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Basic Data Report for Drillhole WIPP 19 (Waste Isolation Pilot Plant - WIPP)

Sandia Laboratories
United States Geological Survey

Sandia National Laboratories

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Basic Data Report
for
Drillhole
WIPP 19

(Waste Isolation Pilot Plant - WIPP)

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Compiled by
Sandia Laboratories
(Division 4511)

and

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1.0 ABSTRACT

WIPP 19 is an exploratory borehole whose objective was to determine the nature of the near-surface formations after seismic information indicated a possible fault. The borehole is located in section 20, T.22S., R.31E., in eastern Eddy County, New Mexico, and was drilled between April 6 and May 4, 1978. The hole was drilled to a depth of 1038.2 feet and encountered, from top to bottom, surficial Holocene deposits (7', including artificial fill for drill pad), the Mescalero caliche (7'), the Santa Rosa Sandstone (82'), the Dewey Lake Red Beds (494'), the Rustler Formation (315'), and the upper portion of the Salado Formation (143'). Cuttings were collected at 10-foot intervals. A suite of geophysical logs was run to measure acoustic velocities, density, and radioactivity. On the basis of comparison with other geologic sections drilled in the area, the WIPP 19 section is a normal stratigraphic sequence and it does not show structural disruption.

The WIPP is to demonstrate (through limited operations) disposal technology for transuranic defense wastes. The WIPP will also provide facilities to research interactions between high-level waste and salt.

2.0 INTRODUCTION

The introduction describes background information on the Waste Isolation Pilot Plant (WIPP) and the investigations at WIPP 18, 19, 21, and 22.

2.1 The Purpose of WIPP

The purpose of the WIPP is distinct from that of several other projects for the disposal of radioactive waste. The WIPP is planned to demonstrate disposal technology for the transuranic (TRU) waste resulting from this nation's defense programs of over 30 years. After a period (5-10 years) of limited (pilot) operation, during which the waste is readily retrievable, it is anticipated that the WIPP will be converted to a full-scale repository for permanent disposal of defense TRU waste. The WIPP plans also include a research facility to examine, on a large scale, the interactions between bedded salt and high-level radioactive waste resulting from thermal and radiation fluxes. There is no plan at this time to dispose of high-level waste or spent fuel in the WIPP. DOE had expressed an intent to request licensing of the WIPP by the Nuclear Regulatory Commission (NRC). This licensing policy was not acceptable to the congressional committees responsible for WIPP and DOE has agreed to proceed without licensing.

Additional information on the WIPP and characterization of the WIPP site may be found in Powers, et. al. (1978).

2.2 The Purpose of WIPP Boreholes 18, 19, 21, 22

Seismic reflection data (see X series in Hern et al., 1978) over the mile immediately north of ERDA 9 was acquired in late 1977. Early in 1978, preliminary interpretation of the data from line X-2 (Figure 1) indicated faulting of the upper Castile Formation. The fault line, as interpreted in the Castile, was extrapolated upward into poorly defined reflectors in the Rustler Formation (Figure 2). The possibility of a fault in the Rustler was investigated because of potential hydrologic connections into or through the evaporites.

In addition, anomalously low resistivity was measured (Elliot, 1977) in the area where WIPP 19 was drilled. The anomaly, though of lesser areal size and intensity than those previously measured over known "breccia pipes," has a pattern similar to the resistivity anomalies associated in these "breccia pipes." These coincident features required further investigation.

Boreholes WIPP 18, 19, 21, and 22 (WIPP 20 was unnecessary and was never drilled) were positioned to test the most probable location of the inferred fault and to bracket that location for added certainty (Figure 2). WIPP 18 was located north of the inferred fault. WIPP 19 was to intersect the fault in the lower Rustler or upper Salado. WIPP 22 was drilled so that the inferred fault might be intersected in the upper Rustler or Dewey Lake Redbeds. WIPP 21 was located farther south, between ERDA 9 and WIPP 22, to test for southward dip of the Rustler interpreted from the seismic reflection records.

For this evaluation, the displacement was to be identified primarily from comparison of stratigraphic thickness and position of marker beds identified on borehole geophysical logs. WIPP 19 was cored from surface to total depth as the borehole which might intercept the fault if it existed in the Rustler Formation.

Basic geologic data in this report may be used for many purposes. The geologic interpretation of borehole data relating to the inferred fault and resistivity anomaly will be a separate document.

Additional details regarding the background and justification for WIPP 18, 19, 21, and 22 are in Appendix A.

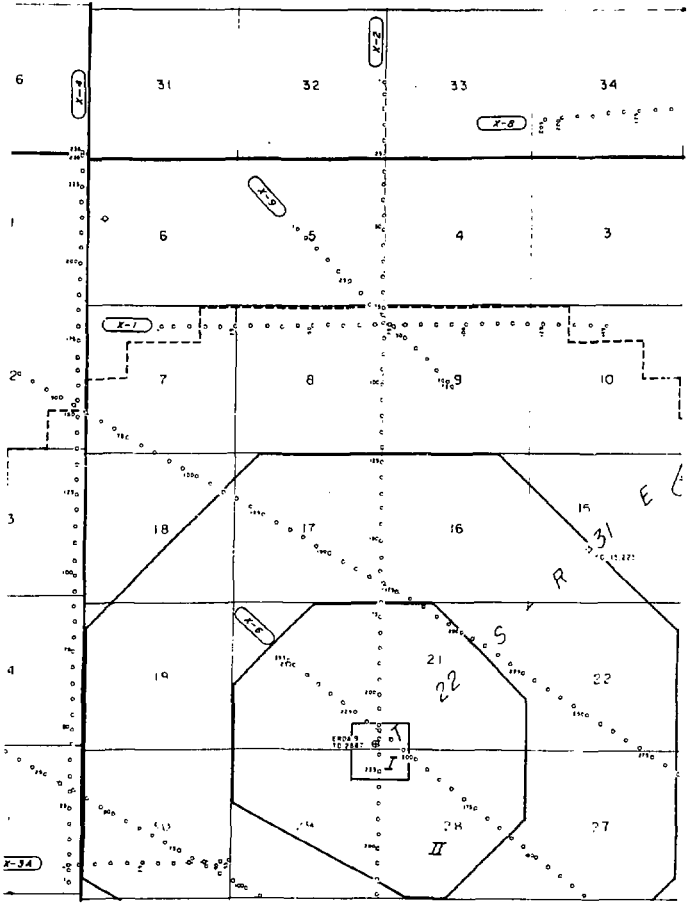

Figure 1. Shot point map of line X-2 north of ERDA 9.

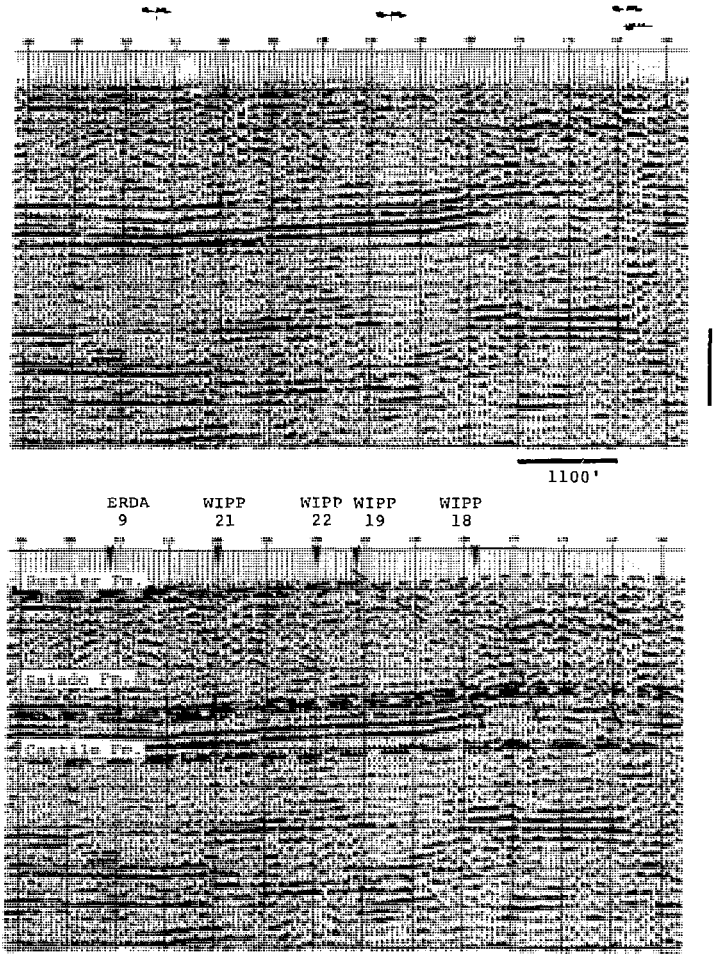

Figure 2. Seismic reflection line X-2 north of ERDA 9.
Top: Uninterpreted. Bottom: Preliminary interpretation displaying features investigated by WIPP 18, 19, 21, 22.

3.0 GEOLOGIC DATA FOR BOREHOLE WIPP 19

By

C. L. Jones[1] and J. L. Gonzales[2]

3.1 Abstract

Borehole WIPP 19 is a stratigraphic test hole drilled in eastern Eddy County, New Mexico, to explore for a possible fault indicated by seismic testing in near-surface formations. The formations penetrated include the Mescalero caliche of Pleistocene age; the Santa Rosa Sandstone of Triassic age; and the Dewey Lake Red Beds, the Rustler Formation, and part of the Salado Formation, all of Permian age. Correlated geologic and geophysical logs of WIPP 19 give lithologic, stratigraphic, and physical details of the near-surface formations and establish a normal stratigraphic sequence, in WIPP 19, unbroken by faulting.

3.2 Introduction

Borehole WIPP 19 is one of a series of stratigraphic holes drilled near the center of the proposed site for a Waste Isolation Pilot Plant (WIPP) in eastern Eddy County, New Mexico (Figure 3) on behalf of the U.S. Department of Energy (DOE). The drilling was done to determine the structure of near-surface formations along part of a seismic reflection survey line. On the basis of seismic records, faulting of the near-surface formations with a possible minimum of 100-150 feet of stratigraphic displacement had been inferred. WIPP 19 was located to intersect the "seismic fault" at a depth interval of about 600-800 feet below the surface.

Geologic details of the rocks penetrated by WIPP 19 are tabulated in this chapter. The tabulation includes correlated lithologic and geophysical logs and stratigraphic details. The correlated lithologic log is an interpretation compiled from descriptions of cores from WIPP 19 and from wireline geophysical logs. Other features of the rocks will be reported elsewhere.

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[1] U.S. Geological Survey, Denver, Colorado

[2] Fenix & Scisson, Inc., Carlsbad, New Mexico

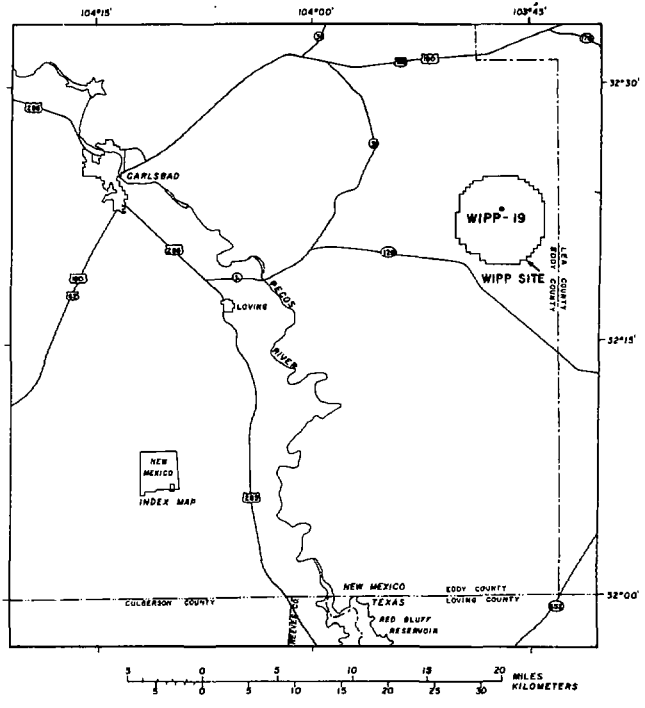

Figure 3. Index map showing location of borehole WIPP 19.

All measurements related to WIPP 19 are reported in the inch-pound system. These units are used to facilitate the comparison of the measurements made by surveyors in establishing the geographic coordinates of the borehole, by drillers in reporting core depths and drilling conditions, and by geophysical loggers in recording inhole variations in rock properties with depth. If the metric equivalents are desired, the following conversion factors are provided:

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)
pounds per square inch (lb/in^2)	0.006895	megapascal (MPa)

3.3 Description of WIPP 19

Borehole WIPP 19 is located in eastern Eddy County, New Mexico, in the NE 1/4 Section 20, T.22S., R.31E. The borehole was drilled between April 6 and May 4, 1978, to a depth of 1038.2 feet measured from a land-surface altitude of 3433.13 feet above MSL (mean sea level). Table 1 gives further details concerning the drilling of WIPP 19.

Wireline coring procedures were used to obtain consecutive cores the full length of WIPP 19. All the cores were cleaned to remove a surficial coating of salt-base mud used as drilling fluid. After cleaning, the cores were marked according to the depths reported by the driller, examined for geologic details, wrapped in polyethylene sheets for preservation, and then transported from the drill site to the warehouse for photographing and storage. The results of the drill site core examination are recorded herein and are interpreted and correlated with selected geophysical logs on Figure 3.

A suite of geophysical logs was run the full length of WIPP 19. The logging was done to facilitate the recognition and correlation of rock units, to assure identification of major lithologies (dolomite, anhydrite,

polyhalite, and other rocks) and to provide depth determinations independent of that indicated by drill-rod measurements. The geophysical logs included a (1) gamma-ray curve that recorded variations in the distribution of radioactive elements (potassium, uranium, and thorium), (2) compensated-neutron porosity curve that essentially recorded variations in the distribution of hydrogen, and (3) compensated formation density porosity curve that essentially recorded variations in rock density.

