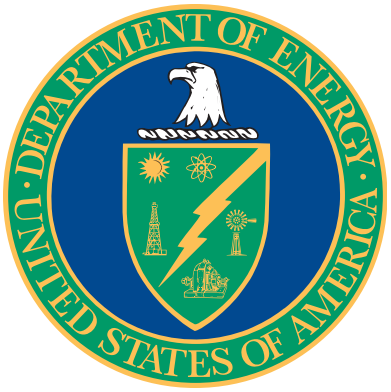
DOE/WIPP-05-3319

Basic Data Report
For Drillhole SNL-13 (C-3139)
(Waste Isolation Pilot Plant)

August 2008



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Basic Data Report
For Drillhole SNL-13 (C-3139)
(Waste Isolation Pilot Plant)

Dennis W. Powers
Consulting Geologist
140 Hemley Road
Anthony, TX 79821

and

Ronald G. Richardson
Washington Regulatory and Environmental Services
P.O. Box 2078
Carlsbad, NM 88220

August 2008

West Texas Water Well Service Rig #15 at SNL-13, viewed toward the northeast. The waste shaft at WIPP is visible between the drill rig and pipe truck. A temporary surface conductor casing is cemented in place in preparation for drilling with air. Taken April 11, 2005, by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-13 (permitted by the New Mexico State Engineer as C-3139) was drilled and completed in April 2005 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation in an area south of the southwest corner of the Waste Isolation Pilot Plant (WIPP) site. SNL-13 provides a monitoring well for southern and western pumping tests. SNL-13 is located in the southeast quarter of section 1, T23S, R30E, in eastern Eddy County, New Mexico. SNL-13 was drilled to a total depth of 480 feet (ft) below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-13 encountered the Mescalero caliche, Gatuña, Dewey Lake, and Rustler Formations. Two intervals of the Rustler were cored: (1) the Magenta Dolomite Member and into the upper Tamarisk Member; and (2) from the lower Tamarisk through the Culebra Dolomite and into the upper Los Medaños Member. Geophysical logs were acquired from the open hole below the surface casing at 192 ft bgl to a depth of ~460 ft, and downhole video was obtained from near the surface to the middle Culebra.

Water inflow was observed in the lower Dewey Lake Formation, and a permanent surface casing was installed and cemented to 192 ft to shut off this flow. The Magenta yielded very little water. Brine was produced from the middle Los Medaños while drilling.

The upper and middle parts of the Los Medaños have generally normal lithology, thickness, and stratigraphic sequence, with the exception that a section of the middle Los Medaños is very poorly indurated. The section of M-1/H-1 that was drilled does not appear to include halite or halite cements. The upper clastic unit (M-2/H-2) of the Los Medaños at SNL-13 was poorly preserved in cores; cuttings and geophysical logs indicate that it did not include halite, which is consistent with estimates. The relationship between the dark gray claystone at the contact with the overlying Culebra is uncertain from the partial core recovery.

The Culebra is 24 ft thick, which is normal for the unit. Core recovery was excellent from the upper 15 ft and only partial from the lower Culebra. The core reveals limited porosity, and a downhole video shows sulfate fillings in fractures through the upper Culebra. The unit is not expected to have high transmissivity based on limited core observations, logs, and observations of water-level rises from the Culebra.

The Tamarisk has a normal stratigraphic sequence and thickness. Thin laminae that drape the surface of the Culebra are algal, as is common in other cores. The basal sulfate unit (A-2) includes an unusual reddish-brown claystone and some deformation that indicates postdepositional solution and filling, most likely during exposure associated with deposition of the overlying mudstone unit (M-3). The upper surface of A-2 has several inches of relief and appears to have been corroded during exposure as the environments changed to mudflats. The mudstone unit (M-3) shows mostly reddish-brown claystone and siltstone. Clasts or intraclasts in M-3 range from angular to subrounded; there is no clear size grading. The upper Tamarisk sulfate (A-3) is fractured near the base. Video images show both deformation and depositional undulations to bedding, with some mudstone matrix between fractures.

The Magenta Dolomite is 26 ft thick and shows algal stromatolites at the base, typical laminar to wavy bedding, some ripples, and two nodular gypsum zones near the top. Carbonate interbeds in sulfate at the basal contact are sparse, indicating depositional environments changed with few fluctuations. The core was well preserved and the unit was apparently completely recovered. Coring appears to have begun at the upper contact, but the transition was not included. Porosity is limited, and the cores indicate a thin zone of slightly greater porosity in the upper part of the Magenta. Video views suggest slight inflow from the upper Magenta. A second thin nodular sulfate bed observed in the upper part of the Magenta is not

common, but it may represent more fluctuations in the environment in the distal (from the depositional center) parts of the basin.

The Forty-niner is represented by a typical sulfate–mudstone–sulfate sequence. Cuttings did not indicate any halite present in the mudstone unit, which is consistent with previous studies. The mudstone cuttings indicate a lower light greenish gray siltstone, estimated to be 3 ft thick, and an upper reddish brown calcareous siltstone.

The Dewey Lake is thinner at SNL-13 than in drillholes to the east. The Dewey Lake was partially eroded prior to deposition of the Gatuña, with erosion generally greater in the direction of Nash Draw (to the west). No sulfate was confirmed in the Dewey Lake, and this is consistent with nearby P-15 that was drilled for WIPP. Casing was installed through the Dewey Lake before geophysical logs were obtained.

The Gatuña at SNL-13 is mainly reddish calcareous sandstone, with carbonate infiltrated at the top. Manganese oxide stains found here in the Gatuña are also common elsewhere.

The Mescalero caliche is ~4 ft thick at SNL-13; cuttings were insufficient to determine the stage of development of the Mescalero at SNL-13, although stage IV characteristics are common in the area.

The Dewey Lake hydrology was not tested. Video camera data indicated seepage at a depth of ~143 ft bgl. MiniTroll data were taken overnight from this zone. Toward the end of the measuring period, pressure changes were starting to level off and were consistent with the estimated top of the saturated zone at this depth. The Dewey Lake is likely saturated from 143 ft to the top of the Rustler at 192 ft (log depth). Field-measured specific gravity was 1.000. Analysis showed measured total dissolved solids of 3,800 milligrams/liter, with calcium and sulfate being the dominant sources.

The Los Medaños was neither hydraulically tested nor observed for fluid level changes. A sample taken from the produced water showed high total dissolved solids (290,000 milligrams/liter measured) dominated by sodium and chloride.

Below the casing at 192 ft, SNL-13 was drilled (and reamed through cored intervals) with an original diameter of 11 inches to the depth for completion, and this diameter was sufficient to complete the hole without additional reaming. The bottom of the drillhole was cemented to 425 ft bgl to prevent circulation into the Los Medaños. Fiberglass-reinforced plastic (FRP) casing (4.85 inches inside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 411.0–384.5 ft bgl. Approximately 2 ft of FRP casing was left above the connector. The annulus was filled with 4/10 Brady sand from 425 to 378 ft (above the Culebra), and bentonite (HolePlug®) was placed to 373 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface.

SNL-13 was initially pumped, mostly at low rates, on May 2 through May 4, 2005, without getting clean water. On May 12, 2005, the well was jetted with 120 barrels of fresh water. On May 13, 2005, the well was pumped at low rates, producing a total of 257 gallons without clearing the water. A small bailer was used on May 18 and 19, 2005, to remove a total of 350 gallons, again without completely clearing the water of sediment.

A miniTroll was installed in SNL-13 in June 2005 to monitor pressure changes associated with pumping of well SNL-14. Water levels have been measured by WRES since June 2005, with an initial depth to water of 286.98 ft below the top of the FRP casing.

Table of Contents

List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-13 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)

Wildflowers near SNL-13. April 2005. Photos by Dennis W. Powers.

1.0 INTRODUCTION

SNL-13 was drilled in the southeast quarter of Section 1, T23S, R30E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 1,770 ft from the south line (fsl) and 602 ft from the east line (fel) of the section (Fig. 1-2). This location places the drillhole southwest of the WIPP site, near the intersection of NM128 and the south access road to WIPP. Drilling at SNL-13 began April 11, 2005, and the well was completed April 27. SNL-13 will be used to test basic hydraulic properties and to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for WIPP.

SNL-13 was permitted by the New Mexico State Engineer as well C-3139. Official correspondence regarding permitting and regulatory information must reference this permit number.

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

1.1 Purpose of WIPP

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

1.2 Purpose of SNL-13

SNL-13 was designed and located to provide information for the integrated hydrology program for the WIPP (Sandia National Laboratories, 2003; see also extracts of letters included in Appendix A). Among the objectives of the integrated hydrology program, SNL-13 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, Sandia National Laboratories, 2003).

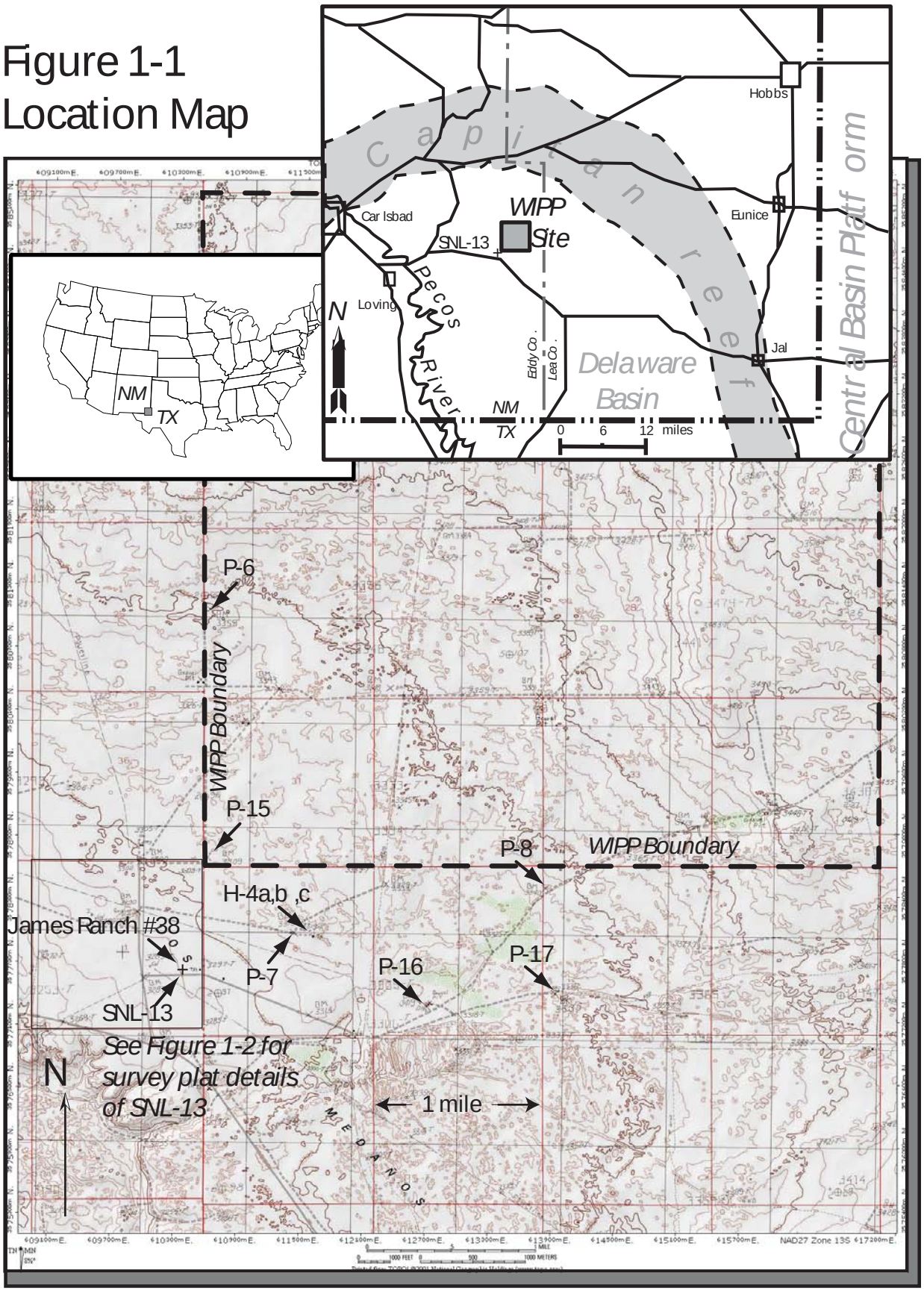
Culebra water levels in many of the wells monitored for WIPP have been rising in recent years, contrasting with the conditions used to calibrate models of the Culebra across the site area (Sandia National Laboratories, 2003) for the Compliance Certification Application (CCA; U.S. DOE, 1996). Hydraulic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

SNL-13 was located to test Culebra hydraulic properties in an area off the southwest corner of WIPP where data are sparse and where models suggest some preferred flow paths. Previous studies indicated that halite would be present in the lower Rustler at SNL-13, and the location appears to be east of the upper Salado halite dissolution margin (Sandia National Laboratories, 2003; Powers, 2002a, 2003a; Powers and others, 2003).

The drillhole is to (Appendix A):

1. Provide a replacement for the location of WTS-4 (and WTS-6, to a lesser degree);
2. Provide control in an area where Culebra flow paths may enter the southeastern arm of Nash Draw; and

Figure 1-1
Location Map



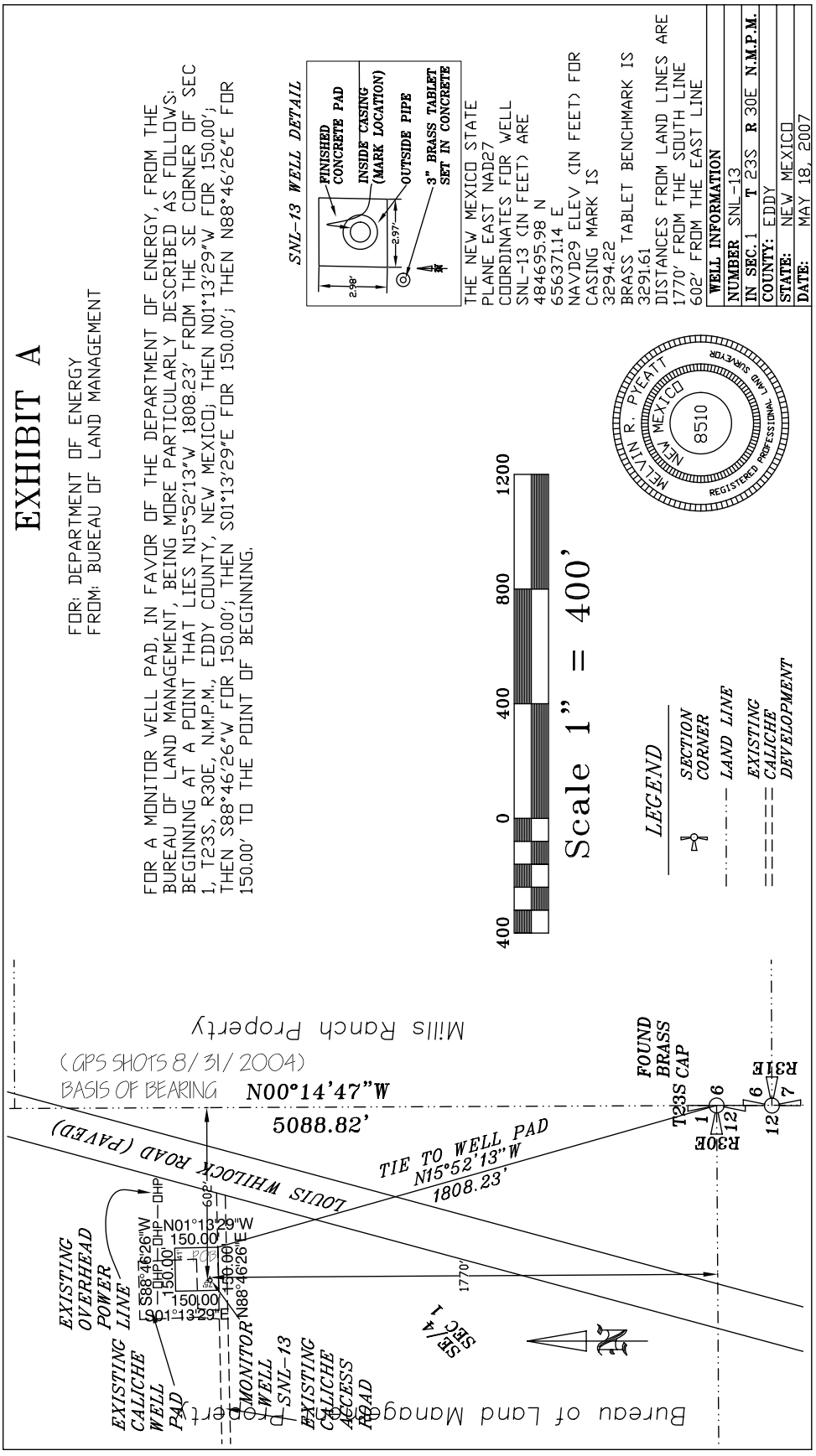


Figure 1-2
Survey Plat
for SNL-13

3. Provide a monitoring location for large-scale pumping tests south and west of WIPP.

An analysis for optimizing the Culebra monitoring network (McKenna, 2004) combined three different approaches to identify areas that should benefit from a new well. SNL-13 is located where these combined approaches indicate relatively high impact on the network (Appendix A).

1.3 SNL-13 Drilling and Completion

The basic information about drilling and completion of SNL-13 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-13 was rotary drilled and cored to a total depth of 480 ft bgl (Fig. 1-3) as measured during drilling and coring. Geophysical logging only reached a depth of 443 ft because of obstacles in the drillhole. There is some difference in depths to stratigraphic units between the drilling/coring depths and logs, with the maximum of approximately 5 ft. SNL-13 was drilled using compressed air (two compressors) with a small added volume of water and Quik-Foam® to improve cuttings returns. Cuttings from SNL-13 were useful because of these methods.

Core recovery was very good, with loss of core only through the basal Culebra and uppermost Los Medaños Members (Table 1-1; Appendix C). The core recovery through the Culebra exceeded what is common (e.g., Powers, 2002b; Mercer and others, 1998).

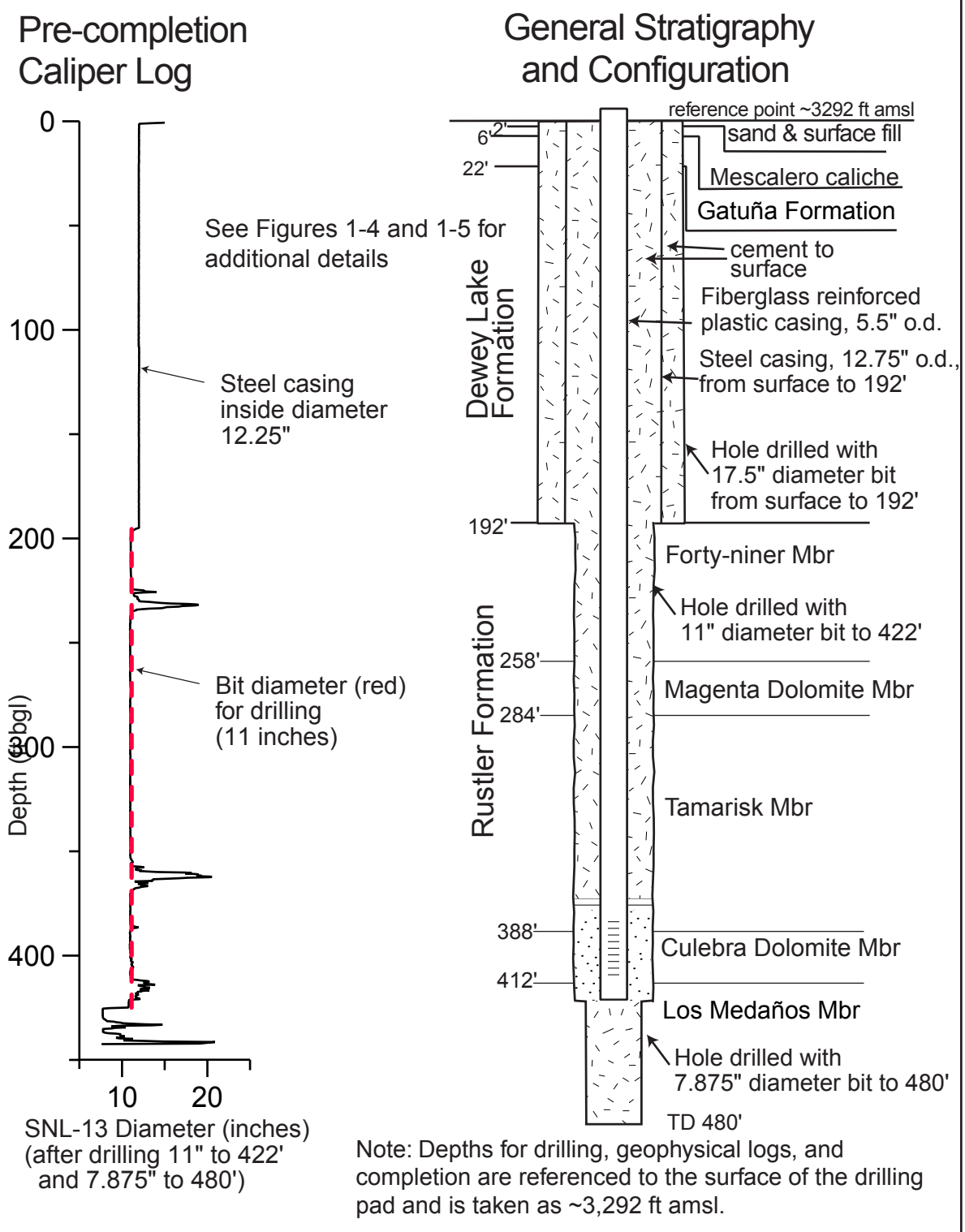
The plan was to drill SNL-13 into the upper part of the Salado Formation to check whether halite had been dissolved at the top of the Salado. The large volume of brine encountered in the middle of the Los Medaños and the poorly consolidated rock at that depth were obstacles to continuing drilling as planned; it was decided to complete the well in the Culebra and not risk losing the drillhole by continuing to drill (Appendix D).

In keeping with recent practice at WIPP, SNL-13 was cased with FRP casing (Centron® 5½ DHC300) 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-13 (Sandia National Laboratories, 2003).

SNL-13 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. If warranted, additional wells can be completed to other intervals, such as the Dewey Lake Formation or Los Medaños Member, on the SNL-13 wellpad, although neither of these activities has been proposed (Sandia National Laboratories, 2003).

Geophysical logs, especially the natural gamma and caliper logs, were used to make the final decisions regarding completion depths at SNL-13 (Fig. 1-4) (Appendices D and E). The drillhole penetrated the upper and middle parts of the Los Medaños, and cement was put into the lower part of SNL-13 to prevent circulation into that interval (Fig. 1-4). The bottom of the Culebra screen interval was placed at 411 ft to remain above the claystone below the Culebra logged at 412 ft and avoid possible plugging of the lowermost slots (Fig. 1-4). The top of the screen, at 384.5 ft, is above the top of the Culebra. The top of the sand pack (4/10 gravel) at 378 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (HolePlug®) was placed to 373 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) before the casing was placed shows zones of drillhole enlargement in the Forty-niner and Tamarisk mudstones as well as in the mudstone just below the Culebra. The annulus behind the casing was cemented through the upper two enlarged intervals.

Figure 1-3
SNL-13 As-Built Diagram



Note: Depths for drilling, geophysical logs, and completion are referenced to the surface of the drilling pad and is taken as ~3,292 ft amsl.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-13 (C-3139)

LOCATION: Southeast ¼, Section 1, Township 23 South (T23S), Range 30 East (R30E)

SURFACE COORDINATES: The well is located 1,770 ft from the south line (fsl) and 602 ft from the east line (fel) of Section 1. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 484695.98 North, 656371.14 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-13 using Corpscon for Windows (v. 6.0): 610394.29 East, 3577599.77 North. Figure 1-1 shows UTM coordinates on a 1000-m grid.

ELEVATION: All depths used in geological and geophysical data were measured from the general surface of the drillpad; the steel surface conductor casing is just above the level of the drillpad surface and was placed after drilling and coring into the Rustler Formation (Fig. 1-5). Depths are reported as below ground level (bgl), which is taken as 3,292 ft above mean sea level (amsl), the rounded up value for the brass tablet benchmark (3,291.61 ft amsl) adjacent to the cement well pad. The primary datum, based on a revised plat (Fig. 1-2) for the completed well, is 3,294.22 ft amsl (NGVD 29) for a mark on the top of the fiberglass reinforced plastic casing inside the protective well pipe. Figures 1-3, 1-4, and 1-5 show the as-built configuration of SNL-13.

DRILLING RECORD:

Dates: Began drilling April 11, 2005; drillhole reached total depth (480 ft) on April 24, 2005. Geophysical logging was conducted on April 25, 2005. Drillhole was prepared for casing, and was cased and cemented April 27, 2005. Rig was moved off the drillpad April 29, 2005. SNL-13 well development began with pumping on May 2, 2005.

Circulation Fluid: SNL-13 was drilled to 210 ft bgl with circulating air, discharging cuttings into a lined portable steel container. The drillhole was reamed to 192 ft to place a steel casing to shut off water flow from the Dewey Lake, and fresh water and Quik-Foam® were used from 120 ft to remove cuttings from reaming. After the conductor casing was cemented, SNL-13 was drilled and cored to 376 ft on air. From 376 ft to total depth, coring, drilling, and reaming were continued with fresh water and Quik-Foam®.

Cored Intervals: 4.0-inch core was taken through these intervals (depths from drilling data):
254.0–284.0 ft bgl: Magenta Dolomite and upper Tamarisk Members
346.0–422.0 ft bgl: lower Tamarisk, Culebra Dolomite, and upper Los Medaños Members

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

Table 1-1. Summary of Drilling and Well Completion Records For Hydrologic Drillhole SNL-13 (C-3139), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
17.5	0	192
11	192	422
7.875	422	480

Casing Record:

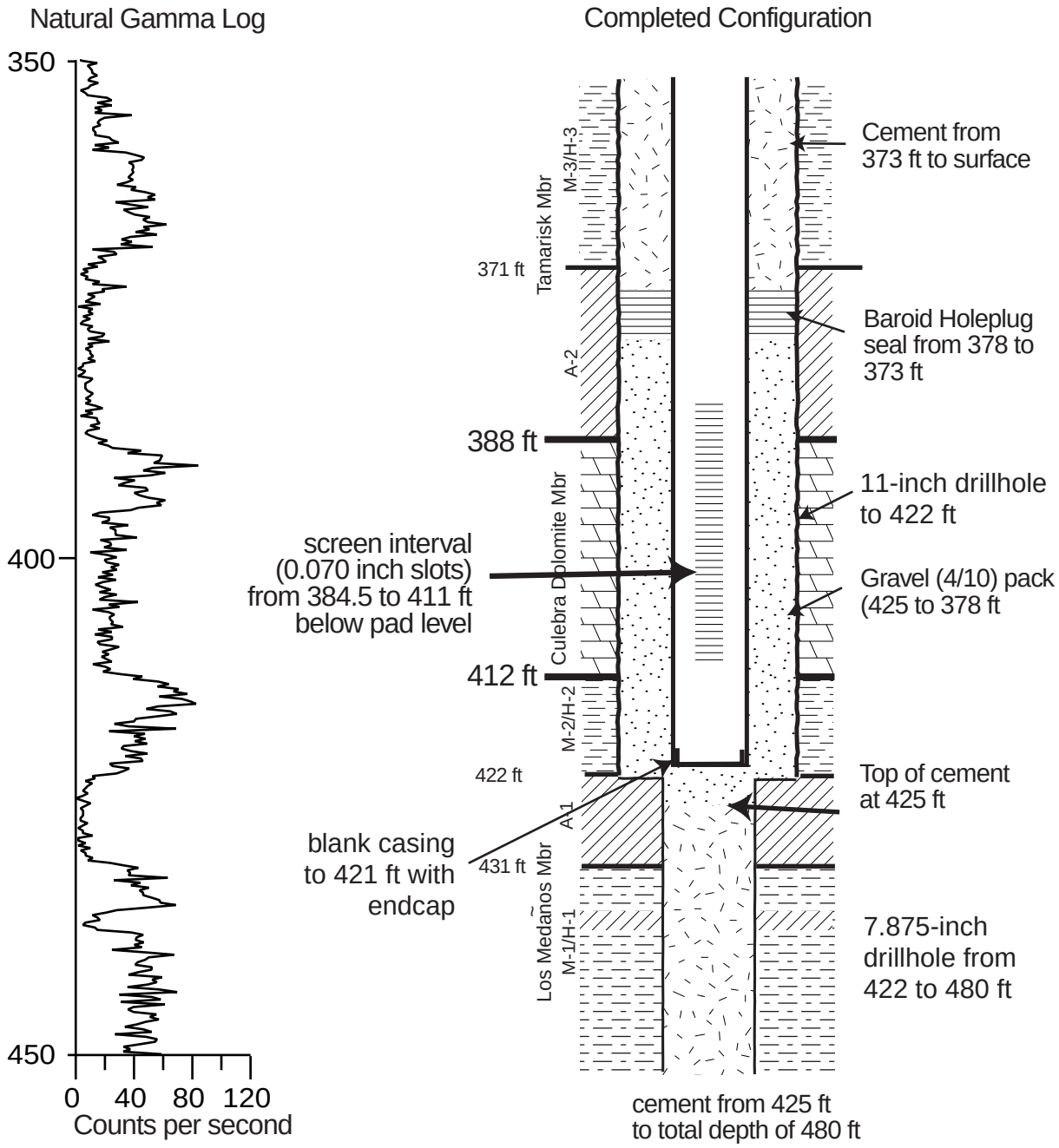
Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
12.75	12.25	33.41 steel	0	192
5.45	4.85	4.40 FRP** blank	-2.0	384.50
5.45	4.85	4.40 FRP screen	384.50	411.0
5.45	4.85	4.40 FRP blank	411.0	421.0

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

Coring Record:

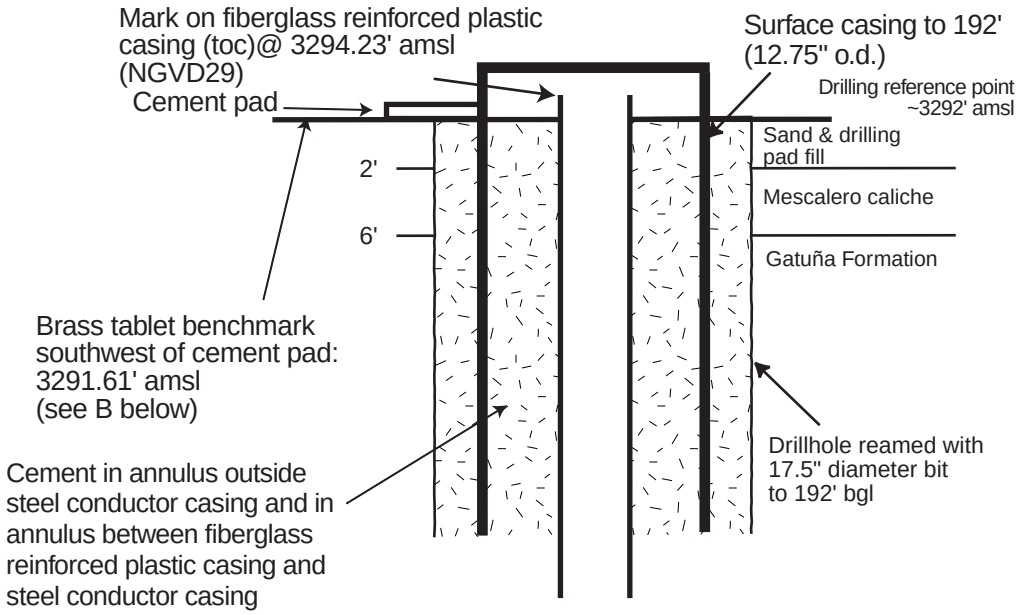
Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered	Recovered %
1	254	284	30	30	100.00%
2	346	376	30	30	100.00%
3	376	401	25	25	100.00%
4	401	413	12	5.5	45.83%
5	413	422	9	9	100.00%
		Totals	106	99.5	93.87%

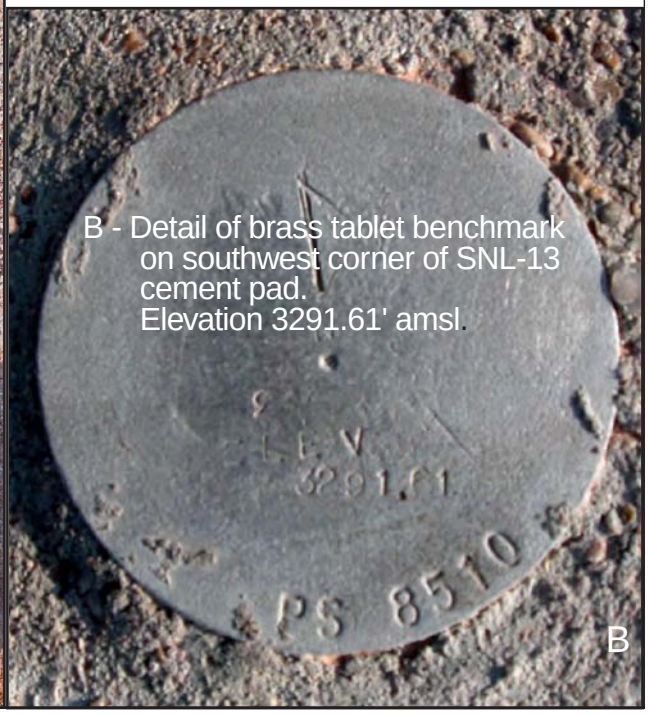
Figure 1-4
SNL-13 Completion and Monitoring Configuration (4/27/05)



Note: Lithologic contacts below logged area have been adjusted from depths determined during drilling to equivalent log depths.

Figure 1-5
SNL-13 Surface Configuration and Elevations (4/27/05)





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.

Reference points for measurements at SNL-13 during the course of drilling and completing the well were taken as the level of the drillpad because the permannent surface casing was not placed until drilling had proceeded to 210 ft. After reaming, a steel surface conductor casing was then cemented in place to a depth of 192 ft below the surface. The drillpad surface was surveyed, and the rounded value of 3292 ft amsl for the benchmark (Figs. 1-3, 1-4, and 1-5) has been used. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,291.61 ft amsl. *Other than water level monitoring, depths are stated as bgl, and the drillpad surface is taken as the reference point for drilling, logging, and completion of SNL-13.* The FRP casing extends ~2 ft above the steel connector on top of the conductor casing. This FRP casing point was resurveyed and a revised plat issued May 18, 2007 (Figs. 1-2, 1-5), providing the reference point and reference elevation (3,294.22 ft amsl) for monitoring water levels.

