9 ft. The recovered core of A-4 (432.9–425 ft) reveals thin laminae separating beds and thin zones (<0.5 inch) with wavy brown laminae that are probably algal. Some of the beds appear nodular. As noted in the discussion of the Magenta, the environmental transition was not abrupt in this location. Above the cored interval, cuttings from A-4 were composed of white to gray gypsum ranging from fine, sugary crystals to coarser flakes.

Mudstone-halite 4 (M-4/H-4; Fig. 2-4) (Holt and Powers, 1988) is ~15 ft thick (418–403 ft), based on the natural gamma log. Cuttings from M-4 revealed distinct beds within the unit. From 418–410 ft, cuttings consisted of dark gray (2.5YRN4, wet), argillaceous, sandy siltstone. It is gypsiferous and not calcareous. Cuttings indicated thin fractures filled with gypsum. From 410–405 ft, cuttings consisted of dark reddish brown (5YR3/4, wet), sandy, silty claystone that is not calcareous. Some gypsum may be present. These units are typical of M-4 (Holt and Powers, 1988), but they are not always distinguished in cuttings.

The upper sulfate unit, *anhydrite-5* (A-5), is ~31 ft thick (403–372 ft) at SNL-12, based on geophysical logs. The interval indicated during drilling is also 31 ft, though the depths differ slightly (405–374 ft). Cuttings from A-5 in SNL-12 were mainly white to very pale brown (10YR8/3) and dark grayish brown (10YR4/2) gypsum and anhydrite. Most of the anhydrite is finer and darker. A slight gamma peak at 388 ft is similar to modest increases noted by Holt and Powers (1988) in the area east of SNL-12 and is attributed to a slight increase in clay or carbonate content. The thin halite found in A-5 east of SNL-12 is not present here.

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 and others (1996, 2001) obtained radiometric (Ar-Ar) ages from ash beds near the base of lithologically equivalent red beds (Quartermaster Formation) in the Texas panhandle. These ages show that the basal Quartermaster is Permian, but most of the formation is early Triassic in age. Although lithologic contacts are not inherently isochronous, the particular relationships of evaporites to red beds suggest that the Dewey Lake is mainly Triassic in age (e.g., Schiel, 1988, 1994; Powers and Holt, 1999). Lucas and Anderson (1993) have asserted that the Quartermaster, and Dewey Lake, are Permian in age, but more recent direct evidence supersedes their discussion.

At SNL-12, the Dewey Lake is 336 ft thick (372–36 ft), based on geophysical logs. During drilling, cuttings clearly identifiable as Dewey Lake were not returned to the surface until a depth of 57 ft (Appendix C, sheet 1). The Dewey Lake is composed mainly of red (2.5YR4/6–5/6) or reddish brown (5YR5/4) siltstone interbedded with claystone and fine to very fine sandstone. Small (< 0.04 inch), greenish gray reduction spots are a common characteristic of the Dewey Lake at SNL-12 and elsewhere. Dewey Lake cuttings are very calcareous to a depth of ~175 ft; from 180 ft, cuttings are gypsiferous and slightly or not calcareous. Most of the Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-12 can be interpreted to indicate different basic sedimentary regimes as well as porosity conditions (e.g., Doveton, 1986). The following information follows the basic template developed for a study of the Dewey Lake hydrogeology (Powers, 2003b) and applied to other drillholes such as C-2737 (Powers, 2002b).

Only the lower two of three general depositional regimes for the Dewey Lake Formation can be distinguished on natural gamma logs of SNL-12, and the second is only partially preserved.

The interval from 372–240 ft in SNL-12 displays the natural gamma and resistivity features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003b). The natural gamma fluctuates around a similar value (~25 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 ~4–25 ft. In the vicinity of the WIPP site, fluctuations appear to correlate across boreholes, suggesting broad scale bedding, and the interval corresponds to a bedded section clearly exposed in the air intake shaft (Holt and Powers, 1988). At SNL-12, the fluctuations are similar to the WIPP site area, but they have not individually been correlated with site area.

The interval from 240–36 ft (204 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, 2003b). A sandstone unit from ~240–224 ft is at the base of this interval.

The interval of fining upward cycles is truncated at SNL-12 by erosion by the overlying unit. Near the center of the site, this interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). At SNL-12, sandstones of the upper fining upward cycles are removed by erosion. Some smaller fining upward cycles are defined, but the trend over much of the interval appears to be mainly a broad fining upward.

The upper coarsening interval of the Dewey Lake at SNL-12 has been removed by erosion. The broad sedimentological units definable by natural gamma logs for the lower Dewey Lake are present and are generally representative below the erosional surface.

Cuttings from SNL-12 showed a downward change from carbonate cement to sulfate cements and fracture fillings at ~180 ft . Resistivity logs also show a change in character at ~180 ft, increasing somewhat below that point. The neutron log was unresponsive at this point. This cement change is observable in other cores from the area (Powers, 2002b, 2003b), and it was reported in the air intake shaft (Holt and Powers, 1988).

The carbonate–sulfate cement boundary in the range of 180 ft is stratigraphically lower in SNL-12 than it is at the middle of the site at drillhole C-2737 (Powers, 2002b) or at the air intake shaft (Holt and Powers, 1990a). This change is consistent with the boundary dropping stratigraphically as the Dewey Lake is more exposed to erosion and weathering (Powers, 2003b), especially to the south of the WIPP site.

The saturated interval in the Dewey Lake (see chapter 3) was not determined; the drillhole depth was 175 ft when the water level was allowed to stabilize. The cement change and resistivity change at 180 ft are consistent with the proposal by Powers (2003b) that natural groundwater is perched on the less porous 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 36–18 ft. Cuttings to a depth of 57 ft were dominated by similar lithology. (The caliper log shows the drillhole diameter was enlarged through the upper part of the formation; this likely diluted cuttings sources for the short period the hole was being deepened through the uppermost Dewey Lake.) The Gatuña at SNL-12 is primarily light reddish-brown (5YR5/4-4/4) to red (2.5YR4/6-5/6) sandstone with interbedded argillaceous zones and argillaceous siltstone.

Gatuña sandstones are very calcareous, with calcite increasing vertically where pedogenic calcrete has infiltrated the unit. Sand grains from the lower Gatuña are fine to medium and include mica and other opaque grains. Sands from the upper Gatuña are very fine to fine, with some medium grains. They are subangular and are poor to medium sorted. MnO_2 stains some of the cuttings, probably from pedogenic processes. Small (<0.04 inch) cylindrical bioturbation probably formed as root casts.

Gatuña depositional patterns are poorly known in the area of SNL-12. There are some outcrops to the west of SNL-12, and Gatuña increases in thickness to the southwest at Pierce Canyon (Powers and Holt, 1993). The Santa Rosa was eroded before Gatuña deposition, as was part of the upper Dewey Lake. Chert pebbles that populate some of the Gatuña where it overlies the Santa Rosa or is adjacent to the erosional edge of the Santa Rosa are missing.

The Gatuña ranges in age from at least 13.5 to ~ 0.5 million years old (Powers and Holt, 1993). SNL-12 is distant from an outcrop of Lava Creek B ash found at the top of the Gatuña by Bachman (Bachman, 1980; Izett and Wilcox, 1982) along Livingston Ridge. The Gatuña at SNL-12 does not provide any direct clues to its age, but it may represent younger portions of the unit range, as is believed the case for much of the upland Gatuña deposits.

2.2.5 Pleistocene Mescalero Caliche

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

At SNL-12, the Mescalero is ~8 ft thick. Mescalero cuttings at SNL-12 provide little evidence of its origin. It ranges from very calcareous sandstone to sandy “limestone” that is pinkish white (2.5YR8/2). The sand grains are similar to the overlying dune sand.

The Mescalero shows evidence of pedogenic processes such as nodule, ped, and laminae development in exposures in the general area of SNL-12. 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 over the term “caliche” because of the wide variation in use of the latter term.) The Mescalero is generally at stage IV–V in the vicinity of SNL-12.

2.2.6 Pleistocene Berino Soil and Surficial Sands

The surficial sands and Berino are strong brown (7.5YR5/6) sand and sandstone that is friable at the surface and increasingly argillaceous with depth. There was no evidence of soil carbonate in either surficial sands or Berino soil. Sand grains are fine to very fine, subrounded, moderately well sorted, and are mostly quartz with a trace of opaque grains. At SNL-12, the cuttings felt slightly moist with depth. The Berino soil is not a geologic unit; it is a pedogenic unit defined by the soil scientists in the area (Chugg and others, 1971). The upper 2 ft consisted of mixed sand and imported Mescalero caliche used to construct the drilling pad.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-12

SNL-12 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 other pumping tests.

3.1 Shallow Groundwater above the Rustler Formation

Groundwater was encountered in the Dewey Lake Formation at SNL-12 on June 26, 2003. As the drillhole reached ~160 ft depth using compressed air, cuttings began to cake and felt moist. At a depth of 170 ft, the drilling was stopped for ~10 minutes and air was circulated without observable water in the return flow. The drillhole was deepened to 175 ft, and the hole was allowed to stand from 11:51 to 13:00 MDT without drilling or circulating air. At 13:00 MDT, the water level in the drillhole was 164.3 ft, an inflow filling ~10.7 ft. Samples for analysis by Sandia National Laboratories were obtained with a small plastic bailer at 13:10 and 14:00 MDT. At 14:17 MDT, the water level was at 155 ft . To provide ample opportunity for the water level to stabilize, drilling was suspended until July 7, 2003. The water level was measured at 141.55 ft at 12:19 MDT on July 7. Additional water samples were obtained on July 7 for analysis by Sandia National Laboratories. After sampling, the hole was drilled to deeper units using fresh water with Baroid Quik-Foam.

3.2 Initial Results from the Magenta Dolomite

During drilling of SNL-12, no specific evidence of water inflow, rates, or water levels for the Magenta Dolomite was obtained.

After the Magenta and upper Tamarisk were cored to 470.5 ft on July 8, 2003, the drillhole remained open overnight. On July 9, 2003, an electric probe was lowered in the open drillhole and encountered water at 142.3 ft . This level is more than 300 ft above the Magenta, and it is ~13 ft higher than the measured water level in the Dewey Lake on the previous day. Both Dewey Lake and Magenta were open to the drillhole.

On July 9, 2003, the drillhole was drilled and cored to a depth of 577 ft, which is ~11 ft above the base of the Culebra. On July 10, the water level was 143.5 ft, slightly less than the previous day, and the drillhole was open to 372.3 ft. Three intervals likely contributed to the water levels (Dewey Lake, Magenta, and Culebra), but the specifics are undetermined. From 577 ft, SNL-12 was drilled with brine and Flowzan.

3.3 Initial Results From the Culebra Dolomite

As indicated above, the combined fluid levels in SNL-12 on July 10, 2003, reached 143.5 ft, and the specific contribution of the Culebra was undetermined.

On August 4, 2003, a pump was placed in the casing to develop the Culebra hydrology and remove drilling fluids. Over a period of ~3.5 hours, the well was pumped during three intervals with two short backwash/surge periods (Appendix B). A total volume of 80 barrels of water were produced during well development, and the water was clear, with a field-measured fluid density of 1.020 g/cc near the end of the pumping. During some initial pumping, rates were as low as 16 gpm (gallons per minute); later stages of pumping were steady at ~26.5 gpm.

From August 2003 through March 2004, static water levels for the Culebra in SNL-12 were regularly measured (Table 3-1). The casing elevation is 3,339.44 ft amsl (Fig. 2-5). The depth to water on March 8, 2004, was 342.41 ft, and the uncorrected water level elevation was 2,997.03 ft amsl. The fresh-water equivalent (FWE) level, corrected for fluid density, was 3,001.57 ft amsl (Siegel, 2004) (Table 3-1; Fig. 3-1).

On April 5, 2004, the screen interval was jetted under pressure with about 150 barrels of clean water to remove sediment (Appendix B). An additional 2,526 gallons of water were pumped from the well at rates of approximately 14 gpm, and the removed water was very clear. The fluid density was measured in the field as 1.004 g/cc. Depth to water on April 13, 2004, was 340.50 ft, and the elevation was 2998.94 ft amsl.The reported FWE head (2999.84 ft amsl; Seigel, 2004) was computed using the lower fluid density reported in April 2004. The change in fluid density affects the apparent changes in FWE levels in April (Fig. 3-1).

3.4 Observations About the Rustler–Salado Contact

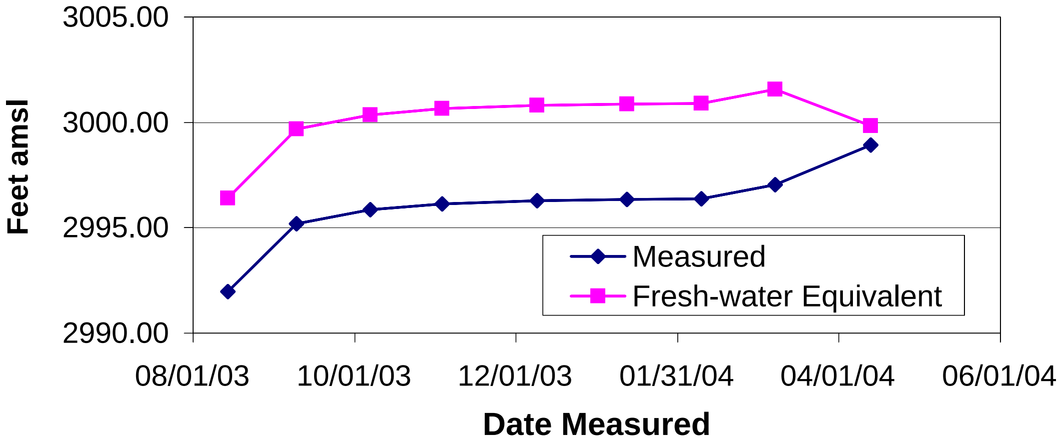
The interval was cored with good recovery. There was no indication during drilling of changes in drilling fluid or of flow into the drillhole from this zone affecting the drilling fluid returns. Cores across the Rustler–Salado contact do not indicate postdepositional dissolution of the upper Salado, and this is consistent with little, if any, water at this zone.

Table 3-1
Culebra Water Levels Measured in SNL-12

Date	Time (MDT)	Depth (ft) to water level	Water Elevation (ft amsl)	
			Measured	Fresh-water Equivalent*
08/14/03	7:05	347.46	2991.98	2996.41
09/09/03	13:04	344.24	2995.20	2999.70
10/07/03	8:04	343.59	2995.85	3000.36
11/03/03	12:45	343.31	2996.13	3000.65
12/09/03	10:14	343.14	2996.30	3000.82
01/12/04	13:45	343.10	2996.34	3000.86
02/09/04	14:12	343.06	2996.38	3000.90
03/08/04	13:40	342.41	2997.03	3001.57
04/13/04	8:12	340.50	2998.94	2999.85

*Fluid density used for determining fresh-water equivalent elevation is 1.020 g/cc through March 2004; from April 2004, the fluid density is 1.004 g/cc.

Figure 3-1
Culebra Water Elevation at SNL-12



4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-12 are expected to be stable over a lengthy monitoring period, in contrast to steel casing in monitoring wells drilled before 1995. Newer monitoring wells provide construction experience for groundwater surveillance wells that may be drilled in the future.

SNL-12 was located south of the WIPP site to accomplish several purposes (Sandia National Laboratories, 2003). It was located east of the apparent line of dissolution of upper Salado halite (Powers, 2002a, 2003a). The specific location was chosen in part to test the possibility of a dissolution reentrant. One nearby borehole indicated a slightly thinner interval between Culebra and Vaca Triste (Fig. 4-1), but there was neither marked thinning nor other indicators of increased Culebra transmissivity, such as existed for SNL-9 (Powers and Richardson, in prep.). SNL-12 was located near surface drainage in the event this feature reflected processes at depth.

The lower Rustler and uppermost Salado were cored to obtain direct evidence bearing on the status of dissolution of halite in the uppermost Salado in this vicinity (Fig. 4-1). In the area south of WIPP and east of the southeastern arm of Nash Draw, Powers (2002a, 2003a), Holt and Powers (2002), and Powers and others (2003) showed a marked decrease in the thickness of the interval between the Vaca Triste Sandstone Member of the Salado Formation and the top of the Culebra Dolomite Member of the Rustler Formation (Fig. 4-1). Geophysical logs supplied data that indicated the change in thickness occurred because of dissolution of halite at the top of the Salado and that also indicated the SNL-12 location would be little, if any, affected by this process. Holt (2002) and Powers and others (2003) related this margin to significant changes in the hydraulic properties of the Culebra.

Upper Salado halite with clastics includes halite with displacive margins, an indicator of deposition and an indicator that these are not residues after postdepositional dissolution.

Macroscopic features of the cores across the boundary reveal thicker sulfate at the boundary that may be a unit amalgamated by syndepositional processes, possibly involving slight dissolution as well as repeated mudflat to gypsum mud flat fluctuations. Although upper Salado halite has been dissolved in other areas to accumulate sulfate beds as a residue, the overlying cores of the basal Rustler show excellent preservation of fine bedding and thin laminae without evidence of distortion or fracturing that would be expected to accompany postdepositional dissolution of halite. At SNL-12, the macroscopic features indicate that upper Salado halite has not been removed after the Rustler was deposited. This confirms the predrilling expectations for the location.

Much of the lower Los Medaños in M-1/H-1 does not show mineral cements. There is some gypsum cement of sandstones near the thin sulfate beds below A-1. The gypsum beds and cement at SNL-12 in this stratigraphic position are more prominent than in the vicinity of WIPP, although there are generally equivalent units.

Halite beds (H-1) for the lower Los Medaños are stratigraphically equivalent to the upper M-1 beds and sulfatic beds below A-1. At SNL-12, cores from this interval are relatively complete, but macroscopic features are not well displayed. Some smeared intraclast textures may occur below A-1, in a stratigraphic interval that also shows some bedding. There is no evidence of postdepositional dissolution of halite from these features, but more detailed study of the cores is appropriate.

The M-2 interval below the Culebra is well sampled and typical of the unit. Bedding and color stratification are consistent with not having halite removed from this unit after deposition.

Culebra core recovery was very good, including zones that commonly are not retained during coring. The Culebra is unusually thick at SNL-12, and it includes a zone of probable öolites ~10 ft thick that account for much of the increased thickness. Although öolites have been reported previously for the Culebra, they have not been identified as a significant part of the unit in the vicinity of WIPP. The main significance to the Culebra at SNL-12 is that this zone likely has relatively high transmissivity and increases the thickness of hydrostratigraphic units CU-2 and CU-3, which are normally the most transmissive units of the Culebra. CU-3 typcially has very large pores or vugs and fractures creating high transmissivity. At SNL-12, the vugs do not appear as concentrated as they are in the same zone in drillholes nearer WIPP. The fractured zone appears shorter and less extensive at SNL-12 compared to some drillholes nearer WIPP. The combined zones of CU-3 and CU-2 likely represent a thicker zone (compared to other drillholes nearer WIPP) of higher transmissivity, but fewer vugs and a less extensive fracture zone may mean the overall transmissivity of the Culebra is less at SNL-12 than might be expected. Although no hydraulic testing has been conducted at the time of this report, it is likely that the zone including CU-2 and CU-3 is the most transmissive for the SNL-12 location by analogy to past experience.

Field testing of fluid density of Culebra water suggests that total dissolved solids will be low relative to measurements of Culebra water nearer the WIPP site center.

Cores from M-3 at SNL-12 showed the basic color, lithologic distinctions, and sedimentary features common to this unit at the WIPP site. Clasts or intraclasts suggest subaerial exposure during deposition, consistent with interpretations elsewhere. Halite is not believed to have been a significant part of this unit at SNL-12 and was not dissolved after deposition.

The Magenta core showed little surface porosity or variation during logging that suggest a highly transmissive zone. The microresistivity log suggests that a zone ~12 ft thick in the upper Magenta is more porous than the rest of the member. This pattern has been observed in several wells (e.g., C-2737, Powers, 2002b; SNL-2, Powers and Richardson, in review). The Magenta shows only one clear fracture, and that fracture is filled with gypsum. Water levels observed during drilling provide no information on whether the Magenta produced water at SNL-12.

Cuttings from M-4 at SNL-12 revealed the color and lithologic changes that are typical of the unit closer to the WIPP site. By analogy, there is not believed to have been any halite removed from M-4/H-4 at SNL-12 after deposition.

Cuttings and resistivity changes suggest that the change in natural mineral cements of the Dewey Lake is ~180 ft , and this is consistent with a broad trend for this boundary to be stratigraphically low west and south of the WIPP site center and stratigraphically higher in the center and eastern part of the site (Powers, 2003b). In the southern part of the site, Powers (2003b) hypothesized that this cement boundary provides a perching horizon for natural groundwater. Although the lower boundary of the saturated zone in SNL-12 has not been established, the saturated zone encountered in SNL-12 is consistent with this hypothesis. The stratigraphic position of the cement boundary is much higher near the WIPP site center (e.g., Holt and Powers, 1990a; Powers, 1997, 2002b, 2003b); some of the Dewey Lake has been removed by erosion at SNL-12.

The saturated zone in the Dewey Lake was not tested to determine hydraulic properties. The water quality is good, as indicated by field measurements of fluid density of 0.999 g/cc.