3.4 Geologic Data

The rocks penetrated by WIPP 19 include continental sediments of Quaternary and Triassic age, and marine red beds and evaporites of Permian age. The rocks units are listed in Table 2, and are briefly described in descending order.

The Quaternary sediments consist of unconsolidated dune sand of Holocene age and a well-lithified calcareous soil, known locally as the Mescalero caliche of Pleistocene age. The two units account for the upper 14 feet of section in WIPP 19 (Figure 3).

The rocks underlying the Mescalero caliche, at 14-96 feet below land surface, belong to the Santa Rosa Sandstone of Triassic age. They are mostly reddish-brown and yellowish-brown sandstone with interbeds of reddish-brown mudstone and siltstone. Much of the rock is slightly calcareous, and part of the sandstone is micaceous. All are liberally peppered with greenish-gray reduction spots and streaks.

The Permian rocks penetrated consist of the Dewey Lake Red Beds, the Rustler Formation, and the upper part of the Salado Formation. They account for 938 feet of the section in WIPP 19.

The Dewey Lake Red Beds, 96-590 feet below land surface, are a lithologically distinctive but somehat monotonous sequence of reddish-brown siltstone and mudstone containing sparse interbeds of fine- to coarse-grained sandstone at irregular short to long intervals. Much of the reddish-brown rock is liberally peppered and streaked with greenish-gray reduction spots and streaky lenticular pods. Veinlets of fibrous, white selenite are common in the lower 375 feet of the red beds, and there are sparse calcite veinlets in the upper 100 feet of rock.

The Rustler Formation, 590-895 feet below land surface, is chiefly anhydrite (or gypsum) and fine-grained clastic rocks with interbeds of dolomite and clayey to silty halite. Rocks above a depth of 795 feet are weathered, and many, to a greater or lesser degree, have lost one or more soluble constituent (NaCl, $CaSO_4$, and $CaMg(CO_3)_2$) to dissolution by groundwater. Gypsum rinds containing corroded remnants of anhydrite are well-developed along the sides of anhydrite beds bordering the clastic rocks and dolomite interbeds, and there are veins and porphyroblasts of gypsum scattered through anhydrite and other rocks. Virtually all the clastic rocks above the depth of 795 feet are essentially structureless, unconsolidated clays and silts that are dissolution residues derived from clayey and silty halite; whereas those below that depth are well-indurated sandstone and siltstone containing crystals and veins of halite.

The Salado Formation is the lower 143 feet of rock, between 895 and 1038 feet, in WIPP 19. The rock is chiefly halite and argillaceous halite with thin interbeds of siltstone, polyhalite, and anhydrite. Much of the halite is white and reddish-orange to orange-pink; whereas the argillaceous halite is dominantly reddish-brown. Additional lithologic and stratigrphic details of the Salado are given in Table 3 and on Figure 3.

The geologic section in WIPP 19 is similar lithologically, stratigraphically, and structurally to that in other exploration test holes drilled at the WIPP site (see, for example, Jones 1978). The section is unbroken by faulting, and there are no anomalous dips or structural features, thinning of section, or missing rock units. It is clear that the geologic findings do not support the interpretations from seismic records of a fault cutting the near-surface formations at WIPP 19.

Table 1.--*Abridged history of borehole WIPP-19*

LOCATION: sec. 20, T. 22 S., R. 31 E.
2,987.34 feet from south line
12.68 feet from east line

ALTITUDE (LAND SURFACE): 3,433.13 feet. Datum for all depth measurements.

DESCRIPTION OF CORE PREPARED BY: J. L. Gonzales, April 6 to May 4, 1978.

DRILLING CONTRACTOR: Boyles Bros. Drilling Co.

DRILLING RECORD: Commenced drilling April 6, 1978, and completed May 4, 1978, at 1,038.2 feet below land surface.

Set 7-inch outside-diameter casing in an 8 3/4-inch hole at 8 feet; packed annulus with gel.

Cut consecutive cores with 4 1/2-inch bit, 8-14 feet; with 3 7/8-inch bit, 14-48 feet; and with 3 15/16-inch bit, 48-1,038.2 feet.

On completion of coring, hole opened to 6 1/8 inches for geophysical logging and then capped pending decision concerning possible additional work.

Core No.	Depth interval Feet	RPM	Weight on bit (lbs)	Circulating pressure (lb/in^2)	Interval Feet cored	Interval Feet recovered	Percent recovered
1	8.0- 9.9	175	2,000	100	1.9	1.9	100
2	9.9- 12.6	175	2,000	100	2.7	2.7	100
3	12.6- 14.1	175	2,000	100	1.5	1.3	87
4	14.1- 17.4	175	2,000	100	3.3	3.2	97
5	17.4- 19.9	175	2,000	100	2.5	2.5	100
6	19.9- 26.9	175	2,000	100	7.0	7.9	113.0
7	26.9- 33.9	175	2,000	100	7.0	7.3	104.0
8	33.9- 41.2	175	2,000	100	7.3	8.2	112
9	41.2- 43.2	175	2,000	100	2.0	1.8	90
10	43.2- 48.2	175	2,000	100	5.0	5.3	106
11	48.2- 53.2	175	3,000	100	5.0	4.4	88
12	53.2- 56.2	175	3,000	100	3.0	3.3	110
13	56.2- 63.2	175	3,000	100	7.0	7.0	100
14	63.2- 71.2	175	3,000	100	8.0	8.0	100
15	71.2- 78.2	175	3,000	100	7.0	7.0	100
16	78.2- 88.2	175	3,000	100	10.0	10.2	102
17	88.2- 97.2	175	3,000	100	9.0	9.0	100
18	97.2-106.2	175	4,000	400	9.0	9.1	101
19	106.2-116.2	175	4,000	400	10.0	10.0	100
20	116.2-123.2	175	4,000	400	7.0	7.0	100
21	123.2-133.2	175	4,000	400	10.0	10.0	100
22	133.2-143.2	175	4,000	400	10.0	10.0	100
23	143.2-153.2	150	3,000	400	10.0	10.0	100
24	153.2-163.2	175	3,000	200/400	10.0	10.0	100
25	163.2-173.2	225	3,000	200/400	10.0	10.0	100

Table 1.--*Abridged history of borehole WIPP-19*--Continued

Core No.	Depth interval Feet	RPM	Weight on bit (lbs)	Circulating pressure (lb/in^2)	Interval		Percent recovered
					Feet cored	Feet recovered	
26	173.2-183.2	225	3,000	400/200	10.0	10.0	100
27	183.2-193.2	225	3,000	200/300	10.0	10.0	100
28	193.2-201.2	200	3,000	200/300	8.0	8.0	100
29	201.2-211.2	200	3,000	200/450	10.0	10.0	100
30	211.2-220.2	200	3,000	200/300	9.0	9.0	100
31	220.2-228.2	200	3,000	200/450	8.0	8.0	100
32	228.2-237.2	200	3,200	300	9.0	8.9	99
33	237.2-246.2	175	3,200	300/400	9.0	9.0	100
34	246.2-253.2	200	3,200	300	7.0	7.0	100
35	253.2-263.2	200	3,200	200/400	10.0	10.0	100
36	263.2-273.2	200	3,000	300/400	10.0	10.0	100
37	273.2-283.2	175	3,000	400	10.0	10.0	100
38	283.2-293.2	200	3,200	400	10.0	10.0	100
39	293.2-298.2	175	3,200	300/400	5.0	3.5	70
40	298.2-305.2	175	3,200	400	7.0	8.5	121
41	305.2-315.2	200	4,000	300	10.0	10.0	100
42	315.2-324.2	175	4,200	400	9.0	8.7	97
43	324.2-333.2	200	4,200	300	9.0	9.0	100
44	333.2-343.2	200	4,200	250	10.0	10.0	100
45	343.2-351.2	200	4,200	250	8.0	8.0	100
46	351.2-360.2	200	4,000	400	9.0	9.1	101
47	360.2-369.2	200	4,200	400	9.0	8.9	99
48	369.2-378.2	200	4,200	400	9.0	9.0	100
49	378.2-384.2	200	4,200	400	6.0	6.0	100
50	384.2-393.2	225	5,300	500	9.0	9.0	100
51	393.2-403.2	200	4,500	500	10.0	10.0	100
52	403.2-413.2	200	4,200	600	10.0	10.0	100
53	413.2-423.2	200	4,200	400	10.0	10.0	100
54	423-2-433.2	200	4,200	400	10.0	10.0	100
55	433.2-443.2	225	4,300	400	10.0	10.0	100
56	443.2-453.2	225	4,300	400	10.0	10.0	100
57	453.2-463.2	225	4,300	400	10.0	10.0	100
58	463.2-473.2	225	4,300	400	10.0	10.0	100
59	473.2-483.2	225	4,500	400	10.0	10.0	100
60	483.2-492.2	225	4,500	500	9.0	9.0	100
61	492.2-502.2	225	4,500	500	10.0	10.0	100
62	502.2-512.2	200	4,500	400	10.0	10.0	100
63	512.2-522.2	200	4,500	400	10.0	10.0	100

Table 1.--*Abridged history of borehole WIPP-19*--Continued

Core No.	Depth interval Feet	RPM	Weight on bit (lbs)	Circulating pressure (lb/in^2)	Interval Feet cored	Interval Feet recovered	Percent recovered
64	522.2-531.2	200	4,500	400	9.0	9.0	100
65	531.2-533.2	200	4,500	400	2.0	2.0	100
66	533.2-543.2	200	4,000	500	10.0	10.0	100
67	543.2-553.2	175	4,800	600	10.0	10.0	100
68	553.2-563.2	200	4,600	500	10.0	10.0	100
69	563.2-570.2	200	4,600	500	7.0	7.0	100
70	570.2-579.2	225	4,600	500	9.0	9.0	100
71	579.2-588.2	200	4,600	500	9.0	9.0	100
72	588.2-598.2	225	5,100	400	10.0	10.0	100
73	598.2-608.2	225	6,000	300	10.0	10.0	100
74	608.2-618.2	225	6,000	300	10.0	10.0	100
75	618.2-623.2	200	5,000	300	5.0	2.0	40
76	623.2-630.2	300	5,000	300	7.0	8.0	114
77	630.2-639.2	200	5,500	400	9.0	9.0	100
78	639.2-648.2	200	6,000	300	9.0	9.0	100
79	648.2-658.2	200	6,000	300	10.0	10.0	100
80	658.2-668.2	200	6,000	300	10.0	10.0	100
81	668.2-678.2	200	6,000	300	10.0	10.0	100
82	678.2-687.2	200	6,000	300	9.0	9.0	100
83	687.2-697.7	200	6,200	300	10.5	10.3	98
84	697.7-707.7	200	6,200	400	10.0	10.0	100
85	707.7-717.2	200	6,200	300	9.5	9.5	100
86	717.2-727.2	200	6,200	300	10.0	10.0	100
87	727.2-737.2	200	6,200	300	10.0	10.0	100
88	737.2-747.2	200	6,200	500	10.0	5.6	56
89	747.2-751.7	200	6,000	400	4.5	7.7	171
90	751.7-760.2	200	200	400	8.5	10.0	118
91	760.2-770.2	225	6,200	300	10.0	10.0	100
92	770.2-780.2	225	6,200	400	10.0	10.0	100
93	780.2-789.2	200	6,000	400	9.0	9.0	100
94	789.2-798.2	225	6,500	300	9.0	9.0	100
95	798.2-808.2	225	6,200	350	10.0	10.0	100
96	808.2-818.2	225	6,200	300	10.0	10.0	100
97	818.2-828.2	225	6,200	300	10.0	10.0	100
98	828.2-836.2	200	6,200	300	8.0	8.0	100
99	836.2-843.2	200	6,200	400/200	7.0	7.0	100
100	843.2-853.2	225	6,200	400	10.0	10.0	100
101	853.2-863.2	225	6,200	450	10	[illegible]	[illegible]

Table 1.--*Abridged history of borehole WIPP-19*--Continued

Core No.	Depth interval Feet	RPM	Weight on bit (lbs)	Circulating pressure (lb/in²)	Interval		Percent recovered
					Feet cored	Feet recovered	
102	863.2-873.2	227	6,200	450	10.0	10.0	100
103	873.2-883.2	225	6,200	500	10.0	10.0	100
104	883.2-893.2	225	6,200	400	10.0	10.0	100
105	893.2-898.2	200	6,000	300	5.0	5.0	100
106	898.2-908.2	200	6,200	300	10.0	10.0	100
107	908.2-918.2	200	6,200	300	10.0	10.0	100
108	918.2-928.2	200	6,200	300	10.0	10.0	100
109	928.2-938.2	200	6,200	300	10.0	10.0	100
110	938.2-948.2	200	6,200	300	10.0	10.0	100
111	948.2-958.2	200	6,200	300	10.0	10.0	100
112	958.2-968.2	200	6,200	300	10.0	9.7	97
113	968.2-978.2	200	6,200	500/300	10.0	10.0	100
114	978.2-988.2	200	6,200	600/300	10.0	10.0	100
115	988.2-998.2	200	6,200	300	10.0	10.0	100
116	998.2-1,008.2	200	6,200	500	10.0	10.0	100
117	1,008.2-1,010.2	200	6,200	400	2.0	2.0	100
118	1,010.2-1,018.2	200	6,000	200	8.0	8.0	100
119	1,018.2-1,028.2	200	6,000	200	10.0	10.0	100
120	1,028.2-1,038.2	200	6,200	200	10.0	9.4	94

Table 2.--*Stragigraphic summary for borehole WIPP-19*

Rock unit	Thickness Feet	Depth interval[1] Feet
Quaternary rocks		
Holocene deposits[2]	7	0- 7
Mescalero caliche	7	7- 14
Triassic rocks		
Santa Rosa Sandstone	82	14- 96
Permian rocks		
Dewey Lake Red Beds	493	96- 590
Rustler Formation	304	590- 895
Dissolution residue	10	619- 629
Magenta Dolomite Member	25	647- 672
Dissolution residue	26	730- 756
Culebra Dolomite Member	23	756- 779
Dissolution residue	14	781- 795
Salt-bearing interval	100	795- 895
Salado Formation	143.2	895-1,038.2
Upper member	143.2	895-1,038.2
[3]MB 101		1,010-1,012
Maximum depth recorded----------		1,034

[1]Depth recorded on Compensated Neutron-Formation Densit, Log made by Schlumberger on May 6, 1978.

