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Basic Data Report for Drillhole WIPP 11 (Waste Isolation Pilot Plant – WIPP)

Sandia National Laboratories, U.S. Geological Survey

Prepared by
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(Division 4511)

and

United States Geological Survey

(Special Projects Branch)

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TABLE OF CONTENTS

1.0 ABSTRACT

Seismic reflection data from petroleum industry sources showed anomalous reflectors in the Castile Formation over a small area about 3 miles north of the center of the Waste Isolation Pilot Plant (WIPP) site. Additional corroborative seismic reflection data were collected as part of WIPP investigations, and WIPP 11 was drilled to investigate the anomaly. WIPP 11 was drilled near the northwest corner of Section 9, T.22.S., R.31E. it penetrated, in descending order, sand dune deposits and the Gatuna Formation (29'), Santa Rosa Sandstone (132'), Dewey Lake Red Beds (502'), Rustler Formation (288'), Salado Formation (1379'), and most of the Castile Formation (1240'). Beds within the lower part of the Salado, and the upper anhydrite of the Castile, are thinner than normal; these beds are displaced upward structurally by the upper Castile halite which is highly thickened (about 968'). The lowest halite is thin (51') and the basal anhydrite was not completely penetrated. Subsequent seismic and borehole data has shown WIPP 11 to be in a structural complex now identified as the "disturbed zone."

The WIPP is a demonstration facility for the disposal of transuranic (TRU) waste from defense programs. The WIPP will also provide a research facility to investigate the interactions between bedded salt and high level waste, though there are no plans at this time to dispose of high level waste or spent fuel at WIPP.

2.0 INTRODUCTION

The introduction describes background information on the WIPP and the investigations involving WIPP 11.

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 TRU waste resulting from this nation's defense programs of over 30 years. After a period (5 years) of limited (pilot) operation, 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 an underground research facility to examine, on a large scale, the interactions between bedded salt and high-level radioactive defense waste with its resultant thermal and radiation fluxes. There is no plan at this time to dispose of high-level waste or spent fuel in the WIPP.

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 11

In 1976, under contract to Sandia Laboratories, G. J. Long and Associates (1977) provided a study of the seismic reflection data for southeastern New Mexico, available from various industry sources. From that data, 26 seismic anomalies of varying types and quality of data were indicated. The anomaly of most apparent significance to the WIPP at the time was identified in the vicinity of the corner between Sections 4, 5, 8, and 9, T.22.S, R.31E. Discussions at the time informally referred to the anomaly as the "seismic dropout" because it showed a lack of coherent seismic reflections across an area of perhaps 1/4 to 1/2 mile. The anomaly appeared on several different seismic lines from various data collection efforts in the same area, and therefore, was accorded much more significance than a single record would have received. The anomaly was judged to be a true effect of the geology, though no firm interpretation of the feature could be made. Speculation about the causes ranged from surface velocity effects to a breccia pipe in the subsurface. Further study, probably including drilling, was judged to be necessary.

In mid-summer 1977, a new phase of seismic data collection (Hern et al., 1978) was initiated to gather information on several seismic anomalies on or in the immediate vicinity of the WIPP study area. Included in that program were three seismic reflection lines over the apparent location of the anomaly. In view of the strong interest in the anomaly, it was decided to ask for permission to drill a borehole on the location before the new seismic data was collected, and ERDA 11 was therefore located in the northeast corner of Section 8, T.22.S, R.31E. It appeared that extreme interest in the anomaly might require drilling before the new seismic work was completed. In August and September, 1977, seismic reflection lines X-1, X-2 and X-9 were run across the area of the "seismic dropout," and the records confirmed a geologic anomaly. Additional information on these records suggested salt flow or thickening in the Castile Formation. In view of the general disturbance in the seismic records in this area and the apparent salt thickening, it was determined to drill the anomaly to see if brine and gas would be associated with the structure as in ERDA 6 and some other similar situations.

The new seismic data indicated a preferable drilling location to ERDA 11; WIPP 11 was located in the northwest corner of Section 9, T.22.S, R.31E along the line of X-1. Initial predictions independently made on the basis of the geology and seismic reflection placed the contact between the Rustler and Salado Formations at 975 and 950 feet depth respectively. Seismic reflection data indicated stratigraphic disturbance might be as shallow as 1800'; depth of 3800' to the Delaware Mountain Group was predicted by both seismic reflection and projections of nearby geology. No predictions of the lower evaporite stratigraphy were possible with the seismic reflection data.

After WIPP 11 was completed, borehole gravity logs were run in both ERDA 9 and WIPP 11 in an effort to better understand the geological structure (see Chapter 5.0). In addition, the borehole was capped and monitored for pressure changes over a period of several months (see Chapter 4.0).

3.0 GEOLOGIC DATA FOR BOREHOLE WIPP 11

by

R. P. Snyder
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3.1 Abstract

Borehole WIPP 11 was drilled in the north-central part of the WIPP site in eastern Eddy County, New Mexico, during February and March 1978, to explore a seismically inferred structural anomaly. Units penetrated by the borehole in descending order are the Quaternary Gatuna Formation, the Triassic Santa Rosa Sandstone, the Permian Dewey Lake Red Beds, Rustler and Salado Formations, and most of the Permian Castile Formation. The Salado Formation is thinner at this location than in nearby drillholes. An unusually thick unit of halite is present in the upper part of the Castile, and the overlying anhydrite is unusually thin. The halite unit in the lower part of the Castile is also unusually thin.

3.2 Introduction

Borehole WIPP 11 is an exploratory borehole drilled to determine the presence of an apparent anomalous geologic structure as interpreted from seismic reflection studies done by G. J. Long and Associates (1977). The borehole is located in the north-central part of the WIPP site (Figure 1). The exploratory drilling and seismic work were done on behalf of the WIPP project office of the U.S. Department of Energy (DOE).

All measurements related to the drill hole are reported in the inch-pound system. These units are used to facilitate direct comparison of measurements made by surveyors in establishing the geographic coordinates of WIPP 11, by drillers in reporting well depths for cuttings and cores, and by geophysical loggers in recording in-hole variations in rock properties with depth. If metric units are desired, the following conversion factors should be used:

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

3.3 Description of WIPP 11

WIPP 11 is located in eastern Eddy County, New Mexico, in the NW 1/4 Sec. 9, T.22S., R.31E. (Figure 1, Table 1). The borehole was drilled between February 6, 1978 and March 12, 1978, to a depth of 3,583 ft measured from KB (Kelly Bushing 13 ft above land surface of 3,426.1 ft above mean sea level). Consecutive cores were taken from 727.0 to 786.0, 856.0 to 891.0, 950.0 to 991.0, 2,244.0 to 3,143.8, and 3,346.7 to 3,538.4 ft. Cuttings in the remaining intervals were not described; interpretation of these intervals was done using geophysical logs. Core was logged at the drill site by C. L. Jones of the U.S. Geological Survey (USGS) and J. L. Gonzales of Fenix and Sisson, Inc. (F&S).

Borehole WIPP 11 penetrated stratigraphy consisting of the Gatuna Formation of Quaternary age, at the Santa Rosa Sandstone of Triassic age; siltstones and sandstones of the Dewey Lake Red Beds; anhydrite, dolomite, and siltstone of the Rustler Formation; and halite, polyhalite, anhydrite, and minor siltstone of the Salado Formation, all of Permian age (Jones, 1973). Below the Salado Formation the borehole penetrated into the lowest anhydrite of the Castile Formation, consisting of thick anhydrite and halite of Permian age.

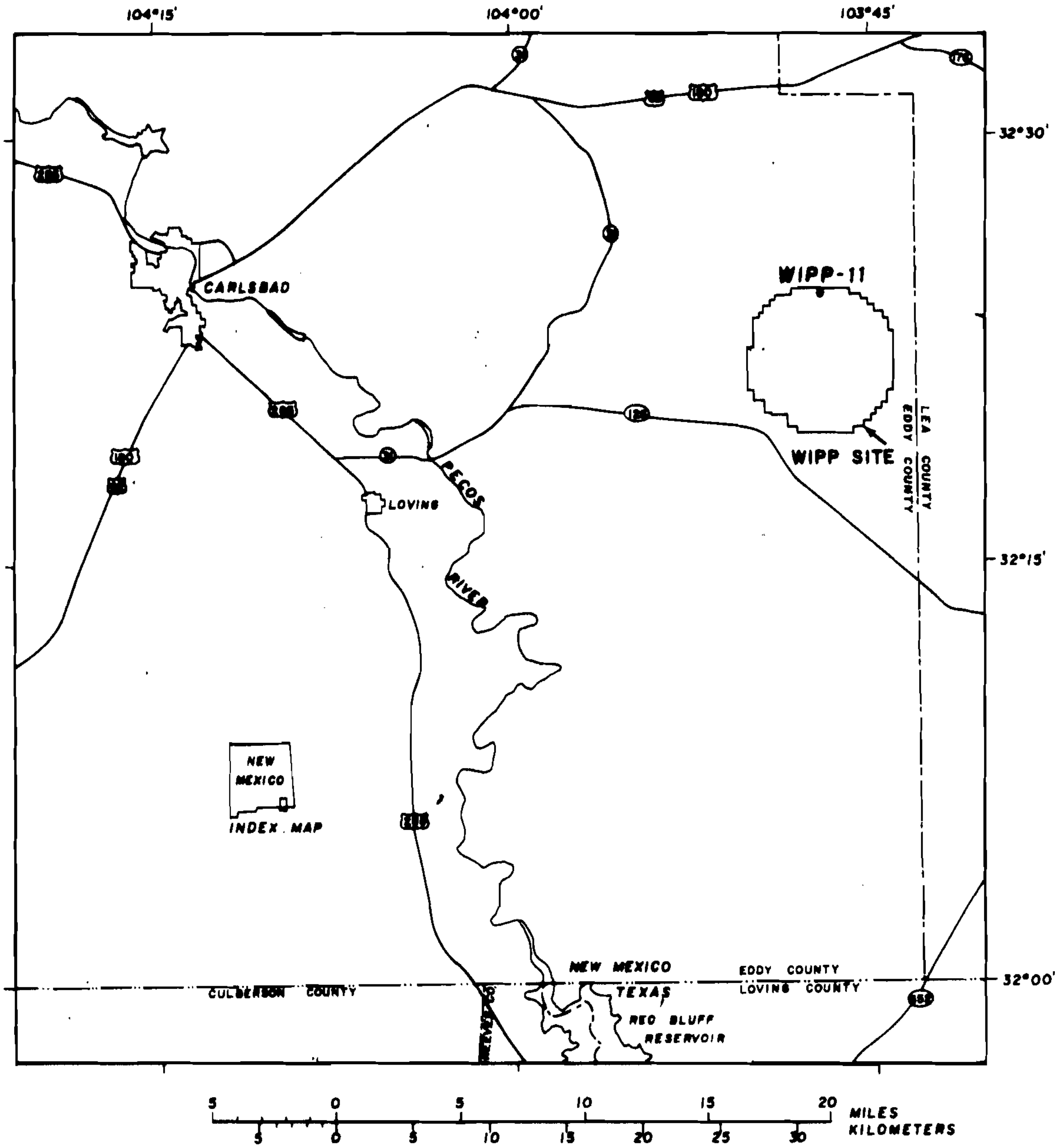

Figure 1.--Location map of the WIPP site in southeast New Mexico, and location of borehole WIPP 11 on the site.

The Salado Formation was found to be thinner than normal in WIPP 11. The difference occurs in the lower one-third of the formation. In the underlying Castile Formation the upper halite (HII) is much thicker than normal and the lower halite (HI) is much thinner. The highest anhydrite (AIII) is much thinner than normal; the middle anhydrite (AII) is of normal thickness. The lowest anhydrite (AI) was not completely penetrated by the borehole. A detailed lithologic description of the rocks penetrated by WIPP 11 is given in Table 3, and a lithologic log prepared from the data in that table is shown on Figure 2.

Geophysical logs were taken the full length of the borehole. The logging was done to facilitate the identification and correlation of rock units, to aid in the identification of gross lithologies (i.e., dolomite, anhydrite, polyhalite, and halite), and to provide a depth determination independent of that indicated by drill-rod measurement. The geophysical logs included (1) a gamma-ray curve that recorded variations in the distribution of potassium and other radioactive elements, (2) a compensated-sonic log that recorded variations in velocity, and (3) a porosity log that recorded variations of porosity of the various rock units. The sonic log is used on Figure 2 as the standard to correlate the lithology with depths.

A dipmeter and directional survey of the borehole provides additional information about the bedding attitudes and borehole response. The "tadpole" plots and hundred-foot cluster analyses (Figure 2) indicate that the beds below about 2200' dip consistently southwest at a few degrees. The bed attitude above this in the Salado is not so consistent. The borehole directional survey, by which the dipmeter survey was corrected, indicates the drilling bit veered into the dip - the borehole is more nearly normal to the dip (Figures 3 and 4). This behavior is expectable in drilling dipping strata.

Table 1.--Abridged borehole history of WIPP-11

LOCATION: Sec. 9, T. 22 S., R. 31 E.
712 feet from north line
294 feet from west line

ALTITUDE (LAND SURFACE): 3,426.1 feet. Datum for depth measurements in drilling and logging operations is 3,439.1 feet (Kelly Bushing height)

LITHOLOGIC LOG PREPARED BY: J. L. Gonzales (F&S) and C. L. Jones (USGS), February 6, 1978 to March 12, 1978.

DRILLING CONTRACTOR: Verna Drilling Company

DRILLING RECORD: Commenced drilling February 6,1978, and completed on March 12, 1978,at 3,583 feet below Kelly Bushing (3,570 ft below land surface).

Hole temporarily abandoned pending further studies.

Core No.	Depth interval,[1] in feet	RPM	Weight on bit (lbs)	Circulating pressure (lbs/in^2)	Interval Feet cored	Interval Feet recovered	Percent recovered
1	727.0- 786.0	50	30,000	800	59	57.0	97
2	856.0- 891.0	60-80	25,000	650	35	16	45.7
3	950.0- 991.0	80	20,000	600	41	26.2	64
4	2,244.0-2,303.0	40	16,000	400	59	58.8	<100
5	2,303.0-2,363.0	40	16,000	400	60	59.5	99
6	2,363.0-2,412.0	48	18,000	600	49	47	96
7	2,412.0-2,450.0	48	18,000	600	38	29	76
8	2,450.0-2,489.0	60	20,000	600	39	30.6	78
9	2,489.0-2,534.0	65	22,000	600	45	38.3	85
10	2,534.0-2,584.0	70	22,000	600	50	43.4	87
11	2,584.0-2,634.0	60	20,000	400	50	46.9	94
12	2,634.0-2,646.0	70	20,000	400	12	11.8	98
13	2,646.0-2,696.4	60	20,000	400	50	50.4	101
14	2,696.4-2,746.4	65	22,000	500	50	50	100
15	2,746.4-2,796.4	65	21,000	600	50	49.9	<100
16	2,796.4-2,846.4	65	20,000	800	50	46.9	94
17	2,846.4-2,893.4	70	24,000	800	47	46.5	99
18	2,893.4-2,943.4	70	24,000	800	50	50	100
19	2,943.4-2,993.4	70	25,000	500	50	50	100
20	2,993.4-3,043.4	70	24,000	500	50	49.2	98
21	3,043.4-3,093.4	70	25,000	500	50	50	100
22	3,093.4-3,143.8	70	22,000	600	50	50.4	101
23	3,346.7-3,396.7	65	25,000	500	50	50	100
24	3,396.7-3,447.1	60	20,000	500	50	50.4	101
25	3,447.1-3,498.1	60	24,000	700	51	50.8	<100
26	3,498.1-3,538.4	60	20,000	500	40	40.3	101

[1]Depth and interval numbers taken from driller's measurements. Some corrections or changes made on table 3 to correspond to geophysical logs.

Table 2.--Stratigraphic summary of borehole WIPP-11--Continued

Rock unit	Depth interval[1] Feet
Lower member	1,756-2,343
[3]MB 127	1,776
[3]MB 128	1,785
[3]MB 129	1,804
[3]MB 130	1,810
[3]MB 131	1,859
[3]MB 132	1,879
[3]MB 133	1,893
[3]MB 134	1,934
[3]MB 135	1,948
[3]MB 136	1,986
[3]MB 138	2,027
[3]MB 139	2,064
[3]MB 140	2,105
[3]MB 141	2,137
[3]MB 142	2,170
[3]MB 143	2,197
[3]MB 144	2,222
Cowden Anhydrite Member[7]	2,228-2,242
Castile Formation	2,343-3,583+
Anhydrite III[8]	2,343-2,424
Halite II[8]	2,424-3,392
Anhydrite II[8]	3,392-3,512+
Halite I[8]	3,512+-3,563
Anhydrite I[8]	3,563-3,583+
Maximum depth recorded	3,583

[1]Depth interval recorded from compensated neutron-formation log, depths are from Kelly Bushing 13 feet above ground level.

[2]Includes artificial fill for drill pad, unnamed sand dune deposits and Gatuna Formation of Pleistocene age.

[3]Marker bed.

[4]When only one depth given for marker beds, it is for the base of the unit.

[5]Of Adams, 1944.

[6]Informal unit of Salado Formation.

[7]Of Giesey and Fulk, 1941.

[8]Of Anderson and others, 1972.