1.4 Other Background

SNL-13 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, Texas, under contract from Washington TRU Solutions LLC (WTS). Coring was done by Billy Pon, Diamond Oil Well Drilling Co., Inc., P.O. Box 7843, Midland, Texas. Geophysical logging was conducted by 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 D). Well drilling wastes (cuttings and mud) were removed from SNL-13 and disposed of at the Lea Land, Inc. landfill north of WIPP. Pumped fluids were disposed of by Sundance Services, Inc., located in Eunice, New Mexico. Archeological clearances obtained from the U.S. Bureau of Land Management were based on field work and reports by Mesa Field Services, Carlsbad, New Mexico (Appendix E). Cores from SNL-13 were photographed with a digital camera, and a photo log is included in Appendix F. Electronic images can be requested from WTS.

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

1.5 Acknowledgements

Drafts of this document were reviewed by Rick Salness, Joel Siegel, and Rick Beauheim, and their comments improved the final report. 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 Luis Armendariz (West Texas Water Well Service) provided drilling data and daily drilling records. West Texas Water Well Service personnel were very helpful in providing access for sampling during drilling. Raymond Federwisch (Geophysical Logging Services) provided the printed and electronic files that were used to develop Figure 2-1. Vivian Allen (L&M) provided useful editorial guidance.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been 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. DOE, 1996). Some salient features of the broader geological history, as well as more recent work on the geohydrology of the Rustler (e.g., Holt and Yarbrough, 2002; Powers, 2002a, 2003a; Powers and others, 2003), are relevant to understanding geology and hydrology at SNL-13.

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

2.2 Geological Data From SNL-13

SNL-13 encountered a normal stratigraphic sequence from ground level to total depth for this location near the southwest corner of the WIPP site (Fig. 2-1; Table 2-1). Units encountered ranged from unconsolidated surficial alluvium to the middle part of the Los Medaños Member of the Permian Rustler Formation. Structural, sedimentological, and diagenetic features were examined during investigation using cuttings, cores, and geophysical logs. Downhole videos of portions of the formations supplement these data (Appendix G, p. 131). Details of the sedimentology of the Rustler extend understanding of that unit.

The geologic units encountered in SNL-13 are described from total depth to the surface, in the order in which they were deposited rather than in the order in which they were encountered in the drillhole. Cores and cuttings were described in the field using mainly drilling depths for depth control. Geologic logs detailing field observations of cuttings and cores are included in Appendix C. The difference between geophysical logs and drilling depths is generally slight. The largest differences between depths determined by geophysical logging and core markings based on depths measured during drilling is approximately 5 ft through lower units in SNL-13. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix G).

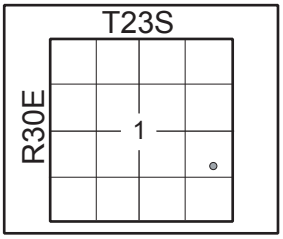
The descriptions that follow use depths based on core markings, with depths noted for geophysical log data.

2.2.1 Permian Rustler Formation

The Rustler was drilled and cored into the middle Los Medaños Member. The contact between the Rustler and the overlying Dewey Lake Formation is at 192 ft (Fig. 2-1), and 288 ft of the Rustler were penetrated (Table 2-1). The plan for SNL-13 was to drill to the base of the Rustler and core and drill the contact with, and upper part of, the Salado Formation. Poorly lithified sand in the middle Los Medaños, and large volumes of brine

Figure 2-1
Well Record SNL-13 (C-3139)

Company: Washington TRU Solutions LLC
Well: SNL-13 (C-3139)
Section: 1 Twp: T23S Rge: R30E
Location: 1770 ft from south line (fsl)
602 ft from east line (fel)



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

Elevation
KB:
DF:
GL: 3292 ft amsl
(benchmark: 3291.61ft)

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: April 11, 2005
Completion date: April 27, 2005
Total depth (TD): 480 ft bgl (driller log)

Casing Record
Conductor: 192 ft
12.75 inch steel o.d.
Casing: 5.45 inch o.d.
fiberglass reinforced
plastic to 421.0 ft bgl
Screened interval:
384.5-411.0 ft

Geophysical Logs Date: April 25, 2005
Micro/Laterolog/Induction/SP: 0-459 ft
Gamma/Fluid: 0-455 ft
Caliper: 0-443 ft
Density/Neutron: 0-444 ft

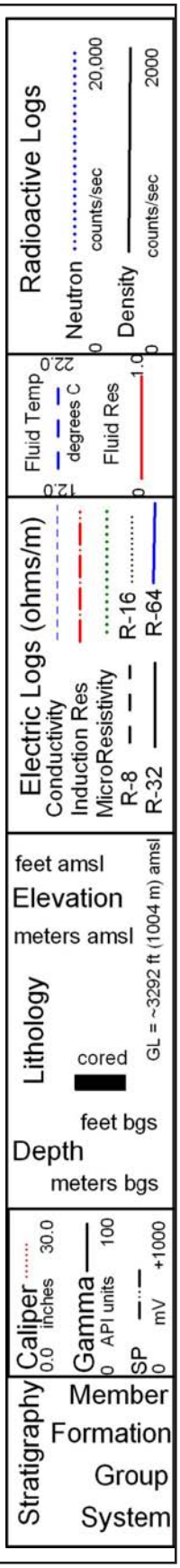
Type fluid in hole:
Water below 316 ft
Res mud: n.d.
Res mud filtrate: n.d.
Max. Rec. Temp.:
21.9°C (in water)

General Lithologic Symbols Used

Dolomite
Mudstone/siltstone
Anhydrite
Halite
Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Symbols may be combined; some may not be used

SNL-13 Well Log Headers



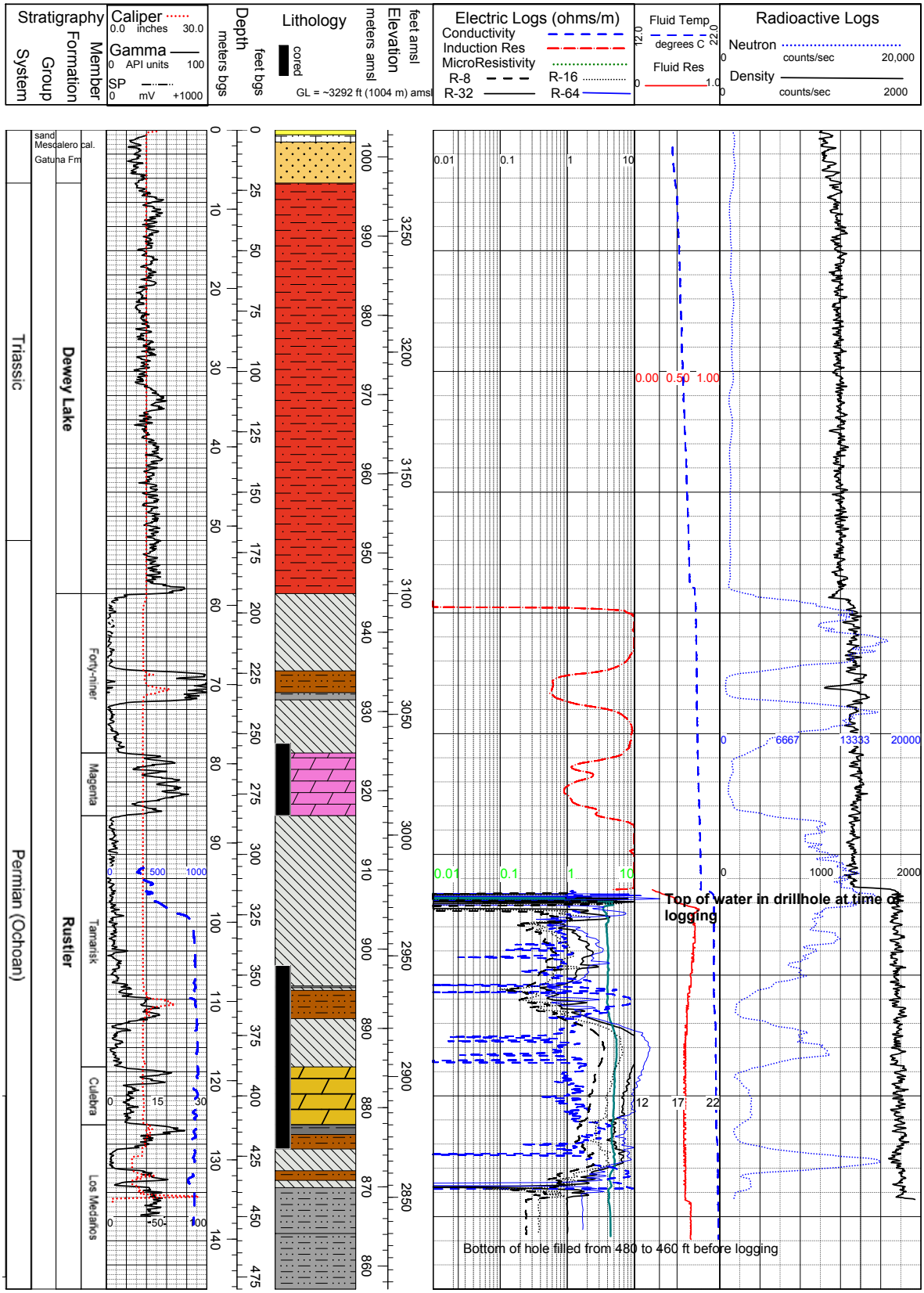


Figure 2-1, continued. See Appendix G for a larger format file of this figure.

Table 2-1
Geology at Drillhole SNL-13

System/ Period/Epoch		**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface dune sand and pad fill		0 - 2 ft
	Pleistocene	Mescalero caliche		2 - 6 ft
	Miocene-Pleistocene	Gatuña		6 ft - 22 ft
Mesozoic	**Triassic**	Santa Rosa[2]		eroded
		Dewey Lake[3]		22 ft - 192 ft
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	192 ft - 258 ft *192 ft - 223 ft* *223 ft - 237 ft* *237 ft - 258 ft*
			Magenta Dolomite	258 ft - 284 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	284 ft - 388 ft *284 ft - 352 ft* *352 ft - 371 ft* *371 ft - 388 ft*
			Culebra Dolomite	388 ft - 412 ft
			Los Medaños[4] *M-2/H-2* *A-1* *M-1/H-1*	412 ft - 480 ft *412 ft - 421 ft* *421 ft - 431 ft* *431 ft - 480 ft (TD)* [5]

[1]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data to total depth (TD) of 480 ft bgl. Geophysical logs and drilling/coring depths begin at the level of the drilling pad; the surface steel casing was installed after drilling reached more than 200 ft bgl. This reference point is taken as 3,292 ft amsl; it is the rounded elevation of the surface benchmark adjacent to SNL-13. Water level depths will be measured and reported relative to the surveyed point on the top of the fiberglass reinforced plastic casing (Fig. 1-5). Geological logs based on field descriptions (Appendix C) and markings on cores (Appendix F) vary modestly from log depths.

[2]The Santa Rosa Formation, part of the Dockum Group or undifferentiated Triassic, is apparently completely eroded at SNL-13.

[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.

[5]The driller's total depth was 480 ft. Geophysical logs showed the top of Culebra 2 ft deeper than drilling logs. A-1 is ~5 ft deeper based on geophysical logs than was indicated during drilling.

produced from this interval, led to the decision to stop drilling and complete the well in the Culebra (Appendices A, C, and D).

2.2.1.1 Los Medaños Member

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

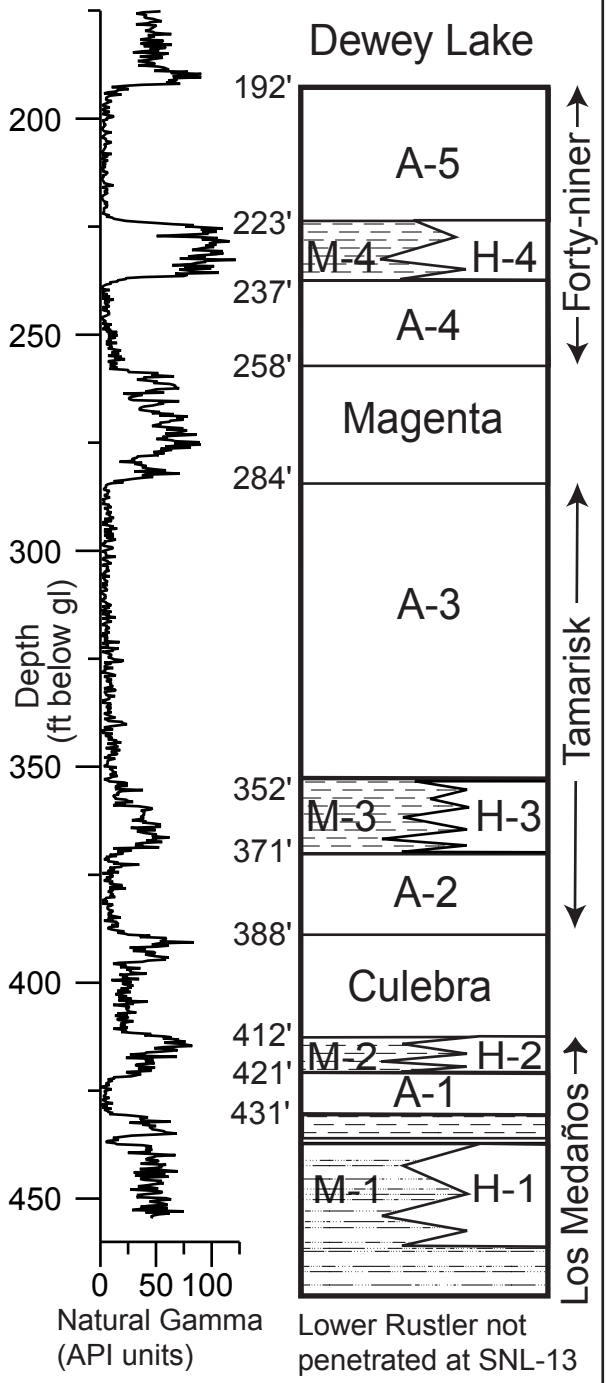
The upper part of the Los Medaños was cored (10 ft) in SNL-13, penetrating part of A-1 (Table 2-1).

The informal unit *mudstone-halite 1* (M-1/H-1; Fig. 2-2) was encountered from 431–480 ft (log and drilling depths) (Table 2-1). Fill in the drillhole prevented geophysical logging below ~460 ft.

No halite was encountered in SNL-13. The lower ~45 ft of SNL-13 yielded cuttings of poorly indurated reddish-brown to gray siltstone and very fine sandstone, accompanied by an inflow of brine (see section 3.0). The gray sandstone likely corresponds to the interval designated sandy transition zone (Holt and Powers, 1988). The reddish-brown siltstone more nearly corresponds to the original definition of M-1/H-1.

A thin anhydrite from 435–438 ft (431-434 ft, drilling depth) is distinct from the main A-1 unit in this and similar drillholes. Holt and Powers (1988) showed that it is regionally continuous, and they interpreted it as part of the original M-1/H-1

Figure 2-2
Rustler Units at SNL-13



Formal and informal Rustler Formation units and depths at SNL-13 based on natural gamma log; below the gamma log, drilling depths have been used. No Rustler halite facies were encountered at SNL-13.

underlying A-1. To the north, it is possible that this thin anhydrite is continuous with the basal A-1.

Approximately 3-5 ft (431–434 ft log depth) of dark reddish-brown to dark gray siltstone and claystone were deposited between this thin anhydrite and the overlying A-1. Cuttings did not reveal evidence of bedding or contacts.

The informal unit *anhydrite 1* (A-1; Fig. 2-2) was encountered from 421–431 ft (417.1–427 ft driller's depth and core markings). The thickness of A-1 at SNL-13 is similar to that encountered elsewhere around WIPP.

Core from upper A-1 at SNL-13 is mainly fine-grained gray to pink anhydrite with thin beds and fine laminae. The basal 2.3 ft display laminar to wavy bedding, with possible small swallowtail gypsum or pseudomorphs in some zones. Some overprinting by bedded nodular textures is present, and the top of this zone includes some fractures. The upper 2.6 ft of core reveal nodular textures that are white with some reddish staining between nodules (Fig. 2-3). Some coarse gypsum fills interstices between nodules. Near the top of A-1, nodular textures give way to laminae and bedding that may indicate temporary algal growth (Fig. 2-4, at tip of black triangle). Coarse gypsum occurs at the top of A-1. The reddish zone may correspond to a polyhalitic interval noted southeast of the WIPP site (Holt and Powers, 1988).

The informal unit *mudstone-halite 2* (M-2/H-2; Fig. 2-2) was encountered from 412–421 ft bgl, based on logging depths. Core of the uppermost black, sticky claystone was marked 406.2 ft and the contact with A-1 was marked 417.1 ft (Fig. 4). Recovery was partial, and it is likely some of the basal Culebra, as well as some of upper M-2, were lost during coring. The ten-foot-thick interval shown by the natural gamma log is normal thickness. The basal contact with A-1 is sharp and slightly undulating (Fig. 2-4). It is not clear that the contact between M-2 and Culebra was recovered as continuous core.

The lower 4 ft of core recovered from M-2 is dark red (2.5YR3/6) siltstone with some gray (2.5YRN5/) mottling. Siltstone clasts are variable in

Figure 2-3. Gray, Nodular Anhydrite with Pinkish Matrix, Upper A-1

Figure 2-4. Possible Algal Growth in Upper A-1

size, and can be rounded (Figs. 2-5, 2-6). The core is generally bedded, with abundant coarse to fibrous gypsum parallel to bedding as well as inclined from about 15–50 degrees from horizontal. Some of the gypsum is displacive (Fig. 2-7). Most of the upper gray zone was not recovered in core.

2.2.1.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-13, the Culebra extends from 388–412 ft bgl, a thickness of 24 ft (Fig. 2-1). Based on drilling depths available at the time, the recovered Culebra core was marked from 386.0–406.2 ft bgl (as used in information in Appendices C and G). Recovered Culebra core (Fig. 2-8) totals 20.2 ft thick. A geophysical log from the oil well (James Ranch Unit 38; API #3001530856) adjacent to SNL-13 shows the Culebra as 25 ft thick, with a depth bgl from 386–411 ft.

Holt and Powers (1988) found a range of 20–30 ft thickness in Culebra cores described from the WIPP Project, and a regional thickness exceeding 40 ft, based on geophysical log data. Significant core loss in the middle of the Culebra is common because of the porosity of that zone. Excellent recovery of core at SNL-13 from the upper 15 ft in one core run (#3) indicates most of the interval lost is from the lower Culebra.

The dolomite recovered in core from SNL-13 is generally brown to gray, thin bedded to laminar, and includes zones of vugs or pores. Vugs are variable in size, and, in general, the vugs decrease in size upward. Gypsum is sparse as either vug filling or fracture fillings. Although vertical to subvertical fractures of varying length and aperture are present in the Culebra, the longer fractures occur between ~390–395 ft.

The basal hydrostratigraphic unit (CU-4) proposed for the Culebra by Holt (1997) is likely represented by the poorly laminated and brecciated core from 405–406.2 ft.

From 399.7–405 ft, the Culebra is grayish, somewhat argillaceous, and can be separated into three zones. This interval probably represents CU-3, although it is likely that the lower part was

Figure 2-5. Siltstone Clasts of Various Sizes in Reddish-Brown Siltstone From M-2, 415+ ft.

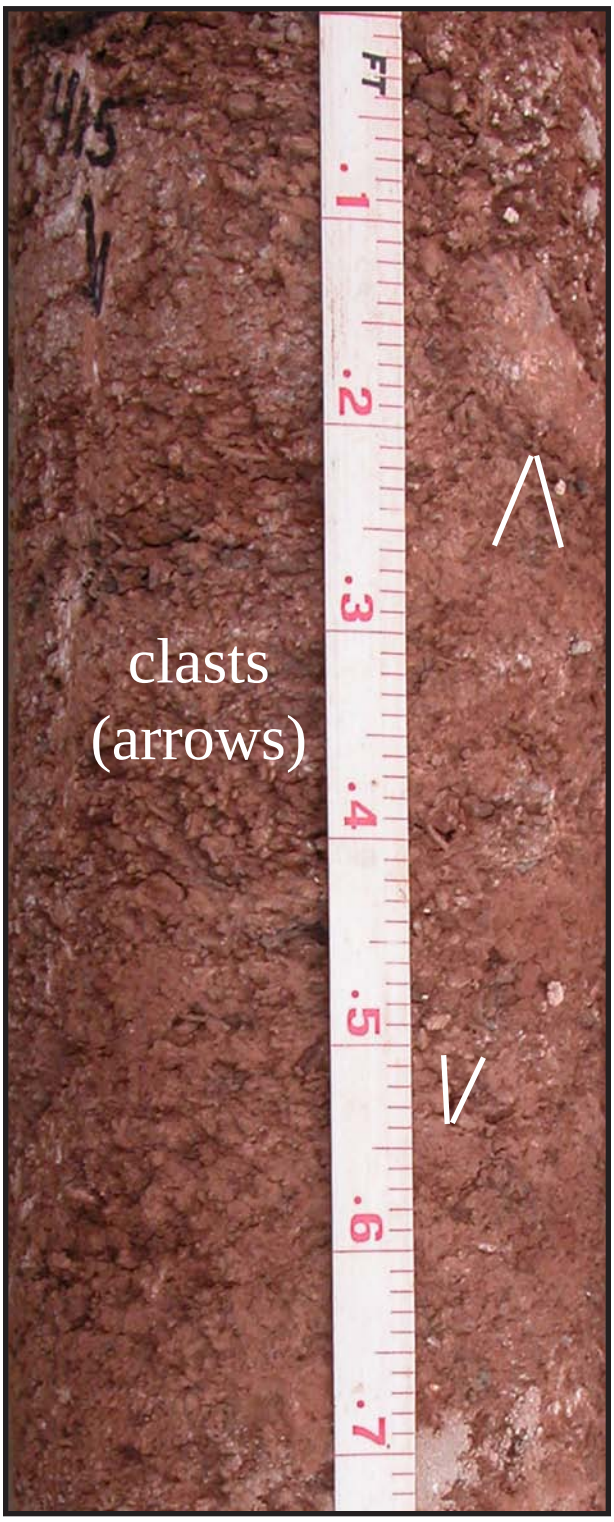


Figure 2-6. Cross-Section of Siltstone Clasts of Various Sizes in Reddish-Brown Siltstone From M-2.

416.3 ft, looking upward

416.3 ft, looking upward, closeup

Figure 2-7. Displacive Gypsum in Reddish-Brown Siltstone From M-2.

poorly sampled during drilling. From 405–404.2 ft, large vugs are distributed among smaller vugs. Vugs range from open to filled with gypsum; some vugs may have silt fillings. From 404.2–401.0 ft, mostly small vugs (<0.25 inch) occur in zones parallel to bedding, with scattered larger vugs. Gypsum fills some vugs. Horizontal separations along bedding planes may partly be controlled by narrow zones of vugs. From 401–399.7 ft, this same gray dolomite has few vugs and little surface evidence of bedding. It is fractured into rectangular blocks with dimensions from about 0.5–2 inches. These fracture surfaces show minor staining.

From 395–399.7 ft, the Culebra is brown and grayish brown, fine-grained dolomite that has decreasing vug concentration upward. In the basal portion, vugs are most commonly small (<0.25 inch) and are poorly zoned. Larger (to 1 inch) vugs are scattered within the lower ~2 ft. No gypsum was observed in these vugs, but some appear to have silt fillings. Vugs become less obvious upward, are likely few near the top, and are apparently more commonly filled with silt upward. This zone is assigned to CU-2 (Holt, 1997).

From 389.4–395 ft, the Culebra is fine dolomite, brown, with few vugs and limited surface evidence of bedding. This zone is dominated by vertical to subvertical fractures that are stained reddish brown to dark gray. Some gypsum fill occurs in one of the lower fractures. From a depositional view, this interval belongs more naturally with CU-1. Hydraulic properties due to fracturing are likely more consistent with CU-2. For the moment, this interval is assigned to CU-1.

From 389.4–386 ft, the Culebra includes more granular to nodular gypsum than is typical, although SNL-13 is not abnormal. Varying gypsum content and form at the transition to the Tamarisk are consistent with the broader depositional variations observed by Holt and Powers (1988) that include algal forms and local waxy organic material. This interval is assigned to CU-1 (Holt, 1997) because of its general properties and position. The downhole video also reveals that fractures in the upper Culebra are more consistently filled with gypsum than is apparent from the core surface.

The geophysical logs (Fig. 2-1) of the Culebra provide few additional details of the unit. The natural gamma shows an eight-foot-thick interval at the top of the Culebra with significant activity, consistent with the poorly porous, silty zone assigned to CU-1 from 386–395.1 ft in core. The uncompensated density log reveals no significant structure correlating to the Culebra overall or zones within the unit. Resistivity profiles, from micro to long spaced (64 inches), also show little variation that is related to Culebra. The uncompensated neutron log shows a considerable decrease through the Culebra and underlying M-2 compared to the relatively high neutron counts (indicating some anhydrite) for A-1 and A-2. Low neutron in the Culebra is consistent with the producing zone, and the clays in the upper M-2 are likely also absorbing neutrons. Overall, the contrast in properties through the Culebra is modest, and the Culebra is not likely to have either high porosity or high transmissivity.

Figure 2-8 Culebra Dolomite Member of the Rustler Formation at SNL-13

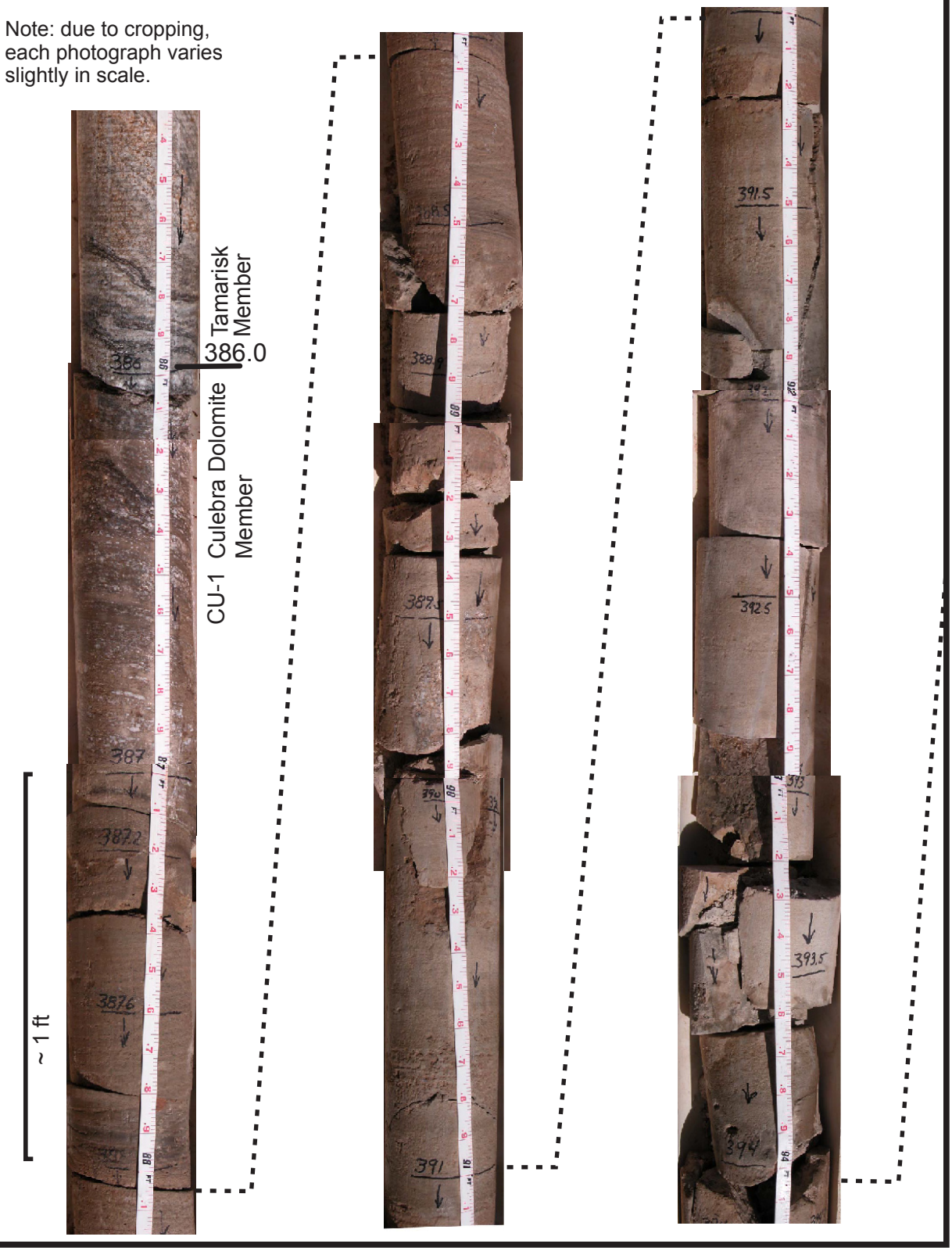
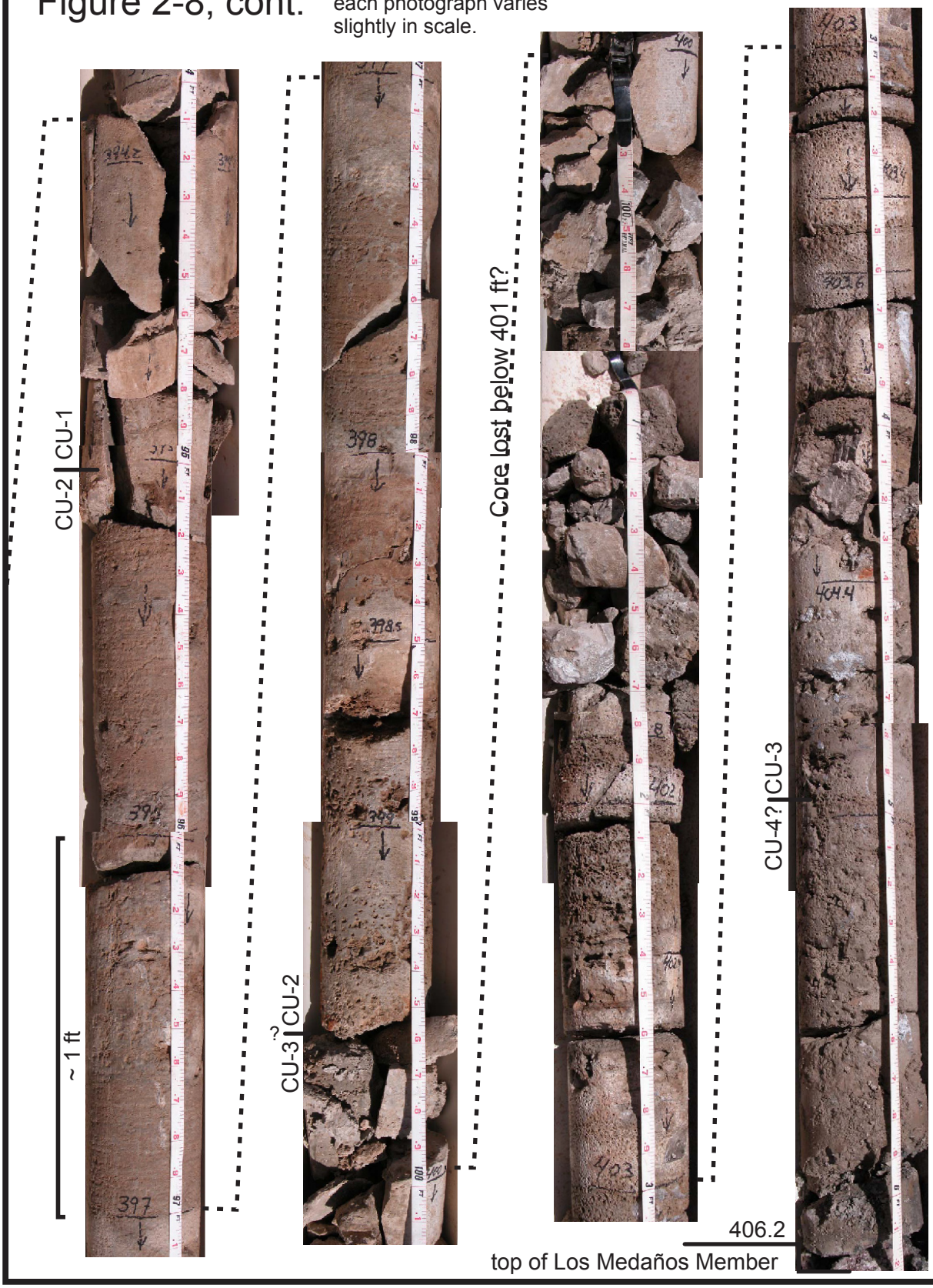


Figure 2-8, cont.