[2]Includes artificial fill for drill pad.

[3]Marker bed.

Table 3.--*Lithologic log for borehole WIPP-19*

[Color designations are from the Rock-Color Chart (Goddard and others, 1948). No core designates intervals where core was not recovered during drilling operations. Depth interval refers to drillers' depth below land surface]

Lithologic description	Depth interval Feet
Dune sand, unconsolidated (includes fill for drill pad)----------	0 - 7
Caliche, white (N9), sandy----------	7 - 14.1
Sandstone, moderate-reddish-brown (10R 4/6), pale-red (10R 6/2), and pale-reddish-brown (10R 5/4), very fine grained to fine-grained, weathered and unconsolidated; slightly calcareous; grades to moderate-reddish-brown (10R 4/6) siltstone peppered with light-greenish-gray (5G 8/1) reduction spots at 40.4-41.2 feet----------	14.1- 41.2
Mudstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) speckled with light-greenish-gray (5G 8/1) and pale-green reduction spots, slightly calcareous----------	41.2- 52.6
No core----------	52.6- 53.2
Mudstone, same as unit at 41.2-52.6 feet----------	53.2- 60.7
Siltstone, greenish-gray (5GY 6/1)----------	60.7- 61.4
Mudstone, moderate-reddish-brown (10R 4/6); interbedded with moderate-reddish-brown (10R 4/6), greenish-gray (5GY 6/1), and dark-yellowish-brown (10YR 4/2) sandstone, very fine grained to fine-grained, in layers about 0.1-1.0 foot thick----------	61.4- 72.3
Siltstone, moderate-reddish-brown (10R 4/6)----------	72.3- 73.3
Sandstone, dark-yellowish-brown (10YR 4/2) peppered with grayish-green (10GY 5/2) reduction spots, grading downward to grayish-green (10GY 5/2) at 93.5 feet, fine-grained to medium-grained, laminated and locally crossbedded, micaceous along bedding surfaces; fracture at 75.0 feet dips 70°----------	73.3- 96.6
Siltstone and mudstone, dark-yellowish-brown (10YR 4/2) grading downward to dark-reddish-brown (10R 3/4); interbeds of pale-olive (10Y 6/2) to yellowish-gray (5Y 7/2), very fine grained sandstone, contains mud cracks, mudstone clasts, small erosional channels, calcite veinlet at 10 .5-100.8 feet----------	96.6-106.2
Mudstone, moderate-reddish-brown (10R 4/6) peppered with greenish-gray (5G 6/1) reduction spots, dolomitic, bedding horizontal and cross-laminated; contain small erosional channels, mud cracks, and mudstone clasts; fractures at 109.0 and 109.5 feet dip about 70°----------	106.2-114.0
Siltstone, light-olive-gray (5Y 6/1), laminated, biotitic; contains mudstone chips and clasts, and interbeds of moderate-reddish-brown (10R 4/6) mudstone peppered with reduction spots----------	114.0-116.2

Table 3.--*Lithologic log for borehole WIPP-19*--Continued

Lithologic description	Depth interval Feet
Mudstone, moderate-reddish-brown (10*R* 4/6) and dark-reddish-brown (10*R* 3/4); interbedded with pale-reddish-brown (10*R* 5/4) sandstone, with a light-olive-gray (5*Y* 6/1) mottling, very fine grained to fine-grained, laminated----------	116.2-123.2
Mudstone, dark-reddish-brown (10R 3/4); interbeds of pale-reddish-brown (10*R* 5/4) siltstone and sandstone, laminated and crossbedded, mud cracks, and small erosional channels; conglomeratic layer, 0.3 foot thick at 125.0 feet, composed of mudstone clasts in a sandstone matrix-----	123.2-126.9
Siltstone, pale-reddish-brown (10*R* 5/4) peppered with reduction spots, cross laminated; interbedded with dark-reddish-brown (10*R* 3/4) mudstone and pale-reddish-brown (10*R* 5/4), very fine grained sandstone-----	126.9-129.7
Mudstone, dark-reddish-brown (10*R* 3/4) peppered and streaked with light-olive-gray (5*Y* 6/1) and moderate-green (5*G* 5/6) reduction spots and seams; interbedded with pale-reddish-brown (10*R* 5/4) and light-olive-gray (5*Y* 6/1), very fine grained sandstone; laminated and crossbedded, contains mud cracks filled with sandstone, mudstone clasts, and small erosional channels; white (*X9*) gypsum forms veinlets at 131.2 feet, bedding dips 2°-3°----------	129.7-159.0
Sandstone, light-olive-gray (5*Y* 6/1) and pale-reddish-brown (10*R* 5/4), very fine grained, silty, micaceous, and laminated; parallel set of fractures between 160.0 and 161.0 feet dip 70°----------	159.0-161.2
Siltstone and mudstone, moderate-reddish-brown (10*R* 4/6) and dark-reddish-brown (10*R* 3/4), laminated; interbedded with light-olive-gray (5*Y* 6/1), very fine grained sandstone at 163.5 feet; bedding dips 3°----------	161.2-164.8
Sandstone, pale-reddish-brown (10*R* 5/4), very fine grained, laminated, dolomitic cement----------	164.8-171.7
Mudstone, dark-reddish-brown (10*R* 3/4), interbedded with moderate-reddish-brown (10*R* 4/6) and pale-brown (5*YR* 5/2) siltstone and moderate-reddish-brown (10*R* 4/6) and light-brown-gray (5*YR* 6/1) sandstone, rock is laminated and crossbedded, contains small erosional channels and mudstone clasts; calcite veinlets at 176.2 feet-	171.7-192.5
Sandstone, moderate-reddish-brown (10*R* 4/6), very fine grained, interbedded with pale-yellowish-brown (10*YR* 6/2) mudstone at 193.2-194.7 feet----------	192.5-194.7
Mudstone, moderate-reddish-brown (10*R* 4/6) and dark-reddish-brown (10*R* 3/4); interbedded with pale-reddish-brown (10*R* 5/4), moderate-reddish-brown (10*R* 4/6), and pale-yellowish-brown (10*YR* 6/2) siltstone, laminated and crossbedded; contains small erosional channels at 202.5-205.7 feet, and calcite veinlets at 207.0 and 208.2 feet, bedding dips 3°----------	[illegible]

Table 3.--*Lithologic log for borehole WIPP-19--Continued*

Lithologic description	Depth interval Feet
Sandstone, dark-reddish-brown (10R 3/4), very fine grained, silty----------	209.6-210.4
Mudstone, dark-reddish-brown (10R 3/4) and moderate-reddish-brown (10R 4/6), laminated----------	210.4-211.5
Siltstone and sandstone, pale-yellowish-brown (10YR6/2)----------	211.5-212.3
Siltstone, dark-reddish-brown (10R 3/4), clayey----------	212.3-212.8
Sandstone, dark-reddish-brown (10R 3/4) grading to pale-yellowish-brown (10YR5/4) at 220.3-220.8 feet, very fine grained----------	212.8-220.8
Mudstone, dark-reddish-brown (10R 3/4), speckled with reduction spots, laminated; interbedded with dark-reddish-brown (10R 3/4), very fine grained, silty sandstone; fracture at 222.3 feet dips 80°----------	220.8-224.2
Siltstone, moderate-reddish-brown (10R 4/6), peppered and seamed with reduction spots and bands, laminated and crossbedded; interbedded throughout with dark-reddish-brown (10R 3/4) mudstone and with pale-yellowish-brown (10YR 6/2), very fine grained sandstone at 224.9 and 227.6 feet; contains horizontal and crisscrossing veins of fibrous selenite----------	224.2-237.1
No core----------	237.1-237.2
Siltstone, moderate-reddish-brown (10R 4/6), laminated and cross-bedded; contains mudstone clasts and microchannels; horizontal and crisscrossing veins of fibrous selenite, and interbeds of dark-reddish-brown (10R 3/4) mudstone, bedding dips 3°----------	237.2-242.2
Sandstone, dark-reddish-brown (10R 3/4), very pale-green (10G 8/2), and pale-yellowish-brown (10YR 6/2), medium-grained; interbedded with dark-reddish-brown (10R 3/4) mudstone, and contains veins of fibrous selenite----------	242.2-249.1
Mudstone, dark-reddish-brown (10R 3/4), silty, banded, contains horizontal veins of fibrous selenite, bedding dips 3°----------	249.1-249.8
Siltstone, moderate-reddish-brown (10R 4/6) and moderate-brown (5YR 3/4), laminated, interbedded with dark-reddish-brown (10R 3/4) mudstone and cut by horizontal and steep veins of fibrous selenite, bedding dips 3°----------	249.8-254.1
Sandstone, pale-yellowish-brown (10YR6/2) banded dark-yellowish-brown (10YR 4/2) and speckled with reduction spots, cut by horizontal veins of fibrous selenite----------	254.1-254.7
Siltstone, pale-reddish-brown (10R 5/4) banded dark-reddish-brown (10R 3/4), laminated, bedding dips 3°----------	254.7-255.[illegible]
Mudstone, dark-reddish-brown (10R 3/4), peppered with reduction spots, interbedded with moderate-reddish-brown (10R 4/6) siltstone, laminated and cross bedded, mudstone clasts, small erosional channels and selenite veins-	[illegible]

Table 3.--*Lithologic log for borehole WIPP-19*--Continued

Lithologic description	Depth interval Feet
Siltstone, pale-reddish-brown (10*R* 5/4), peppered with reduction spots; interbedded with dark-reddish-brown (10R 3/4) and grayish-green (5G 5/2) mudstone, and cut by veins of fibrous selenite----------	261.6-269.9
Mudstone, dark-reddish-brown (10R 3/4), interbedded with moderate-reddish-brown (10R 4/6) siltstone, horizontal and cross-laminated, clasts, small erosional channels, and veins of fibrous selenite----------	269.9-272.7
Siltstone, pale-reddish-brown (10*R* 5/4), peppered with reduction spots, halitic; horizontal and cross-laminated, mudstone clasts, microchannels, mud cracks, veins of fibrous selenite and interbeds of dark-reddish-brown (10*R* 3/4) mudstone; fracture at 290.9 feet dips 40°----------	272.7-293.9
Mudstone, dark-reddish-brown (10*R* 3/4), peppered with reduction spots; interbedded with moderate-reddish-brown (10*R* 4/6), pale-reddish-brown (10*R* 5/4), and grayish-brown (5*YR* 3/2) siltstone, contains reduction spots, horizontal and cross laminated, mudstone clasts, small erosional channels, and veins of fibrous selenite bedding essentially horizontal	293.9-318.6
Siltstone, pale-reddish-brown (10*R* 5/4), peppered with reduction spots, sandy and biotitic; cross laminated, selenite veins, and interbeds of dark-reddish-brown (10*R* 3/4) mudstone----------	318.6-323.9
No core----------	323.9-324.2
Siltstone, same as unit at 318.6-323.9 feet----------	324.2-332.4
Mudstone, same as unit at 293.9-318.6 feet----------	332.4-333.5
Siltstone, pale-reddish-brown (10*R* 5/4), peppered and seamed with greenish-gray (5*GY* 6/1) reduction spots and bands, contains veins of fibrous selenite throughout, interbeds of dark-reddish-brown (10*R* 3/4) mudstone, short intervals of cross lamination, and sparse mud cracks----------	333.5-352.6
Mudstone, dark-reddish-brown (10R 3/4), speckled and seamed with greenish-gray (5*GY* 6/1) reduction spots and bands; contains selenite veins and interbeds of moderate-reddish-brown (10*R* 4/6) siltstone; bedding dips about 6° in basal part of unit----------	352.6-355.3
Siltstone, pale-reddish-brown (10*R* 5/4), speckled and seamed with greenish-gray (5*GY* 6/1) reduction spots and bands; contains horizontal and steep veins of fibrous selenite, cross laminated, mud cracks, small erosional channels, and interbeds of dark-reddish brown (10*R* 3/4) mudstone, bedding is about horizontal----------	355.3-378.2