Table 2.--Stratigraphic summary of borehole WIPP-11

Rock unit	Depth interval[1] Feet
Quaternary deposits[2]	13- 42
Triassic rocks	
Santa Rosa Sandstone	42- 174
Permian rocks	
Dewey Lake Red Beds	174- 676
Sandstone marker	272- 280
Sandstone marker	322- 328
Rustler Formation	676- 964
Magenta Dolomite Member	740- 763
Culebra Dolomite Member	857- 880
Salado Formation	964-2,343
Upper member	964-1,429
[3]MB 101	[4]1,082
[3]MB 102	1,114
[3]MB 103	1,138
[3]MB 104	1,149
[3]MB 105	1,164
[3]MB 106	1,181
[3]MB 107	1,221
[3]MB 108	1,229
[3]MB 109	1,273
[3]MB 111	1,318
[3]MB 112	1,335
[3]MB 113	1,358
[3]MB 114	1,379
[3]MB 115	1,412
[3]MB 116	1,423
McNutt potash unit	1,429-1,756
Vaca Triste Sandstone Member[5]	1,429-1,434
[3]MB 117	1,491
[3]MB 118	1,511
[3]MB 119	1,533
[3]MB 120	1,555
[3]MB 121	1,571
[3]MB 122	1,578
Union anhydrite[6]	1,599-1,606
[3]MB 123	1,675
[3]MB 124	1,690
[3]MB 126	1,756

Table 3.--Lithologic description of borehole WIPP-11

[Contacts shown on fig. 2. Where no core or cuttings are described, depths are taken from compensated-sonic log; color designations are from the Rock-Color Chart (Goddard and others, 1948)]

Lithologic description	Depth interval (in feet)
Depth from KB to ground level..	0- 13.0
No description of cuttings..	13.0- 727.0
Anhydrite, medium-light-gray (N6), brecciated, granular and fibrous gypsum filling interstices between clasts...............	727.0- 740.3
Dolomite, light-gray (N7), tinted with purple and green, fine-grained to dense, thin-bedded and laminated, ripple-marked and cross-laminated; dotted with gypsum porphyroblasts and criss-crossed with fibrous gypsum veins..................	740.3- 763.3
Anhydrite, medium-light-gray (N6), brecciated, granular gypsum filling interstices between clasts...........................	763.3- 784.0
No core..	784.0- 786.0
No description of cuttings..	786.0- 857.0
Dolomite, medium-light-gray (N6), extensively fractured and solution pitted..	857.0- 865.5
No core (lost when core barrel lifted to make connection)............	865.5- 880.0
Shale, bluish-gray (5B 5/1), grading to moderate-reddish-brown (10R 4/6) silty shale in lower 2 ft.................................	880.0- 887.0
Gypsum, grayish-red (10R 4/2), coarsely crystalline, argillic.........	887.0- 887.5
No core..	887.5- 892.0
No description of cuttings..	892.0- 950.0
Siltstone, grayish-brown (5YR 3/2), areas of grayish-blue (5PB 5/2), argillic sparse to rare halite crystals.................	950.0- 955.0
No core (lost when lifting core barrel to make connection)............	955.0- 964.4
Halite, light-brownish-gray (10YR 6/1), argillic; few anhydrite stringers...	964.4- 964.8
Clay, moderate-reddish-brown (10R 4/6); sparse halite crystals..	964.8- 965.7
Anhydrite, pale-brown (5YR 5/2)..	965.7- 966.0
Halite, pale-brown (5YR 5/2), coarsely crystalline, very argillic; scattered stringers and masses of anhydrite...............	966.0- 969.7
Halite, translucent, coarsely crystalline; light-gray (N 7) clay decreasing downward; scattered stringers and masses of anhydrite..	969.7- 973.2
Halite, transparent, coarsely crystalline; trace of anhydrite...	973.2- 974.2
Halite, light-brownish-gray (5YR 6/1), very coarsely crystalline; many anhydrite stringers and masses; brown clay parting at 974.5-974.7 ft......................................	974.2- 976.7
Halite, transparent, medium- to coarsely crystalline; trace of anhydrite stringers and masses..................................	976.7- 984.7

Lithologic description	Depth interval (in feet)
Halite, translucent, moderate-brown (5YR 4/4) argillic concentrations along crystal boundaries; minor amount of anhydrite stringers and masses; clay parting at 985.1-985.4 ft	984.7- 985.9
No core	985.9- 991.0
No cuttings described	991.0-2,244.0
Halite, light-gray (N7), banded with medium-light-gray (N6) at 0.3-0.5 ft intervals, medium-crystalline, equigranular to very slightly schistose; sparingly argillic intervals at 2,244.8-2,245.8, 2,249.2-2,249.4, and 2,251.5-2,253.2 ft	2,244.0-2,267.7
Halite, light-gray to medium-light-gray (N7-N6), medium-crystalline, equigranular to very slightly schistose; crystal elongations dip 10° from horizontal; argillic, as much as 2 percent clay concentrated along crystal boundaries	2,267.7-2,277.0
Anhydrite, very light gray (N8), mottled medium-light-gray (N6), dips 7°-10°	2,277.0-2,277.2
Halite, light-gray (N7), minor medium-light-gray (N6) banding at 0.2-0.4 ft intervals, sparingly anhydritic and argillic; few thin seamlets of anhydrite in lower 0.2 ft	2,277.2-2,284.7
Anhydrite, very light gray (N8), very finely crystalline; halitic, minor lenses of halite and pseudomorphs after gypsum in upper 0.4 ft; argillic in lower 0.1 ft, clay parting at 2,285.4 ft, dips 20°	2,284.7-2,285.5
Halite, light-gray (N7), mottled medium-light-gray (N6), medium-crystalline, equigranular, very sparingly anhydritic and argillic	2,285.5-2,290.7
Anhydrite, same as unit at 2,284.7-2,285.5 ft; lenticular halite seamlets in upper half of unit, discontinuous clay stringers in lower half; dips 2°-3°	2,290.7-2,291.1
Halite, same as unit at 2,285.5-2,290.7 ft; very argillic at 2,291.7-2,291.9 ft	2,291.1-2,292.8
Anhydrite; same as unit at 2,284.7-2,285.5 ft	2,292.8-2,293.2
Halite, same as unit at 2,285.5-2,290.7 ft; 0.1-ft argillic zone at 2,297.2 ft	2,293.2-2,302.8
No core	2,302.8-2,303.0
Halite, medium-gray (N5); light-gray (N7) banding at intervals of a few tenths of a foot; medium-crystalline; equigranular to very slightly schistose, crystal elongation nearly horizontal, sparingly anhydritic and argillic; thin irregular seamlets of anhydrite from 2,320.9 to 2,321.5 ft	2,303.0-2,321.5
Anhydrite, light-gray (N7), very finely crystalline to dense; lenticular seams of halite; unit dips 5°-7°	2,321.5-2,322.0
Halite, light-gray to medium-light-gray (N7-N6), medium-crystalline; equigranular to very slightly schistose; irregularly banded; sparingly anhydritic; concentration of broken anhydrite seamlets at 2,323.3-2,323.7 ft; very sparingly argillic	2,322.0-2,326.8
Anhydrite, light-gray (N7) to greenish-gray (5GY 6/1); very finely to coarsely crystalline; banded with numerous lenticular seams of halite; unit dips 5°-10°	2,326.8-2,328.5

Table 3.--Lithologic description of borehole WIPP-11--Continued

Lithologic description	Depth interval (in feet)
Halite, light-gray (N7), medium-crystalline; equigranular, sparingly anhydritic	2,328.5-2,330.4
Anhydrite, light-gray (N7) to greenish-gray (5GY 6/1), dense to very finely crystalline, mostly thinly laminated, sparingly magnesitic and locally argillic; abundant small (3-5 mm) multizoned halite pseudomorphs after gypsum from 2,330.4 to 2,331.0 ft; 0.2-ft seam of halite at 2,332.0 cuts sharply into overlying anhydrite and truncates pseudomorphic structure; 0.5-ft halite seam at 2,332.9 ft	2,330.4-2,335.1
Anhydrite, light-gray (N7) to greenish-gray (5GY 6/1), dense; interlayered with numerous thin lenticular seams of halite	2,335.1-2,336.1
Anhydrite, same as unit above, decreased number of halite seams, unit dips 15°-20°, base of unit truncated by underlying halite	2,336.1-2,337.1
Halite, light-gray (N7), medium-crystalline, equigranular; sparingly anhydritic; upper 0.5 ft of unit includes broken fragments of anhydrite derived from overlying unit	2,337.1-2,339.5
Anhydrite, light-gray (N7), dense; sparse lenticular seams of halite; base of unit intruded by underlying halite which cuts sharply across anhydrite bedding	2,339.5-2,339.9
Halite, light-gray to medium-light-gray (N7-N6), medium-crystalline; sparingly argillic and anhydritic; 0.1-ft seam of dense anhydrite at 2,342.8 ft	2,339.9-2,343.0
Anhydrite, light-gray (N7) to greenish-gray (5GY 6/1), dense; lenticular seams of halite; unit dips 10°	2,343.0-2,343.8
Halite, light-gray (N7), medium-crystalline; equigranular; sparingly anhydritic; 0.2-ft broken fragment of anhydrite seamed with halite at 2,344.0 ft	2,343.8-2,345.1
Anhydrite, light-gray (N7), dense; few thin lenticular seams of halite in upper 0.5 ft; 0.2-ft seam of halite containing anhydrite seamlets at 2,346.3 ft; 0.7-ft seam of anhydritic halite at 2,348.6 ft; most anhydrite is thinly and irregularly laminated in shades of gray; unit dips 10°	2,345.1-2,349.0
Anhydrite, light-gray (N7), dense, laminated in shades of gray; lenticular seams of halite in upper 0.3 ft are truncated by overlying halite; laminated anhydrite between 2,350.0 and 2,351.0 ft cut by halite-filled fractures dipping 20°; other halite-filled fractures from 2,354.0 to 2,355.0 ft; unit dips 10°	2,349.0-2,362.5
No core	2,362.5-2,363.0
Anhydrite, moderate-brown (5YR 3/4), dark-gray (N3), and dark-yellowish-brown (10YR 4/2), very finely crystalline, laminated, grading downward to light-gray and medium-light-gray (N7-N6); near base unit dips 30°; rest of unit nearly horizontal	2,363.0-2,373.5
Anhydrite, medium-gray (N5), laminated with dark-gray (N3) bituminous noncalcareous material at 0.1-ft intervals, very finely crystalline; unit dips 30°	2,373.5-2,387.9
Anhydrite, light-gray (N7), laminated with 0.5-mm-thick light-brownish-gray (5YR 6/1) bituminous layers at intervals of about 0.1 ft, very finely crystalline; halite-filled "gash" fractures (en echelon) between 2,398.0 and 2,399.2 ft; unit dips 30°	2,387.9-2,410.0
No core	2,410.0-2,413.0

Lithologic description	Depth interval (in feet)
Anhydrite, light-gray to medium-light-gray (N7-N6); banded with brownish-gray (5YR 4/1) laminae of bituminous calcite, very finely crystalline; laminations fairly even and uniform except for wavy lenticular bedding from 2,422.8 to 2,424.0 ft; between 2,417.5 and 2,419.5 ft rock is cut by halite-filled fractures along which the laminations are offset an unknown amount; basal contact with halite is irregular and plucking of the anhydrite by the halite is evident; unit dips 35°..............................	2,413.0-2,425.1
Halite, transparent to very light gray (N8), medium-crystalline; equigranular to slightly schistose locally; banded at 0.1-ft intervals with white (N9) calcitic anhydrite 1 cm thick; bands are broken and contorted; most are feathery and contain various amounts of halite; unit dips 30°-35°..	2,425.1-2,431.5
Anhydrite, light-gray to medium-light-gray (N7-N6), very finely crystalline; banded with laminae of brownish-gray (5YR 4/1) bituminous calcite at 0.5-cm intervals; 0.2-ft lens of clear to white (N9) halite at 2,431.7 ft; unit dips 35°..	2,431.5-2,433.0
Halite, transparent to very light gray (N8), medium-crystalline to slightly schistose; banded with broken feathery layers of white (N9) calcitic anhydrite..................................	2,433.0-2,435.1
Anhydrite, light-gray to medium-light-gray (N7-N6), very finely crystalline; banded with laminae of brownish-gray (5YR 4/1) bituminous calcite; fractured and broken in irregular fragments and separated by intrusive veins of transparent halite..	2,435.1-2,436.4
Halite, transparent to very light gray (N8), medium-crystalline, banded at irregular intervals with broken feathery layers of white (N8) calcitic anhydrite a few millimeters to 0.1 ft thick; unit dips 35°...	2,436.4-2,442.0
No core..	2,442.0-2,450.0
Halite, transparent to white (N9), medium-crystalline, schistose; banded at short irregular intervals with layers of lacy-white (N9) to light-gray (N8) anhydrite containing laminae of brownish-gray (5YR 4/1) bituminous calcite; layers are broken and exhibit well-developed boudin structure; unit dips 30°-40°...	2,450.0-2,462.0
Anhydrite, medium-dark-gray (N4), very finely crystalline; rhythmically banded with laminae of brownish-gray (5YR 4/1) bituminous calcite; 1.0-ft lens of transparent, very coarsely crystalline halite cuts unit at 2,465.0 ft; margins of lens cut anhydrite at nearly right angle to bedding; halite-filled "gash" fractures cut bedding in anhydrite below lens at right angles; individual fractures about 1-2 mm wide; unit dips 40°...................................	2,462.0-2,467.0
Halite, transparent to white (N9), medium-crystalline and schistose; boudinaged layers of lacy white (N9) to very light gray (N8), finely crystalline anhydrite containing laminae of brownish-gray (5YR 4/1) bituminous calcite; unit dips from 30°-45°..............................	2,467.0-2,480.6
No core..	2,480.6-2,489.0
Halite, transparent to white (N9), medium-crystalline; banded at intervals of 0.5-3.0 ft with laminae of white (N9), very finely crystalline anhydrite (3-5 mm thick); strongly folded and sheared with occasional development of boudinage structure; dip of anhydrite layers and schistosity 40°-50°, but locally variable..	2,489.0-2,527.3

Lithologic description	Depth interval (in feet)
No core	2,527.3-2,534.0
Halite, transparent to white (N9), medium-crystalline, moderately to strongly schistose, dotted with equigranular halite; banded at 0.5-1.5-ft intervals with sheared layers of white (N9), very finely crystalline anhydrite, strongly folded and showing well-developed boudinage structures; unit dips 40°-45°	2,534.0-2,577.4
No core	2,577.4-2,584.0
Halite, transparent to white (N9); medium-crystalline, schistose; dotted with patches of equigranular halite, transparent to white (N9); banded at intervals of 0.2-0.6 ft with anhydrite a few millimeters thick; anhydrite layers are twisted in shear folds and show boudinage structures; unit dips about 30°	2,584.0-2,630.9
No core	2,630.9-2,634.0
Halite, same as unit at 2,584.0-2,630.9 ft; some anhydrite laminae bent in shear and isoclinal folds; dips on fold axes range from vertical to 40°; planes of schistosity dip 40°, locally much less	2,634.0-2,645.8
Halite, same as unit at 2,634.0-2,645.8 ft; many anhydrite laminae have well-developed boudinage structures; planes of schistosity dip from 40° to 60°; heavy inclusion of anhydrite laminae at 2,652.0-2,654.3, 2,671.5-2,679.5, and 2,695.0-2,696.4 ft	2,645.8-2,696.4
Halite, transparent to white (N9), medium-crystalline, schistose; locally recrystallized and equigranular; laminae of very finely crystalline anhydrite becoming very slightly calcitic downward; all laminae twisted into steeply dipping isoclinal folds with well-developed boudinage structures; unit intensely deformed; heavy inclusion of anhydrite laminae at 2,696.4-2,702.0 ft	2,696.4-2,746.0
Halite, transparent, medium-crystalline, schistose, locally recrystallized; light-gray (N7) laminae of very finely crystalline anhydrite at 0.3-2.0-ft intervals; laminae 1-4 mm thick are shearfolded and show boudinage structures; a few laminae contain calcite; heavy concentration of anhydrite laminae at 2,778.7-2,784.0 ft; schistosity dips 40°	2,746.0-2,797.9
No core	2,797.9-2,798.0
Halite, same as unit at 2,746.0-2,797.9 ft; schistosity dips 45°	2,798.0-2,844.9
No core	2,844.9-2,848.0
Halite, transparent to white (N9), medium-crystalline, schistose; local recrystallization and coarsening of crystal size; upper 1 ft of unit banded with folded laminae of very finely crystalline white (N9) to very light gray (N8) anhydrite showing shearing and boudinage structures; lower 29.5 ft banded with white (N9) and light-gray (N8-N7) anhydrite at intervals of 0.5 ft as knots and clusters of anhydrite fragments and crystals dipping 35°-40° essentially parallel to schistosity	2,848.0-2,894.5
No core	2,894.5-2,895.0
Halite, same as unit at 2,848.0-2,894.5 ft; occasional folded laminae of anhydrite; well-developed boudinage structure at 2,922.0-2,922.5 ft	2,895.0-2,945.0

Table 3.--Lithologic description of borehole WIPP-11--Continued

Lithologic description	Depth interval (in feet)
Halite, transparent to white (N9), medium-crystalline; locally schistose and recrystallized with some coarsening of crystals; banded at 0.3-0.6-ft intervals with layers of light-gray (N7-N6) anhydritic halite containing sheared laminae and fragments of very finely crystalline anhydrite and traces of calcite; some halite crystals as large as 0.1 x 0.2 ft contain parallel lines of minute anhydrite crystals (lathlike); unit dips 40°..................................	2,945.0-2,995.0
Halite, same as unit above; anhydrite laminae intricately folded; shistosity dips 50°; concentrated anhydritic halite at 3,022.6-3,028.0 ft; laminae contain 1-2 mm square and rectangular halite crystals.............................	2,995.0-3,044.2
No core..	3,044.2,3,045.0
Halite, same as unit at 2,995.0-3,044.2 ft............................	3,045.0-3,095.0
Halite, transparent to white (N9), medium- to coarsely crystalline, schistose to equigranular; banded at 0.1-2.0-ft intervals with light-gray (N7) to white (N9) anhydritic halite containing a single laminae of very finely crystalline white to light-gray (N9-N7) calcitic anhydrite and 1-2 mm euhedral crystals of halite; recurrent stratigraphic sequences (0.1-2 ft thick) indicate a basal layer of anhydrite and an overlying unit of white (N9) banded halite with lines of microscopic anhydrite crystals parallel to bedding grading upward to transparent halite free of anhydrite; most anhydrite laminae are twisted into intricate shear folds and show well-developed boudinage structures; dip on bedding at 3,107.0 ft is 50°..	3,095.0-3,145.4
No description of cuttings..	3,145.4-3,345.4
Halite, same as unit at 3,095.0-3,145.4 ft; dips range from 40° to 60°; scattered through halite layers are broken fragments of white (N9), banded halite as large as 0.1 ft, showing parallel lines of microscopic anhydrite crystals...........	3,345.4-3,392.0
No cuttings described (rock bit used; drilling time log indicates halite-anhydrite contact at 3,392.0 ft)..................	3,392.0-3,397.0
Anhydrite, medium-dark-gray (N4), very finely crystalline; rhythmically banded (1 mm) with bituminous calcite; halite-filled tensional fractures 0.1-0.3 ft long and as wide as 0.1 ft cut bedding at steep angles and are near vertical (80°); surfaces of most fractures lined with glassy, colorless anhydrite laths and tabular crystals; centers of fracture fillings are colorless glassy halite; fractures at 3,397.1, 3,398.0, 3,398.6, 3,399.8, 3,402.1, and 3,407.8 ft; the last has cavities partially halite-filled; folding of laminae below groups of fractures between 3,399.0 and 3,400.0 ft; unit dips 10°-15° near top, increasing to 25° near base......................	3,397.0-3,408.0
Anhydrite, moderate-dark-gray (N4), very finely crystalline; rhythmically banded with millimeter-thick laminae of bituminous calcite; short intervals of microfolding between 3,408.0-3,410.5 ft; dips range from 15° to 25°.............	3,408.0-3,424.9
Anhydrite, medium-dark-gray (N4), very finely crystalline; alternating bands and massive anhydrite containing zones (0.1-0.6 ft) of rhythmic laminations alternating with thinner bands (0.1-0.2 ft) of massive, very finely crystalline, medium-gray (N5) anhydrite free of calcite; dips range from 10° to 15°...	3,424.9-3,434.8
Anhydrite, medium-dark-gray (N4), very finely crystalline; rhythmically laminated with bituminous calcite; unit dips 10°..	3,434.8-3,438.1

Lithologic description	Depth interval (in feet)
Anhydrite, medium-dark-gray (N4), very finely crystalline; alternately rhythmically laminated and massive bands (0.1-0.5 ft); massive bands are calcite-free and possibly recrystallized transparent to light-gray (N7) anhydrite tending to intrude the laminated portions; prominent kink-folds grade downward to microfolds at 3,442.0-3,442.5 ft; unit dips 10°....................................	3,438.1-3,445.5
Anhydrite, medium-dark-gray (N4), very finely crystalline; nodular with short intervals (0.1 ft) of irregular calcite laminations..	3,445.5-3,447.4
Anhydrite, medium-gray (N5-N4), very finely crystalline; irregular laminations of bituminous calcite at 5-10 mm intervals near upper part of unit decreasing to 1 mm near base; unit dips 10°..	3,447.4-3,449.5
Anhydrite, medium-gray (N5-N4), very finely crystalline, massive and free of calcite (recrystallized).........................	3,449.5-3,450.5
Anhydrite, medium-gray (N5-N4), very finely crystalline; regular rhythmic laminations of bituminous calcite 1 mm thick, interrupted occasionally by irregular bands of light-gray (N7) anhydrite free of stratification and calcite, less fetid than the laminated portion; margins of bands cut into laminated rock; bands of recrystallized anhydrite at 3,451.1-3,451.3, 3,453.3-3,453.8, 3,454.2-3,454.3, 3,454.7-3,454.8, 3,456.4-3,456.5,3,456.7-3,457.2, 3,458.3-3,458.8, 3,459.1-3,459.2,3,459.9-3,460.1, 3,461.2-3,461.7, 3,462.5-3,462.7, 3,463.1-3,463.5, 3,463.8-3,464.1, 3,464.2-3,464.3, 3,466.3-3,466.5, 3,469.5-3,470.1, 3,470.6-3,471.0, 3,471.3-3,471.5, 3,471.7-3,471.8, 3,472.7-3,472.8, 3,473.1-3,473.4, 3,473.8, 3,474.0, 3,474.4-3,474.5, 3,474.9-3,475.0, 3,477.2-3,477.3, 3,480.9-3,481.3 (underlain by near-vertical veinlike lens of glassy anhydrite 0.1 ft thick cutting sharply through banded anhydrite about 0.3 ft long), 3,483.2-3,483.3, 3,483.5-3,483.6, 3,484.6-3,484.7, 3,485.1-3,485.2, 3,485.6-3,485.7, 3,486.1-3,486.3, 3,486.7-3,486.8, 3,488.7-3,488.8, 3,490.6-3,490.7, 3,491.5-3,491.6, 3,492.5-3,492.6, 3,494.3-3,494.5, 3,495.4-3,495.5, 3,495.7-3,495.8, 3,497.4-3,497.5; unit dips 15° at 3,454.0 ft, 15° at 3,461.0 ft, 20° at 3,463.0 ft, 15° at 3,465.0 ft, 10° at 3,468.0 ft, 15° at 3,476.0 ft, 10° at 3,481.0 ft, and 15° at 3,493.0 ft; well-developed microfolds at 3,449.2-3,449.5, 3,450.6-3,450.7, 3,454.0-3,454.2, and 3,474.2-3,474.8 ft............................	3,450.5-3,497.8
No core...	3,497.8-3,498.4
Anhydrite, medium-dark- to dark-gray (N4-N3), very finely crystalline; alternately banded and massive at short intervals; banded portion is marked by regular rhythmic laminations of very finely crystalline, moderate-brown (5GY 3/4) bituminous calcite 1 mm thick; massive portion is very finely crystalline (recrystallized); medium-gray (N5) anhydrite free of calcite and cutting into the laminated portion; the recrystallized bands range from 0.05-0.2 ft thick, are irregular in thickness, and are separated by 0.05-0.2 ft; laminated portion from 3,502.4 to 3,502.7 ft is cut by an essentially vertical veinlet of halite 1 mm thick; unit dips 15°................................	3,498.4-3,503.2
Anhydrite, medium-dark- to dark-gray (N4-N3), very finely crystalline; incipiently banded at intervals of 1 mm to as much as 0.1 ft; wavy uneven laminae of moderate-brown (5YR 3/4), very finely crystalline bituminous calcite; many calcite laminae cut by intrusive anhydrite containing small pods and crystals of halite; unit dips 15°................	3,503.2-3,510.4