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



2.2.1.3 Tamarisk Member

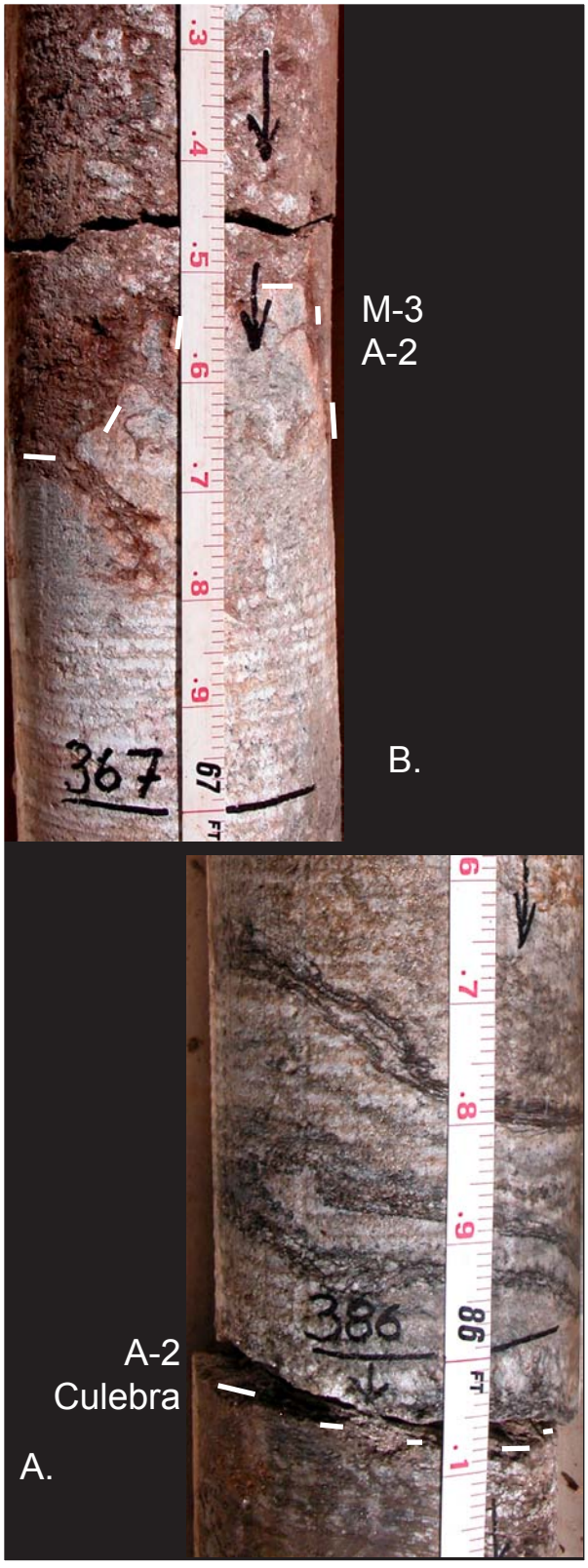
The natural gamma log of SNL-13 shows that the Tamarisk occurs from 284–388 ft bgl. The upper contact was marked at 281.9 ft and the lower contact was marked at 386 ft on cores. The Tamarisk comprises three basic subunits: a lower anhydrite, a middle mudstone to halite, and an upper anhydrite; all three are clearly shown by geophysical logs and were recorded by cores and cuttings during drilling. Powers and Holt (2000) labeled these A-2, M-3/H-3, and A-3, respectively, and showed that the lateral gradation from mudstone M-3 to halite H-3 generally reflects lateral changes in deposition. SNL-13 is located in the mudflat or M-3 facies of these beds. The basal 40.0 ft and upper 2.1 ft of the Tamarisk were cored; the remainder of the unit is described on the basis of cuttings and geophysical logs.

The informal unit *anhydrite 2* (A-2; Fig. 2-2) at the base of the Tamarisk is 17 ft thick (371–388 ft) based on the geophysical logs. Core retained from the interval was marked from 366.6–386.0 ft, an interval thickness of 19.4 ft. A-2 is predominantly gray gypsum, with some anhydrite as well as thin claystone interbeds.

The basal contact with the Culebra (Fig. 2-9A) is sharp. The upper contact is sharp but irregular, with ~0.2 ft relief across the core diameter (Fig. 2-9B).

Bedding is more prominent in the lower 8–10 ft of A-2. Dips range from horizontal to inclined, appearing somewhat deformed in some zones. Downhole video images through these zones show bedding continuity around the circumference of the drillhole with an 11-inch diameter and vertical damping of amplitude showing some of these dips are depositional, not later deformation. Some of the bedding is due to algal development, especially at the base of A-2 (Fig. 2-9A), and the video shows confirming detail of the bedding and an estimated 4 inches of relief on this surface. Crinkly bedding on the core surface at 377 ft may be due to draping over bottom-grown gypsum crystals, but the relationships are not clear. The video also records

Figure 2-9 Lower (A) and Upper (B) Contacts of A-2 in SNL-13



more complicated structure associated with the siltstone in the lower part of A-2.

A-2 displays variable bedding, ranging from laminar to thin beds, through most of the unit. The upper contact of A-2 (Fig. 2-9B) displays relief of 0.2 ft in the core, with some penetration of reddish-brown siltstone and claystone into low points on the irregular surface. This is likely an exposure surface as the depositional environment changed from a sulfatic lagoon to a restricted halite pan and mudflat environment. SNL-13 is located west of the depositional center that existed at this time (e.g., Holt and Powers, 1988; Powers and Holt, 2000).

An argillaceous zone from 370–370.4 ft (373 ft on natural gamma) likely corresponds to a thin argillaceous zone found in most cores in approximately this stratigraphic position below the top of A-2. This argillaceous zone indicates a short-lived contraction of the sulfatic lagoon and transport of clastics. It also is notable that the gray color signifies more reducing conditions, as compared to the dominant reddish-brown of mudstone units higher in the Rustler. The downhole video that corresponds to this interval indicates a surface with some relief on which the argillaceous (and organic?) sediment was deposited.

A reddish-brown claystone at 383.8–384.1 ft is not known from other drillholes in the general area. The claystone is slickensided at an angle of about 45 degrees, and a very large, clear gypsum crystal at 383.7 ft immediately overlies the claystone. The coarse gypsum indicates void space to grow in, and the reddish-brown claystone may also be a filling of void space. Given the channeling through A-2 elsewhere at the WIPP site (Holt and Powers, 1988; Powers and Holt, 2000), and the likely exposure of the upper surface before M-3 was deposited, some cavernous porosity apparently developed in lower A-2 that filled with claystone. There is no indication of open porosity in the core, caliper log, or video of the drillhole after it was reamed to 11 inches in diameter. The video does show clasts from the upper sulfate separated by claystone matrix.

The informal Tamarisk unit *mudstone-halite 3* (M-3/H-3; Fig. 2-2) appears to be 19 ft thick (352–371 ft bgl) at SNL-13, based on the natural gamma log. The cored interval for M-3 is marked from 354.5–366.6 ft, a thickness of 12.1 ft. No halite (H-3) is present at SNL-13. The complete interval appears to have been recovered in cores. The difference in thicknesses is likely due to the zone of argillaceous, and possibly organic-rich, sulfate in the lower part of A-3 (see following paragraphs). The natural gamma log shows a broad shoulder on the upper contact that indicates relatively low natural gamma consistent with less concentrated clay minerals. There may also be some infiltration of clays into the underlying A-2 that extends the lower contact. The caliper log shows an enlarged diameter through about 12 ft, which is more consistent with the core findings, as the sulfate beds at the top of A-2 and base of A-3 are less likely to enlarge during drilling.

M-3 is dominantly reddish-brown (2.5YR4/4) argillaceous siltstone and claystone with ~1 ft of gypsum and anhydrite near the top of the unit. The lower 9.5 ft of M-3 include subangular to rounded clasts to 1.5 inches diameter of gypsum, siltstone, and claystone. Bedding is partially preserved, but the clasts are not obviously graded in the core. The upper 0.7 ft of reddish-brown siltstone, above the sulfate bed, includes gray siltstone clasts. Bedding in the upper part of M-3 dips ~20–30 degrees from horizontal.

The informal unit *anhydrite 3* (A-3; Fig. 2-2) occurs from 284–352 ft bgl on geophysical logs, a thickness of 68 ft, which is thicker than at the WIPP site. Core from the bottom and top of A-3 have contacts marked at 354.5 and 281.9 ft, implying a thickness of 72.6 ft. The main part of A-3 was drilled.

The basal part of A-3 (18.5 ft) was cored, and this part of the unit is mainly gray gypsum and anhydrite that is bedded to laminar, with wavy to inclined beds dipping ~20–30 degrees. A thin-bedded argillaceous and calcareous zone from 351–351.2 ft includes possible intraclasts of gray clay. This zone likely contributes to the gamma signature associated with the underlying M-3. Downhole video camera views in the reamed

drillhole show that these dipping beds undulate around the circumference due to syndepositional ridges in the sulfate beds, similar to those formed at the surface in some modern sulfate pans. The video camera also shows that there is fracturing and separation of blocks in the lower part of A-3, with claystone or mudstone separations. The core features appear more limited and regular than is shown in the video.

The bulk of A-3 cuttings is gray gypsum that is coarse-grained, with some irregular laminae that are more calcareous. The video through A-3 displays persistent bedding through the unit, although some sections appear more massive.

The upper 2.1 ft of A-3 were cored and show laminated to thin-bedded, dark gray, fine gypsum and anhydrite. The transition upward to the Magenta is sharp, without alternations of carbonate and sulfate observed in cores from many drillholes.

The Tamarisk stratigraphy and thickness are generally consistent with other drillholes and shafts in the area (Holt and Powers, 1988), although A-3 is somewhat thicker.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-13 is 26 ft thick (258–284 ft). Core from the Magenta is marked from 254.0–281.9 ft, a thickness of ~27.9 ft (Fig. 2-10). Coring appears to have begun at the very top of the Magenta. Recovery was complete, with little fragmentation.

The Magenta consists of gypsiferous dolomite and gypsum, and it is commonly light olive gray (5Y6/2) to white (5Y8/2) at SNL-13. 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-13, like outcrops and shaft exposures of the Magenta, is strong wavy to laminar bedding.

From 277–281.9 ft, wavy and thin beds have higher amplitudes indicating algal growth (Fig. 2-10). From 265.5–277 ft, low-angle to wavy bedding dominates, with some low-angle cross-cutting and erosional surfaces with <0.25 inches of relief. From 263–265.5 ft, bedding is thicker, includes white gypsum grains, and has low-angle surfaces similar to lower zones. A nodular anhydrite and gypsum bed occurs from 261.6–263 ft (Fig. 2-11) and is stratigraphically lower than another nodular zone found across much of the WIPP site. Ripple bedding is more pronounced from 258.5–261.6 ft, there is less gypsum, and the zone is more porous than other parts of the Magenta. Bedding is similar from 256–258.5 ft, but there is more gypsum and less porosity. Another nodular gypsum bed occurs from 254.5–256 ft, and this bed is in the same stratigraphic position near the top of Magenta as found in most other drillholes.

Bedding-plane separations up to 1 inch, filled with fibrous gypsum, occur in two zones, from 263–265.5 ft and 277.1–279.3 ft. Very narrow, high-angle fractures filled with gypsum are present from 256.6–257.6 ft, 258.5–259 ft, and 260.3–261.3 ft. A gypsum-filled fracture (Fig. 2-10) from 272.6–272.9 ft dips at about 45 degrees.

The dolomite appears most porous from 258.5–261.6 ft, and there is little evidence of sulfate through this interval. This zone is stratigraphically similar to more porous zones in other drillholes though the interval is not nearly as thick as in many other drillholes. Geophysical logs do not indicate strong differences in porosity through the Magenta. The neutron counts are low throughout the Magenta. The microresistivity and conductivity appear to show generally moderate conductivity with a narrow higher resistivity zone that corresponds to the lower nodular gypsum zone.

The Magenta is typical in thickness, composition, and sedimentary features. The lower nodular zone is the biggest difference from most Magenta cores. The more porous zone in the upper Magenta is consistent in stratigraphic position with porous zones in many other Magenta cores, although the porosity may not be great. The Magenta is less fractured at SNL-13 than it is at SNL-2, near Livingston Ridge.

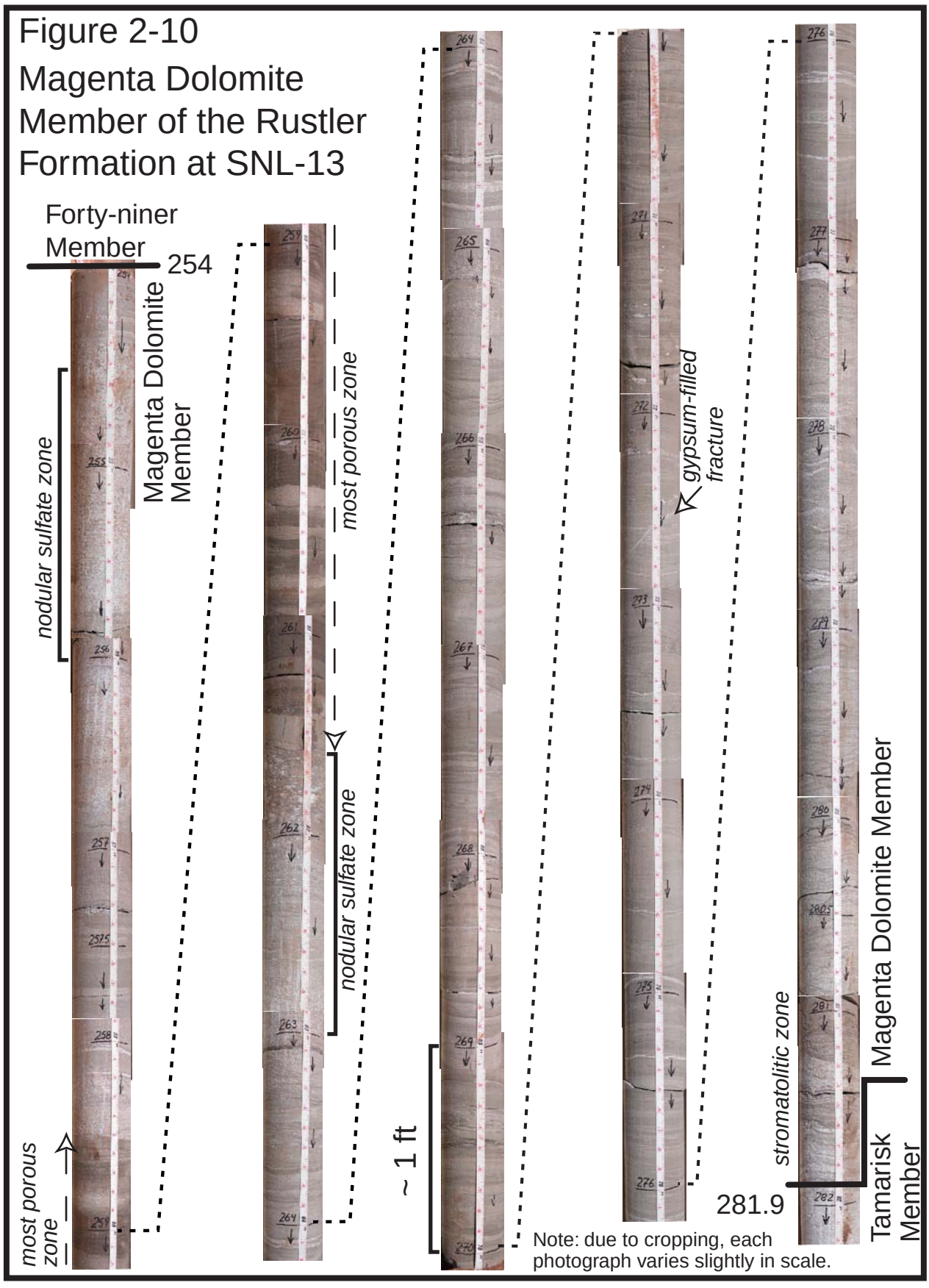


Figure 2-10
Magenta Dolomite Member of the Rustler Formation at SNL-13
Forty-niner Member
254
Magenta Dolomite Member
nodular sulfate zone
most porous zone
most porous zone
nodular sulfate zone
~ 1 ft
gypsum-filled fracture
stromatolitic zone
281.9
Magenta Dolomite Member
Tamarisk Member
Note: due to cropping, each photograph varies slightly in scale.

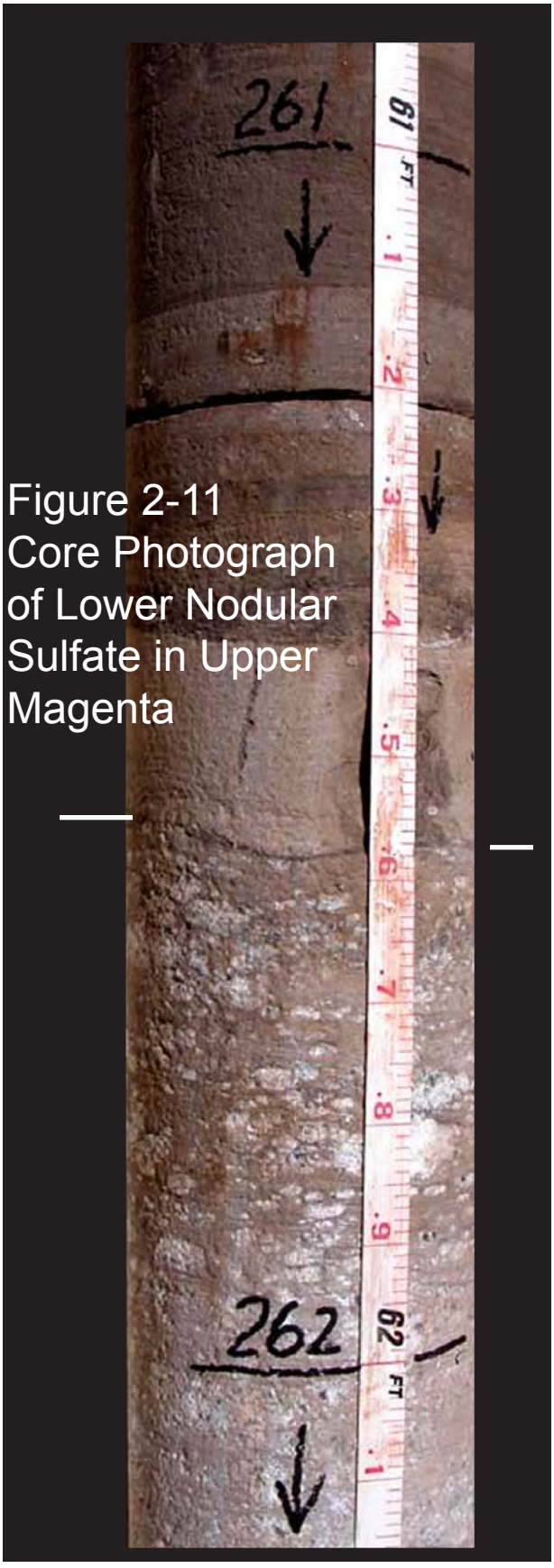


Figure 2-11
Core Photograph of Lower Nodular Sulfate in Upper Magenta

2.2.1.5 Forty-niner Member

The Forty-niner at SNL-13 is 66 ft thick (192–258 ft), based on geophysical logs. Downhole video camera data taken prior to installing a surface casing to 192 ft are consistent with the logging depths for the top of the Forty-niner. Drilling rate changes and cuttings indicated a depth of 190 ft to the top of the Forty-niner, and the core at the top of Magenta is marked 254 ft, a thickness of 64 ft. The Forty-niner was not cored. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that ranges from claystone at SNL-13 to halite east of the WIPP site area. Powers and Holt (2000) informally designated these units as A-4, M-4/H-4, and A-5, from bottom to top. They attributed the lateral relationship between clastic beds (M-4) and halite (H-4) to depositional facies of mudflat–saline mudflat–saltpan environments.

The lower unit, *anhydrite 4* (A-4; Fig. 2-2), is white or clear to gray, coarse to fine anhydrite and gypsum. A-4 is 20 ft thick (238–258 ft), based on geophysical logs. The interval from drilling is from 236–254 ft, a thickness of 18 ft. The video showed a middle unit, ~5 ft thick, with several near-vertical fractures filled with gray material that could be siltstone or gypsum. Fractures continue downward to the lower part of A-4, but they are less frequent.

Mudstone-halite 4 (M-4/H-4; Fig. 2-2) is ~15 ft thick (223–238 ft), based on the natural gamma log. Cuttings returns and drilling rates indicating clastics from about 224–236 ft are generally consistent with the geophysical log. Cuttings from M-4 showed a lower (233–236 ft) greenish-gray (white: 5YR8/1) slightly sandy siltstone that is also slightly calcareous. The video through the lower M-4 showed horizontal bedding with lighter colored beds more resistant to the drilling. These may be the calcareous beds. Cuttings were moderately indurated and revealed fine laminar bedding. From 224–233 ft, reddish-brown (5YR4/4) siltstone cuttings were recovered that were calcareous, slightly sandy, loose, and compacted to indicate slight moisture. Through

the upper M-4, bedding was little apparent on the video. No halite was observed in cuttings, nor was any indicated by geophysical log signatures.

The upper sulfate unit, *anhydrite-5* (A-5), is white to light gray gypsum (and anhydrite?) composed of fine crystals. At SNL-13, it is 31 ft thick (192–223 ft bgl) based on natural gamma logs; it is 34 ft thick (190–224 ft bgl) based on drilling rates and cuttings.

The downhole video shows bedding and a few near-vertical fractures filled with gypsum and apparently having little or no displacement.

2.2.2 Permo-Triassic Dewey Lake Formation

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

At SNL-13, the Dewey Lake is 174 ft thick (22–196 ft bgl) based on natural gamma and 168 ft thick (22–190 ft bgl) based on drilling rates and cuttings. The Dewey Lake is composed mainly of red (2.5YR4/8) interbedded sandy siltstone, argillaceous siltstone, and fine-grained sandstone. Small light gray (2.5Y7/2) reduction spots and zones are a common characteristic of the Dewey Lake and are recorded by the cuttings at SNL-13. The Dewey Lake is variably calcareous throughout, and there was no confirmed gypsum in cuttings. A downhole video taken prior to installing the surface casing shows high-angle fractures with white filling from ~58 ft bgl. This may be gypsum, but the filling is more likely carbonate, given the lack of gypsum in cuttings where the hole was drilled with air. White material on fractures and the surface of the drillhole in the video are likely pasted on from drilling the gypsum beds of the upper Rustler, combined with some water from the Dewey Lake. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-13 can be interpreted only generally to indicate different basic sedimentary regimes of the Dewey Lake (e.g., Doveton, 1986) because the drillhole was cased through the formation before logging. The following information follows the basic template developed for a study of the Dewey Lake hydrogeology (Powers, 2003b) and applied to other drillholes such as C-2737 (Powers, 2002b) and SNL-2 (Powers and Richardson, 2004).

Only the lower two of three general depositional regimes for the Dewey Lake Formation can be clearly distinguished on natural gamma logs of SNL-13. The third, and part of the middle, have been eroded.

The interval from 115–196 ft bgl in SNL-13 displays the natural gamma features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003b). The natural gamma fluctuates around a similar value (~ 50 cps in this case) over this vertical interval. The patterns are very generally consistent with broad-scale bedding, and the interval corresponds to a bedded section clearly exposed in the WIPP air intake shaft (Holt and Powers, 1988).

The interval from 22–115 ft bgl (93 ft thick) is marked by generally upward-increasing gamma with poorly defined subcycles having basal low gamma units (sandstones). These are interpreted as part of the interval of *fining-upward cycles* because increasing natural gamma is frequently an

indicator of finer clastic grain sizes (Doveton, 1986; Powers, 2003b). The base of this interval is defined by a sandstone unit from ~94–115 ft. Near the center of the site, the fining-upward cycle interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). The *coarsening-upward sequence* (Powers, 2002b) of the upper Dewey Lake is entirely missing at SNL-13 due to erosion. This is entirely consistent with the general pattern of progressive stripping of the Dewey Lake westward where the Santa Rosa Formation has also been removed.

The natural gamma log through the fining-upward cycles does not show marked decreases over thin intervals corresponding to very fine to medium-grained sandstones found across the site area (Powers, 2003b). These also have been removed by erosion.

The broad sedimentological units definable by natural gamma logs for the lower Dewey Lake are present and generally representative below 22 ft.

Cuttings from the Dewey Lake were calcareous to the base of the formation, and no gypsum was confirmed. This is consistent with the general findings of drillhole P-15 in the southwest corner of the WIPP site (Jones, 1978). Geophysical logs that might have indicated resistivity or other properties related to porosity or water were unusable because of casing.

Water was encountered in the lower Dewey Lake, consistent with the encounter at P-15 and the general hypothesis of Powers (2002b) relating to cement changes. The data are described in Section 3.0.

2.2.3 Miocene-Pleistocene Gatuña Formation

The Gatuña at SNL-13 is about 16 ft thick (6–22 ft). It is mainly red (2.5YR4/8), fine to medium sandstone that is very calcareous. The sand grains are subangular to subround, with stained surfaces and ~1% opaque black grains. There are some manganese oxide stains, similar to findings in broader studies of the Gatuña (Powers and Holt, 1993).

2.2.4 Pleistocene Mescalero Caliche

The Mescalero is an informal soil stratigraphic unit defined by Bachman (1973). It is widespread in southeastern New Mexico, and it is a continuous stratigraphic unit at the WIPP site. Uranium-disequilibrium ages indicate the Mescalero formed as a pedogenic unit between ~570,000 (± 100,000) and ~420,000 (± 60,000) years ago (Rosholt and McKinney, 1980). The age is further bounded by the Lava Creek B ash (~600,000 years old), which underlies the Mescalero north of SNL-2 along Livingston Ridge (Izett and Wilcox, 1982).

At SNL-13, the Mescalero is ~4 ft thick (2–6 ft). From cuttings, the Mescalero is a white (10YR8/2) to very pale brown (10YR7/3), very calcareous sandstone to sandy limestone. Sand grains were fine to medium, subangular to subround.

Bachman and Machette (1977) classified six useful stages of pedogenic calcrete development, ranging from I as the least developed to VI morphologies showing multiple generations of calcrete development. ("Pedogenic calcrete" is preferred by many geologists and pedologists over the term "caliche" because of the wide variation in use of the latter term.) The Mescalero could not be classified at SNL-13 based on limited cuttings and use of this material, obtained from a borrow pit, for constructing the drilling pad. In the general area of SNL-13, the Mescalero commonly displays characteristics classified IV.

2.2.5 Surficial Deposits

Construction fill is about 2 ft thick at the drillhole location. It appears to mostly overlie the Mescalero. The Berino soil was not observed at SNL-13 overlying caliche; the Simona-Bippus complex is a thin, brownish-gray soil developed directly on the Mescalero at SNL-13 (Chugg and others, 1971).

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-13

SNL-13 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 observations during multi-well tests south and west of the WIPP site.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

Damp cuttings were observed within the Dewey Lake at a depth of 185 ft. At the end of that day of drilling (April 11, 2005), the hole had been advanced to 210 ft, within the upper sulfate bed of the Rustler Formation. The hole was drilled to this depth using compressed air. The SNL video camera was run into the uncased drillhole (see Appendix G), and the side wall of the hole was damp or wet from a depth of ~143–144 ft. A miniTroll from SNL was placed in the drillhole to a depth of 205 ft bgl for overnight observations of water-level rises (Figs 3-1, 3-2).

On the morning of April 12, 2005, the miniTroll was removed from SNL-13, and the water level was measured at 150.7 ft bgl with an SNL Solinst meter. A bailer sample of water was recovered, and the field specific gravity was measured at 1.000. A sample was collected and analyzed indicating relatively low total dissolved solids dominated by calcium and sulfate (see analyses in Appendix D); with measured values (in milligrams/liter) of 3,800; 680; and 2,200; respectively.

The graph of pressure recovery with time over the period of 14 hours shows a decrease in slope (Fig. 3-1) that is generally consistent with the observations made above. The pressure increase is appropriate to a water-level rise of ~54 ft above depth of the miniTroll. It is also generally consistent with a saturated zone below ~143 ft, as observed by downhole video camera. The average inflow over the period from drilling shutdown to water-level measurement is estimated to be ~0.35 gallons per minute (gpm).

The decision was made to ream the hole to the top of the Rustler Formation and case off the producing zone within the Dewey Lake.

Figure 3-1
SNL-13 Dewey Lake Pressure/Temperature Curves

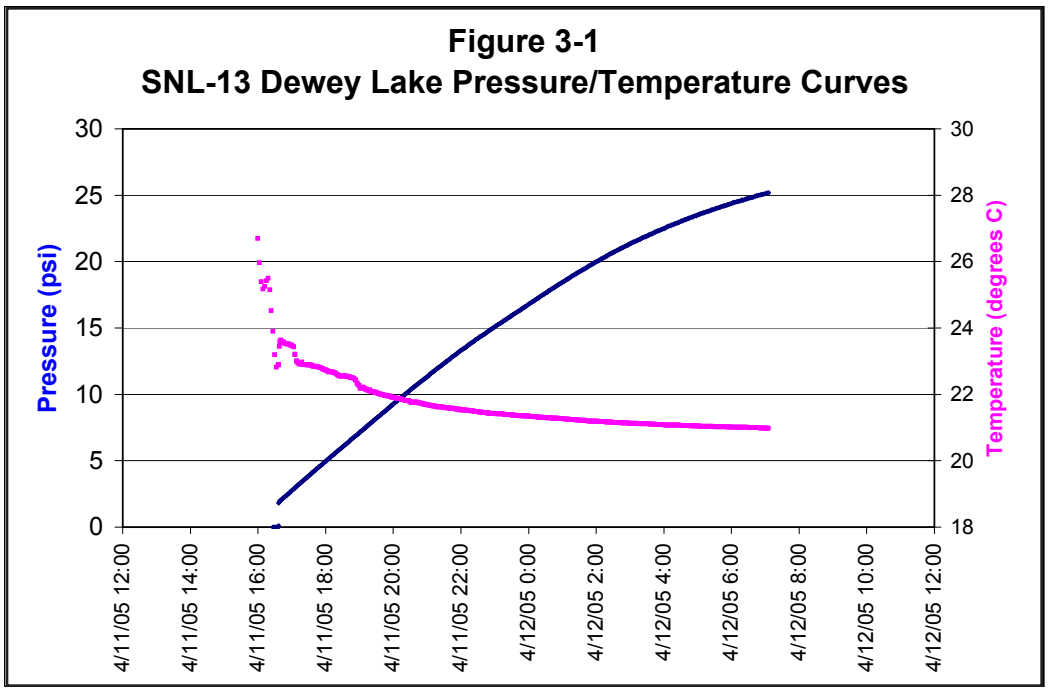


Figure 3-2. MiniTroll being set up at SNL-13 on April 11, 2005 to monitor Dewey Lake water.

3.2 Initial Results From the Forty-niner

After the Dewey Lake was cased off, drilling and coring resumed to 254 ft (uppermost Magenta Dolomite) using compressed air. At the end of drilling on April 18, 2005, a miniTroll was installed at a depth of 252 ft. Data downloaded early April 19 from the miniTroll indicated no change in pressure and the miniTroll was extracted.

3.3 Initial Results From the Magenta Dolomite

After SNL-13 was cased through the Dewey Lake, drilling and coring resumed from 210 ft using compressed air. The Magenta was cored April 19, 2005. The cored interval was reamed to 11-inch diameter on April 19, and the drillhole was advanced to 346 ft, which is in the lower part of A-3. After removing the drillpipe and bit, the SNL downhole video camera was run to total depth, mainly to check possible inflow from the Magenta. The surface character and color changed at 259 ft, near the top of the more porous zone in cores, and wetting fingers could be observed to ~279 ft, near the base of the Magenta. The drillhole surface below this point was dry, and the bottom of the drillhole had not accumulated any standing water. A miniTroll was installed at the end of drilling April 19, 2005, to a depth of 345 ft. Data downloaded from the miniTroll on the morning of April 20 showed no increase in pressure. A check on the morning of April 20 with a Solinst meter provided a weak signal at total depth, but there was no indication of accumulated water in the drillhole. Coring from 346 ft was continued using compressed air without blowing any perceptible moisture from the drillhole. Based on video observations, the Magenta at SNL-13 does yield water to an open hole, but the inflow rate is very low and could not be calculated.

3.4 Initial Results From the Culebra Dolomite

The upper to middle Culebra was cored (~15 ft) to a depth of 401 ft on April 20 using compressed air with mist. Coring stopped at 13:25 MDT. At 06:55 MDT, April 21, the water level (possibly foam) in the drillhole was at 384.7 ft bgl. The average inflow over the period of time was < 0.1 gpm. On April 21, coring was continued to 413 ft and was stopped at 10:15 MDT. Activities halted for rig repairs and a break. On April 23, the depth to water (or foam) was measured at 314.6 ft bgl at 07:15 MDT. The average inflow over that period was about 0.05 gpm; it is not known if the water level had stabilized prior to measurement.

The activities during development of the Culebra suggested low flow rates as well.

On April 27, 2005, the FRP casing was placed in the hole, and the well was completed for Culebra testing and monitoring (Figs. 3-3, 3-4).

After the well was completed, the Culebra was developed to prepare it for future testing and monitoring. On May 2 through May 4, 2005, the well was pumped to try to develop it. After an initial pumping at 12 gpm, the well was pumped at much lower rates, even less than 1 gpm, without complete success in clearing up the water (see Appendix B for details). On May 12, 120 barrels of water were used to jet the FRP casing at SNL-13 to clean out the casing and screen. On May 13, a pump was installed in SNL-13, and the pump was run at different rates for different periods, producing 257 gallons of water without clearing the well of sediment. On May 18, a small bailer was used to extract 87.5 gallons of water and sediment without clearing the well. On May 19, the small bailer was used to remove an additional 262.5 gallons of water from SNL-13, but the water remained dirty.

Water levels for the Culebra in SNL-13 have been measured by WRES since June 21, 2005. The initial measured depth on June 21, 2005, was 286.98 ft below the top of the FRP casing (US DOE, 2006).

Figure 3-3. Fiberglass-reinforced Plastic Casing (FRP) Screen with 0.070-inch Slots

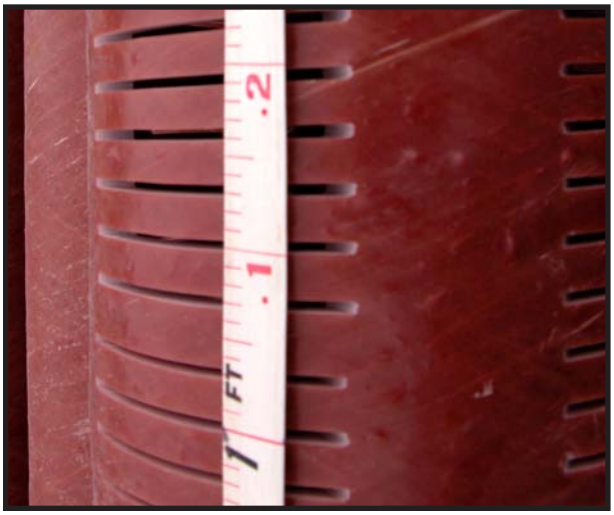


Figure 3-4. Gravel (4/10) Used to Pack Annulus Behind Screen

3.5 Initial Results From the Los Medaños Member

The well was deepened below the Culebra to obtain geological information from the Los Medaños and from the upper Salado. On April 24, the drillhole began producing large volumes of brine after reaching a depth of 468 ft. The interval was very sandy and poorly indurated. At a depth of 480 ft, drilling was halted due to the large volume of produced brine. Subsequent logging also showed considerable fill in the hole, and stability was a concern (Appendix G).