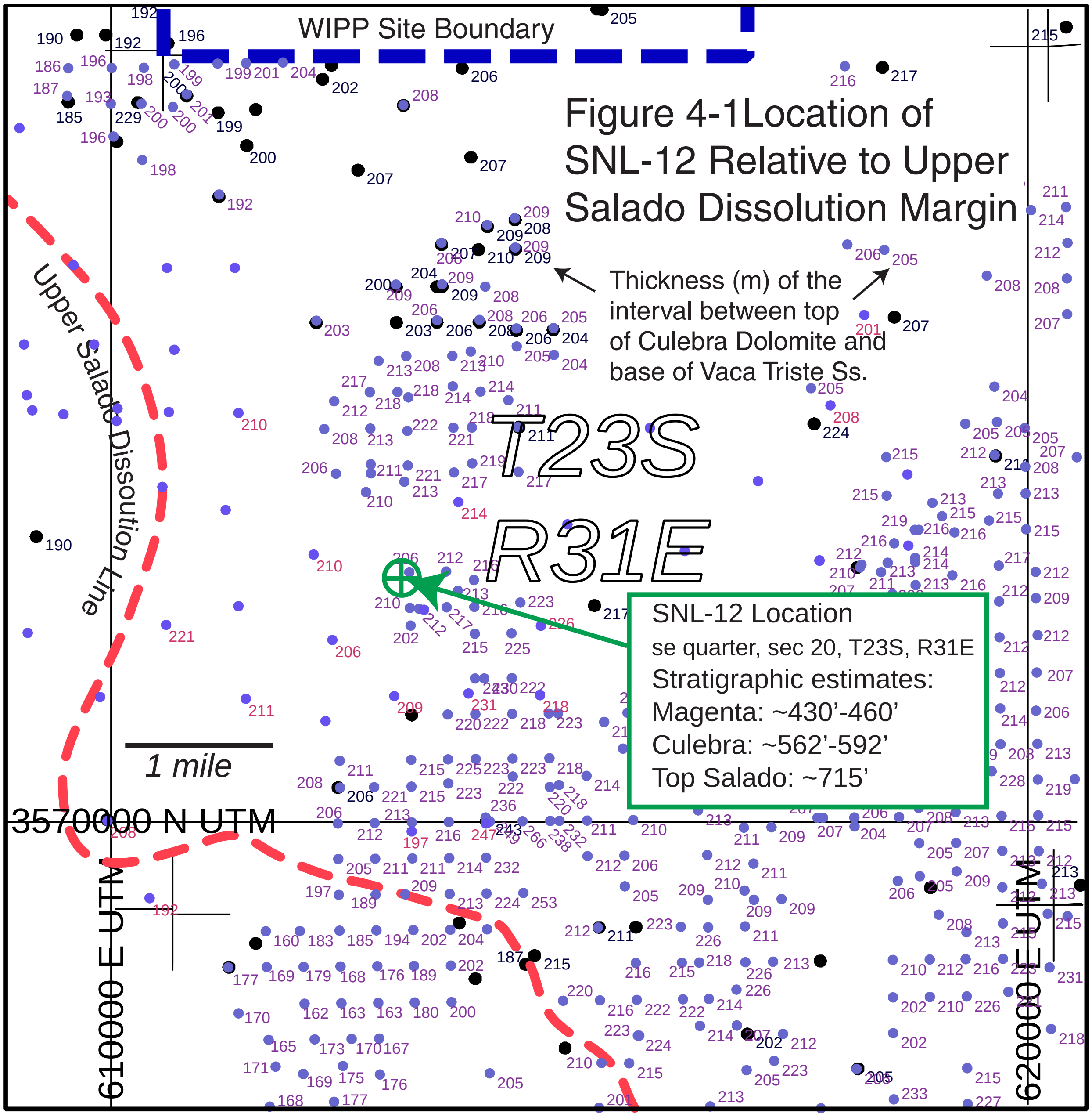


Figure 4-1 Location of SNL-12 Relative to Upper Salado Dissolution Margin

Modified from Powers (2003b).

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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. Two 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.

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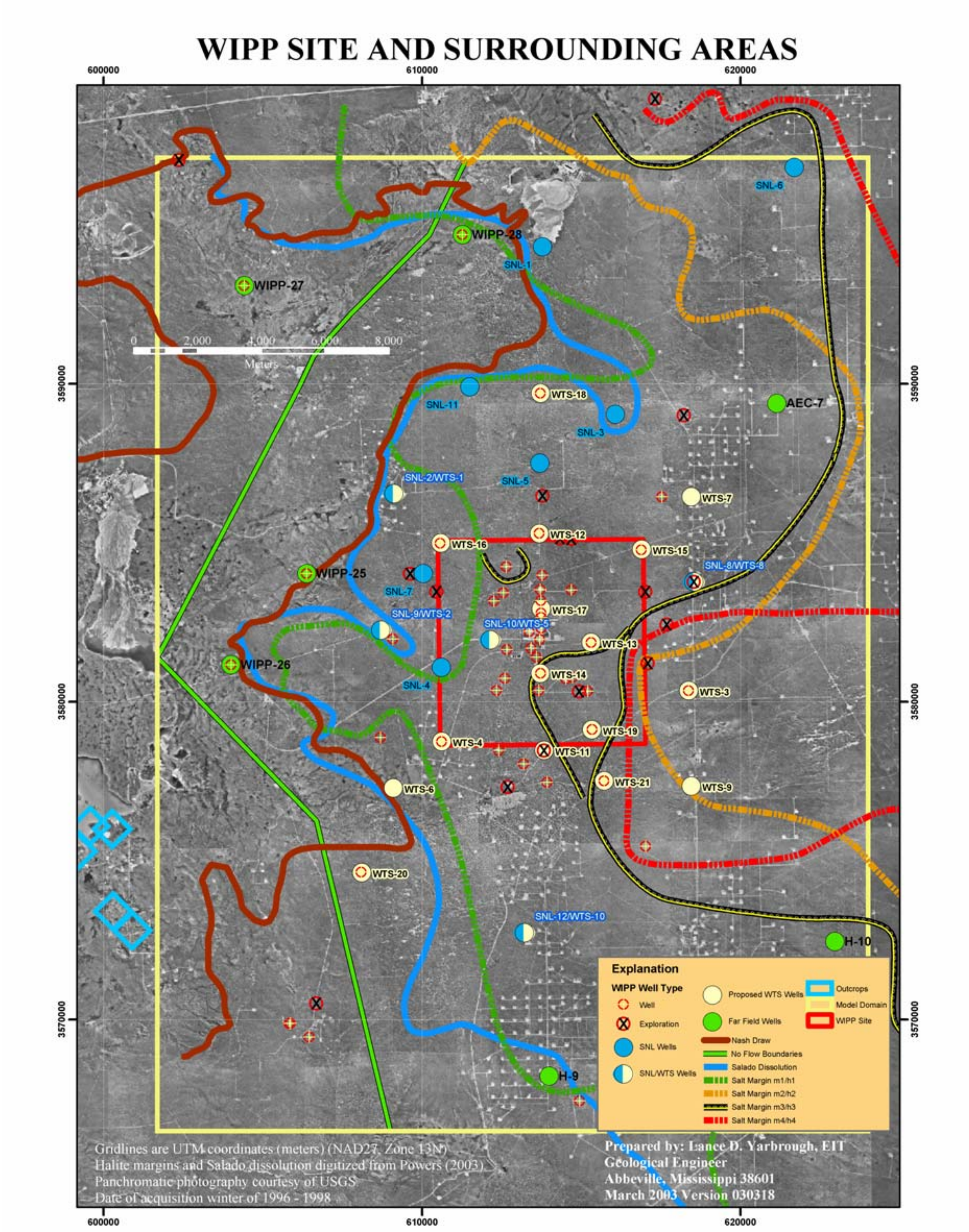

Figure 8. Air-photo map of WIPP area showing halite margins, locations of planned new wells, and Culebra model domain.

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5. Description of Field Activities

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

5.1 New and Replacement Wells

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

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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-12/ WTS-10			x	x		x		

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SNL-12/WTS-10: A Culebra well will be installed south of the WIPP site in an area where there has been extensive drilling for oil and gas (see Figures 6 and 8). This is an area where our Culebra flow models always indicate the Culebra must have high transmissivity, but no wells have been available to confirm this. It is also an area through which the water-level changes observed most markedly at H-9 propagate to the southern WIPP wells. Logs were obtained from new oil wells and potash holes in this region to help optimize the location of SNL-12. Specifically, the logs were used to identify any features that may be related to high transmissivity, especially potential dissolution of the upper Salado, to maximize the probability that SNL-12 will be located in a high-T zone. The data do not indicate local re-entrants along the Salado dissolution margin. The location was chosen to sample an area where Salado may not be dissolved, but Culebra T is likely to be high. A well at the SNL-12 location will:

1. confirm that the high transmissivity south of the site indicated by our models exists;
2. determine if dissolution of the upper Salado has occurred in this area;
3. determine if the dimensionality of flow (inferred from a pumping test) indicates that the high transmissivity is channelized (focused) or is widely distributed (diffuse);
4. provide another monitoring point to help determine the source and/or cause of the water-level changes regularly observed at H-9;
5. provide information on Culebra heads in an area with many nearby oil and gas wells; and
6. provide a pumping location for a large-scale (multipad) test to provide transient data for calibration of the Culebra model south of the WIPP site.

In addition, a well at the SNL-12 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-10).

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5.3 Testing Activities

A variety of testing and sampling activities will be performed in different wells as this program advances. Table 2 shows the types of tests currently anticipated to be performed in each new well. …

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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-12/WTS-10	C		C?	C?	

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

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5.3.2 Multipad Pumping Tests

Large-scale (multipad) pumping tests of the Culebra are planned for three locations to provide transient response data needed for flow-model calibration. Multipad pumping tests typically involve pumping for a month or longer at one location while monitoring responses at surrounding observation wells up to several miles away. Such tests have been performed in the past within the WIPP site boundaries at the H-3, H-11, H-19, and WIPP-13 locations, greatly facilitating model calibration in the affected areas where observation wells were present. The new wells to be installed provide the opportunity to extend the increased model-calibration capability provided by multipad tests to the regions surrounding the WIPP site, which is needed to improve our understanding of how hydraulic stresses originating off-site propagate to the wells on the WIPP site. In particular, one of the primary objectives of the multipad tests will be to determine the presence or absence of high-transmissivity connections between known areas of high T, such as between H-6 and P-14, and between H-11 and H-9. These types of features are important because, if present, they provide pathways for water from Nash Draw to flow under the Livingston Ridge surface or, if absent, they prevent that flow so that the only effect of increased heads in Nash Draw is to decrease the east-to-west gradient in the Culebra, causing heads to rise. Multipad tests will be performed north, south, and west of the WIPP site. (Transmissivity is too low east of the site to sustain the necessary pumping for a multipad test, and our conceptual model assumes the Culebra does not show the heterogeneity in this region that multipad tests are designed to address. The individual well tests at the new wells east of the site should be sufficient to confirm this assumption.)

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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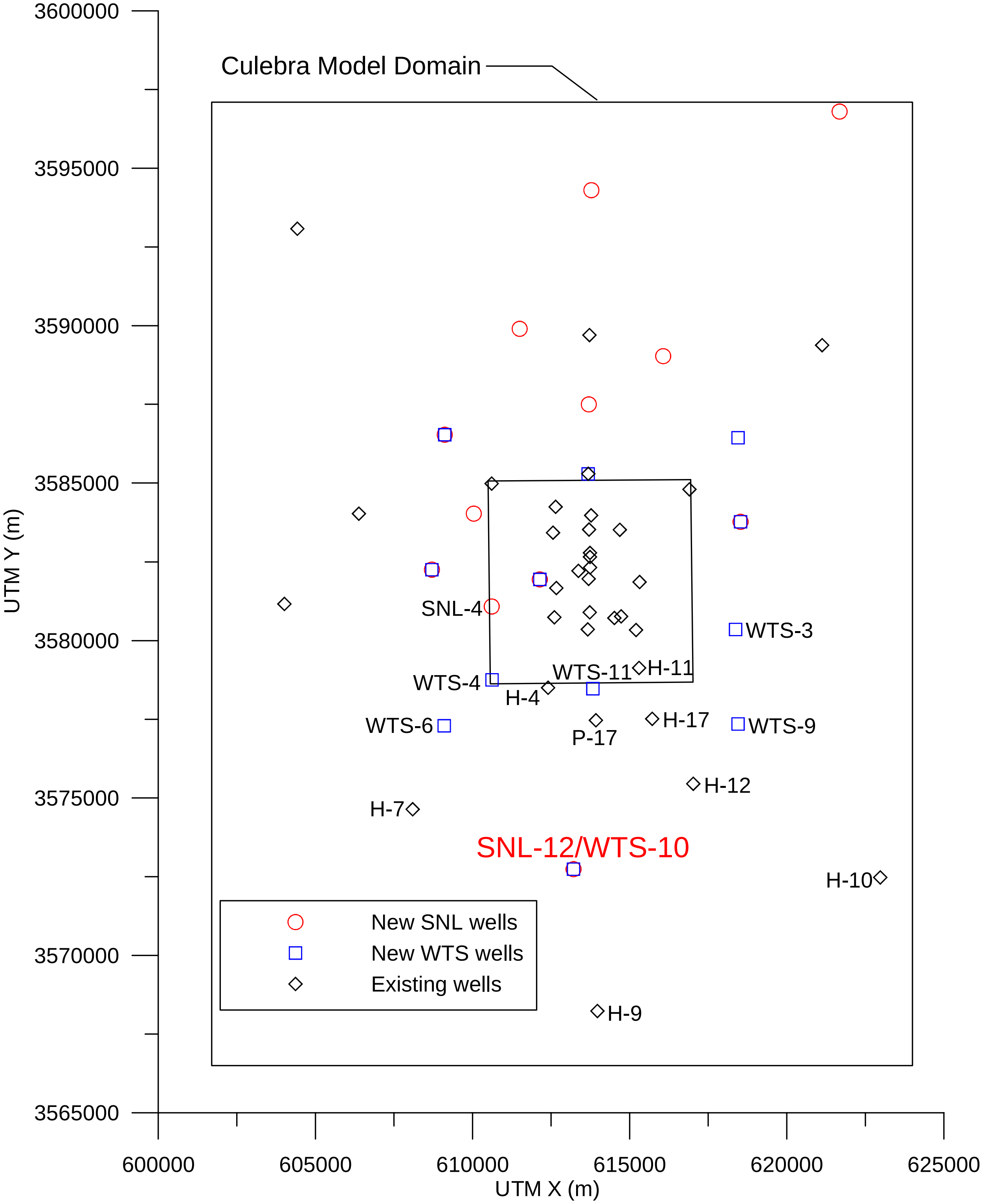

Figure 20. Pumping well and principal observation wells for southern multipad pumping test.

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6.3 Decision Points …

If high Culebra T is not found at the SNL-12 location, we would have to re-evaluate the lines of geologic evidence that led us to site the well where we did, evaluate whether the information gained from drilling the hole allowed us to make a better prediction of where high T could be found, and decide if drilling another hole to try to find it was worthwhile.

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Table 4. Expectations and Contingent Actions for New Wells.

Well	Expectations	Possible Actions if Expectations Not Met
SNL-12/ WTS-10	• moderate to high Culebra T • possible dissolution of upper Salado	• reconsider geologic data and determine location for possible 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-12/WTS-10	920*		

*depth to MB103

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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.

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

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

6-23-03 Arrived at SNL-9 site at 11:20 CDT (*see note above*). 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 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 by 14:00. Rigged up on SNL-12. Left site at 17:30.

6-25-03 Arrived at site at 07:00. Held safety meeting. Lined pit at 07:15. Drilled 30' of 7.875" hole from 08:05 to 08:22. *Collected cutting samples C-1 through C-7. Blowing out cavity at bottom of hole.* Set up to ream hole *with air and mist*. Began reaming out 18'' hole at 09:39. Reamed to 30' at 11:00. Set 30' of 13.385" casing with 2' hole plug from 11:00 to 11:30. Rigged up to mix cement at 11:30. Pumped 28 bags of cement in 300 gallons of water by 12:30. Shut down rig and generator for night and left site at 12:45.

6-26-03 Arrived at site 07:00 and held safety meeting. From 07:15-07:25, tagged cement at 7' and mixed 6 sacks of cement. Rigged diverter up from 07:25-09:06. Drilled 7.875" hole from 30' to 175' *with compressed air. Collected cutting samples C-8 through C-22.* Tripped out from 12:55 to 13:10 for hold point to determine if well makes water. Water level was 164.3 ft below top of casing at 14:00. *Pulled a water sample at 14:10 for Sandia to obtain major cations and anions. Took another water sample at 15:00 for Sandia analysis. Measured depth at 155' from top of casing at 15:16. Decided to break for holiday and allow well to recover for further sampling. Crew removed hydraulic pump to repair during drilling break.*

7-07-03 Arrived on site at 10:30. (Held safety meeting at 08:20 in Odessa.) Began setting up rig and trailer for continued drilling. Completed installing rig pumps by 13:15. Static water level at 141.55' at 13:18. *Collected two bailer samples from Dewey Lake water bearing zone from 13:18 to 13:30. Sample measurements: density at 0.999 g/cc; temperature at approximately 22.5° C.* Tripped into hole at 13:30 to 13:40. *Began drilling using foam mist at 13:45.* Drilled 7.875" hole from 175' to 371'. *Still in Dewey Lake. Collected cutting samples C-23 through C-42. Still in Dewey Lake.* Pulled out of hole for the night at 17:42. *Planned on coring in the morning.*

7-08-03 Arrived on site at 06:50. Held safety meeting. Serviced rig from 07:10. *Measured water level at 155.0' at 07:35.* Tripped into hole at 07:45. Began drilling 7.875" hole at 371' and drilled to

425'. *Collected cutting samples C-43 through C-52.* Started tripping out of hole at 09:40, installed core barrel, and tripped back into hole with core barrel by 11:35. Began core run #1 at 11:35 using compressed air and foam. Cored approximately 29' from 425' to 454' by 12:16. Cleaned hole with circulating foam. Tripped out of hole. *Retrieved core at 12:40 and placed core in tray.* Stopped for lunch 13:15 to 13:45. *Cleaned and measured core. Retained 29.3'.* Tripped back into hole at 13:45. Began core run #2 at 14:05. Cored 16.5' from 454' to 470.5' by 14:20. Cleaned hole. Tripped out. *Retrieved and laid out core.* Retained 16.5'. Boxed cores. Secured tools and equipment. Left site at 16:00.

7-09-03 Arrived on site at 06:50. Held safety meeting. Measured water level at 142.3' at 07:30. Tripped into and cleaned out hole. Began reaming through cored interval at 08:30. Continued drilling from 470.5' to 520'. *Collected cutting samples C-53 through C055.* Stopped to repair rig (bearing out) at 09:49. Resumed drilling at 11:38. Reached coring point and tripped out of hole to attach core barrel at 12:30. Stopped for lunch. Tripped back down hole at 13:00 and got a load of fresh water. Began core run #3 at 14:00 and ended at 14:25. Cored 28' from 520' to 548'. Circulated mist in hole. Retrieved core at 15:10 and laid down core. Tripped back down into hole and began core run #4 at 15:54. Cored 29' from 548' to 577'. *Last anhydrite and into Culebra. Retrieved core to Culebra at 16:15.* Retained 29'. *Boxed cores at 17:00. Advised Beauheim that drilling with brine would begin tomorrow.* Secured site. Left site at 18:00.

7-10-03 Arrived on site at 06:50. Held safety meeting. Rigged up portable mud system. Prepared for drilling. *Took generator off-site to be cleaned.* Steam radiator on auxillary generator. Two loads of brine delivered by I/W. Measured static water level at 143.5' at 11:00. Tripped into hole with core barrel at 11:50. *Cleaned hole near Culebra base at 577'. Began core run #5, drilling with brine with Flowzan.* Cored approximately 13' from 577' to 590'. Halted coring for lunch at 12:25. Resumed core run #5 at 12:40. Cored additional 10' to 600' when core barrel jammed at 14:11. Circulated on bottom, and tripped out by 14:53. Retrieved core and laid down in tray. Measured 23' of core recovered from *middle to lower Culebra.* Tripped back down hole at 15:37. Began core run #6. Blew hydraulic hose on pump for mist at 16:50. Pulled out of hole. *Needed to replace hose off-site (unable to isolate leak). Returned to site with repaired/replaced parts at 18:00.* Tripped into hole and circulated to prepare for continuation of coring. Began core run #6 at 18:10. Cored 10' from 600' to 610'. Ceased coring at 18:48 and circulated until 18:55. Tripped out of hole. Left core in barrel and planned to lay out core the next morning. Left site at 19:28.

7-11-03 Arrived on site at 06:50. Held safety meeting. Measured static water level *(from drilling brine)* at 28'. Laid down core from previous night's runs at 07:00. *Measured 10' of core recovered (as planned) at 07:30.* Tripped down hole and began core run #7 at 08:22. *Boxed core from run #6 at 08:30.* Cored approximately 28' from 610' to 638' by 10:30. Tripped out of hole, laid down core, and prepared to trip into hole by 11:10. *Attempted to remove core from core barrel. Only small portion of crumbled clay removed. Lost an estimated 10' of core. Recovered 18' of 28' run.* Tripped back down hole by 12:15 and stopped for lunch. Began core run #8 at 12:30. Cored 28' from 638' to 666' by 14:50. Circulated hole and tripped out by 15:45. Laid core in trough and measured 20' of recovered core. WTWWS serviced rig and left site at 16:30. *Described, boxed, and secured core by 17:30.*

7-12-03 Arrived on site at 06:50. Held safety meeting. Set up rig and coring equipment. Tripped into hole and began core run #9 at 08:05. Cored 24.5' from 666' to 690.5' *before barrel jammed; circulated in hole. Tripped out of hole at 10:26. Extracted core from barrel. Recovered 17.8' of 24.5'.* Tripped into hole and began core run #10 at 11:25. *Cored 29.5' from 690.5' to 720' by 13:05.* Circulated hole. Stopped for lunch. Pulled core barrel and extracted core at 14:37. *Coring complete.* Disassembled core barrel and loaded for J.W. Woods (DOWDCO) and released him. *Measured 30' of recovered core. Prepared core for boxing and description. Completed boxing core at 16:15.* Left site at 16:20.

7-13-03 Arrived on site at 06:50. Held safety meeting. *Started generator.* Tripped down hole. Began reaming 6¾" to 7.875" hole from 520' *to 720' for sampling Salado MB 103* at 07:45. *Noted 8' of washout from 528' to 536' at 08:00.* Noted 10' of washout from 590' to 600'. Noted 5' of washout from 610' to 615'. *Hole is holding fluid; no loss.* Reamed to 720' by 12:20. *Began drilling at 720' in Salado at 12:20. Collected cutting samples C-56 through C-67 (905', TD).* Reached total depth of 905' at 19:00. Circulated hole until 19:15. Tripped out of hole and secured site. Left site for Carlsbad at 20:20.