Table 3.--Lithologic description of borehole WIPP-11--Continued

Lithologic description	Depth interval (in feet)
Halite, transparent to very light gray (N8), medium crystalline; banded at intervals of 0.2-1.5 ft with light-gray (N7) anhydritic halite containing disseminated fragments and broken laminae of very finely crystalline, gray (N7) anhydrite; the more competent laminae contain euhedral crystals of halite and flecks of brown calcite; very coarsely crystalline transparent halite (recrystallized) forms 0.5-ft lens at 3,513.4 ft and a 0.3-ft lens at 3,531.1 ft; unit dips 15°..	3,510.4-3,538.7
No cuttings described (geophysical log indicates halite-anhydrite contact at 3,563.0 ft)..................................	3,538.7-3,583.0

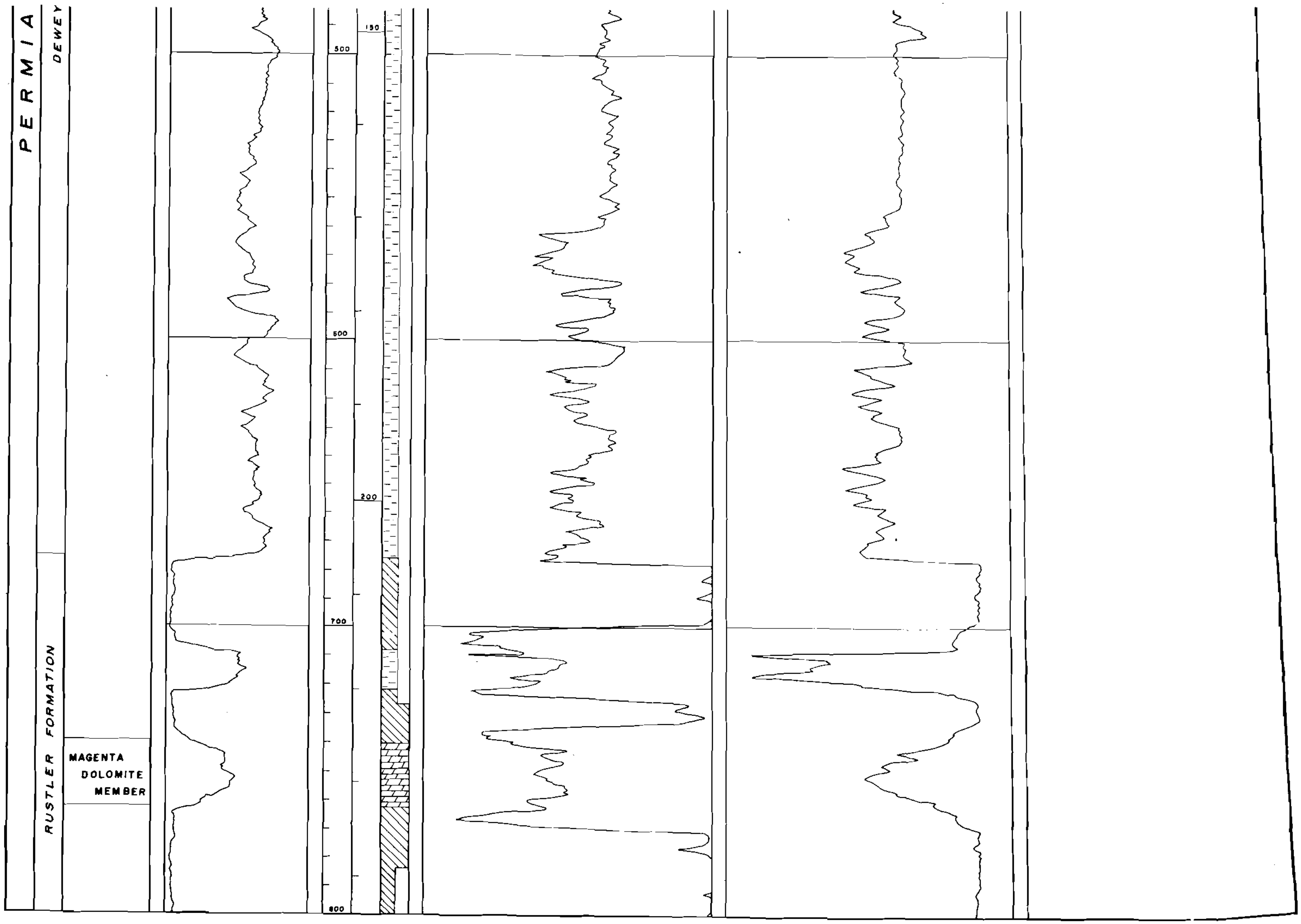

FIGURE 2A.--LITHOLOGIC AND GEOPHYSICAL LOGS OF BOREHOLE WIPP-11.

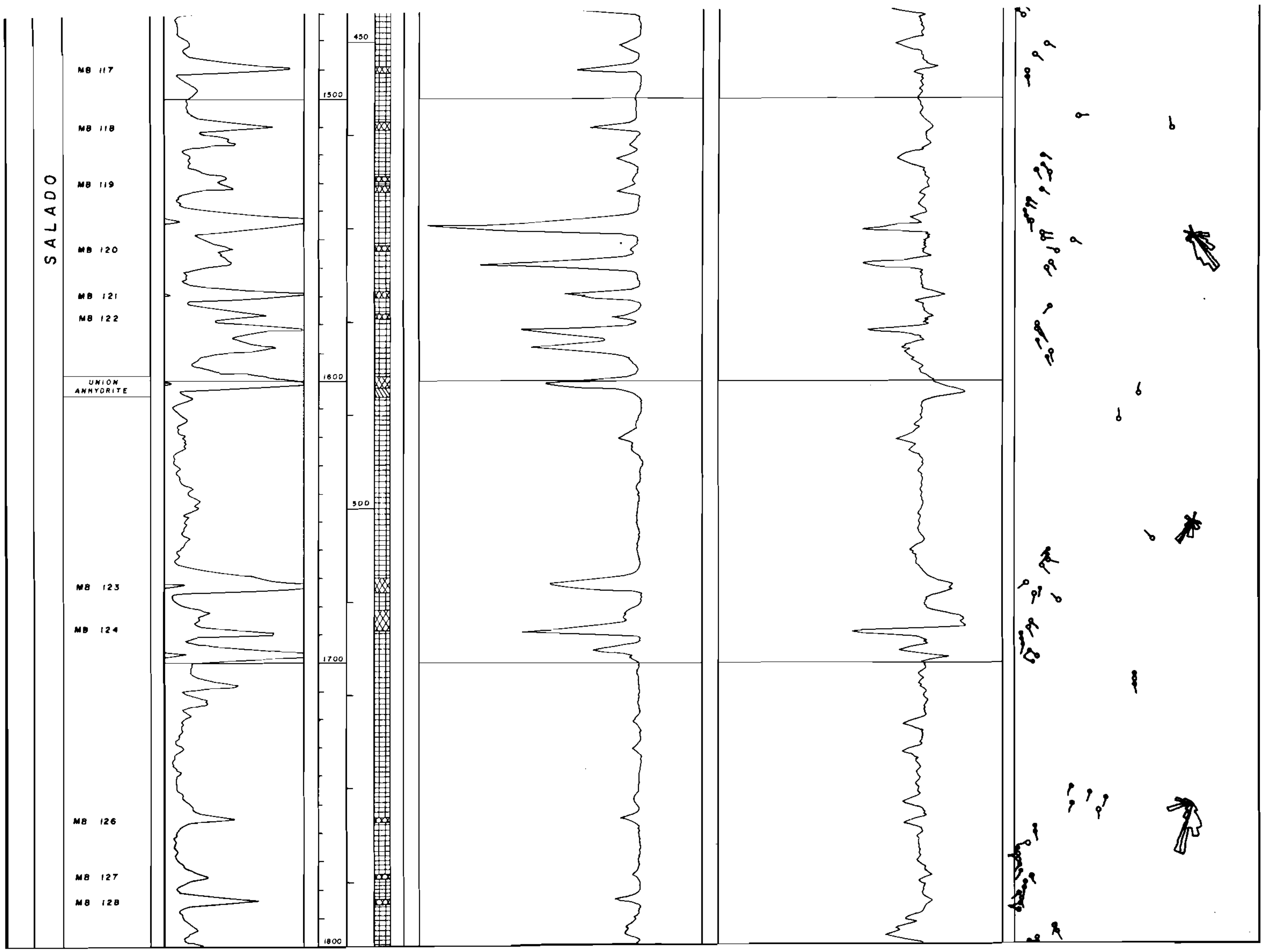

FIGURE 28.-- LITHOLOGIC AND GEOPHYSICAL LOGS OF BOREHOLE WIPP-11.

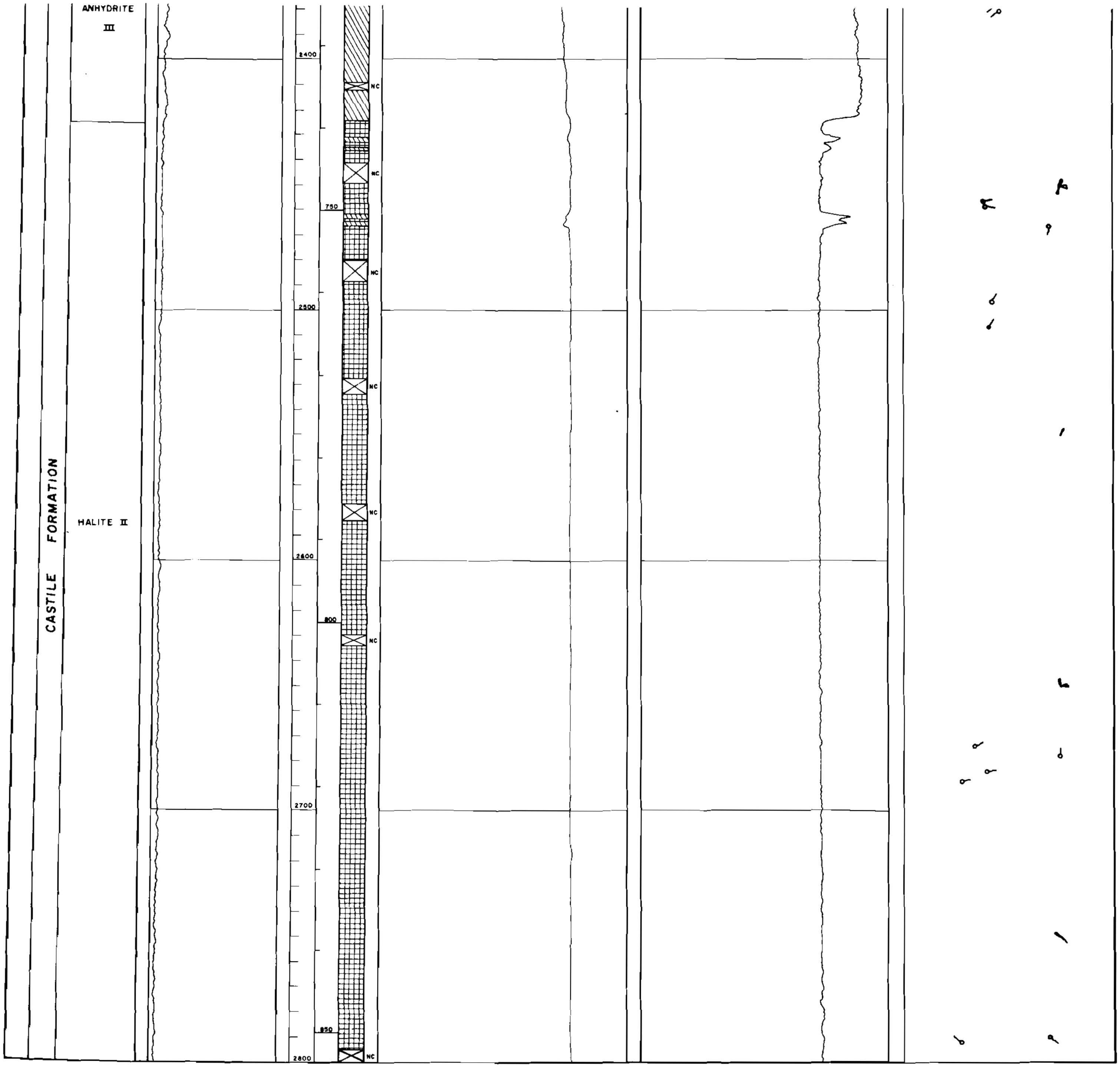

FIGURE 2C.--LITHOLOGIC AND GEOPHYSICAL LOGS OF BOREHOLE WIPP-11.

FIGURE 2D.-- LITHOLOGIC AND GEOPHYSICAL LOGS OF BOREHOLE WIPP-11.

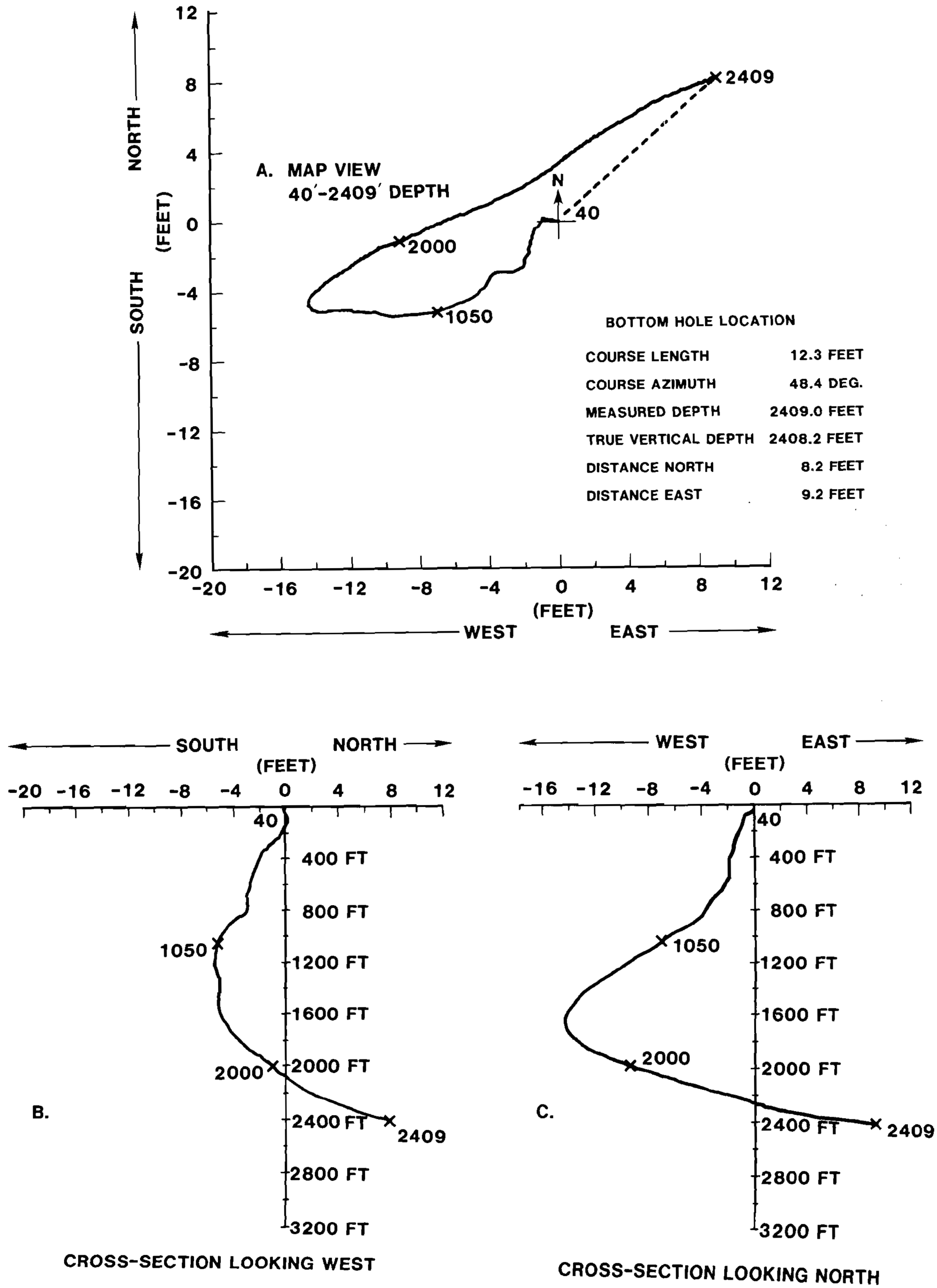

Figure 3.--WIPP 11 Directional Survey to 2409'.