A grab sample from the rolloff containing this water had a field-measured specific gravity of 1.19 and a temperature of 21.7 degrees Centigrade. These measurements were made with uncalibrated field equipment. A sample collected from the fluid in the rolloff was sent for analysis, indicating high total dissolved solids, chloride, and sodium (see analyses in Appendix D) with measured values (in milligrams/liter) of 290,000; 190,000; and 95,000; respectively.

Both a Solinst meter and an M-Scope were used to try to determine fluid depth and produced signals at 260 ft. Because of the soap being used during the last drilling to create mist, it is unknown if this represents a true fluid level. Geophysical logging the following day (April 25, 2005) showed a fluid level 316 ft bgl, and this is likely to be a better estimate of the potentiometric surface for this brine. Nevertheless, the Culebra and lower Tamarisk Member were open at this time, and their inflow or intake are indeterminate. The Magenta is unlikely to have contributed significantly, in view of the limited inflow observed from the unit.

4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-13 are expected to be stable over a lengthy monitoring period, in contrast to steel casing in monitoring wells drilled before 1995. Newer monitoring wells provide construction experience for groundwater surveillance wells that may be drilled in the future.

The lower Rustler and upper Salado were not penetrated at SNL-13. Previous studies of thickness changes between the Culebra and Vaca Triste Sandstone Member of the Salado Formation (Powers, 2002a, 2003a; Powers and others, 2003) indicated that SNL-13 was located slightly east of the upper Salado dissolution margin, on the side where upper Salado halite has not been dissolved (Fig. 4-1). SNL-13 is located ~¾ mile (~3,800 ft) south-southwest of drillhole P-15 (Figs. 1-1, 4-1), where bedded halite was encountered in M-1/H-1 (Jones, 1978). Predrilling estimates (Appendix A) suggested that halite cements might also be present in this area. The lowermost Los Medaños was not drilled because the rock was poorly consolidated and yielded significant brine. The portion drilled did not indicate the presence of halite.

No halite was encountered in any other unit of the Rustler. This is consistent with halite margins as previously estimated for this unit (Powers, 2002a, 2003a) and a depositional origin for mudstone-halite facies.

The brine encountered in the Los Medaños at SNL-13 is of undetermined origin. The record from a nearby well does not indicates whether lost drilling fluid may have contributed to this occurrence. No brine was reported from this interval at P-15.

Culebra core recovery was exellent through the upper 15 ft of the member. Below that, core recovered is somewhat uncertain in its stratigraphic position. This is a common result of coring through the more porous zones of the middle and lower Culebra around the WIPP site area. The initial slow water inflow during drilling suggests limited hydraulic conductivity, but the geological data from the cores are inadequate to add to this inference.

The more noticeable feature of the Culebra core is the presence of several fractures between 388 and 397 ft that are near-vertical or diagonal (i.e., nearer 45 degrees from vertical); are stained black, gray, or brown; and have some silt filling. For lack of comparative information by testing or from the downhole video, the relative import of this fractured zone to the lower Culebra cannot be assessed. The geophysical log characteristics do not show important zonation within the Culebra that is relatable to this question.

The upper Culebra was accessible for a downhole video on April 23, 2005. Foam was present at the middle of the unit, obscuring views below that point. The fractured zone was apparent, with many fractures cemented with gypsum. The nodular zone at the top of the Culebra and the algal formation at the contact were observable as well.

A-2, the sulfate bed above the Culebra, shows gray laminae in the basal 2 ft that increase in dip upward to a thin, reddish-brown claystone from 384.1–383.8 ft. The claystone is not known from other cores and shafts. The video shows more fracturing than is apparent from the core. The claystone around the fractured blocks is similar in appearance to the clastics in M-3. There are different possibilities for explaining the unit. It may in part represent an exposure zone distal to the depositional center, with postdepositional fracturing and squeezing. The claystone may also be infiltrated from M-3 in response to partial solution of A-2. With the general bedded structure of A-2 intact, it seems likely that this would have occurred during exposure of the mudflat area of M-3, which is a Permian event.

The fracturing of the lower part of A-3 at SNL-13 is better represented in the video than in the core. The core would appear to represent zones or interbeds of sulfate and claystone, whereas the video reveals a more complicated breccia. The lower A-3 is laminar and undulatory, with the undulations damping upward. Fractured blocks are generally separated, with claystone between.

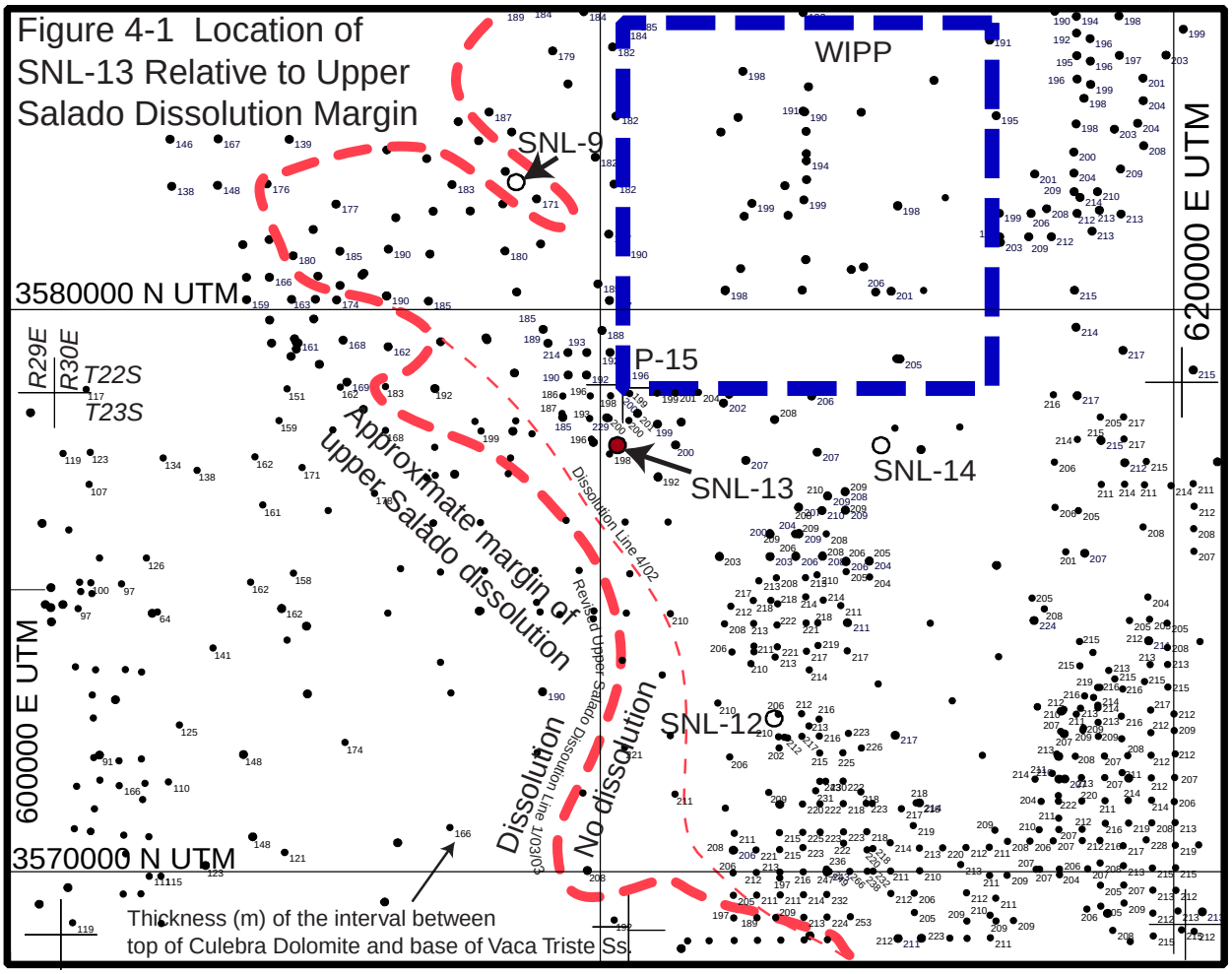


Figure 4-1 Location of SNL-13 Relative to Upper Salado Dissolution Margin

The Magenta core showed some slight porosity through an interval in the upper part of the Magenta between two nodular zones. The main difference in resistivity through the Magenta is a narrow zone of higher resistivity that corresponds to a nodular gypsum in the upper Magenta. There were no indications during drilling of water inflow from the Magenta, but decreased return of cuttings at greater depths, before reaching the Culebra, required using air and mist for drilling. Video evidence reveals the small inflow and source in the upper Magenta.

Because the Dewey Lake was cased before logging, there is no resistivity evidence for a change in natural mineral cements of the Dewey Lake. Drilling and video evidence is consistent with seepage from ~143 ft bgl. The upper Rustler sulfate does not appear to have significant porosity and did not yield water. From these indicators, we infer that the Dewey Lake is saturated from 143–192 ft. Dewey Lake water here is consistent with earlier encounters in P-15 (Jones, 1978) and the general hypothesis of Powers (2002a) regarding the areal extent of this saturated zone.

The Gatuña is ~16 ft thick at SNL-13. This is consistent with a general thinning to the east, toward the eastern side of the WIPP site, and thicker deposits toward the west and Nash Draw.

Drillhole data are dense near SNL-13, and the depths of stratigraphic units encountered at SNL-13 are very similar to James Ranch #38 on the adjacent pad. SNL-13 data do not change the basic map of the elevation of the top of Culebra.

5.0 REFERENCES CITED

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

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

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

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

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

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

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

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

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

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

Jones, C.L., 1978, Test Drilling for Potash Resources: Waste Isolation Pilot Plant Site, Eddy County, New Mexico: Open-file Report 78-592, v. 1 & 2.

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

McKenna, S.A., 2004, Analysis Report, AP-111, Culebra Water Leveling Monitoring Network Design. Copy on file in the Sandia National Laboratories WIPP records Center under ERMS 540477.

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

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

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

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

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

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

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

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

Powers, D.W., Holt, R.M., Beauheim, R.L., and McKenna, S.A., 2003, Geological Factors Related to the Transmissivity of the Culebra Dolomite Member, Permian Rustler Formation, Delaware Basin, Southeastern New Mexico, *in* Johnson, K.S., and Neal, J.T., eds., Evaporite Karst and Engineering/Environmental

Problems in the United States: Oklahoma Geological Survey Circular 109, p. 211-218.

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

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

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

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

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

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

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

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

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

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

Appendix A
Drillhole Objectives

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

SNL-13 was not designated as a location in the original groundwater hydrology program (Sandia National Laboratories, 2003). Within the program, the nearest designated well with similar characteristics is WTS-4. That location is not planned to be drilled. SNL-13 generally serves the objectives for monitoring that were included for WTS-4. The location of SNL-13 was also conditioned by results of optimization modeling (McKenna, 2004) indicating that a location south of the southwest corner of WIPP would serve better than the location of WTS-4.

The material selected here for WTS-4 and WTS-6 representing some objectives for SNL-13 has been excerpted from Sandia National Laboratories (2003). In addition, some material from one or more letter reports regarding the locations and characteristics of wells drilled during FY05 has been excerpted where it is germane to SNL-13. Note that some pages reproduced here have been reduced in scale to fit the report page format. Short portions of McKenna (2004) have been included to illustrate optimization of the network relative to the SNL-13 location.

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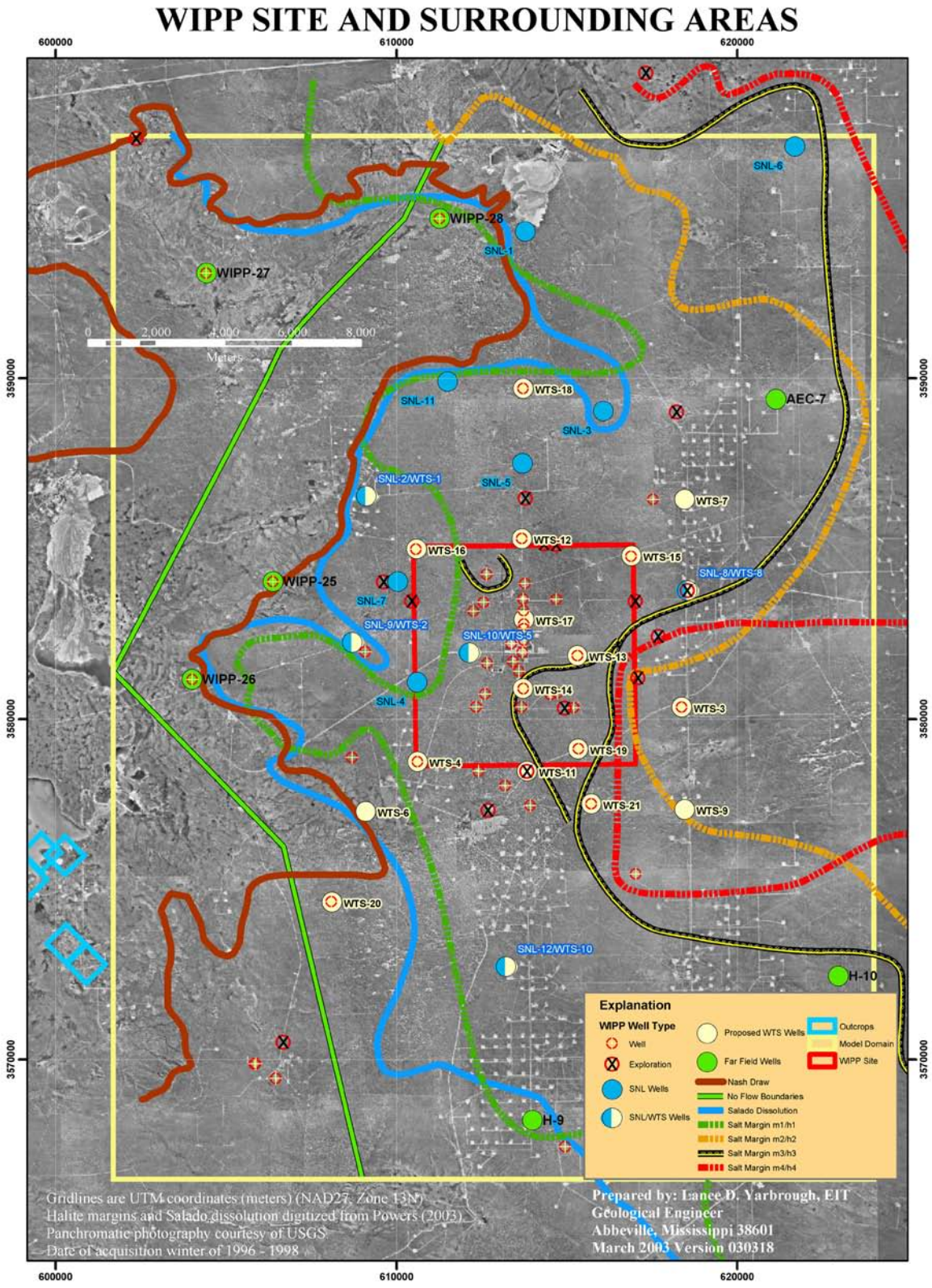
WIPP SITE AND SURROUNDING AREAS
600000
610000
620000
3590000
3580000
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WIPP-28
WIPP-27
WIPP-25
WIPP-26
SNL-1
SNL-2/WTS-1
SNL-3
SNL-4
SNL-5
SNL-6
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SNL-8/WTS-8
SNL-9/WTS-2
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0 2,000 4,000 6,000 8,000
Meters
Explanation
WIPP Well Type
Well
Exploration
SNL Wells
SNL/WTS Wells
Proposed WTS Wells
Far Field Wells
Nash Draw
No Flow Boundaries
Salado Dissolution
Salt Margin m1/h1
Salt Margin m2/h2
Salt Margin m3/h3
Salt Margin m4/h4
Outcrops
Model Domain
WIPP Site
Gridlines are UTM coordinates (meters) (NAD27, Zone 13N)
Halite margins and Salado dissolution digitized from Powers (2003)
Panchromatic photography courtesy of USGS
Date of acquisition winter of 1996 - 1998
Prepared by: Lance D. Yarbrough, EIT
Geological Engineer
Abbeville, Mississippi 38601
March 2003 Version 030318

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5. Description of Field Activities

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

5.1 New and Replacement Wells

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

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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
WTS-4			**X**	**X**		**X**		**X**

5.1.2 WTS Well Justifications…

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WTS-4: This well will replace plugged and abandoned well P-15 in the southwest corner of the WIPP site. This corner of the WIPP site is surrounded by recently drilled oil and gas wells.

…

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5.1.6 Dewey Lake Wells

… while the presence of Dewey Lake water is expected at southern locations such as WTS-4, 6, and 11, only locations from the southern dissolution re-entrant to the north are considered for potential wells.

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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
WTS-4					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. …The pumping well for the southern multipad test will prospectively be SNL-12/WTS-10, with observation wells as shown in Figure 20…

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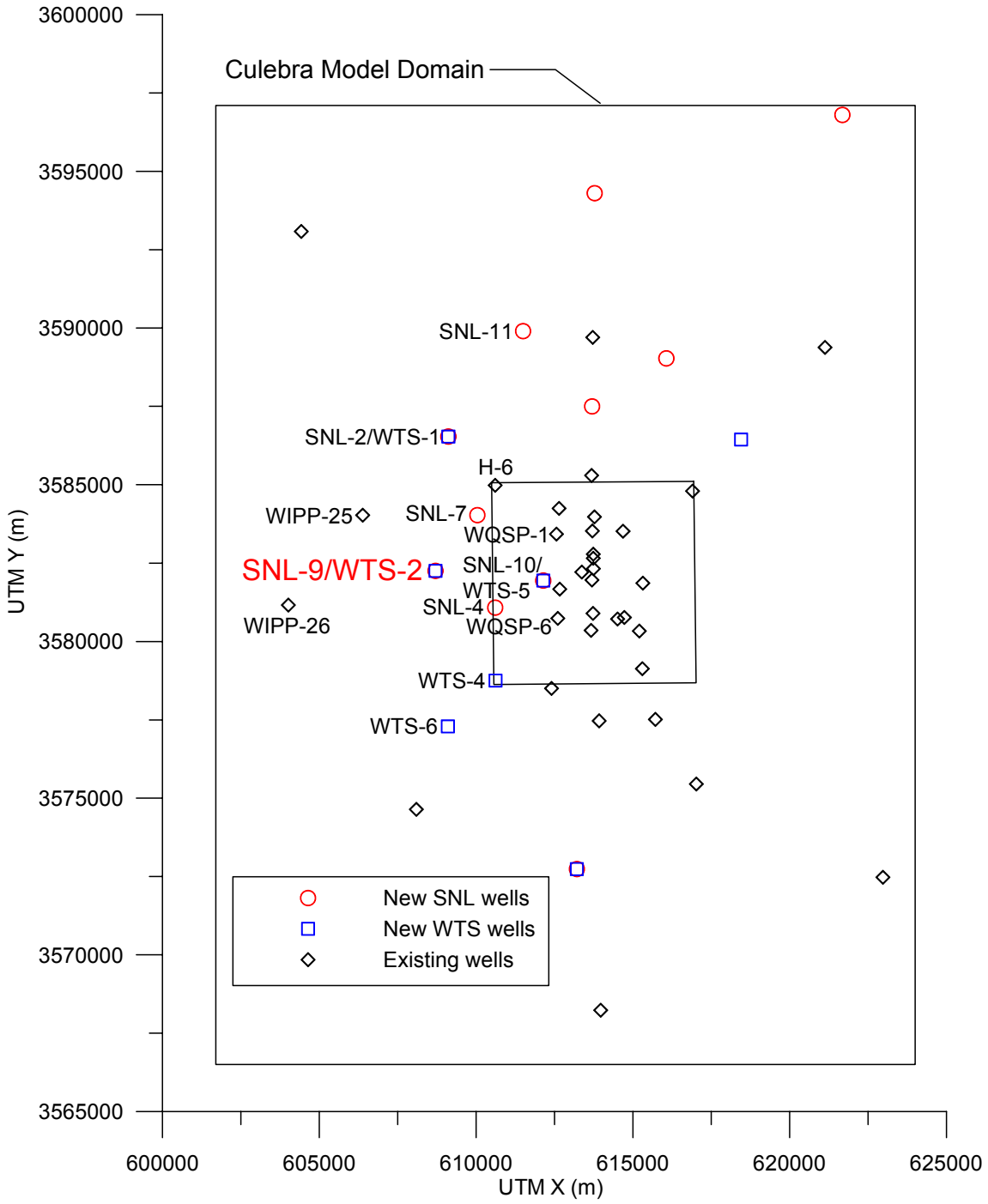

Figure 18. Pumping well and principal observation wells for western multipad pumping test.

p. 60

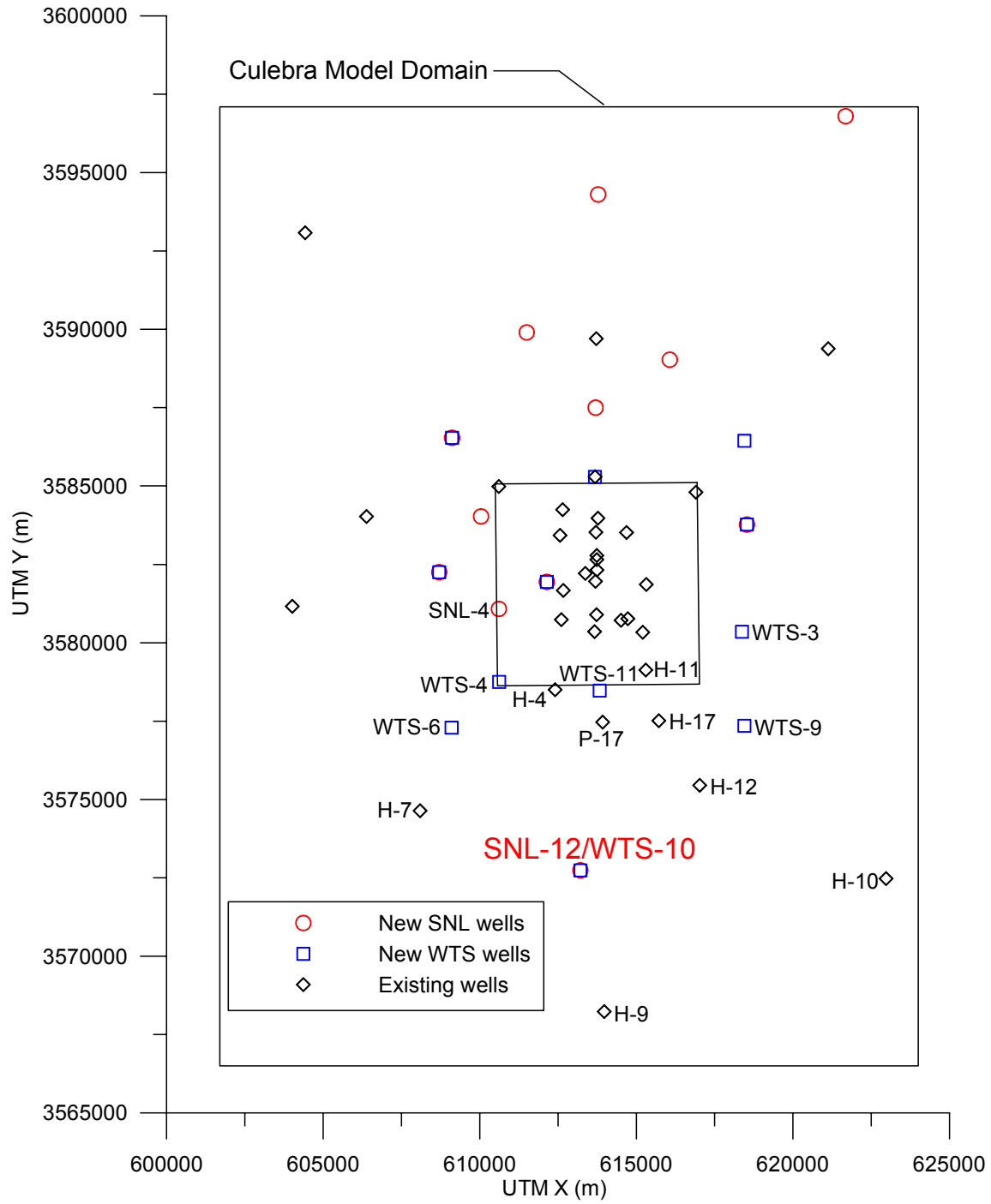

Figure 20. Pumping well and principal observation wells for southern multipad pumping test.

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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)
WTS-4	565*		

*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.

Available information is adequate to justify coring the upper Salado in holes SNL-2, SNL-3, and SNL-9. WTS-4 will provide reference data from a location where dissolution of the upper Salado is not believed to have occurred. … if conditions encountered while drilling any other borehole for this program (outside of Nash Draw) indicate the potential for dissolution of the upper Salado, drilling will continue through MB103.

Dennis W. Powers, Ph. D.
Consulting Geologist

August 1, 2004

Richard L. Beauheim
Hydrology Lead
Sandia National Laboratories
4100 National Parks Highway
Carlsbad, NM 88220

Ronald G. Richardson
Field Lead
Washington Regulatory and Environmental Services
P.O. 2078
Carlsbad, NM 88220

Dear Rick and Ron:

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

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

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

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

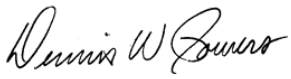
P-17, the drillhole should be located where H-3 is not present to minimize effects it may have on Culebra T values. Nevertheless, there are no drillholes between H-17 and P-17 to help delineate this margin. SNL-14 was therefore located approximately midway between the drillholes.

The coordinates for the drilling pads for each hole are:

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

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

Sincerely,



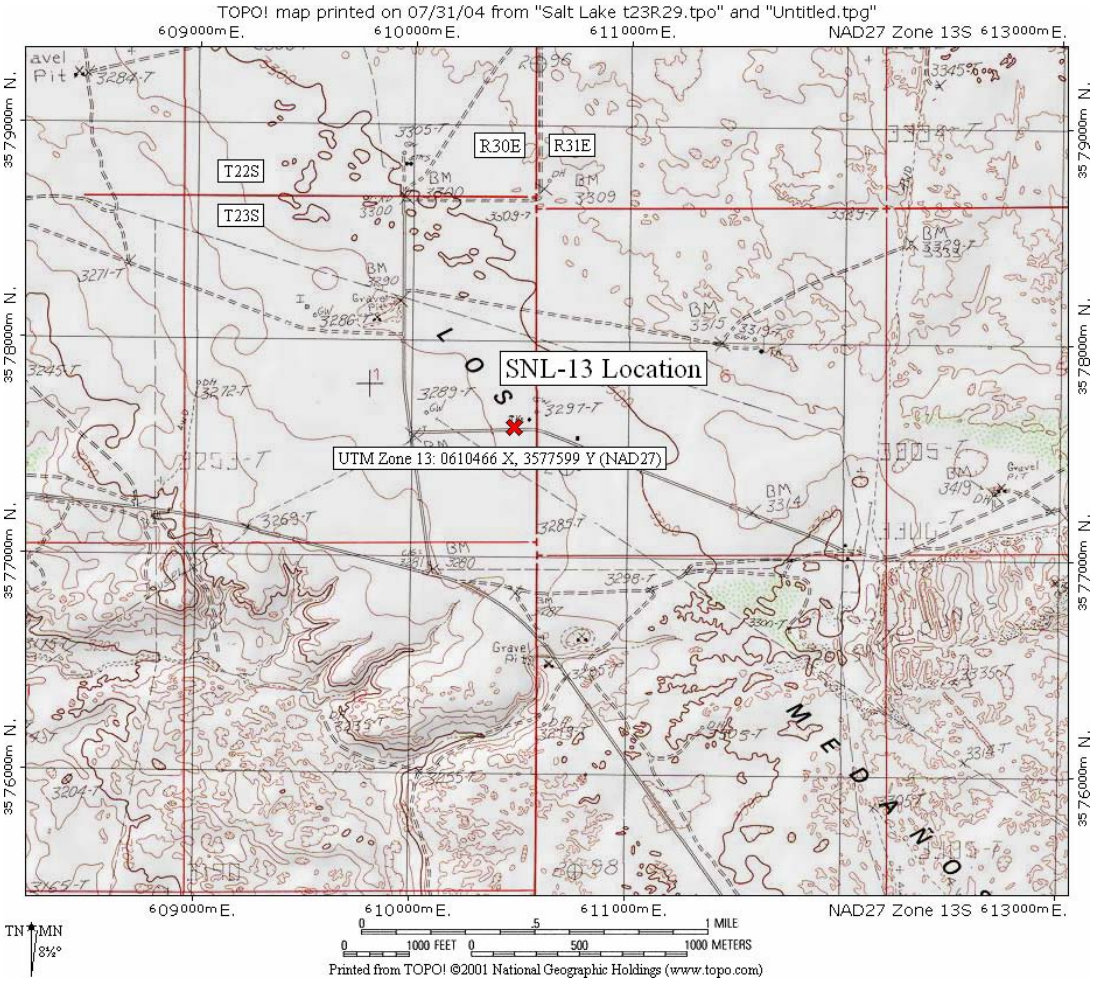
Dennis W. Powers

Parts of the memorandum following this page have not been reproduced as not relevant to SNL-13.

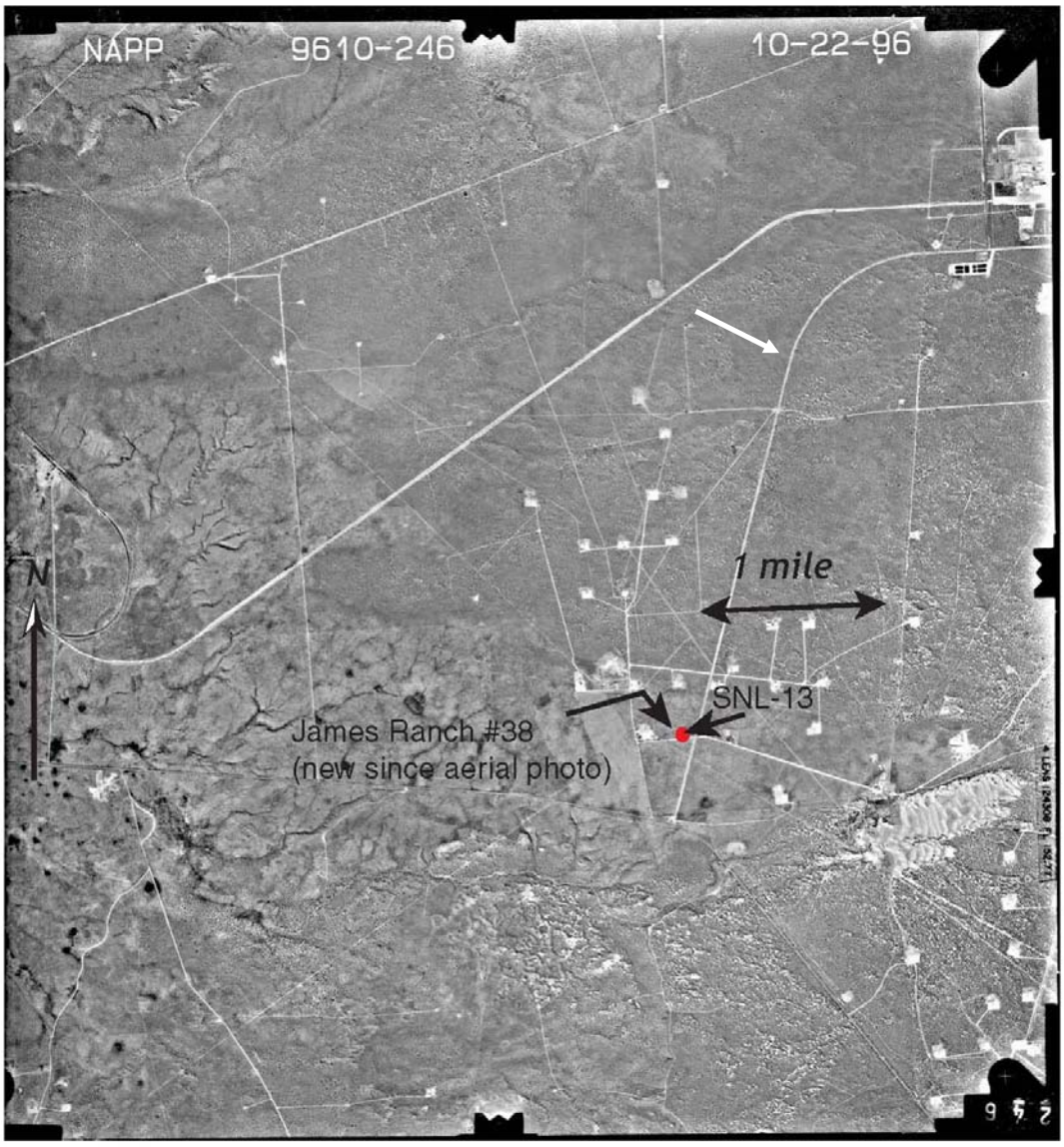
Dennis W. Powers, Ph. D.
Consulting Geologist

Assessing FY05 Drillhole Locations
August 1, 2004

Topographic map shows SNL-13 location. Bottom left shows location relative to adjacent drilling pad. Bottom right shows location with WIPP on horizon (arrow added May 28, 2007).



Dennis W. Powers, Ph. D.
Consulting Geologist



Aerial photograph showing location of SNL-13 relative to drillholes and WIPP access road (indicated by white arrow, added May 28, 2007, for clarity).

Dennis W. Powers, Ph. D.
Consulting Geologist

March 6, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Drilling Estimates and Revisions for New Hydrology Wells FY2005

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

SNL-6

Prior Expectations for SNL-6

SNL-6 was originally located in the area of the northeast corner of the hydrological modeling domain. Its purpose is to establish model boundary conditions that are important in evaluating potential vertical-leakage pathways to the Culebra. In addition, the transmissivity of the Culebra at SNL-6 was expected to be low because it is generally in the vicinity of halite in Rustler units M-2/H-2 and M-3/H-3. SNL-6 was originally scheduled to be drilled during FY04.

The hydrology plan generically indicated that wells such as SNL-6 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to about 20 ft below the Culebra Dolomite (~70 ft) for a total of about 100 ft.