Table 3.--*Lithologic log of borehole WIPP-19--Continued*

Lithologic description	Depth interval Feet
Mudstone, dark-reddish-brown (10R 3/4), peppered and seamed with greenish-gray (5GY 6/1) reduction spots and bands; contains both horizontal and steep veins of fibrous selenite, sparse mud cracks and cross laminae, and interbeds of pale- and moderate-reddish-brown (10R 5/4 and 10R 4/6) siltstone, bedding essentially horizontal----------	378.2-403.2
Siltstone, moderate-reddish-brown (10R 4/6), peppered and irregularly seamed with greenish-gray (5GY 6/1) reduction spots and bands; irregularly interbedded throughout with dark-reddish-brown (10R 3/4) mudstone and with pale-reddish-brown (10R 5/4) fine-grained sandstone at 462.0-467.4 feet; contains a fine network of fibrous selenite veinlets and veins; bedding irregular and dip changes from 0° at 403.2 feet to 16° at 413.0-423.2 feet, to 5° at 423.2-443.2 feet, to 15° at 443.2-453.2 feet, and to 10° at 453.2-467.4 feet----------	403.2-467.4
Sandstone, light-greenish-gray (5G 8/1) and pale-reddish-brown (10R 5/4), very fine grained----------	467.4-469.0
Siltstone, moderate-reddish-brown (10R 4/6), peppered with greenish-gray (5GY 6/1) reduction spots; interbedded with dark-reddish-brown (10R 3/4) mudstone throughout and pale-reddish-brown (10R 5/4) sandstone at 469.0-471.0 feet; contains a coarse network of selenite veins; fracture at 475.2 feet dips 80°, bedding dip changes from 5°-10° at 469.0-473.2 feet, to 15° at 473.2-481.9 feet----------	469.0-481.9
Mudstone, dark-reddish-brown (10R 3/4), peppered with greenish-gray (5GY 6/1) reduction spots; contains veinlets of fibrous selenite----------	481.9-492.6
Siltstone, moderate-reddish-brown (10R 4/6), peppered with greenish-gray (5GY 6/1) reduction spots, contains veinlets of fibrous selenite-----	492.6-499.1
Mudstone, same as unit at 481.9-492.6 feet, interbedded with siltstone, same as unit at 492.6-499.1 feet; contains veinlets of fibrous selenite, a near-vertical vein of selenite starts at 511.5 feet, extends downward, splitting into two parts at 515.8 feet and continues downward terminating at a horizontal selenite vein at 517.0 feet; bedding essentially horizontal at 522.2-526.6 feet----------	499.1-543.2
Siltstone, moderate-reddish-brown (10R 4/6), peppered with greenish-gray (5GY 6/1) reduction spots, argillaceous; contains irregular laminae of dark-reddish-brown (10R 3/4) mudstone and narrow veins of fibrous selenite; bedding essentially horizontal at 570.0-571.0 feet------	543.2-571.1

Table 3.--*Lithologic log of borehole WIPP-19*--Continued

Lithologic description	Depth interval Feet
Siltstone, moderate-reddish-brown (10R 4/6), peppered with greenish-gray (5GY 6/1) reduction spots; contains interbeds of dark-reddish-brown (10R 3/4) mudstone and veins of fibrous selenite----------	571.1-589.9
Anhydrite, medium-gray (N5) with a crude, irregular banding in light and dark shades of gray, very finely crystalline; locally gypsiferous in narrow bands subparallel to bedding; contains veins of gypsum throughout and gypsum porphyroblasts at 589.9-590.9 feet; bedding is essentially horizontal----------	589.9-615.5
Gypsum, light-brownish-gray (5YR 6/1), medium-crystalline, irregularly mottled and crudely banded; argillaceous at 618.0-619.0 feet----------	615.5-619.0
Mudstone, light-greenish-gray (5GY 6/1) at 619.0-619.2 feet, dark-reddish-brown (10R 3/4) at 619.2-620.2 feet, silty, free of bedding structures--------	619.0-620.2
No core----------	620.2-622.3
Mudstone, moderate-brown (5YR 3/4), silty, free of bedding structures----------	622.3-623.2
Siltstone, moderate-brown (5YR 4/4) at 623.2-629.5 feet and light-gray (N6) at 629.5-630.2 feet; contains chips and flakes of pale-brown (5YR 5/2) siltstone, light-gray (N7), very fine grained sandstone, and white (N9) gypsum----------	623.2-630.2
Mudstone, medium-dark-gray (N4); contains veins of white (N9) gypsum----------	630.2-630.9
Gypsum, medium-dark-gray (N4), medium-crystalline, crudely banded with gypsum veins subparallel to bedding, nodular in part, sparingly dolomitic at 642.4-647.8 feet; contains remnants of medium-gray (N4) anhydrite through middle of unit; bedding is essentially horizontal----------	630.9-647.8
Dolomite, light-olive-gray (5Y 6/1), finely crystalline, laminated and cross-laminated; contains gypsum porphyroblasts at 647.8-649.8 feet, bedding is essentially horizontal----------	647.8-650.8
Dolomite, greenish-gray (5G 6/1), finely crystalline, silty, cross-laminated; contains veins and porphyroblasts of gypsum; bedding is essentially horizontal----------	650.8-672.3
Gypsum, olive-gray (5Y 4/1) to medium-gray (N5); crudely banded throughout, contains dolomite laminae at 672.3-672.8 feet and remnants of medium-gray (N5) anhydrite----------	672.3-677.2
Anhydrite, olive-gray (5Y 4/1) to medium-gray (N5), very finely crystalline, crude banding with nodularlike structure; contains gypsum in narrow bands, small porphyroblasts and veins----------	677.2-697.5
No core----------	697.5-697.7
Anhydrite, medium-light-gray (N6), very finely crystalline, crude banding with nodularlike structure at 697.7-703.5 feet, abundant pseudomorphs of anhydrite after gypsum at 703.5-707.7 feet; contains laminae of yellow-gray (5Y 7/2) dolomite at 711.0-717.2 feet; gypsum forms narrow bands essentially parallel to bedding, porphyroblasts, and veins near top and base of unit; bedding is essentially horizontal----------	697.7-719.0

Table 3.--*Lithologic log of borehole WIPP-19*--Continued

Lithologic description	Depth interval Feet
Gypsum, light-olive-gray (5Y 6/1), very finely crystalline to medium-crystalline, banded; contains veins of gypsum; bedding essentially horizontal at 722.6-727.2 feet and dips about 30° at 727.2-737.2 feet	719.0-740.3
Mudstone, dark-greenish-gray (5GY 4/1) and grayish-red (10R 4/2), peppered and seamed with greenish-gray (5G 6/1) patches and bands, silty; contains small porphyroblasts and veins of gypsum, sparingly calcareous at 750.6-754.8 feet, essentially free of bedding structure	740.3-754.8
Mudstone, dark-yellowish-brown (10YR 4/2) with dusky-yellowish-brown (10YR 2/2) and pale-reddish-brown (10R 5/6) laminae, calcareous, bedding dips about 5°	754.8-756.3
Dolomite, pale-yellowish-brown (10YR 6/2), very finely crystalline, pitted; contains gypsum veins at 765.7-770.2 feet and small gypsum porphyroblasts throughout; bedding essentially horizontal	756.3-778.5
Mudstone, grayish-black (N2)	778.5-780.9
Mudstone, grayish-red (10R 4/2) and moderate-reddish-brown (10R 4/6); contains veins and porphyroblasts of white (N9) gypsum	780.9-788.0
Anhydrite, grayish-red (10R 4/2) to medium-light-gray (N6); very finely crystalline; crude irregular lamination; gypsiferous at 788.0-795.1 feet; containing laminae of halite pseudomorphs after gypsum at 795.1-796.7 feet; bedding is essentially horizontal	788.0-797.0
Siltstone, light-gray (N7); contains nodules of anhydrite and veins of halite	797.0-797.8
Siltstone, moderate-reddish-brown (10R 4/6); contains crystals of halite	797.8-798.2
Halite, moderate-reddish-brown (10R 4/6) and dark-reddish-brown (10R 3/4), medium-crystalline, very argillaceous and silty; contains narrow bands of silty, halitic mudstone	798.2-810.1
Anhydrite, medium-light-gray (N6), very finely crystalline, halitic	810.1-811.4
Halite, moderate-reddish-orange (10R 4/2), medium-crystalline, sparingly anhydritic	811.4-815.6
Halite, moderate-reddish-brown (10R 4/6), medium-crystalline, very argillaceous and silty; contains interbeds of dark-reddish-brown (10R 3/4) to moderate-reddish-brown (10R 4/6), halitic mudstone and siltstone	815.6-828.2
Sandstone, grayish-red (10R 4/2), very fine grained, silty and halitic; contains halite vein dipping 50° at 829.3 feet	828.2-837.8
Sandstone, medium-gray (N5) with dark-gray (N3) laminae; very fine grained, silty and halitic	[illegible]

Table 3.--*Lithologic log of borehole WIPP-19*--Continued

Lithologic description	Depth interval Feet
Sandstone, grayish-red (10R 4/2), very fine grained; contains grayish-brown (5YR 3/2) silt laminae, as well as veins and nodules of medium-light-gray (N6) anhydrite	833.3-837.1
Siltstone, grayish-red (10R 4/2), sandy, interlaminated with grayish-brown (5YR 3/2) mudstone at 837.1-843.2 feet and with olive-gray (5Y 4/1) siltstone at 843.2-851.0 feet; contains veins and lenses of halite; bedding dips about 3°	837.1-851.0
Siltstone, olive-gray (5Y 4/1) to olive-black (5Y 2/1), laminated throughout and cross-laminated in places, contains vertical to near-vertical veins of halite extending through much of unit, a few lenses of grayish-red (10R 4/2) siltstone at 870.0-873.2 feet, and small nodules of anhydrite at 890.0-892.7 feet; bedding dips about 5° at base	851.0-892.7
Mudstone, dark-reddish-brown (10R 3/4), silty, laminated; contains crystals and veins of halite and lenses and seamlet of pale-olive (10Y 6/2) anhydrite	892.7-895.2
Halite, moderate-reddish-brown (10R 4/6), medium-crystalline, very argillaceous and sparingly anhydritic	895.2-902.2
Halite, white (N9) and colorless, medium-crystalline, very sparingly anhydritic	902.2-906.0
Halite, moderate-reddish-brown (10R 4/6), medium-crystalline, argillaceous and anhydritic; contains 0.4-foot band of light-gray (N7) anhydrite at 906.1 feet and a 0.2-foot band of dark-reddish-brown (10R 3/4) mudstone at 906.5 feet	906.0-908.2
Halite, white (N9), colorless, and pale-red (10R 6/2), medium-crystalline, sparingly anhydritic and polyhalitic	908.2-916.0
Halite, pale-reddish-brown (10R 5/4) and moderate-reddish-brown (10R 4/6), medium-crystalline, very argillaceous and silty, sparingly anhydritic	916.0-925.5
Siltstone, moderate-reddish-brown (10R 4/6) bleached greenish-gray (5G 6/1) in places; halitic at top and base of unit	925.5-929.6
Halite, moderate-reddish-brown (10R 4/6), medium-crystalline, very silty and argillaceous	929.6-933.5
Halite, moderate-orange-pink (10R 7/4), medium-crystalline, sparingly anhydritic throughout and argillaceous at 936.1-936.8 feet	933.5-937.5
Halite, moderate-reddish-brown (10R 4/6), medium-crystalline, argillaceous, capped by mudstone parting	937.5-938.4
Halite, white (N9) and moderate-orange-pink (10R 7/4), medium-crystalline, sparingly anhydritic	938.4-941.5
Halite, medium-gray (N4) and moderate-reddish-brown (10R 4/6), medium-crystalline, argillaceous and sparingly anhydritic	941.5-944.1
Halite, medium-gray (N5) and moderate-orange-pink (10R 7/4) to moderate-reddish-brown (10R 4/6), medium-crystalline, anhydritic and sparingly argillaceous	944.1-953.3
Halite, white (N9) to moderate-orange-pink (10R 7/4), medium-crystalline, sparingly anhydritic	953.3-955.3

Table 3.--*Lithologic log of borehole WIPP-19*--Continued

Lithologic description	Depth interval Feet
Halite, medium-dark-gray (*N4*) and moderate-reddish-brown (10*R* 4/6), medium-crystalline, very argillaceous and silty, interbedded with moderate-reddish-brown (10*R* 4/6) mudstone at 957.0-957.8 feet----------	955.3-958.3
Halite, medium-dark-gray (*N4*) and moderate-reddish-brown (10*R* 4/6), sparingly argillaceous----------	958.3-961.8
Halite, pale-reddish-brown (10*R* 5/4) to colorless, medium-crystalline, sparingly anhydritic----------	961.8-967.9
No core----------	967.9-968.2
Halite, white (*N9*) and moderate-orange-pink (10*R* 7/4); contains interbeds of light-gray (*N7*) anhydrite at 968.3-968.4 feet and light-gray (*N7*) to pale-reddish-brown (10*R* 5/4), halitic and polyhalitic anhydrite at 968.7-968.9 feet----------	968.2-971.0
Halite, medium-dark-gray (*N4*), finely to medium-crystalline, very argillaceous----------	971.0-971.5
Halite, moderate-reddish-brown (10*R* 4/6), medium- to coarsely crystalline, very argillaceous and silty; contains narrow interbeds of moderate-reddish-brown (10*R* 4/6), silty, halitic mudstone----------	971.5-974.7
Halite, moderate-reddish-brown (10*R* 4/6), medium-crystalline, sparingly anhydritic and argillaceous----------	974.7-978.8
Halite, white (*N9*), moderate-orange-pink (10*R* 7/4) and pale-reddish-brown (10*R* 5/4), medium-crystalline, sparingly anhydritic throughout and sparingly argillaceous at 982.3-984.0 feet, and 985.5-986.0 feet--------	978.8-986.0
Mudstone, moderate-reddish-brown (10*R* 4/6), very halitic and sparingly anhydritic----------	986.0-988.2
Halite, medium-dark-gray (*N4*) and moderate-reddish-brown (10*R* 4/6), medium- to coarsely crystalline, very argillaceous and sparingly anhydritic; contains seam of moderate-reddish-brown (10*R* 4/6) halitic mudstone at 994.5-995.5 feet----------	988.2-996.0
Halite, moderate-reddish-brown (10*R* 4/6), medium-crystalline, sparingly anhydritic and polyhalitic; contains band of moderate-reddish-brown (10*R* 4/6), very finely crystalline polyhalite at 998.5-998.8 feet; underlain by 0.1-foot vein of fibrous halite----------	996.0-999.0
Siltstone, moderate-reddish-brown (10*R* 4/6) and pale-yellowish-brown (10*YR* 6/2), halitic in upper and lower 1.0 foot of unit----------	999.0-1,006.2
Halite, pale-reddish-brown (10*R* 5/4), medium-crystalline, polyhalitic and argillaceous----------	1,006.2-1,008.8
Polyhalite, moderate-reddish-orange (10*R* 6/6), moderate-reddish-brown (10*R* 4/6), and light-gray (*N7*), very finely crystalline; contains abundant lenses of halite at 1,008.8-1,008.9, 1,009.4-1,009.7, 1,010.5-1,011.0 feet----------	1,008.8-1,011.0

Table 3.--*Lithologic log of borehole WIPP-19*--Continued

Lithologic description	Depth interval Feet
Halite, moderate-reddish-orange (10R 6/6), medium-crystalline; contains seamlets and a band of moderate-reddish-orange (10R 6/6) polyhalite at 1,013.2-1,013.4 feet	1,012.0-1,013.6
Halite, moderate-reddish-brown (10R 4/6), finely to medium-crystalline, argillaceous and polyhalitic	1,013.6-1,018.2
Halite, moderate-reddish-brown (10R 4/6) and medium-gray (N5) to very light gray (N8), finely to medium-crystalline, polyhalitic, sparingly argillaceous at irregular intervals	1,018.2-1,028.0
Mudstone, light-gray (N7), silty and halitic	1,028.0-1,028.5
Halite, moderate-reddish-brown (10R 4/6), medium-crystalline, polyhalitic and very argillaceous	1,028.5-1,035.0
Halite, white (N9) and yellowish-gray (5Y 8/1), finely to medium-crystalline, sparingly polyhalitic and anhydritic	1,035.0-1,037.6
No core	1,037.6-1,038.2

4.0 HYDROLOGIC DATA

No hydrologic test data have been obtained to date from WIPP 19, and there are no plans at present to convert these boreholes for hydrologic testing.