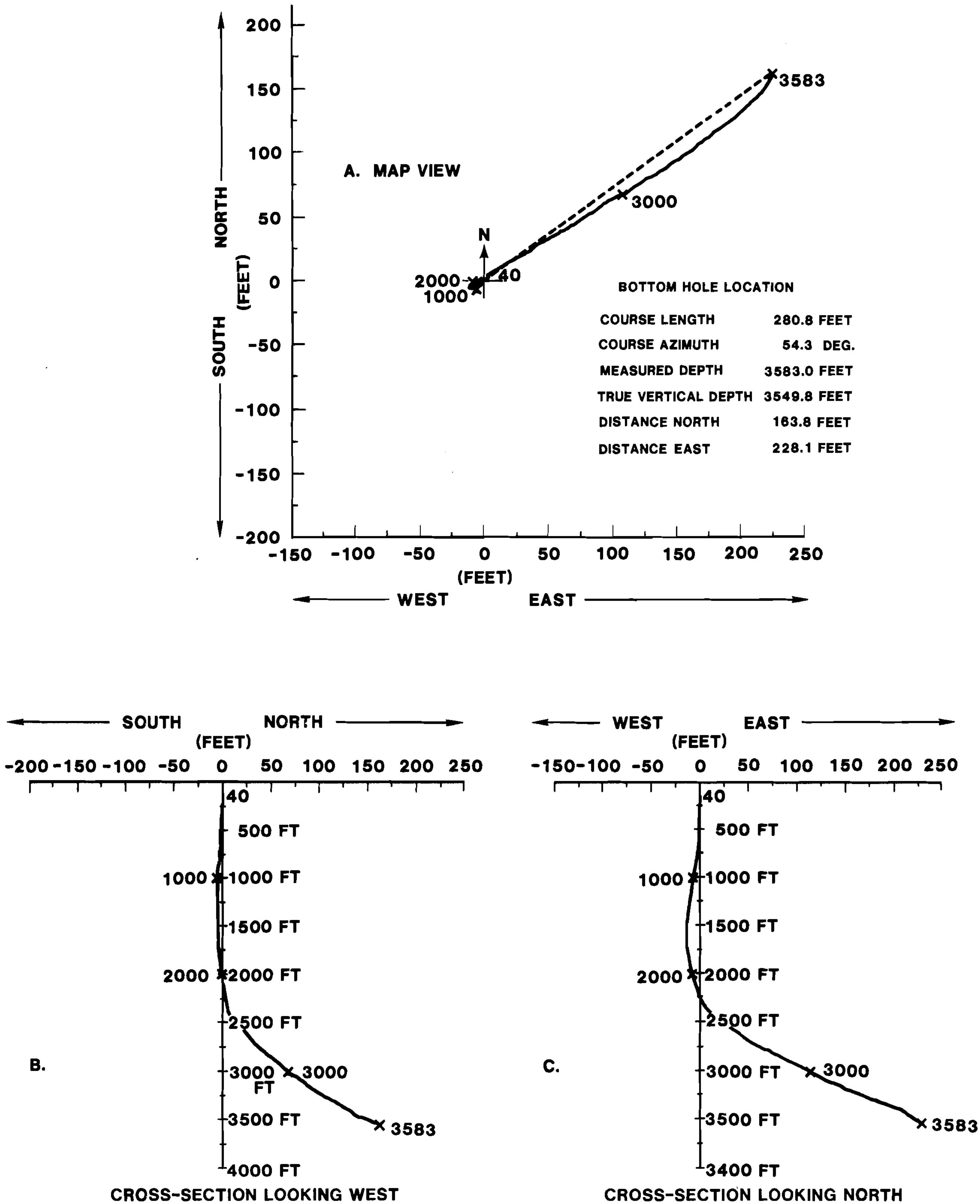

Figure 4.--WIPP 11 Directional Survey to 3583'.

4.0 HYDROLOGY

No drill stem tests were performed as no in-flow of gas or pressurized fluids were detected during drilling. The wellhead was fitted with a pressure gauge in June 1980 and it was monitored at intervals up to 2 weeks for several months. The gauge showed a steady 6 psi over the period June through November. In December the pressure was indicated to be 16-18 psi. The pressure is no longer being monitored.

5.0 REMARKS

Various studies of the borehole geology resulted in additional information which will be useful in interpretation.

5.1 Borehole Gravity

The USGS used a borehole gravimeter to survey both ERDA 9 (Kososki et al., 1978) and WIPP 11. The data were compared and indicate the presence of the structure at WIPP 11 (Schmoker, 1980). However, model studies indicated that the technique has very limited application for detecting such structures in evaporites, but the generalized salt anticline model used by Schmoker is reasonably consistent with the measurements in WIPP 11. Other anticlinal structures have been reported from the northern Delaware Basin (Anderson and Powers, 1978) which may be similar to the structure at WIPP 11.

5.2 Further Studies

Since WIPP 11 was completed, a high precision gravity survey has been conducted over much of the site to determine if structures, such as that at WIPP 11, could be detected and modeled. The results of the investigation are to be reported elsewhere.

Macroscopic and petrographic studies of core from the "disturbed zone" have been initiated in a further effort to discern the mechanisms of deformation. Samples are examined as well for minerals which may be radiometrically dated to determine the age of the "disturbed zone". Information from this study will be reported separately.

6.0 BIBLIOGRAPHY

1. Adams, J. E., 1944, Upper Permian Ochoa series of the Delaware Basin, West Texas and southeastern New Mexico: American Association of Petroleum Geologists Bulletin, v. 28, p. 1596-1625.

2. Anderson, R. Y., W. E. Dean, Jr., D. W. Kirkland, and H. I. Snider, 1972, Permian Castile varved evaporite sequence, West Texas and New Mexico: Geological Society of America Bulletin, v. 82, no. 1, p. 59-86.

3. Anderson, R. Y. and D. W. Powers, 1978, Salt anticlines in Castile-Salado evaporite sequence, northern Delaware Basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circ. 159, p. 79-84.

4. Giesey, S. C., and F. F. Fulk, 1941, North Cowden Field, Ector County, Texas: American Association of Petroleum Geologists Bulletin, v. 25, no. 4, p. 593-629.

5. Goddard, E. N., chm., and others, 1948, Rock-Color Chart: Washington, National Research Council (reprinted by Geological Society of America, 1975).

6. Jones, C. L., 1973, Salt deposits of Los Medanos area, Eddy and Lea Counties, New Mexico, with sections on Ground-water hydrology, by M. E. Cooley and Surficial geology, by G. O. Bachman: U.S. Geological Survey Open-File Report USGS-4339-7, 67 p.

7. Kososki, B. A., S. L. Robbins, and J. W. Schmoker, 1978, Principal facts for borehole gravity stations in stratigraphic test well ERDA No. 9, Eddy County, New Mexico: U.S. Geological Survey Open-File Report 78-696.

8. Long, G. J., and Associates, 1977, Waste Isolation Pilot Plant (WIPP) site review--final report: G. J. Long and Associates, Open-File Report to Sandia National Laboratories.

9. Powers, D. W., S. J. Lambert, S-E. Shaffer, L. R. Hill, and W. D. Weart, eds., 1978, Geological characterization report, Waste Isolation Pilot Plant (WIPP site, southeastern New Mexico: SAND78-1596, v. I & II.

10. Schmoker, J. W., 1980, Effect upon borehole-gravity data of salt structures typical of the WIPP site (northern Delaware Basin), Eddy County, New Mexico: U.S. Geological Survey Chart OC-109.

APPENDIX A

JUSTIFICATION

by

D. W. Powers

Division 4511

Sandia National Laboratories

INTRODUCTION TO APPENDIX A, JUSTIFICATION

Appendix A consists of the memorandum from D. W. Powers to L. R. Hill, dated 1/10/78, "WIPP 11". This document provides details of background information and program options as understood at the time of initiation. The reader is cautioned, therefore, that the details of the program may have been altered as information became available and that preliminary interpretative 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: January 10, 1978

to: L. R. Hill - 5311

from: D. W. Powers - 5311

subject: WIPP 11

Summary: WIPP 11 will be drilled in the northwest corner of Section 9, T22S, R31E, to explore a structural anomaly in the Castile, Salado, and Rustler Formations. The anomaly is interpreted, on the basis of seismic reflection profiles, to be an anticlinal structure in the upper Castile and Salado Formations caused by salt flowage and thickening in the lower Castile. Lower Rustler and upper Salado show an apparent syncline; the synclinal structure may the the result of salt thinning or dissolutioning over the structure. Drilling is expected to be complete at 3200 to 3500 feet when the second anhydrite or lower halite of the Castile Formation is encountered. Core will be taken from potential aquifer zones, levels equivalent to repository horizons, and some of the upper Castile Fm. Geophysical logs, drill-stem tests, and mud logging will be important parts of the drilling operation. If suitable, the borehole will be maintained open for later testing of *in situ* stress and eventually will be converted to a hydrological observation hole.

Background: The area (Fig. 1) of the structural anomaly was originally pinpointed as anomalous by G. J. Long and Associates, Inc., during a review of seismic reflection data made available by the petroleum industry (G. J. Long and Associates, Inc., 1977). That review resulted in the location of 2 areas of anomalous seismic records in the northern Delaware Basin in the Salt Lake quadrangle. Fourteen of those anomalies are within the study area and its immediate surroundings. Because the anomalous records varied in quality, a program for new data collection was initiated in 1977 directed specifically at those 14 anomalies and the upper stratigraphic section of interest. That data is now available (Long and Associates, December 30, 1977) and is summarized below for the drilling of WIPP 11.

Geological Data: The geological data relevant to WIPP 11 consists of relatively shallow borehole data from potash holes, seismic reflection data, and resistivity data. The data from the seismic reflection program is most relevant to drilling WIPP 11.

The most consistent information available from industry and ERDA potash holes is marker bed 124 near the base of the McNutt postash zone of the Salado Formation. Griswold (1977) shows on his Figure 13 that the 124 marker bed slopes southeast at about 100 feet/mile (1°). A low point, with about 50 feet of closure, occurs about one mile south of the WIPP 11 site. Contours of the top of the Salado (Griswold, 1977) are not as reliable although several low points with 20 - 70 feet of closures are shown within about one mile of WIPP 11. The top of Salado at WIPP 11 also dips southeast.

The resistivity data in sections 4, 5, 8, and 9 (T22S, R31E) show no anomalies associated with the WIPP 11 site. The trend of resistivity readings is from high in the east to low in the west. Other anomalies in the resistivity data in the study area are addressed elsewhere (Elliot, in preparation).

Seismic reflection data collected for Sandia is available from parts of three lines (X-1,X-2, X-9) in the immediate vicinity of the WIPP 11 location (Fig. 1). The data (Figs. 2, 3, 4) are shown with preliminary interpretations of some reflectors. The interpretation is that salt flowage has occurred within the Castile Formation and has bulged upward within the upper Castile and lower Salado. Line X-1 (Fig. 2) shows evidence of faulting west of the WIPP 11 location through the upper Delaware Mountain Group and into the Salado. Line X-2 (Fig. 3) also shows apparent synclinal structure near the top of the Salado Formation. Line X-9 is apparently along strike (Fig. 4) and shows less distinct dips. The approximate limits of the anomaly as shown on Figure 1 imply an anomaly as much as 2,500 feet across.

The seismic data is showing a geologic anomaly possibly involving faulting and salt flowage forming on anticlinal structure. This structure bears some resemblance to that at ERDA 6 and may be related to the deformation zone in front of the Capitan reef (Anderson & Powers, in press).

Recommendations: The anomaly located near the northwest corner of section 9, T22S, R31E, must be drilled to determine the extent and origin of salt flowage within the Castile and Salado at this location. The anomaly bears some structural resemblance to ERDA 6, and drilling will be necessary to determine if brine and gas are also associated with this structure. Indirect methods, such as seismic reflection, are not of value for this purpose.

The anomaly appears to be generally restricted to below the Salado Formation in view of resistivity data. The Rustler Formation is probably suited for hydrologic testing, and the borehole will be prepared for that circumstance.

Interpretation of the structural conditions within the lower Salado and upper Castile are of high priority in this borehole, and the stratigraphic relations may be difficult. Our experience in ERDA 6 shows that borehole geophysical logs may not be obtainable when brine and H_2S are present. The core taken is necessary for our structural interpretations. The recommendation here is to begin just above the Cowden with continuous core, as far as is consistent with safety requirements, to the middle anhydrite (Anhydrite 2) of the Castile Formation. Special care is needed to not penetrate into the Delaware Mountain Group because of the location of the borehole within the Known Potash Area (KPA).

Because of some potential for brine and gas within this structure, safety precautions during drilling operations will be extensive with special emphasis on blowout preventers, H_2S detection and protection, and gas sampling.

References

Anderson, R. Y. and Powers, D. W. Salt anticlines in the Castile-Salado evaporite sequence, northern Delaware Basin, New Mexico. Circular, New Mexico Bureau of Mines and Mineral Resources (in press).

Griswold, G. B. Site selection and evaluation studies of the Waste Isolation Pilot Plant (WIPP), Los Medanos, Eddy County, New Mexico. SAND77-0946, Sandia Laboratories, Albuquerque, New Mexico (1977).

Long, G. J. and Associates. Waste Isolation Pilot Plant (WIPP) Site Review - Final Report: open file report to Sandia Laboratories (1977).

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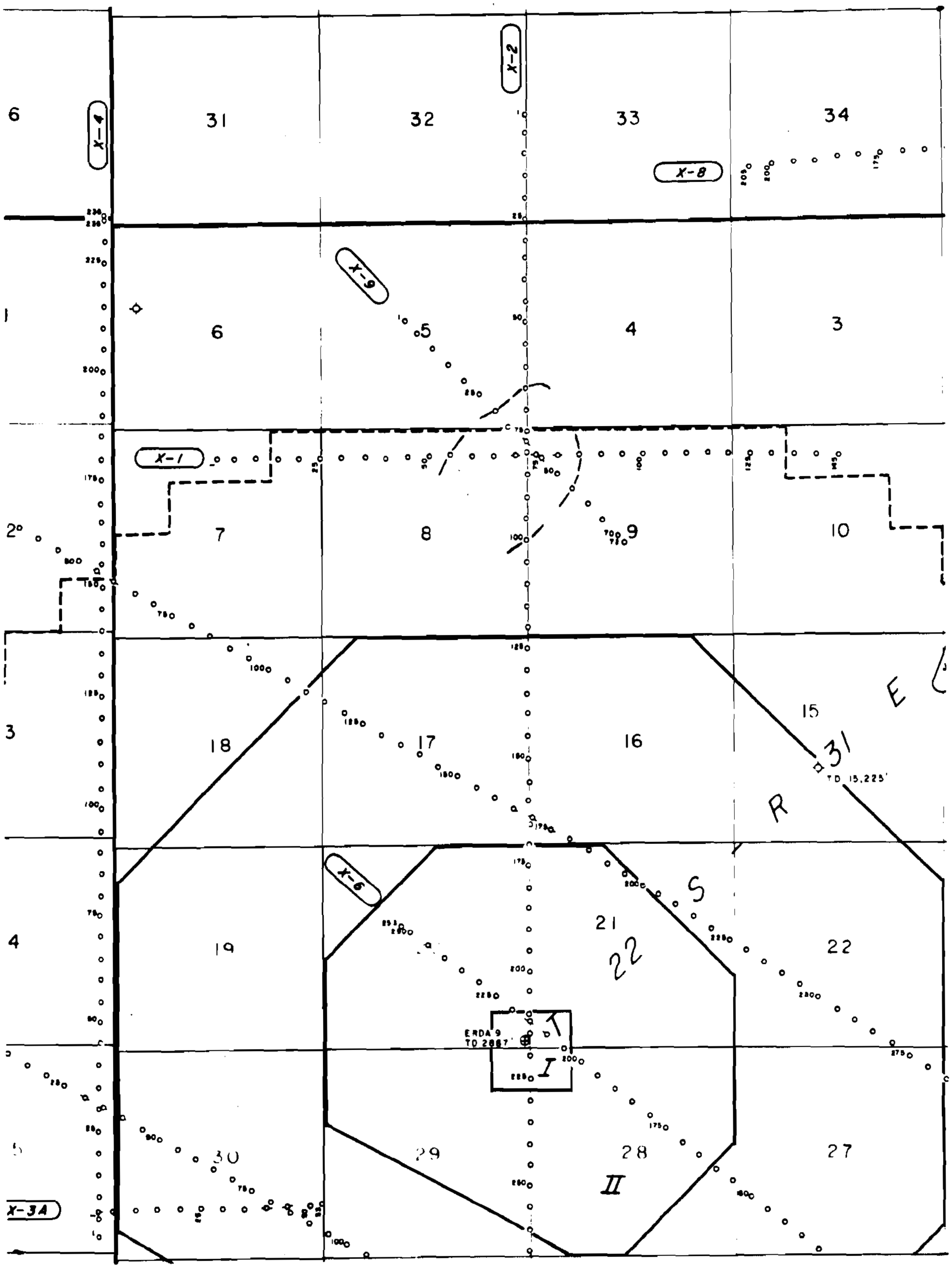
5311 Archives (2)



Map showing location of seismic reflections lines X-1, X-2, and X-9. Dashed lines show location and approximate limits to anomaly in sections 8 and 9, T22S, R31E. WIPP 11 is located at point 77 along X-1.

FIGURE 1

FIGURE 2

Part of line X-1 showing anomaly between points 55 and 85 and WIPP 11 location. Scale is about 1:1; 550 feet between dark vertical lines

A. Without interpretation.
B. Interpretation showing top of Salado Formation, Castile horizon near top of formation, and Delaware sand reflector.