My initial forecast called for coring from the uppermost anhydrite of the Forty-niner Member through the base of the Rustler and into the upper Salado, a total of about 350 ft. This more ambitious plan was based on the lack of control for the mudstone/halite facies in all units and unknown effects on the hydrology of the Culebra and other units. It is not believed that the upper Salado is being dissolved at this location and drilling was projected for about 50 ft below an expected top of Salado. Coring above and beyond the hydrology plan included the Forty-niner mudstone and basal anhydrite, all of the upper Tamarisk anhydrite, and all of the Los Medaños plus a short interval in the upper Salado.

Current Plan for SNL-6

The current location for SNL-6 is south of the original location, but it is in the same geological setting. Halite is anticipated in M-2/H-2, although data are sparse. The current location is not within the boundary for halite in either M-3/H-3 or M-4/H-4, but the boundary for M-3/H-3 is also not well constrained in this area.

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

Dennis W. Powers, Ph. D.
Consulting Geologist

The revised drilling estimate is only to the depth below the Culebra necessary to establish the casing and screen interval through the Culebra. The revised core intervals include the Forty-niner mudstone and Magenta to examine the M-4/H-4 halite margin. The Tamarisk mudstone (M-3/H-3) above the Culebra is partially cored under this plan. It is expected that halite is present in this unit.

The revised plan will eliminate coring and drilling of intervals through the lower Rustler and into the upper Salado. There will be no extension of detailed facies relationships or estimation of dissolution effects, if any, from these zones.

SNL-8

Prior Expectations for SNL-8

SNL-8 is located adjacent to the north edge of the drilling pad used for P-20. Because it is located west of the apparent margin of halite in M-3/H-3, it will provide information on the relationship of Culebra transmissivity to the presence or absence of salt in the unit. It also is in the vicinity of numerous oil and gas wells and will provide information on Culebra heads in such an area. The location of SNL-8 is also expected to provide information about the direction and rate of groundwater flow across the WIPP for annual reporting to the NMED. SNL-8 was originally scheduled to be drilled during FY05.

The hydrology plan generically indicated that wells such as SNL-8 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to about 20 ft below the Culebra Dolomite (~70 ft) for a total of about 100 ft.

My initial forecast called for coring from the uppermost anhydrite of the Forty-niner Member through the Magenta and from above the Tamarisk mudstone into the upper Salado, a total of about 280 ft. This plan was based on the lack of detail for the mudstone/halite facies in all units, although the halite facies limits for each unit has already been estimated based on the descriptions from drillhole P-20. It is not believed that the upper Salado is being dissolved at this location and drilling was projected for about 100 ft below an expected top of Salado. Coring above and beyond the hydrology plan included the Forty-niner mudstone and basal anhydrite, and all of the Los Medaños plus a short interval in the upper Salado.

Current Plan for SNL-8

The location for SNL-8 has not changed. Halite is not anticipated in M-2/H-2, although the margin is not distant. The current location is not within the boundary for halite in either M-3/H-3 or M-4/H-4.

The revised drilling estimate is to a depth about 40 ft below the Culebra to try to establish the presence of halite in the upper part of M-1/H-1 and obtain some textural details through coring. The revised core interval eliminates coring of the Forty-niner mudstone to examine the M-4/H-4 halite margin; the Magenta is cored to provide regional data. The Tamarisk mudstone (M-3/H-3) above the Culebra is cored under this plan. It is expected that halite is not present in this unit. The lower Rustler and upper Salado are neither drilled nor cored in this revised plan.

Dennis W. Powers, Ph. D.
Consulting Geologist

The revised plan will eliminate coring and drilling of intervals through and around the Magenta as well as through the lower Rustler and into the upper Salado. There will be no extension of detailed facies relationships or estimation of dissolution effects, if any, from these zones.

SNL-13

Prior Expectations for SNL-13

No drillhole designated SNL-13 was included in the original hydrological program plan. SNL-13 is located southwest of the southwest corner of the WIPP site, in an area estimated to be near the margin of halite in the lower Rustler (M-1/H-1). This location is approximately midpoint between two wells (WTS-4 and WTS-6) proposed for the groundwater monitoring program. WTS-4 was meant to replace the P&A drillhole P-15 that was monitored for a number of years. WTS-6 was to provide monitoring information as well as Culebra transmissivity data near the upper Salado dissolution margin. In addition, a Magenta well was proposed for the WTS-6 location to provided needed transmissivity and head data for modeling. WTS-4 was scheduled to be drilled in FY03; WTS-6 was scheduled to be drilled in FY04. The location of SNL-13 likely will provide information about the direction and rate of groundwater flow across the WIPP for annual reporting to the NMED.

The hydrology plan generically indicated that wells WTS-4 and WTS-6 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to the upper Salado (~145 ft) for a total of about 175 ft.

My initial forecast called for coring of the Magenta and from above the Tamarisk mudstone into the upper Salado, a total of up to 320 ft. This plan was based on the lack of detail for the mudstone/halite facies in all units in this area, although the halite facies limits for each unit has already been estimated based on the descriptions from nearby drillholes. It is not known whether the upper Salado is being dissolved at this location and drilling was projected as much as 235 ft below an expected top of Salado to reach a marker bed. Coring above and beyond the hydrology plan included more of the lower Tamarisk and a longer interval in the upper Salado.

Current Plan for SNL-13

The location for SNL-13 has not changed significantly since it was first proposed. Halite not anticipated in M-2/H-2 or higher. The halite margin for M-1/H-1 is not well constrained in this area. Geophysical logs from surrounding drillholes have been briefly examined and are expected to yield enough information to supplement data from drilling and coring the Rustler/Salado contact.

The revised drilling estimate is to a depth about 10 ft below the Rustler/Salado contact to try to establish whether halite has been dissolved from the uppermost Salado. The core and drilling will also investigate the presence of halite in the upper part of M-1/H-1 and obtain some textural details. The Tamarisk mudstone (M-3/H-3) through Culebra is cored under this plan. The revised

core interval includes coring of the Magenta; Magenta hydraulic properties in this area are likely to be important, and the hydrology plan locates a Magenta well in this area (WTS-6).

End of excerpted material from this memorandum

p. 9, McKenna (2004)

1.0 Introduction

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

p. 100, McKenna (2004)

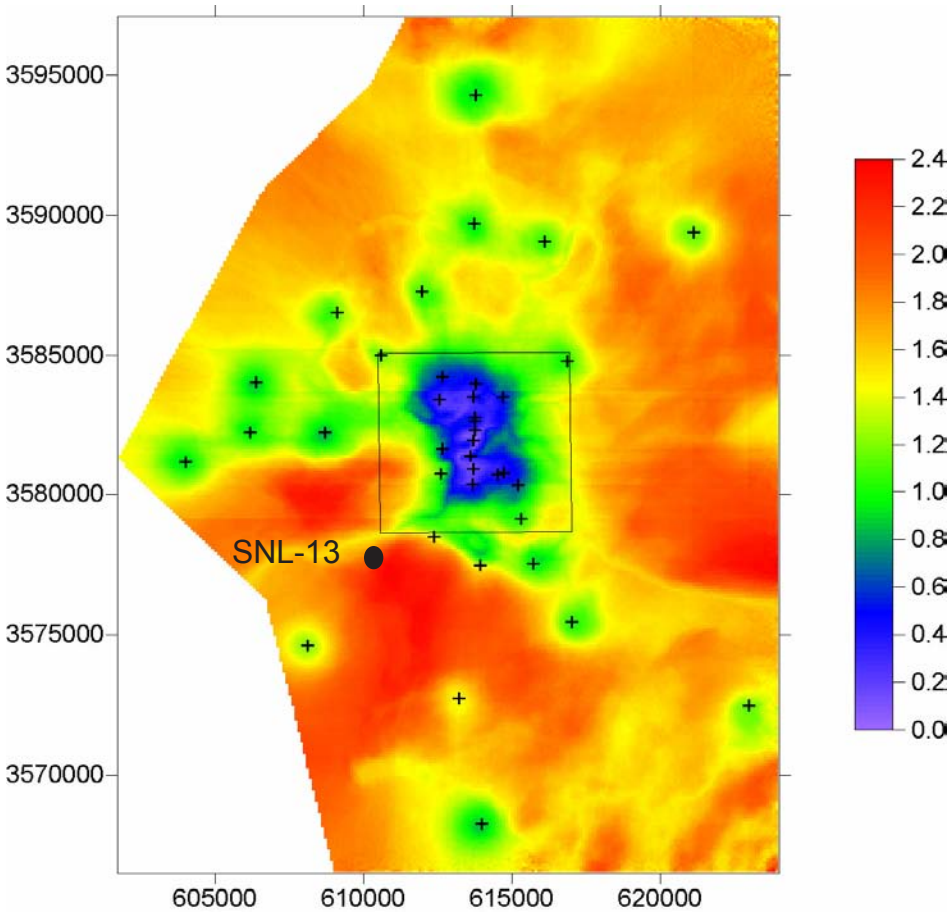


Figure 38. Combined score values map including estimation variance, number of three-point estimators and sensitivity of travel time to head. The wells in the expanded monitoring network are shown as plus signs.

Note that the identifier and dot showing the approximate location of SNL-13 have been added to this figure and are not part of McKenna (2004).

p. 102, McKenna (2004)

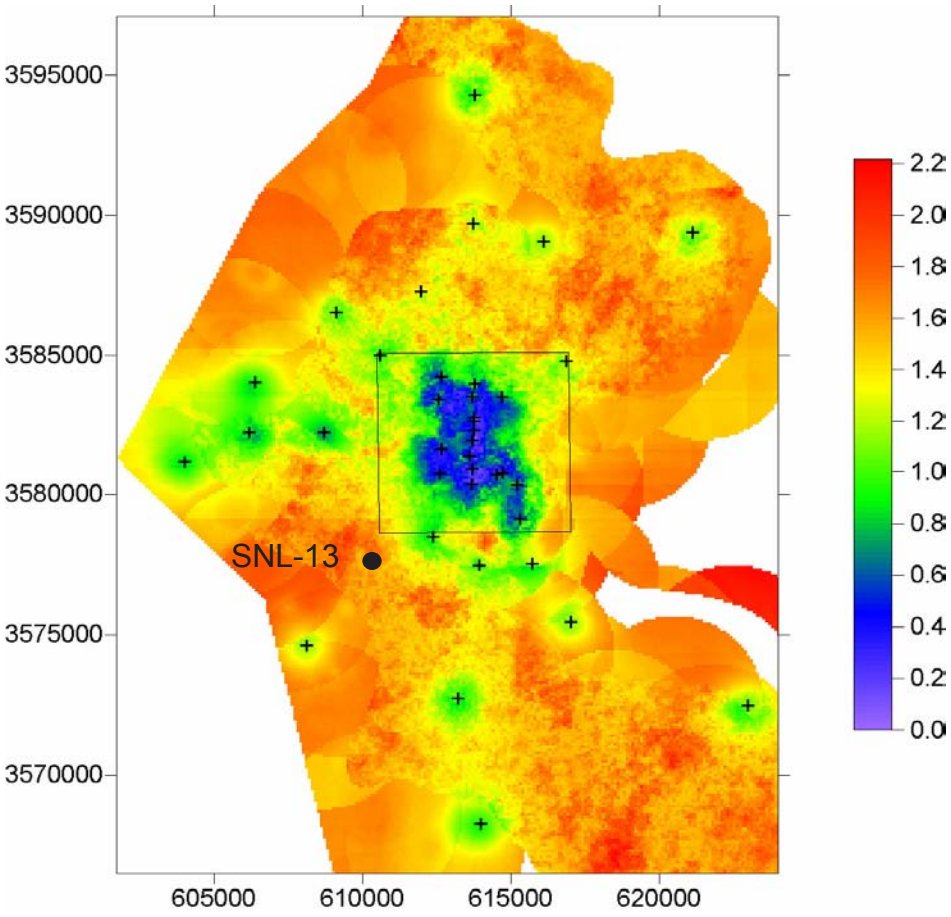


Figure 39. Combined score values map including estimation variance, number of three-point estimators and sensitivity of travel time to transmissivity. The wells in the expanded monitoring network are shown as plus signs.

Note that the identifier and dot showing the approximate location of SNL-13 have been added to this figure and are not part of McKenna (2004).

Appendix B
Abridged Borehole History

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

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

4-11-05 Left Odessa, TX, at 07:10 CDT (*see note above*) and arrived at SNL-13 drillpad site at 09:10. Conducted safety meeting. Crew went for water (90 bbls fresh). On standby from 10:20 to 11:25 for compressors. Rigged up two Sullair 1150 compressors to drilling rig by 12:03. Started drilling 11" hole at 12:03; reached 210' at 17:10. *Observed moisture in cuttings after adding joint at 185' in lower Dewey Lake Formation.* Tripped out by 17:30. *Sandia National Laboratories (Ed and Anne Schaub) on location with downhole camera and miniTroll. Rigged up and ran camera in hole; observed water seeping from side of hole at about 141' and top of water at about 204.75' below pad level. Placed miniTroll at depth of 205' below pad level and secured equipment. Departed site at 18:30.*

4-12-05 *Ed and Anne Schaub on site at 07:18 and recovered miniTroll data. Measured standing water level at 150.7' below pad level with SNL Solinst meter. Left miniTroll in hole until 09:05, collected final data, and removed miniTroll from drillhole. Collected water sample for SNL analysis; measured specific gravity at 1.000 g/cc with Anton Parr Density Meter Model DMA 35N S SN 622394 (from WRES).* WTWWS crew on site 08:25; held safety meeting. *Determined that hole should be cased to 192', just into upper Rustler Formation, to restrict water flow into the hole from Dewey Lake Formation.* Rigged up and began reaming 17.5" hole at 10:40. Drilled to 120'; began using air with foam to lift cuttings. Used 2.5 gallons Baroid Quik-Foam®. *Steve Travis (WRES) inspected site and provided instructions on containment.* On standby from 15:20 to 16:35 for Constructors to build berm to contain foam/mist. Drilled from 16:35 to 18:04, reached 192'. Shut down and returned to Carlsbad.

4-13-05 Arrived on site at 07:15. Held safety meeting. Unloaded casing from 07:30 to 08:15. *Static water level at about 160' at 09:15.*Tripped in and out of hole from 08:15 to 08:30; found 2' fill. Ran tremmie pipe in hole from 08:50 to 09:32. Ran 12.75" outside diameter casing (0.25" wall) into hole from 09:32 to 10:25. *Put 3 bags Baroid HolePlug® in bottom of hole around casing.* On standby from 10:25 to 15:00 for cement. Mike Stapleton of NM State Engineer Office arrived 14:20. *LaFarge arrived on site at 15:00 and* pumped 189 bags of sand-based cement into annulus through tremmie pipe. *Returned cement to surface.* Completed cement pumping by 15:20. Cleaned up equipment, shut down, and left site by 15:45.

4-14-05 Arrived on site at 07:30; held safety meeting. On standby from 07:45 to 12:35 for Constructors to remove cuttings from well site and put in rolloff. Attempted to install new

diverter. Will not work; Rory and Ronnie Keith left for Odessa at 12:35 to get old diverter. Crew poured 3' x 3' cement slab around casing. Left site at 16:10.

4-15-05 *WTWWS crew visited site briefly on way to Odessa, TX, for additional measurements of rig for rehab of old diverter. Shut down for weekend until diverter is ready.*

4-18-05 Left Odessa, arrived on site at 08:00. Held safety meeting. Completed rigging up diverter at 12:15. Broke for lunch. Ran reamers and collars into drillhole and installed diverter by 14:30. Cleaned out 11" hole from 192' to 210' by 14:57. Drilled from 210' to 254', completed at 17:00. Tripped out of hole, removed diverter and shut down for day at 18:00. *Ed and Anne Schaub (SNL) arrive on site at 18:05. Installed miniTroll at depth of 252' below rim of 12.75" casing. No water detected by miniTroll. Departed site at 18:30.*

4-19-05 *Ed and Anne Schaub (SNL) arrived on site at 07:00. Download miniTroll readings (no change in pressure). Ran SNL Solinst meter into drillhole to total depth and recorded no accumulated moisture in drillhole at 07:20. Schaubs removed miniTroll from drillhole and departed site. Billy Pon (DOWDCO) arrived on-site at 07:00 with core barrel.* WTWWS arrived on site at 07:25; held safety meeting. Installed diverter, and rigged up to core. Ran core barrel into hole to total depth of 254' and began coring at 09:38. Cut 30' of 4-inch-diameter core to 284', completed at 10:50. Pulled core barrel from hole and laid down core at 11:40. Recovered 30'. Laid down core barrel, assembled drilling pipe with 11" bit. Ran in hole to top of cored interval and began reaming from 254' at 14:00. Reached 284' at 14:56 and began to drill. Drilled 11" hole from 284' to 346' at 17:48. Tripped out of drillhole and removed diverter by 18:38. *Anne Schaub (SNL) rigged up downhole video camera and photographed from surface to total depth, noting slight inflow of water from Magenta. Bottom of the drillhole was clean and dry. Anne Schaub programmed and installed miniTroll at 345' below ground level for overnight monitoring of water inflow. Secured and left site.*

4-20-05 *Ed and Anne Schaub (SNL) arrived on site at 06:55, downloaded data from miniTroll indicating no change in pressure, and removed miniTroll from drillhole. Schaubs used SNL Solinst meter to check for water at bottom of SNL-13 and did not detect any standing fluid.* WTWWS arrived on site at 07:30. Held safety meeting. Installed diverter by 07:55 and began to run core barrel and drilling pipe into the hole. Began to core at 346' at 08:37. Cored to 376' at 09:55. Tripped out by 10:20 and laid down core. Recovered full 30' of core. Built berm around hole and began to trip into hole at 11:30. Rigged up to mist and began to core at 376' at 13:00. Cored to 401' at 14:25. Tripped core tool out and laid down core at 15:03. Recovered 25' of core. Serviced pump and tripped into hole to 180'. Used 2 quarts of Quik-Foam® during coring. Shut down and left site at 16:02.

4-21-05 Arrived on site at 07:00. Held safety meeting. *Water level at about 344.7' below pad level at 07:55.* Tripped into hole with core barrel to begin coring from 401' at 09:03. About 7' of fill in hole. Cored from 401-413' at 11:15. Tripped out and laid down core by 12:00. Recovered 5.5' of core. Removed mist pump from rig and left for Odessa, TX.

4-22-05 Left Odessa, TX, at 16:15; arrived on site at 18:00. Installed new mist pump on rig and left site at 20:00 for Carlsbad. No drilling.

4-23-05 Arrived on site at 07:30. Held safety meeting. *Water level (or foam) at about 315.1' below pad level at 08:10.* Tripped into hole with core barrel and blew water from hole. Set up pump system and cleaned out hole while tripping in. Began coring from 413' at 09:45. Reached 422' at 10:22; circulated on bottom and tripped out with core barrel. Laid down core at 11:05. Drilled 9' and recovered 9'. Laid down core barrel. Removed diverter, added 11" bit, re-installed diverter, and ran bit and drill pipe into hole to 346' to start reaming cored interval. Reached reaming depth of 422' at 16:00. Circulated air on bottom and tripped out with bit and drilling pipe. Used 2.5 gallons of Quik-Foam®. WTWWS crew left site at 17:00. *Ran SNL video camera in hole to camera depth of 415'; encountered top of foam at about 404' and could not see bottom of hole or detect foam/water boundary. Surveyed portions of Culebra above foam. Removed camera from drillhole, secured site, and returned camera trailer to SNL porta-camp at 19:30.*

4-24-05 WTWWS crew arrived on site at about 07:30. Held safety meeting. Uncovered drillhole and used Solinst meter to measure water level at 388.1' below rim of surface conductor pipe at 07:40. Ran 7.875" bit, collars, and drill pipe into hole to begin drilling new hole from 422'. Began drilling at 09:27 and reached 480' at 11:30. Used 2 gallons of Quik-Foam® during drilling. Shut down because water was produced at 25–30 gpm from lower part of hole. Tripped out of hole with drill pipe and bit by 13:15. Broke down core barrel and sent Billy Pon home. *Conferred with Rick Beauheim (Sandia National Laboratories) and decided to terminate drilling and complete Culebra well based on concern about stability of lower hole with continued drilling and water production as well as lack of storage for produced water. Measured specific gravity of produced water in clean roll-off as 1.19 and temperature of 21.7*°C. *Ran Solinst meter and M-Scope into hole and found fluid level (or foam) at about 260' below pad level. Shut down, secured site, and departed at 13:30.*

4-25-05 Arrived on site at 07:25. Held safety meeting. Rigged up to log hole. Completed logging at 11:30. *Bridge or fill in hole at about 443' below pad level. Determined depth for cementing lower hole interval, screen interval, and depths for gravel pack, bentonite seal, and cement for setting casing.* Hauled 70 barrels of fresh water from WIPP pipeline. Tripped into hole with drill pipe from 12:10 to 12:45. Mixed ~0.5 cubic yard (13 bags) of Portland cement to fill from 443–~422'. Pumped cement by 13:04. Tripped out of hole and changed to 7.875" bit and went 180' into hole. Shut down at 14:06 to allow cement to set overnight. Secured site and left.

4-26-05 Arrived on site at 07:30. Held safety meeting. Static water level at about 299.8' below pad level (301.35' measured at top of diverter, minus 1.7', rounded up). Tripped into hole with drill pipe from 07:45 to 08:10 and tagged top of cement at 442'. Pumped fluid out of roll-off into frac tank. Mixed ~0.5 cubic yard (15 bags) of Portland cement to fill from 442–~422'. Pumped cement by 09:50. *Tripped out of hole and shut down at 10:30 to allow cement to set overnight. Secured site and left.*

4-27-05 Arrived on site at 07:25. Held safety meeting. Tripped into hole with drill pipe by 07:50 and tagged top of cement at 425'. Tripped out of hole and removed diverter. Ran tremmie pipe into hole from 08:45–09:27. Epoxied end cap on bottom casing and let dry. Began running 5.5" (nominal outside diameter) fiberglass reinforced plastic casing into hole at 10:15 and finished at 11:48. Set blank casing from 421–411', screen (0.07" slots) from 411–384.5', and blank casing from 384.5–2' above ground level. Ran 2500 pounds of 4/10 gravel pack into hole from 425–378'. Pumped 3 bags of Holeplug® from 378–373'. State Engineer representative (Mike Stapleton) on site to observe cementing. Pumped 240 sacks of Portland cement in annulus from 373' to surface. Cleaned up site and left at 16:30.

5-02-05 *M. Crawley on site 09:00; WTWWS and W-H-B Pumps (Lovington, NM) crew arrives by 10:40. Tallied tubing, prepared to set pump at total depth of 402.75' below top of casing. Pump and tubing set by 12:05; discharge pipe to frac tank set up by 12:30. Pump turned on at 12:30; began discharge at 12:35 with initial flow of 12 gpm. Water was clear to milky. Shut pump off at 12:40 after total disharge of about 100 gallons with water muddy brown. Turned pump on at 12:50 for 3-4 minutes; water still dirty grayish brown color. Turned pump on at 13:15 at 1.75 gpm. Flow dropped to 1 gpm at 13:40 and pump turned off at 13:45 because well won't sustain even 1 gpm. Very dirty water. Turned pump on at 14:00, but well had not recovered yet; turned pump off. Turned pump on at 14:15, but not producing any water. Opened valve wide to allow water to fall back and flush pipe and pump. Turned pump on again at 14:20 with flow of 0.7 gpm. Well pumped down at 14:33; turned pump off to recover. Turned pump on at 14:50 to 15:00, produced for 2-3 minutes at 5 gpm. Turned pump on at 15:30, pumped for 5 minutes at 1 gpm.*

5-03-05 *Started pump at 09:12 at ~ 0.5 gpm and turned off at 11:10 for a total of 50-60 gallons of dirty gray brown, silty water. Turned pump back on at 11:45 at 1 gpm. Water too dirty to test for density. Turned pump off at 11:53 after pumping 8-10 gallons. Turned pump on at 12:22 at 1.5 gpm, turned off at 12:34 after pumping 5 gallons. Turned pump on again at 13:15 at 1.5 gpm; water cleared up and density was measured at 1.054 g/cc. Turned pump off again at 13:27 after pumping about 6.5 gallons. Turned pump on at 14:00 at 0.5 gpm and turned off at 13:10 after pumping 4.5 gallons. Turned pump on at 14:56 at 0.5 gpm, with flow starting about 15:00. Turned off at 15:11 after pumping 5.5 gallons.*

5-04-05 *Started pump at 08:35at ~ 0.5 gpm. Collected sample; still fairly dirty water. Turned off pump at 09:55 for a total of 48 gallons of water. Turned pump back on at 10:33 at 0.5 gpm. Turned pump off at 10:40 after pumping 4 gallons. Turned pump on at 11:16 at 0.5 gpm, still medium silty water. Choked flow back more at 10:26; still pumping for a few minutes at very low flow. Turned pump off at 11:45 after pumping 8 gallons of water that was very dirty at the end. Turned pump on at 12:20 for 10 minutes; pumped 4 gallons of very dirty water. Turned pump on at 13:25 for 5 minutes and pumped 3.5 gallons of cleaner water. Turned pump on at 13:45 for 6 minutes and pumped 3.5 gallons. Turned pump on at 14:00 for 12 minutes; pumped 4.5 gallons of silty water. Shut down. Well has not cleaned up. Will have to pressure jet well to clean out dirty water and reinstall pump.*

5-12-05 *Crew from W-H-B arrives at 09:00. A&B Transport arrives at 09:20 with 120 bbls of water from Jal. Need to start jet tool at ~415-416' below top of casing and go up and down in 30' lifts. Pulled pipe and pump out of well by 10:25. Set jet tool for 417.0'; tool and pipe back in hole at 10:56. Prepared to jet at 11:20, but pipe not taking water and must be plugged up. Tubing and jet out of hole at 12:10; jet tool is totally stopped up with gray to brown clay of unknown origin. Cleaned up tool and reinstalled half the length of pipe by 12:30. Tested system and tool is open and flowing well. Back at total depth at 13:25. Jetting is working well, producing brown water and soap bubbles. Water clear at 13:35 with little gray clay flakes. Increased pressure at 13:40, producing higher flow rate and very dirty gray water. Water clearing some by 13:45. Water still very dirty brown at 14:05; must be a lot of mud below screen in sump. Water still muddy at 14:25 with small pieces of sandpack washing through screen. Water cleaner at 14:35. Appears to be muddier when washing two intervals of screen. Used 120 bbls by 15:10. Water mostly clear but did pump some fine sand. Began pulling tool and pipe from well at 15:45 and completed by 16:15. Set pump in well by 17:30 and shut down.*

5-13-05 *Picked up generator and prepared for pumping well. Started pump at 08:05 at 1 gpm. Still pumping at 08:30; water is very clear. Still pumping at 1 gpm at 09:10 but water is now dirty brown and silty. Still pumping at 09:40 and have produced about 90 gallons. Still pumping silty water at 1 gpm at 10:00. Turned pump off and removed choke to allow greater flow. Pumped 120 gallons total. Turned pump back on at 10:35 at 2.5 gpm. Well pumped down to zero flow at 11:06; turned pump off for recovery. Produced 77 gallons. Turned pump on at 11:45 at 1.5 gpm to 1.75 gpm average. Turned pump off at 12:05 after producing 30 gallons; water cleaner. Turned pump back on at 1-1.5 gpm at 12:45 and turned off at 12:55 after producing 15 gallons. Turned pump on at 13:25 at 1.5 gpm and turned off at 13:33 after producing 15 gallons. Decided to stop pumping and leave pump in well. Will decide about continuing to pump well next week.*

5-18-05 *W-H-B staff pull pipe and pump from SNL-13 by 11:00 and prepared for bailing. Water level 292.63' below top of casing at 11:50. Started bailing at 12:05; tried 6 times without retrieving any water. Different bailer being sent from Odessa. Began bailing with new bailer at 14:30. Pulled 35 bailers of 2.5 gallons per bailer run for total of 87.5 gallons. Ended at 16:30 after hydraulic oil of rig became too hot to continue.*

5-19-05 *Met W-H-B crew at porta-camp at 08:30; took rig to site for bailing. Stated bailing with 2.5 gallon bailer at 08:50. Stopped at 10:30 after bailing 85 gallons to allow hydraulic fluid on bailing rig to cool. Began to bail again at 11:35. Stopped at 13:10 for lunch break. Well is making more water than before and have not drawn well down to bottom yet. Water has not cleaned up and is still dirty brown with clay. Started bailing at 14:00 and stopped at 15:40. Removed 262.5 gallons from well for the day.*

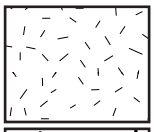
Appendix C
Geologic Logs

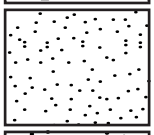
Note: The original field descriptions and graphic logs were prepared at differing scales, and the graphic logs for publication were generally produced at 10 or 20 vertical ft per inch, as indicated in the header for the log.

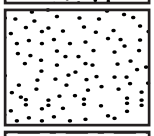
The field descriptions were related to depth based on drilling information and core recovery as best determined in the field. Core and sample footages are marked accordingly and can vary somewhat from depths determined for stratigraphic units based on geophysical logs (see Table 2-1 of text). Core depth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

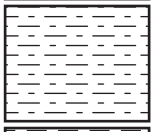
Explanation of Symbols Used in Lithologic Logs (Appendix C)

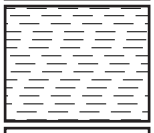
Lithology

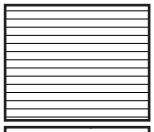

Construction fill

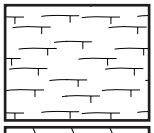

Fine sand or sandstone

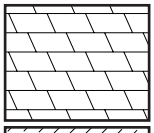

Medium or coarse sand or sandstone

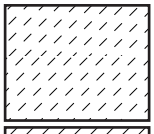

Siltstone

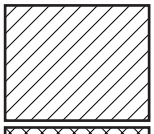

Claystone

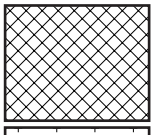

Organic-rich, claystone

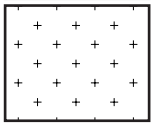

Carbonate (pedogenic calcrete)


Dolomite


Gypsum


Anhydrite


Polyhalite


Halite

Features


Cross-cutting strata


Ripples


Bioturbation

Stylolite


Wavy bedding


Stromatolites, algal bedding


Vertical gypsum crystals


Gypsum nodules


Clasts, may show lithology as fill pattern


Brecciated, fractures

Fracture, unfilled or filled (f_g for gypsum-filled)

Erosional boundary

Sharp lithologic contact


Gradational lithologic contacts

hz Hard-drilling zone

sl Slickensides

ns No cuttings sample

Symbols may be combined; not all symbols may be used

CORE LOG Sheet 1 of 7

Hole ID: SNL-13
Location: 1770 fsl, 602' fel (SE 1/4), section 1, T23S, R30E, Eddy County, NM

Drill Date: 4/11/05-4/24/05
Drill Crew: WTWWS; Ronnie Keith & Luis Armendariz, Drillers
Drill Method: Rotary
Hole Diameter: 18"(192'); 11"(425'); 7.875"(480')
Hole Depth: 480'
Hole Orient: vertical
Drill Make/Model: Gardner-Denver 1500
Barrel Specs: 6" o.d.; 4" core
Drill Fluid: air with mist
Core Preserv: core boxes

Logged by: Dennis W. Powers, Ph.D.
Date: 4/11/05- 4/24/05
Scale: 1" = 10'; variable

UTM Zone 13 (NAD27)	Northing	Easting	Reference Point Elevation
Survey Coordinate: (m)	3577599.77	610394.29	3292 ft amsl (benchmark 3291.61 ft amsl)

Comments: This drillhole was permitted by the State Engineer (New Mexico) as C-3139.
Munsell Soil Color Chart (1971 ed) used for rock colors; dry unless noted otherwise
Reamed 17.5-inch hole to 192 ft and set 12.75-inch outside diameter steel casing 4/12-4/13/05

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	0				Temporary surface casing. All depths based on drilling.	Drilling with air in portable pit
N/A		N/A	N/A		0-2': construction fill; cement, caliche 2-6': Mescalero caliche; sandstone, sandy limestone, white (10YR8/2) to very pale brown (10YR7/3); fine to medium sand, subangular to subround. calcareous	Begin 1105 MDT 3.5' @ 1108 MDT with 11" bit 5' @ 1110 MDT; reset bonnet; 6' @ 1112 MDT
	10	C-1 3' C-2 6' C-3 10'			6-22': Gatuña Formation. Sandstone, red (2.5YR5/6), calcareous; fine to medium sand, subangular to subround, stained grains and ~1% opaque black grains; some MnO_2 spots.	10' @ 1116 MDT 16' @ 1120 MDT
		C-4 16'				20' @ 1124 MDT; add 2nd compressor; begin 1140 MDT
	20	C-5 20'			Base of Gatuña Formation 22' Top of Dewey Lake Formation	25' @ 1142 MDT
		C-6 25'			22-190': Dewey Lake Formation; sandstone, very fine to fine, and siltstone with argillaceous beds; red (2.5YR4/8), with zones and spots of white (light gray; 2.5Y7/2); generally slightly calcareous to moderately calcareous; no gypsum in cuttings.	30' @ 1144 MDT
	30	C-7 30'				35' @ 1147 MDT 37' @ 1149 MDT; add joint, reamers; start 1215 MDT
	40	C-8 40			hz: 42	40' @ 1218 MDT 45' @ 1222 MDT
		C-x indicates cuttings sample number			hz: 47	50' @ 1226 MDT
	50	C-9 50'			hz: 50	