7-14-03 Arrived on site at 08:15. Held safety meeting. Prepared for electric logs. Began running logs at 08:40. Completed logs and stopped for lunch at 12:30. Tripped tremmie pipe down hole at 13:00, off bottom by 7'. Started mixing first tub of cement at 13:44 using 30 sacks. Pumped first tub from 14:17 to 14:25. Pulled 1 full joint of tremmie pipe, 1 pug joint; 45' total. Began mixing second tub using 27 sacks at 14:25. Pumped second tub from 15:19 to 15:23. Pulled 4 joints; tremmie approximately 120'. Started mixing approximately ¼ tub using 13 sacks at 15:23. Pumped third tub from 16:00 to 16:05. Tripped out and shut down rig for evening at 16:27.

7-15-03 Arrived on site at 08:15. Held safety meeting. Performed rig maintenance from 08:30 to 10:00. Trip into hole and tag cement at 603'; 2' of fill on top of cement. Tripped out from 10:35 to 11:10. Rigged up 12 ¼" bit and hauled 1 load of water at 11:10. Left site at 12:15.

7-16-03 Arrived on site at 07:00. Held safety meeting. Measured static water at 76.2'. Prepared to ream hole *from 7.875"* to 12 ¼". Began reaming at 30' at 08:00. *Reamed to 62' by 08:30. Reamed to 91' by 09:30. Reamed to 152' by 13:00. Reamed to 183' by 15:00. Drilling rate approximately 15' per hour. Reamed to 214' by 16:43.* Reamed to 230' by 17:50. Circulated hole. Tripped out from 18:00 to 18:10. Secured site for evening *and left at 18:25.*

7-17-03 Arrived on site at 07:00. Held safety meeting. Measured static water at 29.6'. Tripped into hole at 07:10. Began reaming to 12 ¼" at 230' at 07:20. *Reamed to 278' by 09:45. Reamed to 341' by 14:45.* Reamed to 373' by 16:15. Circulated hole. Tripped out at 16:30. Secured site for evening.

7-21-03 Arrived on site at 08:30. Held safety meeting. Measured static water at 86.4'. Rigged up auxillary mud pump at 08:45. Reamed back to bottom from 09:15 to 10:30. Began drilling 12 ¼" from 373' at 10:30. *Progress slow. Drilled first joint, taking 3 hours to drill 30'. Casing inspected by state engineer at 12:30. Pulled out at 436' to add another joint of pipe in order to ream deeper.*

Previous joint took 2½ hours to drill. Drilled to 463' by 17:45. Circulated hole. Tripped out at 18:00. Secured site for evening.

7-22-03 Arrived on site at 07:00. Held safety meeting. Tightened rotary joints on rotary table. Measured static water at 72'. Tripped into hole at 07:45. *Hole closed in at 200'. Reamed through and continued tripping into hole.* Began drilling 12 ¼" at 463' at 08:35. Drilled to 531' by 18:40. Circulated hole. Started tripping out of hole at 18:50. Hung in hole temporarily at 410'. Completed tripping out at 19:40.

7-23-03 Arrived on site at 07:00. Held safety meeting. Serviced rig and changed bits. Began tripping in at 08:00. Reamed back to bottom. Circulated hole at 09:30. Began drilling at 531' at 09:50. Drilled to 571' by 16:30. Circulated hole. Tripped out at 16:45. Changed bit and shut down rig at 17:40. *Left site at 18:00.*

7-24-03 Arrived on site at 07:00. Held safety meeting. Serviced rig and changed bits. Measured static water level at 74.3'. Tripped drill pipe into hole at 08:00. Began reaming hole at 571' at 09:00. Reamed to *603*' by 12:10. Circulated hole. Tripped out of hole at 12:45. Ran caliper well log at 13:20. Stopped for lunch at 14:15. Left site at 14:40 for WTS#4.

7-25-03 Arrived on site at 07:00. Held safety meeting. Measured static water level at 74'. Tripped drill pipe down hole at 07:15. Reamed through tight spots and circulated hole. Ran tremmie pipe in hole at 10:24. Began to run 5" fiberglass reinforced plastic casing at 11:10. *Encountered fill in hole at 13:00. Attempted to wash out. Calculations indicated the fill to be approximately 30' from bottom of hole.* Unable to clean out hole by pumping through tremmie. R. Richardson and WTWWS decided to pull casing and reenter hole next week. Began to pull 5" casing out of hole at 14:20. Pulled tremmie pipe out of hole at 15:56. Two loads of brine delivered by I/W. Secured site and left for weekend.

7-28-03 Arrived on site at 11:00. Performed rig maintenance. Left site at 16:00.

7-29-03 Arrived on site at 06:00. Held safety meeting. Changed generator for portable mud system at 06:15. Tripped into hole at 06:45. Necessary to ream almost entirely to bottom. Circulated hole until 10:47, and tripped drill pipe out of hole. Ran tremmie pipe at 11:18. Began to run 5" fiberglass reinforced plastic casing at 12:15 (0' – 546' blank; 546' top of screen; 584' bottom of screen; 595' to bottom is blank). Stopped for lunch at 13:45. Prepared to gravel pack at 14:10. Used 34 sacks (*3100 pounds of* 8/16) to bring gravel pack up to 540'. Pumped 4 sacks of Baroid Holeplug at 15:20 *to bring level to 535'*. Prepared to pump cement at 15:30. State Engineer representative (Mike Stapleton) arrived on site at 15:50 to witness cementing. LaFarge on location with 15 yards. Pumped cement from 17:00 to 17:55. Laid down tremmie pipe from 17:55 to 18:20. Cleaned up cement pump and shut down for evening. Left site at 18:35.

7-30-03 Arrived on site at 09:15. Held safety meeting. Serviced rig at 09:30. Tripped 2" pipe into hole at 10:00. Flushed casing out with clean water from 10:30 to 12:30. Tripped 2" out at 12:30. Stopped for lunch at 13:00. Rig down from 14:00 to 18:00.

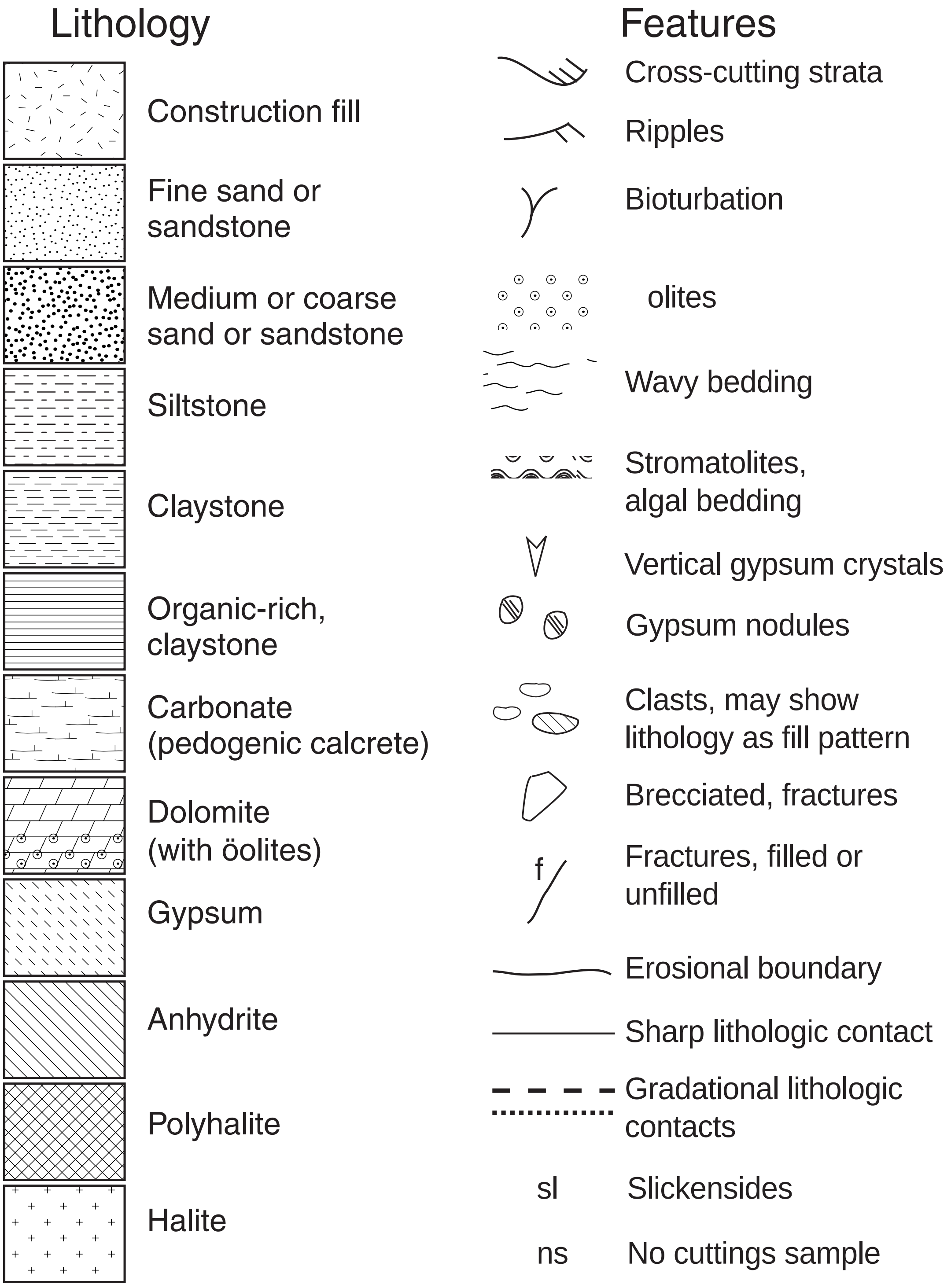
8-04-03 *Arrived on site at 11:00. Started initial pumping at 11:05; water is muddy. First flow rate of 691 BPD (barrels per day) at 11:15. Pumped steadily for 15 minutes until water clear at 11:30. Pumped total of 7 barrels; rate of 16 gpm. Started backwash/surge at 11:40; total of 11 barrels pumped. Resumed pumping at 12:00; rate of 26 gpm (steady). Measured drop in flow to 23.3 gpm at 12:15; total of 20 barrels pumped. Regained steady clear flow of 23 gpm at 12:25; total of 25 barrels pumped. Started backwash/surge again at 12:32. Started pumping, full open, at 12:47; rate of 26.5 gpm, total of 32 barrels pumped. Flow very steady and clear at 13:15; total of 44 barrels pumped. Measured density of 1.020 g/cc at 14:20. Total production of 80 barrels at 14:25. Stopped pumping at 14:30; water totally clear and clean.*

4-05-04 *Arrived at portacamp at 07:30. Crew arrivee at portacamp at 09:00. Arrived at SNl-12 at 09:30. Started down hole. Screen interval from 546–584 ft, added joints to 588 ft. Jet tool set at 10:15; ready for development. One hundred fifty barrels of water from Jal Municipal water supply was available. Started jettying at 10:30; water started pretty clean and became real dirty. Water was very dark brown and muddy by 10:40, with chunks of mud floating up. Jetted entire screen interval plus about 1 ft above and below screen. Completed first full past by 10:55; water still dirty. Completed second full pass by 11:25; water becoming cleaner. Completed last half pass by 11:35. Flushed 150 barrels through well and pumped into frac tank. Water was still cloudy and light gray color. Removed pipe and jet tool from well by 12:15 and began to set 3 horsepower pump. Pump was set at 12:55; set up to start pumping. Began pumping at 13:10 at 14 gpm. Flow rate 14 gpm at 13:20; water slightly cloudy. Flow rate 14 gpm at 13:30. Flow rate 13.8 gpm at 13:45. Flow rate at 14.2 gpm at 14:00. Flow rate at 15.0 gpm at 14:15; water milky, cloudy. Flow rate at 15.0 gpm at 14:30; water slightly cloudy. Flow rate at 14.3 gpm at 15:00. Fluid density 1.004 g/cc, and water was very clear. Flow rate at 15:30 was 14.7 gpm. Water very clear, and fluid density at 1.004 g/cc. Flow rate was 14.7 gpm at 16:00. Density was 1.004 g/cc, and water was very clear. Turned pump off at 14:05. Water showed no sediment. Pumped total of 2526 gallons. Removed pipe and pump from hole by 17:00. Returned pipe trailer to portacamp by 17:30.*

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 to 95% of 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; not all symbols may be used

CORE LOG

Sheet 1 of 10

Hole ID: SNL-12

Location: 1171 ft fsl, about 2137 ft fel, section 20, T23S, R31E

Drill Date: 6/25/03- 7/29/03
Drill Crew: West Texas Water Well Service (Ronnie Keith, driller)

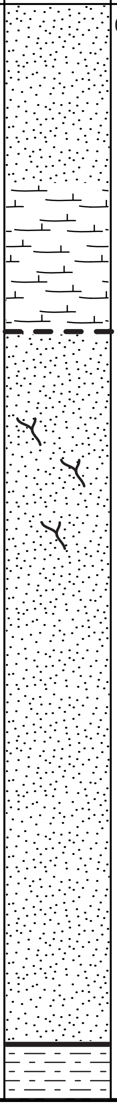
Drill Method: rotary
Hole Diameter: initial 7.875 inches
Hole Depth: TD 905 ft
Hole Orient: vertical downward

Drill Make/Model: Denver-Gardner 1500
Barrel Specs: 4 inch i.d.; 6.5 o.d.
Drill Fluid: air to 175'; foam to 577'; brine & foam
Core Preserv: marked and boxed at site

Logged by: Dennis W. Powers, Ph.D., Consulting Geologist
Date: 6/25-26/03
Scale: 1":10'; 1":20'

	Northing	Easting	Elevation
Survey Coordinate: (Ft)	468653.74 NM SP (NAD27)	665510.03 NM SP (NAD27)	3337.28 ft amsl (brass tablet at surface)

Comments: The State Engineer assigned the number C-2954 to this drillhole. It is also co-designated WTS-10. The reference elevation for coring and drilling is 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 at the time of drilling and coring.

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	0 10 20 30 40 50 60	cutting sample depths noted 3 7 10 15 20 25 30 35 40 45 50 55 60 N/A	N/A		0-3' 3-7' 7-30' 0-10': Sand, strong brown (7.5YR5/6); friable at surface; fine, mixed with caliche from pad construction in upper 2'; roots and organic matter to ~3.5'; more argillaceous w/depth, slightly moist; non-calcarous below pad material. Berino soil below surface sand. Sand is generally f-vf, subrounded, mod well sorted; mostly quartz, trace dark grains. 10-18': Mescalero caliche; sandstone, very calcareous, to sandy "limestone," pinkish white (7.5YR8/2); sand grains similar to overlying sand 18-57'(?): Gatuæa Formation 18-30': Sandstone, reddish-brown (5YR5/4-4/4); very calcareous at top, carbonate content decreases downward; very fine to fine, some medium grains, subangular, poor to medium sorted; small (< 0.04" diameter) cylindrical bioturbation, probable root casts; some MnO_2 stains. 30-40': Sandstone, as above, red (2.5YR4/6-5/6), with argillaceous zone from ~35-40'; fine to medium sandstone, with ~ 1% dark grains, some mica; very calcareous. 40-57': Sandstone, as above, red (2.5YR4/6-5/6), mixed sandstone and argillaceous siltstone; very calcareous. 57'(?)-374': Dewey Lake Formation	begin 7:09a MDT drill 7.875" pilot hole to 30'; ream to 18" & set conductor casing 3' @ 0710 MDT 7' @ 0713 MDT 10' @ 0714 MDT 15' @ 0715 MDT 20' @ 0717 MDT 25' @ 0719 MDT 30' @ 0722 MDT ream to 30' using freshwater mist & Baroid QuikFoam. start @ 30; @ 0807 MDT 6/26/03; drilling with air 34' @ 0809 MDT add jt 40' @ 0842 MDT 50' @ 0851 MDT 60' @ 0857 MDT

Hole ID: SNL-12

CORE LOG
(cont. sheet)

Sheet 2 of 10

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

Date: 6/26/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	60	cutting sample depths noted			57-374': Siltstone, interbedded with claystone and fine to very fine sandstone; commonly red (2.5YR4/6-5/6) or reddish brown (5YR5/4), with small greenish gray reduction spots. Very calcareous from 57-175' bgl; gypsiferous below 180' bgl and slightly to non-calcareous.	add joint
	70	70				70' @0920 MDT cuttings returns may indicate hole diameter increasing below conductor
	80	80				80' @0932 MDT
	90	90				90' @ 0939 MDT add jt
N/A		N/A	N/A			
	100	100				100' @ 0956 MDT
	110	110				110' @ 1010 MDT
		118				
	120	120				120' @ 1030 MDT add jt
	130	130				130' @ 1037 MDT
	140	140				140' @ 1045 MDT

Hole ID: SNL-12

CORE LOG
(cont. sheet)

Sheet 3 of 10

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

Date: 6/26/03; 7/7/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks

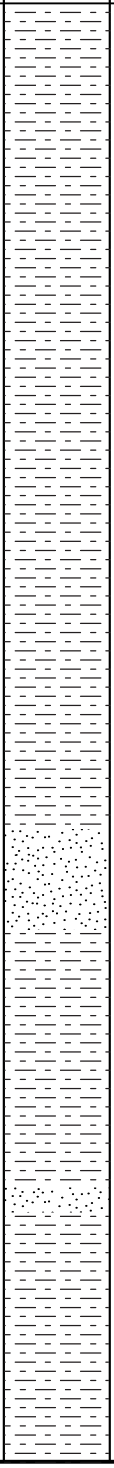
Note graphic scale change

Run Number: N/A

Depth (feet): 140, 160, 180, 200, 220, 240, 260, 280, 300

% Recovered: 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300; cutting sample depths noted; N/A

RQD: N/A



57-374’: Siltstone, interbedded with claystone and fine to very fine sandstone; commonly red (2.5YR4/6-5/6) or reddish brown (5YR5/4), with small greenish gray reduction spots. Very calcareous from 57-175’ bgl; gypsiferous below 180’ bgl and slightly to non-calcareous.

~230-242’: Sandstone, medium, well rounded, sorted, reddish yellow (5YR6/6) and white (10YR8/1) at top to mostly white (10YR8/1) and fine grained at bottom.

Slightly calcareous @ 250'; reddish brown (5YR5/4)

Gypsum as fracture fillings and as small pore fillings @ 260'

Reddish brown, very fine sandstone @ 270'

Remarks:

150’ @ 1055 MDT add joint

160’ @ 1115 MDT cuttings beginning to cake

170’ @ 1132 MDT blew air for ~ 10 min w/o water

175’ @ 1151 MDT stop for water level check: 164.3’ @ 1300 MDT, 155’ @ 1417 MDT rel to top of casing collar. Samples @ 1310 & 1400 MDT for general chemistry. End 6/26/03

Begin 7/7/03. Water level 141.55 ft below casing collar. Begin drilling @ 175’ @ 1219 MDT with foam and fresh water

180 ft @ 1302 MDT

190 ft @ 1320 MDT

200 ft @ 1330 MDT

210 ft @ 1341 MDT add jt

220 ft @ 1358 MDT

230 ft @ 1409 MDT

240 ft @ 1420 MDT

add jt

250 ft @ 1438 MDT

260 ft @ 1445 MDT

270 ft @ 1455 MDT add jt

280 ft @ 1515 MDT

290 ft @ 1522 MDT

300 ft @ 1529 MDT; add jt

Hole ID: SNL-12

CORE LOG
(cont. sheet)

Sheet 4 of 10

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

Date: 7/7/03-7/8/03

Run Number | Depth (feet) | % Recovered | RQD | Profile (Rock Type) | Description | Remarks

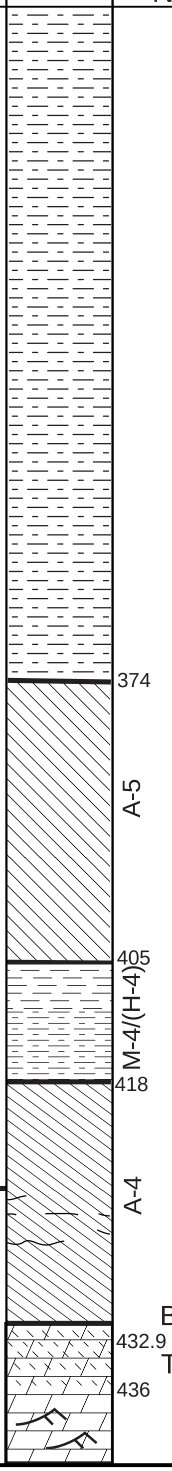
Note graphic scale change @ 420’

Run Number: N/A (300–425); Core Run 1 (425–440)

Depth (feet): 300, 320, 340, 360, 380, 400, 420, 425, 430, 440

% Recovered: N/A — cutting sample depths noted: 310, 320, 330, 340, 350, 360, 370, 375, 380, 390, 400, 402, 405, 410, 415, 418-419, 420; Cut 29 ft; recovered 29 ft (100.0%)

RQD: N/A; 0.5’ length in segments < 4" (RQD: 98.3)



57-374’: Siltstone, interbedded with claystone and fine to very fine sandstone; commonly red (2.5YR4/6-5/6) or reddish brown (5YR5/4), with small greenish gray reduction spots. Very calcareous from 57-175’ bgl; gypsiferous below 180’ bgl and slightly to non-calcareous.

374-405: Gypsum and anhydrite, white to very pale brown (10YR8/3) with dark grayish brown (10YR4/2). Some coarse gypsum. Most anhydrite is fine crystalline, darker.