LINE X-1

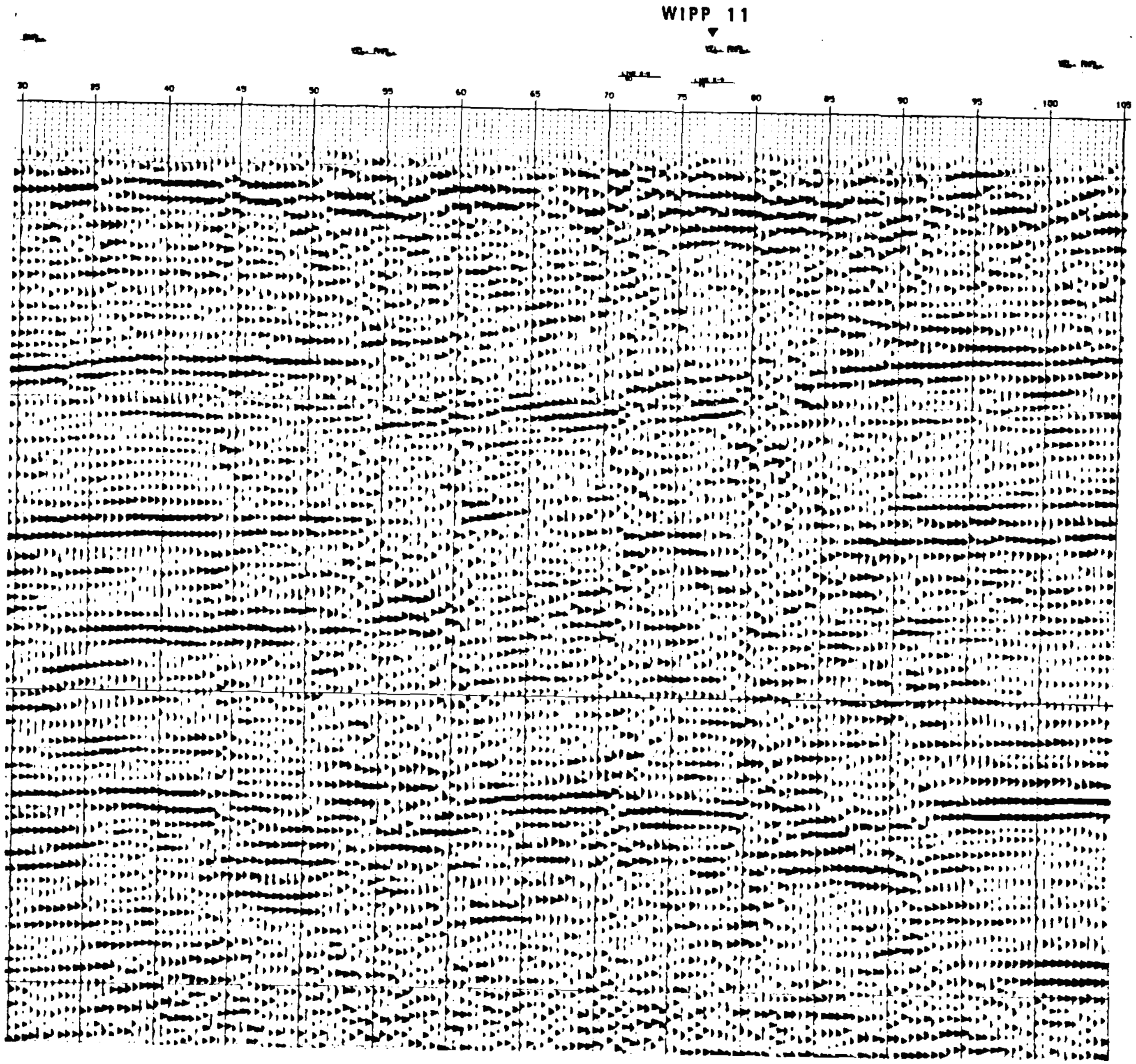


FIGURE 2A

LINE X-1

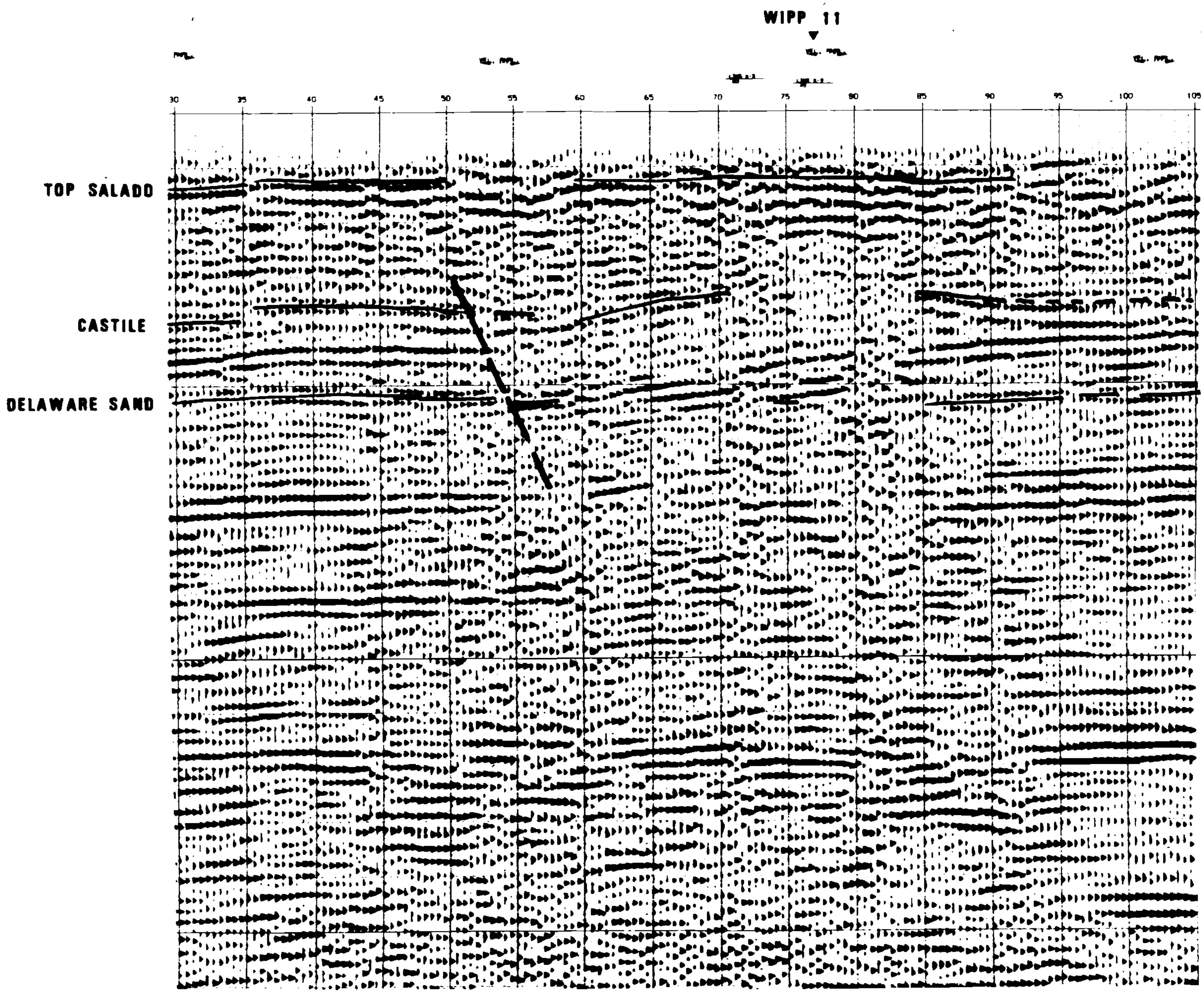


FIGURE 2B

Figure 3.

Part of lines X-1 showing anomalous region between points 65 and 100. Scale is about 1:1; 550 feet between dark vertical lines

A. Without interpretation.
B. Interpretation showing top of Salado Formation, Castile horizon near top of formation, and Delaware sand reflector.

LINE X-2

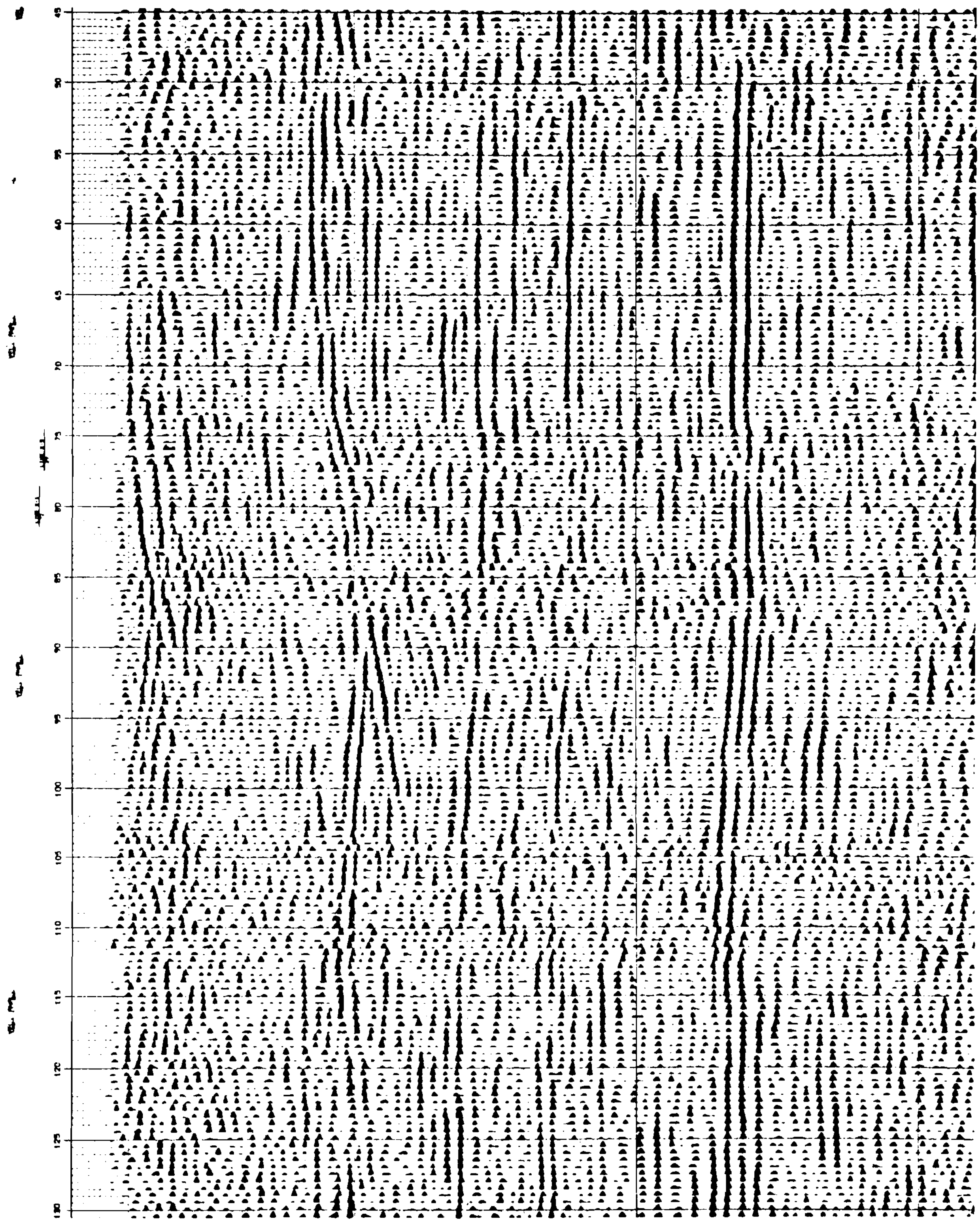


FIGURE 3A

LINE X-2

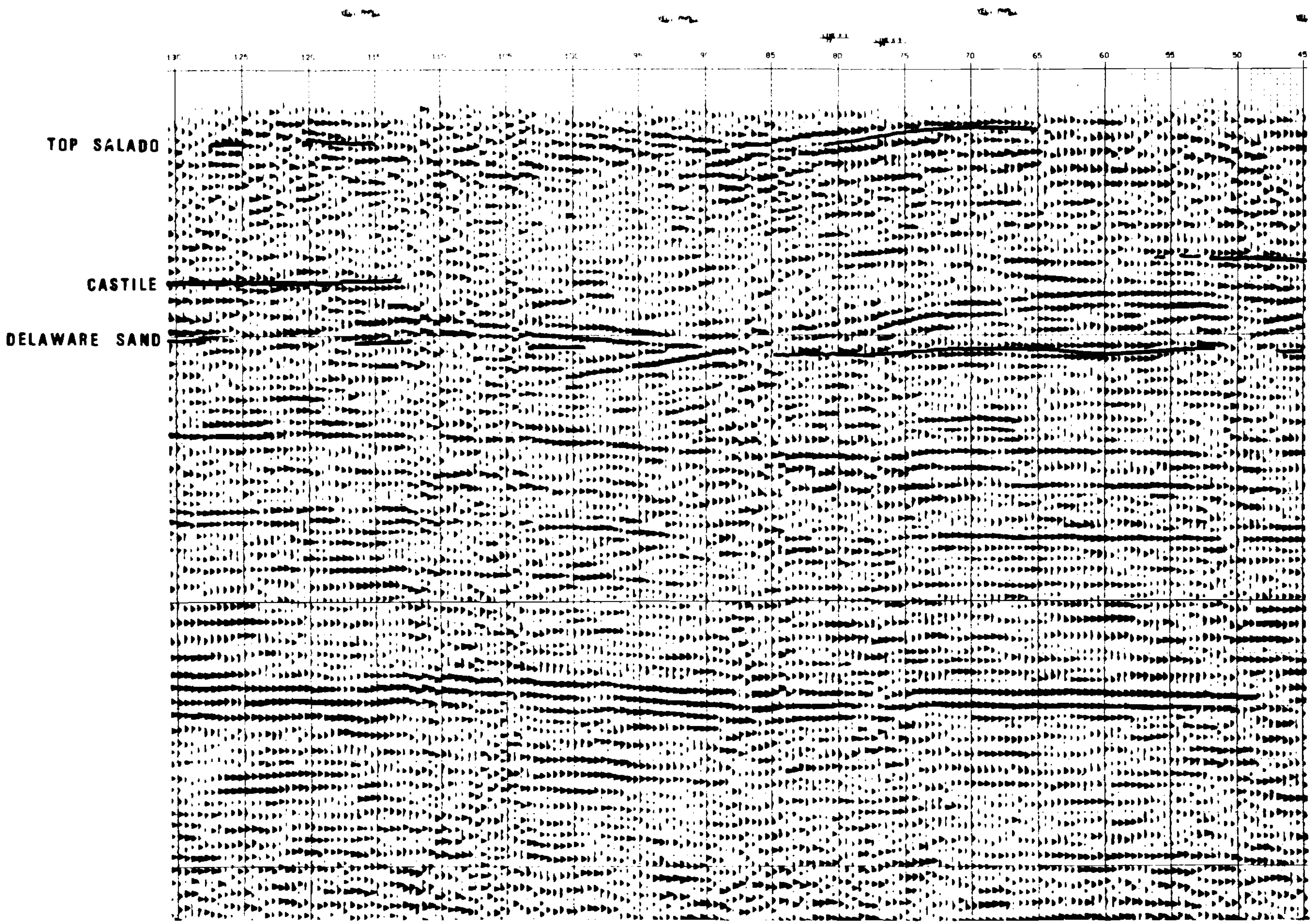


FIGURE 3B

FIGURE 4

Part of line X-9 showing anomalous region between points 30 and 55. Scale is about 1:1; 550 feet between dark vertical lines.

A. Without interpretation.
B. Interpretation showing top of Salado Formation, Castile horizon near top of formation, and Delaware sand reflector.

LINE X-9

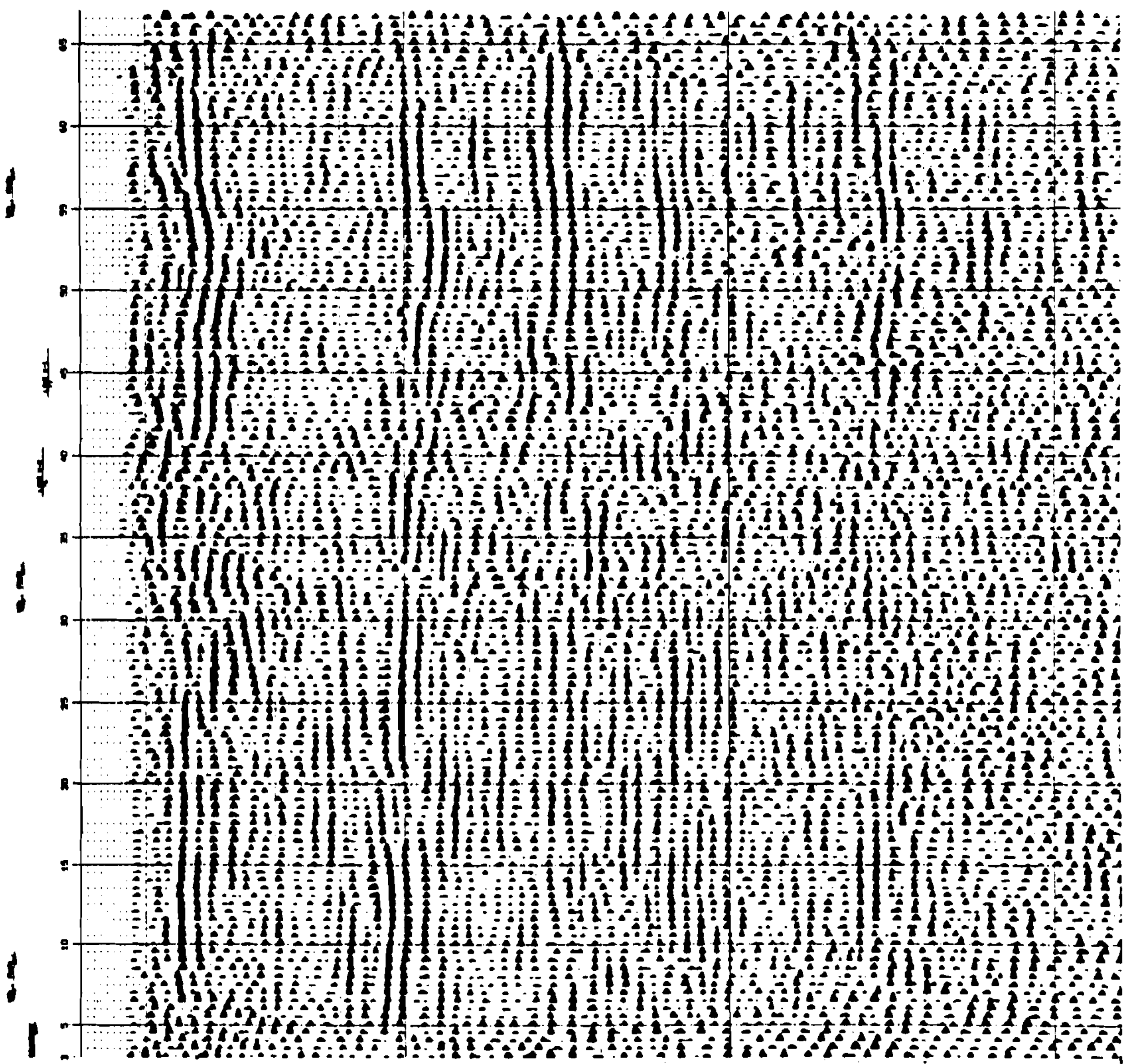


FIGURE 4A

LINE X-9

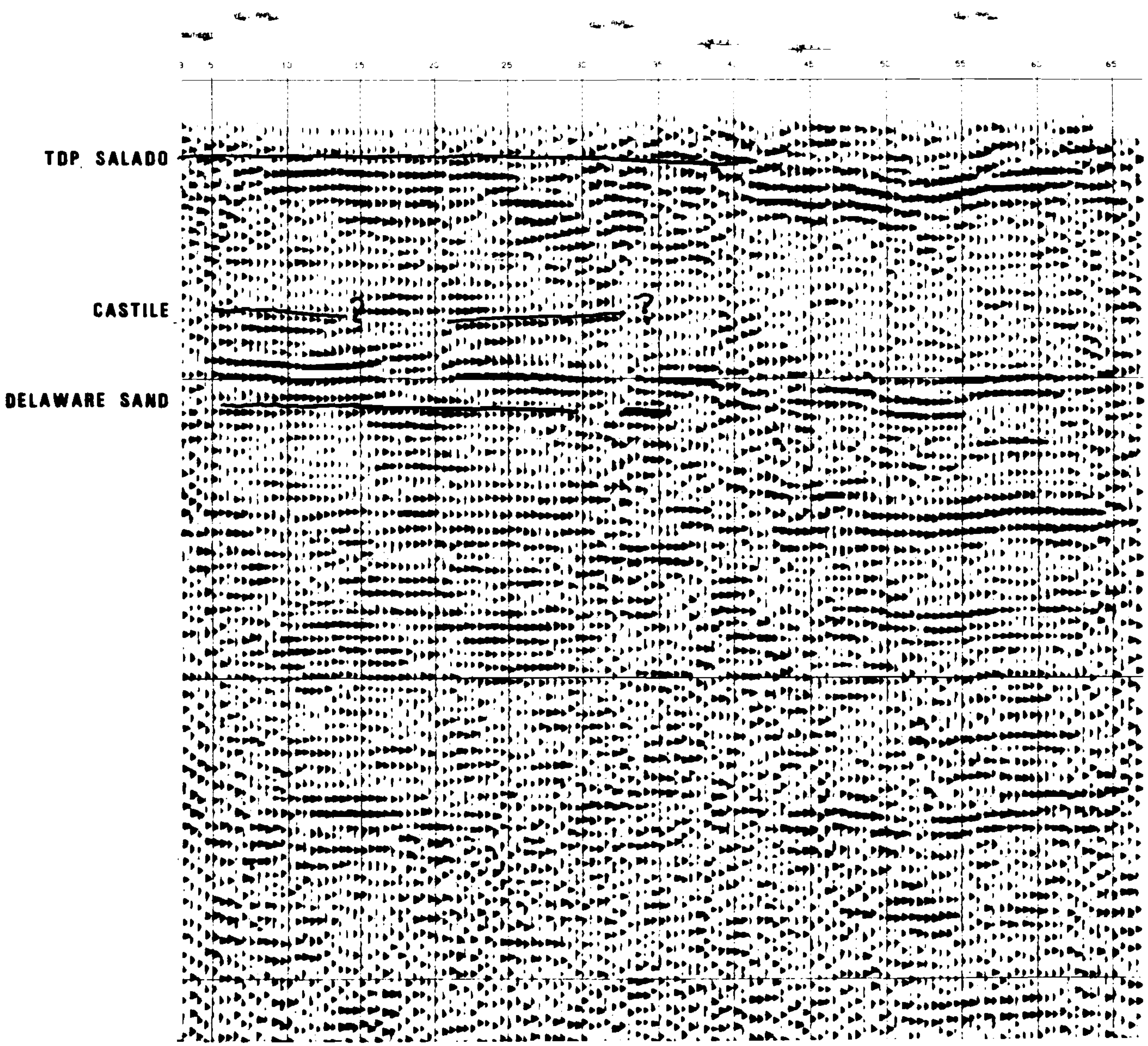


FIGURE 4B

APPENDIX B

DRILLING AND TESTING PLAN

compiled by

R. D. Statler

Division 1133

and

P. D. Seward

Division 1135

Sandia National Laboratories

INTRODUCTION TO APPENDIX B, DRILLING AND TEST PLAN

The drilling and testing plan is the translation of technical objectives contained in the document 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.

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: January 26, 1978

to: Distribution

from: R. D. Statler - 1133

subject: WIPP 11 Drilling Program, Schedule and Test Plans

The exploratory hole designated as WIPP 11 is scheduled to be drilled beginning late January 1978. The selected location is very nearly three miles due north of ERDA 9 exploratory hole.

The enclosed document describes the drilling plan, schedule and test plans as they are presently understood. The testing program (Appendix C) will be forwarded to you under separate cover.