Hole ID: SNL-13 CORE LOG (cont. sheet) Sheet 2 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/11/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description (Note scale change)	Remarks
N/A	50	N/A	N/A		22-190': Dewey Lake Formation; sandstone, very fine to fine, and siltstone with argillaceous beds; red (2.5YR4/8), with zones and spots of white (light gray; 2.5Y7/2); generally slightly calcareous to moderately calcareous; no gypsum in cuttings.	
		C-10 60'			hz: 60, 61, 68 ft	60' @ 1233 MDT
						65' @ 1238 MDT
	70	C-11 70'				68' @ 1241 MDT; add jt, begin 1300
		C-12 72'-74'			71-74': sandstone, fine, white (10YR8/1), calcareous; harder drilling below sandstone.	
					hz: 78'	70' @ 1303 MDT
		C-13 80'			80': similar to general formation lithology above harder drilling from 82', still slightly calcareous; check sulfate cement	75' @ 1310 MDT 80' @ 1316 MDT 85' @ 1323 MDT
	90	C-14 90'			Sandy zone 88-90'	90' @ 1326 MDT
					90': as at 80'	95' @ 1331 MDT
		C-15 100'			100': as above	96' @ 1332 MDT; add jt, begin 1340 100' @ 1343 MDT 105' @ 1347 MDT
	110	C-16 110'			110': as above	110' @ 1353 MDT
						115' @ 1358 MDT
		C-17 120'			120': as above	120' @ 1402 MDT
						124' @ 1406 MDT; add jt, begin 1414
	130	C-18 130'			130': as above	130' @ 1419 MDT 135' @ 1423 MDT
		C-19 140'			140': as above (143-144' shows wet on video after drilling)	140' @ 1428 MDT
	150	C-20 150'			150': as above	150' @ 1437 MDT 153' @ 1440 MDT; add jt, begin 1449
		C-21 160'			160': as above possible gypsum flake below ~162', not confirmed by additional samples	160' @ 1452 MDT 165' @ 1455 MDT 170' @ 1501 MDT 175' @ 1503 MDT
	170	C-22 170'			170': as above	180' @ 1508 MDT 184' @ 1512 MDT; add jt, begin 1520 MDT; moist cuttings
		C-23 180'			180': as above	185' @ 1521 MDT
		C-24 185'			Base of Dewey Lake Formation	190' @ 1524 MDT
	190	C-25 190'			190' Top of Rustler Formation	200' @ 1541 MDT
		C-26 200'			190-224': Gypsum and anhydrite (?), white to light gray, fine to medium crystalline.	210' @ 1609 MDT; end drilling 4/11/05; video camera showed water; placed miniTroll
	210	ns 210'				

Hole ID: SNL-13 CORE LOG (cont. sheet) Sheet 3 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/18/05-4/19/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	210				Note scale change	
N/A		N/A	N/A		190-224': Gypsum and anhydrite (?), white to light gray, fine to medium crystalline.	blew hole dry to 210' Begin 210' @ 1358 MDT; few cuttings
						215' @ 1418 MDT; add jt @ 216'
	220	C-27 220'			A-5	220' @ 1443 MDT
						225' @ 1450 MDT
					224-233': Siltstone, very slightly sandy, generally loose, compacts to indicate slight moisture; reddish brown (5YR4/4); calcareous	230' @ 1454 MDT 235' @ 1459 MDT
		C-28 226'				236' @ 1502 MDT 240' @ 1512 MDT
	230	C-29 230'			M-4	245' @ 1529 MDT 247' @ 1537 MDT; add jt, begin 1549
		C-30 235'			233-236': Siltstone, very slighty sandy, medium induration, dry; very slightly calcareous; greenish gray (white; 5Y8/1); laminar	254' @ 1600 MDT; prep for coring; end drilling 4/18/05
					236-254': Gypsum and anhydrite, white to clear to gray; coarse to fine crystalline	Begin 4/19/05; hole dry to total depth at 0620 MDT; remove miniTroll
	240	C-31 240'			A-4	Begin coring from 254' @ 0838 MDT, 4/19/05
						Completed coring @ 0950 MDT; recovered core
	250	ns 250'			Base of Forty-niner Member 254' Top of Magenta Dolomite Member	
1		30' cored; 30' recovered (100%)	more porous zone all segments > 4"; RQD=100.0		Dolomite and gypsum, generally light olive gray (5Y6/2) to white (5Y8/2); laminar to thin-bedded, with dark (organic-rich?) thin laminae. 254.5-256.0': nodular gypsum. 258.5-261.6': less gypsum, more ripple bedding; more porous zone. 261.8-263.0': nodular anhydrite & gypsum. 263.0-265.5': thicker bedding with white gypsum grains; low-angle bedding similar to lower beds. Intraclasts @ 269.5'. 265.5-277.2': low-angle bedding, wavy, with some cross-cutting and small erosional cuts (<0.25" relief), bedding 0.05-0.5"; few small gypsum nodules. Subhorizontal to wavy bedding, with higher amplitude laminae (stromatolitic zone) from 281.9-277'; amplitude of bedding decreases upward. Nodular gypsum/anhydrite from 254.5-256' & 261.8-263.0'. 263.0-265.5' & 277.1-279.3': bedding plane separations to 1", filled with fibrous gypsum. High-angle fractures (<0.06") with gypsum: 256.5-257.6', 258.5-259', 260.3-261.3'; 45° fracture (0.25") with gypsum 272.6-272.9'.	
	260					
	270					
	280				Base of Magenta Dolomite Member 281.9' Top of Tamarisk Member	Reamed cored interval to 11": began drilling @ 284'
					Gypsum, gray, generally coarse crystalline; some irregular laminae observed. Transition upward is short, without alternations observed in some other drillholes.	
		C-32 290'				290' @ 1408 MDT
	290					

Hole ID: SNL-13 CORE LOG (cont. sheet) Sheet 4 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/19/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	290	N/A	N/A	A-3	290-330': Anhydrite and gypsum, dark gray, mainly fine crystalline.	
	295					
	300	C-33 300'				300' @ 1357 MDT
	305					
	310	C-34 310'				added jt @ 309' 310' @ 1510 MDT
	315					
	320	C-35 320'				320' @ 1537 MDT
	325					
	330	C-36 330'				330' @ 1606 MDT

Hole ID: SNL-13 CORE LOG (cont. sheet) Sheet 5 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/19/05-4/20/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	330	N/A	N/A		330': more gypsiferous, lighter gray	
	335					
	340	C-37 340'			A-3	
	345	C-38 346'				346' @ 1648 MDT; end drilling 4/19/05 Trace water detected with Solinst meter 4/20/05; coring with air
		346'			346-354.5': Gypsum and anhydrite, gray, some reddish zones; coarse to fine crystalline; bedded to laminar, with most bedding inclined ~20-30° from horizontal. (Video shows growth ridge and probably algal structures in continuous bedding around hole circumference.) Thin-bedded argillaceous and calcareous zone 351-351.2', with possible clay intraclasts; clay laminae at 352.4'.	
	350					
					354.5'	
	355				354.5-355.2': Siltstone, reddish-brown, with gray clasts (top of M-3).	
					355.2-356.3': Gypsum and anhydrite, gray, similar to A-3, above 354.5'.	
2		Cut 30'; recovered 30'	all segments > 4" long (RQD = 100.00)		356.3-357.1': Siltstone, argillaceous, dark reddish brown; bedding dips ~20-30°.	
	360				357.1-366.6': Siltstone, argillaceous, very slightly sandy, reddish brown (2.5YR4/4), with clasts of gypsum, siltstone, claystone; clasts range from subangular to rounded, up to 1.5" diameter; siltstone and claystone clasts both gray and reddish-brown; some zones show bedding and laminae, but grading is not evident on core surface.	
	365				M-3	
					366.6'	
					(see next sheet for description of A-2)	
					A-2	
	370					

Hole ID: SNL-13 CORE LOG (cont. sheet) Sheet 6 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/20/05-4/21/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	370			f_g	A-2	
	375			f_g	366.6-383.8': Gypsum and some anhydrite, light to dark gray, very coarse to fine crystalline; bedded to laminar, with bedding from ~horizontal to inclined to irregular or deformed, with bedding and laminae more prominent in lower 8-10'; some crinkly bedding may be due to small vertical growth gypsum at 377'; some possible algal bedding; few high- to moderate-angle (45°) fractures filled with gypsum; large fracture from ~370.5-372' has coarse gypsum crystals; other fractures and bedding plane separations filled with fibrous gypsum; argillaceous and calcareous from 370-370.4'; argillaceous from 367-367.6'; clasts or growth textures at top with clay. Very large gypsum crystal at 383.7'. (Video camera showed horizontal to inclined bedding in sedimentary growth features in A-2.)	
		376'			383.8-384.1': Claystone, reddish brown (5YR5/4-4/4), slickensided along ~45° plane.	
	380				384.1-386.0': Gypsum, gray laminae with increasing dip upward.	
	385				386.0 Base of Tamarisk Member Top of Culebra Dolomite Member	
3		Cut 25'; recovered 25' (100%)	~2.5' in segments < 4" long (RQD = 90.0)		386.0-406.2': Dolomite, brown, poor to laminar bedding, nodular in zones, fractured with some gypsum fill. 386-387': interbedded with flat gypsum nodules 387-389.4': dark brown, with granular gypsum 389.4-395.1': grayish brown, fine grained, no larger pores or vugs 395.1-399.7': grayish brown and brown, with larger pores and vugs increasing to base; some silt fillings, no gypsum fill in pores or vugs 399.7-401': gray, argillaceous; no vugs or pores 401-404.2': gray, with mostly small vugs (<0.25") and a few larger vugs; gypsum in some vugs. 404.2-406.2': grayish brown, with some larger vugs; some with gypsum; brecciated basal 1'. *Bedding plane separations (ft)*: 387.1, 387.34, 387.8, 388.1, 388.8, 390, 390.1, 390.3, 391.2, 392.4, 393.2, 393.6, 394.1, 394.8, 395.2, 396.1, 396.6, 398.3, 398.7, 399.6. *Fractures*: interval, angle from horizontal, fill or stain 386-387', ~90° and irregular, some gypsum filling 388.6-388.8', 80°, silty and no stain 389.45-390.4', ~90°, silty, gypsum, reddish-brown stain 390.8-391', 40°, gray stain 391.2-392.0', ~90° but irregular, gray stain 392.0-393.2', 80° and planar, black stain and gypsum fill 393.3-?395', vertical and irregular, brown stain 394-?395', vertical and planar, no stain 395-396', 50° and 80° intersecting, with silt fill? 396-397', ~ 90° and irregular, silt and gypsum filling 399.5-401', irregular and short, some stained dark gray 404.8-405.6', vertical and irregular, some gypsum fill	
	390					
	395					
	400					401' @ 1325 MDT; stopped coring 4/20/05 Begin 4/21/05; water level 384.7' bgl @ 0655 MDT.
		401'				
4	405	Cut 12'; recovered 5.5' (45.8%)	~3.5' in segments > 4" long (RQD = 63.6)	lost core	406.2 Base of Culebra Dolomite Member Top of Los Medaños Member	Drilling pressure and rate indicates change at 408.5'; possible core loss - 2.5' from upper core 4, 4.5' from Los Medaños
	410				406.2-406.5': Clay, black, sticky	

Hole ID: SNL-13 CORE LOG (cont. sheet) Sheet 7 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/21/05, 4/23/05-4/24/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description Note Scale Change	Remarks
	410			lost core	413-417.1': Siltstone, dark red (2.5YR3/6) with gray (2.5YRN5/) from 413-415', red (2.5YR5/6) from 415-417.1'; more calcareous in red zones, less in gray; broadly bedded; abundant coarse to fibrous gypsum, generally parallel to bedding, some inclined 15-50°; possible displacive gypsum; some gray intraclasts; irregular, sharp basal contact.	
		413'			M-2	
5		Cut 9'; rec 9' (100%)	All segments > 4" (RQD = 100)		A-1	end coring 4/23/05; run video camera Begin 4/24/05, water level 388.1' below casing at 0640 MDT
	420				417.1-418.4': Gypsum, gray, white, pink; thin bedded to laminar (~0.5") upward, probably bedded nodular; possibly algal at 417.6'.	
		422'			418.4-419.7': Gypsum, nodular, white, stained reddish between nodules; fine, with coarse gypsum in some interstices.	
NA		NA	NA		419.7-422': Gypsum, light gray (5YR7/1) and anhydrite; laminar (0.2-1.0") to wavy bedding; possible bedded nodule overprint. Possible small (<0.2") swallowtail gypsum or pseudomorphs in some zones; fracturing in upper 0.2'.	
	430				422-427': Gypsum, generally as above.	430' @ 0842 MDT addt jt, begin 0854
					427-431': Siltstone and claystone; dark reddish brown (2.5YR3/4, wet) to dark gray (2.5YRN4/, wet); non-calcareous to slightly calcareous.	435' @ 0900 MDT
	440				M-1	440' @ 0902 MDT
					431-434': Gypsum and anhydrite, white, finely crystalline.	445' @ 0903 MDT
	450				434-452': Siltstone and fine sandstone, not well indurated.	450' @ 0905 MDT
						452' @ 0910 MDT
					452-468': Siltstone and very fine sandstone, reddish brown to gray, slightly calcareous; more indurated than overlying siltstone and sandstone.	455' @ 0916 MDT
	460				468-480': sandstone and siltstone?, poor cuttings, brine flowing in at increasing rate.	460' @ 0925 MDT
						462' @ 0928 MDT add jt, begin 0939
						465' @ 0944 MDT
	470					470' @ 0948 MDT stop to shift rolloffs
						480' @ 1030 MDT shut down because water production too great
	480				Total depth: 480'. Note that geophysical logs from upper Rustler to upper Los Medaños Member consistently show depths 5' greater than drilling information; thicknesses are comparable. TD may be 485'.	Sample from rolloff had field specific gravity of 1.19 g/cc and temperature of 21.7°C. Water level at 260' @ 1130 MDT (may be foam)
	490					

Wildflowers on land adjacent to the SNL-13 wellpad. Photograph by Dennis Powers 4/11/05.

Appendix D
Permitting and Completion Information

A case file for SNL-13 (C-3139) containing official documents is maintained by the land management coordinator, Environmental Monitoring and Hydrology Section of Washington Regulatory and Environmental Services for the WIPP Project. Selected documents are reproduced here for ease of access. Originals have been reduced to fit page formats.

As noted in the text, all official correspondence concerning permitting and regulatory matters should refer to the New Mexico State Engineer permit number C-3139.

Information on management of well-drilling wastes for SNL-13 is not included; at the time of basic data report preparation, these wastes were still being characterized for disposal.

Basic water chemistry for samples taken from inflow from the Dewey Lake and at total depth in the Los Medaños has been included as images scanned from laboratory reports to SNL.

Dennis W. Powers, Ph. D.
Consulting Geologist

April 25, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Completion Decision on SNL-13

Our discussions (which included Ronnie Keith, WTWWS) yesterday regarding a large increase in water (brine) production as the Los Medaños was being drilled led me to recommend that drilling be terminated at the current depth of ~480 ft below ground level and that the drillhole be completed in the Culebra as originally scheduled. The principal reason for drilling SNL-13 is to obtain Culebra hydraulic data. Continued drilling under the current situation may jeopardize this objective through hole enlargement and collapse as this water is produced from the drillhole with compressed air lift. Geophysical logging today indicates nearly 40 ft of fill in the drillhole, consistent with these considerations. As a consequence of this decision, the basal Rustler and uppermost Salado will not be drilled and cored to determine the extent, if any, of upper Salado dissolution at SNL-13.

Given information from the Culebra in this area, and the information obtained during drilling, it appears likely that the Los Medaños below the Culebra Dolomite is producing much of the water (brine) in SNL-13. The water quality and water levels from the completed Culebra well will be important factors to confirm or reject this initial impression. Given the current hole configuration and fill, I do not recommend that any attempt be made to test directly for a water-bearing zone in the Los Medaños in SNL-13.

These are basic factors and information considered in this decision for SNL-13:

- Downhole video camera images show that mudstone zones above the Culebra are irregular and enlarged due to drilling prior to encountering increased water production. Fill in the lower 40 ft or so indicated by geophysical logging this morning shows some instability in the drillhole.
- The Culebra (388–412 ft below pad level from geophysical logging) does not appear to be very productive, based on a water level measured after a 40 hour break in drillhole activities, inspection of a part of the Culebra by borehole video camera, and limited returns of water during drilling with compressed air and some mist. The highest water level measured after the 40 hour period without drilling activities was about 315.1 ft below pad level.
- Water (brine) was produced in much greater quantities during drilling with compressed air and mist after reaching a depth of about 468 ft, nearly 60 ft below the Culebra. While drilling from 470 ft to 480 ft over less than 30 minutes, SNL-13 produced an estimated 2000 gallons of brine, including limited mist used during drilling.
- Brine produced while drilling from 470 to 480 ft had a specific gravity of 1.19 g/cc, as measured in the field. This brine is a composite of the water produced from the top of the Rustler to the lower Los Medaños as well as a small amount of fresh water (obtained from the WIPP pipeline) used during drilling. Although the brine is a composite, the specific gravity is much higher than has been found in the Culebra in the vicinity, including at P-15. Specific gravity was not measured for water produced from the Rustler before this deeper interval was drilled.

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

- The exposed Rustler above the Culebra (the two mudstones, M-3 and M-4, and the Magenta) were not observed to produce more than a trace of water.
- After penetrating the last 10–12 ft drilled on April 24 (~468–480 ft), the drillpipe and bit were removed from the drillhole. Pressure built up in the drillhole from the inflow of water while this operation progressed. Shortly after the drillpipe and bit were removed, the apparent water level was about 259 ft below the level of the pad, as detected with two different electric probes. This depth is approximately at the most porous zone of the Magenta, but downhole images indicated only slight seepage there.
- Geophysical logs, however, show the fluid level on April 25, 2005, at about 312 ft below pad level, similar to the fluid level in the drillhole following a 40 hour down time.

The basic reason to stop drilling SNL-13 and to complete it through the Culebra now is the concern that further drilling jeopardizes stability of the hole above and below the Culebra. The increased volume of water (brine) now produced by the drillhole, whatever the source, and the method of drilling with compressed air combine to enlarge uncased Rustler mudstones, and this is confirmed by borehole videos, caliper logs, and fill detected during logging.

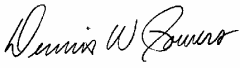
Circumstantial evidence for another water-bearing zone below the Culebra is considerable but not conclusive. The most important factors are: high salinity that is not known to exist in the Culebra in this area, high productivity after drilling the zone from about 468–480 ft, and indications of anomalously high water levels compared to known levels for the Culebra. The Magenta and other Rustler zones above the Culebra appear to yield only traces of water over short periods. Water levels did not rise rapidly when the Culebra was open.

The difference between apparent water levels on April 24 and April 25 has two explanations that might be considered: 1) fill in the drillhole prevented further inflow from a confined lower saturated zone and some of the fluid entered the Culebra overnight, dropping the fluid level to a Culebra hydrostatic level, or 2) the two electric probe measurements were erroneous, reflecting either foam or inflow from the Magenta.

Early information from the completed Culebra well can be compared for water quality and water levels. If the Culebra produces a high-specific-gravity brine and is productive, it may be that drilling activities on April 24 essentially "developed" the Culebra. That combination will be interesting, if it exists. The circumstantial evidence now available points to the possibility of another saturated zone that is not previously known to occur in this area. If it exists, it may also be confined. I am skeptical of the existence of another saturated zone, but comparing our current information with the Culebra information as the well is developed will help to confirm or reject the notion.

I believe this letter summarizes our discussions and presents the hydrological and drilling background for deciding to terminate drilling of SNL-13 before reaching the Rustler-Salado contact. It also provides circumstantial evidence of a possible saturated zone below the Culebra.

Sincerely,



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

April 26, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-13

Our discussions regarding the Culebra Dolomite Member in SNL-13 indicate that the best interval to screen is from 411–384.5 ft below the drilling pad level. This decision is based on geophysical logs completed on April 25, 2005 (see attached figure) and cores from SNL-13.

These are factors considered in this decision for SNL-13:

- The Culebra interval, based on the natural gamma geophysical log, is from 388–412 ft. This interval is 24 ft thick, about average around the WIPP site.
- Core across the transition from Culebra to Los Medaños was not recovered intact, although gray plastic claystone was encountered. The base of the screen will be placed at 411 ft, about 1 ft above this contact to prevent squeezing of the claystone into the screen.
- The screened or slotted section of the casing joint is 26.5 ft long. This will provide a screened interval that can incorporate all of the Culebra, although the basal 1 ft will be excluded (see above). The top of the screened interval will be at 384.5 ft.
- The laminated claystone and mudstone (M-2/H-2) below the Culebra was partially cored. No salt was detected in this section, and it does not need to be cemented.
- Cuttings through most of A-1 and into M-1/H-1 did not reveal any halite to the final drilled depth of 480 ft. The smaller diameter hole (7.875 inch) hole below 422 ft was partially logged because of an obstacle at a depth of about 443 ft, based on geophysical logs taken April 25, 2005. The drillhole will be cemented back to a depth expected to be about 422 ± ~3 ft (level will be determined by re-entering the drillhole).
- Geophysical logs and core above the Culebra indicate the anhydrite/gypsum unit (A-2) is relatively intact and separates the Culebra from the Tamarisk Member mudstone (M-3) by 16 ft. The base of M-3 is at 371 ft.
- The sand/gravel pack should be placed from the lower cement to a depth of about 380 ft, just above the upper screen. The bentonite seal will be placed from 380 to 375 ft, and the annulus will be cemented from 375 ft to the surface. This should prevent circulation into the Tamarisk mudstone (M-3).

To provide sump space below the screen interval, 5+ ft of blank casing with an end cap will be added below the screen. The length will be determined when the level of cement in A-1 has been established. The hole is to be separated hydraulically from the lower Los Medaños, and the sand pack will be started from the cement top, expected to be in the vicinity of 422 ft.

I believe this letter summarizes our discussions and presents the hydrological and geological justification for setting the screened interval and preparing SNL-13 for completion.

Sincerely,

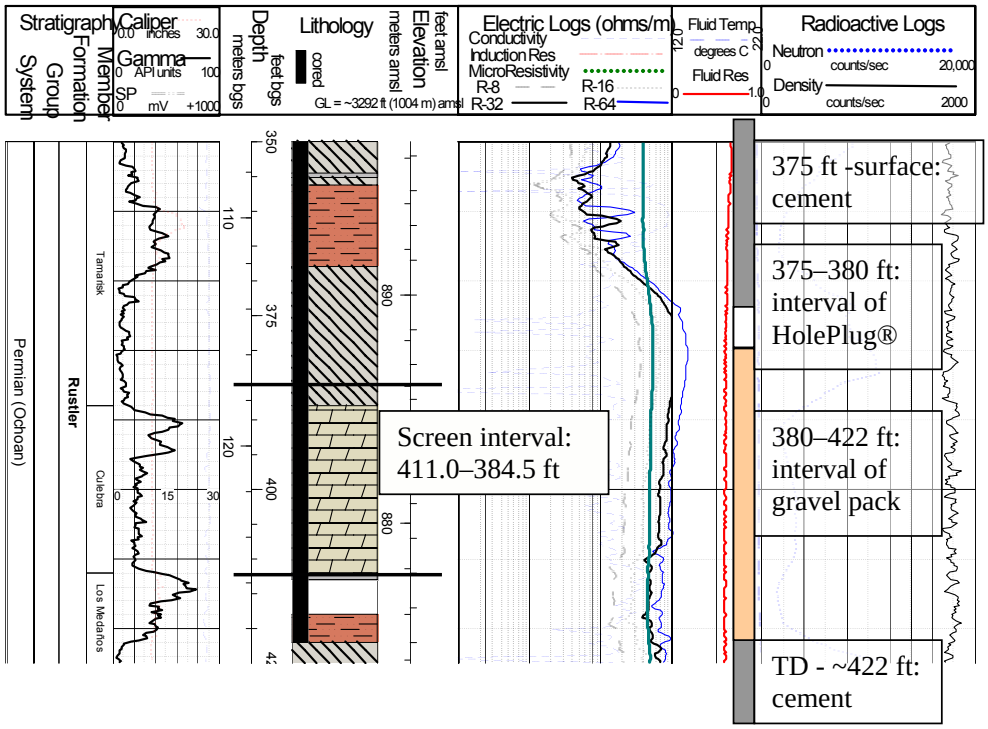
Dennis W. Powers

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

April 26, 2005

Partial Geophysical Log of SNL-13



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

April 25, 2005

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-13

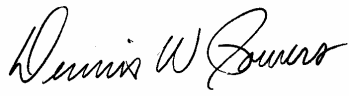
Background
Cores and cutting samples have been collected from drillhole SNL-13 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me or WRES personnel. SNL-13 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-13 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-13 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-13 be maintained indefinitely under normal storage conditions because of their relevance to hydrology and monitoring programs. The cores can be accessed for observations, and they can be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

It is recommended that cuttings samples be retained under normal storage conditions through the approval by EPA of the second CRA. The cuttings are commonly very fine in shallow sections and add little to the geologic record from initial observations as well as geophysical logs. Cuttings may be accessed for observation, and they may be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

Supplemental Information
Descriptive core logs and digital photographs of cores with a photograph log will be provided to you on CD-ROM format in accessible formats when the content has been reviewed for the basic data report for SNL-13.



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*

United States Department of the Interior

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

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

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

JAN 25 2005

RIGHT-OF-WAY RESERVATION AMENDMENT

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Maria Telleen

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

1-25-2005
Date

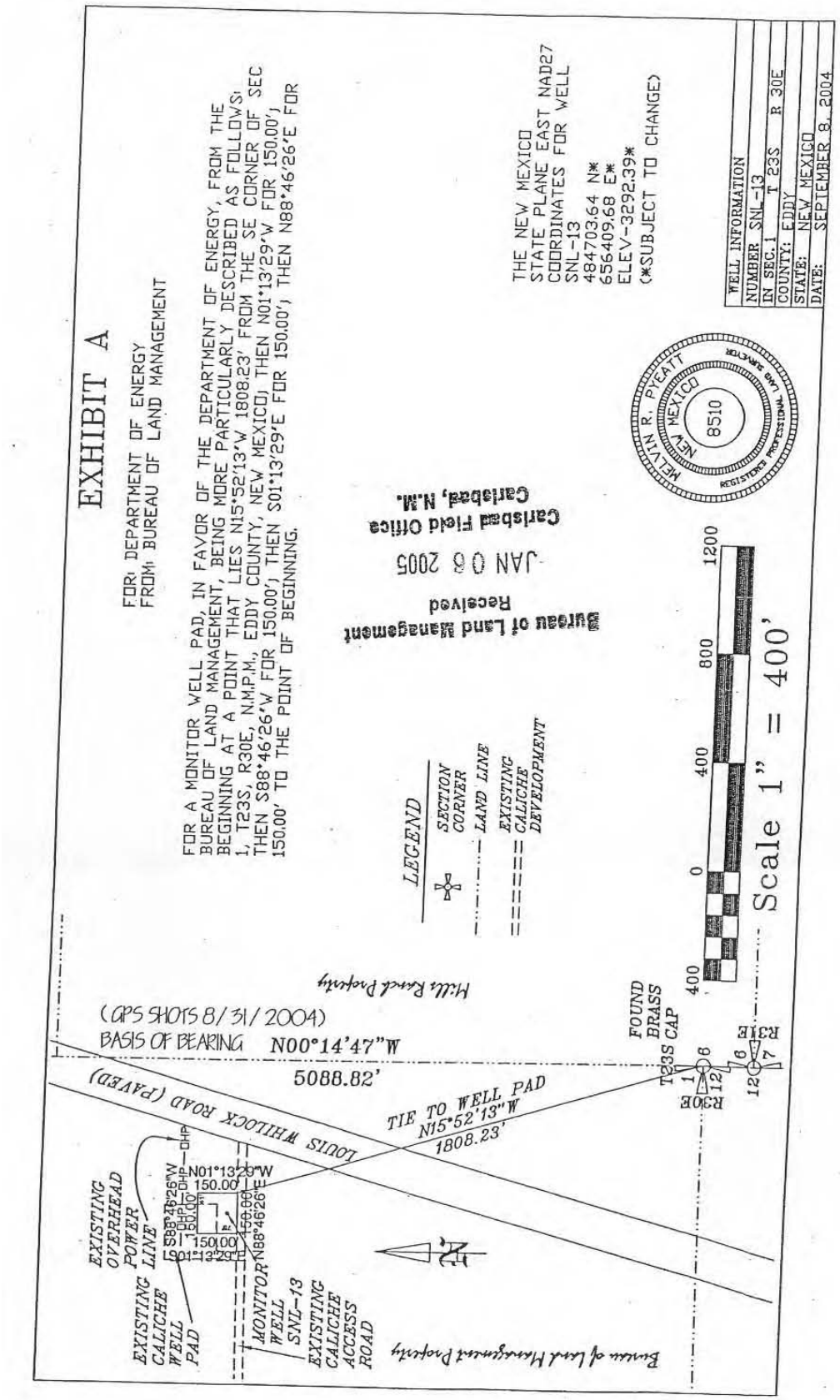
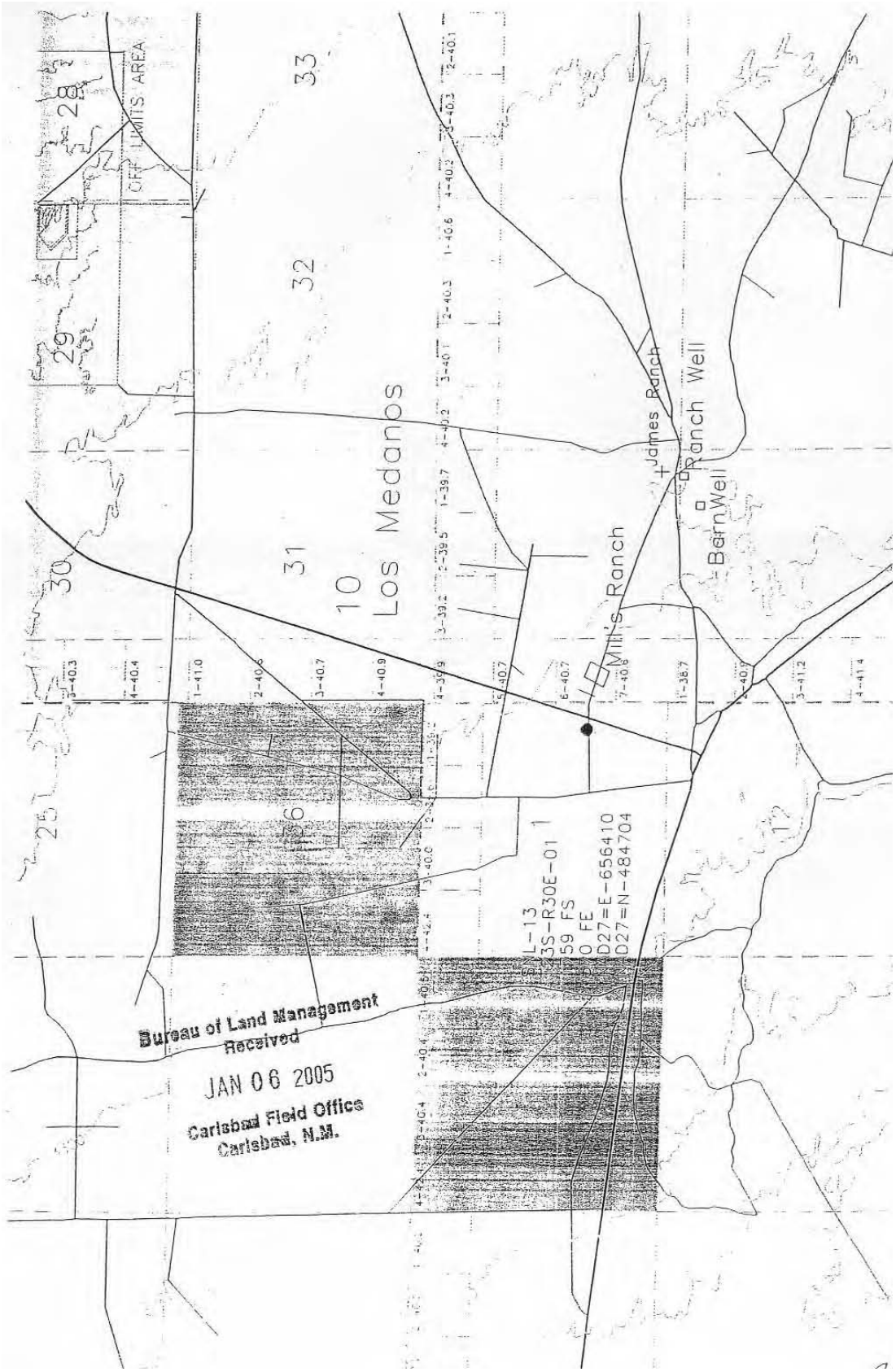


EXHIBIT A
FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT
FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES N15°52'13"W 1808.23' FROM THE SE CORNER OF SEC 1, T23S, R30E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N01°13'29"W FOR 150.00'; THEN S88°46'26"W FOR 150.00'; THEN S01°13'29"E FOR 150.00'; THEN N88°46'26"E FOR 150.00' TO THE POINT OF BEGINNING.
THE NEW MEXICO
STATE PLANE EAST NAD27
COORDINATES FOR WELL
SNL-13
484703.64 N*
656409.68 E*
ELEV-3292.39*
(*SUBJECT TO CHANGE)
WELL INFORMATION
NUMBER SNL-13
IN SEC. 1 T 23S R 30E
COUNTY: EDDY
STATE: NEW MEXICO
DATE: SEPTEMBER 8, 2004
MELVIN R. PYCATT
NEW MEXICO
8510
REGISTERED PROFESSIONAL LAND SURVEYOR
Bureau of Land Management
Received
JAN 05 2005
Carlsbad Field Office
Carlsbad, N.M.
LEGEND
SECTION CORNER
LAND LINE
EXISTING CALICHE DEVELOPMENT
Scale 1" = 400'
0
400
800
1200
400
(GPS SHOTS 8/31/2004)
BASIS OF BEARING N00°14'47"W
5088.82'
TIE TO WELL PAD
N15°52'13"W
1808.23'
FOUND BRASS CAP
T23S
R30E
R31E
LOUIS WHILOCK ROAD (PAVED)
EXISTING OVERHEAD POWER LINE
EXISTING CALICHE WELL PAD
MONITOR WELL SNL-13
EXISTING CALICHE ACCESS ROAD
N01°13'29"W
150.00'
S88°46'26"W
150.00'
S01°13'29"E
150.00'
N88°46'26"E
150.00'
OHP
Bureau of Land Management Property
Mills Ranch Property


OFF LIMITS AREA
28
29
30
31
32
33
10
Los Medanos
James Ranch
Ranch Well
Barn Well
Mill's Ranch
6
1
12
25
L-13
23S-R30E-01
59 FS
0 FE
D27=E-656410
D27=N-484704
Bureau of Land Management
Received
JAN 06 2005
Carlsbad Field Office
Carlsbad, N.M.