405-410: Claystone, sandy, silty; non-calcareous, may include some gypsum; sticky; dark reddish brown (5YR3/4 wet)

410-418: Siltstone, argillaceous, sandy; non-calcareous; gypsiferous, some gypsum fracture fills; dark gray (2.5YRN4)

418-425’: Gypsum, white to gray; fine, sugary crystals to coarser flakes of gypsum

425-432.9’: Gypsum and anhydrite, dark gray; bedded, with thin (< 0.04 in) laminae separating beds, may be nodular; also thin zones (< 0.5 in) with several wavy brown laminae, carbonaceous, calcareous (probably algal).

Base of Forty-niner Member

Top of Magenta Dolomite Member

432.9-436’: Interbedded dolomite and gypsum; thin organic carbonate laminae. Horizontal fractures filled with fibrous gypsum (~0.04 in, spaced ~ 0.5 in)

Remarks:

300’ @ 1529 MDT add joint

310’ @ 1545 MDT

320’ @ 1552 MDT

330’ @ 1601 MDT

340’ @1608 MDT add jt

350’ @ 1621 MDT

360’ @1628 MDT

370’ @ 1638 MDT stop 371’ @ 1639 MDT 7/7/03; begin 7/8/03. Water level 155’ below collar @ 0615 MDT

375’ @ 0723 MDT

380’ @ 0731 MDT

390’ @ 0750 MDT

400’ @ 0808 MDT

402’ @ 0815 MDT add jt

410’ @ 0824 MDT

420’ @ 0830 MDT

425’ @ 0840 MDT; change to coring

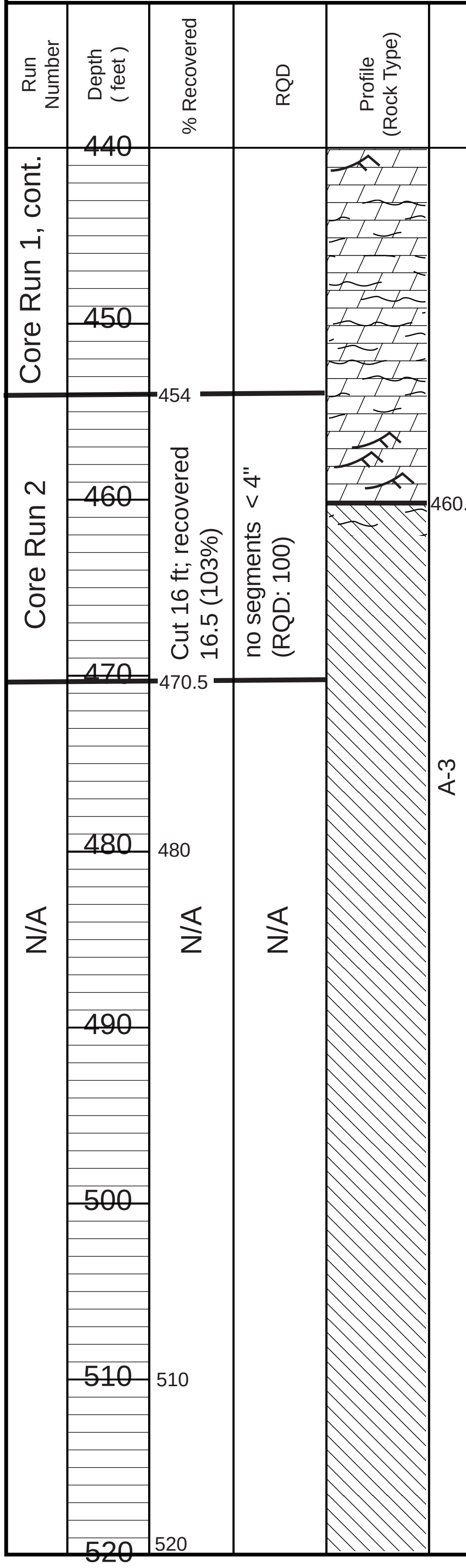
Hole ID: SNL-12

CORE LOG
(cont. sheet)

Sheet 5 of 10

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

Date: 7/8/03-7/9/03



Description

436-460.3: Dolomite, gypsiferous, mainly white (10Y8/2) to gray (10YR6/1 to 10YR5/1). Mostly granular or sandy; possible oolites 436.8-437.3, rippled ~ 0.5 inch high. 437.3-456.5', bedding is more wavy, ripples less abundant and smaller. 456.5-460.3: higher amplitude wavy bedding and ripples, with thin (< 0.04 inch dark brown organic surfaces bounding ripples, with algal stromatolites at base. This basal zone also is marked by 0.04-0.10 inch fibrous gypsum perpendicular to bedding along separations. Both contacts somewhat gradational.

Base of Magenta Dolomite Member

Top of Tamarisk Member

460.3-461': Gypsum, gray, fine to coarse, with irregular thin laminae of brown carbonate (algal).

461-470.5': Gypsum and anhydrite, gray, fine, some coarse crystals; poorly defined laminar bedding and possible small nodules.

470.5-520': Gypsum and anhydrite, gray.

Remarks

454' @ 1114 MDT

470.5' end coring 7/8/03; begin 7/9/03; water level 142.3' below collar on casing; ream to 7.875" from 425-470.5; begin drilling @ 0800 MDT;

480' @ 0814 MDT

490' @ 0830 MDT
no cuttings retained
repair bearing

500' @ 1041 MDT
no cuttings retained

510' @ 1051 MDT

520' @ 1059 MDT
switch to coring

Hole ID: SNL-12

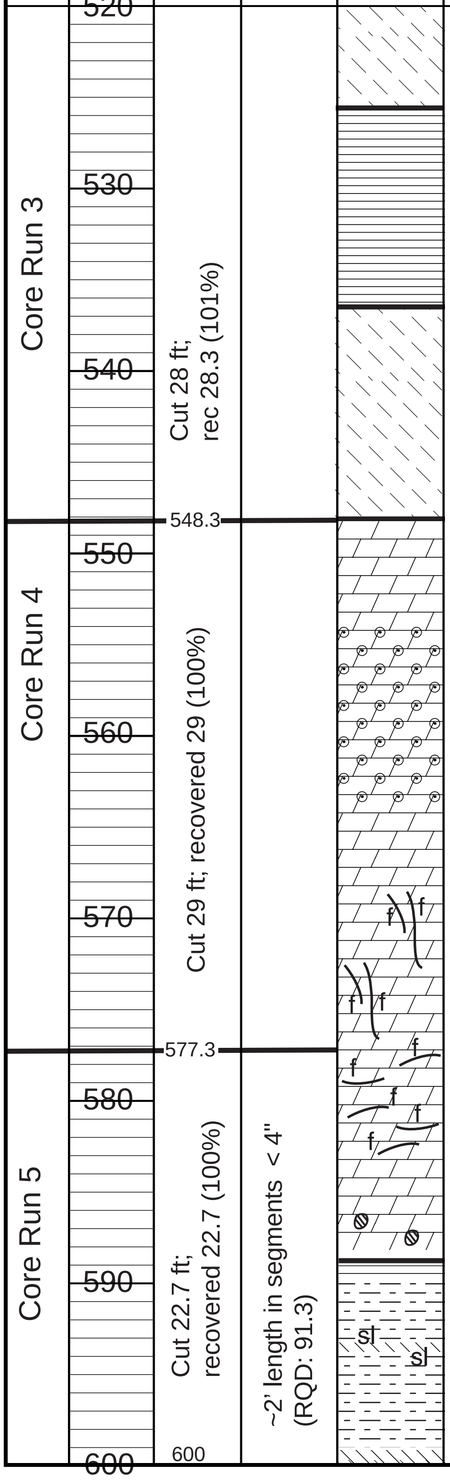
CORE LOG
(cont. sheet)

Sheet 6 of 10

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

Date: 7/9/03-7/10/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks



A-3 520-525.6 ft: Anhydrite and gypsum, dark gray, coarse to fine crystals; bedded, may also have some small nodules

525.6

M-3/H-3 525.6-536.7: Claystone, generally reddish brown lower and gray upward. 525.6-527.6: dark gray, bedded to disrupted bedding, increasing gypsum downward. Some gypsum may be clasts or intraclasts in upper part, bedded lower part. 527.6-529: silty, dark gray, with gypsum along probable bedding and as subvertical crystals up to 1" high. 529-529.2: reddish brown, with gypsum as above. 529.2-529.8: like 527.6-529. 529.8-533: reddish brown, gray. 533-536.7: reddish brown, bedded, possible smeared intraclast textures; some gypsum as clasts.

536.7

A-2 536.7-548.1: Gypsum and anhydrite, dark gray, fine to very coarse. Possible nodules 539.5-537. Clay, organic layer at 540.4. Thin beds and laminae of carbonate dispersed, some crinkly beds, with possible tiny swallowtails; also stylolite at 545.3. Mixed clay and sulfate in upper 1 ft. Transitional base over ~ 0.2 ft from brown organic carbonate to laminar gypsum.

548.1

Base of Tamarisk Member

Top of Culebra Dolomite Member

548.1-577: Dolomite; very pale brown (10YR7/3) to pale brown (10YR6/3); silty, possibly gypsiferous; thin bedded to laminar, with stromatolites from 549.8-550; large pores from 551-553.5; oolitic from 553.5-563.5, with large vugs and rare subvertical fractures; small pores, some flattened, from 563.5-569; few large pores 569-569.8; scattered larger pores, to ~0.5 inch diameter, and vertical to subvertical fractures from 569.8-577.

f

577-588.8: Dolomite; light gray (5Y7/1) to gray (5Y6/1); estimated 20% porosity, with pores to ~ 0.5 inch from 577-584.3, about 1-2% filled porosity in zone except for 15-20% filled porosity from 579-582; horizontal fractures with black organic matter at 0.5-1 ft spacing from 577-584; small to large vugs, mainly gypsum-filled, from 584.3-586.2; few small pores, filled with gypsum, thin bedding and flat laminae, with some slight erosion on surfaces from 586.2-588.8.

End coring 7/9/03 @ 577.3 ft; begin 7/10/03 with brine and Flowzan.

588.8

Base of Culebra Dolomite Member

Top of Los Medaños Member

M-2/H-2 588.8-589.6: Claystone, dark gray (2.5YRN4), silty, clasts at top. 589.6-599.3: Siltstone, argillaceous, and claystone; laminae and thin beds, some inclined; horizontal gypsum vein with vertical fibers at 593.4 and slickensided contacts; gypsum rosette at 589.8; Slickensides on blocks have differing orientations; gray above 593.4, reddish brown below; gypsiferous zones and displacive gypsum below 593.4. 599.3-600: Gypsum, white, nodular (?), with claystone infiltrated.

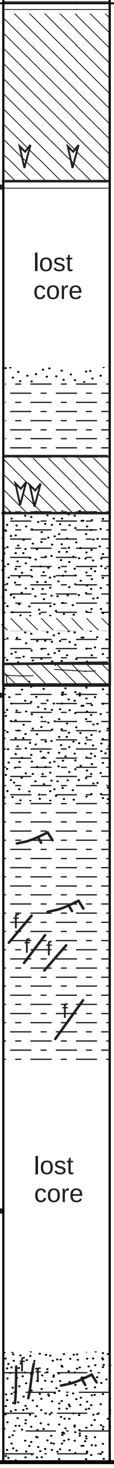
Hole ID: SNL-12

CORE LOG
(cont. sheet)

Sheet 7 of 10

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

Date: 7/10/03-7/12/03



Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
Core Run 6	600 610	Cut 10 ft; rec 10 (100%) 610.0	all sements > 4" (RQD=100)		A-1 600-600.5: Claystone, mainly reddish brown; silty, with gypsum blebs in lower part. 600.5-601: Gypsum, dark gray, with some gray clay. Irregular upper contact. 601-609.8: Anhydrite, gray, with slightly pink area ~ 609; interbedded laminae and nodular beds at ~0.5-1.0 ft vertical scale. 609.8-610: Claystone.	end coring @ 610 ft 7/10/03; begin 7/11/03
Core Run 7	620 630	Cut 28.7 ft; recovered 18 (64.3%) 638	~ 1 ft in segments > 4" (RQD=94.4)		M-1/H-1 620-624.8: Sandstone, reddish brown (5YR4/4), silty, argillaceous; poorly indurated; very thin horizontal laminae, slight crosscutting and deformation, sulfatic; overlies claystone, dark reddish brown (5YR3/4), sandy, silty; subhorizontal mottled zones and gray layers (2.5YN6/). May have smeared intraclast textures. 624.8-627.9: Anhydrite, gray (5Y5/1), thin laminae, probable growth ridge 626-626.5; possible tiny swallowtails 626-627; possible nodules in upper part; irregular upper contact. 627.9-633.7: Sandstone, dark reddish brown (5YR3/4), silty, argillaceous; poorly defined beds; possible claystone clasts; laminar at top. 633.7-634.3: Sandstone, cemented by anhydrite. 634.3-636.2: similar to 627.9-633.7. 636.2-637.1: Anhydrite, light brown, sandy. 637.1-638: Sandstone, gray, anhydrite-cemented, laminar.	Assumed lost core zone from 610-620 ft likely incorrect; core recovery from this zone was probably near 100%; see text discussion; core was not re-marked after interpretation of logs.
Core Run 8	640 650 660	Cut 28. ft; recovered 20 (71.4%) 666	~ 1 ft in segments > 4" (RQD=94.4)		638-644: Siltstone, dark grayish brown (2.5YR4/2), sandy; horizontal to subhorizontal laminae ~ 0.04" thick; non-calcareous; some slight mottling in zones with vague bedding - possible bioturbation? 644-658: Siltstone, gray to dark gray (5Y5/1-4/1), argillaceous; very slightly calcareous; laminae ~ 0.04-0.08 inch, some in sets to 0.2 ft thick and in low angle ~planar cross-bedding (see 650-650.2). Series of fractures 652-657 @ ~45^o to vertical with no fill. Short segments of similar orientation have washouts. Scattered nodules of gypsum from ~ 0.125-0.25 inch diameter as well as irregular vugs to ~ 1 inch diameter.	Core loss from core run 8 was assigned to the lower end for marking purposes. Area of core loss is not certain. end coring @ 666 ft 7/11/03; begin 7/12/03
Core Run 9	670 680	Cut 24.5. ft; rec 17.8 (72.7%)	6 ft in segments < 4" (RQD=70.0)		673-679: Sandstone, dark gray (5Y4/1), very fine, silty, argillaceous; moderate to poor induration; ~ vertical fractures, no fill; some washout of small (< 0.5 inch) pores and some bedding planes; a few pores (673-674) are gypsum filled. Bedding faint in some thin zones (2-4 inches), very fine laminae with cross-cutting in 2-4 inch beds.	Core loss from core run 9 was assigned to top of core run; core was marked from 640.5 upward.

Hole ID: SNL-12

CORE LOG
(cont. sheet)

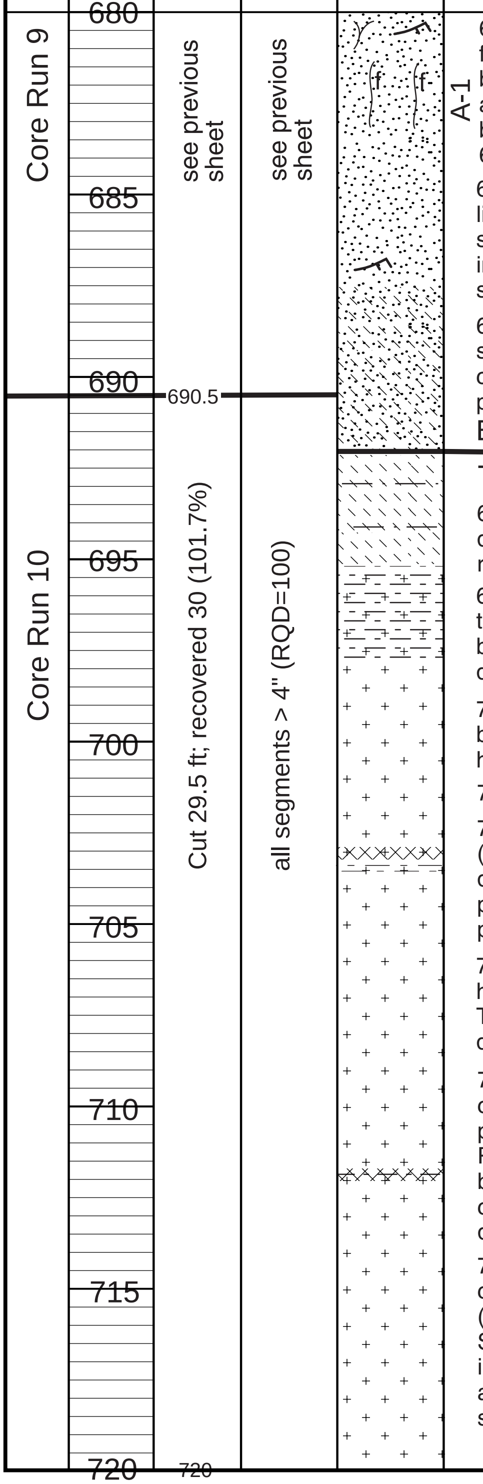
Sheet 8 of 10

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

Date: 7/12/03-7/13/03

Run Number | Depth (feet) | % Recovered | RQD | Profile (Rock Type) | Description | Remarks

Note scale change 680-720 ft



679-683.5: Sandstone, grayish brown (2.5Y5/2), very fine, silty, argillaceous; moderate to good induration; bedding as above; fractures ~ vertical; some bedding and fracture washouts; small holes in core - possible bioturbation - 680-681; possible pelecypod molds 681-681.2; coarser basal sand.

683.5-689.5: Sandstone, grayish brown (2.5YR5/2) to light grayish brown (2.5Y6/2); slightly fining upward; silty, argillaceous at top, gypsum cement, but less indurated upward. Small intraclasts of brown sandstone at 689.2.

689.5--692.1: Sandstone, reddish brown (2.5YR4/4), similar to above, but with more wavy bedding and more cemented by gypsum. Possible intraclasts below 690. Well preserved bedding below 690.5.

Base of Los Medaños Member, Rustler Fm

692.1

Top of Salado Fm

692.1-694.7: Gypsum, white, with subhorizontal and disrupted bedding; and siltstone and sandstone, reddish brown. Siltstone may infiltrate.

694.7-701: Halite, brown, argillaceous; mosaic crystals to 1 inch; clay blebs and stringers, minor displacive boundaries; to sandy siltstone at the top, with displacive halite; faint bedding.

701-703.4: Similar to 703.4-708, except halite boundaries less obviously displacive. Polyhlaite and halite zone 703-703.3.

703.4: Siltstone, gray, sandy, ~ 0.25 inch thick.

703.4-708: Halite, argillaceous and poyhalitic (~3-5% insolubles); halite from ~ 0.2-1.0 inch. Some displacive halite, most halite margins with mud and polyhalite are irregular; some incorporative mud and polyhalite.

708-711.7: Halite, light orange, very coarse crystals; hint of bedding by transparency and color changes. Trace polyhalite in blebs and on halite surfaces. Some displacive halite margins.

711.7-712: Polyhalite with 0.5 inch reddish brown claystone, mottled gray, and halite. Some halite-filled pores in polyhalite may have polyhalite needles. Possible dessication crack filled with halite. Undulatory bedding from expalnsive growth. Upper surface may be corroded by dissolution before overlying bed was deposited.

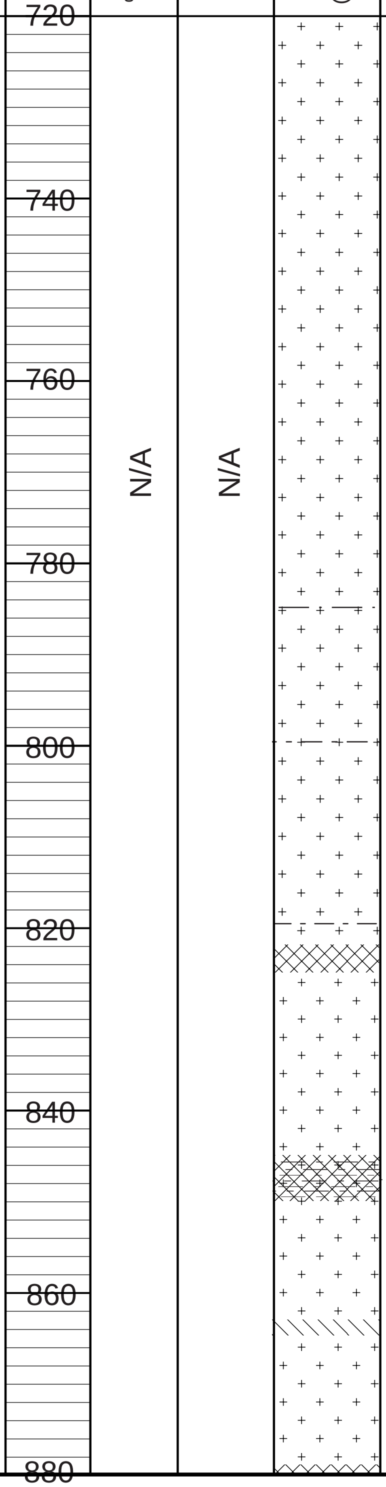
712-720.6: Halite, translucent, colorless to light orange; coarse (0.25-2 inches); bedded 2-6 inches with thin (0.04 inch) laminae or color changes from 720.6-715.3. Solution surfaces with very coarse halite and large fluid inclusions at 715.3, 714. 3, 713.5. Polyhalite in laminae and around halite just above 716 and just below each solution surface.

Assumed lost core zone from 610-620 ft likely incorrect; core recovery from this zone was probably near 100%; see text discussion; core was not re-marked after interpretation of logs.

Hole ID: SNL-12
CORE LOG
(cont. sheet)
Sheet 9 of 10

Logged by: Dennis W. Powers, Ph.D., consulting geologist
Date: 7/13/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)
N/A	720–880	N/A	N/A	



Description

Note scale change at 720 ft

720-822: Halite, white to clear, with some polyhalite; claystones are thin

785: Claystone, thin, black.