5.0 REMARKS

The immediate objective of testing for stratigraphic continuity of the Rustler Formation and upper Salado was reached through drilling of the complementary boreholes WIPP 18, 19, 21, 22. As a consequence, the seismic reflection data down to the upper Salado are treated with extreme caution; the apparent reflectors are generally considered unreliable for this area. Later generations of seismic reflection data ("Y" series, Hern et al., 1978; "GG" series, Bell and Murphy, 1979), synthetic seismograms, and review of field data contribute to understanding of the seismic data in this particular area. Interpretive reports will deal with this aspect.

Trenches were dug through the Mescalero caliche in the road at the projected surface trace of the inferred fault. The caliche was examined by the USGS for displacements, but none were observed. This examination and caliche data are not reported explicitly for this problem, but the information is available in more general form (Bachman, USGS, in preparation.

6.0 BIBLIOGRAPHY

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Powers, D. W., Lambert, S. J., Shaffer, S-E., Hill, L. R., and Weart, W. D., editors, 1978, Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico: Vol. I & II, SAND78-1596, Sandia Laboratories, Albuquerque, NM.

Insert fig 4, WIPP 19 here

PERMIAN
SALADO FORMATION
RUSTLER FORMATION

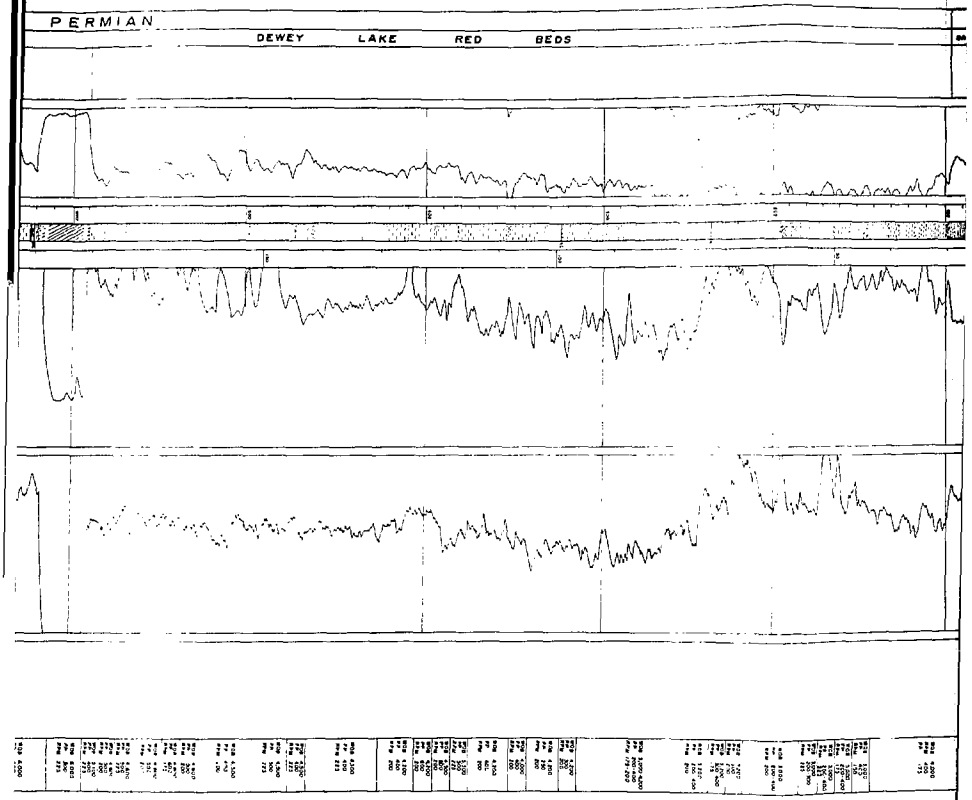
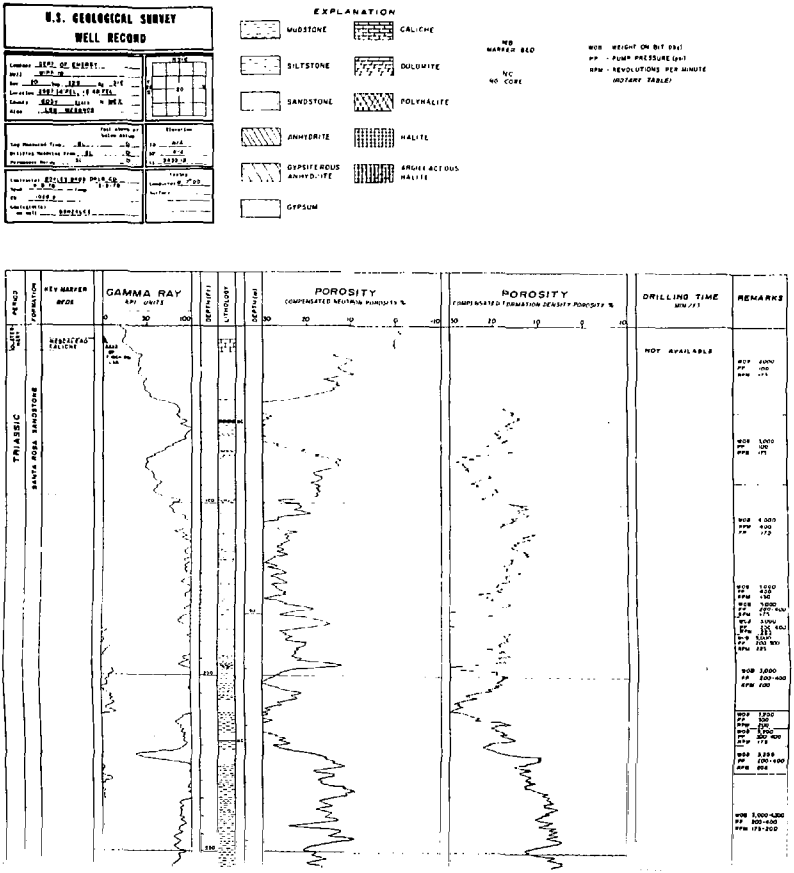

PERMIAN
DEWEY LAKE RED BEDS

Figure 4.--Geologic and geophysical logs of borehole WIPP-19



APPENDIX A

JUSTIFICATION

INTRODUCTION TO APPENDIX A, JUSTIFICATION

Appendix A consists of relevant portions of two related documents:

1) memorandum from D. W. Powers to L. R. Hill, dated 2/15/78, "Stratigraphic Test Holes," and
2) memorandum from D. W. Powers to L. R. Hill, dated 3/15/78, "Shallow Cores for Testing Displacement of Pleistocene Sediments."

These documents provide details of background information and program options as understood at the time of initiation. The reader is cautioned, therefore, that details of the program may have been altered as information became available and that preliminary interpretive hypotheses or ideas guiding the program formulation may need revision based on information presented in this report. Later interpretive reports may deal with such items.

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date February 15, 1978

to L.R. Hill 5311

from D.W. Powers 5311

subject Stratigraphic Test Holes

Objective: to determine the depth of the top of the Salado Formation rather precisely over a half-mile interval beginning about a half-mile north of ERDA 9, section 20, T22S, R31E. In addition, the stratigraphy of the beds above the Salado will be evaluated, and some core from the upper part of the Salado Formation may be taken. One of the holes may be established as a hydrology hole.

Method: 3-5 drill holes may be required along seismic reflection line X-2. If necessary, 2 drill holes may be located along or near line X-5. Extensive logging will be required to support stratigraphic inferences, and some of the holes may be cored extensively.

Details: WIPP 18 should be rotary drilled to the top of the Salado at an expected depth of about 1100'. The logs required are sonic, gamma ray, neutron, microlaterolog, and diplog. In addition, determination of the seismic velocity through downhole measurements will probably be required. The USGS/WRD should plan to log this hole to provide continuity between commercial logs on this, and other holes, and the USGS/WRD logs on the potash holes, particularly P-5. WIPP 18 should be located at vibrating point (VP) 179 of X-2.

WIPP 19 should be cored from "grassroots" to the top of the Salado at an expected depth of about 900'. Logs should be run as on 18, with the exception of the seismic velocity log. The location is at VP 191 of X-2. Core in this hole may help to locate the depth of faults more precisely, and help determine the character of any fault (including fluid movement). If the stratigraphy is relatively undisturbed through normal aquifer zones, the hole may be cased for hydrologic studies.

This hole is located to intersect both possible faults to aid projections toward the surface, and should intersect the top of the Salado immediately south of the fault zone on the ~~hanging~~ west wall. This borehole should, with WIPP 18, provide boundaries for the zone of apparent displacement.

WIPP 20 should be drilled to a depth of about 700' (contingent on the depths indicated in WIPP 18), and then cored to a depth of about 1500'. Logs should be similar to WIPP 19. The location is at VP 187 of X-2. The core will indicate the depth of faults, and the nature of the fault plane(s). Solutioning of salt may be determined by examination of core within the Salado.

This hole is located in the zone showing greatest probable disturbance. It may be the last of the test holes necessary around this anomaly.

WIPP 21 may be drilled to a depth of about 1200-1300' to obtain additional data on the disturbed zone. Logs are similar to WIPP 19. The location is at VP 185 of X-2. Some core may be required to determine the effects of faulting and any dissolution of salt. The location and need for this hole are tentative.

An alternative location (WIPP 23) for this hole is at VP 110 on line X-5. This area shows about 100' difference in depth to top of Salado when compared with hole F-82 about one-quarter mile north. In addition, apparent faulting of the top of the Salado occurs at about VP 120.

WIPP 22 may be drilled to the top of the Salado at a depth of about 900'. The logs would be the same as for WIPP 19. The location is VP 195 along X-2. This location is tentative, and may be used only if WIPP 19 is more disturbed than expected. This location might be an alternative for conversion to hydrologic purposes.

An alternate location (WIPP 24) is near F-82 to confirm information on the top of the Salado in that hole.

Background: interpretation of the recently acquired seismic reflection data in the WIPP area indicates a possible northwest trending fault through this area. The displacement on the fault, if properly interpreted, may be 100-250'. There is a need to confirm or reject this interpretation in order to further assess the study area as suitable for the WIPP. This drilling program is expected to provide appropriate data.

Field Support: support for engineering programs is requested from Division 1133. Geologic field support is expected through the USGS and F&S.

DWP:5311:dp

Distribution:
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5310 W.D. Weart
5311 D.W. Powers (2)
5311 Archives (2)

Sandia Laboratories
Albuquerque New Mexico
Livermore California

date March 15, 1978

to L.R. Hill 5311

from D.W. Powers 5311

subject Shallow cores for testing displacement of Pleistocene sediments

Objective: to provide core of significant stratigraphic horizons from very shallow depths north of ERDA 9 to test for displacement.

Method: use normal soil coring techniques to provide generally continuous core from above the caliche to a depth of 5-15 feet into the uppermost Permian or Triassic sediments. Contacts of the caliche and any Gatuna are most significant; other traceable horizons may be useful as well. Surveying of the drilling locations will provide the lateral and vertical control necessary to establish possible displacement.

Location: the location of interest for these 10-12 coreholes is between vibrating points (VP) 191 and 195 of seismic line X-2. The locations are in section 20, T22S, R31E, and are between about 2500 and 3000' north of the south boundary of the section. The line of holes will probably be located west of the access road through section 20 to avoid caliche disturbed by construction.

Timing: shallow coring will be initiated as soon as practicable after WIPP 19 has drilled the redbed section. This will allow further refinements to the location of initial shallow cores.

Background: This program is directed at further delineation of the zone north of ERDA 9 where possible faulting has been interpreted on the basis of recent seismic reflection data. If the drilling of WIPP 18 and 19 disproves such faulting, this program for shallow core drilling will not be necessary. If WIPP 18 and 19 indicate the presence of faulting, this program will help determine how recently such faulting has been active.

Field Support: support in establishing the contracting, surveying, and other field engineering is requested from Division 1133. Geologic field support is expected from the USGS, F&S, and the New Mexico Bureau of Mines and Mineral Resources (Dr. John Hawley).

DWP:5311:dp

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APPENDIX B

DRILLING AND TESTING PLAN

compiled by

R. D. Statler
Division 1133
and
P. D. Seward
Division 1135
Sandia Laboratories

INTRODUCTION TO APPENDIX B, DRILLING AND TESTING PLAN

The drilling and testing plan is the translation of technical objectives contained in documents in Appendix A into field engineering terms. Changes or amendments are included as well. The approvals and permits obtained from various agencies prior to drilling are kept on file but are not included here.