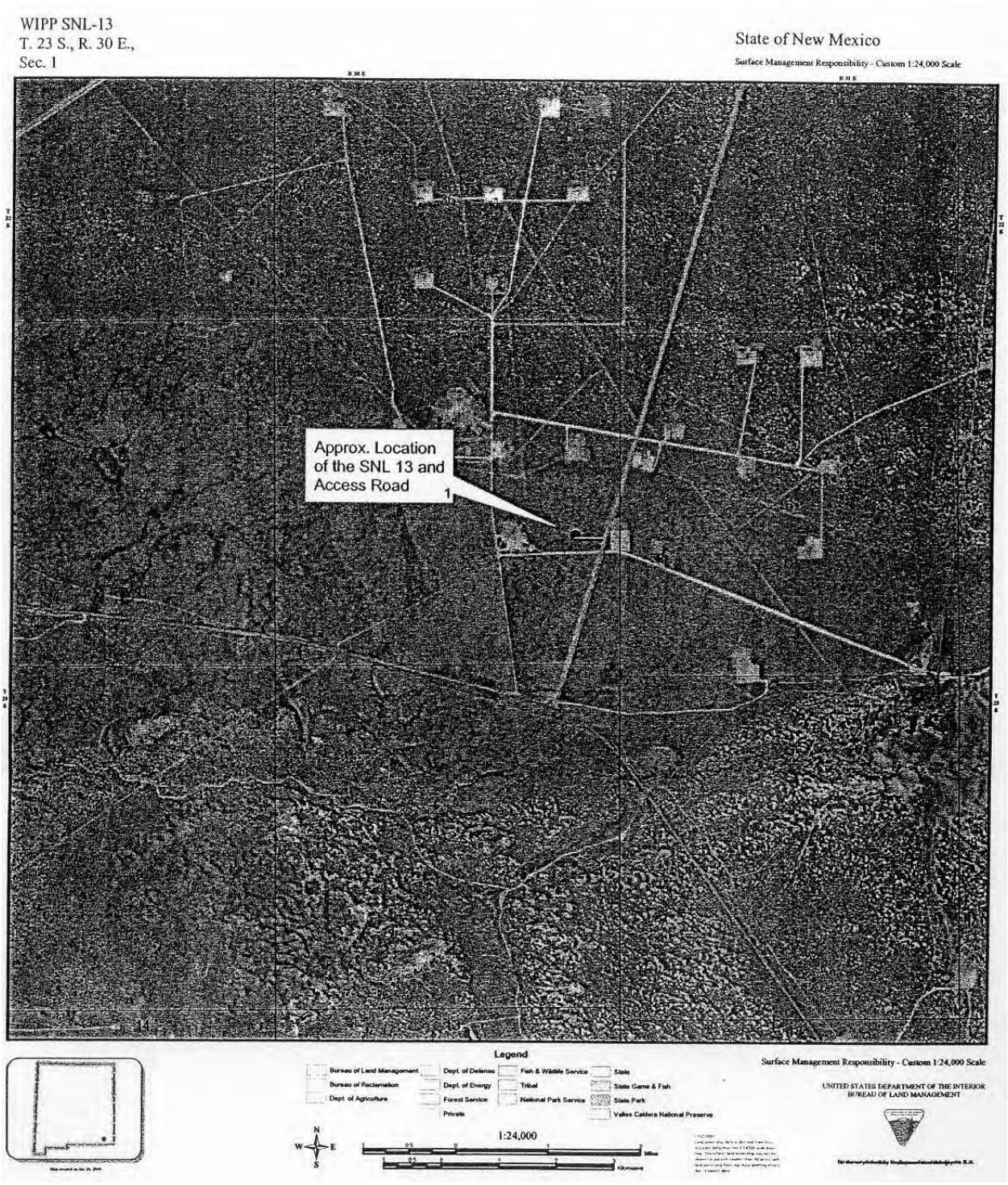

WIPP SNL-13
T. 23 S., R. 30 E.,
Sec. 1
State of New Mexico
Surface Management Responsibility - Custom 1:24,000 Scale
Approx. Location of the SNL 13 and Access Road
1
Legend
Bureau of Land Management
Bureau of Reclamation
Dept. of Agriculture
Dept. of Defense
Dept. of Energy
Forest Service
Private
Fish & Wildlife Service
Tribal
National Park Service
State
State Game & Fish
State Park
Valles Caldera National Preserve
1:24,000
Surface Management Responsibility - Custom 1:24,000 Scale
UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

EXHIBIT B
January 21, 2005
NM-108365

STIPULATIONS FOR FLPMA SITES

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

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

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

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

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

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

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

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

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

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

Special Stipulations:

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

EXHIBIT C

BLM Serial No.: NM-108365
Company Reference:

Seed Mixture for LPC Sand/Shinnery Sites

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

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

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

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

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

*Pounds of pure live seed:

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

SPECIAL STIPULATIONS

RIGHT-OF-WAY RESERVATION
NM-108365

Casing / Plugging & Abandonment Requirements

(1) Casing Program

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

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

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

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

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

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

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

(2) Plugging and Abandonment

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

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

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

STANDARD STIPULATIONS FOR PERMANENT RESOURCE ROADS
CARLSBAD FIELD OFFICE

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

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

GENERAL REQUIREMENTS

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

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

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

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

1

damages to Federal lands resulting therefrom, the Authorized

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

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

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

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

Holder agrees to comply with the following stipulations:

1. ROAD WIDTH AND GRADE

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

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

2. CROWNING AND DITCHING

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

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

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

2

3. DRAINAGE

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

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

SPACING INTERVAL FOR TURNOUT DITCHES

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

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

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

/_x_/ 400 foot intervals.

/__/ _____ foot intervals.

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

/__/ locations delineated on the attached map.

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

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

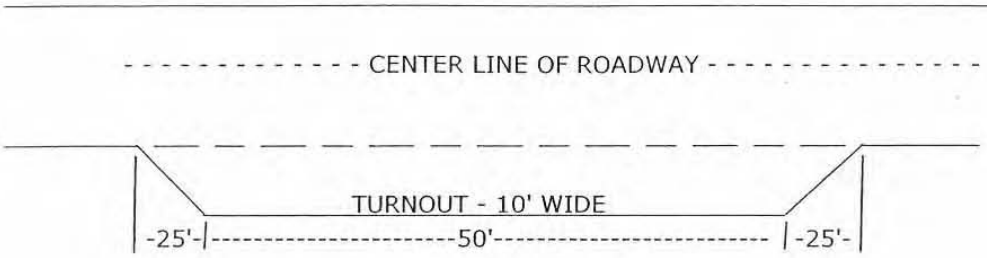
$$\text{spacing interval} = \frac{400'}{\text{road slope in \%}} + 100'$$

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

3

4. TURNOUTS

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



STANDARD TURNOUT - PLAN VIEW

5. SURFACING

Surfacing of the road or those portions identified on the attached map may, at the direction of the Authorized Officer, be required, if necessary, to maintain traffic within the right-of-way with caliche, gravel, or other surfacing material which shall be approved by the Authorized Officer. When surfacing is required, surfacing materials will be compacted to a minimum thickness of six inches with caliche material. The width of surfacing shall be no less
than the driving surface. Prior to using any mineral materials from an existing or proposed Federal source, authorization must be obtained from the Authorized Officer.

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

6. CATTLEGUARDS

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

7. MAINTENANCE

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

8. PUBLIC ACCESS

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

9. CULTURAL RESOURCES

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

10. SPECIAL STIPULATIONS:

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

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

SPECIFIC CONDITIONS OF APPROVAL

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

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

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

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

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

LOG The Point of Diversion C 03139 must be completed and the Well Log filed on or before 12/31/2005.

ACTION OF STATE ENGINEER

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

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

By: Art Mason

Trn Desc: C 03139 MONITORING WELL

File Number: C 03139
Trn Number: 318420

page: 1

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

Date Received 12/6/04 File No. C-3139

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 se ¼ ne ¼ se ¼, Section 1 Township 23 South
   Range 30 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Carlsbad, District,
   on land owned by State of New Mexico

4. Description of well: name of driller West Texas Water Well Service
   Outside Diameter of casing < 7 inches; Approximate depth to be drilled 750 then plugged back to 425 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

STATE ENGINEER OFFICE
ROSWELL, NEW MEXICO
2004 DEC -6 AM 11:54

7. Additional statements or explanations The intent of this application is to provide authorization to drill a groundwater monitoring well in support of Performance Assessment for the U. S. Department of Energy's Waste Isolation Pilot Plant. This well will be completed in the Culebra Dolomite Member of the Rustler Formation and will not be used to appropriate water for beneficial use. Initial pump tests will be conducted, not to exceed 30 days @ less than or equal to, 20 gal/min. Thereafter, the subject well will be used for water level measurements only.

I, Douglas C. Lynn, WIPP Land Use Coordinator, 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, Carlsbad Field Office, Permittee,

By: Harold Johnson

Subscribed and sworn to before me this 2nd day of Dec, A.D., 2004

My commission expires Oct. 3, 2005 Sharon Warren-Briggs
Notary Public
#318420

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-13

Street or Post Office Address P.O. BOX 2078

City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C 03139 and is located in the:

a. S.E. ¼ ¼ ¼ ¼ of Section 1 Township 23 S Range 30 E N.M.P.M.

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 in the _____ Grant.

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

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 4-11-05 Completed 4-27-05 Type tools MUD ROTARY Size of hole 11" in.

Elevation of land surface or _____ at well is 3292.37 ft. Total depth of well 480 ft.

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

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
388	412	24	LIGHT BROWN DOLOMITE	

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
12-3/4	33.41	WELDED	2.5 AGL	192	194.5			
5-1/2 FIBERGLASS	4.4	4	2' AGL	423	423		384.5	0.70 SCREEN 411

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
0	192	17-1/2"		189	TRIMMIE
0	378	11" 5-1/2 CSG		240	TRIMMIE
480	425	7-7/8		28	TRIMMIE

Section 5. PLUGGING RECORD

Plugging Contractor _____

Address _____

Plugging Method _____

Date Well Plugged _____

Plugging approved by: _____ State Engineer Representative

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

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad _____ FWL _____ FSL _____

File No. _____ Use _____ Location No. _____

From	To	Thickness in Feet	Color and Type of Material Encountered
0	2	2	CONSTRUCTION FILL
2	6	4	WHITE CALICHE & CALCAREOUS SAND (MESCALERO)
6	22	16	YELLOWISH RED CALCAREOUS SANDSTONE (GATUNA FORMATION)
22	196	174	RED TO REDDISH BROWN CALCAREOUS SANDY SILTSTONE & SILTY CLAYSTON (MIDDLE TO LOWER DEWEY LAKE FORMATION)
196	258	62	WHITE GYPSUM & ANHYDRITE BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN C STONE (FORTY-NINER MEMBER OF RUSTLER FORMATION)
258	284	26	WHITE TO GRAYISH BROWN GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
284	388	104	WHITE GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTO (TAMARISK MEMBER OF THE RUSTLER FORMATION)
388	412	24	LIGHT BROWN DOLOMITE (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
412	422	10	DARK GRAY TO REDDISH BROWN GYPSIFEROUS CLAYSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
422	430	8	WHITE ANHYDRITE & GYPSUM (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
430	480	50	REDDISH BROWN MUDSTONE & GRAY SILTSTONE (MIDDLE LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)

Section 7. REMARKS AND ADDITIONAL INFORMATION

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

Tommy Tuttle
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

HALL
ENVIRONMENTAL
ANALYSIS
LABORATORY

COVER LETTER

April 28, 2005

Rick Beauheim
Sandia National Lab
4100 National Parks Hwy.
MS1395
Carlsbad, NM 88220
TEL: (505) 234-0065
FAX (505) 234-0061

RE: WIPP Site/SP 13-1-1 Order No.: 0504146

Dear Rick Beauheim:

Hall Environmental Analysis Laboratory received 1 sample on 4/15/2005 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent.

Reporting limits are determined by EPA methodology. No determination of compounds below these (denoted by the ND or < sign) has been made.

Please don't hesitate to contact HEAL for any additional information or clarifications.

Sincerely,

Andy Freeman, Business Manager
Nancy McDuffie, Laboratory Manager

4901 Hawkins NE ■ Suite D ■ Albuquerque, NM 87109
505.345.3975 ■ Fax 505.345.4107
www.hallenvironmental.com

Hall Environmental Analysis Laboratory

Date: *28-Apr-05*

CLIENT: Sandia National Lab
Lab Order: 0504146
Project: WIPP Site/SP 13-1-1
Lab ID: 0504146-01

Client Sample ID: SNL-13(DL)
Collection Date: 4/12/2005 8:25:00 AM
Matrix: AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 300.0: ANIONS						Analyst: **MAP**
Fluoride	1.6	0.10		mg/L	1	4/15/2005
Chloride	440	2.0		mg/L	20	4/15/2005
Nitrogen, Nitrite (As N)	ND	0.10	H	mg/L	1	4/15/2005
Bromide	1.3	0.50		mg/L	1	4/15/2005
Nitrogen, Nitrate (As N)	5.2	0.10	H	mg/L	1	4/15/2005
Phosphorus, Orthophosphate (As P)	ND	0.50	H	mg/L	1	4/15/2005
Sulfate	2200	25		mg/L	50	4/26/2005
EPA METHOD 310.1: ALKALINITY						Analyst: **CMC**
Alkalinity, Total (As CaCO3)	58	2.0		mg/L CaCO3	1	4/21/2005
Carbonate	ND	2.0		mg/L CaCO3	1	4/21/2005
Bicarbonate	58	2.0		mg/L CaCO3	1	4/21/2005
EPA 120.1: SPECIFIC CONDUCTANCE						Analyst: **CMC**
Specific Conductance	4300	0.010		µmhos/cm	1	4/21/2005
EPA METHOD 6010C: DISSOLVED METALS						Analyst: **NMO**
Calcium	680	10		mg/L	10	4/22/2005 12:45:27 PM
Iron	ND	0.020		mg/L	1	4/22/2005 10:26:48 AM
Magnesium	150	1.0		mg/L	1	4/22/2005 10:26:48 AM
Potassium	5.7	1.0		mg/L	1	4/22/2005 10:26:48 AM
Sodium	270	10		mg/L	10	4/22/2005 12:45:27 PM
EPA METHOD 150.1: PH						Analyst: **CMC**
pH	8.02	0.010		pH units	1	4/21/2005
EPA METHOD 160.1: TDS						Analyst: **MAP**
Total Dissolved Solids	3800	50		mg/L	1	4/19/2005

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
* - Value exceeds Maximum Contaminant Level
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
E - Value above quantitation range

Page 1 of 1

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HALL ENVIRONMENTAL ANALYSIS LABORATORY

CATION/ANION BALANCE SHEET FOR WATER ANALYSES

HEAL LAB NUMBER	SNL-13(DL) 0504146-1											
CATIONS	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Sodium	270	11.74										
Potassium	5.7	0.15										
Calcium	680	33.93										
Magnesium	150	12.35										
Total Cations		58.17										
ANIONS	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Sulfate	2200	45.80										
Chloride	440	12.41										
Bicarbonate (CaCO3)	58	1.16										
Carbonate (CaCO3)	ND	*										
Phosphate (P)	ND	*										
Nitrite (N)	ND	*										
Nitrate (N)	5.2	0.37										
Fluoride	1.6	0.08										
Bromide	1.3	0.02										
Total Anions		59.85										
Elect. Cond. (µMhos/cm)	4300											
CATION/ANION RATIO		0.97										
% Difference		1										
TOTAL DISSOLVED SOLIDS RATIOS												
TDS (measured)	3800											
TDS (calculated)	3806											
Ratio meas TDS:calc TDS		1.0										
Ratio Meas. TDS:EC		0.88										
Ratio Calc. TDS:EC		0.89										
Ratio of anion sum:EC		1.4										
Ratio of cation sum:EC		1.4										

* Analyte not detected (below method detection limit).

** Values below 0.55 can be obtained in waters containing appreciable concentrations of free acid or alkalinity, or not within pH 6 to 9. Values much higher than 0.7 are possible in highly saline waters.

GENERALLY ACCEPTED RANGES

Cation/Anion balance: 0-3 meq/L- 0.2 meq/L, 3-10 meq/L- 2%, >10 meq/L - 5%

Ratio measured TDS:calculated TDS -- 1.0-1.2. Ratio Calculated TDS:EC -- 0.55-0.7. Ratio Measured TDS:EC--0.55-0.7. Ratio of anion sum:EC -- 0.9-1.1.

Ratio of cation sum:EC -- 0.9-1.1

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Hall Environmental Analysis Laboratory

Date: *28-Apr-05*

CLIENT: Sandia National Lab
Work Order: 0504146
Project: WIPP Site/SP 13-1-1

QC SUMMARY REPORT
Method Blank

Sample ID **MBLK** Batch ID: **R15111** Test Code: **E300** Units: **mg/L** Analysis Date **4/15/2005** Prep Date
Client ID: Run ID: **LC_050415A** SeqNo: **352687**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.1									
Chloride	ND	0.1									
Nitrogen, Nitrite (As N)	ND	0.1									
Bromide	ND	0.5									
Nitrogen, Nitrate (As N)	ND	0.1									
Phosphorus, Orthophosphate (As P)	ND	0.5									
Sulfate	ND	0.5									

Sample ID **MBLK** Batch ID: **R15214** Test Code: **E300** Units: **mg/Kg** Analysis Date **4/26/2005** Prep Date
Client ID: Run ID: **LC_050426A** SeqNo: **355853**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.3									
Chloride	ND	0.3									
Nitrogen, Nitrite (As N)	ND	0.3									
Bromide	ND	0.3									
Nitrogen, Nitrate (As N)	ND	0.3									
Phosphorus, Orthophosphate (As P)	ND	1.5									
Sulfate	ND	1.5									

Qualifiers: ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

CLIENT: Sandia National Lab
Work Order: 0504146
Project: WIPP Site/SP 13-1-1

QC SUMMARY REPORT

Method Blank

Sample ID **MB** Batch ID: **R15182** Test Code: **SW6010A** Units: **mg/L** Analysis Date **4/22/2005 9:59:53 AM** Prep Date

Client ID: Run ID: **ICP_050422A** SeqNo: **354758**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	1									
Iron	ND	0.02									
Magnesium	ND	1									
Potassium	ND	1									
Sodium	ND	1									

Sample ID **MB-7793** Batch ID: **7793** Test Code: **E160.1** Units: **mg/L** Analysis Date **4/19/2005** Prep Date **4/18/2005**

Client ID: Run ID: **WC_050419A** SeqNo: **353240**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids	ND	50									

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

2

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Hall Environmental Analysis Laboratory

Date: *28-Apr-05*

CLIENT: Sandia National Lab
Work Order: 0504146
Project: WIPP Site/SP 13-1-1

QC SUMMARY REPORT

Laboratory Control Spike - generic

Sample ID **LCS** Batch ID: **R15111** Test Code: **E300** Units: **mg/L** Analysis Date **4/15/2005** Prep Date
Client ID: Run ID: **LC_050415A** SeqNo: **352688**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.509	0.1	0.5	0	102	90	110	0			
Chloride	4.697	0.1	5	0	93.9	90	110	0			
Nitrogen, Nitrite (As N)	0.937	0.1	1	0	93.7	90	110	0			
Bromide	2.544	0.5	2.5	0	102	90	110	0			
Nitrogen, Nitrate (As N)	2.393	0.1	2.5	0	95.7	90	110	0			
Phosphorus, Orthophosphate (As P)	4.817	0.5	5	0	96.3	90	110	0			
Sulfate	9.535	0.5	10	0	95.4	90	110	0			

Sample ID **LCS** Batch ID: **R15214** Test Code: **E300** Units: **mg/L** Analysis Date **4/26/2005** Prep Date
Client ID: Run ID: **LC_050426A** SeqNo: **355854**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.534	0.1	0.5	0	107	90	110	0			
Chloride	4.683	0.1	5	0	93.7	90	110	0			
Nitrogen, Nitrite (As N)	0.91	0.1	1	0	91.0	90	110	0			
Bromide	2.535	0.5	2.5	0	101	90	110	0			
Nitrogen, Nitrate (As N)	2.416	0.1	2.5	0	96.6	90	110	0			
Phosphorus, Orthophosphate (As P)	4.834	0.5	5	0	96.7	90	110	0			
Sulfate	9.546	0.5	10	0	95.5	90	110	0			

Qualifiers: ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

1

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CLIENT: Sandia National Lab
Work Order: 0504146
Project: WIPP Site/SP 13-1-1

QC SUMMARY REPORT

Laboratory Control Spike - generic

Sample ID **LCS** | Batch ID: **R15182** | Test Code: **SW6010A** | Units: **mg/L** | Analysis Date **4/22/2005 10:11:58 AM** | Prep Date

Client ID: | Run ID: **ICP_050422A** | SeqNo: **354760**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	50.51	1	50.5	0	100	80	120	0			
Iron	0.5068	0.02	0.5	0	101	80	120	0			
Magnesium	49.93	1	50.5	0	98.9	80	120	0			
Potassium	50.92	1	55	0	92.6	80	120	0			
Sodium	51.81	1	50.5	0	103	80	120	0			

Sample ID **LCSD** | Batch ID: **R15182** | Test Code: **SW6010A** | Units: **mg/L** | Analysis Date **4/22/2005 10:14:23 AM** | Prep Date

Client ID: | Run ID: **ICP_050422A** | SeqNo: **354761**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	50.69	1	50.5	0	100	80	120	50.51	0.362	20	
Iron	0.5055	0.02	0.5	0	101	80	120	0.5068	0.254	20	
Magnesium	50.39	1	50.5	0	99.8	80	120	49.93	0.923	20	
Potassium	51.54	1	55	0	93.7	80	120	50.92	1.23	20	
Sodium	52.45	1	50.5	0	104	80	120	51.81	1.23	20	

Sample ID **LCS-7793** | Batch ID: **7793** | Test Code: **E160.1** | Units: **mg/L** | Analysis Date **4/19/2005** | Prep Date **4/18/2005**

Client ID: | Run ID: **WC_050419A** | SeqNo: **353241**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids	1024	50	1000	0	102	80	120	0			

Qualifiers: ND - Not Detected at the Reporting Limit; S - Spike Recovery outside accepted recovery limits; B - Analyte detected in the associated Method Blank; J - Analyte detected below quantitation limits; R - RPD outside accepted recovery limits

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Hall Environmental Analysis Laboratory

Sample Receipt Checklist

Client Name SANDIA CARLSBAD — Date and Time Received: 4/15/2005

Work Order Number 0504146 — Received by AMG

Checklist completed by [signature] 4-15-05
Signature — Date

Matrix — Carrier name FedEx

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐		
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑	Not Shipped ☐	
Custody seals intact on sample bottles?	Yes ☑	No ☐	N/A ☐		
Chain of custody present?	Yes ☑	No ☐			
Chain of custody signed when relinquished and received?	Yes ☑	No ☐			
Chain of custody agrees with sample labels?	Yes ☐	No ☑			
Samples in proper container/bottle?	Yes ☐	No ☑			
Sample containers intact?	Yes ☑	No ☐			
Sufficient sample volume for indicated test?	Yes ☑	No ☐			
All samples received within holding time?	Yes ☐	No ☑			
Water - VOA vials have zero headspace?	No VOA vials submitted ☑	Yes ☐	No ☐		
Water - pH acceptable upon receipt?	Yes ☑	No ☐	N/A ☐		
Container/Temp Blank temperature?	6°	*4° C ± 2 Acceptable* If given sufficient time to cool.			

COMMENTS:

Client contacted _____ Date contacted: _____ Person contacted _____

Contacted by: _____ Regarding _____

Comments: _____

Corrective Action _____

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SNL-13(2M)

TD 480 ft open hole

Collected from roll-off

HALL ENVIRONMENTAL ANALYSIS LABORATORY

COVER LETTER

May 17, 2005

Rick Beauheim
Sandia National Lab
4100 National Parks Hwy.
MS1395
Carlsbad, NM 88220
TEL: (505) 234-0065
FAX (505) 234-0061

RE: WIPP Site/KSKP 13-1-1 Order No.: 0504272

Dear Rick Beauheim:

Hall Environmental Analysis Laboratory received 1 sample on 4/28/2005 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent.

Reporting limits are determined by EPA methodology. No determination of compounds below these (denoted by the ND or < sign) has been made.

Please don't hesitate to contact HEAL for any additional information or clarifications.

Sincerely,

Andy Freeman, Business Manager
Nancy McDuffie, Laboratory Manager

4901 Hawkins NE ■ Suite D ■ Albuquerque, NM 87109
505.345.3975 ■ Fax 505.345.4107
www.hallenvironmental.com

Hall Environmental Analysis Laboratory

Date: *18-May-05*

CLIENT: Sandia National Lab
Lab Order: 0504272
Project: WIPP Site/KSKP 13-1-1
Lab ID: 0504272-01

Client Sample ID: SNL-13 (LM)
Collection Date: 4/26/2005 11:00:00 AM
Matrix: AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 300.0: ANIONS						Analyst: **MAP**
Fluoride	ND	20		mg/L	200	5/3/2005
Chloride	190000	500		mg/L	5000	5/3/2005
Bromide	1400	100		mg/L	200	5/3/2005
Phosphorus, Orthophosphate (As P)	ND	100	H	mg/L	200	5/3/2005
Sulfate	5300	100		mg/L	200	5/3/2005
Nitrate (As N)+Nitrite (As N)	ND	50		mg/L	500	5/4/2005
EPA METHOD 310.1: ALKALINITY						Analyst: **MAP**
Alkalinity, Total (As CaCO3)	76	4.0		mg/L CaCO3	2	5/9/2005
Carbonate	ND	4.0		mg/L CaCO3	2	5/9/2005
Bicarbonate	76	4.0		mg/L CaCO3	2	5/9/2005
EPA 120.1: SPECIFIC CONDUCTANCE						Analyst: **CMC**
Specific Conductance	190000	0.010		µmhos/cm	1	5/12/2005
EPA METHOD 6010C: DISSOLVED METALS						Analyst: **NMO**
Calcium	3700	100		mg/L	100	5/5/2005 2:50:46 PM
Iron	ND	2.0		mg/L	100	5/5/2005 2:50:46 PM
Magnesium	10000	100		mg/L	100	5/5/2005 2:50:46 PM
Potassium	2300	100		mg/L	100	5/5/2005 2:50:46 PM
Sodium	95000	1000		mg/L	1000	5/6/2005 8:34:31 AM
EPA METHOD 150.1: PH						Analyst: **MAP**
pH	6.55	0.010		pH units	1	5/9/2005
EPA METHOD 160.1: TDS						Analyst: **MAP**
Total Dissolved Solids	290000	100		mg/L	2	5/4/2005

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
* - Value exceeds Maximum Contaminant Level
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
E - Value above quantitation range

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HALL ENVIRONMENTAL ANALYSIS LABORATORY

CATION/ANION BALANCE SHEET FOR WATER ANALYSES

HEAL LAB NUMBER	SNL-13(LM) 0504272-1											
CATIONS	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Sodium	95000	4132.23										
Potassium	2300	58.82										
Calcium	3700	184.63										
Magnesium	10000	823.05										
Total Cations		5198.73										
ANIONS	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Sulfate	5300	110.35										
Chloride	190000	5359.66										
Bicarbonate (CaCO3)	76	1.52										
Carbonate (CaCO3)	ND	*										
Phosphate (P)	ND	*										
Nitrite (N)	ND	*										
Nitrate (N)	ND	*										
Fluoride	ND	*										
Bromide	1400	17.52										
Total Anions		5489.05										
Elect. Cond. (μMhos/cm)	190000											
CATION/ANION RATIO		0.95										
% Difference		3										
TOTAL DISSOLVED SOLIDS RATIOS												
TDS (measured)	290000											
TDS (calculated)	307746											
Ratio meas TDS:calc TDS		0.9										
Ratio Meas. TDS:EC		1.53										
Ratio Calc. TDS:EC		1.62										
Ratio of anion sum:EC		2.9										
Ratio of cation sum:EC		2.7										

* Analyte not detected (below method detection limit).

** Values below 0.55 can be obtained in waters containing appreciable concentrations of free acid or alkalinity, or not within pH 6 to 9. Values much higher than 0.7 are possible in highly saline waters.

GENERALLY ACCEPTED RANGES

Cation/Anion balance: 0-3 meq/L- 0.2 meq/L, 3-10 meq/L- 2%, >10 meq/L - 5%

Ratio measured TDS:calculated TDS -- 1.0-1.2. Ratio Calculated TDS:EC -- 0.55-0.7. Ratio Measured TDS:EC--0.55-0.7. Ratio of anion sum:EC -- 0.9-1.1.

Ratio of cation sum:EC -- 0.9-1.1

Hall Environmental Analysis Laboratory

Date: *18-May-05*

CLIENT: Sandia National Lab
Work Order: 0504272
Project: WIPP Site/KSKP 13-1-1

QC SUMMARY REPORT

Method Blank

Sample ID **MBLK** | Batch ID: **R15238** | Test Code: **E300** | Units: **mg/L** | Analysis Date **4/28/2005** | Prep Date
Client ID: | Run ID: **LC_050428A** | SeqNo: **356747**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.1									
Chloride	ND	0.1									
Bromide	ND	0.5									
Phosphorus, Orthophosphate (As P)	ND	0.5									
Sulfate	ND	0.5									
Nitrate (As N)+Nitrite (As N)	ND	0.1									

Sample ID **MBLK** | Batch ID: **R15238** | Test Code: **E300** | Units: **mg/L** | Analysis Date **4/28/2005** | Prep Date
Client ID: | Run ID: **LC_050428A** | SeqNo: **356776**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.1									
Chloride	ND	0.1									
Bromide	ND	0.5									
Phosphorus, Orthophosphate (As P)	ND	0.5									
Sulfate	0.374	0.5									J
Nitrate (As N)+Nitrite (As N)	ND	0.1									

Qualifiers: ND - Not Detected at the Reporting Limit; S - Spike Recovery outside accepted recovery limits; B - Analyte detected in the associated Method Blank; J - Analyte detected below quantitation limits; R - RPD outside accepted recovery limits

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CLIENT: Sandia National Lab
Work Order: 0504272
Project: WIPP Site/KSKP 13-1-1

QC SUMMARY REPORT

Method Blank

Sample ID **MBLK** Batch ID: **R15274** Test Code: **E300** Units: **mg/L** Analysis Date **5/3/2005** Prep Date
Client ID: Run ID: **LC_050503A** SeqNo: **357902**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.1									
Chloride	ND	0.1									
Bromide	ND	0.5									
Phosphorus, Orthophosphate (As P)	ND	0.5									
Sulfate	ND	0.5									
Nitrate (As N)+Nitrite (As N)	ND	0.1									

Sample ID **MBLK** Batch ID: **R15287** Test Code: **E300** Units: **mg/L** Analysis Date **5/4/2005** Prep Date
Client ID: Run ID: **LC_050504A** SeqNo: **358175**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.1									
Chloride	ND	0.1									
Bromide	ND	0.5									
Phosphorus, Orthophosphate (As P)	ND	0.5									
Sulfate	ND	0.5									
Nitrate (As N)+Nitrite (As N)	ND	0.1									

Sample ID **MBLK** Batch ID: **R15326** Test Code: **E310.1** Units: **mg/L CaCO3** Analysis Date **5/9/2005** Prep Date
Client ID: Run ID: **WC_050509C** SeqNo: **359307**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2									
Carbonate	ND	2									
Bicarbonate	ND	2									

Qualifiers: ND - Not Detected at the Reporting Limit; S - Spike Recovery outside accepted recovery limits; B - Analyte detected in the associated Method Blank
J - Analyte detected below quantitation limits; R - RPD outside accepted recovery limits

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CLIENT: Sandia National Lab
Work Order: 0504272
Project: WIPP Site/KSKP 13-1-1

QC SUMMARY REPORT

Method Blank

Sample ID **MB** | Batch ID: **R15313** | Test Code: **SW6010A** | Units: **mg/L** | Analysis Date **5/5/2005 11:25:02 AM** | Prep Date
Client ID: | Run ID: **ICP_050505B** | SeqNo: **358789**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	0.4605	1									J
Iron	ND	0.02									
Magnesium	0.459	1									J
Potassium	0.5357	1									J
Sodium	0.4486	1									J

Sample ID **MB-7898** | Batch ID: **7898** | Test Code: **E160.1** | Units: **mg/L** | Analysis Date **5/4/2005** | Prep Date **5/3/2005**
Client ID: | Run ID: **WC_050504E** | SeqNo: **358103**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids	ND	50									

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

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Hall Environmental Analysis Laboratory

Date: *18-May-05*

CLIENT: Sandia National Lab
Work Order: 0504272
Project: WIPP Site/KSKP 13-1-1

QC SUMMARY REPORT
Laboratory Control Spike - generic

Sample ID **LCS** Batch ID: **R15238** Test Code: **E300** Units: **mg/L** Analysis Date **4/28/2005** Prep Date
Client ID: Run ID: **LC_050428A** SeqNo: **356748**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.516	0.1	0.5	0	103	90	110	0			
Chloride	4.682	0.1	5	0	93.6	90	110	0			
Bromide	2.498	0.5	2.5	0	99.9	90	110	0			
Phosphorus, Orthophosphate (As P)	4.73	0.5	5	0	94.6	90	110	0			
Sulfate	9.515	0.5	10	0	95.2	90	110	0			
Nitrate (As N)+Nitrite (As N)	3.324	0.1	3.5	0	95.0	90	110	0			

Sample ID **LCS** Batch ID: **R15238** Test Code: **E300** Units: **mg/L** Analysis Date Prep Date
Client ID: Run ID: **LC_050428A** SeqNo: **356777**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.501	0.1	0.5	0	100	90	110	0			
Chloride	4.557	0.1	5	0	91.1	90	110	0			
Bromide	2.412	0.5	2.5	0	96.5	90	110	0			
Phosphorus, Orthophosphate (As P)	4.64	0.5	5	0	92.8	90	110	0			
Sulfate	9.384	0.5	10	0.374	90.1	90	110	0			
Nitrate (As N)+Nitrite (As N)	3.218	0.1	3.5	0	91.9	90	110	0			

Qualifiers: ND - Not Detected at the Reporting Limit; S - Spike Recovery outside accepted recovery limits; B - Analyte detected in the associated Method Blank
J - Analyte detected below quantitation limits; R - RPD outside accepted recovery limits

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CLIENT: Sandia National Lab
Work Order: 0504272
Project: WIPP Site/KSKP 13-1-1

QC SUMMARY REPORT

Laboratory Control Spike - generic

Sample ID **LCS** Batch ID: **R15274** Test Code: **E300** Units: **mg/L** Analysis Date **5/3/2005** Prep Date
Client ID: Run ID: **LC_050503A** SeqNo: **357931**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.491	0.1	0.5	0	98.2	90	110	0			
Chloride	4.62	0.1	5	0	92.4	90	110	0			
Bromide	2.475	0.5	2.5	0	99.0	90	110	0			
Phosphorus, Orthophosphate (As P)	4.711	0.5	5	0	94.2	90	110	0			
Sulfate	9.356	0.5	10	0	93.6	90	110	0			
Nitrate (As N)+Nitrite (As N)	3.29	0.1	3.5	0	94.0	90	110	0			

Sample ID **LCS** Batch ID: **R15287** Test Code: **E300** Units: **mg/L** Analysis Date **5/4/2005** Prep Date
Client ID: Run ID: **LC_050504A** SeqNo: **358176**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.523	0.1	0.5	0	105	90	110	0			
Chloride	4.657	0.1	5	0	93.1	90	110	0			
Bromide	2.506	0.5	2.5	0	100	90	110	0			
Phosphorus, Orthophosphate (As P)	4.754	0.5	5	0	95.1	90	110	0			
Sulfate	9.448	0.5	10	0	94.5	90	110	0			
Nitrate (As N)+Nitrite (As N)	3.317	0.1	3.5	0	94.8	90	110	0			

Sample ID **LCS** Batch ID: **R15313** Test Code: **SW6010A** Units: **mg/L** Analysis Date **5/5/2005 11:27:27 AM** Prep Date
Client ID: Run ID: **ICP_050505B** SeqNo: **358790**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	52.68	1	50.5	0.4605	103	80	120	0			
Iron	0.4678	0.02	0.5	0	93.6	80	120	0			
Magnesium	52.28	1	50.5	0.459	103	80	120	0			
Potassium	52.77	1	55	0.5357	95.0	80	120	0			
Sodium	52.81	1	50.5	0.4486	104	80	120	0			

Qualifiers: ND - Not Detected at the Reporting Limit; S - Spike Recovery outside accepted recovery limits; B - Analyte detected in the associated Method Blank; J - Analyte detected below quantitation limits; R - RPD outside accepted recovery limits

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CLIENT: Sandia National Lab
Work Order: 0504272
Project: WIPP Site/KSKP 13-1-1

QC SUMMARY REPORT

Laboratory Control Spike Duplicate

Sample ID LCSD | Batch ID: R15313 | Test Code: SW6010A | Units: mg/L | Analysis Date 5/5/2005 11:30:31 AM | Prep Date
Client ID: | Run ID: ICP_050505B | SeqNo: 358791

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	53.62	1	50.5	0.4605	105	80	120	52.68	1.76	20	
Iron	0.4693	0.02	0.5	0	93.9	80	120	0.4678	0.322	20	
Magnesium	53.31	1	50.5	0.459	105	80	120	52.28	1.96	20	
Potassium	53.95	1	55	0.5357	97.1	80	120	52.77	2.22	20	
Sodium	54.01	1	50.5	0.4486	106	80	120	52.81	2.24	20	

Sample ID LCS-7898 | Batch ID: 7898 | Test Code: E160.1 | Units: mg/L | Analysis Date 5/4/2005 | Prep Date 5/3/2005
Client ID: | Run ID: WC_050504E | SeqNo: 358104

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids	1042	50	1000	0	104	80	120	0			

Qualifiers: ND - Not Detected at the Reporting Limit; S - Spike Recovery outside accepted recovery limits; B - Analyte detected in the associated Method Blank; J - Analyte detected below quantitation limits; R - RPD outside accepted recovery limits

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Hall Environmental Analysis Laboratory

Sample Receipt Checklist

Client Name SANDIA CARLSBAD — Date and Time Received: 4/28/2005

Work Order Number 0504272 — Received by AT

Checklist completed by _____ 4/29/05
Signature — Date

Matrix — Carrier name FedEx

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐	
Custody seals intact on shipping container/cooler?	Yes ☑	No ☐	Not Present ☐	Not Shipped ☐
Custody seals intact on sample bottles?	Yes ☑	No ☐	N/A ☐	
Chain of custody present?	Yes ☑	No ☐		
Chain of custody signed when relinquished and received?	Yes ☑	No ☐		
Chain of custody agrees with sample labels?	Yes ☑	No ☐		
Samples in proper container/bottle?	Yes ☑	No ☐		
Sample containers intact?	Yes ☑	No ☐		
Sufficient sample volume for indicated test?	Yes ☑	No ☐		
All samples received within holding time?	Yes ☑	No ☐		
...r - VOA vials have zero headspace?	No VOA vials submitted ☑	Yes ☐	No ☐	
Water - pH acceptable upon receipt?	Yes ☑	No ☐	N/A ☐	

Container/Temp Blank temperature? 6° — *4° C ± 2 Acceptable* If given sufficient time to cool.