799-800: Claystone, thin, black.

819: Claystone, thin, black.

822-825: Polyhalite, salmon colored (MB101); location based on harder drilling interval.

825-845: Halite, white to clear.

845-850: Halite with polyhalite and clay.

850-863: Halite, white to clear.

863-864.5: Anhydrite (MB102)

864.5-879: Halite, white to clear.

879-894: Anhydrite, white (MB103)

Remarks

Resumed drilling @ 1120 MDT @ 720' after reaming hole from 520-720' to 7.875 inches; add jt
735' @ 1141 MDT
740' @ 1149 MDT
745' @ 1157 MDT

750' @ 1205MDT
755' @ 1211 MDT
add jt @ 759'

760' @ 1227 MDT

765' @ 1234 MDT

770' @ 1240 MDT

775' @ 1247 MDT

780' @ 1256 MDT

785' @ 1307 MDT

790' @ 1315 MDT
add jt @ 790', begin 1324 MDT
795' @ 1331 MDT
800' @ 1338 MDT

805' @ 1345 MDT

810' @ 1353 MDT

815' @ 1401 MDT

820' @ 1412 MDT
add jt @ 821', begin 1423 MDT
825' @ 1436 MDT
830' @ 1442 MDT

835' @ 1450 MDT

840' @ 1458 MDT

845' @ 1506 MDT

850' @ 1513 MDT
add jt @ 853.8 '
855' @ 1531 MDT
860' @ 1540 MDT

870' @ 1600 MDT

875' @ 1606 MDT

880' @ 1614 MDT

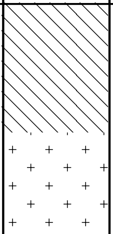
Hole ID: SNL-12

CORE LOG
(cont. sheet)

Sheet 10 of 10

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

Date: 7/13/03

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	880	N/A	N/A		879-894: Anhydrite, white (MB103)	885' @ 1633 MDT stop, add jt, begin 1641 MDT 890' @ 1706 MDT 895' @ 1724 MDT
					894-905 (total depth): Halite, clear to white	
	900					900' @ 1733 MDT
					Total Depth of SNL-12: 905 ft	905' @ 1746 MDT end drilling
	920					

Appendix D
Geophysical Logs

Geophysical logging of SNL-12 was conducted by Raymond Federwisch of Geophysical Logging Services, 6250 Michele Lane, Prescott, AZ 86305 on May 7, 2003, and on May 14, 2003. Copies of the logs are maintained by WRES, Environmental Monitoring and Hydrology Section, for the WIPP Project. A CD-ROM is being retained by the Environmental Monitoring and Hydrology Section 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 July 14, 2003, the following geophysical logs were obtained:

- Caliper
- Natural gamma
- Neutron
- Density
- Formation resistivity (see comment below)
- Conductivity (see comment below)
- Spontaneous potential (SP)
- Fluid resistivity (see comment below)
- Fluid temperature

The drillhole was open to about 905 ft bgl at the time of logging. A conductor casing had been emplaced to a depth of 30 ft bgl. The top of the connector on the conductor casing was used as the reference point for depths during drilling and logging. The fluid level at the time of logging was near the top of the connector on the conductor casing, approximately surface level of the drilling pad. The density log has been included on Figure 2-1 of the main text, but it does not appear to be reliable, as it does not provide the basis for distinguishing between beds of known contrasting density. The neutron log indicates zones through units such as the Culebra, but it is of somewhat uncertain value.

On July 24, 2003, the following geophysical logs were obtained after the drillhole was reamed using a 12.25 inch diameter bit to a depth of about 603 ft bgl:

- Caliper (0-600.8 ft)

This log was used in final calculations of the annulus around the fiberglass casing for completing the well.

Revised files were provided by Geophysical Logging Services August 26, 2003, indicating that fluid resistivity was not valid. Header comments indicated that the conductivity and microresistivity logs were shifted upward by 4 ft due to an error in tool setup during logging on July 14, 2003.

Electronic files for the geophysical logs are maintained for the WIPP Project by the Environmental Monitoring and Hydrology Section, WRES.

Logging truck from Geophysical Logging Services seting up at SNL-12 for initial logging.

Raymond Federwisch (r) prepares logging tool for initial logging at SNL-12 as Luis Armendariz (l) and Don Brasil (c) from WTWWS assist.

Logging tool at "zero depth" at initial logging of SNL-12.

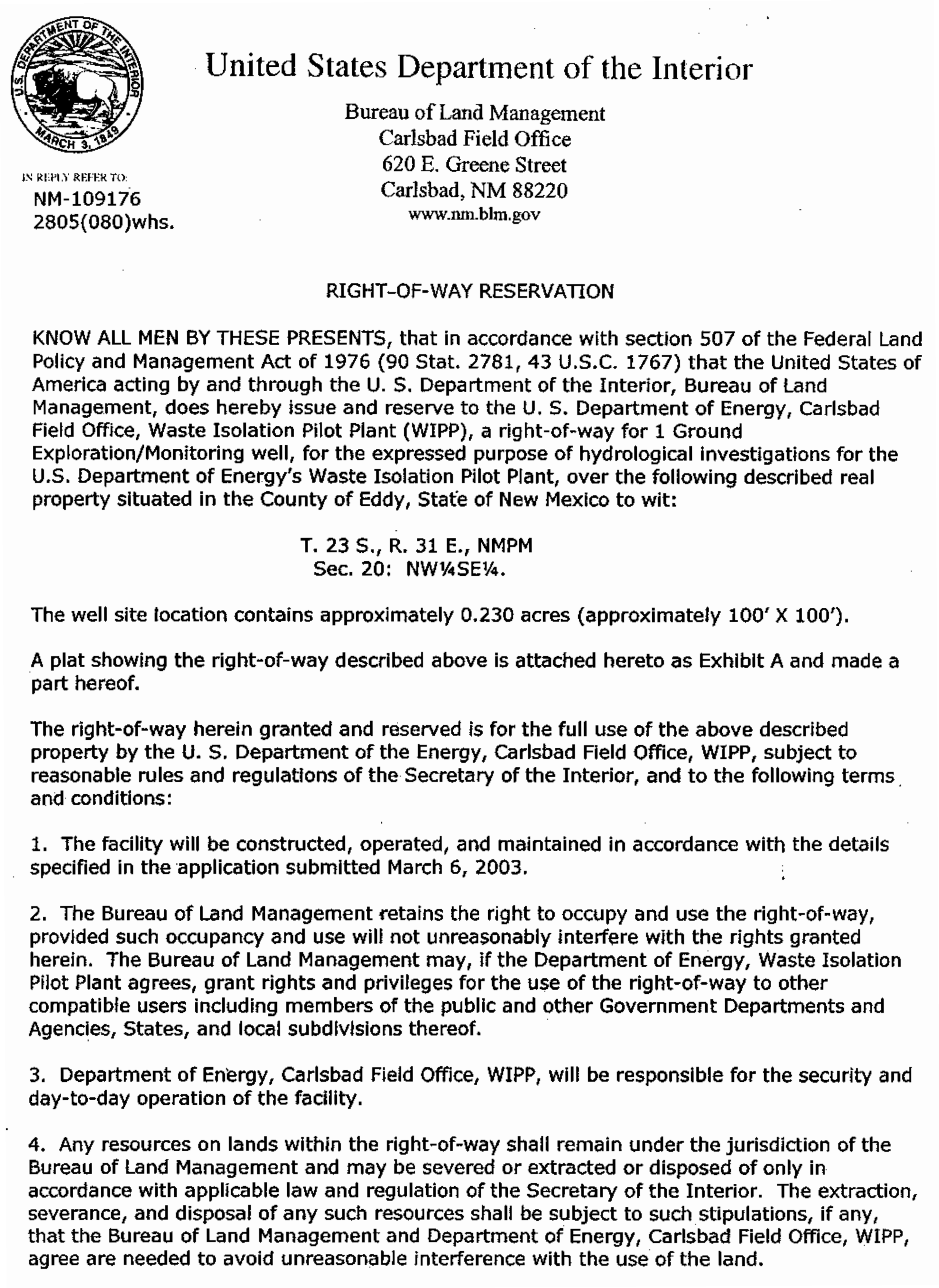
Raymond Federwisch (l) explains logging procedures to Sandia National Laboratories interns Tesha Roberts (c) and Mike McKenna (r).

Appendix E
Permitting and Completion Information

A case file for SNL-12 (C-2954) containing official documents is maintained by the land management coordinator of the Environmental Monitoring and Hydrology Section (of WRES) for the WIPP Project. Selected documents are reproduced here for ease of access. Originals have been reduced to fit page formats.

As noted in the text, all official correspondence concerning permitting and regulatory matters should refer to the New Mexico State Engineer permit number, C-2954.

Information on management of well-drilling wastes for SNL-12 is included at the end of this appendix. Original files are maintained by WRES.



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-109176
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. 23 S., R. 31 E., NMPM
Sec. 20: NW¼SE¼.

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.

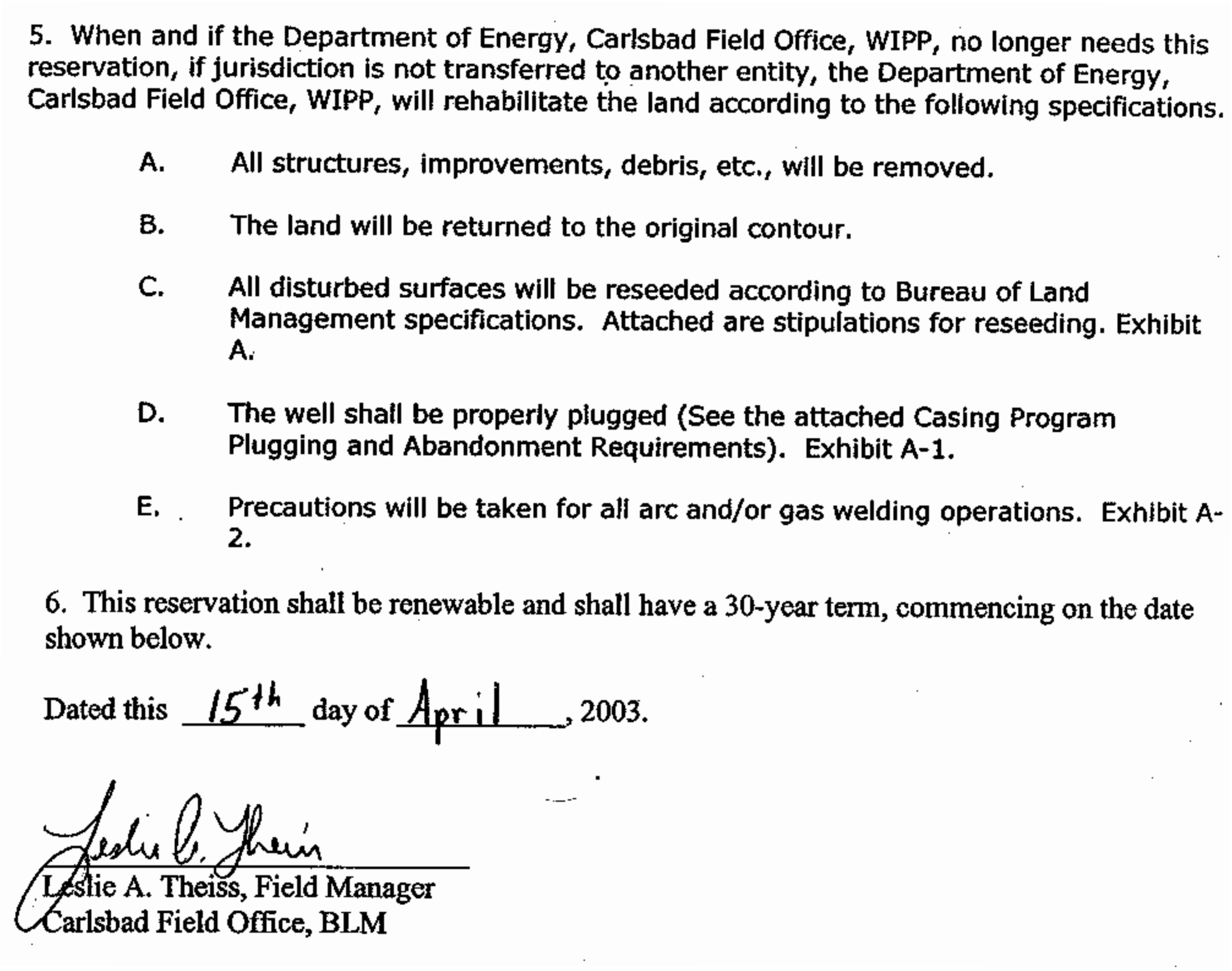
The right-of-way herein granted and reserved is for the full use of the above described property by the U. S. Department of the Energy, Carlsbad Field Office, WIPP, subject to reasonable rules and regulations of the Secretary of the Interior, and to the following terms and conditions:

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

EXHIBIT A
April 15, 2003

BLM Serial No.: NM-109176
Company Reference: SNL-12

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-109176

Casing / Plugging & Abandonment Requirements

(1) Casing Program

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

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

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

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

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

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

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

(2) Plugging and Abandonment

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

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

NM-109176
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:

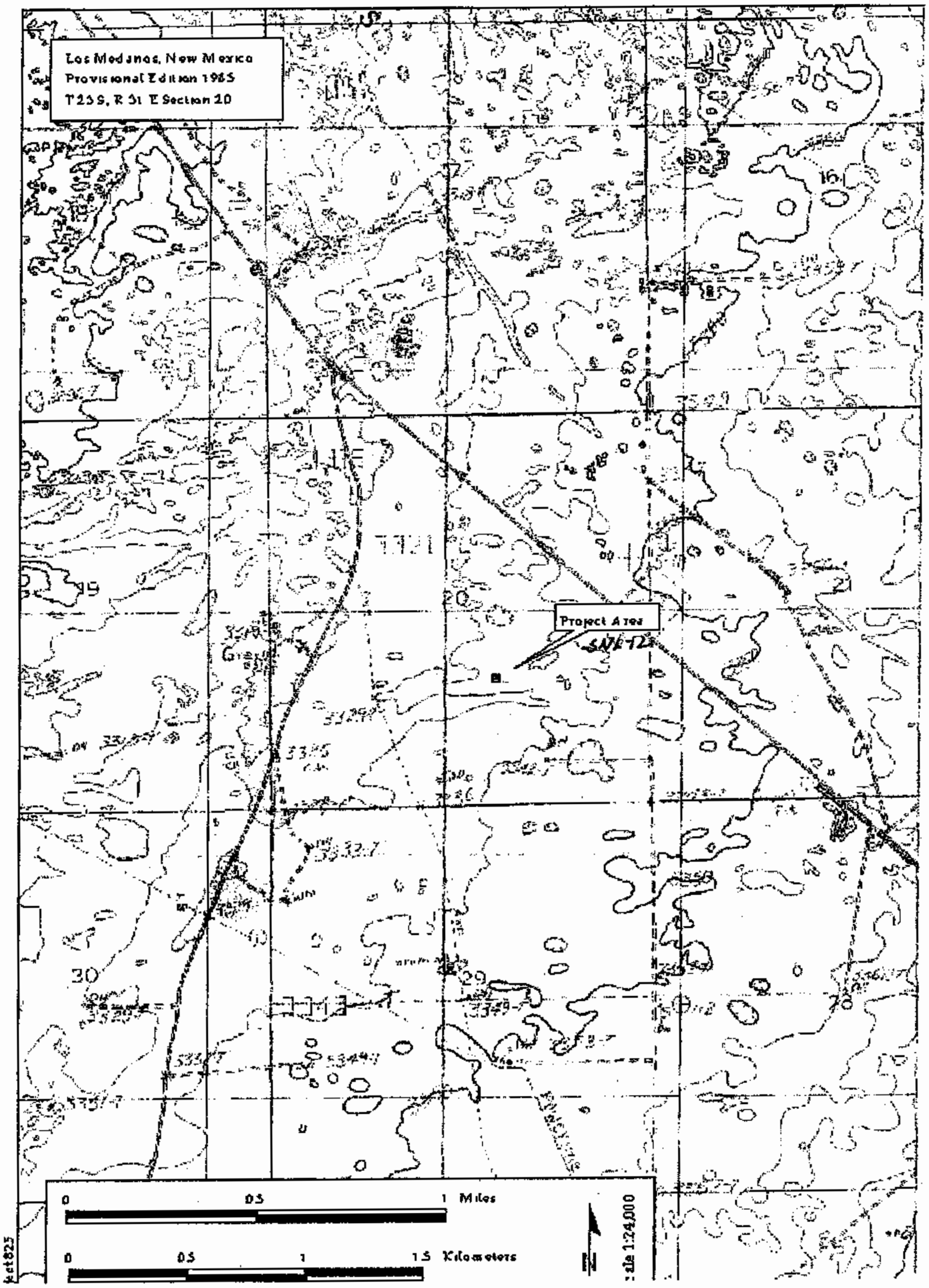
Five (5) gallons of water and/or;
A five (5) pound multi-purpose dry fire extinguisher and a round point shovel.

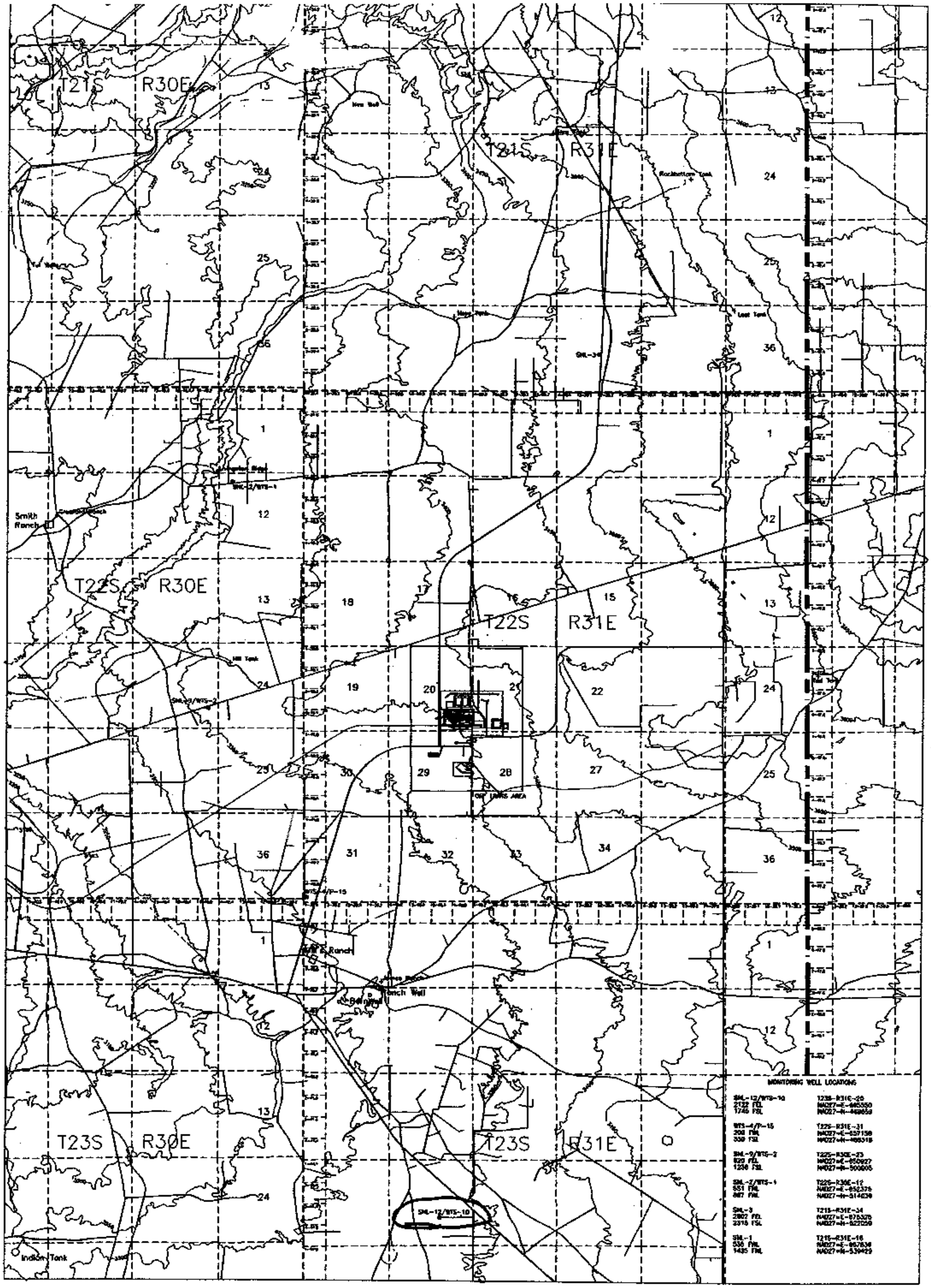
3. After welding/cutting activities are completed, a routine return to the site will be required within 1 hour after the completion of the activity to check for any potential hot material that may start a wildland fire.

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.