RDS:rj

Distribution w/enclosures:
C. L. Jones, USGS, Special Projects, Denver, CO
J. W. Mercer, USGS-WRD, Albuquerque, NM
R. E. Ashlock, F&S, Las Vegas NV
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1130 H. E. Viney
1135 P. D. Seward
5311 L. R. Hill
5311 D. W. Powers (3)
5311 S. J. Lambert
5311 J. W. McKiernan
5732 G. B. Griswold
9517 F. L. McFarling (2)
5311 Archives (2)
1133 R. D. Statler (5)

WIPP 11 Drilling Plan, Schedule
and Test Plans

A. Objective (as defined in memo, D. W. Powers to L. R. Hill, dtd 1/10/78, subject, WIPP-1

Summary - WIPP 11 will be drilled in the northwest corner of Section 9, T22S, R31E, to explore a structural anomaly in the Castile, Salado, and Rustler Formations. The anomaly is interpreted, on the basis of seismic reflection profiles, to be an anticlinal structure in the upper Castile and Salado Formations caused by salt flowage and thickening in the lower Castile. Lower Rustler and upper Salado show an apparent syncline; the synclinal structure may be the result of salt thinning or dissolutioning over the structure. Drilling is expected to be complete at 3200 to 3500 feet when the second anhydrite or lower halite of the Castile Formation is encountered. Core will be taken from potential aquifer zones, levels equivalent to repository horizons, and some of the upper Castile Formation. Geophysical logs, drill-stem tests, and mud logging will be important parts of the drilling operation. If suitable, the borehole will be maintained open for later testing of in situ stress and eventually will be converted to a hydrological osbservation hole.

Background - The area of the structural anomaly was originally pinpointed as anomalous by G. J. Long and Associates, Inc., during a review of seismic reflection data made available by the petroleum industry (G. J. Long and Associates, Inc., 1977). That review resulted in the location of two areas of anomalous seismic records in the northern Delaware Basin in the Salt Lake quadrangle. Fourteen of those anomalies are within the study area and its immediate surroundings. Because the anomalous records varied in quality, a program for new data collection was initiated in 1977 directed specifically at those 14 anomalies and the upper stratigraphic section of interest. That data is now available (Long and Associates, December 30, 1977) and is summarized below for the drilling of WIPP 11.

Geological Data - The geological data relevant to WIPP 11 consists of relatively shallow borehole data from potash holes, seismic reflection data, and resistivity data. The data from the seismic reflection program is most relevant to drilling WIPP 11.

The most consistent information available from industry and ERDA potash holes is marker bed 124 near the base of the McNutt potash zone of the Salado Formation. Griswold (1977) shows on his Figure 13 that the 124 marker bed slopes southeast at about 100 feet/mile (1^{o}). A low point, with about 50 feet of closure, occurs about one mile south of the WIPP 11 site. Contours of the top of the Salado (Griswold, 1977) are not as reliable although several low points with 20 - 70 feet of closures are shown within about one mile of WIPP 11. The top of Salado at WIPP 11 also dips southeast.

The resistivity data in sections 4, 5, 8, and 9 (T22S, R31E) show no anomalies associated with the WIPP 11 site. The trend of resistivity readings is from high in the east to low in the west. Other anomalies in the resistivity data in the study area are addressed elsewhere (Elliot, in preparation).

Seismic reflection data collected for Sandia is available from parts of three lines (X-1, X-2, X-9) in the immediate vicinity of the WIPP 11 location. The data are shown with preliminary interpretations of some reflectors. The interpretation is that salt flowage has occurred within the Castile Formation and has bulged upward within the upper Castile and lower Salado. Line X-1 shows evidence of faulting west of the WIPP 11 location through the upper Delaware Mountain Group and into the Salado. Line X-2 shows apparent synclinal structure near the top of the Salado Formation. Line X-9 is apparently along strike and shows less distinct dips. The approximate limits of the anomaly imply an anomaly as much as 2500 feet across.

The seismic data is showing a geologic anomaly possibly involving faulting and salt flowage forming on anticlinal structure. This structure bears some resemblance to that at ERDA 6 and may be related to the deformation zone in front of the Capitan reef (Anderson and Powers, in press).

Recommendations - The anomaly located near the northwest corner of Section 9, T22S, R31E, must be drilled to determine the extent and origin of salt flowage within the Castile and Salado at this location. The anomaly bears some structural resemblance to ERDA 6, and drilling will be necessary to determine if brine and gas are also associated with this structure. Indirect methods, such as seismic reflection, are not of value for this purpose.

The anomaly appears to be generally restricted to below the Salado Formation in view of resistivity data. The Rustler Formation is probably suited for hydrologic testing, and the borehole will be prepared for the circumstance.

Interpretation of the structural conditions within the lower Salado and upper Castile are of high priority in this borehole, and the stratigraphic relations may be difficult. Our experience in ERDA 6 shows that borehole geophysical logs may not be obtainable when brine and H_2S are present. The core taken is necessary for our structural interpretations. The recommendation here is to begin just above the Cowden with continuous core, as far as is consistent with safety requirements, to the middle anhydrite (Anhydrite 2) of the Castile Formation. Special core is needed to not penetrate into the Delaware Mountain Group because of the location of the borehole within the Known Potash Area (KPA).

Because of some potential for brine and gas within this structure, safety precautions during drilling operations will be extensive with special emphasis on blowout preventers, H_2S detection and protection, and gas sampling.

References - Anderson, R. Y., and Powers, D. W. Salt anticlines in the Castile-Salado evaporite sequence, northern Delaware Basin, New Mexico. Circular, New Mexico Bureau of Mines and Mineral Resources (in press).

Griswold, G. B. Site selection and evaluation studies of the Waste Isolation Pilot Plant (WIPP), Los Medanos, Eddy County, New Mexico. SAND77-0946, Sandia Laboratories, Albuquerque, New Mexico (1977).

Long, G. J., and Associates. Waste Isolation Pilot Plant (WIPP) Site Review - Final Report: open file report to Sandia Laboratories (1977).

B. Schedule

1. Drilling contract awarded December 1977

2. BLM permit received December 1977

3. Access road and drill pad complete by January 15, 1978

4. Notice to proceed given to drill contractor January 16, 1978

5. Expect spudding of hole to be approximately January 23, 1978

6. Completion data estimate by early March 1978.

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

Field Operations

1. Site selected and land surveyed. Land survey should consist of a plot showing Township, Range, Section, and distance in feet to the closest section boundary. Plot should show route of a 25 foot wide access road and layout of 300 feet x 300 feet drill pad. A temporary monument should be placed in a convenient corner of the drill pad and elevation above sea level to closest 1/10 of foot be established.

2. Archeological survey taken in conjunction with land survey for filing with land use permit application.

3. Temporary land use permit application for specific site filed with BLM for access road and drill pad.

4. File "Notice of Intention to Drill Exploratory Well" with USGS Area Geologist, Roswell; USGS Oil & Gas Commission, Artesia; USGS Area Mining Supervisor, Carlsbad; NM State Engineer, Roswell; NM Oil Conservation Commission, Santa Fe; as appropriate. Notify surface land lease holder and notify lease holder of Oil & Gas rights and lease holder of mineral rights, if any.

5. Award drill contract, purchase long lead time items. Negotiate other pertinent contracts as appropriate (mud, casing, coring, logging testing, etc.).

6. Award dirt contract, construct access road and drill pad with 6 inch caliche base, excavate 6 foot x 6 foot x 6 foot cellar, line with 3 inch timbers. Dry hole auger approximately 40 feet of approximately 18 inch diameter hole. Set 13-3/8 J-55 54# casing to GL. Cement annulus from TD to floor of cellar.

7. Excavate brine pit and reserve pits line with suitable material.

8. Move in rig and associated equipment required for safe drilling of wells containing hydrogen sulfide. Pad layout should be adapted from recommendation published by American Petroleum Institute Bulletin API RP49, latest edition.

9. Rotary a nominal 8 inch hole to approximately 1000 feet or about 40 feet below Rustler formation into the top of Salado Salt. Use conventional circulation with salt base mud as required to match formation. At each of three intervals, the Magenta, the Culebra and the Rustler/Salado interface take one or more 50 foot x 4-1/4 inch Ø core. Core is intended to aid in the analysis of fresh water acquifers above the salt. USGS-WRD representative will specify core intervals. Core will be logged, photographed, packaged and stored according to procedure outlined in Appendix A of this procedure.

   Drill crew will take cuttings at approximately 10 foot intervals from bottom of surface casing to TD. Depths of cutting source will be recorded on each package and made available on daily basis to geologist on duty. Cuttings will be handled and stored as outlined in Appendix A.

10. USGS-WRD crew may run gamma and neutron logs of top 1000 feet. Other commercial logs may be run as technical director chooses.

11. Make up hole opener and open hole to nominal 12 inch diameter to TD. Caliper log may be run at discretion of F&S manager. Run 9-5/8 inch OD 36# J-55 casing to TD with centralizers placed on at least two locations. Cement annulus using class "C" cement with 2% calcium chloride circulate, a minimum of 50% excess above calipered volume calculated to fill annulus. Test stand a minimum of 12 hours under pressure and a total of 24 hours before drilling plug to resume drilling.

12. Rig up gas and mud control equipment including B.O.P., drilling head, gas separator, choke manifold, kill lines, kelly-cock, remote B.O.P. controls, flare lines, wind indicators, and mud logging units. B.O.P. should be selected commensurate with possible severe hole conditions and tested and certified accordingly. A possibility exists of an Artesian brine pocket charged with high concentration of H_2S gas. Brine flow rates in the 10,000 barrel/day range may exist. Sufficient storage capacity should be on site to handle these maximums. Gas separator lines and flare lines should be equipped to allow samples to be taken of any fluids or gas produced. Drilling fluid should be saturated brine to match formation. Have a sufficient supply of H_2S inhibitor on hand for adding to drilling mud system as may be required.

13. Pick up nominal 8 inch drill bit and rotary down to approximately 30 feet above Cowden formation. Upon advice of duty geologist, switch to coring operation.

14. Take continuous 4-1/4 inch± core down to middle of massive anhydrite bed at the top of the Castile formation. Core logging, photographing, packaging, and handling will be carried out as defined in Appendix A. Clean and dress hole as necessary, and prepare for logging program as defined in Appendix B and drill stem tests as defined in Appendix C.

    Particular attention needs to be given to the nature of any gas pocket present for at this time a decision must be made whether or not to set a production string of casing. If hole is judged sufficiently safe, then coring operations can resume through the open hole down to the TD in Anhydrite Bed II in the Castile. This is the formation which is expected to produce the brine flow with or without H_2S.

    If serious gas pockets have been encountered in the drilling thus far, or if the Technical Director and/or the Manager of F&S operations suspect an unsafe condition, then a production casing string will be stood in upper massive anhydrite bed to the surface after logging and drill stem tests are completed.

    The production string will be 7 inches OD J-55 23# cemented at least up to Cowden with a mud pack in the annulus to the surface. Hole conditions may be such that cementing of annulus should be run even higher. After the cementing process, similar to that used in cementing surface casing, let cement stand a minimum of 12 hours under pressure and a total of 24 hours before drilling the plug to resume coring.

15. Resume coring with coring tool suitable for safe working inside 7 inch production string. Take continuous core to final TD in the middle anhydrite bed (Anhydrite II) of the Castile Formation. Special care must be exercised not to penetrate into the Delaware Mountain Group below the Castile. Geologists should closely monitor hole production to be sure TD is set without risk of a serious penetration below the Castile.

    Upon reaching TD in Anhydrite II, the objective is to complete the logging program and make tests for such as formation pressure and size of fluid reservoir if any, and take samples of fluids and gases present. Several options may exist for conducting test program. It is important to select one or more methods that are compatible with hole conditions and maintain acceptable safe practices.

    It should be noted that seismic reflection data may be interpreted to indicate that salt flowage has occurred in the Castile and has bulged upward within the upper Castile and lower Salado. Top of the Castile may occur any depth below 2500 feet as opposed to the 3000 feet earlier predicted.

16. When coring, testing and logging is completed, hole should be conditioned for setting a cement plug. If production string has been stood into the upper anhydrite bed of the Castile, then the hole should be plugged back to the level of cement in annulus around production casing. If no production casing has been stood, then hole should be plugged up into the lower salt unit of the Salado. Top of cement is uncertain at this writing, and will be established according to data given by logs and cores.

17. Condition well and leave loaded with salt based mud system. Remove B.O.P. and associated hardware. Install casing head with appropriate fixtures, valves and gages to monitor any gas release from well.

18. Rig down and release rig.

Quality Assurance

Certain features of this exploratory well may have a significant bearing on decisions about site selection and therefore a Quality Assurance Program is required for those activities that will produce important data and information. The activities or features requiring quality assurance are:

1. Location of the well.

2. Measurement of the ground level above sea level, and rig measurement such as height of kelly bushing and length of drill stems.

3. Drill depths as they affect determination of marker bed intercepts, core intervals, and formation thicknesses.

4. Direction of hole to establish that deviation is controlled within API recommended practices.

5. Drilling fluids monitoring and logging to the extent it is used to determine presence of formation gases and gluids.

6. Geologic logs to the extent they are used to determine formation geology and supplement data taken from core and cuttings examinations.

7. Coring, core logging, and handling.

8. Well bore and drill stem tests to the extent they are used to define well characteristics, formation character, fluid and/or gas reservoir strengths and character.

9. Cementing of casing annulus as required to separate specific aquifers and formations from communication when required by State and Federal regulation.

10. Bore hole plugging to the extent required to plug open hole and prevent intermixing of fluids and gases of different zones within salt beds.

Actual procedures to be followed during coring, logging, testing, cementing, and plugging operations will be published as appendices to this document.

Appendix A - Core and Core Handling Program
Appendix B - Logging Program
Appendix C - Testing Program
Appendix D - Cementing and Plugging Program

WIPP 11
Appendix A. Core and Core Handling Program

Cores with 4-1/4 inch nominal diameter are to be taken at four intervals in WIPP 11. The first three intervals are within the Rustler Formation through the Magenta, the Culebra and across the Rustler/Salado interface. Careful monitoring of drilling progress should permit minimizing core intervals to 50 feet for each of the three zones occurring in the first 1000 feet of hole.

The fourth interval should begin just above the Cowden, estimated between 2000 feet and 2500 feet depth. Coring should be continuous down to the TD estimated at 3200 feet.

If production string is necessary, coring will be interrupted within the upper anhydrite bed of the Castile until geologic logs, drill stem tests and casing operations are complete. Coring may then continue down to TD taking 3-1/2 inch core.

A duty geologist will log and measure core as it is removed from core barrel. Core will then be cleaned and photographed, and sealed within plastic sleeving before packaging in standard cardboard boxes. Boxes will be marked with hole identity and core interval. Core will then carefully be loaded in a transport vehicle by contractor personnel, as supervised by duty geologist, and taken to core storage in Carlsbad, New Mexico on South Canyon Street.

A coring record should be kept showing: date and tour, sequence of core interval, length of interval, depth of interval, footage of core recovered and percentage. 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 remove core from core barrel. All pieces are to be recovered and placed in troughs in the order they come out of the barrel for inspection and measurement. Troughs are marked orange or red indicating top end, and black indicating down direction.
2. Each major piece should be marked with a water-proof black ink arrow pointing in the direction the hole is advancing.
3. Log, identify and measure all core pieces, express to the 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 photo shed, set up to color photograph in sequence. Each picture should show Hole identity "WIPP 11", core run number, direction hole is advancing, and depth of interval.
5. As the photos are completed, separate pieces 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.
6. Transport boxed core to core storage taking particular care in handling and delivery to avoid damage to core.

WIPP 11

Appendix B. Logging Program

Geologic logs will be run in WIPP 11 to determine formation character as well as hole dimensions and direction. The information of interest and the probable logs to assist in the determination are:

Information	Probable Log
Sonic or Acoustic Property	BHC Acoustilog
Clay/Water (Hydrogen)	Neutron Log
Density	Densilog
Resistivity, Porosity, Water Saturation	Dual Laterolog, Dual Induction, Micro Laterolog
Lithology/Natural Radiation	Gamma Ray
Formation Dip	Dip Log
Hole Diameter	Caliper
Hole Direction	Directional Survey
Temperature	Top of Cement

It should be noted that the list of probable logs are trade names of a particular company and are not intended to imply the need for sole sourcing. An exception is the Dip Log, where the requirement does exist that it be done by Schlumberger.

The drilling plan for WIPP 11 is such that logging will probably have to be done in three phases as follows:

Phase 1: 0-1000 feet before casing.

1. Acoustilog BHC
2. Dual Induction Log
3. Micro-Laterolog
4. Densilog
5. Gamma
6. Neutron
7. Caliper

A temperature log may be desired to locate top of cement in annulus after casing.

<u>Phase 2</u>: 1000 feet to top of Castile before standing production string

1. Acoustilog BHC
2. Densilog
3. Dual Laterolog
4. Gamma and Neutron
5. Dip Log
6. Caliper
7. Directional Survey

<u>Phase 3</u>: To TD if possible

1. Acoustilog BHC
2. Densilog
3. Dual Laterolog
4. Gamma and Neutron
5. Dip Log
6. Caliper
7. Directional Survey

Mud logging service should be employed to determine the presence of hydrocarbons, H_2S, CO_2, and nitrogen. Systems used should be selected to minimize any interference within the measuring due to coexisting gases. Standard industry hydrocarbon measurements should be used to indicate the species of hydrocarbons as well as total hydrocarbons expressed as methane.

Approximate detection limits are:

H_2S - Lower limit: 1ppm or less

CO_2 - Lower limit: About 10ppm

N_2 - Lower Limit: About 2000ppm

Samples of gases or fluids are desired when requested by Technical Director.

The original recordings and 10 copies of all logs should be delivered to Fenix & Scisson, Carlsbad office, upon completion of service. A limited number of field prints may be requested at the well site as soon as logs have been run.

F&S will distribute log records as follows:

USGS-WRD J. W. Mercer (2)
USGS-Spec Proj. C. S. Jones
F&S, Carlsbad W. E. Cunningham (2)
5311 D. W. Powers (original + 1)
5311 S. J. Lambert
5311 Archives File

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: March 1, 1978

to: Distribution

from: R. D. Statler - 1133

subject: WIPP 11 Drilling

Attached for your information is WIPP 11, Appendix C, Testing Program.

enc.

Distribution:

C. L. Jones, USGS, Special Projects, Denver, CO
J. W. Mercer, USGS-WRD, Albuquerque, NM
R. E. Ashlock, F&S, Las Vegas NV
W. E. Cunningham, F&S, Carlsbad, NM (3)
1130 H. E. Viney
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5311 L. R. Hill
5311 D. W. Powers (3)
5311 S. J. Lambert
5311 J. W. McKiernan
5732 G. B. Griswold
9517 F. L. McFarling (2)
5311 Archives (2)
1133 R. D. Statler (5)

Appendix C - Testing Program

One objective in drilling the exploratory well WIPP-11 is to analyze and understand fluid or gas entry into the well base. The thickness of the formation, volume of the "reservoir" as well as the pressure and composition of the fluids are all important information.

During the drilling operation, difficulty can be expected in determining the presence of small pockets of gas. Particular attention must be given such things as any anomalous drilling rates, changes in mud density, gas detected at the separator or any visual evidence that might signify the existence of gas pockets or fluids and indicate a need for running a drill stem test.

If no significant quantities of fluids or gas have been encountered during the drilling or coring operation then the drill stem test intervals will be established after review of geological logs to be run after reaching TD.

Conventional drill stem tests will be used as a means of determining productivity of the subsurface formation in WIPP-11. In order to accomplish this, the selected test interval must be opened to atmospheric or reduced pressure.

The procedure is to lower the testing tool into the well bore on drill pipe with the tool closed to prevent entry of well fluids into the drill pipe. Well-bore packers will be included in the assembly below and above the testing tool, and expanded to block-off the zone to be tested.

The testing tool will then be opened, leaving formation fluids exposed to atmospheric pressure and allowed to flow into the empty drill pipe. The amount of fluid flow into the drill pipe will be used as a measure of the ability of the well to produce fluid. After a certain prescribed flow period, probably 30 minutes, the testing tool will be caused to close. This will allow the pressure of the formation to build back up while being recorded on a clock-driven recording device located within the testing tool.