Date: February 27, 1978

To: Distribution

From: R. D. Statler - SLA 1133

Subject: WIPP Nos. 18 thru 22, Drilling Program Schedule and Coring Plan

The attached document describes the plans and program for drilling up to five exploratory holes designated as WIPP 18, 19, 20, 21, and 22. It is expected these holes will begin during March 1978 and be completed by the end of May 1978, presuming necessary clearances and permits can be quickly obtained.

RDS:rj

Distribution:
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USGS Albuq. J. Mercer
F&S Las Vegas R. E. Ashlock
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5342 J. W. McKiernan
9512 F. L. McFarling
1133 R. D. Statler (5)

WIPP 18, 19, 20, 21 22
OPERATIONAL PROCEDURE, CORING & TEST PLANS

A. OBJECTIVE (Ref Memo of Record, D. W. Powers, 5311, dtd 2/15/78)
To determine depth of the top of Salado formation precisely over a half-mile interval within the mile immediatley north of ERDA 9. To evaluate the stratigraphy in the overlying beds above the Salado and possibly establish a hydrological test well.

B. SCHEDULING SEQUENCE

WIPP 18 will be initiated first by rotary drilling to the top of Salado. After a suite of logs are run, the hole will be plugged to surface and abandoned. Expect to begin mid-March and be complete in about one week.

WIPP 19 will be set up second to take continuous core from "grass-roots" to the top of Salado. After a suite of logs have been run and evaluated, the hole may be opened and then casing stood and cemented for subsequent conversion into a hydrological test well. If hole not considered suitable, it will be plugged to surface and abandoned.

WIPP 20 will be drilled third to a depth of about 700' (contingent on evaluation of results from WIPP 18 and 19) and then a continuous core taken to a depth of about 1500'. After suite of logs taken, hole will be plugged to surface and abandoned.

WIPP 21 may be drilled to a depth of 1200-1300' to obtain additional data if information from 18, 19 and 20 is considered incomplete. Suite of logs will be run and several hundred feet of core may be taken. Hole will then be plugged to surface and abandoned. Location may be moved to an alternate site along seismic line X-5.

WIPP 22 may be drilled to the top of Salado. After suite of logs, hole will be evaluated and either plugged or set up as hydrologic test well.

C. ORGANIZATION

Technical direction will originate within Sandia Division 5311 under Dennis Powers. Field operations, managed by Bob Statler, Sandia Division 1133, will be conducted by W. E. Cunningham, Fenix & Scisson. Drilling contract and associated support service contracts will be let and administered by F&S as arranged for by Federal agency order through Nevada Operations Office, DOE.

Identification of marker beds, core logging and other geologic interpretations will be provided by Charlie Jones, USGS-Special Projects, Jerry Mercer, USGS-WRD, and Joe Gonzales, F&S.

Quality Assurance Program will be administered by F. L. McFarling and Jim Jones, Sandia Division 9517.

Industrial Safety program will be administered by specialists from Fenix & Scisson, Las Vegas.

Administrative assistance logistical support of Sandia Programs will be provided by P. D. Seward and J. E. Magruder, Sandia Division 1135.

D. FIELD OPERATIONS

1. Sites selected and archaeological survey conducted. Land survey made. BLM permits obtained. "Notice of Intention to Drill Exploratory Well" filed with NM State Engineer's office.

2. Award dirt contract. Construct 3/4 mile of 12' wide access road, 6" thick caliche base, five each 100' x 100' drill pads around drill site stake.

3. Begin WIPP 18 as follows:

3. (Continued)

WIPP 18 (located adjacent to seismic shot point 179 of X-2).

a. Set nominal diameter conductor pipe to permit use of rotary bit to make a 6" ± diameter hole to total depth.

b. Rotary hole to top of Salado salt; collect drill cuttings every 10'; use drilling fluids to match formation.

c. Run commercial logs as follows:

(1) BHC Sonic
(2) Dual Induction
(3) Micro-Laterolog
(4) Compensated Neutron
(5) Formation Density
(6) Gamma
(7) Continuous Dip Meter

d. Plug hole to surface using 50/50 PoZ mix, Class "C" cement.

d. Rig down.

4. WIPP 19 (located adjacent to shot point 191 of line X-2)

a. Move in rig and associated equipment for taking continuous core from "grass-roots" to the top of Salado.

b. Dry punch hole and extract first core using Pitcher Sampler. Continue using until formation appears competent enough to begin using wire line rotary diamond coring procedures. Estimated to be 7-10'.

c. Pick up 3-1/4" x 2-1/4" diamond core bit with split barrel and take continuous core to approximately 30'.

4. (Continued)

d. Pick up 8-3/4" bit and ream hole to approximately 30'. Set 8-5/8"+ O.D. conductor pipe, cement to surface. Install appropriate well head equipment to protect from gas pockets.

e. Pick up 3-1/4" x 2-1/4" diameter core bit and take continuous core to total depth.

f. Open hole as necessary to accommodate taking commercial logs with 4-5/8" diameter tool.

g. Call out and run same suite of logs as for WIPP 18.

h. If hole shows bore-hole fluids of interest, hole may be cased with 5-1/2" casing, cemented to surface and set up for hydrological test well.

i. If no fluids of interest, plug hole to surface as WIPP 18.

j. Rig down.

5. WIPP 20 (located adjacent to shot point 187 of X-2)

a. Move in rig and associated equipment for alternating between rotary drilling and diamond coring.

b. Pick up 8-3/4" bit and rotary to approximatley 30'. Set 8-5/8"+ conductor pipe, cement to surface. Install appropriate well head equipment to protect from gas pockets.

c. Pick up nominal 6" diameter rotary bit and rotary to an approximate depth of 700', taking cuttings every 10'. Actual depth will depend on review of findings from WIPP 18 and 19.

5. (Continued)

d. Pick up 3-1/4" x 2-1/4" diameter core bit and take continuous core to a depth of about 1500'.

e. Open hole as necessary to accommodate use of commercial logging tool 4-5/8" diameter.

f. Call out and run same suite of logs as for WIPP 18.

g. Plug hole to surface as in WIPP 18.

h. Rig down.

6. WIPP 21 & 22 (location to be determined after review of WIPP 18, 19, 20)

a. Move in rig and associated equipment for alternating between rotary drilling and diamond coring. Take cutting every 10'.

b. Pick up 8-3/4" bit and rotary to approximately 30'; set 8-5/8"+ O.D. conductor pipe, cement to surface. Install appropriate well head equipment to protect from gas pockets.

c. Pick up nominal 6" diameter rotary bit and drill to 900-1200'. Selected 2-1/4" cores may be taken.

d. Open hole and condition to accommodate commercial logging tool 4-5/8" diameter.

e. Either hole may be selected as hydro test well if significant fluids are encountered while drilling. If so, prepare hole to run 5-1/2" casing and cement to surface.

f. If not set up as hydro well, plug to surface and abandon.

g. Rig down.

E. CORE HANDLING PROGRAM

Cores with 2-1/4" nominal diameter are to be taken. One from ground surface to the total depth. It is recognized that formations may be encountered which are soft and/or rubblized; therefore, particular attention must be paid to rate of rotation, penetration and drilling fluid properties to assure as complete a recovery as possible.

A split core barrel is to be utilized to ease the removal of core from the barrel and to lessen the possibility of damaging or mixing core components.

A duty geologist will log and measure core as it is removed from core barrel. Core will then be sealed within plastic sleeving and packaged in standard cardboard boxes. If core is soft and/or badly rubblized, additional cushioning material will be placed around core within box. Boxes will then be marked with hole identity and core interval. Core will then be carefully loaded in a transport vehicle by contractor personnel as supervised by duty geologist, and taken to core storage in Carlsbad.

A coring record should be kept showing: date and tour, sequence of core interval, depth of interval, footage of core recovered and percentage. If significant intervals are missing, the depth and interval of missing core should be recorded as well as any determinable physical properties of the formation. Rig operating conditions such as RPM, weight on bit, circulating pressure should also be kept.

For sake of consistency, a routine has been established for handling and marking core at the drill pad as follows:

1. Coring contractor and roustabouts will lay barrel down and open barrel. The duty geologist will photograph core and supervise removal from core barrel and placement in troughs in the order they come out of barrel for inspection and measurement. Troughs are marked orange or red indicating top end and black indicating down direction.

2. If core is suitable for marking, each major piece should be marked with a water-proof black ink arrow, pointing in the direction the hole is advancing. If core is not suitable for marking, the above is to be marked on sleeving using an indelible, water-proof black marking pen.

3. Log, identify and measure all core pieces, express to closest 1/10th of foot. Note; All depth measurements are from the top side of the Kelly Bushing unless otherwise specified.

4. Move troughs to core shed and separate into appropriate lengths. Sleeve and seal and insert into boxes. Tape boxes and mark outside of box with hole identity and depths of core interval.

5. Transport boxed core to core storage taking particular care in handling and delivery to avoid core damage.

F. LOGGING PROGRAM

The original records and 10 copies of all logs should be delivered to F&S, Carlsbad. F&S will distribute as follows:

USGS-WRD, Albuq. - J. W. Mercer (1)
USGS-Spec. Proj., Denver - C. Jones (1)
F&S, Carlsbad - W. Cunningham (2)
5311 D. W. Powers (Orig. & 1)
5311 S. J. Lambert (1)
5311 Archives (2)
F&S Carlsbad (2)

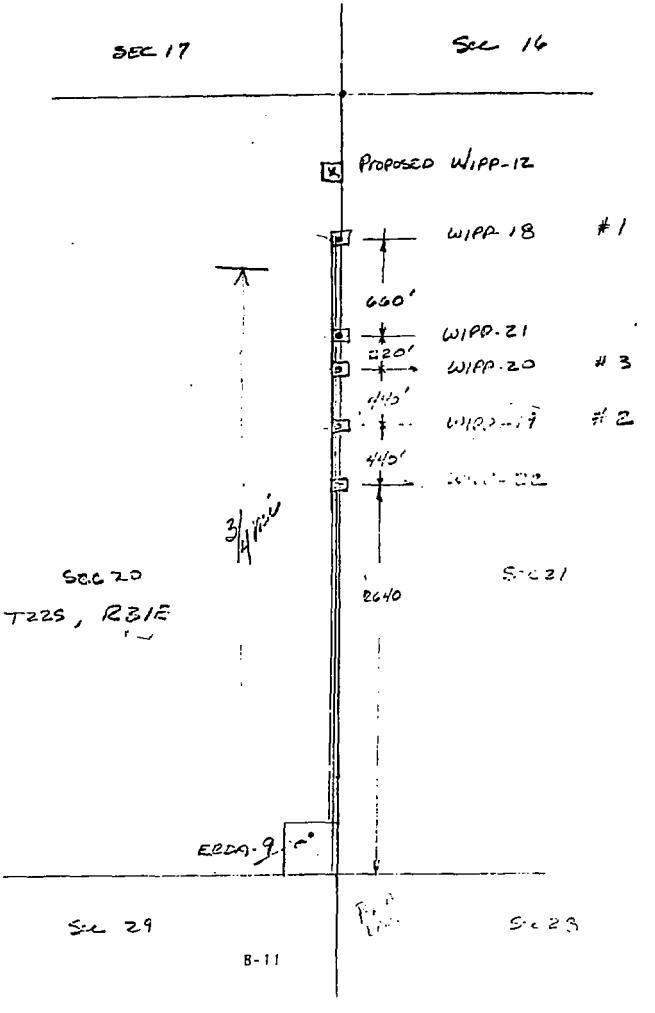
G. PLUGGING AND ABANDONMENT

1. Notice of intention to plug must be filed with appropriate agencies including State Engineer, since all wells are believed to be within a Water District as declared by the State Engineer of New Mexico.

2. Plugging should be in manner to confine water in the separate strata originally containing them.

3. A length of 4" steel tubing approximately 20' long will be placed in the freshly poured plug with 4' protruding above the ground surface. The identity of the well, i.e., WIPP 18, as well as the location: X feet FEL, X feet FSL, Section, Township and Range, shall be welded or stamped in the tubing.