NM-109176

Survey for the SNL-12/WTS-10 Water Monitoring Well




T21S R30E
13
24
25
36
T21S R31E
New Well
Rockbottom Tank
Lost Tank
SNL-3
1
12
13
24
25
36
Smith Ranch
SNL-2/WTS-1
T22S R30E
13
18
17
16
15
T22S R31E
Hill Tank
SNL-9/WTS-2
19
20
21
22
24
25
30
29
28
27
36
31
32
33
34
WTS-4/P-15
1
Ranch Well
12
13
24
T23S R30E
T23S R31E
SNL-12/WTS-10
Indian Tank
MONITORING WELL LOCATIONS
SNL-12/WTS-10
2122 FEL
1745 FSL
T23S-R31E-20
NAD27-E-665350
NAD27-N-469659
WTS-4/P-15
200 FNL
330 FSL
T22S-R31E-31
NAD27-E-657158
NAD27-N-486318
SNL-9/WTS-2
820 FEL
1230 FSL
T22S-R30E-23
NAD27-E-650927
NAD27-N-500005
SNL-2/WTS-1
551 FNL
867 FWL
T22S-R30E-12
NAD27-E-652376
NAD27-N-514030
SNL-3
2802 FEL
2318 FSL
T21S-R31E-34
NAD27-E-675326
NAD27-N-522050
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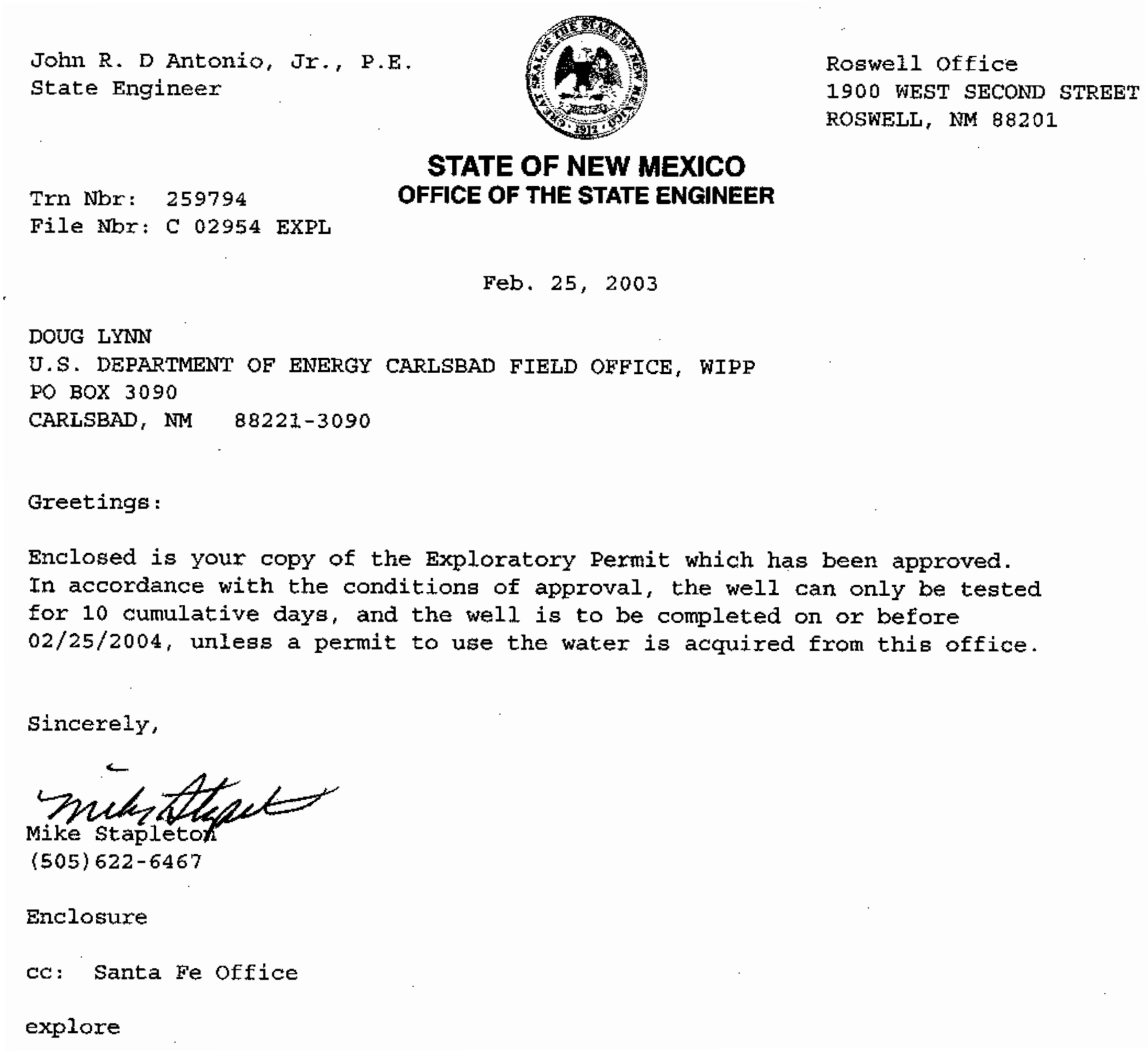
NAD27-N-539429



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

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

1912

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 259794
File Nbr: C 02954 EXPL

Feb. 25, 2003

DOUG LYNN
U.S. DEPARTMENT 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 02/25/2004, unless a permit to use the water is acquired from this office.

Sincerely,

Mike Stapleton
(505)622-6467

Enclosure

cc: Santa Fe Office

explore

SNL-12

Revised August 1967

IMPORTANT - READ INSTRUCTIONS ON BACK BEFORE FILLING OUT THIS FORM

APPLICATION FOR PERMIT

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

2003 FEB 24 AM 9:06
STATE ENGINEER OFFICE
ROSWELL, NEW MEXICO

Date Received February 24, 2003 File No. C-2954 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 SW. 1/4 NW 1/4 SE 1/4, Section 20 Township 23 South Range 31 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Carlsbad, District, on land owned by State of New Mexico - See Attached Plat of Survey

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 795' bgs feet;

5. Quantity of water to be appropriated and beneficially used N/A (Consumptive use, diversion) acre feet, 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 795' bgs. in order to acquire core samples from Marker Bed 103. After core sample acquisition, the well will be cemented back to the Culebra Dolomite interval @475'-495' 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).

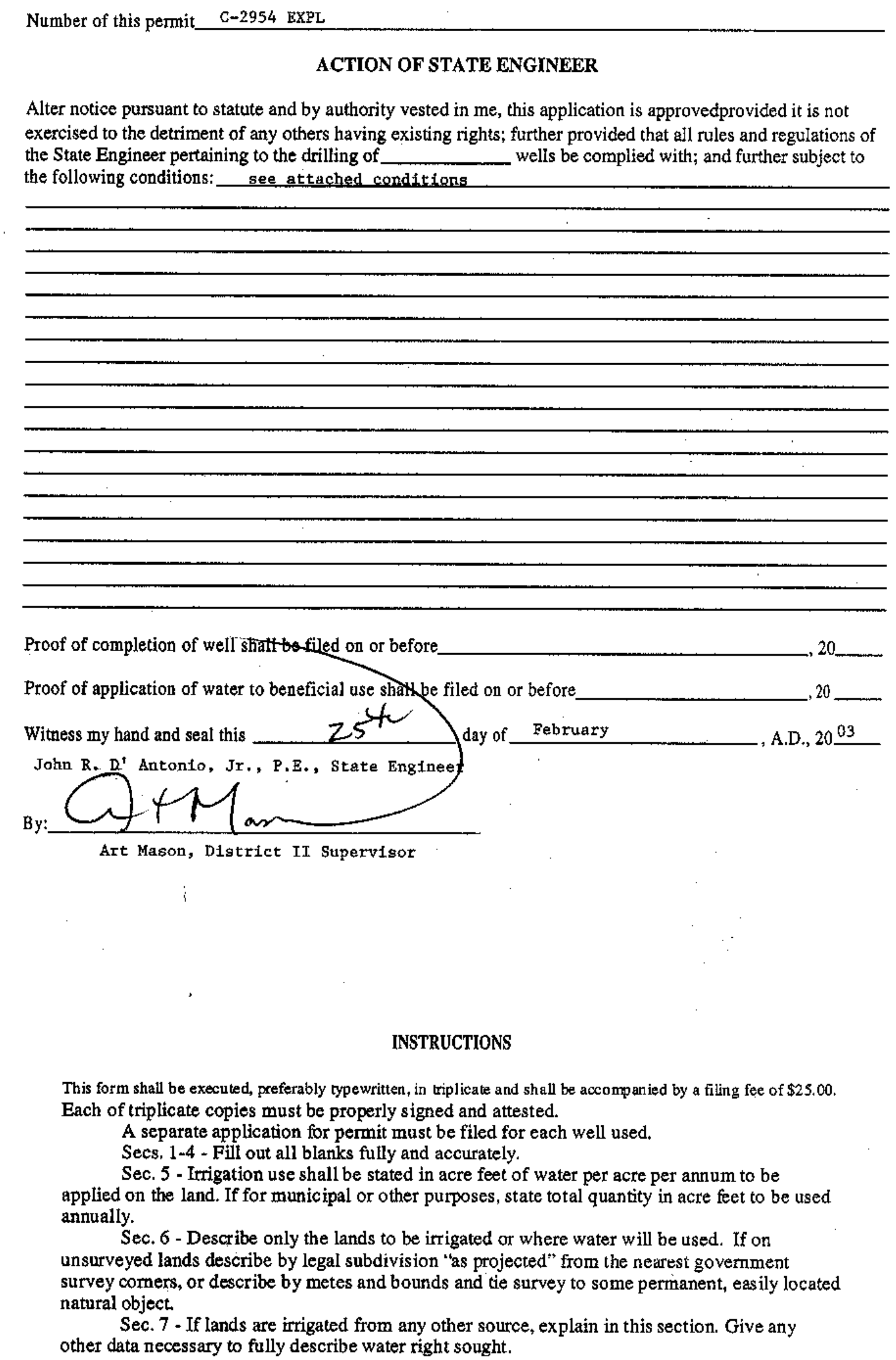
I, Harold Johnson, affirm that the foregoing statements are true to the best of my knowledge and belief and that development shall not commence until approval of the permit has been obtained.

U.S. Department of Energy, Permittee,

By: Harold Johnson

Subscribed and sworn to before me this 24th day of Feb A.D., 2003

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



Number of this permit C-2954 EXPL

ACTION OF STATE ENGINEER

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

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 25th day of February, A.D., 2003

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

By: ______________________

Art Mason, District II Supervisor

INSTRUCTIONS

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

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

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

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

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

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 02954 EXPL must be completed and the Well Log filed on or before 02/25/2004.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd:
Formal Application Rcvd: 02/24/2003
Date Returned - Correction:

Date Rcvd. Corrected:
Pub. of Notice Ordered:
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 25 day of Feb A.D., 2003

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

By: AHMason
Art Mason

Trn Desc: C 02954 EXPL

File Number: C 02954
Trn Number: 259794

page: 1

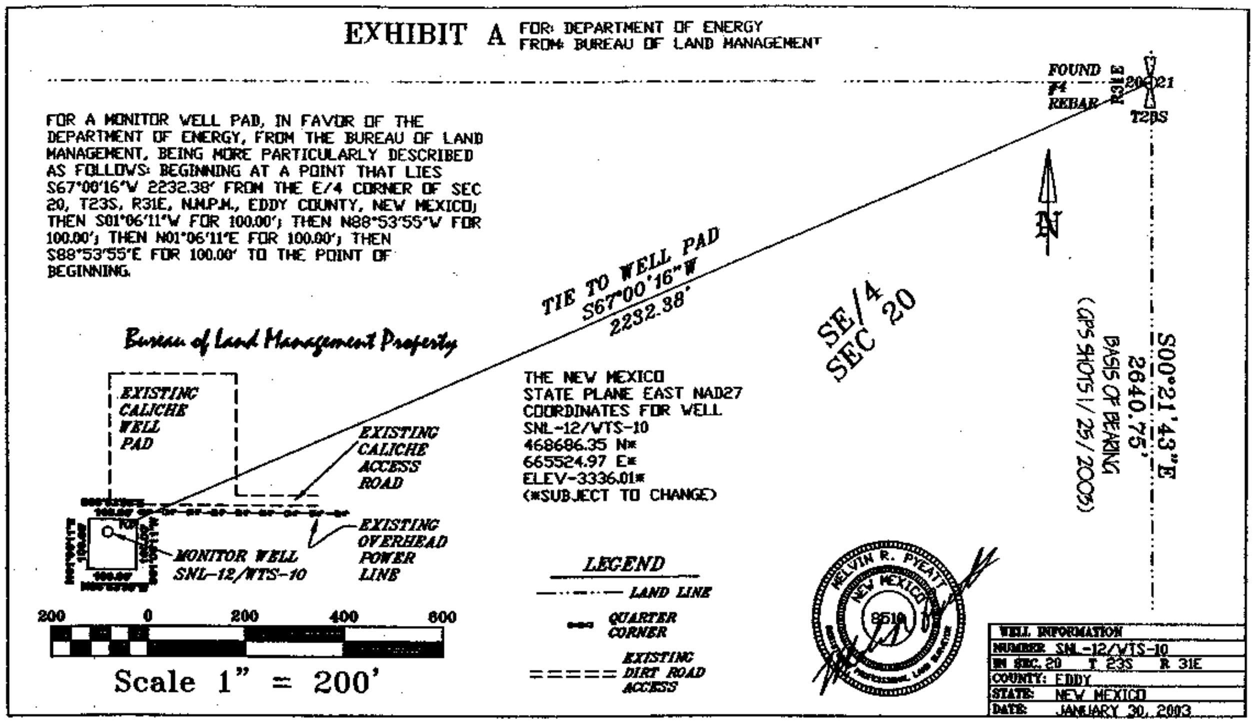


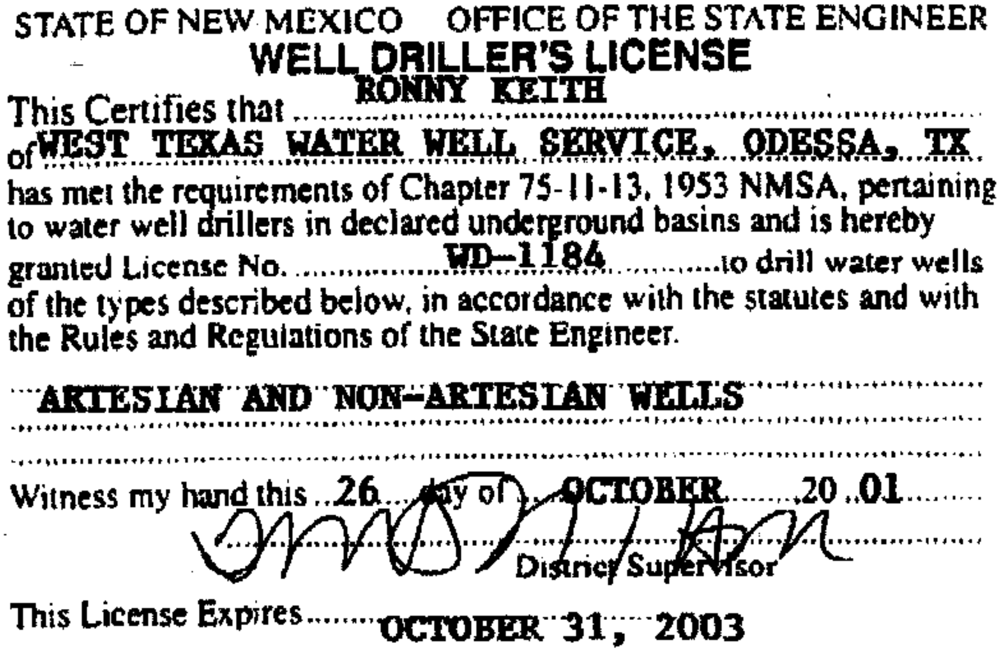
EXHIBIT A FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT

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 S67°00'16"W 2232.38' FROM THE E/4 CORNER OF SEC 20, T23S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN S01°06'11"W FOR 100.00'; THEN N88°53'55"W FOR 100.00'; THEN N01°06'11"E FOR 100.00'; THEN S88°53'55"E FOR 100.00' TO THE POINT OF BEGINNING.

THE NEW MEXICO
STATE PLANE EAST NAD27
COORDINATES FOR WELL
SNL-12/WTS-10
468686.35 N*
665524.97 E*
ELEV-3336.01*
(*SUBJECT TO CHANGE)

WELL INFORMATION	
NUMBER	SNL-12/WTS-10
IN SEC. 20	T 23S R 31E
COUNTY:	EDDY
STATE:	NEW MEXICO
DATE:	JANUARY 30, 2003

Scale 1" = 200'



STATE OF NEW MEXICO OFFICE OF THE STATE ENGINEER

WELL DRILLER'S LICENSE

This Certifies that **RONNY KEITH**

of **WEST TEXAS WATER WELL SERVICE, ODESSA, TX**

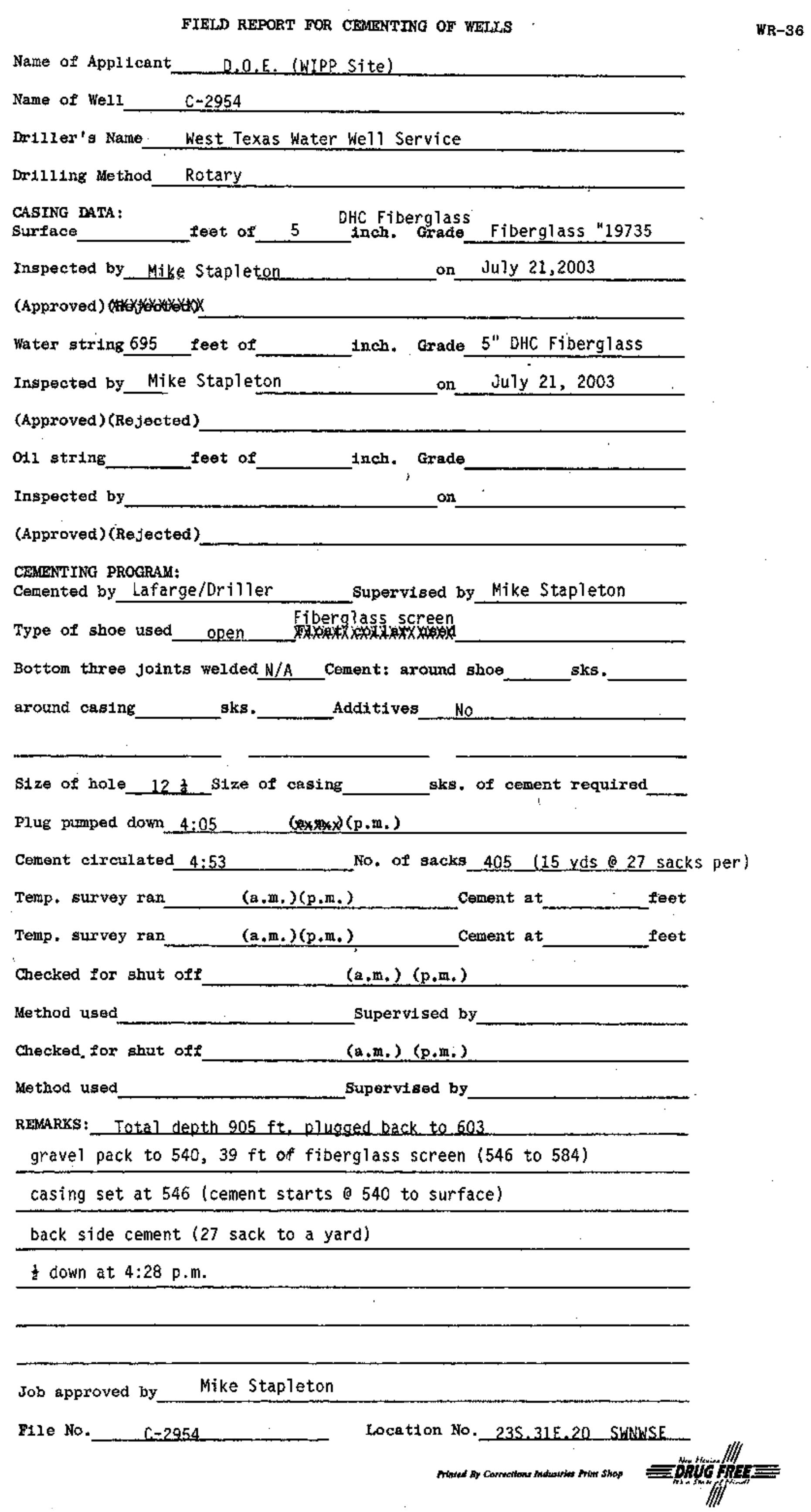
has met the requirements of Chapter 75-11-13, 1953 NMSA, pertaining to water well drillers in declared underground basins and is hereby granted License No. **WD-1184** to drill water wells of the types described below, in accordance with the statutes and with the Rules and Regulations of the State Engineer.

ARTESIAN AND NON-ARTESIAN WELLS

Witness my hand this 26 day of OCTOBER 20 01

District Supervisor

This License Expires **OCTOBER 31, 2003**



FIELD REPORT FOR CEMENTING OF WELLS **WR-36**

Name of Applicant D.O.E. (WIPP Site)

Name of Well C-2954

Driller's Name West Texas Water Well Service

Drilling Method Rotary

CASING DATA:

Surface ____ feet of 5 inch. DHC Fiberglass Grade Fiberglass "19735

Inspected by Mike Stapleton on July 21,2003

(Approved)~~(Rejected)~~

Water string 695 feet of ____ inch. Grade 5" DHC Fiberglass

Inspected by Mike Stapleton on July 21, 2003

(Approved)(Rejected)

Oil string ____ feet of ____ inch. Grade ____

Inspected by ____ on ____

(Approved)(Rejected)

CEMENTING PROGRAM:

Cemented by Lafarge/Driller Supervised by Mike Stapleton

Type of shoe used open Fiberglass screen ~~Float collar used~~

Bottom three joints welded N/A Cement: around shoe ____ sks. ____

around casing ____ sks. ____ Additives No

Size of hole 12 ¼ Size of casing ____ sks. of cement required ____

Plug pumped down 4:05 ~~(a.m.)~~(p.m.)

Cement circulated 4:53 No. of sacks 405 (15 yds @ 27 sacks per)

Temp. survey ran ____ (a.m.)(p.m.) ____ Cement at ____ feet

Temp. survey ran ____ (a.m.)(p.m.) ____ Cement at ____ feet

Checked for shut off ____ (a.m.) (p.m.)

Method used ____ Supervised by ____

Checked for shut off ____ (a.m.) (p.m.)