COMMENTS:

Client contacted _____ Date contacted: _____ Person contacted _____

Contacted by: _____ Regarding _____

Comments: Sample poured off into 1 x 500 H_2SO_4 plastic & 1 x 125 HNO_3 plas-(filtered in lab)

Corrective Action _____

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Appendix A

NUCLEAR WASTE MANAGEMENT PROGRAM
Sandia National Laboratories

Chain of Custody

Form Number: SP 13-1-1

Page 1 of 1
Attach more forms as needed

1. Initial Sample Custodian Dennis Powers (Printed Name) Organization: 6822 Date: ~~4/23/05~~ 4-24-05 A.S. 4-26-05

2. Sample Collection or Creation Information Scientific Notebook ID: N/A A.S. 4-26-05

Test Plan ID: TP 03-01 Field Log ID: ~~N/A~~ Sheet 9 of core log

Sample Location: WIPP Monitoring Well SNL-13 A.S. 4-26-05
i.e. borehole/core no./lab bldg. no./etc...

Sample Team Members/Organization.
Dennis Powers / 6822
N/A
enter n/a if none

3. Sample Identification Sample/Sub-Sample #	Date Collected	Container Type	Container Volume	Preservative	Associated Test	Sample Description
SNL-13(C) 1 of 1	~~4/23/05~~	PE Bottle	500 mL	N/A	Cation/	SNL-13 ~~Culebra~~ Water Sample- Unpreserved
END OF SAMPLE LIST	4-24-05				Anion Bal,	A.S. 4-26-05
	A.S.				Dissolved	Sample poured into 2 bottles at the lab: 1- 500ml H_2SO_4
	4-26-05				Iron, and	1- 125ml HNO_3 (filtered)
					pH	1- 500ml unpres.

enter n/a if none

4. Sample Requirements

Handling:	Keep Sealed Until Use
Storage & Preservation:	Keep Chilled / Refrigerated
Shipping:	Hand Carry / Federal Express
Disposition:	Dispose of as Non-hazardous Waste
Expiration Date:	5/14/2005

5. Custody Transfer	Printed Name	Signature	Organization/Company	Date-Time	Sample Condition
a. Relinquished by:	Dennis Powers	Dennis Powers	6822/Consulting Geologist	4/26/05 0940 MDT	Container Intact & Sealed
a. Received by:	Anne T. Schaub	Anne T. Schaub	6822/ RESPEC	4/26/05 0940 MDT	Container Intact + Sealed
b. Relinquished by:	~~Dennis W. Powers~~	~~Dennis W. Powers~~	~~6822/Consulting Geologist~~	~~4/26/05 0940 MDT~~	
b. Received by:					
c. Relinquished by:					
c. Received by:					
d. Relinquished by:					
d. Received by:					
e. Relinquished by:					
e. Received by:					

Upon sample receipt, note condition. This form (copy for your records) should follow samples through its life, until final disposition, then send original to NWMP Records Center.
For samples that are potentially hazardous and/or radioactive & require packaging and shipping, contact Center 6800 ES&H Coordinator or see SNL ES&H Manual, Chpt. 12.

CHAIN-OF-CUSTODY RECORD

HALL ENVIRONMENT ANALYSIS LABORATORY
4901 Hawkins NE, Suite D
Albuquerque, New Mexico 87109
Tel. 505.345.3975 Fax 505.345.4107
www.hallenvironmental.com

Client: Sandia National Labs (David Chace)

Address: 4100 National Parks Hwy Carlsbad, NM. 88220

Phone #: (505) 234-0065

Fax #: (505) 234-0061

QA / QC Package: Std ☐ Level 4 ☐

Other:

Project Name: WIPP

Project #: 68298/1.4.2.3

Project Manager: Rick Beauheim

Sampler: Dennis Powers

Sample Temperature: 6

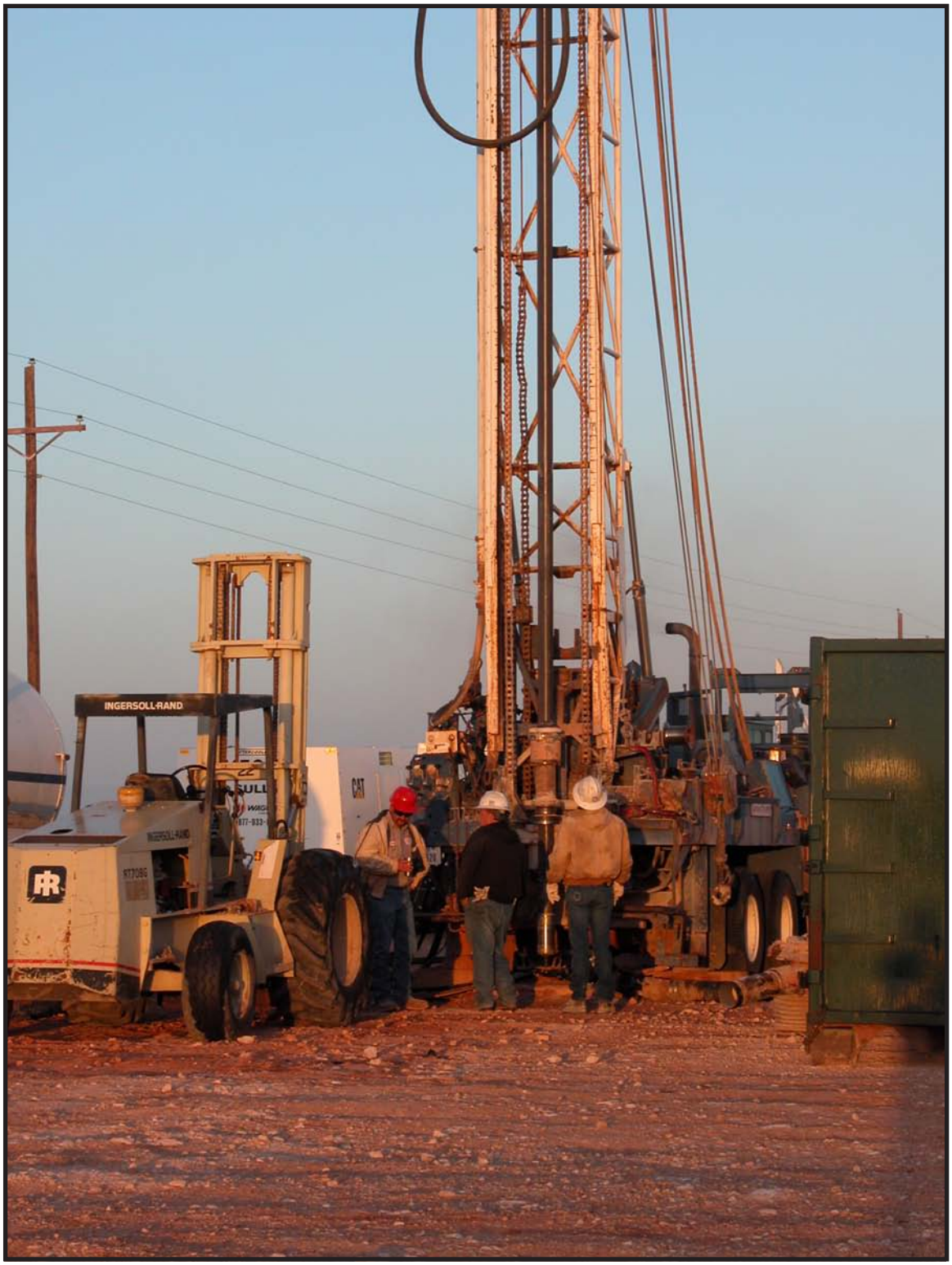
Date	Time	Matrix	Sample I.D. No.	Number/Volume	Preservative: ~~HgCl2~~ NONE (9.5, 4-26-05)	Preservative: HNO_3	HEAL No.
4-26-05	1100	H_2O	SNL-13 1of1	1/500mL	X		0504221

ANALYSIS REQUEST

Analysis	Requested
BTEX + MTBE + TMB's (8021)	
BTEX + MTBE + TPH (Gasoline Only)	
TPH Method 8015B (Gas/Diesel)	
TPH (Method 418.1)	
EDB (Method 504.1)	
EDC (Method 8021)	
8310 (PNA or PAH)	
RCRA 8 Metals	
Anions (F, Cl, NO_3, NO_2, PO_4, SO_4)	
8081 Pesticides / PCB's (8082)	
8260B (VOA)	
8270 (Semi-VOA)	
Cation/Anion Bal.	X
Dissolved Iron	X
pH	X
Air Bubbles or Headspace (Y or N)	

Date	Time	Relinquished By: (Signature)	Received By: (Signature)
4/26/05	0940MDT	Dennis W. Powers	Anne J. Schaub
4/27/05	13:30	Anne J. Schaub	[illegible signature] 4/28/05 1337

Remarks: • Sample may contain High Salts
Sample pour into 2 bottles at the lab: 1- 500ml H_2SO_4
1- 125ml HNO_3 (Gl)
1- 500ml unpres



Early morning April 19, 2005, at SNL-13 prior to beginning coring. Ronnie Keith (l), Billy Pon (c), Luis Armendariz (r). Photo by Dennis W. Powers.

Appendix E
Archeological Clearance Report

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

1. (For BLM Use) **BLM Report No.**	**2. (For BLM Use)** **Reviewer's Initials/Date_____** **Accepted ( ) Rejected ( )**	**3. NMCRIS Number:** 90915
4. Type of Report: **Negative (X)** **Positive ( )**		
5. Title of Report: A Cultural Resource Survey for the SNL-13 Monitor Well Pad		**6. Fieldwork Date(s):** November 22, 2004
Author(s): Theresa Straight		**7. Report Date:** November 29, 2004
8. Consultant Name/Address: Mesa Field Services **Direct Charge:** Sean Simpson **Field Personnel Names:** Sean Simpson and Theresa Straight **Address:** P.O. Box 3072 Carlsbad, New Mexico 88221-3072 **Phone (**505**)** 628-8885		**9. Cultural Resource Permit No.:** 153-2920-03-N **10. Consultant Report No.:** MFS-1098
11. Customer Name: Westinghouse TRU Solutions, LLC **Responsible Individual:** Ron Richardson **Address:** P.O. Box 2078 Carlsbad, NM 88221 **Phone:** (505) 234-8395		**12. Customer Project No.:** P.O. No. 107596

13. Land Status	**BLM**	**State**	**Private**	**Other**	**Total**
a. Area Surveyed (acres)	2.09				2.09
b. Area of Effect (acres)	0.38				0.38

14. Linear **Length**__N/A____ **Width**__N/A__
Block irregular – see description of undertaking

15. Location (Map[s] Attached):

a. State: New Mexico

b. County: Eddy County

c. BLM Office: Carlsbad Field Office

d. Nearest City or Town: Carlsbad, NM

e. Legal Description: T23S, R30E, Section 1: NE¼ SE¼

f. Well Pad Footages: 1,750 ft FSL and 400 ft FEL

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

16. Project Data:

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

are located within 0.25 mile. An expanded search revealed 13 previously recorded sites within 1 mile: LA 43928, LA 47659, LA 100382, LA 104746, LA 105264, LA 122571, LA 129217, LA 129218, LA 129220, LA 143703, LA 143704, LA 143705, and LA 143706.

b. Description of Undertaking: Westinghouse TRU Solutions, LLC plans to build a monitor well. The pad will be locate adjacent to the southeast corner of an existing pad. An L-shaped area was staked in the field around the well pad corner. An existing caliche capped access road is present along the southern edge of the staked pad. An addition 100 ft was surveyed along the each side, except where the staked area is adjacent to the pad. The surveyed area measured 355 ft along the east side, 153 along the north edge, 181 along the west edge, and 357 along the south edge. The surveyed area is on land owned and administered by the BLM-CFO.

c. Environmental Setting (NRCS soil designation; vegetative community; elevation; etc.): The project area is located 13 miles east of Carlsbad, NM. The terrain slopes to the southwest at a grade of 0.7 percent. Soils are of the Simona-Pajarito association as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Local vegetation is typical of Chihuahuan Desert Scrub and includes various grasses, mesquite, and forbs. Due to the vegetative cover, ground surface visibility averaged 50 percent at the time of the survey.

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

d. Field Methods (transect intervals; crew size; time in field; etc.): A crew of two spent 0.5 hour surveying the project area. A 15 m wide transect was used.

e. Artifacts Collected?: None

17. Cultural Resource Findings: No cultural material was encountered in the project area.

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

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

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

19.

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

Responsible Archaeologist_____ _____
Signature **Date**

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

Survey for the SNL-13 Monitor Well

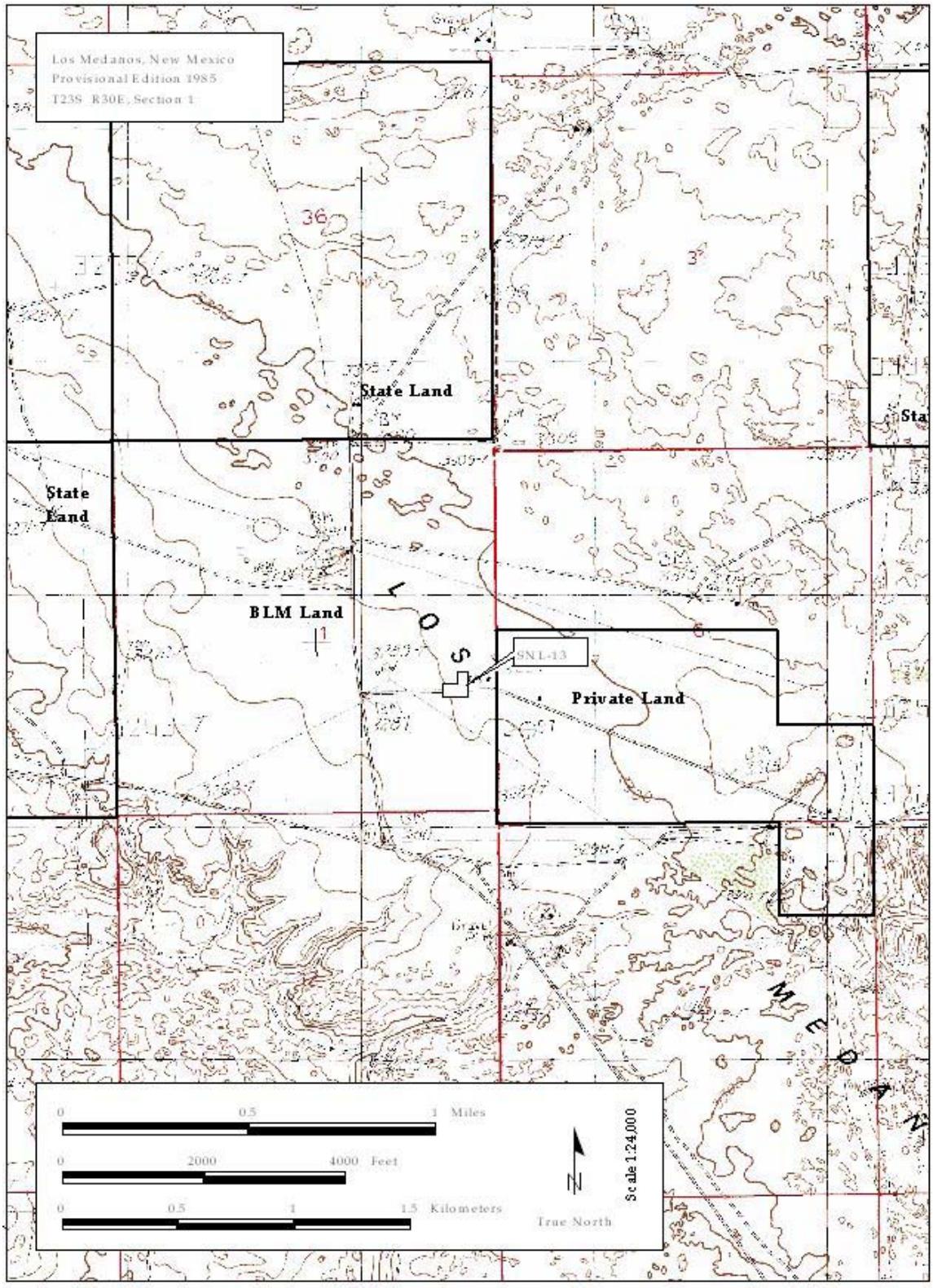


Figure 1. Project Area Map *Mesa Field Services*

Appendix F
Photograph Logs

Digital photographs were taken of the cores from SNL-13. A listing of consecutive photos, beginning with the uppermost core (Magenta Dolomite Member of the Rustler Formation) and ending with the lowermost (upper Los Medaños Member of the Rustler Formation), has been compiled and is included here in Appendix F. The photographs were taken in the field shortly after recovery. A CD-ROM with these images (jpeg format) is being archived, and a copy with photographic log is maintained by Geotechnical Engineering (Washington TRU Solutions LLC) with records of the cores stored for WIPP.

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-13_Core001.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 254.0 - 255.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core002.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 254.9 - 256.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core003.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 255.9 - 257.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core004.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 256.9 - 258.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core005.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 257.9 - 259.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core006.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 258.9 - 260.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core007.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 259.9 - 261.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core008.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 260.9 - 262.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core009.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 261.9 - 263.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core010.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 262.9 - 264.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core011.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 263.9 - 265.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core012.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 264.9 - 266.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core013.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 265.9 - 267.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core014.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 266.9 - 268.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core015.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 267.8 - 269.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core016.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 268.9 - 270.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-13_Core017.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 270.1 - 271.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core018.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 270.9 - 272.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core019.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 271.9 - 273.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core020.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 272.9 - 274.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core021.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 273.9 - 275.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core022.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 274.9 - 276.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core023.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 275.9 - 277.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core024.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 276.9 - 278.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core025.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 277.9 - 279.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core026.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 278.9 - 280.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core027.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite Mbr core, 279.9 - 281.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core028.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Magenta Dolomite/ Tamarisk Mbrs core, 280.9 - 282.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core029.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 281.9 - 283.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core030.jpg	4-19-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 282.9 - 284.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core031.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 346.0 - 347.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core032.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 346.9 - 348.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-13_Core033.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 347.9 - 349.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core034.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 348.9 - 350.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core035.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 350.0 - 351.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core036.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 351.0 - 352.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core037.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 352.0 - 353.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core038.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 353.0 - 354.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core039.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 354.0 - 355.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core040.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 355.0 - 356.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core041.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 356.0 - 357.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core042.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 357.0 - 358.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core043.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 358.0 - 359.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core044.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 359.0 - 360.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core045.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 360.0 - 361.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core046.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 361 - 362.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core047.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 362.0 - 363.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core048.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 363.0 - 364.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-13_Core049.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 364.0 - 365.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core050.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 365.0 - 366.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core051.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 366.0 - 367.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core052.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 367 - 368.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core053.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 368.0 - 369.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core054.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 369.0 - 370.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core055.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 370.0 - 371.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core056.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 371.0 - 372.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core057.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 372.0 - 373.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core058.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 373.0 - 374.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core059.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 374.0 - 375.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core060.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 375.0 - 376.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core061.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 376.0 - 377.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core062.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 376.9 - 378.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core063.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 377.9 - 379.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core064.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 378.9 - 380.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-13_Core065.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 379.9 - 381.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core066.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 380.9 - 382.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core067.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 381.9 - 383.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core068.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 382.9 - 383.6 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core069.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 383.6 - 384.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-13_Core070.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk Mbr core, 384.0 - 385.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core071.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Tamarisk/Culebra Dolomite Mbrs core, 385.0 - 386.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core072.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 386.0 - 387.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core073.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 387.0 - 388.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core074.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 388.0 - 389.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core075.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 389.0 - 390.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core076.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 390.0 - 391.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core077.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 391.0 - 392.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core078.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 392.0 - 393.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core079.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 393.0 - 394.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core080.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 394.0 - 395.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-13_Core081.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 395.0 - 396.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core082.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 396.0 - 397.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core083.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 397.0 - 398.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core084.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 398.0 - 399.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core085.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 399.0 - 400.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core086.jpg	4-20-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Culebra Dolomite Mbr core, 400.0 - 401.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core087.jpg	4-21-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 400.9 - 402.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core088.jpg	4-21-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 401.8 - 403.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core089.jpg	4-21-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 402.8 - 404.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core090.jpg	4-21-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 403.8 - 405.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core091.jpg	4-21-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 404.8 - 406.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core092.jpg	4-21-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 405.8 - 406.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core093.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 413.0 - 414.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core094.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 414.0 - 415.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core095.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 415.0 - 416.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core096.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 416.0 - 417.3 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-13_Core097.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 417.0 - 418.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core098.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 417.9 - 419.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core099.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 418.9 - 420.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core100.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 420.0 - 421.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-13_Core101.jpg	4-23-05	SNL-13 drillpad; T23S, R30E, sec 1	Close-up photo of Los Medaños Mbr core, 420.9 - 422.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

Appendix G
Geophysical and Video Logs

Geophysical logging of SNL-13 was conducted by Geophysical Logging Services, 6250 Michele Lane, Prescott, AZ 86305, on April 25, 2005. The operator was Raymond Federwisch. Copies of the logs are maintained by Washington Regulatory and Environmental Services, Environmental Monitoring and Hydrology Section, for the WIPP project. A CD-ROM is being retained that includes:

1) Electronic copies of the logs produced by 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.

The following geophysical logs were obtained:

- Caliper
- Natural gamma
- Neutron
- Density
- Formation resistivity
- Fluid resistivity
- Fluid temperature
- Formation conductivity
- Spontaneous potential (SP)

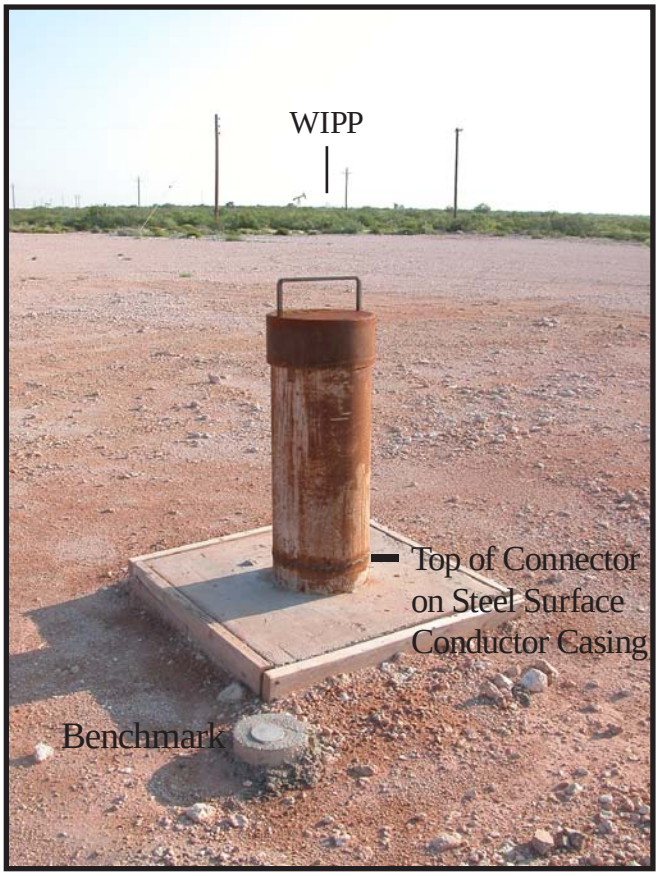
SNL-13 had been cored and drilled to about 480 ft at the time of logging. A bridge or fill in the hole prevented logging below 443 ft. A conductor casing had been placed to a depth of 192 ft bgl. The fluid level had risen in the drillhole, from inflow, to approximately 316 ft below the surface at the time of logging. SNL-13 was drilled with air and foam, with little water introduced during drilling.

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

The reference point (0 ft depth) for geophysical logging was the level of the pad, which was observable relative to the surface conductor casing (see photo, next page). This point was assigned an elevation of 3292.4 ft amsl on the logs, based on the pre-drilling pad elevation of 3292.37 ft. A benchmark placed near the drillhole after completion has an elevation of 3291.61 ft amsl (see Fig. 1-5 and Table 1-1 in the main text). The rounded elevation of 3292 ft amsl for the reference point is appropriate for the measurements and elevations of units for later studies.

On April 11, April 19, and April 23, 2005, a video camera was used to obtain images of the

Geophysical Logging Services logging vehicle set up and logging SNL-13 on April 25, 2005.



Well pad surface level was taken as the zero point for geophysical logging and well completion depths.

borehole. The video camera is the property of Sandia National Laboratories, Carlsbad, NM.

On April 11, SNL-13 had been drilled to 210 ft, into the upper Rustler Formation. The Dewey Lake Formation was producing water, and the decision was made to place a surface conductor casing into the uppermost Rustler. After the drill pipe, collars, and drill bit were removed from the hole, Anne and Ed Schaub (SNL) ran the video camera to a depth of 205 ft. This run recorded seepage into the drillhole from about 143 ft down, and the water level was slightly above 205 ft. The Rustler to Dewey Lake transition was also recorded.

On April 19, SNL-13 had been drilled to a depth of 346 ft, through the Magenta and most of the upper Tamarisk anhydrite (A-3). A surface conductor casing to 192 ft (into the top of Rustler) isolated the Dewey Lake saturated zone. The video camera was run by Anne and Ed Schaub to total depth, recording the lack of accumulated water at that time. The Magenta was observed to be producing a slight amount of water.

On April 23, SNL-13 had been drilled with air and some foam to a depth of 422 ft, through the Culebra Dolomite and into A-1 of the Los Medaños Member. After the drill pipe, collars, and bit were removed from the drill hole, Dennis Powers ran the camera to a depth of about 405 ft, in the lower part of the Culebra. The Magenta was observed to produce a slight amount of water. The drillhole was irregular in cross-section through the Tamarisk mudstone (M-3) interval from the effects of drilling with air and foam. The Culebra was observed to be seeping water, but there were no discrete points of flow (e.g., a crack) that could be identified. The lower Culebra could not be observed due to foam in the hole. Good conditions in the drillhole also resulted in identifying numerous bedding features in the Culebra and Tamarisk sulfate units. Depths recorded by this video differ by ~5 ft from the drilling record.

These three camera runs have been recorded on a VHS tape that is retained by SNL with a record number ERMS #543799 (Record title: Machine-readable Media for SNL-13 video log 4-11-2005, 4-19-2005, and 4-23-2005). A copy is retained by WRES as well.

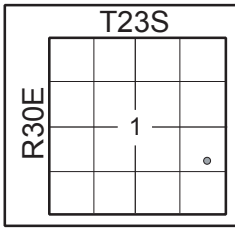
Video camera with centralizers above temporary surface conductor casing at SNL-13 on April 11, 2005. Camera lights are on in preparation for the video run.

Sandia National Laboratories borehole video camera with centralizer and back of camera trailer at SNL-13, April 11, 2005

Anne Schaub (right) in video camera trailer setting up to record downhole images of SNL-13 on April 11, 2005.

Figure 2-1
Well Record SNL-13 (C-3139)

Company: Washington TRU Solutions LLC
Well: SNL-13 (C-3139)
Section: 1 Twp: T23S Rge: R30E
Location: 1770 ft from south line (fsl)
602 ft from east line (fel)



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

Elevation
KB:
DF:
GL: 3292 ft amsl
(benchmark: 3291.61ft)

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: April 11, 2005
Completion date: April 27, 2005
Total depth (TD): 480 ft bgl (driller log)

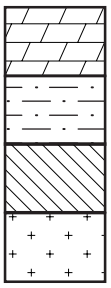
Casing Record
Conductor: 192 ft
12.75 inch steel o.d.
Casing: 5.45 inch o.d.
fiberglass reinforced
plastic to 421.0 ft bgl
Screened interval:
384.5-411.0 ft

Geophysical Logs Date: April 25, 2005

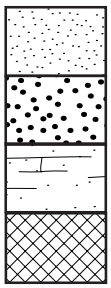
Micro/Laterolog/Induction/SP:	0-459 ft
Gamma/Fluid:	0-455 ft
Caliper:	0-443 ft
Density/Neutron:	0-444 ft

Type fluid in hole:
Water below 316 ft
Res mud: n.d.
Res mud filtrate: n.d.
Max. Rec. Temp.:
21.9°C (in water)

General Lithologic Symbols Used



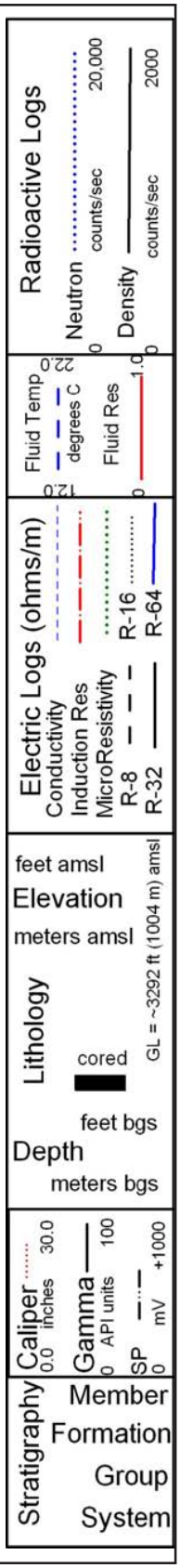
Dolomite
Mudstone/siltstone
Anhydrite
Halite



Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Symbols may be combined; some may not be used

SNL-13 Well Log Headers



Radioactive Logs
Neutron ..... counts/sec 0 20,000
Density ——— counts/sec 0 2000
Fluid Temp - - - degrees C 12.0 22.0
Fluid Res ——— 0 1.0
Electric Logs (ohms/m)
Conductivity - - -
Induction Res ——
MicroResistivity .....
R-8 - - -
R-16 .....
R-32 ——
R-64 ——
feet amsl
Elevation
meters amsl
GL = ~3292 ft (1004 m) amsl
Lithology
cored
feet bgs
Depth
meters bgs
Caliper ..... 0.0 inches 30.0
Gamma ——— 0 API units 100
SP -.-.-. 0 mV +1000
Stratigraphy
Member
Formation
Group
System
Top of water in drillhole at time of logging
Bottom of hole filled from 480 to 460 ft before logging
Forty-niner
Magenta
Tamarisk
Culebra
Los Medaños
Dewey Lake
Rustler
sand
Mescalero cal.
Gatuna Fm
Triassic
Permian (Ochoan)
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