RDStatler:rj


SEC 17
Sec 16
Proposed WIPP-12
WIPP-18
#1
660'
WIPP-21
220'
WIPP-20
#3
440'
WIPP-19
#2
440'
3/4 Mile
Sec 20
T22S, R31E
Sec 21
2640
ERDA-9
Sec 29
Sec 28

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date February 27, 1978

to Distribution

R. D. Statler/rj

from R. D. Statler - 1133

subject WIPP Nos. 18 thru 22, Drilling Program Schedule and Coring Plan

Ref: Memo, R. D. Statler to Distribution, dtd 2/27/78, same subject

Please attach the enclosed chart to the subject memo.

rj

Distribution:
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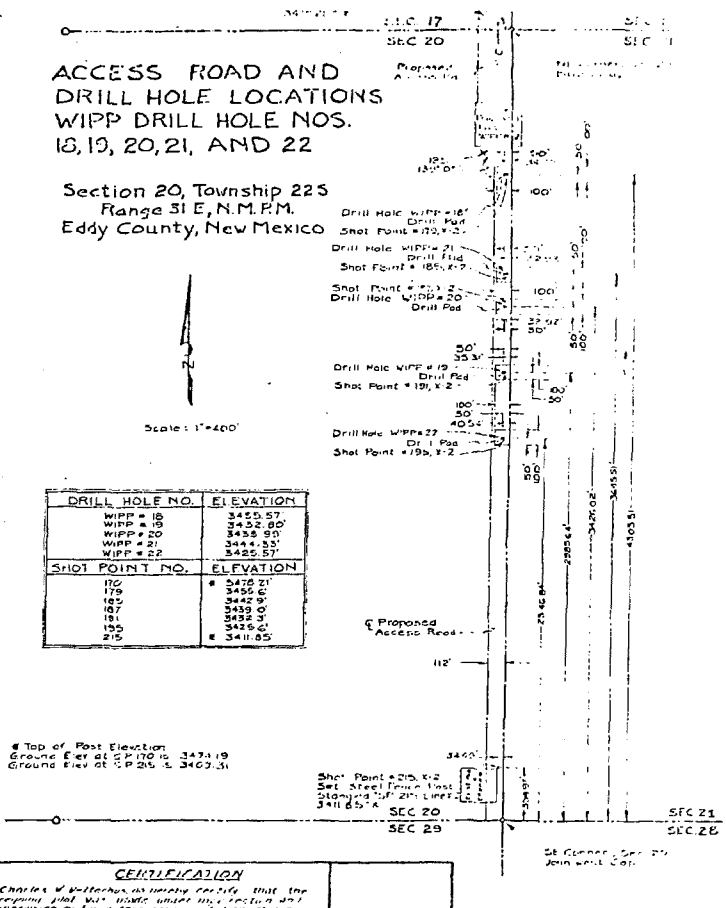
9512 F. L. McFarling
1133 R. D. Statler (5)

ACCESS ROAD AND DRILL HOLE LOCATIONS WIPP DRILL HOLE NOS. 18, 19, 20, 21, AND 22

Section 20, Township 22 S
Range 31 E, N.M.P.M.
Eddy County, New Mexico



DRILL HOLE NO.	ELEVATION
WIPP # 18	3455.57
WIPP # 19	3452.80
WIPP # 20	3458.99
WIPP # 21	3444.35
WIPP # 22	3425.57

SHOT POINT NO.	ELEVATION
170	± 3478.21
178	3456.61
185	3442.91
187	3439.01
191	3432.31
195	3429.61
215	± 3411.85

± Top of Post Elevation
Ground Elev at S.P. 170 is 3473.19
Ground Elev at S.P. 215 is 3409.31

CERTIFICATION

I, Charles W. Witherspoon, do hereby certify that the foregoing plat was made under my direction and supervision and is a true representation of a survey on the ground, to the best of my knowledge and belief.

Charles W. Witherspoon

Charles W. Witherspoon, N.M. P.E. & L.S. No. 5412

MOLZEN-CORBIN & Assoc.
Consulting Engineers

B-13

Date May 18, 1978

Sandia Laboratories
Albuquerque, New Mexico
Livermore, California

To W. E. Cunningham - F&S, Carlsbad

From R. D. Statler - 1133, SLA

Subject: Land-Use Permit for Relocating Drill Sites for WIPP 20 and 21

On this date we have received verbal permission from BLM to relocate the hole locations of WIPP 20 and 21.

You are authorized to proceed with the necessary dirt work to prepare drill pads for WIPP 21, 1000' due south of WIPP 22, and for WIPP 20, 770' due south of WIPP 22.

You are also authorized to resume drilling of WIPP 22 and then proceed with the program as outlined in my memorandum to you dated May 17, 1978, subject, Stratigraphic Hole Drilling Plans.

RDS:1133:rj

Copy to:
C. Jones, USGS, Special Projects Branch, Denver, CO
J. Mercer, USGS-WRD, Albuquerque, NM
1135 P. D. Seward
5311 D. W. Powers
1133 File (2)

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

Date: May 23, 1978

To: W. E. Cunningham - F&S, Carlsbad

R. D. Statler/rj

From: R. D. Statler - 1133, SLA

Subject: Land-Use Permit for Relocating Drill Sites for WIPP 20 and 21

Ref: Memo, Statler to Cunningham, dtd 5/18/78, same subject

This memorandum is to correct the Southerly dimension on the WIPP 21 drill location as quoted in the referenced memorandum. The attached survey plat gives the correct location.

PDS:1135:rj

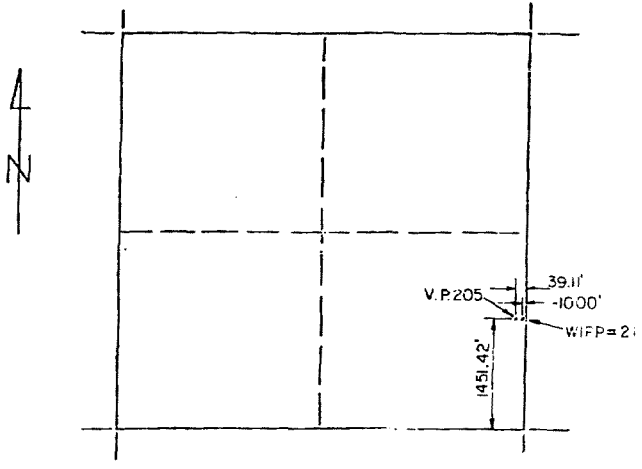
Copy to:
C. Jones, USGS, Special Projects Branch, Denver, CO
J. Mercer, USGS-WRD, Albuquerque, NM
G. Bachman, USGS-WRD, Albuquerque, NM
1135 P. D. Seward
5311 D. W. Powers
1133 File (2)

DRILL HOLE LOCATION

DRILL HOLE NO. WIPP#21

SECTION 20, TOWNSHIP 22S, RANGE 31E, N.M.P.M.

EDDY COUNTY, NEW MEXICO



GROUND ELEVATION AT HOLE: 3417.05'

MOLZEN-CORBIN & ASSOCIATE

CONSULTING ENGINEERS

CARLSBAD, NEW MEXICO

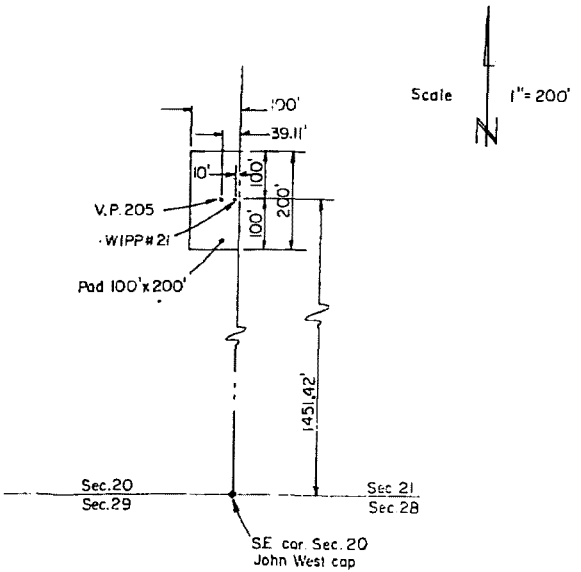
DATE MAY 1978

PAD AND
DRILL HOLE LOCATION

DRILL HOLE NO. WIPP # 21

SECTION 20, TOWNSHIP 22 S, RANGE 31 E, N.M.P.M.

EDDY COUNTY, NEW MEXICO



MOLZEN-CORBIN & ASSOC.
CONSULTING ENGINEERS
CARLSBAD, NEW MEX.

B-17

DATE: MAY 19, 1976

APPENDIX C

HOLE HISTORY

compiled by

R. D. Statler
Division 1133
and
P. D. Seward
Division 1135
Sandia Laboratories

INTRODUCTION TO APPENDIX C, HOLE HISTORY

The hole history is a document provided soon after completion of the borehole, and it summarizes the relevant information on the daily log kept by the contractor. The hole history is not edited to ensure conformance in every detail with later information developed for previous chapters. Further information may be obtained as necessary through examination of the original daily time logs.

FENIX & SCISSON, INC.

HOLE HISTORY DATA

October 16, 1978 (Rev. #1)

DATE: June 8, 1978

HOLE NO.: WIPP #19	W. O. NO.:	I. D. NO.:
USER: Sandia Lab.	TYPE HOLE: Exploratory	
LOCATION: New Mexico	COUNTY: Eddy	AREA:
SURFACE COORDINATES: * 2989.60' FSL, 14.94' FEL Sec. 20, T22S, R31E		
GROUND ELEVATION: *	PAD ELEVATION:	TOP CASING ELEVATION:
RIG ON LOCATION:	SPUDDED: 4-6-78	COMPLETED: 5-8-78
CIRCULATING MEDIA: Salt base mud.		
MAIN RIG & CONTRACTOR		NO. OF COMPRESSORS & CAPACITY:

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	I.D.	WT./FT.	WALL	GRADE	CPL'G.	FROM	TO	CU. FT. CMT.
0'	8'	8-3/4"	7" O.D.			Used		0'	8'	NONE
8'	1038'	6-1/8"								

TOTAL DEPTH: 1038' GL | AVERAGE MANDREL DEPTH: | FROM REFERENCE ELEVATION @

JUNK & PLUGS LEFT IN HOLE:

SURVEYS PAGE: | CORING PAGE: 3 | CU. FT. CMT. TOTAL IN PLUGS, ETC:

LOGGING DATA: Page 2

BOTTOM HOLE COORDINATES: 3004.70' FSL, 3.24' FEL @ 1020' | REFERENCE: Schlumberger

RIGS USED *(Site Prep Rigs *)*

RIG NO.	NAME	TYPE	CLASS	DAYS OPERATING	SECURED W CREW	SECURED W/O CREW	TOTAL DAYS ON LOC.
3625	Boyles Bros.	Failing 2000		10.91	-	21.09	32.00

REMARKS:

* Location of brass monument: 2985.88' FSL, 16.40' FEL, Sec.20, T22S, R31E. Elevation 3433.13'.

Horizontal displacement at 1020' was 19.2', N 37.6° E (Schlumberger Directional Survey.)

PREPARED BY: WDS/lkm

TIME BREAKDOWN ON NEXT PAGE

FENIX & SCISSON, INC.

HOLE HISTORY DATA

DATE: June 8, 1978

HOLE NO.:	WIPP #19	W. O. NO.:			I. D. NO.:
USER:	Sandia Lab	TYPE HOLE:	Exploratory		
LOCATION	New Mexico	COUNTY:	Eddy	AREA:	
SURFACE COORDINATES:	2987.34 FSL, 12.87 FEL Sec. 20, T22S, R31E				
GROUND ELEVATION:	3432.8'	PAD ELEVATION:		TOP CASING ELEVATION:	
RIG ON LOCATION:		SPUDDED:	4-6-78	COMPLETED:	5-8-78
CIRCULATING MEDIA:	Salt base mud.				
MAIN RIG & CONTRACTOR				NO. OF COMPRESSORS & CAPACITY:	

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	I.D.	WT./FT.	WALL	GRADE	CPL'G.	FROM	TO	CU. FT. CMT.
0'	8'	8-3/4"	7" O.D.			Used		0'	8'	NONE
8'	1038'	6-1/8"								

TOTAL DEPTH: 1038'GL | AVERAGE MANDREL DEPTH: | FROM REFERENCE ELEVATION @

JUNK & PLUGS LEFT IN HOLE:

SURVEYS PAGE: | CORING PAGE: 3 | CU. FT. CMT, TOTAL IN PLUGS, ETC:

LOGGING DATA: Page 2

BOTTOM HOLE COORDINATES: 3002.44' FSL, 1.17' FEL @ 1020' | REFERENCE: Schlumberger

RIGS USED

RIG NO.	NAME	TYPE	CLASS	DAYS OPERATING	SECURED W CREW	SECURED W/O CREW	TOTAL DAYS ON LOC.
3625	Boyles Bros.	Failing 2000		10.91	-	21.09	32.00

REMARKS:

Horizontal displacement at 1020' was 19.2', N 37.6° E (Schlumberger Directional Survey.)

PREPARED BY: WDS/ic

WIPP #19
HOLE HISTORY

4-5-78	Moved in Boyles Bros. rig #3625 and rigged up.
4-6-78	Drilled 8-3/4" hole from 0' to 8'. Set 7" O.D. used casing at 8' and packed annulus with gel. Made up soil sample type tool with 4¾" bit and made 3 runs from 8' to 14', recovery 100%. Made up 3-7/8" Christensen insert type bit on a wire line core barrel and cored from 14' to 48'. Cored with salt base mud. Worked days only.
4-7-78	Cored 3-7/8" hole from 48' to 97'.
4-10-78	Rig secured from 4-7-78 to 4-10-78. Changed out bit to a 3-15/16" diamond bit and cored from 97' to 143'.
4-11-78	Cored 3-15/16" hole from 143' to 201'.
4-12-78	Cored 3-15/16" hole from 201' to 263.2'.
4-13-78	Cored 3-15/16" hole from 263.2' to 305.2', 98% mud returns to surface.
4-14-78	Cored 3-15/16" hole from 305.2' to 351.2'.
4-17-78	Rig secured from 4-14-78 to 4-17-78. Fluid level in the hole at 215'. Cored 3-15/16" hole from 351.2' to 384.2'. Had 50% returns from 351.2' to 360.2', regained 85% returns at 384.2'. Lost 50 barrels of mud.
4-18-78	Cored 3-15/16" hole from 384.2' to 433.2'. Returns decreased from 50% to 30%. Pumped in a slug of paper for lost circulation material at 200'.
4-19-78	Cored 3-15/16" hole from 433.2' to 492.2'. 15% lost circulation.
4-20-78	Cored 3-15/16" hole from 492.2' to 533.2'. 15% lost circulation.
4-21-78	Cored 3-15/16" hole from 533.2' to 570.2'. 15% lost circulation.
4-24-78	Rig secured from 4-21-78 to 4-24-78. Cored 3-15/16" hole from 570.2' to 623.2'. 55% lost circulation. Pumped in a slug of paper for lost circulation at 200'.
4-25-78	Cored 3-15/16" hole from 623.2' to 678.2'. 45% lost circulation.
4-26-78	Cored 3-15/16" hole from 678.2' to 727.2'. 50% lost circulation. Pumped in a paper slug at 200'.
4-27-78	Cored 3-15/16" hole from 727.2' to 780.2'. 50% lost circulation at 727.2' reduced to 30% at 780.2'.

2-28-78	Cored 3-15/16" hole from 780.2' to 828.2'. 50% lost circulation.
5-1-78	Rig secured from 4-28-78 to 5-1-78. Cored 3-15/16" hole from 828.2' to 893.2'. 30% lost circulation.
5-2-78	Cored 3-15/16" hole from 893.2' to 958.2'. 30% lost circulation.
5-3-78	Cored 3-15/16" hole from 958.2' to 1010.2'. 30% lost circulation.
5-4-78	Cored 3-15/16" hole from 1010.2' to 1038.2'. 30% lost circulation. Rigged up to open hole. Reamed hole to 6-1/8" from 8' to 97'.
5-5-78	Opened hole to 6-1/8" from 97' to 717'. 2% lost circulation.
5-6-78	Opened hole to 6-1/8" from 717' to 1038'. Ran Schlumberger logs.
5-7-78	Ran USGS logs.
5-8-78	Rigged down. Hole completed.

LOG INDEX

TYPE LOG	DATE	RUN NO.	DEPTH DRILLER	DEPTH LOGGER	LOGGED FROM	LOGGED TO
SCHLUMBERGER LOGS						
Dual Laterolog Micro - SFL	5-6-78	1	1038	1036	0	1034
Compensated Neutron-Formation Density	5-6-78	1	1038	1036	0	1034
Borehole Compensated Sonic	5-6-78	1	1038	1036	0	1033
Continuous Dipmeter	5-6-78	1	1038	1029	0	1028
Dipmeter-Arrow Plot	5-6-78	1	1038	1029	0	1028
Continuous Directional	5-6-78	1	1038	1029	0	1028

NOTE: Listing of logs furnished F&S/Mercury.

WIPP #19 CORE RECORD

CORE NO.	INTERVAL	FEET	RPM	~~WEIGHT~~ ON BIT	~~CIRCUL.~~ PRESS. P.S.I.	FEET CORED	FEET RECOVERED	% RECOVERY	
1	8	9.9	175	2000	100	1.9	1.9	100%	
2	9.9	12.6	175	2000	100	2.7	2.7	100%	
3	12.6	14.1	175	2000	100	1.5	1.3	87%	
4	14.1	17.4	175	2000	100	3.3	3.2	97%	
5	17.4	19.9	175	2000	100	2.5	2.5	100%	
6	19.9	26.9	175	2000	100	7	7.85	100%±	
7	26.9	33.9	175	2000	100	7	7.33	100%±	
8	33.9	41.2	175	2000	100	7.3	8.2	100%±	
9	41.2	43.2	175	2000	100	2	1.75	88%	
10	43.2	48.2	175	2000	100	5	5.25	100%±	
11	48.2	53.2	175	3000	100	5	4.4	88%	
12	53.2	56.2	175	3000	100	3	3.3	100%±	
13	56.2	63.2	175	3000	100	7	7	100%	
14	63.2	71.2	175	3000	100	8	8	100%	
15	71.2	78.2	175	3000	100	7	7	100%	
16	78.2	88.2	175	3000	100	10	10.2	100%±	
17	88.2	97.2	175	3000	100	9	9	100%	
18	97.2	106.2	175	4000	400	9	9.1	100%±	
19	106.2	116.2	175	4000	400	10	10	100%	
20	116.2	123.2	175	4000	400	7	7	100%	
21	123.2	133.2	175	4000	400	10	10	100%	
22	133.2	143.2	175	4000	400	10	10	100%	
23	143.2	153.2	150	3000	400	10	10	100%	
24	153.2	163.2	175	3000	200/400	10	10	100%	
25	163.2	173.2	225	3000	200/400	10	10	100%	
26	173.2	183.2	225	3000	400/200	10	10	100%	
27	183.2	193.2	225	3000	200/300	10	10	100%	
28	193.2	201.2	200	3000	200/300	8	8	100%	
29	201.2	211.2	200	3000	200/450	10	10	100%	
30	211.2	220.2	200	3000	200/300	9	9	100%	Some Fluid Loss
31	220.2	228.2	200	3000	200/450	8	8	100%	
32	228.2	237.2	200	3200	300	9	8.9	99%	
33	237.2	246.2	175	3200	300/400	9	9	100%	
34	246.2	256.2	200	3200	300	7	7	100%	
35	256.2	263.2	200	3200	200/400	10	10	100%	
36	263.2	273.2	200	3000	300/400	10	10	100%	
37	273.2	283.2	175	3000	400	10	10	100%	
38	283.2	293.2	200	3200	400	10	10	100%	
39	293.2	298.2	175	3200	300/400	5	3.5	70%	

WIPP #19 CORE RECORD

CORE NO.	INTERVAL	FEET	RPM	WEIGHT ON BIT	CIRCUL. PRESS. P.S.I.	FEET CORED	FEET RECOVERED	% RECOVERY	
40	298.2	305.2	175	3200	400	7	8.5	100%±	
41	305.2	315.2	200	4000	300	10	10	100%	
42	315.2	324.2	175	4200	400	9	8.7	97%	
43	324.2	333.2	200	4200	300	9	9	100%	Some Fluid Loss
44	333.2	343.2	200	4200	250	10	10	100%	Some Fluid Loss
45	343.2	351.2	200	4200	250	8	8	100%	"
46	351.2	360.2	200	4000	400	9	9.1	100%±	"
47	360.2	369.2	200	4200	400	9	8.9	99%	"
48	369.2	378.2	200	4200	400	9	9	100%	"
49	378.2	384.2	200	4200	400	6	6	100%	"
50	384.2	393.2	225	5300	500	9	9	100%	"
51	393.2	403.2	200	4500	500	10	10	100%	Some Fluid Loss
52	403.2	413.2	200	4200	600	10	10	100%	"
53	413.2	423.2	200	4200	400	10	10	100%	"
54	423.2	433.2	200	4200	400	10	10	100%	"
55	433.2	443.2	225	4300	400	10	10	100%	"
56	443.2	453.2	225	4300	400	10	10	100%	"
57	453.2	463.2	225	4300	400	10	10	100%	"
58	463.2	473.2	225	4300	400	10	10	100%	Some Fluid Loss
59	473.2	483.2	225	4500	400	10	10	100%	"
60	483.2	492.2	225	4500	500	9	9	100%	"
61	492.2	502.2	225	4500	500	10	10	100%	"
62	502.2	512.2	200	4500	400	10	10	100%	"
63	512.2	522.2	200	4500	400	10	10	100%	"
64	522.2	531.2	200	4500	400	9	9	100%	"
65	531.2	533.2	200	4500	400	2	2	100%	"
66	533.2	543.2	200	4600	500	10	10	100%	"
67	543.2	553.2	175	4800	600	10	10	100%	Some Fluid Loss
68	553.2	563.2	200	4600	500	10	10	100%	"
69	563.2	570.2	200	4600	500	7	7	100%	"
70	570.2	579.2	225	4600	500	9	9	100%	"
71	579.2	588.2	200	4600	500	9	9	100%	"
72	588.2	598.2	225	5100	400	10	10	100%	"
73	598.2	608.2	225	6000	300	10	10	100%	"
74	608.2	618.2	225	6000	300	10	10	100%	Some Fluid Loss
75	618.2	623.2	200	5000	300	5	2	40%	"
76	623.2	630.2	300	5000	300	7	8	100%±	"
77	630.2	639.2	200	5500	400	9	9	100%	"
78	639.2	648.2	200	6000	300	9	9	100%	"

WIPP #19 CORE RECORD

CORE NO.	INTERVAL	FEET	RPM	~~WEIGHT~~ ON BIT	~~CIRCU.~~ PRESS. P.S.I.	FEET CORED	FEET RECOVERED	% RECOVERY	
79	648.2	658.2	200	6000	300	10	10	100%	Some Fluid Loss
80	658.2	668.2	200	6000	300	10	10	100%	Some Fluid Loss
81	668.2	678.2	200	6000	300	10	10	100%	"
82	678.2	687.2	200	6000	300	9	9	100%	"
83	687.2	697.7	200	6200	300	10.5	10.3	98%	
84	697.7	707.7	200	6200	400	10	10	100%	
85	707.7	717.2	200	6200	300	9.5	9.5	100%	
86	717.2	727.2	200	6200	300	10	10	100%	
87	727.2	737.2	200	6200	300	10	10	100%	
88	737.2	747.2	200	6200	500	10	5.6	56%	
89	747.2	751.7	200	6000	400	4.5	7.7	100%±	
90	751.7	760.2	200	6200	400	8.5	10	100%±	
91	760.2	770.2	225	6200	300	10	10	100%±	
92	770.2	780.2	225	6200	400	10	10	100%	
93	780.7	789.2	200	6000	400	9	9	100%	
94	789.2	798.2	225	6500	300	9	9	100%	
95	798.2	808.2	225	6200	350	10	10	100%	
96	808.2	818.2	225	6200	300	10	10	100%	
97	818.2	828.2	225	6200	300	10	10	100%	
98	828.2	836.2	200	6200	300	8	8	100%	
99	836.2	843.2	200	6200	400/200	7	7	100%	
100	843.2	853.2	225	6200	400	10	10	100%	
101	853.2	863.2	225	6200	450	10	10	100%	
102	863.2	873.2	227	6200	450	10	10	100%	
103	873.2	883.2	225	6200	500	10	10	100%	
104	883.2	893.2	225	6200	400	10	10	100%	
105	893.2	898.2	200	6000	300	5	5	100%	
106	898.2	908.2	200	6200	300	10	10	100%	
107	908.2	918.2	200	6200	300	10	10	100%	
108	918.2	928.2	200	6200	300	10	10	100%	
109	928.2	938.2	200	6200	300	10	10	100%	
110	938.2	948.2	200	6200	300	10	10	100%	
111	948.2	958.2	200	6200	300	10	10	100%	
112	958.2	968.2	200	6200	300	10	9.7	97%	
113	968.2	978.2	200	6200	500/300	10	10	100%	
114	978.2	988.2	200	6200	600/300	10	10	100%	
115	988.2	998.2	200	6200	300	10	10	100%	

WIPP #19 CORE RECORD

CORE NO.	INTERVAL	FEET	RPM	WEIGHT ON BIT	CIRCUL. PRESS. P.S.I.	FEET CORED	FEET RECOVERED	% RECOVERY
116	998.2	1008.2	200	6200	500	10	10	100%
117	1008.2	1010.2	200	6200	400	2	2	100%
118	1010.2	1018.2	200	6000	200	8	8	100%
119	1018.2	1028.2	200	6000	200	10	10	100%
120	1028.2	1038.2	200	6200	200	10	9.4	94%

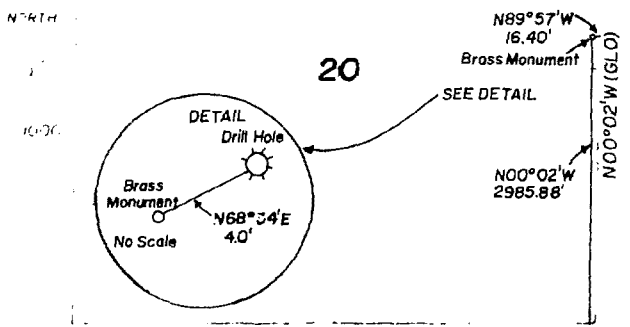
SURVEY MONUMENT "AS BUILT"

W.I.P.P. 19

SECTION **20**, TOWNSHIP **22 S**, RANGE **31 E** N.M.P.M.
EDDY COUNTY, NEW MEXICO

[illegible] 3433.13'
2985.88' FSL & 16.40' FEL

N89°57'W (GLO)

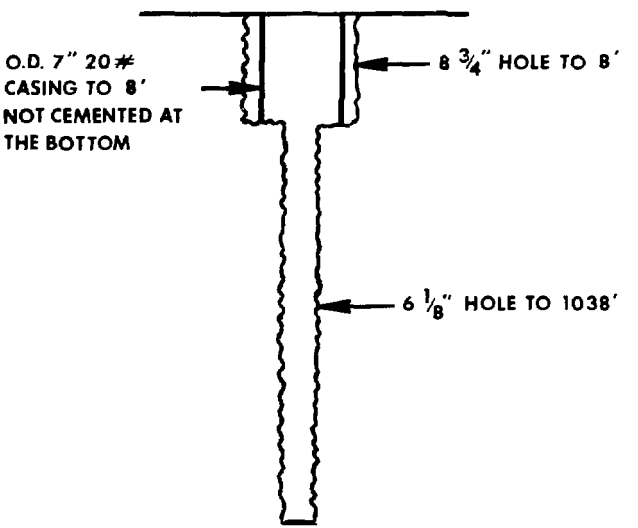


This is to certify that the foregoing plat was made from field notes of actual surveys made by me or under my supervision and that the same is true and correct to the best of my knowledge and belief.

[illegible]
Date Surveyed
NM [illegible]

DAN R. REDDY
NEW MEXICO
5412
LAND SURVEYOR
REGISTERED PROFESSIONAL ENGINEER

WIPP 19
AS BUILT HOLE CONDITIONS
AS OF 5/8/78



NOT TO SCALE

APPENDIX D

LOGS

compiled by

S-E. Shaffer
Division 4511
Sandia Laboratories

WIPP 19 Logs[1]

Log	Company	ELSI#[2]	Top of Logged Interval[3] (feet)	Bottom Logged Interval (feet)	Date
BHC Sonic Log	Schlumberger	W6645X	Surf.	1038	5/6/78
Compensated Neutron Formation Density	Schlumberger	W6645S	Surf.	1034	5/6/78
Dual Laterolog Micro-SFL	Schlumberger	W6645W	Surf.	1034	5/6/78
4-Arm High Resolution Continuous Dipmeter	Schlumberger	W7108W	Surf.	1028	5/6/78

[1]Original data is retained in Sandia WIPP Central File, Division 4542, Sandia Laboratories, Albuquerque, NM, 87185.

[2]Order number for logs available through West Texas Electric Log Service, Inc. (ELSI), 105 West Wall Avenue, Midland, TX.

[3]Depths measured from ground surface; elevation officially 3432.8' above MSL.