Method used ____ Supervised by ____

REMARKS: Total depth 905 ft. plugged back to 603

gravel pack to 540, 39 ft of fiberglass screen (546 to 584)

casing set at 546 (cement starts @ 540 to surface)

back side cement (27 sack to a yard)

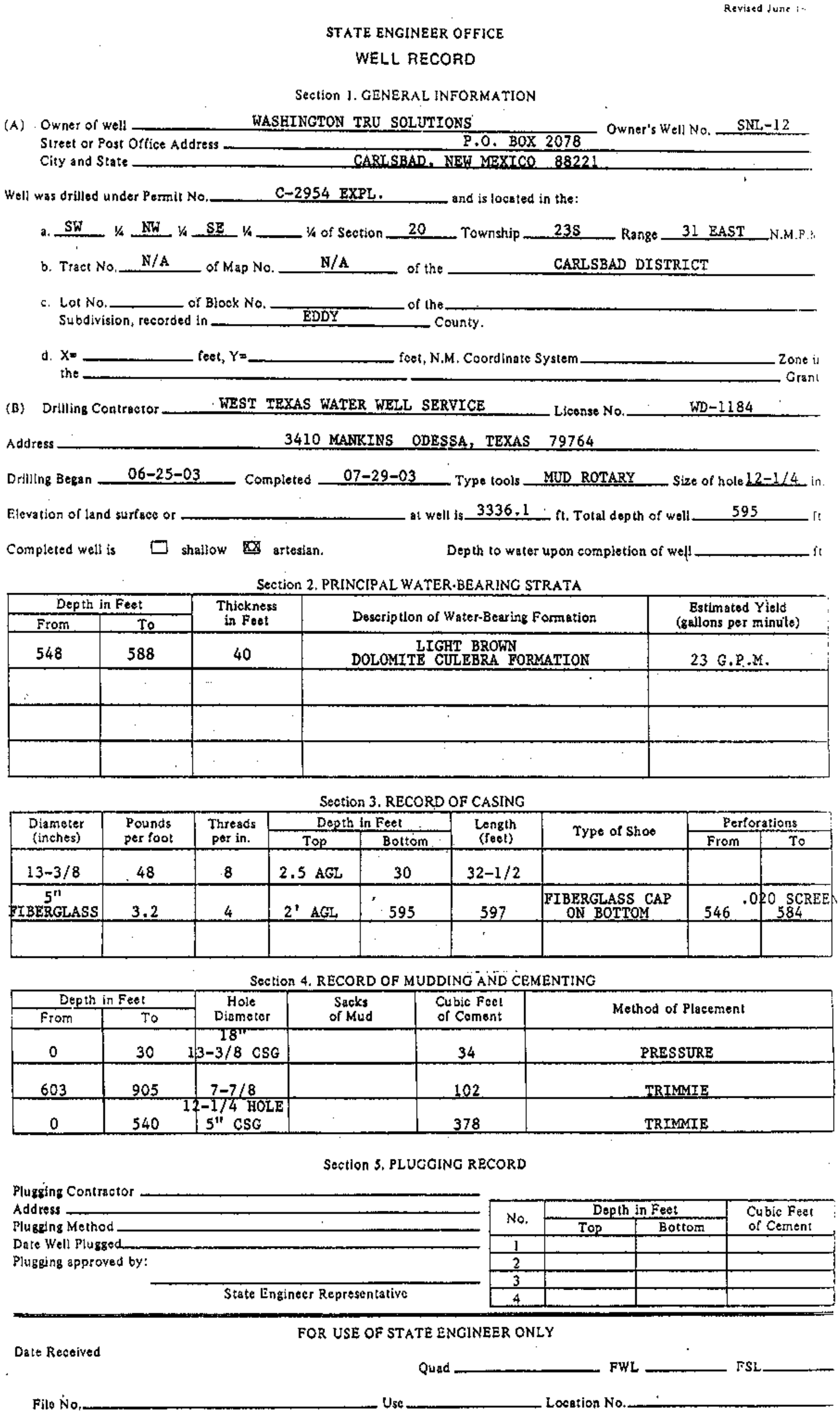
½ down at 4:28 p.m.

Job approved by Mike Stapleton

File No. C-2954 Location No. 23S.31E.20 SWNWSE

Printed By Corrections Industries Print Shop

New Mexico DRUG FREE It's a State of Mind!



Revised June

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-12
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C-2954 EXPL. and is located in the:

a. SW ¼ NW ¼ SE ¼ ______ ¼ of Section 20 Township 23S Range 31 EAST N.M.P.

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

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

d. X= ______ feet, Y= ______ feet, N.M. Coordinate System ______ Zone i
the ______ Grant

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

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 06-25-03 Completed 07-29-03 Type tools MUD ROTARY Size of hole 12-1/4 in.

Elevation of land surface or ______ at well is 3336.1 ft. Total depth of well 595 ft

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

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
From	To			
548	588	40	LIGHT BROWN DOLOMITE CULEBRA FORMATION	23 G.P.M.

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet		Length (feet)	Type of Shoe	Perforations	
			Top	Bottom			From	To
13-3/8	48	8	2.5 AGL	30	32-1/2			
5" FIBERGLASS	3.2	4	2' AGL	595	597	FIBERGLASS CAP ON BOTTOM	546	.020 SCREE 584

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
From	To				
0	30	18" 13-3/8 CSG		34	PRESSURE
603	905	7-7/8		102	TRIMMIE
0	540	12-1/4 HOLE 5" CSG		378	TRIMMIE

Section 5. PLUGGING RECORD

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

______
State Engineer Representative

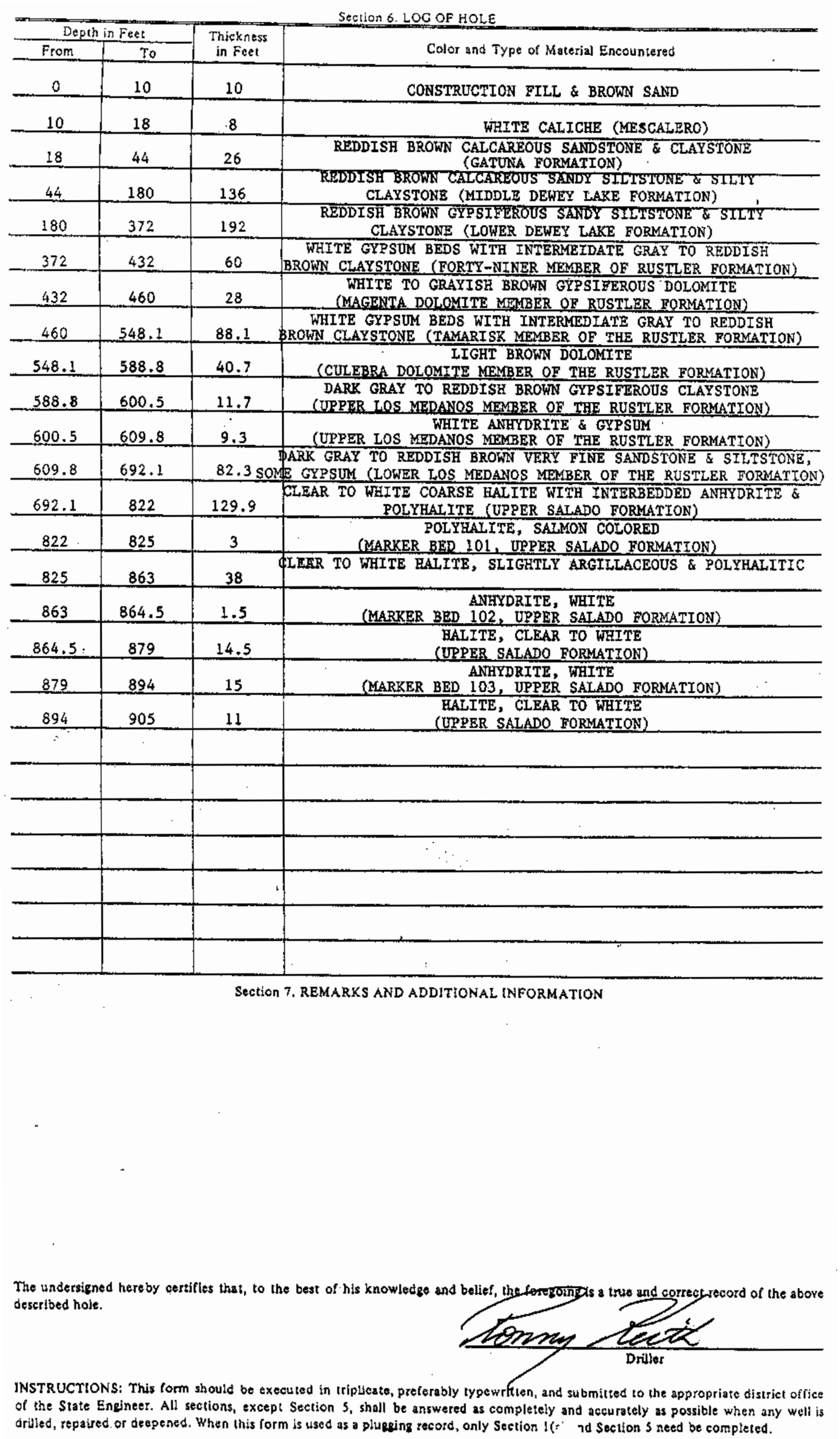
No.	Depth in Feet		Cubic Feet of Cement
	Top	Bottom	
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad ______ FWL ______ FSL ______

File No. ______ Use ______ Location No. ______



Section 6. LOG OF HOLE

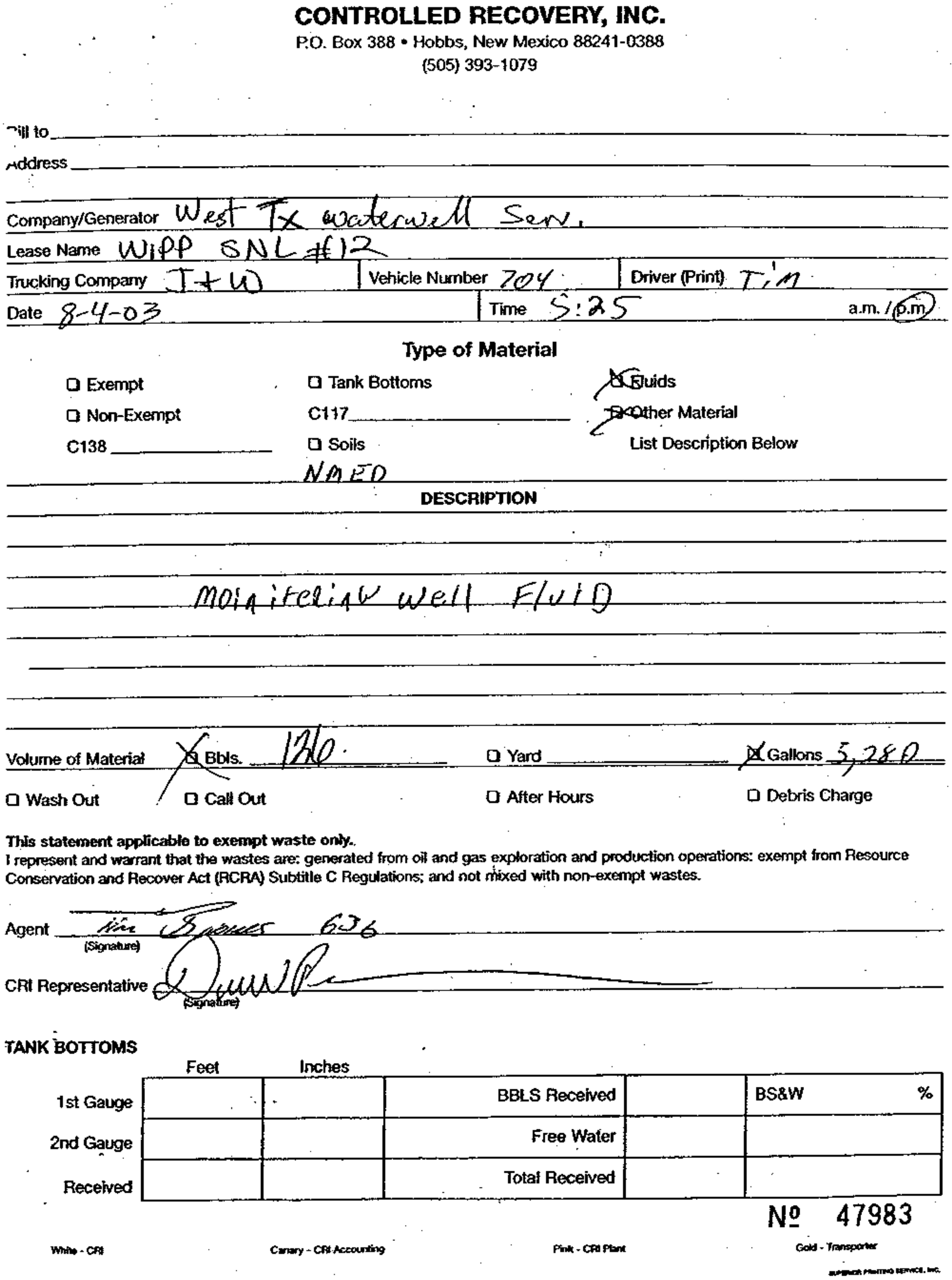
Depth in Feet		Thickness in Feet	Color and Type of Material Encountered
From	To		
0	10	10	CONSTRUCTION FILL & BROWN SAND
10	18	8	WHITE CALICHE (MESCALERO)
18	44	26	REDDISH BROWN CALCAREOUS SANDSTONE & CLAYSTONE (GATUNA FORMATION)
44	180	136	REDDISH BROWN CALCAREOUS SANDY SILTSTONE & SILTY CLAYSTONE (MIDDLE DEWEY LAKE FORMATION)
180	372	192	REDDISH BROWN GYPSIFEROUS SANDY SILTSTONE & SILTY CLAYSTONE (LOWER DEWEY LAKE FORMATION)
372	432	60	WHITE GYPSUM BEDS WITH INTERMEIDATE GRAY TO REDDISH BROWN CLAYSTONE (FORTY-NINER MEMBER OF RUSTLER FORMATION)
432	460	28	WHITE TO GRAYISH BROWN GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
460	548.1	88.1	WHITE GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE (TAMARISK MEMBER OF THE RUSTLER FORMATION)
548.1	588.8	40.7	LIGHT BROWN DOLOMITE (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
588.8	600.5	11.7	DARK GRAY TO REDDISH BROWN GYPSIFEROUS CLAYSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
600.5	609.8	9.3	WHITE ANHYDRITE & GYPSUM (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
609.8	692.1	82.3	DARK GRAY TO REDDISH BROWN VERY FINE SANDSTONE & SILTSTONE, SOME GYPSUM (LOWER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
692.1	822	129.9	CLEAR TO WHITE COARSE HALITE WITH INTERBEDDED ANHYDRITE & POLYHALITE (UPPER SALADO FORMATION)
822	825	3	POLYHALITE, SALMON COLORED (MARKER BED 101, UPPER SALADO FORMATION)
825	863	38	CLEAR TO WHITE HALITE, SLIGHTLY ARGILLACEOUS & POLYHALITIC
863	864.5	1.5	ANHYDRITE, WHITE (MARKER BED 102, UPPER SALADO FORMATION)
864.5	879	14.5	HALITE, CLEAR TO WHITE (UPPER SALADO FORMATION)
879	894	15	ANHYDRITE, WHITE (MARKER BED 103, UPPER SALADO FORMATION)
894	905	11	HALITE, CLEAR TO WHITE (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.

Driller

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



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

Bill to ______
Address ______

Company/Generator West Tx waterwell Serv.
Lease Name WIPP SNL #12
Trucking Company J+W | Vehicle Number 704 | Driver (Print) Tim
Date 8-4-03 | Time 5:25 a.m. / [✓ p.m.]

Type of Material

☐ Exempt
☐ Non-Exempt
C138 ______

☐ Tank Bottoms
C117 ______
☐ Soils

☒ Fluids
☒ Other Material
List Description Below

NMED

DESCRIPTION

Moinitering well Fluid

Volume of Material ☒ Bbls. 126. ☐ Yard ______ ☒ Gallons 5,280

☐ 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 Tim Barnes 636
(Signature)

CRI Representative
(Signature)

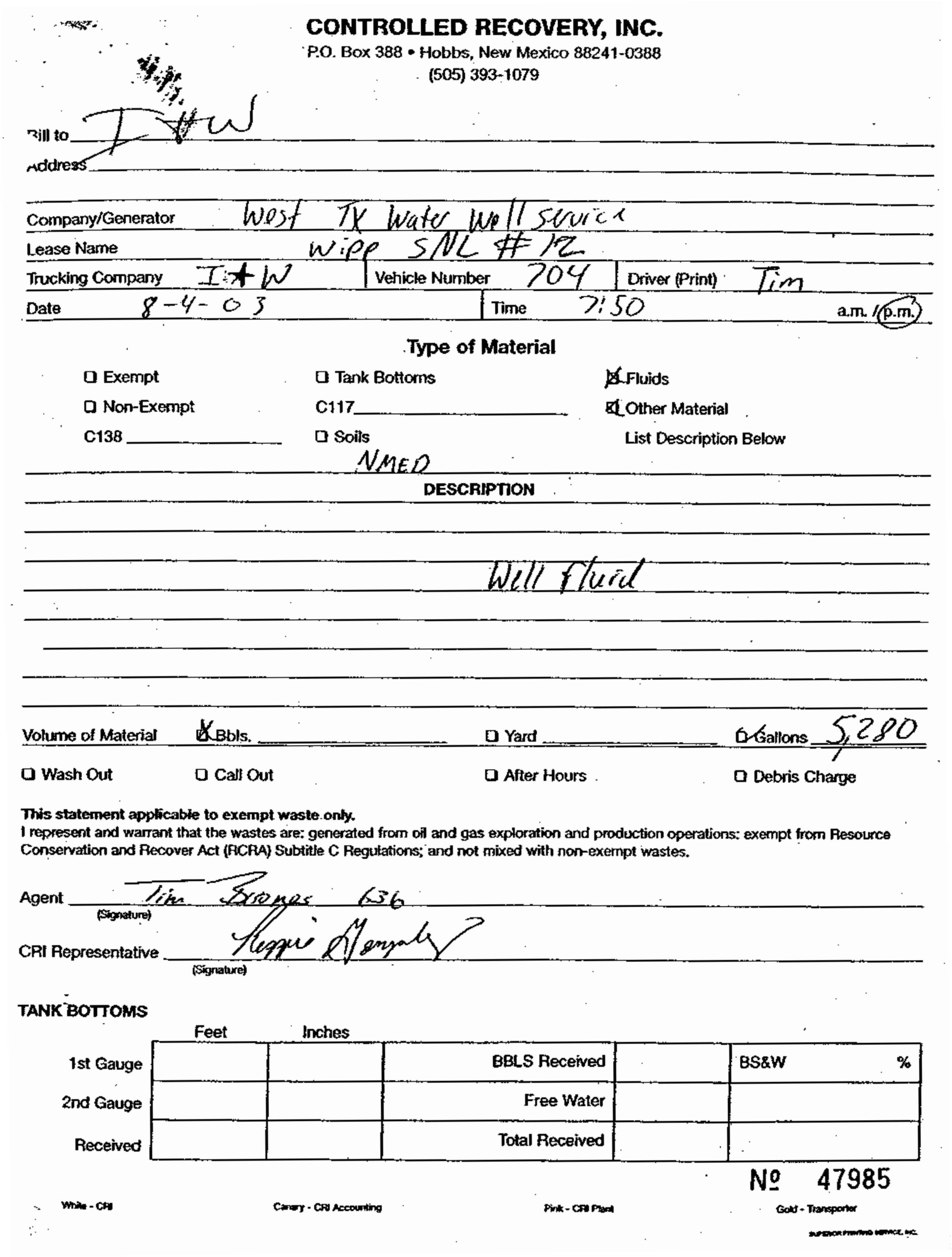
TANK BOTTOMS

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

№ 47983

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

SUPERIOR PRINTING SERVICE, INC.



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

Bill to I+W

Address

Company/Generator West TX Water Well Service

Lease Name WIPP SNL #12

Trucking Company I+W | Vehicle Number 704 | Driver (Print) Tim

Date 8-4-03 | Time 7:50 a.m. / [✓ p.m.]