The "shut-in pressure" will probably be held for 120 minutes during the first cycle. Alternate flow and shut-in pressures may be conducted up to three times with flow #2 probably held for 120 minutes and shut-in #2 held for 360 minutes. If flow #3 is considered desirable the flow period and shut-in period will be established in the field by the Technical Director.

It is estimated that three separate DST's will be run in WIPP-11 and that each test will take 36 hours to complete.

WIPP 11

Appendix D. Cementing and Plugging Program

The WIPP 11 exploratory hole is located within the known potash area (KPA) and within a water basin as designated by New Mexico State Engineers office.

State regulations require that acquifers be kept separate to avoid comingling and be kept out of the salt beds below.

Cementing of the casing will be carried out according to existing practices by a reputable supplier knowledgeable of such regulations.

Hole should be calipered for establishing the volume of cement required to fill annulus.

Sufficient quantity of class "C" cement with 2% calcium chloride to circulate up to 50% excess should be provided.

A casing pressure test should be applied as follows: displace mud with clear water; apply a pressure of 600psi and hold for 30 minutes and observe. If a pressure drop of 100psi or more should occur within 30 minutes, take corrective measures and repeat test. If pressure drop is less, cementing job is considered complete.

See page 2, Appendix D.

After completion of the drilling program for WIPP #11 the hole will consist of 9-5/8 inch casing set and cemented from the surface into the top of the salt at about 1000 feet depth. Below this depth the hole will be 7-7/8 inch down to the second Anhydrite bed in the Castile at approximately 3200 feet depth. The plugging operation will be done in two phases and will plug the hole from total depth to the bottom of the casing.

The first phase will place a continuous plug from total depth to approximately 2750 feet. After a period of testing and studies in the remaining open hole the phase 2 plugging operation will be accomplished. This plug may be continuous from about 2750 feet to the bottom of the casing or placed in two stages dependent on any "loss of circulation" zones noted during the drilling and coring operations.

The grout mixture for both phases of the plugging operation will be the same as the grout placed in plugs two and three of the ERDA #10 drill hole which was plugged during the early part of October 1977. The grout mixture is 70 percent Class C (sulfate resistant) cement/30% flyash with water and additives. This 70/30 mixture by volume equals 75/25 by weight. The mixing water will be salt-saturated (approximately 36 percent by weight of water). Other additives will include 2 percent Attapulgite (Brine gel), 2 percent calcium chloride, and a dispersant or friction reducing agent to improve flow characteristics of the grout during pumping. A silica sand (about 5 percent by weight) may be added to reduce the loss to the formation.

Volumes of each plug will be calculated from the caliper logs. My tentative recommendation for each plug is to include enough volume of grout for 50 percent excess over the calculated volume of the hole through the plug distance plus an additional 100 feet of hole (to be reversed out). This amount of excess volume is subject to adjustment during the preliminary meetings and the reviews of the drilling data and logs.

Preliminary meetings with the potential grouting contractors should be held during the next few weeks. These meetings should discuss the above proposed grouting plan including materials, equipment and operational procedures and quality control.

The quality control program will be provided by the Wagerways Experiment Station (WES) and will be similar to the one for the plugging of the ERDA #10 drill hole. WES will inspect the batching plant and all of the equipment before the grouting operations. Samples of all materials will be taken from storage and from the blended batches. Samples of the grout will be taken before and during the pumping of each plug and any grout returned to the surface during the "reversing out" of the grout from above the desired location of the top of the plug. The samples will be tested and evaluated at the WES Lab in Vicksburg as a part of the Borehole Plugging Development Program investigations.

The pumping rate and pressure will be monitored and continuously recorded. A flow meter will be added to the discharge line to the mud pit to compare directly with the pumping rate and to check for loss of grout to the formation.

I will maintain close liaison with Mr. Earl Cunningham of Fenix & Scisson, Inc., Ralph Bendinelli of WES, the grouting contractor and interested Sandia personnel until the plugging of WIPP #11 is completed.

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: March 9, 1978

to: W. E. Cunningham - F&S

from: R. D. Statler - 1133

subject: Modification to Drilling Program WIPP-11

Upon completion of taking core #23, expected to be at an approximate depth of 3191 feet, suspend continuous coring operations and begin rotary drilling. Drill until intercept with Anhydrite I has been definitely established. Estimate this to be about 3550 - 3600. Take a final core at total depth and then prepare for logging and any possible drill stem tests.

Following logging and testing leave well temporarily completed with saturated column of fluid standing.

Rig down and de-mobilize site.

RDS:ah

Distribution
C. L. Jones, USGS, Special Projects Denver, CO
J. W. Mercer, USGS-WRD, Albuquerque, NM
R. E. Ashlock, F&S, Las Vegas, NV
W. E. Cunningham, F&S, Carlsbad, NM (3)
1130 H. E. Viney
1135 P. D. Seward
5311 L. R. Hill
✓5311 D. W. Powers (3)
5311 S. J. Lambert
5311 J. W. McKiernan
5732 G. B. Griswold
9517 F. L. McFarling (2)
5311 Archives (2)
1133 R. D. Statler (5)

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: August 1, 1977

to: R. D. Statler - 1133

from: D. W. Powers - 1141

subject: Logging Program for ERDA #11

The primary purpose of ERDA #11 is to test the so-called seismic dropout in Section 8, T22S, R31E. Secondary purposes of the hole are to test the dissolution of the upper part of the Castile Formation and the hydrology associated with the Rustler Formation. In accordance with those purposes the following logging program is anticipated:

1. The USGS/WRD from Albuquerque will log the Rustler Formation as soon as that drilling is completed.

2. The entire hole will be logged, as appropriate, for the following:

Formation Character	Probable Log
Sonic or acoustic property	Acoustic log (BHC)
gamma ray	gamma ray
clay/water (hydrogen)	neutron
density	densilog
resistivity	dual laterolog
*dips	diplog
*velocity	up-hole seismic

*logs that are contingent on the information from the borehole.

It is possible that the gamma ray and sonic log will be necessary prior to initiating coring at the Cowden anhydrite to facilitate stratigraphic picks; however, it is likely that the WRD logging truck will be available for this purpose.

DWPowers:1141:bv

Copy to:
C. Jones, USGS, Denver, CO
W. Mercer, USGS, Albuquerque, NM
1140 W. D. Weart
1141 L. R. Hill
1141 S. J. Lambert
1141 D. W. Powers

Sandia Laboratories
Albuquerque, New Mexico
Livermore, California

date: August 4, 1977

to: R. D. Statler - 1133

from: D. W. Powers - 1141

subject: Mud Logging for ERDA 10 and 11

As we have previously discussed, there are four basic pieces of information desired from sampling gas separated from the mud in ERDA 10 and 11: hydrocarbons, H_2S, CO_2, and nitrogen. The further requirements of the monitoring system are:

1) Minimal interference within the measuring systems due to coexisting gases.

2) Standard industry hydrocarbon measurements indicating the species of hydrocarbons, and total hydrocarbons expressed as methane.

3) Detection limits approximately as follows:

for H_2S: lower limit 1 ppm or less

for CO_2: lower limit about 10 ppm

for N_2: lower detection limit about 2000 ppm.

Please understand that these are approximate limits that are not purposely designed to eliminate any potential contractor. These limits have been given in each instance by at least one field operator as reasonably obtained in the field. If further precision is readily available, we should take advantage of it.

As we also discussed with Mr. Cunningham, a system should be available where Steve Lambert can sample gases or fluids. He has expressed the desire to use glass sample bottles, and will, I presume, be able to advise you concerning any characteristics of the system he envisages.

DWP:1141:bv

Copy to:
W. E. Cunningham, F&S, Carlsbad
1141 L. R. Hill
1141 S. J. Lambert

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: January 25, 1978

to: R. D. Statler - 1133

from: D. W. Powers - 5311

subject: Borehole Logging of WIPP #11

After discussions with John Hern, it is apparent that a sonic or acoustic log will be sufficient for aiding interpretation of seismic reflection data. The uphole seismic velocity log requested in a previous memo may be disregarded. The sonic or acoustic log will be required from the surface down.

Our previous experience has indicated some contractors have difficulty supplying sonic logs through the section of interest. Because the interpretation of the seismic reflection work here is so important to analyzing the structure around WIPP 11, care should be taken in selecting the contractor best able to provide the sonic logging service.

DWP:5311:blk

Copy to:
W. D. Cunningham - F&S/Carlsbad, N.M.
5311 L. R. Hill
5311 D. W. Powers

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: February 6, 1978

to: R.D. Statler 1133

from: D.W. Powers 5311

subject: Marker Horizons in WIPP 11

Charlie Jones has estimated (verbally) the following depths at WIPP 11:

top Rustler Fm	630'
Magenta Dolomite	710'
Culebra Dolomite	810'
top Salado Fm	950'

Jerry Mercer has supplied approximate depths as follows:

Santa Rosa	20-140'
Dewey Lake	140-635'
Rustler Fm	635-935'
Magenta Dolomite	690-715'
Culebra Dolomite	810-885'
Salado Fm	935-2835'

John Hern has estimated depths from seismic data at WIPP 11:

top Salado Fm	950'
top disturbed zone	1830'
top Delaware	3900'

Carrying a Castile reflector through the disturbed zone indicates the top of Castile may be as shallow as 2500-2600'. The disturbed nature of the reflectors indicates we should be prepared for unusual stratigraphy in any case.

DWP:5311:dp

Distribution:
W.E. Cunningham, F&S, Carlsbad, NM (3)
C.L. Jones, USGS, Special Projects (c/o SLA, Carlsbad)
J.W. Mercer, USGS - WRD (c/o SLA, Carlsbad)
5311 L.R. Hill
5311 D.W. Powers

APPENDIX C

HOLE HISTORY

compiled by

R. D. Statler

Division 1133

and

P. D. Seward

Division 1135

Sandia National 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.
FS
engineering construction management
TULSA LAS VEGAS

PLEASE REPLY TO: TES:1204
P. O. BOX 498
MERCURY, NEVADA 89023

June 16, 1978

Mr. R. D. Statler, 1133
Sandia Laboratories
P.O. Box 5800
Albuquerque, New México
87115

CARLSBAD HOLE HISTORY

Enclosed is the original hole history on WIPP #11 for your distribution.

G. T. BRUESCH, MANAGER
TECHNICAL SUPPORT

GTB:it

cc: W. E. Cunningham w/encl. (4)
W. D. Sutherland w/encl.

FENIX & SCISSON, INC.

HOLE HISTORY DATA

DATE: June 8, 1978

HOLE NO.: WIPP #11	W. O. NO.:	I. D. NO.:
USER: Sandia Lab	TYPE HOLE: Exploratory	
LOCATION New Mexico	COUNTY: Eddy	AREA:
SURFACE COORDINATES: 709' FNL, 294' FWL, Sec. 9, T22S, R31E		
GROUND ELEVATION: 3426.12'	PAD ELEVATION:	TOP CASING ELEVATION:
RIG ON LOCATION: 2-4-78	SPUDDED: 2-6-78	COMPLETED: 3-14-78
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'	5'	Excavated		(6'x6'CELLAR)				0'	5'	Dirt
* 5'	40.4'	18"	12.715"	48#		H-40		0'	40.4'	81
53'	985'	12¼"	8.921"	36#		J-55		0'	985'	656
985'	3580'	8-3/4'								

TOTAL DEPTH: 3580'	AVERAGE MANDREL DEPTH:	FROM REFERENCE ELEVATION @
JUNK & PLUGS LEFT IN HOLE:		
SURVEYS PAGE:	CORING PAGE: 7	CU. FT. CMT. TOTAL IN PLUGS, ETC:
LOGGING DATA: Page 6		
BOTTOM HOLE COORDINATES: 872.8' FNL, 522.1' FEL @ 3583'		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.
13	Verna Drilling Co.	Brewster/Skytop		36.38			36.38
		N-4					

REMARKS: * *Site Prep Items*, Depths shown at ground level.

All depths shown are from kelly bushing elevation, 13' above ground level, except for site prep work.

Horizontal deviation at 3583' (log depth) was 280.8', N 35° E- Schlumberger dipmeter calculations.

PREPARED BY: DWS/it

TIME BREAKDOWN ON NEXT PAGE

WIPP #11

TIME BREAKDOWN

SITE PREPARATION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL		MOVE		RIG REPAIRS	
TRIPS		RUN CASING		W. O. DRILLING SUPPLIES	
SURVEYS		CEMENT CASING		CLEAN OUT FILL	
				SECURED WITH CREWS	
SITE DOT ______ DAYS		SITE OST ______ DAYS		SITE ODT ______	

TOTAL SITE PREP TIME ______ DAYS

REMARKS:

MAIN HOLE CONSTRUCTION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL	4.11	MOBILIZATION & DEMOBILIZATION		RIG REPAIRS	2.60
TRIPS	0.79	CORE	15.90	W. O. EQUIPMENT	0.19
DRESS DRILLING ASSEMBLY		LOG	2.40	FISH	1.62
SINGLE SHOT DEV. SURVEYS	0.25	CASED HOLE DIR. SURVEYS		CLEAN OUT FILL	
OPEN HOLE DIRECTION SURVEYS		UNLOAD CASED HOLE		UNLOAD WATER INFLOW	
EN HOLE	1.67	RUN MANDREL		REAM	2.13
		HYDROLOGICAL TESTS		PLUG BACK	
		Rig Up & Down Government Equipment	1.58	DRILL OUT PLUGS	
MAIN HOLE DOT 6.82 DAYS				SECURED WITH CREWS	
CASING OPERATION TIME (COT)		Circulate Samples	0.15	W.O. Loggers	0.18
RUN 9-5/8" CASING	0.29	Nipple Up	0.19	Mix & Condition Mud	0.39
RUN ______ CASING		Lay Down Drill Pipe	0.41	Repair Government Equipment	0.28
CEMENT 9-5/8" CASING	0.92				
CEMENT ______ CASING				Magnaflux Drill Collars	0.27
DRILL OUT SHOE	0.06				
MAIN HOLE COT 1.27 DAYS		MAIN HOLE OST 20.63 DAYS		MAIN HOLE ODT 7.66 DAYS	

TOTAL MAIN HOLE CONST. TIME 36.38 DAYS

REMARKS:

TOTAL ELAPSED TIME

TOTAL SITE PREP TIME		DAYS
TOTAL MAIN HOLE CONST. TIME	36.38	DAYS
SEC. W/O CREW SITE PREP		DAYS
.. W/O CREW MAIN HOLE CONST.		DAYS
TOTAL SUSPENDED (NO RIG)		DAYS
TOTAL ELAPSED TIME	36.38	DAYS

REMARKS:

WIPP #11

HOLE HISTORY

1-17-78	A 6' x 6' cellar was excavated to 5' and lined with 3" x 12" boards. Link Rat Hole drilled an 18" hole to 40.4' with an auger rig. Set 13-3/8" O.D., 48#, H-40 casing at 40.4' (GL). Cemented annulus to the bottom of the cellar with 81 ft^3 of ready mix.
	Note: Depths reported will be from kelly bushing (KB) elevation 13' above ground level (GL) unless otherwise noted.
2-4-78	Moved in Verna Drilling N-4 Brewster rig #13 with a 96' L.C. Moore derrick and started rigging up.
2-5-78	Continued rigging up.
2-6-78	Completed rigging up at 1500 hours. Drilled 8-3/4" hole from 53' to 181' using mud.
2-7-78	Drilled 8-3/4" hole from 181' to 727'. Rigged up International Diamond Coring, Inc. equipment with 8-11/16" diamond core bit.
2-8-78	Cut core #1 from 727' to 786', recovered 57'. Ran 8-3/4" bit in the hole, reamed and washed to bottom. Drilled 8-3/4" hole from 786' to 856'.
2-9-78	Cut core #2 from 856' to 891', recovered 20'. Reamed core hole and drilled 8-3/4" hole from 891' to 950'. Cut core #3 from 950' to 991'. Lost 250 barrels of mud on trip in hole with core barrel.
2-10-78	Recovered 26.2' on core #3. Ran 8-3/4" bit in the hole washed and reamed to bottom. Conditioned mud for logging. Ran Schlumberger logs. Lost 7.5 barrels of mud while logging. Made up 12¼" hole opener and reamed hole from 53' to 263'.
2-11-78	Opened 8-3/4" hole to 12¼" from 263' to 784'. Pecos Valley Construction Co. sandblasted 9-5/8" O.D. casing.
2-12-78	Opened 8-3/4" hole to 12¼" from 784' to 985'. Conditioned mud to run casing. Ran Schlumberger caliper log. Ran 9-5/8" O.D., 36#, J-55 Foster casing in the hole to 985.18' (972.18' GL). Installed a Davis type guide shoe on bottom and a Davis type 702 float collar on top of the bottom joint at 943.68'. Centralizers were placed at 963.5', 701' and 357.96'.
2-13-78	Finished running casing. Cemented annulus to surface using BJ with 25 barrels of water ahead of 154 ft^3 of thix set cement with lost circulation material followed by 502 ft^3 of class "C" cement with 2% calcuim chloride. Displaced cement with 79 barrels of water and bumped plug with 1100 psi, Cement in place at 0425 hours. Waited on cement.

2-14-78 Cut off 13-3/8" O.D. and 9-5/8" O.D. casing at ground level. Welded a 7" casing hanger on the 9-5/8" casing. Welded the 13-3/8" casing to the 9-5/8". Installed 10" series 900 blow out preventer with Payne accumulator and 2 sets of controls, gas separator, choke manifold, flow line and flare line. Repaired blind rams.

2-15-78 Completed connecting up blow out hardware and tested to 1000 psi. Repaired leaks where inducated. Drilled out cement and 8-3/4" hole from 991' to 1130' using salt base mud.

2-16-78 Drilled 8-3/4" hole from 1130' to 1675'.

2-17-78 Drilled 8-3/4" hole from 1675' to 1997'. Ran USGS log.

2-18-78 Drilled 8-3/4" hole from 1997' to 2240'. Conditioned hole for logging. Ran USGS log. Made up 8-11/16" core bit and cut core #4 from 2240' to 2243'.

2-19-78 Completed cutting core #4 from 2243' to 2299', recovered 58.8'. Cut core #5 from 2299' to 2307'.

2-20-78 Completed core #5 from 2307' to 2359', recovered 59.5'. Cut core #6 from 2359' to 2368'.

2-21-78 Completed core #6 from 2368' to 2408'. Pulled out of hole, recovered 47' of core. Top 3' of outer core barrel had twisted off leaving 65' of outer barrel in the hole, top of fish at 2343'. Made up Star Fishing Tool's spear and bumper sub.

2-22-78 Ran in hole and recovered fish. Corrected depth to 2409'. Ran Schlumberger logs. Ran Sandia special instrumented drill collar in the hole and tested. Test was negative.

2-23-78 Laid down drill collar. Made up coring assembly and cut core #7 from 2409' to 2446'. Pulled out of hole, recovered 29' of core. Found bottom part of outer barrel had twisted off, overall length was 29.85'. Top of fish at 2412'. Made up fishing tools. Started in hole.

2-24-78 Completed trip in hole. Latched onto fish and recovered same. Ran Drilco bottom hole reaming assembly with 8-3/4" bit in the hole. Reamed from 2160' to 2170' and twisted off. Pulled out of hole and left 9 drill collars and Drilco assembly in the hole. Made up Star Fishing Tool's 7½" overshot, bumper sub and jars. Washed to top of fish and knocked to bottom. Latched onto fish and recovered same.

2-25-78 Joe's Inspection Service magnafluxed drill collar tool joints and found 1 cracked box. Ran 8-3/4" reaming assembly in the hole and reamed from 2160' to 2446'.

2-26-78 Pulled up to 2160' to ream second pass. Reamed to 2352' and twisted off. Pulled out of hole and left 10 drill collars and Drilco tools in the hole. Made up fishing tools and recovered fish. Ran 8-3/4" Drilco reaming assembly in the hole and reamed from 2360' to 2398'.

2-27-78	Reamed hole from 2398' to 2446', made 2 passes. Made up coring assembly with 8-11/16" diamond core head. Cut core #8 from 2446' to 2462'.
2-28-78	Completed core #8 from 2462' to 2485', recovered 30.6'. Cut core #9 from 2485' to 2530'.
3-1-78	Recovered 38.3' on core #9. Cut core #10 from 2530' to 2580', recovered 43.4'. Cut core #11 from 2580' to 2621'.
3-2-78	Completed core #11 from 2621' to 2630', recovered 46.9'. Cut core #12 from 2630' to 2642'. Started out of hole and shut down at 1000 hours for rig repairs.
3-3-78	Completed repairs at 0915 hours. Pulled out of hole and recovered 11.8' on core #12. Cut core #13 from 2642' to 2692', recovered 50.4'.
3-4-78	Cut core #14 from 2692' to 2742', recovered 50'. Measured out of hole and corrected depth to 2744'. Cut core #15 from 2744' to 2794'.
3-5-78	Recovered 49.9' on core #15. Cut core #16 from 2794' to 2844', recovered 46.9'. Ran in hole and washed 15' to bottom. Mixed mud and lost circulation material. Started cutting core #17.
3-6-78	Completed core #17 from 2844' to 2891', recovered 46.5'. Cut core #18 from 2891' to 2941', recovered 50'.
3-7-78	Cut core #19 from 2941' to 2991', recovered 50'. Rotary table locked up at 2953', repaired same.
3-8-78	Cut core #20 from 2991' to 3041', recovered 49.2'. Cut core #21 from 3041' to 3091', recovered 50'.
3-9-78	Cut core #22 from 3091' to 3141', recovered 50.4'. Cut core #23 from 3141' to 3191', recovered 50'. Repaired rotary chain. Made up 8-3/4" drilling assembly and ran in hole.
3-10-78	Reamed hole to bottom and drilled 8-3/4" hole from 3191' to 3394'. Pulled out of hole and made up core barrel. Started cutting core #24.
3-11-78	Completed core #24 from 3394' to 3444', recovered 50.45'. Cut core #25 from 3444' to 3479'.
3-12-78	Completed core #25 from 3479' to 3495', recovered 50.8'. Made 1' depth correction and cut core #26 from 3494' to 3534', recovered 40.3'. Coring assembly was stuck on bottom and worked loose by pulling 60,000# over weight of string. Core bit was damaged. Found 3/8" x 1" hex head bolt missing from drilling head flange, may have fallen in hole.

3-13-78 Made up 8-3/4" drilling assembly and ran in hole. Reamed and washed 60' to bottom. Drilled 8-3/4" hole from 3534' to 3577'. Measured out of hole and corrected total depth to 3580'. Ran Schlumberger logs.

3-14-78 Completed logging. Laid down drill pipe and tools. Removed blow out equipment. Released rig at 2400 hours. Hole completed. Cut off the 7" casing hanger and welded a 10" series 900 flange on the 9-5/8" casing.

BIT RECORD

BIT NO.	MAKE	SIZE	TYPE	DEPTH OUT	FEET DRILLED	ROTATING HOURS
1	Hughes	8-3/4"	OSC3-J	950	897	28-3/4
2	Security	8-3/4"	S4TJ	2240	1249	53-1/4
3	Security	8-3/4"	M44N	2446	0	30-1/2 Reaming
4	Hughes	8-3/4"	OWVJ	3394	203	5-1/4
4 Rerun				3580	46	6-1/2

DEVIATION SURVEYS

DATE	DEPTH - FT	DEVIATION - DEGREES
2-6-78	96	1/4
2-7-78	237	1/2
	378	3/4
	478	3/4
2-8-78	856	1
2-16-78	1311	3/4
	1486	3/4
	1691	3/4
2-17-78	1964	1-1/2
2-18-78	2225	3
2-25-78	2351	2-3/4
	2398	6
2-26-78	2391	6
2-27-78	2391	6
	2422	6
3-2-78	2642	5-3/4

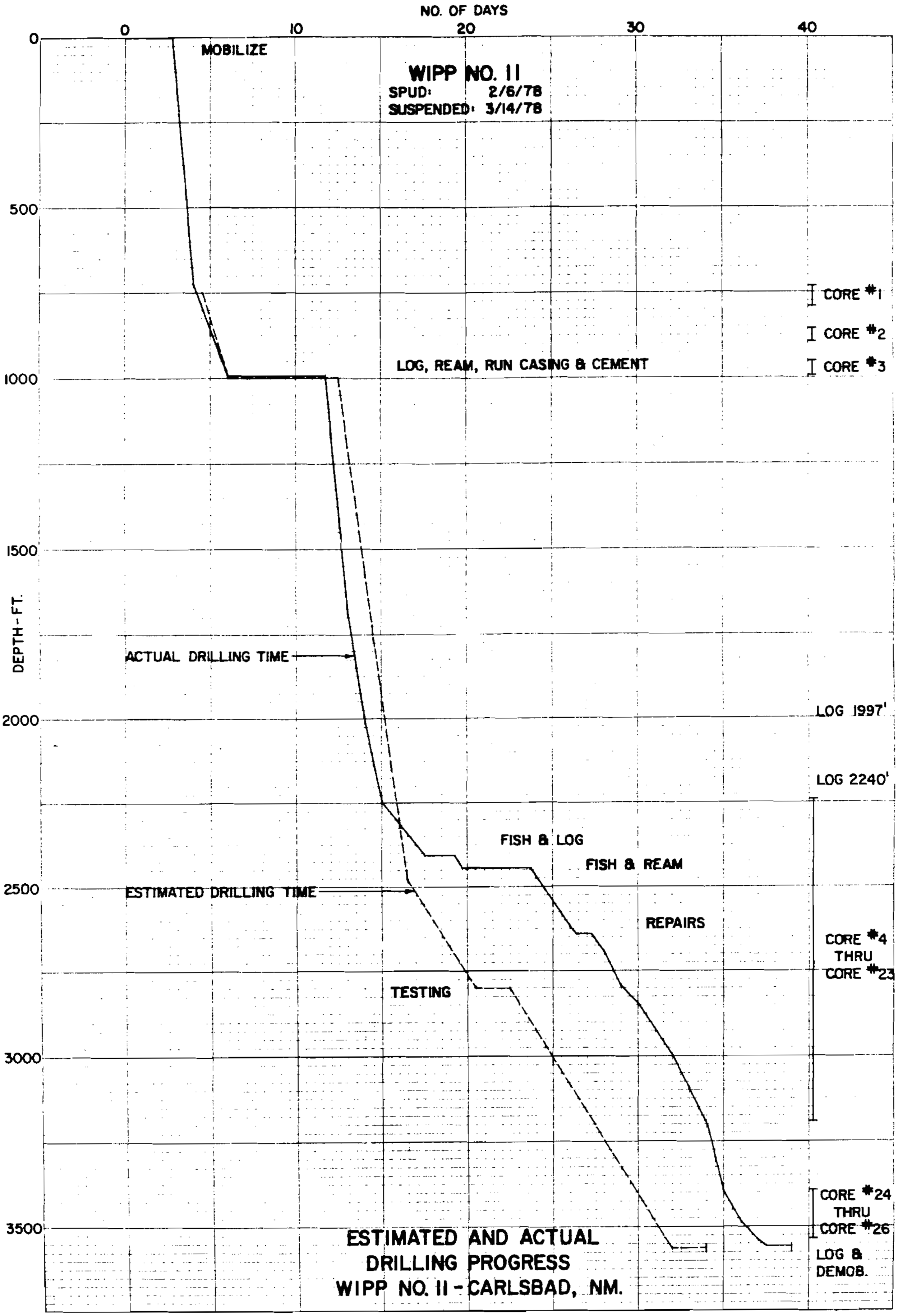
LOG INDEX SHEET

TYPE LOG	DATE	RUN NO.	DEPTH DRILLER	DEPTH LOGGER	LOGGED FROM	LOGGED TO
SCHLUMBERGER LOGS						
Caliper	2-12-78	1	987	987	53	986
Borehole Compensated Sonic Log	2-10-78	1	991	991	53	989
	2-22-78	2	2409	2411	900	2408
	3-13-78	3	3577	3577	2200	3580
Compensated Neutron-Formation Density	2-10-78	1	991	991	0	990
	2-22-78	2	2409	2411	900	2397
	3-13-78	3	3577	3583	2200	3582
Dual Laterolog Micro-SFL	2-10-78	1	991	991	53	989
	2-22-78	2	2409	2411	900	2397
	3-13-78	3	3577	3583	2200	3581
Dipmeter - Basic Data Log for Directional	2-10-78	1	991	991	53	990
	3-13-78	3	3577	3583	2200	3582
Continual Directional	2-10-78	1	991	991	53	990
	2-22-78	2	2409	2411	986	2410
	3-13-78	3	3577	3583	2200	3582
Directional Print - Out	2-10-78	1			40	991
	2-22-78	2			992	2409
	3-13-78	3			2212	3583
Dipmeter Arrow Plot- Job #2412	2-22-78	2	2409	2411	986	2410
Job #2427	3-13-78	3	3577	3583	2200	3582
Job #2443	3-13-78	3	3577	3583	2200	3582
Dipmeter Cluster Calculation Job #2412	2-23-78	2				
Job #2427	3-17-78	3				
Job #2443	3-30-78	1-2				
Core Lab Mud Log	3-17-78				40	3577

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

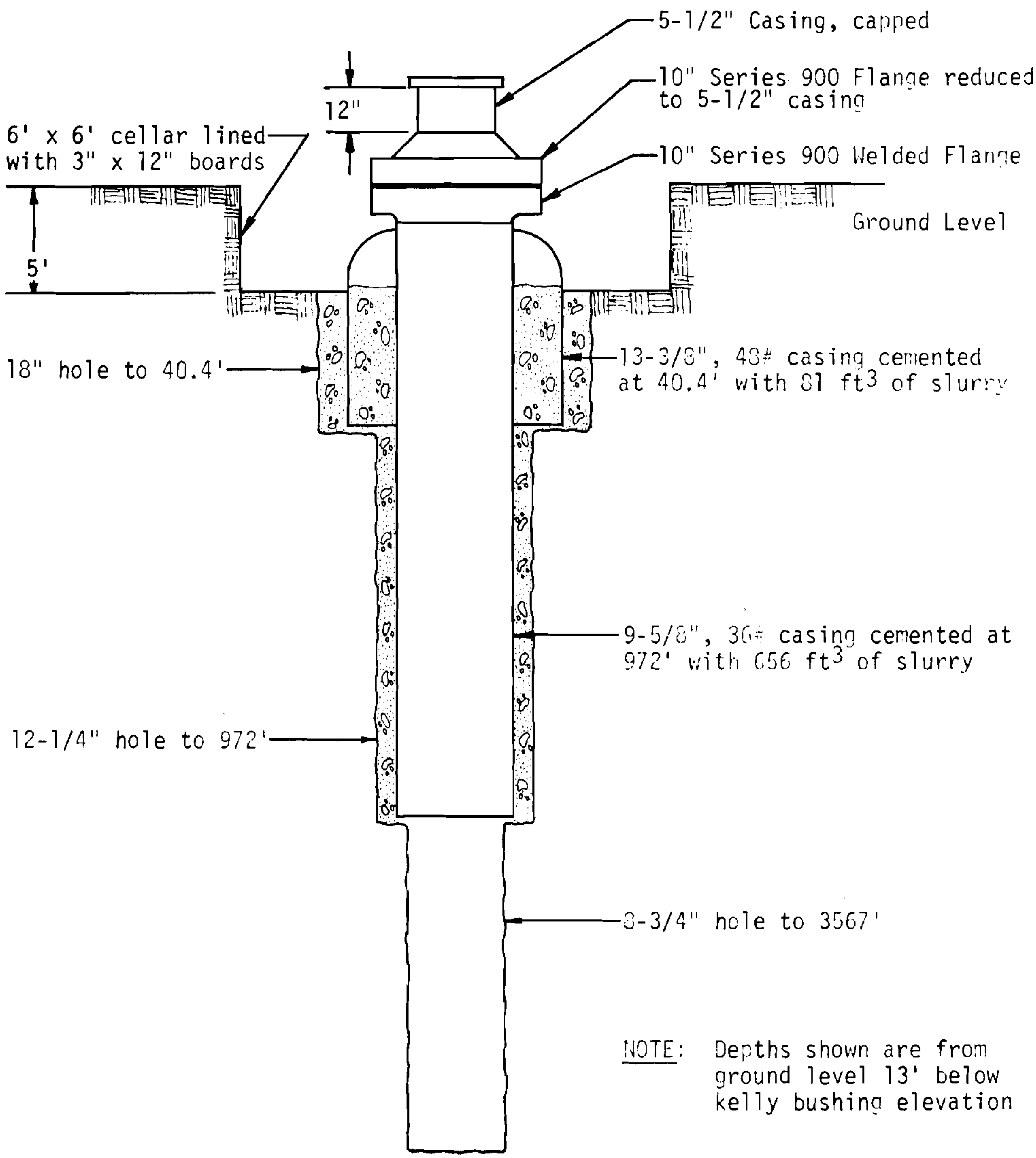
CORE RECORD
WIPP #11 HOLE HISTORY

CORE NO.	INTERVAL	FEET	RPM	WEIGHT ON BIT 000#	CIRCUL. PRESS PSI	FEET CORED	FEET RECOVERED	% RECOVERED	
	727	786	50	30,000	800	59	57	96.6	
2	856	891	60-80	25,000	650	35	20	57.0	
3	950	991	80	20,000	600	41	26.2	63.9	
4	2240	2299	40	16,000	400	59	58.8	99.7	
5	2299	2359	40	16,000	400	60	59.5	99.2	
6	2359	2408	48	18,000	600	49	47	96.0	
7	2409	2446	48	18,000	600	37	29	78.4	
8	2446	2485	60	20,000	600	39	30.6	78.5	
9	2485	2530	65	22,000	600	45	38.3	85.1	
10	2530	2580	70	22,000	600	50	43.4	86.8	
11	2580	2630	60	20,000	400	50	46.9	93.8	
12	2630	2642	70	20,000	400	12	11.8	98.3	
13	2642	2692.0	60	20,000	400	50	50.4	100.8	
14	2692	2742	65	22,000	500	50	50	100	NOTE: Pipe Talley Correc. 2742=274
15	2744	2794	65	21,000	600	50	49.9	99.8	
16	2794	2844	65	20,000	800	50	46.9	93.8	
17	2844	2891	70	24,000	800	47	46.5	98.9	
	2891	2941	70	24,000	800	50	50	100%	
19	2941	2991	70	25,000	500	50	50	100%	
20	2991	3041	70	24,000	500	50	49.2	98.4	
21	3041	3091	70	25,000	500	50	50	100	
22	3091	3141.0	70	22,000	600	50	50.4	100+	
23	3141	3191	65	25,000	500	50	50	100	Core Marked From 3141.4-3191.4
24	3394	3444	60	20,000	500	50	50.45	100+	Core Marked From 3394-3444
25	3444	3495	60	24,000	700	51	50.8	99.6	Core Marked From 3444.45-3494.1
26	3494	3534	60	20,000	500	40	40.3	100+	1-foot Correctio



ESTIMATED AND ACTUAL DRILLING PROGRESS WIPP NO. 11 - CARLSBAD, NM.

WIPP NO. 11



Not to scale.
As built hole conditions
as of 3-14-78.

SURVEY MONUMENT "AS BUILT"

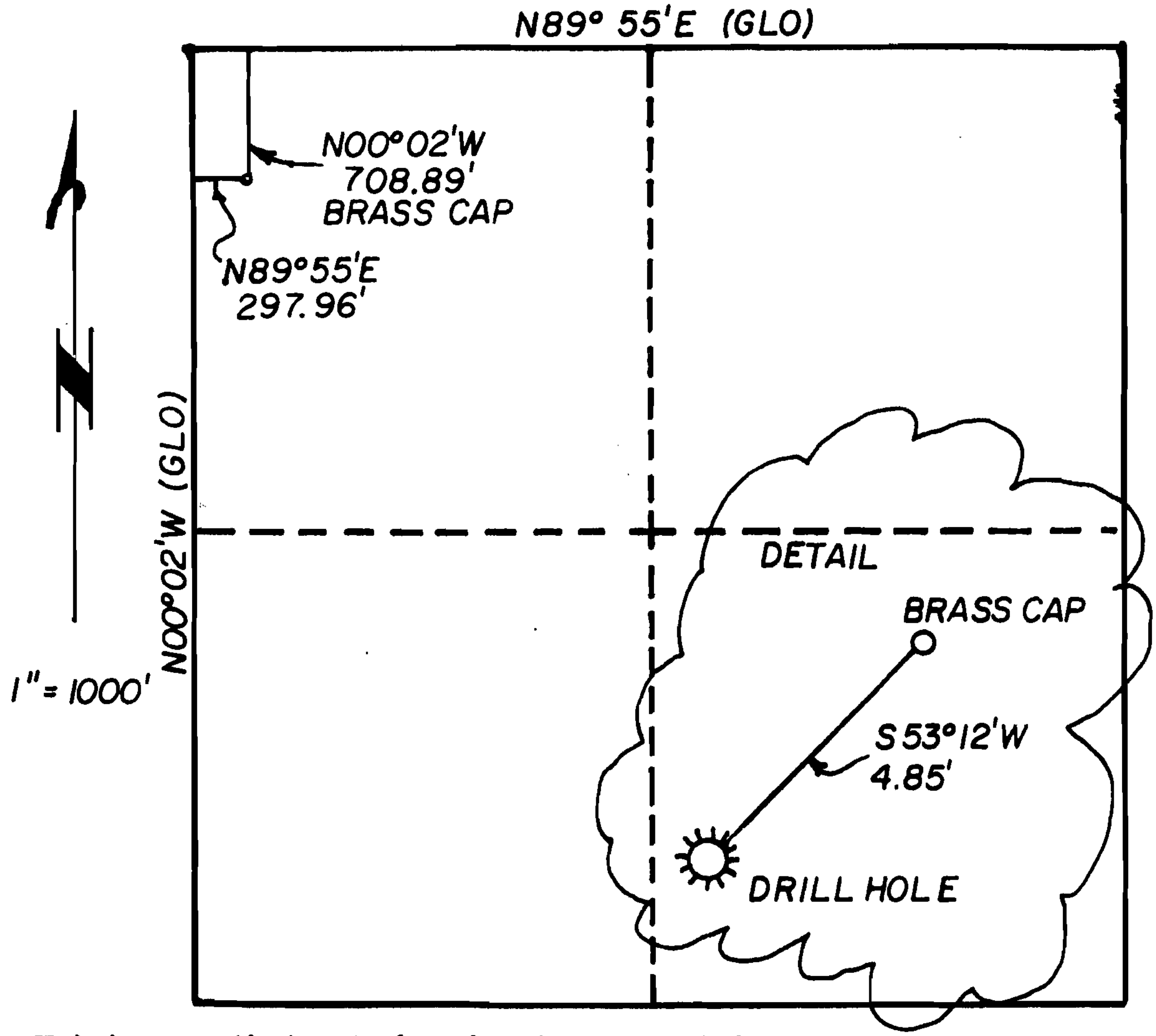
W.I.P.P. II

SECTION 9 , TOWNSHIP 22 S , RANGE 31 E, N.M.P.M.

EDDY COUNTY, NEW MEXICO

ELEVATION OF BRASS MONUMENT 3426.07'

708.89' FNL & 297.96' FWL



This is to certify that the forgoing plat was made from field notes of a bonafide survey made by me and is true and correct to my best knowledge and belief.

Dan R. Reddy

N.M.P.E. & L.S. NO. 5412

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

APPENDIX D

LOGS

compiled by

S-E. Shaffer
Division 4511
Sandia National Laboratories

WIPP 11 Logs[1]

Log	Company	ELSI#[2]	Top of Logged Interval[3] (feet)	Bottom Logged Interval (feet)	Date
BHC Sonic	Schlumberger	W7099W	Surface	3580	3-13-78
Compensated Neutron Formation Density	Schlumberger	W7099S	Surface	3582	3-13-78
Dual-Laterolog Micro-SFL	Schlumberger	W7099X	Surface	3581	3-13-78
Continuous Dipmeter	Schlumberger	W7099L	53	3582	3-13-78
Continuous Directional	Schlumberger	N/A	986	3582	3-13-78

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

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

[3]Depths measured from ground surface; elevation officially 3426.1' above MSL.

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