Type of Material

☐ Exempt ☐ Tank Bottoms ☒ Fluids

☐ Non-Exempt C117 ☒ Other Material

C138 ☐ Soils List Description Below

NMED

DESCRIPTION

Well Fluid

Volume of Material ☒ Bbls. ☐ Yard ☒ Gallons 5,280

☐ 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 Tim Brones 636
(Signature)

CRI Representative Reggie Gonzales
(Signature)

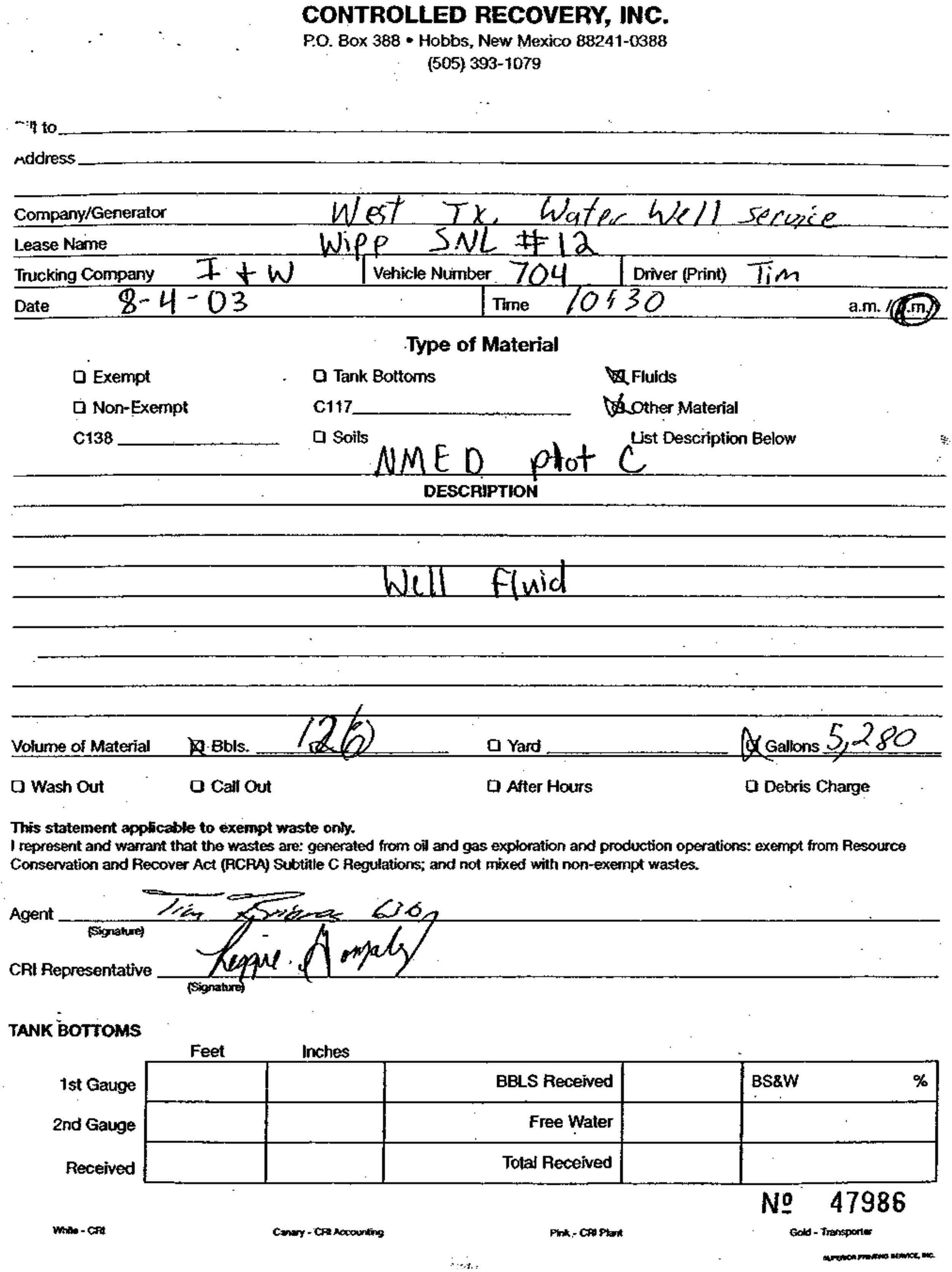
TANK BOTTOMS

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

№ 47985

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

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 Tx. Water Well service
Lease Name Wipp SNL #12
Trucking Company I + W | Vehicle Number 704 | Driver (Print) Tim
Date 8-4-03 | Time 10:30 a.m. / [✓ p.m.]

Type of Material

☐ Exempt
☐ Non-Exempt
C138 ______

☐ Tank Bottoms
C117 ______
☐ Soils

☒ Fluids
☒ Other Material
List Description Below

NMED plot C

DESCRIPTION

Well fluid

Volume of Material ☒ Bbls. 126 ☐ Yard ______ ☒ Gallons 5,280

☐ 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 Tim
(Signature)

CRI Representative Reggie
(Signature)

TANK BOTTOMS

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

№ 47986

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

SUPERIOR PRINTING SERVICE, INC.

Dennis W. Powers, Ph. D.
Consulting Geologist

July 28, 2003

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-12

Our discussions regarding the Culebra Dolomite Member in SNL-12 indicate that the best interval to screen is from 584-546 ft below the top of the permanent conductor casing. This decision is based on geophysical logs completed on July 14, 2003 (see attached figure).

These are the factors we considered in this decision for SNL-12:

- The Culebra interval, as indicated by the natural gamma geophysical log, is from 587-547 ft below the top of the temporary conductor casing. This interval is 40 ft thick, which is more than the average around the WIPP site. Recovered cores from the Culebra also show a consistent depth and thickness for the Culebra.
- The screened or slotted section of a single casing joint is ~ 27 ft long. A shorter slotted casing, about 10 ft long, added to the longer joint provides a total screened interval of ~ 38 ft. This will provide a screened interval that will incorporate all but the base of the Culebra.
- The core, although incomplete below the Culebra, indicated that the laminated claystone immediately underlying the Culebra behaves somewhat 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 ~ 11 ft.
- There is no indication of halite in the mudstone unit (M-2) below the Culebra and above the anhydrite (A-1) about 13 ft below the Culebra.

By placing the bottom of the screened interval 584 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 546 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. It can range from about 545–540 ft below the conductor casing top.

To provide adequate space below the screened interval for pumping, a minimum 10 ft long blank casing should be added below the screened casing. 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 600–608 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-12.

I believe this letter summarizes our discussions and presents the hydrological and geological justification for setting the screened interval and preparing SNL-12 for completion.

Sincerely,

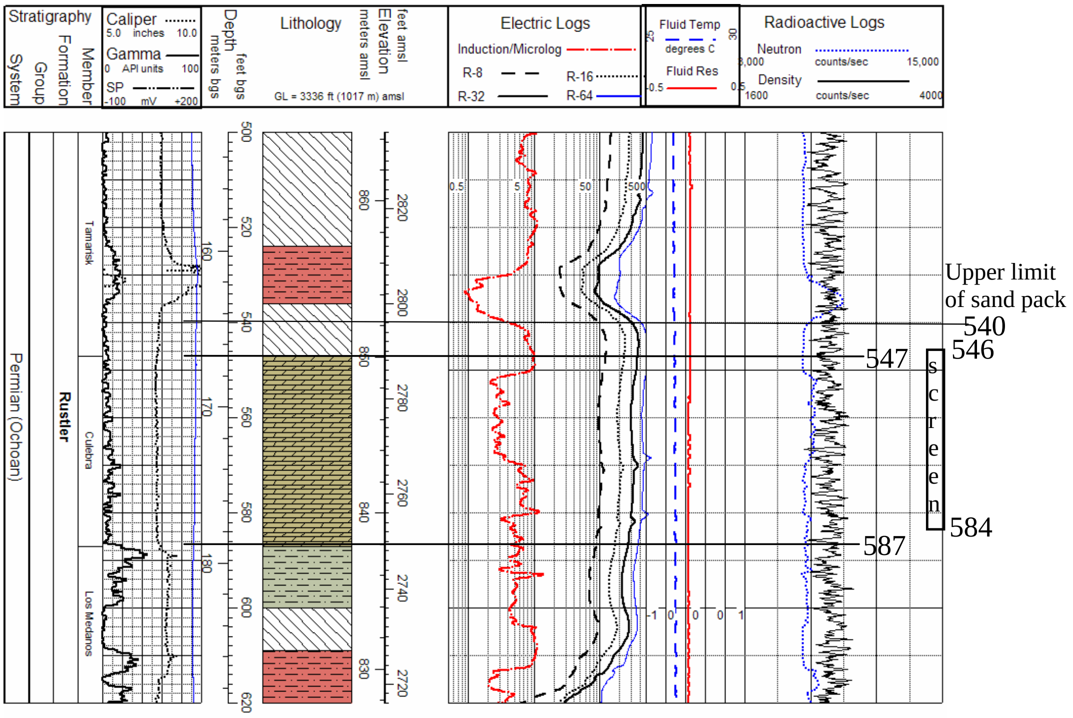
Dennis W Powers

Dennis W. Powers

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

Dennis W. Powers, Ph. D.
Consulting Geologist

Partial Geophysical Log of SNL-12



Dennis W. Powers, Ph. D.
Consulting Geologist

July 14, 2003

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-12

Background

Cores and cutting samples have been collected from drillhole SNL-12 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me and other WRES personnel. SNL-12 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-12 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-12 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-12 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-12.

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*

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 the land management coordinator, Environmental Monitoring and Hydrology Section (of WRES) 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.: 82099

4. Title of Report (Project Title): An Archaeological Survey for a the SNL-12/WTS-10 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 – 825

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 23S, R 31E, Section 20: SW¼ NW¼ 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): No previously recorded archaeological sites are within 0.25 miles of the project area.

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 200ft area was surveyed to ensure the protection of cultural resources. The pad is located just off an existing well pad. The small corridor between the existing well pad and proposed pad was covered under the 50 ft wide buffer surrounding the pad. This area will serve as access to the pad.

c. Environmental Setting (NRCS soil designation, vegetative community, etc.): The project is located on a plain with reddish brown sand of the Kermit-Berino soil association as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Project elevations average 3,335 ft above mean sea level. Local vegetation is characteristic of Chihuahuan Desert Scrub and includes mesquite, yucca, bunch grasses, and noxious weeds. Due to this vegetative cover, ground surface visibility averaged 70 percent.

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

15. Cultural Resource Findings: No cultural resources were observed within the project area.
Identification and Description (location shown on project map):

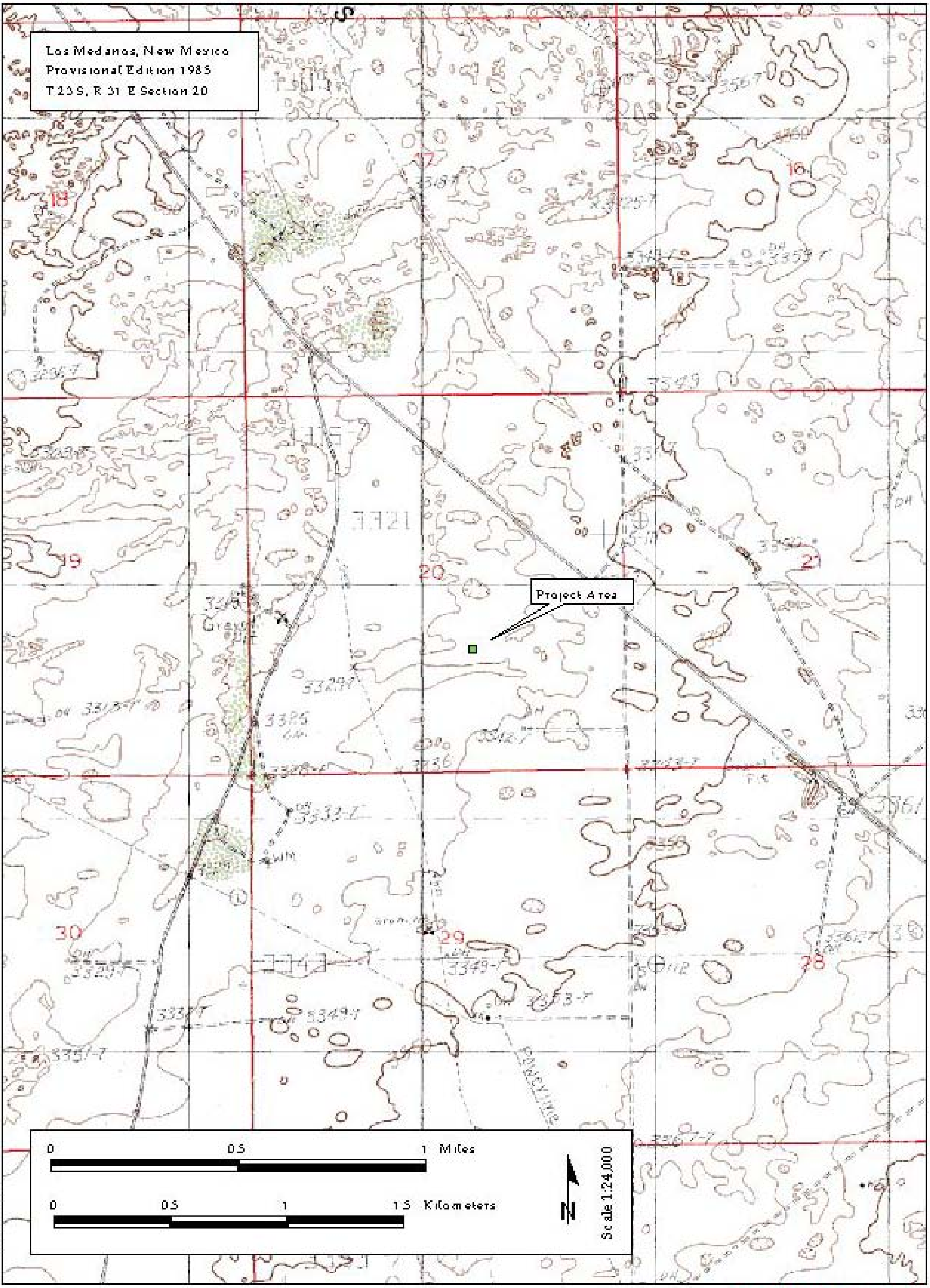
16. Management Summary (recommendations): Because no cultural material was encountered archaeological clearance is recommended for the project area as staked. If any cultural material is encountered during construction activities, work at that location should stop and archaeologists at the BLM-CFO should 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-12/WTS-10 Water Monitoring Well



Project825

Figure 1. Project Area Map

Mesa Field Services

Appendix G

Photograph Logs

Digital photographs were taken of the cores from SNL-12. 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. Cores are marked with depths and with arrows that point down, in the direction the drillhole is advancing. A CD-ROM with these images (jpeg format) is being archived, and a copy with photographic log is maintained by Geotechnical Engineering (of WTS) with records of the cores stored for WIPP.

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-12_Core001.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 425.0 - 426.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core002.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 425.9 - 427.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core003.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 426.6 - 428.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core004.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 427.9 - 429.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core005.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 429.2 - 430.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core006.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 429.8 - 431.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core007.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 430.5 - 432.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core008.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner Mbr core, 431.5 - 433.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core009.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Forty-niner / Magenta Dolomite Mbrs core, 432.5 - 434.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core010.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 433.5 - 435.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core011.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 434.6 - 436.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core012.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 436.0 - 437.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core013.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 436.8 - 438.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core014.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 437.8 - 439.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core015.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 438.8 - 440.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core016.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 439.8 - 441.3 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 15**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-12_Core017.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 440.7 - 442.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core018.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 441.6 - 443.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core019.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 442.7 - 444.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core020.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 443.7 - 445.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core021.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	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-12_Core022.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	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-12_Core023.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 446.8 - 448.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core024.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	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-12_Core025.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 448.8 - 450.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core026.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 449.8 - 451.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core027.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 450.8 - 452.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core028.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 451.8 - 453.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core029.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 452.7 - 454.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core030.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 454.0 - 455.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core031.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 454.7 - 456.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core032.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 455.7 - 457.0 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 15**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-12_Core033.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 456.8 - 458.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core034.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 457.8 - 459.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core035.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite Mbr core, 458.8 - 460.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core036.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Magenta Dolomite / Tamarisk Mbrs core, 459.7 - 461.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core037.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 460.9 - 462.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core038.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 461.8 - 463.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core039.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 462.8 - 464.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core040.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 463.8 - 465.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core041.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 464.9 - 466.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core042.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 465.8 - 467.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core043.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 466.8 - 468.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core044.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 467.8 - 469.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core045.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 468.8 - 470.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core046.jpg	7-08-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 469.4 - 470.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core047.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 520.0 - 521.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core048.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 520.8 - 522.1 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-12_Core049.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 521.8 - 523.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core050.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 522.9 - 524.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core051.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3) Mbr core, 523.8 - 525.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core052.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A3 to M3/H3) Mbr core, 524.8 - 526.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core053.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 525.8 - 527.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core054.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 526.8 - 528.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core055.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 527.7 - 529.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core056.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 528.8 - 530.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core057.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 529.6 - 530.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core058.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 530.3 - 531.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core059.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 530.8 - 532.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core060.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 531.8 - 533.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core061.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 532.7 - 534.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core062.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 533.8 - 535.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core063.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 534.8 - 536.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core064.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3) Mbr core, 534.9 - 536.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page** 4 **of 15**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-12_Core065.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (M3/H3 to A2) Mbr core, 535.8 - 537.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core066.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 536.7 - 538.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core067.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 537.7 - 539.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core068.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 538.8 - 540.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core069.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 539.8 - 541.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core070.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 540.8 - 542.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core071.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 541.8 - 543.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core072.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 542.8 - 544.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core073.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 543.7 - 545.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core074.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 544.8 - 546.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core075.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 545.8 - 547.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core076.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) Mbr core, 546.7 - 548.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core077.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Tamarisk (A2) and Culebra Dolomite Mbrs core, 547.3 - 548.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core078.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 548.2 - 549.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core079.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 548.7 - 550.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core080.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 549.7 - 551.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page** 5 **of 15**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-12_Core081.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 550.7 - 552.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core082.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 551.7 - 553.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core083.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 552.7 - 554.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core084.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 553.7 - 555.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core085.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 554.7 - 556.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core086.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 555.7 - 557.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core087.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 556.7 - 558.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core088.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 557.6 - 559.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core089.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 558.3 - 559.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core090.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 559.3 - 560.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core091.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 559.7 - 561.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core092.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 560.7 - 562.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core093.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	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-12_Core094.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	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-12_Core095.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 563.7 - 565.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core096.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 564.8 - 566.2 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-12_Core097.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 565.8 - 567.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core098.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 566.7 - 568.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core099.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 567.7 - 569.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core100.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 568.7 - 570.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core101.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 569.8 - 571.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core102.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 570.9 - 572.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core103.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 571.8 - 573.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core104.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 572.8 - 574.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core105.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 573.8 - 575.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core106.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 574.8 - 576.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core107.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 575.8 - 577.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core108.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 576.9 - 578.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core109.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	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-12_Core110.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 578.9 - 580.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core111.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 579.9 - 581.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core112.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 580.9 - 582.0 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-12_Core113.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 582.0 - 583.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core114.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 582.9 - 584.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core115.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 583.8 - 585.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core116.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 584.8 - 586.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core117.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 585.8 - 587.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core118.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite Mbr core, 586.8 - 588.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core119.jpg	7-09-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Culebra Dolomite and Los Medaños (M2/H2) Mbrs core, 587.8 - 589.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core120.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 588.9 - 590.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core121.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 589.9 - 591.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core122.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 590.8 - 592.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core123.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 591.8 - 593.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core124.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 592.8 - 594.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core125.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 593.9 - 595.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core126.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 594.9 - 596.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core127.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 595.8 - 597.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core128.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 596.8 - 598.2 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-12_Core129.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 597.9 - 599.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core130.jpg	7-10-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2) Mbr core, 598.8 - 600.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core131.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M2/H2 & A1) Mbr core, 600.0 - 601.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core132.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 600.9 - 602.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core133.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 601.9 - 603.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core134.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 602.9 - 604.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core135.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 603.8 - 605.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core136.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 604.9 - 606.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core137.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 605.9 - 607.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core138.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 606.8 - 608.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core139.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1) Mbr core, 607.9 - 609.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core140.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (A1 and M1/H1) Mbr core, 608.9 - 610.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core141.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 620.0 - 621.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core142.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 620.9 - 622.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core143.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 621.9 - 623.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core144.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 622.8 - 624.0 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-12_Core145.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 623.9 - 625.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core146.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 624.8 - 626.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core147.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 625.8 - 627.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core148.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 626.8 - 628.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core149.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 627.8 - 629.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core150.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 628.8 - 630.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core151.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 629.8 - 631.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core152.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 630.8 - 632.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core153.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 631.8 - 633.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core154.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 632.8 - 634.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core155.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 633.8 - 635.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core156.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 634.8 - 636.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core157.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 635.9 - 637.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core158.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 636.8 - 638.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core159.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 638.9 - 640.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core160.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 639.9 - 641.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core161.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 640.8 - 642.2 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-12_Core162.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 641.8 - 643.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core163.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 642.8 - 644.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core164.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 643.8 - 645.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core165.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 644.8 - 646.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core166.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 645.8 - 647.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core167.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 646.9 - 648.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core168.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 647.8 - 649.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core169.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 648.8 - 650.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core170.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 649.9 - 651.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core171.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 650.9 - 652.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core172.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 651.8 - 653.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core173.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 652.9 - 654.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core174.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 653.9 - 655.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core175.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 654.9 - 656.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core176.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 655.8 - 657.2 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-12_Core177.jpg	7-11-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 656.8 - 658.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core178.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 672.9 - 674.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core179.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 673.9 - 675.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core180.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 674.8 - 676.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core181.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 675.9 - 677.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core182.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 676.8 - 678.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core183.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 677.8 - 679.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core184.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 678.8 - 680.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core185.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 679.9 - 681.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core186.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 680.8 - 682.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core187.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 681.9 - 683.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core188.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 682.9 - 684.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core189.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 683.8 - 685.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core190.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 684.8 - 686.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core191.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 685.8 - 687.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core192.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 686.8 - 688.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Photograph Log Sheet

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SNL-12_Core193.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 687.8 - 689.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core194.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 688.8 - 690.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core195.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 689.7 - 690.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core196.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 689.9 - 691.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core197.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr core, 690.8 - 692.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core198.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Los Medaños (M1/H1) Mbr and Salado Fm core, 691.8 - 693.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core199.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 692.9 - 694.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core200.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 693.8 - 695.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core201.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 694.8 - 696.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core202.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 695.8 - 697.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core203.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 696.8 - 698.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core204.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 697.8 - 699.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core205.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 698.9 - 700.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core206.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 699.9 - 701.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core207.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 700.9 - 702.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core208.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 701.8 - 703.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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SNL-12_Core209.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 702.8 - 704.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core210.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 703.8 - 705.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core211.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 704.8 - 706.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core212.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 705.8 - 707.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core213.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 706.8 - 708.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core214.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 707.9 - 709.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core215.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 708.8 - 710.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core216.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 709.8 - 711.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core217.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 710.8 - 712.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core218.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 711.9 - 713.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core219.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 712.8 - 714.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core220.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 713.8 - 715.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core221.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 714.9 - 716.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page** 14 **of 15**

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SNL-12_Core222.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 715.8 - 717.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core223.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 716.9 - 718.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core224.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 717.8 - 719.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core225.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 718.9 - 720.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-12_Core226.jpg	7-12-03	SNL-12 drillpad; T23S, R31E, sec20	Close-up photo of Salado Fm core, 719.7 - 720.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS