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Basic Data Report for Drillhole WIPP 30 (Waste Isolation Pilot Plant - WIPP)

Sandia Laboratories
United States Geological Survey

Sandia National Laboratories

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WIPP 30

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Compiled by
Sandia Laboratories
(Division 4511)

and

United States Geological Survey
(Special Projects Branch)

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by S. J. Lambert, 4511

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compiled by R. D. Statler, 1133, and P. D. Seward, 1135

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compiled by R. D. Statler, 1133, and P. D. Seward, 1135

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compiled by S-E. Shaffer, 4511

1.0 ABSTRACT

WIPP 30 was drilled in east-central Eddy County, New Mexico, in NW 1/4, Sec. 33, T21S, R31E, to obtain drill core for the study of dissolution of near-surface rocks. The borehole encountered from top to bottom, the Dewey Lake Red Beds (449' including artificial fill for drill pad), Rustler Formation (299'), and the upper 160' of the Salado Formation. Continuous core was cut from the surface to total depth. Geophysical logs were taken the full length of the borehole to measure acoustic velocities, density, and distribution of potassium and other radioactive elements. Information from this borehole will be included in an interpretive report on dissolution in Nash Draw based on combined borehole data, surface mapping, and laboratory analyses of rocks and fluids.

The WIPP is to demonstrate (through limited operations) disposal technology for transuranic defense wastes and to then be converted to a repository. The WIPP will also provide research facilities for interactions between high-level waste and salt. Administration policy as of February, 1980, is to hold the WIPP site in reserve until the first disposal site can be chosen from several potential sites, including the WIPP.

2.0 INTRODUCTION

The introduction describes background information on the Waste Isolation Pilot Plant (WIPP) and the investigations in Nash Draw which include WIPP 30.

2.1 The Purpose of WIPP

The purpose of the WIPP is distinct from that of several other projects for the disposal of radioactive waste. The WIPP is planned to demonstrate disposal technology for the transuranic (TRU) waste resulting from this nation's defense programs of over 30 years. After a period (5-10 years) of limited (pilot) operation, during which the waste is readily retrievable, it is anticipated that the WIPP will be converted to a full-scale repository for permanent disposal of defense TRU waste. The WIPP pla also include a research facility to examine, on a large scale, the interactions between bedded salt and high-level radioactive waste resulting from thermal and radiation fluxes. There is no plan at this time to dispose of high-level waste or spent fuel in the WIPP. DOE had expressed an intent to request licensing of the WIPP by the Nuclear Regulatory Commission (NRC). This licensing policy was not acceptable to the Congressional committees responsible for WIPP and DOE agreed to proceed without licensing. At this time (February, 1980) the Administration and the DOE are adopting the policy that the WIPP site should be held in reserve until the first disposal site can be chosen from several potential sites, including the WIPP. In addition, the Administration policy reflects a desire to dispose of military waste in licensed commercial waste repositories rather than in separate facilities.

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

2.2 The Purpose of WIPP Boreholes in Nash Draw

The origin of Nash Draw, located several miles west of the WIPP site, has most commonly been attributed to solution of underlying soluble

evaporite rocks and subsidence of the overlying rocks (e.g., Vine, 1963; Jones, 1973). The concern with the development of Nash Draw is to determine dissolution rates and/or processes such that the long-term threat to the WIPP may be evaluated. Bachman and Johnson (1973) estimated the lateral movement of the salt dissolution front as 6 to 8 miles per million years since the end of Ogallala time. Bachman (1974) also estimated the average rate of vertical dissolution in the area of Nash Draw over the past 600,000 years; that rate is about 330 feet per million years. Piper (1973) estimated the vertical dissolution rate as about 210 feet per million years; Swenson (in Bachman and Johnson, 1973) independently estimated the rate of vertical dissolution as about 500 feet per million years. Bachman (1976) recognizes additional, older episodes of dissolution in southeastern New Mexico which imply that the average rates may be too high over the shorter time period. The estimates of dissolution as average rates imply little apparent long-term threat to the WIPP.

The important problem remaining then is to determine the short-term (geologically) rates to assess any threat to the WIPP. The dissolution which occurred may be episodic rather than continuous. The Nash Draw boreholes (WIPP 25 through 30) are a direct approach to determining the processes and rates over shorter times. The processes can be determined by direct analysis of the core and borehole information. Stratigraphic analyses can reveal the affected beds and general time frame. Mineralogical and geochemical analyses of dissolution products may indicate process and rates. Hydrologic analysis is to determine if dissolution is currently active. The analysis of data from all boreholes may be combined with other data sources to interpret these processes and rates.

This is a report of basic geological and hydrological data from [illegible] as part of the investigation of dissolution in Nash Draw.

Additional details regarding the background and justification for [illegible] are found in Appendix A.

3.0 GEOLOGICAL DATA

by

R. P. Snyder[1] and S. L. Drellack, Jr.[2]

3.1 Abstract

Borehole WIPP 30 was drilled in east-central Eddy County, New Mexico, to obtain drill core for the study of dissolution of near-surface rocks. The borehole penetrated the Dewey Lake Red Beds and the Rustler Formation of Permian age and bottomed at a depth of 912 feet in the Salado Formation, also of Permian age. Evidence of dissolution was found in the Rustler Formation. Lithology and selected geophysical logs are presented in this report.

3.2 Introduction

Borehole WIPP 30 was drilled in east-central Eddy County, New Mexico. The surveyed location is 667.5 feet FNL (from north line) and 177.41 feet FWL (from west line), in Section 33, T21S, R31E (Figure 1). Continuous core was cut from the surface to TD (total depth) of 912 feet measured from a land-surface altitude of 3427.54 feet above MSL (mean sea level). Soil sample tubes (hollow tubes 30 in x 3 in. driven into the ground) were used for the first three cores to a depth of 6.6 feet, and a 10-foot split barrel with a 6 1/8-inch x 3 1/2-inch diameter core head was used for cores 4 through 44 (6.6-663 feet). A 25-foot barrel was used for cores 45 through 55 (663-912 feet) (Table 1). Drilling began on September 8, 1978, and ended on September 23, 1978. This hole is one of a series of holes drilled in Nash Draw to obtain data for use in studies of dissolution of the evaporite rocks of the Rustler and Salado Formation. The work was done for the Waste Isolation Pilot Plant (WIPP) project study on behalf of the DOE (U.S. Department of Energy).

All measurements related to the borehole (only) are reported in the inch-pound system. These units are used to facilitate direct comparison

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

[2] Fenix & Scisson, Inc., Carlsbad, NM.

WIPP-30
WIPP SITE

Table 1.--*Abridged borehole history of WIPP-30*

LOCATION: sec. 33, T. 21 S., R. 31 E.
667.50 feet FNL
177.41 feet FWL

ALTITUDE (LAND SURFACE): 3,427.54 feet. Datum for depth measurements in drilling and logging operations.

LITHOLOGIC LOG PREPARED BY: S. L. Drellack, Jr., J. L. Gonzales, and A. F. McIntyre (F&S), September 8 to 23, 1978.

DRILLING CONTRACTOR: Pennsylvania Drilling Co.

DRILLING RECORD: *Commenced drilling September 8, 1978, and completed on September 23, 1978.* Hole cased and capped pending conversion to hydrologic observation well.

Core No.	Depth interval Feet	RPM	Weight on bit (lbs)	Circulating pressure (lb/in²)	Interval Feet cored	Interval Feet recovered	Percent recovered
1	0 - 2.2	---	---	---	2.2	2.2	100.0
2	2.2- 4.4	---	---	---	2.2	2.2	100.0
3	4.4- 6.6	---	---	---	2.2	2.2	100.0
4	6.6- 12.0	85	1,000	150	5.4	3.0	56.0
5	12.0- 17.0	85	1,000	150	5.0	2.0	40.0
6	17.0- 21.0	70	5,000	200	4.0	2.6	65.0
7	21.0- 31.0	70	6,000	200	10.0	9.3	93.0
8	31.0- 41.0	75	6,000	200	10.0	7.3	73.0
9	41.0- 51.0	75	6,000	200	10.0	8.1	81.0
10	51.0- 61.0	75	6,000	200	10.0	9.3	93.0
11	61.0- 71.0	75	6,000	200	10.0	10.2	102.0
12	71.0- 81.0	75	6,000	200	10.0	10.0	100.0
13	81.0-102.0	78	8,000	200	21.0	15.3	72.4
14	102.0-121.0	78	8,000	200	19.0	14.0	74.0
15	121.0-131.0	75	8,000	200	10.0	9.1	91.0
16	131.0-156.0	75	8,000	225	25.0	18.6	74.4
17	156.0-166.0	75	5,000	400	10.0	[illegible]	[illegible]
18	166.0-176.0	70	7,000	[illegible]	10.	[illegible]	[illegible]
19	176.0-184.0	60	5,000	250	8.0	3.0	38.0
20	184.0-194.0	85	5,000	175	10.0	8.[illegible]	80.0
21	194.0-204.0	85	5,000	175	10.0	10	100.0
22	204.0-214.0	85	5,000	200	10.0	9.0	90
23	214.0-224.0	85	5,000	200	10.0	9.6	96
24	224.0-234.0	85	5,000	200	10.0	9.6	96
25	234.0-259.0	83	9,000	150	25	[illegible]	[illegible]
26	259.0-284.0	104	12,000	250	25.[illegible]	25.[illegible]	[illegible]
27	284.0-307.0	108	12,000	250	23	[illegible]	[illegible]
28	307.0-332.0	80	12,000	[illegible]	25	[illegible]	[illegible]
29	332.0-348.0	80	12,000	25.	[illegible]	[illegible]	[illegible]

Table 1.--*Abridged borehole history of WIPP-33*--Continued

Core No	Depth interval Feet	RPM	Weight on bit (lbs)	Circulating pressure (lb/in)	Interval Feet cored	Interval Feet recovered	Percent recovered
[illegible]	348.0-369.0	80	14,000	300	21.0	22.7	108.1
[illegible]	369.0-394.0	100	14,000	250	25.0	26.2	104.8
[illegible]	394.0-419.0	75	14,000	250	25.0	24.0	96.0
[illegible]	419.0-444.0	95	14,000	250	25.0	23.5	94.0
[illegible]	444.0-467.0	95	15,000	200	23.0	25.7	109.6
[illegible]	467.0-487.0	95	15,000	200	20.0	17.3	86.5
[illegible]	487.0-512.0	85	12,000	150	25.0	22.4	89.0
[illegible]	512.0-537.0	85	12,000	175	25.0	24.9	99.6
[illegible]	537.0-562.0	90	14,000	200	25.0	25.0	100.0
[illegible]	562.0-587.0	90	14,000	200	25.0	24.9	99.6
[illegible]	587.0-612.0	95	14,000	200	25.0	19.1	76.4
[illegible]	612.0-633.0	90	14,000	200	21.0	23.6	112.4
[illegible]	633.0-643.0	90	14,000	200	10.0	9.7	97.0
[illegible]	643.0-654.0	90	14,000	200	11.0	11.0	100.0
[illegible]	654.0-663.0	90	10,000	200	9.0	3.8	42.2
[illegible]	663.0-679.0	90	10,000	200	16.0	15.8	98.8
[illegible]	679.0-704.0	80	10,000	200	25.0	6.5	26.0
[illegible]	704.0-727.0	80	10,000	200	23.0	8.1	35.2
4[illegible]	727.0-744.0	75	8,000	200	17.0	8.0	47.1
4[illegible]	744.0-762.0	50/65	7,000-8,000	200	18.0	15.2	84.4
[illegible]	762.0-787.0	65	8,000	200	25.0	25.3	101.2
5[illegible]	787.0-812.0	100	12,000	200	25.0	24.7	98.8
5[illegible]	812.0-837.0	100	12,000	150	25.0	25.3	101.2
[illegible]	837.0-862.0	100	12,000	150	25.0	25.0	100.0
5[illegible]	862.0-887.0	85	12,000	150	25.0	25.0	100.0
[illegible]	887.0-912.0	85	12,000	150	25.0	25.1	100.4

[illegible] barrels 2.5 feet X 3.0 inches.

of measurements made by surveyors in establishing the geographic coordinates of the WIPP 30, by drillers in reporting well depth for cuttings and cores, and by geophysical loggers in recording inhole 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 Borehole WIPP 30

WIPP 30 was spudded in the Dewey Lake Red Beds of Permian age and penetrated 449 feet of siltstone and sandstone of this formation. Below the red beds, the hole penetrated 300 feet of evaporites (anhydrite, gypsum, and dolomite), siltstone, and mudstone (dissolution residue) of the Rustler Formation of Permian age. The normal thickness of the Rustler is about 460 feet (drill hole P-18, Jones, 1978). A minimum of 160 feet of the Rustler has been removed by dissolution of salt. The present thickness at the drill site may include an increased volume that occurs when anhydrite alters to gypsum.

Below the Rustler Formation, the borehole penetrated 164 feet into, and bottomed in the Salado Formation of Permian age. No evidence of dissolution of the formation was noted in the core. The base of Marker Bed 101 is about 111 feet below the top of the formation and this distance is within a few feet of the normal distance. Additional stratigraphic details are summarized in Table 2 and on Figure 2.

Core was logged at the drill site and a detailed lithologic log (Table 3) prepared by S. L. Drellack, Jr., J. I. Gonzales, and A. F. McIntyre of F&S (Fenix & Scisson, Inc.). Geophysical logs were taken the full length of the borehole as part of the exploratory work. The logging was done to facilitate the identification and correlation of rock units,

Table 2.--*Stratigraphic summary of borehole WIPP-33*

Rock unit	Depth interval[1] Feet
Permian rocks	
Dewey Lake Red Beds[2]	0-449
Rustler Formation	449-748
Magenta Dolomite Member	513-537
Tamarack Dolomite Member	631-653
Salado Formation	748-912 (TD)
Upper member	748-912
Salt interval	748-912
[3]MB 101	[4]862
[3]MB 102	[4]894
[3]MB 103	([5])
Maximum depth recorded	906

[1]Depth interval recorded from Compensated Densilog.
[2]Includes artificial fill for drill pad.
[3]Marker Bed.
[4]Base of rock unit.
[5]In bed at total depth.

Table 3.--*Lithologic log for borehole WIFP-1*

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

Lithologic description	Depth interval, feet
Siltstone, dark-reddish-brown (10R 3/4), fissile, calcareous, weathered; parts approaching mudstone in lithology	[illegible]
Siltstone, same as above; some moderately hard	2.2-[illegible]
Siltstone, same as above; two greenish-gray (5GY 6/1) zones approximately 2.5 cm thick; rock is laminated with alternating layers of siltstone and mudstone; trace manganese oxide stain coats bedding planes and vertical fractures; calcareous in part	6.6-9.5
No core	9.5-12.0
Siltstone, same as unit at 6.6-9.5 feet, with trace of greenish-gray (5GY 6/1) reduction spots 1-3 mm in diameter	12.0-14.[illegible]
No core	[illegible]
Siltstone, grayish-red (10R 4/2) to dark-reddish-brown (10R 3/4), hard to very hard; discontinuous, irregular, greenish-gray (5GY 6/1) 2.5-cm siltstone bands at 18.3 and 19.3 feet; irregular cavities 1-3 mm wide concentrated in 1-cm-thick zone at 18.8 feet; trace manganese-oxide staining	[illegible]
No core	[illegible]
Siltstone, dark-reddish-brown (10R 3/4), very hard, contains interbedded dark-reddish-brown (10R 3/4) moderately hard mudstone in laminae and beds 2 cm thick; numerous biotite crystals less than 1 mm wide, randomly dispersed; few grayish-green (10GY 5/2) reduction spots 1-2 mm in diameter. Sandstone bands, light-olive-gray (5Y 6/1) [illegible] yellowish-brown (10YR 6/2), very fine grained, very hard, well-sorted at 21.3, 22.5-23.0, 24.2-25.0, and 28.3-28.8 feet	[illegible]
Sandstone, dark-reddish-brown (10R 3/4), very hard, very fine grained, well-sorted	28.8-[illegible]
No core	[illegible]
Sandstone, grayish-red (10R 4/2) to dark-reddish-brown (10R 3/4), at 34.8 feet in a band of grayish-red (10R 4/2) to dark-reddish-brown (10R 3/4), soft, clayey, horizontal mudstone, 1 cm thick	[illegible]
Siltstone, dark-reddish-brown (10R 3/4), well-indurated; interbedded dark-reddish-brown (10R 3/4) moderately hard to hard mudstone, fissile, with horizontal partings; grayish-green (10GY 5/2) siltstone bands, horizontal, irregular, 1 cm thick at 36.9 and 37.5 feet; grayish-green (10GY 5/2) reduction spots, irregularly shaped, 1-8 mm in diameter at 36.2-37.0 feet	[illegible]
No core	[illegible]
Mudstone, dark-reddish-brown (10R 3/4), moderately hard, fissile, horizontal parting, some grading toward siltstone; two zones 3.05 and 9.2 cm thick of grayish-green (10GY 5/2) reduction spots 1-8 mm in diameter at 41.0 and 41.7 feet	[illegible]

Table 3.--[illegible] for borehole WIPP-30--Continued

Lithologic description	Depth interval, feet
[illegible] 4/2) to dark-reddish-brown (10R 3/4), hard, [illegible] grained sandstone, dark-reddish-brown [illegible] moderately hard mudstone, grayish-green (10GY 5/2) [illegible] hard siltstone bands 3 cm thick at 42.7, 43.3, 44.1, 45.2, [illegible] feet, horizontal zones of grayish-green (10GY 5/2) reduction [illegible] 4 mm in diameter, 1-2 cm thick----------	42.7- 48.[illegible]
[illegible] dark-reddish-brown (10R 3/4), very fine grained, very hard, [illegible] ----------	48.2- 49.1
[illegible] ----------	49.[illegible]- 5[illegible]
[illegible] (10R 3/4) to moderate-reddish-brown [illegible] to very fine grained sandstone and [illegible] moderate-reddish-brown (10R 4/6) firm, mudstone, [illegible] of greenish-gray (5GY 6/1) reduction spots, [illegible] few reduction zones 1-10 cm thick, core tends [illegible] low-angle partings 10°-15°, fractures 82° [illegible] ----------	[illegible]
[illegible] ----------	[illegible]
[illegible] at [illegible] feet, fractured in 76.8-77.3-foot [illegible] no displacement----------	[illegible]
[illegible] moderate-reddish-brown (10R 4/6) to dark- [illegible] hard, very fine grained sandstone at 81.0- [illegible] hard, horizontal siltstone band, [illegible] fractures at 85.0 and 95.5 feet, dip 70° and [illegible] perpendicular----------	81.0- 96.2
[illegible] ----------	96.2-102.0
[illegible] moderate-reddish-brown (10R 4/6) to dark-reddish-brown [illegible] hard greenish-gray (5GY 6/1) reduction spots 1-4 mm, [illegible] in diameter, some local small-scale crossbedding; [illegible] veinlets of gypsum (selenite) less than 1 mm thick; [illegible] siltstone band, [illegible] cm thick at 106.6 feet----------	102.0-116.2
[illegible] ----------	116.2-121.[illegible]
[illegible] same as unit at 102.0-116.2, slightly calcareous; some [illegible] elongated vuggy cavities associated with gypsum veinlets; fractures dip [illegible] at 12[illegible] feet and 67° at 123.4 feet; trace manganese-oxide on bedding and fracture surface----------	[illegible]-12[illegible]
[illegible] ----------	12[illegible]-131.[illegible]
[illegible] same as unit at 102.0-116.2 feet, parts approaching very [illegible] grained sandstone, some laminae of softer mudstone; fractures [illegible] at [illegible] feet, 45° at 13[illegible] feet, 60° at 140 feet and 70° at [illegible] ----------	13[illegible]-14[illegible]

Table 3.--*Lithologic log for borehole WIPP-30*--Continued

Lithologic description	Depth interval (feet)
No core	[illegible]
Siltstone, same as unit at 102.0-116.2 feet	[illegible]
No core	[illegible]
Siltstone, same as unit at 102.0-116.2 feet, fracture dips 30° at 177 feet	[illegible]
No core	[illegible]
Siltstone, moderate-reddish-brown (10R 4/6) to dark-reddish-brown ([illegible]), hard to very hard, some grading toward very fine grained sandstone, numerous greenish-gray (5GY 6/1) reduction spots 1-4 mm in diameter, well fractured, many very irregular hairline fractures dipping 0°-10° from horizontal	[illegible]
No core	[illegible]
Siltstone, same as unit at 184.0-192.2 feet; some hairline fractures partially filled with gypsum, fracture dipping 60° at 210.2 feet	[illegible]
No core	[illegible]
Siltstone, same as unit at 184.0-192.2 feet, greenish-gray (5GY 6/1) reduction spots, 2-8 mm in diameter; complex network of selenite veins [illegible] and 1.6 cm thick dipping 0°-5° from horizontal, mostly horizontal at 217.1 and 220.1 feet, reduction bands 6.0 and 3.5 cm thick at 224.4 and 222.7 feet	[illegible]
No core	[illegible]
Siltstone, same as unit at 184.0-192.2 feet, selenite veins 4 mm thick dip [illegible] from horizontal at 227.8 feet, 2 mm thick at [illegible] feet and dip 3° from horizontal	[illegible]
No core	[illegible]
Siltstone, same as unit at 184.0-192.2 feet, irregular selenite veins, many dipping 20°-50° from horizontal, parallel and conjugate at 234.0-239.4 feet, greenish-gray (10GY 6/2), slightly wavy, continuous horizontal siltstone bands at 237.4, 239.2, 241.3, 245.4, 246.0, and 249.7 feet, 3.4-6.1 cm thick	[illegible]
No core	[illegible]
Siltstone, same as unit at 184.0-192.2 feet; two gypsum-filled fractures 2 mm thick dip 70° from horizontal at 271.0-273.0 feet, horizontal gypsum band, 3.0 cm thick at 270.8 feet	[illegible]
Siltstone, same as unit at 184.0-192.2 feet, selenite veins [illegible] mm thick, mostly dip 0°-5° from horizontal, some dip [illegible]	[illegible]
No core	[illegible]
Siltstone, same as unit at 184.0-192.2 feet; some gypsum-filled veinlets, truncated and offset several millimeters by right-angle fractures dipping 60°-80°, zone of reduction at 232.9-332.9 feet	[illegible]
Mudstone, dark-reddish-brown (10R 3/4), very hard, greenish-gray ([illegible]) reduction spots 2-8 mm in diameter; few gypsum-filled [illegible]	[illegible]
same as above, some cut by 40°-70° fractures	[illegible]

Table 3.--Lithologic log for borehole WIPP-[illegible]--Continued

Lithologic description	Depth interval feet
[illegible], same as unit at 184.0-192.2 feet	350.6-3[illegible]
Mudstone, same as unit at 341.0-350.6 feet; silty unit from 371.5 to [illegible] feet	[illegible]
Siltstone, same as unit at 184.0-192.2 feet	394.[illegible]-4[illegible]
Mudstone, same as unit at 341.0-350.6 feet	4[illegible]3.5-4[illegible]
Siltstone, same as unit at 307.0-341.0 feet, at 420.4 feet trace pin-point [illegible], pits less than 1 mm deep in a band of greenish-gray (5Y 6/1) siltstone	418.0-4[illegible]
Mudstone, same as unit at 341.0-350.6 feet	421.3-42[illegible]
Siltstone, same as unit at 307.0-341.0 feet	42[illegible]
Mudstone, same as unit at 341.0-350.6 feet	425.[illegible]-42[illegible]
Siltstone, same as unit at 307.0-341.0 feet; mud parting at 430.3 and 439.5 feet, with coarsely crystalline selenite in partings	429.[illegible]-44[illegible]
Mudstone, same as unit at 341.0-350.6 feet	441.[illegible]-449
Gypsum, light-olive-gray (5Y 5/2) to olive-gray (5Y 3/2), finely crystalline, [illegible], some remnant anhydrite, medium-light-gray (N6) mud parting [illegible] at 450.2 feet	449.[illegible]-4[illegible]
Anhydrite, light-olive-gray (5Y 5/2), very finely crystalline, many parallel, wavy, irregular gypsum bands, mostly 2-6 mm thick, dipping [illegible] from horizontal	45[illegible].5-4[illegible]
Anhydrite and gypsiferous anhydrite, contact with unit below is wavy	454.[illegible]-4[illegible]
Mudstone, light-olive-gray (5Y 5/2), silty, soft, minor rounded gypsum fragments	48[illegible]-484
No core	484.3-48[illegible]
Mudstone, moderate reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), soft, silty, some pitting; parallel fractures at 487.6 and 489.0 feet, dip 4[illegible] from horizontal; minor gypsum nodules	[illegible]-4[illegible]
Mudstone and siltstone, medium-dark-gray (N4), very hard, gypsiferous; gradational contact with above unit	49[illegible]-4[illegible]
Gypsum, olive-gray (5Y 3/2) and light-olive-gray (5Y 5/2), mottled, finely to medium-crystalline; contact with siltstone above dips 12	4[illegible]
Gypsiferous anhydrite, moderate-brown (5YR 3/4) to light-olive-gray (5Y 5/2), very finely crystalline, with many irregular masses 1-3 cm thick and wavy bands of gypsum 1-2 mm thick, band of very finely crystalline gypsum 6 cm thick at 504.2 feet	5[illegible]
No core	5[illegible]
Gypsum, same as unit at 495.0-500.0 feet	[illegible]
Dolomite, light-olive-gray (5Y 5/2), and olive-black (5Y 2/1), banded with very thin, wavy, olive-gray (5Y 4/1) laminae, wavy, small-scale cross-bedding, gypsum pleb 2 X 5 cm at 538.0 feet	[illegible]

Table 3.--Lithologic log for borehole WIPP-[illegible]--Continued

Lithologic description	Depth interval, feet
Gypsum, light-olive-gray (5Y 6/1), olive-black (5Y 2/1), and pale-yellowish-brown (10YR 6/2), very finely crystalline, dispersed irregular veins and veinlets give mottled appearance	[illegible]
Anhydrite and gypsiferous anhydrite, medium-light-gray (N5) and light-gray (N7), very finely crystalline; branching veinlets of gypsum give "chicken-wire" appearance; gypsum-filled fracture 2 cm thick, dips 50° from horizontal at 558.3 feet	[illegible]
Mudstone, dark-greenish-gray (5G 4/1), soft, mottled with gypsum blebs throughout	[illegible]
No core	[illegible]
Mudstone, dark-reddish-brown (10R 3/4) and minor dark-greenish-gray (5G 4/1), soft, firm; few isolated gypsum crystals; contains gypsum nodules as large as 5 cm at 615.4-616.3 feet	[illegible]
Gypsum, brownish-black (5YR 2/1), very finely crystalline, shattered, contact with mudstone above dips 2°; grayish-green (10Y 5/2) remnant anhydrite in irregular, discontinuous bands and large irregular masses at 619.[illegible]-620.[illegible] feet	[illegible]
Mudstone, dark-reddish-brown (10R 3/4), and greenish-gray (5GY 4/1) gypsum	[illegible]
Gypsum, dusky-yellowish-brown (10YR 2/2), very finely crystalline	[illegible]
Anhydrite, medium-dark-gray (N4), very finely crystalline, many thin 0.5-1-mm dolomitic laminae, continuous and almost horizontal in lower 0.5 foot	[illegible]
Gypsum, dusky-yellowish-brown (10YR 2/2), very finely crystalline	[illegible]
Dolomite, moderate-yellowish-green (10Y 6/2), very finely crystalline laminated with dark-yellowish-green (10Y 4/4) laminae, with pits less than 1 mm in diameter; concentration of dark-yellowish-green (10Y 4/4) silty, dolomitic laminae 3 cm thick at 633.4 feet	[illegible]
Dolomite, light-olive-gray (5Y 6/1), with moderate-yellowish-green (10Y 6/4) tint, very finely crystalline, with pits 1-10 mm and some as much as 3 cm in diameter; some irregular cavities and hairline fractures filled with gypsum; few isolated zones of dark-yellowish-green (10GY 4/4) wavy laminae less than 1 cm thick at 643.7-651.0 feet	[illegible]
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, arcillaceous, with pits 1-2 mm in diameter; most pits filled with gypsum in lower foot; core gradually becomes olive-gray (5Y 4/1) towards bottom and is distinctly laminated	[illegible]
Mudstone, olive-black (5Y 2/1), soft, firm, numerous gypsum veins irregular, some interconnecting, low-angle to horizontal in lower 0.7 foot	[illegible]

[illegible] boreh[illegible] WIPP-[illegible]--Continued

[illegible]	Depth interval feet
[illegible]	65[illegible]
[illegible] (10R 4/[illegible]), soft, many fine crystals of [illegible] blebs, of [illegible]-gray (5Y 5/1) silt in [illegible] clasts of light-olive-gray (5Y 5/1) and olive-gray [illegible] in size at 663.5-663.9 feet	66[illegible]
[illegible] light-olive-gray (5Y 6/1) and medium-light-gray (N6), very [illegible], few irregular very thin laminae, 1 mm or less [illegible] horizontal trend, some areas of light-red [illegible] 7 feet, wavy band olive-gray (5Y 4/1) [illegible] horizontal, wavy irregular bands and stringers [illegible] (10R 4/6) to grayish-red (10R 4/2), clay in [illegible]	664.[illegible]
[illegible] 4/4 to grayish-red (10R 4/2), soft, pliable, [illegible] and fragments	671.[illegible]
[illegible]	684.[illegible]
[illegible] 4/[illegible], very argillaceous, moderately [illegible] at random angles, no specific orientation; [illegible]	703.1-711.[illegible]
[illegible]	711.2-726.[illegible]
[illegible] (5Y 5/1) to medium-dark-gray (N4), [illegible] hard, [illegible] fractured, numerous vugs [illegible] or [illegible]	726.1-734.[illegible]
[illegible]	734.1-74[illegible]
[illegible] dark-greenish-gray (5Y 4/1) and minor medium-gray (N5), [illegible] fracture dips 7[illegible] through section	743.1-744.4
[illegible] moderate-brown (5YR 4/4) and grayish-red (10R 4/2)	744.4-746.1
[illegible] medium-dark-gray (N4) and dark-reddish-brown (10R 3/4), soft, [illegible]	746.1-747.[illegible]
[illegible] crystalline, very argillaceous with dark-reddish-[illegible] clay	747.7-748.[illegible]
[illegible] dark-reddish-brown (10R 3/4), hard, halitic	74[illegible]-748.[illegible]
[illegible] translucent to transparent, pale-reddish-brown (10R 5/4) and [illegible] brown (10R 3/4) tint, finely to medium-crystalline; [illegible] anhydritic blebs and stringers; scattered [illegible] (10R 3/4) interstitial clay	74[illegible]
[illegible] translucent to transparent, medium-crystalline; trace of anhydrite [illegible] and stringers	76[illegible]
[illegible] crystalline, dark-reddish-brown (10R 3/4), [illegible]	76[illegible]

Table 3--Lithologic log for borehole WIPP-[illegible]

Lithologic description	Depth interval (feet)
Halite, translucent to transparent, moderate-reddish-brown (10R 4/6) [illegible], medium-crystalline; trace of greenish-gray (10G 5/2) clay, trace of anhydrite blebs and stringers	[illegible]
Halite, translucent to transparent, finely crystalline; dark-reddish-brown (10R 3/4) clay	[illegible]
Siltstone, moderate-reddish-brown (10R 4/6) to moderate-brown (5YR 4/4), halite, mottled with greenish-gray (10G 5/2), siltstone	[illegible]
Halite, translucent to transparent, medium-crystalline, argillaceous, dark-reddish-brown (10R 3/4); interstitial silt, trace of light-olive gray (5Y 6/1) and pale-red (5R 6/2) anhydrite blebs and stringers	[illegible]
Halite, finely crystalline, very argillaceous, dark-reddish-brown (10R 3/4) clay, trace of greenish-gray (5G 6/1) mud, vertical fracture as much as 1 cm wide at 792.2-793.5 feet	[illegible]
Halite, translucent to transparent, medium-crystalline, some finely crystalline, dark-reddish-brown (10R 3/4), clay, trace anhydrite blebs and stringers	[illegible]
Halite, translucent to transparent, finely to coarsely crystalline, moderate-reddish-brown (10R 4/6) to moderate-reddish-orange (10R 6/6) polyhalite blebs and stringers; interstitial silt, clay, moderate-reddish-brown (10R 4/6), some greenish-gray (5G 6/1), soft to moderately hard	[illegible]
Polyhalite, moderate-reddish-orange (10R 6/6), and white (N9), possibly trace of very light gray (N8) anhydrite, very concentrated network of halite stringers and blebs	[illegible]
Halite, translucent to transparent, medium-crystalline to coarsely crystalline, moderate-reddish-orange (10R 6/6), polyhalite blebs and stringers	[illegible]
Halite, moderate-reddish-brown (10R 4/6), very argillaceous	[illegible]
Halite, translucent to transparent, medium-crystalline to coarsely crystalline, interstitial moderate-reddish-brown (10R 4/6) clay, moderate-reddish-orange (10R 6/6) polyhalite blebs and stringers, white (N9) polyhalite blebs and stringers in lower 17 feet, very clean, nonargillaceous halite from 835.0 to 837.0 feet	[illegible]
Polyhalite and halite, moderate-reddish-orange (10R 6/6), very concentrated, medium- to coarsely crystalline polyhalite blebs and stringers, colorless halite	[illegible]
Siltstone, moderate-reddish-brown (10R 4/6), pale-red (5R 6/2) and medium-light-gray (N6), very hard, argillaceous	[illegible]
Clay, moderate-reddish-brown (10R 4/6), soft, randomly dispersed fine to medium crystals of clear halite	[illegible]

Table 3.--Lithologic log for borehole WIPP [illegible]

Lithologic description	Depth interval Feet
[illegible] at [illegible] 824.0 feet	[illegible]
[illegible] moderate-reddish-orange (10R 6/6) to light-red (5R 6/6), and [illegible] massive, numerous medium-crystalline halite blebs [illegible] to 86[illegible] feet	[illegible]
Halite, moderate-reddish-orange (10R 6/6), few stringers and many [illegible] horizontal polyhalite bands, 2-5 cm thick at 862.6, 8[illegible].9, [illegible] feet	[illegible]
[illegible] moderate-reddish-brown (5R 4/6) to grayish-red (5R 4/2), soft, [illegible] randomly dispersed finely to medium-crystalline, [illegible] crystals	[illegible]
[illegible], medium- [illegible] coarsely crystalline, moderate- [illegible] 4/6 to grayish-red (10R 4/2), soft, interstitial [illegible]	[illegible]
[illegible] unit at [illegible] 1-864.6 feet, finely to medium-crystalline, [illegible] white (N9) polyhalite or anhydrite, irregular, pale [illegible] polyhalite band [illegible] cm thick at 874.8 feet, some localized [illegible] interstitial clay 1-10 cm thick at 875.7-877.1 feet	[illegible]
Halite, same as unit at 866.3-873.3 feet	[illegible]
Halite, same as unit at 866.3-87[illegible] feet, less interstitial clay, few [illegible] 5R 6/6 to moderate-red (5R 4/6) polyhalite blebs, 1-6 cm [illegible] at 883.0-885.0 feet	[illegible]
Halite and polyhalite, halite, translucent to transparent, medium- [illegible] coarsely crystalline, numerous moderate-reddish-orange [illegible] and white (N9) irregular bands, stringers, and blebs of [illegible] polyhalite, irregular and branching polyhalite bands at 890.0-894.4 feet, [illegible] polyhalite bands at 892.1-892.4 and 893.9-894.5 feet, with 3-cm [illegible] light-gray (N6) clay band at bottom of second band	[illegible]
[illegible], colorless, finely to medium-crystalline; with interstitial [illegible] moderate-reddish-brown (10R 4/6) and dark-greenish-gray (5R 4/1) soft clay, some blebs of moderate-reddish-orange (10R 6/6) polyhalite, [illegible] mm in size, irregular stringers and blebs of light-olive-gray [illegible] anhydrite at 902.8-904.[illegible] feet	[illegible]
Anhydrite, olive-gray (5Y 4/1) to light-olive-gray (5Y 6/1), grading downward to gypsiferous anhydrite, very finely crystalline, numerous [illegible] zones of halite pseudomorphs after gypsum, 1-4 mm in diameter [illegible] and 9[illegible].4-9[illegible].1 feet	[illegible]

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 measurements. The geophysical logs included (1) a gamma-ray curve that recorded variations in the distribution of potassium and other radioactive elements, (2) a gamma-gamma curve that recorded variations in rock density, and (3) a neutron curve that recorded variations in the distribution of hydrogen.

4.0 HYDROLOGICAL DATA

No hydrological data have been obtained to date from WIPP 30. However, the borehole has been perforated, and observations have begun.

5.0 REMARKS

The first objective of the Nash Draw drilling program, to determine the stratigraphy of near-surface formations, is partially fulfilled; this report now provides the stratigraphic data to the top of the Salado Formation, and a few marker beds within the upper Salado, at WIPP 30.

The second objective, to examine the relationship between subsurface structure and surficial features and deposits, will be fulfilled through the integrated interpretation of the Nash Draw surface and subsurface data in this and other reports.

The third objective, to investigate the dissolution of soluble rocks by groundwater, will be met through field hydrology tests and laboratory examination of dissolution products to determine, as possible, ages and genesis. Both hydrological and laboratory programs are being initiated.

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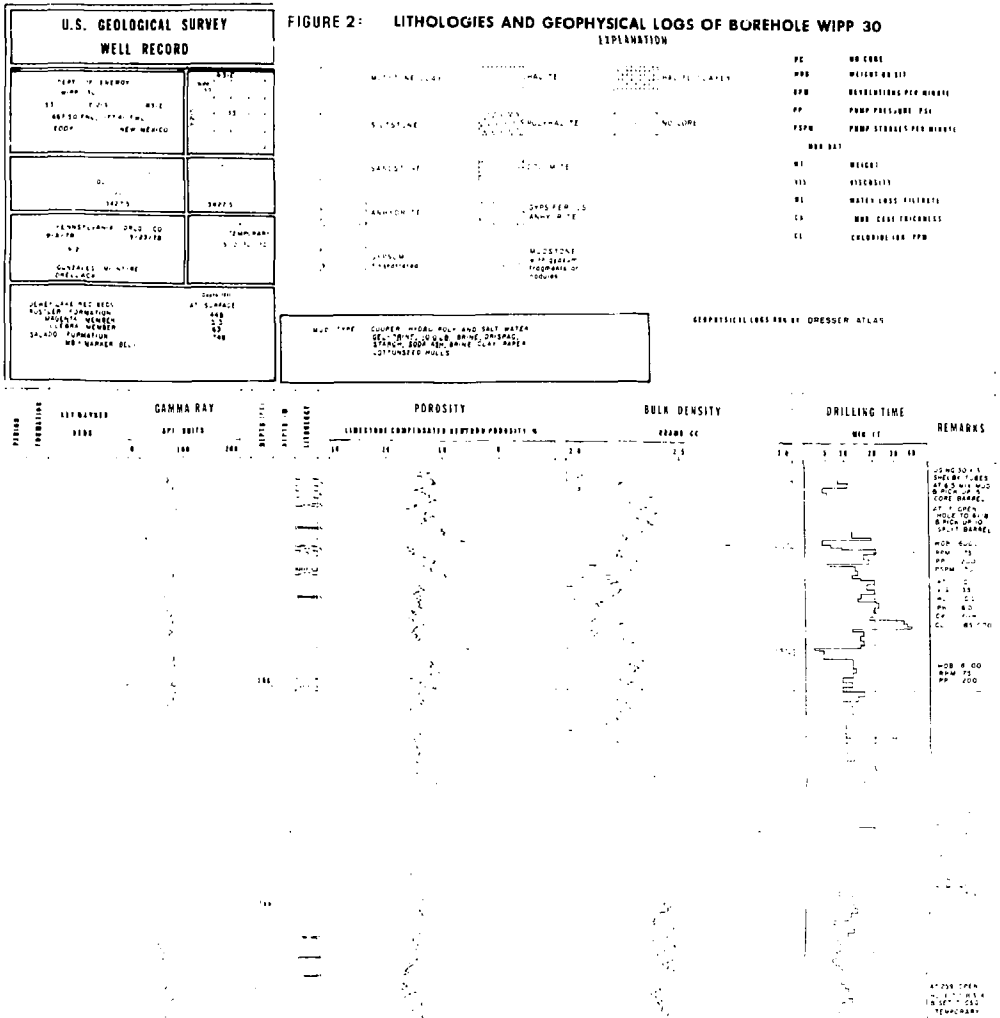

U.S. GEOLOGICAL SURVEY
WELL RECORD
FIGURE 2: LITHOLOGIES AND GEOPHYSICAL LOGS OF BOREHOLE WIPP 30
EXPLANATION
GAMMA RAY
POROSITY
BULK DENSITY
DRILLING TIME
REMARKS

PERMIAN

ORMATION

DEWEY LAKE RED BEDS

PERMIAN

APPENDIX A

JUSTIFICATION

by

S. J. Lambert
Division 4511
Sandia Laboratories

INTRODUCTION TO APPENDIX A, JUSTIFICATION

Appendix A consists of relevant portions of two related documents:

1) memorandum from S. J. Lambert to Distribution, dated 6/8/78, "WIPP Programs to Investigate the Nature and Effects of Salt Dissolution and Overburden Subsidence in the Vicinity of the WIPP site," and
2) memorandum from S. J. Lambert to R. D. Statler, dated 6/29/78, "Criteria for WIPP 25 Through WIPP 30, and Their Quality Assurance."

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

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

Date June 8, 1978

To Distribution

From S. J. Lambert - 5311

Subject WIPP Programs to Investigate the Nature and Effects of Salt Dissolution and Overburden Subsidence in the Vicinity of the WIPP Site

Definitions of Problems

Bedded deposits of Permian rock salt of the Ochoan epoch in southeastern New Mexico's portion of the Delaware Basin are not found near the surface because of halite's appreciable solubility. These deposits are preserved at depth where the overburden rocks' permeability is low enough to preclude the exposure of rock salt to significant amounts of circulating solutions which are not saturated with sodium chloride. When the overburden barrier is somehow breached, fluids may more easily reach the salt. The salt dissolves, is removed, and the overburden collapses into the void space left as a result of salt removal. Commonly this collapse is expressed at the surface as a set of features such as sinkholes, and a karst topography reminiscent of limestone terrain develops. Since the most prevalent soluble rocks of the Delaware Basin are halite and anhydrite, not limestone, the relationship between salt dissolution and subsequent development of karst-like surface features is not altogether well defined. Whereas limestone is but sparingly soluble in meteorically-derived water, and spectacular sinkholes may be observed at the surface in some localities, sinkholes which might develop in salt at depth are obscured by the overburden, which has since collapsed into commonly chaotic rubble, particularly near the surface. In addition, limestone has greater mechanical strength than rock salt, and has greater potential of maintaining an open sinkhole than salt, which has a tendency to self-seal under overburden pressure. Gypsum (formed from the original anhydrite by interaction with near-surface groundwaters) is intermediate in solubility between limestone and rock salt, and might more readily maintain a cavity than would rock salt.

An additional complication encountered in studying karstic features in southeastern New Mexico is the climate. The sparse vegetative cover in semiarid karstic regions leads to minimal soil stabilization; many small scale features indicative of subsurface dissolution of rock and collapse of overburden are filled in with poorly consolidated surface material almost as soon as they are formed. This appears to be the case of surface

fractures associated with subsidence over mines and cataclysmic collapse episodes (such as occurred at San Simon Sink in historic times). These fractures were quickly filled by blowing sand.

A primary concern for a radioactive waste repository in bedded salt is long-term integrity of the salt itself. In the case of the WIPP site at Los Medanos, a zone of apparently active dissolution of salt has been identified near the top of the Salado Formation (about 1300 feet or 400 meters above the uppermost horizon proposed for waste emplacement) at the western periphery of the proposed 30-square-mile land withdrawal area. Whereas no small-scale karstic features are developed in this area, and evidence for dissolution in the area is based entirely upon subsurface borehole data, a large depression called Nash Draw is developed to the west of the area. Exploratory drilling for potash in Nash Draw has revealed the removal of halite in the Rustler and Salado Formations and the development of a permeable brine-bearing zone of residue of dissolved evaporites called the "brine aquifer". The brine aquifer was probably encountered in hole P14 on the western margin of the WIPP area, yet the actual topographic edge of Nash Draw is no closer than one mile west of the WIPP land withdrawal area. Thus the development of Nash Draw is shrouded in mystery: what has been the relationship between dissolution of salt and subsidence of overburden in Nash Draw?

What are the implications (regarding WIPP-horizon salt integrity) of fluid movement, dissolution and subsidence involving salt above the WIPP? And how do these implications relate to safety assessment of WIPP through scenarios involving the supra-Salado rocks at the WIPP site and the ability to carry radionuclides in their aquifers into the biosphere? G. Buchman in USGS Open-File report 74-194 (1974) estimated average rates of salt dissolution in this area of about six to eight miles per million years horizontally, and 1/3 foot per thousand years vertically. If these estimates are correct, further evaluation of [illegible] is unnecessary; it would, however, provide confidence in the earlier estimates.

An additional concern is the region that must be controlled around the WIPP. Currently, DOE prescriptions specify control of a two-mile radius around the possible WIPP workings. Within this zone, various degrees of resource production will be allowed. If the effects of subsidence were understood and of lesser consequences than allowed for today, greater production of potash and hydrocarbons might be acceptable within portions of the two-mile zone.

Program Objectives

The program of investigation of dissolution and subsidence has four fundamental purposes, with one special-case consideration:

1. To correlate surficial collapse features and deposits with subsurface dissolution, in order to develop criteria for determining if there is an evolutionary pattern of collapse.

2. To characterize subsurface dissolution products adjacent to the WIPP site.

3. To determine the behavior of fluids in dissolution products adjacent to the WIPP site.

4. To analyze potential impacts of evolution of dissolution products at and near the WIPP site with respect to repository breachment and radionuclide transport.

The special case is to determine the nature of subsidence over mines in salt, and its effects on the overlying groundwater system.

An elaboration of these purposes follows.

Nash Draw Investigations

Nash Draw, the "dog-bone" shaped depression west of the WIPP site, is thought to have originated by some combination of surface erosion and subsidence following subsurface dissolution. If the process of formation is overwhelmingly erosion, then the potential for removal of overburden at the WIPP site is probably about the same as it has been in Nash Draw. If, however, the process is overwhelmingly dissolution of salt and collapse of overburden, the potential exists for the development of a complex system of stratigraphic and hydrological relationships over the WIPP, much as what has developed in Nash Draw. At present, there is no conclusive way of defining an instantaneous rate of growth of Nash Draw toward the WIPP site; therefore, the only alternative is to understand the processes which have resulted in Nash Draw, and incorporate their implications into the mathematical modeling efforts directed toward safety assessment involving the WIPP site in general, and radionuclide escape and migration in particular.

First, the Nash Draw program is a series of core holes, which will be geophysically logged. This operation will obtain data to serve three purposes: 1) reveal the subsurface Nash Draw stratigraphy at carefully chosen points, 2) reveal the relationships between the subsurface structure and surface features and deposits, 3) reveal how much halite and anhydrite (or gypsum) has been removed by dissolution. The holes will indeed be

located near surface features which suggest that dissolution and collapse in the subsurface has taken place, so that the relationships between surface and subsurface can be verified (item #2). Stratigraphy of post-Nash Draw deposits will help to unravel the history of development of the depression (#1 above). Examination for missing evaporites will identify how much dissolution has taken place to produce the observed surface features, and where dissolution has taken place to various degrees (#3). Characterization of surface features found at sites having experienced various degrees of dissolution will allow for the determination of the pattern of evolutionary collapse, if any. Thus, the fulfilling of these three data requirements should satisfy the spirit of program objective #1.

Second, the Nash Draw program is a source of geologic material for petrographic and geochemical examination. Making thin sections of recovered rock will allow the mineralogy of dissolution products to be determined, i.e. identification of what was dissolved and what remains. Mineralogy and textures of dissolution residues and cemented collapse fill can then be compared with those of dissolution features sampled in other programs, such as the one to investigate the cemented rubble chimneys (oft called "karstic domal features" or, incorrectly, "breccia pipes"). Comparisons can be made to see if Nash Draw and cemented rubble chimneys have involved similar processes of formation. Geochemical analyses of core materials for trace constituents will reveal their degree of interaction with groundwaters, and possibly an age of formation. Also, permeabilities toward fluids can be obtained on cores. Thus, the second program objective is satisfied.

Third, the Nash Draw program will become a series of hydrology holes. The "brine aquifer" underlying Nash Draw has been attributed responsibility for much of the dissolution and collapse observed today. The same "brine aquifer" has been attributed responsibility for carrying radionuclides should they escape from WIPP to the biosphere, allegedly <u>via</u> the seeps at Malaga. It therefore behooves us to understand the potentiometric patterns, permeability variations and fluid quantities found in that aquifer. Furthermore, the safety assessment scenarios for radionuclide escape and migration involve movement from WIPP into Rustler Formation waters into the "brine aquifer" and out at Malaga. It also behooves us to understand the hydrologic relationships between the "brine aquifer" and the Rustler water-bearing rocks in Nash Draw. And with this understanding, program objective #3 is satisfied.

For fiscal year 1978, four and possibly five Nash Draw holes have been proposed. It is expected that the program will extend through the fiscal year 1979, with up to nine additional holes, logistic resources permitting. The first six holes are located and identified according to nearest named landmark as follows:

WIPP-ND-1	S15-T22S-R30E	Crawford Ranch
WIPP-ND-2	S29-T22S-R30E	Fortyniner Ridge
WIPP-ND-3	S21-T21S-R30E	Red Lake
WIPP-ND-4	S18-T21S-R31E	New Well
WIPP-ND-5	S35-T22S-R29E	Tamarisk Flat
WIPP-ND-6	S32-T21S-R31E	Noye Tank

Surface casing (conductor pipe) is to be set similar to WIPP 1[illegible]. Holes 1, 2 and 4, are to be cored as completely as possible in the upper Salado Formation to an identifiable marker bed. The core size should be 3 5/8 nominally, taken to TD. Approximate predicted TD's for the first four holes are 500, 350-400, 400 and 500-600 ft, respectively. A geologic prognosis of each location will be provided by C. L. Jones (USGS) prior to drilling each hole. In addition, resistivity surveying in Nash Draw will precede drilling, if possible. Loss of circulation is anticipated in holes 1, 2 and 3.

Geophysical logs in the holes should include: resistivity, density, gamma, neutron, sidescan, and caliper. The sonic log might not be obtainable if the hole cannot maintain a fluid column long enough, but is desirable. Up-hole velocity to aid seismic interpretation might be appropriate.

After the drilling (and/or coring) and logging, it is planned to stand 5 1/2 inch casing and cement it to the surface. Each hole then becomes available for hydrologic testing and monitoring. Each hole will then be subjected to the same sorts of treatment as described in SAND 77-1401. Information so obtained includes piezometric potentials, permeabilities, quantities of fluids and the degree of connectedness between the Rustler rocks and the "brine aquifer." In addition, water samples will be analyzed to determine their origins and role in dissolution. The cores of water-bearing rocks can be analyzed for porosity and nuclide-sorption affinity. The results can be implemented in modeling efforts for safety assessment, and program objective #4 will have been satisfied.

As well as modeling groundwater movement, it may be advantageous to attempt to model the dissolution that might govern the future development of Nash Draw, once the evolutionary realtionships among processes in the cycle: dissolution - collapse - fracturing - water entry - dissolution, are understood.

Cemented Rubble Chimney Investigations

One of the "karstic domal features" described by J. D. Vine (called Hill "C") was encountered at the level of the McNutt potash zone by Mississippi Chemical Corporation. It was found to be a chimney in the Salado Formation filled with clay-cemented brecciated rock belonging to strata above the McNutt. Similarly a breccia-filled chimney was encountered in drilling near a circular hill near the Weaver Mine. There are numerous other erosion-breached domes such as Vine's Hill "C" in the vicinity of Nash Draw; the subsurface expression of them, if any, is virtually unknown. Recent geophysical surveys of the region have revealed that many of these domes, including the Wells-Weaver and Hill "C", are associated with resistivity lows.

One such resistivity low, without conspicuous surface expression, has been reported in section 17, T22S, R31E, inside the WIPP area. This suggests a localized increase in fluid content of rock and possibly a local porosity high and calls for an evaluation of the resistivity low as a possible fluid-carrying avenue. Implications of fluid movement in evaporites are, of course, dissolution and collapse. Once the initial resistivity survey and location of the section 17 low is corroborated by a second survey, WIPP borehole #13 will be drilled to determine the nature of the low. Should the low prove to be a rubble chimney near the surface, a decision point is defined, requiring 1) careful investigation of the nature and properties of the section 17 feature including a deep exploratory [illegible], WIPP [illegible] to determine the threat, if any, or 2) temporary abandonment of WIPP 13 while WIPP 16 is drilled in another [illegible] which might have a breached dome, or even [illegible] the known cemented rubble chimneys, or [illegible] site abandonment of the [illegible] tions regarding threat of such a feature to WIPP [illegible] never to be understood.

Should a decision be necessary, the most scientifically expedient yet intellectually conservative approach is optional. Experience in drilling and perhaps instrumentation development gained from WIPP 16 in a "known" (or at least strongly suspected) rubble chimney will be welcome when the [illegible] is revisited to investigate it in detail.

A program for WIPP 16 in the case of a "known" [illegible] consider the following information requirements:

1. Recovery of core from as many portions of the structure as possible.

2. Recovery of representative analyzeable samples of any liquid encountered.

3. Recovery of representative analyzeable samples of any gases encountered.

4. The option to make in situ determinations of permeabilities to liquids and diffusion coefficients for gases.

5. Determination of the reservoir size, if any, of liquids and gases.

6. As complete a description of the physical, chemical and geological properties of the structure as is practicably obtainable.

The achievement of these goals will probably require the following considerations:

1. Use of a drill rig able to penetrate about 5000 feet of section.

2. Employment of blowout preventers, fluid detection, alarm and collection systems.

3. The option of drilling with air or mud.

4. The ability to take 4-inch core by the rotary method from top to bottom insofar as practicable.

5. The option of whipstocking off a central (axial ?) hole, to take radial cores.

6. Directional surveys to allow "mapping" the subsurface extent of the structure.

7. The taking of geophysical logs, including resistivity, density, gamma, neutron, sidescan and caliper; sonic if possible.

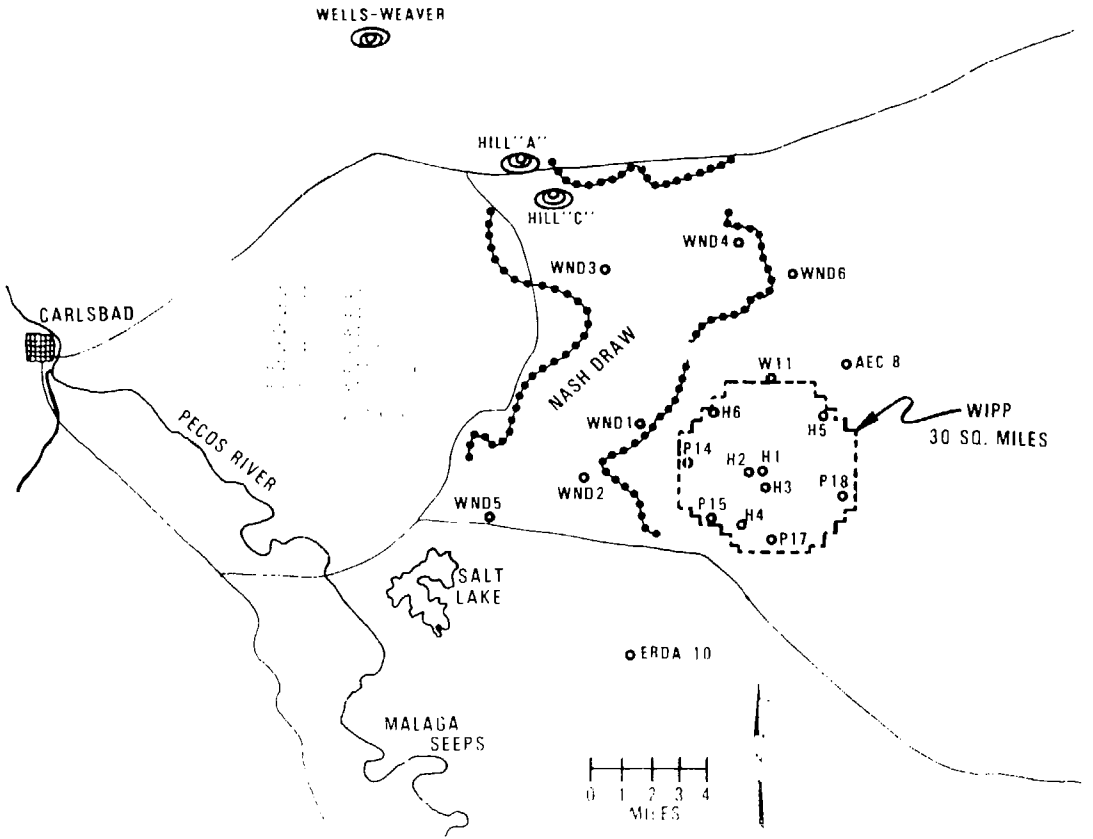
8. The option to multiply complete the resulting hole(s) for hydrologic testing.

It is desirable that this hole be drilled to a depth at which non-fractured rock is found. Should solid rock be encountered in the roof complex, it is recommended that the hole be cased through the carbonate for hydrologic observation. Hydrologic observation (including water sampling and piezometry) in fluid-bearing zones of the structure itself and in "bedrock" and in nearby rocks will help to determine the degree of connectedness of the structure with aquifers of regional extent.

Petrographic analyses of core recovered will allow comparisons to be made with dissolution products recovered from Nash Draw investigations, described previously. Such material also lends itself to geochemical analyses for the determination of rock-water interaction history and age. Similarly, fluid analyses will provide an indication of how the fluids have interacted with their host rocks, helping to determine the processes at work in such structures. The rock geochemistry from WIPP 16 can also be compared with Hill "C," sampled in MCC mine.

Since the modeling of radionuclide escape and migration must take into account fluid movement, cemented rubble chimneys should be evaluated for the potential as a path for such movement. They should also be evaluated as members of the evolutionary pattern of dissolution and collapse features, and might be generically related to the development of Nash Draw. Consequently, it is desirable to measure in situ the permeability of the structure. WIPP 16 could provide the opportunity for development of necessary instrumentation to be used in the exploration of the WIPP 13 feature. In addition, the hydrologic relationships between the chimney and surrounding rocks should be understood in order to formulate a complete hydrologic model for risk assessment. Thus, the four program objectives will have been met for the case of cemented rubble chimneys and these dissolution products can then be related to those encountered in the Nash Draw program.

HYDROLOGY TEST PROGRAM



Sandia Laboratories

Date June 29, 1978

R. D. Statler, 1133

S. J. Lambert, 5311

Criteria for WIPP 25 Through WIPP 30, and Their Quality Assurance

Reference: S. J. Lambert to Distribution, dtd. 6/8/78, "WIPP Programs to Investigate the Nature and Effects of Salt Dissolution and Overburden Subsidence in the Vicinity of the WIPP Site"

Purposes

The holes WIPP 25 through WIPP 30 are informally known as ND1 through ND6.

First, these are a series of core holes to be geophysically logged, to serve three purposes: (1) reveal the subsurface Nash Draw stratigraphy at carefully chosen points, (2) reveal the relationships between the subsurface structure and surface features and deposits, (3) reveal how much halite and anhydrite (or gypsum) has been removed by dissolution.

Second, these holes are a source of natural geologic material for petrographic and geochemical examination of products of dissolution of evaporites adjacent to the WIPP area, for studies of age-dating, rock-water interactions and related phenomena.

Third, the Nash Draw holes are to become a series of hydrology holes to provide the modelling (safety assessment) effort with data regarding dissolution and groundwater flow in a geologically complex piece of territory, between the west border of the WIPP area (Livingston Ridge) and the Pecos River, the nearest permanent surface water accessible to humans.

Locations

The lateral location of each hole was selected by the Water Resources Division of the United States Geological Survey. The precise location of each hole is governed by the surface feature it is designed to explore. In general, a lateral

location tolerance less than ± 1/2 mile is sufficient, but some features of interest might measure less than 1/2 mile in any surface dimension, and, therefore, the hole must fall within the feature of interest. The as-built location of each hole is to be surveyed after completion of all operations so as to be known within one foot with respect to existing section boundaries, usually the nearest marked section corner.

The approximate hole locations are given in the document referenced above.

Surface Elevations
A datum point at the surface at each hole location should be established to within ± one foot vertically with respect to known elevations nearby, usually the nearest National Geodetic Survey first-order levelling survey markers, to serve as a reference for depths measured in each hole. A recoverable survey marker should be emplaced at the surface near each hole to identify the lateral and vertical co-ordinates of this datum with respect to geographic co-ordinates and to the location of the hole itself.

Drilling and Coring
Continuous core is to be taken in each hole from surface to total depth. The core should be at least 3-5/8 inches in diameter, or the largest practically obtainable with a shallow-hole rig. Anticipated total depths are those described in the letter of C. L. Jones (USGS) to P. D. Seward (SLA-1135) dated June 7, 1978. It is permissible to drill with mud gel, but circulation might be lost so appropriate additives to the mud are warranted. Completion of all holes as hydrology holes is anticipated for water sampling and measurements of piezometric elevations and permeabilities.

Full core recovery (with origin depths documented to within ± one foot) is highly desirable to facilitate thorough investigation of rocks associated with evaporite dissolution in Nash Draw. However, the exploratory nature of this program takes account of the fact that geological conditions in these holes are imprecisely known, and might not be conducive to full core recovery. In this case, core obtained should be documented according to actual percentage of recovery, and origin depths of recovered core should be approximately determined through combinations of other techniques, including geophysical logs and comparison with stratigraphically equivalent cores from other holes.

Core should be handled in accordance with established Sandia procedures. These general procedures have been given in the

letter to distribution from R. D. Statler (dtd. 5/15/78) containing the field operations program for WIPP holes H4a, b, and c.

Geophysical Logging

Three kinds of information are to be obtained by geophysical logging: (1) maintenance of stratigraphic control, identification of rock types in the hole and verification of core depths; (2) identification of fluid-bearing zones and qualitative evaluation of relative permeabilities for future hydrologic investigations; (3) measurement of up-hole sound-wave velocity, to determine elastic properties of the rock to aid in the interpretation of future seismic surveys of Nash Draw, if any. For example, the first kind of information might entail density, natural gamma, neutron and sonic logs. The second kind might entail R_{xo}, R_t and neutron logs. The third kind might entail sonic and up-hole velocity logs.

Casing

All the holes are to be cased to about 50 feet below the top of salt (past the evaporite residuum at the top of the Salado Formation), using 5-1/2 inches (minimum) outside diameter steel casing, to allow for multiple completion for hydrologic testing at a future time.

Cementing

Cementing of casing is to be accomplished so as to isolate aquifers from one another so that fluids from them do not cross-flow through the cement. Bond logs and tracer testing will be prescribed later during the hydrologic testing program, at which time the integrity of the cement behind casing will be evaluated.

Final Operation

After casing and cementing, the holes are to be filled with fresh water and temporarily abandoned, awaiting hydrologic testing.

Sincerely yours,

Approved: Leslie R. Hill

L. R. Hill, Supervisor
Nuclear Waste Technology
Division 5311

APPENDIX B

DRILLING AND TESTING PLAN

compiled by

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

INTRODUCTION TO APPENDIX B, DRILLING AND TESTING PLAN

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

Field Operations Program of Sandia Labs

WIPP Site Investigations

(Nature & Effects of Salt Dissolution, Nash Draw)

Exploratory Wells:	Nash Draw Locations Sections:
WIPP 25	15, T22S, R30E
WIPP 26	29, T22S, R30E
WIPP 27	21, T21S, R30E
WIPP 28	18, T21S, R31E
WIPP 29	34, T22S, ~~R30E~~
WIPP 30	33, T21S, R31E

Purpose: To reveal subsurface stratigraphy and hydrologic settings in Nash Draw in order to determine the relation between structures, surface features and evaporate dissolution.

Prepared by _____
R. D. Statler, Supervisor
Division 1133
Field Engineering Projects

Approved by _____
L. R. Hill, Supervisor
Division 5311
Nuclear Waste Technology

Approved by _____
J. W. McKiernan, Supervisor
Division 5342
Nuclear Waste Programs

Sandia Laboratories

July 26, 1978

Distribution

R. D. Statler - [illegible]

Nash Draw Exploratory Wells, WIPP [illegible] through [illegible]

The attached document contains the Field Operations Plan for Conducting [illegible] Site Investigations in the Nash Draw. Drilling, logging, coring, and [illegible] procedures are included for your use and information. Revisions and additions shall be added to this document as required and appropriate distribution made.

RDS:[illegible]

Distribution:
[illegible], USGS, Special Projects Division, Denver, [illegible]
J. W. Mercer, USGS/WRD, Albuquerque, NM
[illegible] Bachman, USGS/WRD, Albuquerque, NM
[illegible], DOE/NVOO, Las Vegas, NV
[illegible], DOE/ALO
[illegible], F&S, Las Vegas, NV
W. [illegible] Cunningham, F&S, Carlsbad (3)

[illegible] H. E. Vinck
[illegible] W. Gulick
[illegible] D. Seward
[illegible] Magnifier
[illegible] Archives (2)
[illegible] R. Hill
[illegible] J. Lambert
[illegible] W. Powers
[illegible] Walker
[illegible] W. M Kiernan
[illegible] Hogan
[illegible] M Earling (2)
[illegible] Statler (3)

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INTRODUCTION

This document contains design criteria for six exploratory wells to investigate stratigraphy and hydrology in the Nash Draw. It describes the operational plan for conducting the field activities required to meet specified objectives. It includes procedures with drawings, specifications, and instructions necessary for good quality control of essential features. The Sandia Quality Assurance Program Plan for WIPP Site Evaluation is expected to cover activities associated with this field program.

July 26, 1978

[illegible] PERATIONS PROGRAM CRITERIA

The following memorandum has been accepted as design criteria for the WIPP Site Investigations of the Nash Draw. Therefore, it is being reproduced in its entirety for use in the conduct of this project.

Sandia Laboratories

[illegible]

June 29, 1978

R. D. Statler, 1133

Steven J. Lambert

S. J. Lambert, 5311

Criteria for WIPP 25 Through WIPP 30, and Their Quality Assurance

This memorandum is separately reproduced in Appendix A. Pages 1-3 of the drilling and testing program are therefore abridged.

[illegible]

[illegible] PLAN

A. Organization

[illegible] Direction will originate within [illegible] operations, managed by Bob Statler, Sandia Division [illegible] conducted by W. F. Cunningham, Fenix & Scisson. [illegible] associated support service contracts will be let and administered [illegible] F&S as arranged for by Federal Agency Order [illegible] Office, DOE.

Identification of marker beds, core logging and [illegible] pretations will be provided by duty geologist.

Quality control and inspection will be conducted [illegible] Quality assurance program will be administered [illegible] Jim Jones, Sandia Division [illegible].

Industrial Safety Program will be [illegible] Fenix & Scisson, Las Vegas.

Administrative assistance, logistical [illegible] be provided by P. D. Seward and [illegible] Magnuson, [illegible]

b. Supporting Data

Geology

The data for the following chart was provided by Charles L. Jones, Geologist, USGS, Special Projects Division, Denver, CO, in a letter from Jones to P. D. Seward, 1135, dtd 6/7/78.

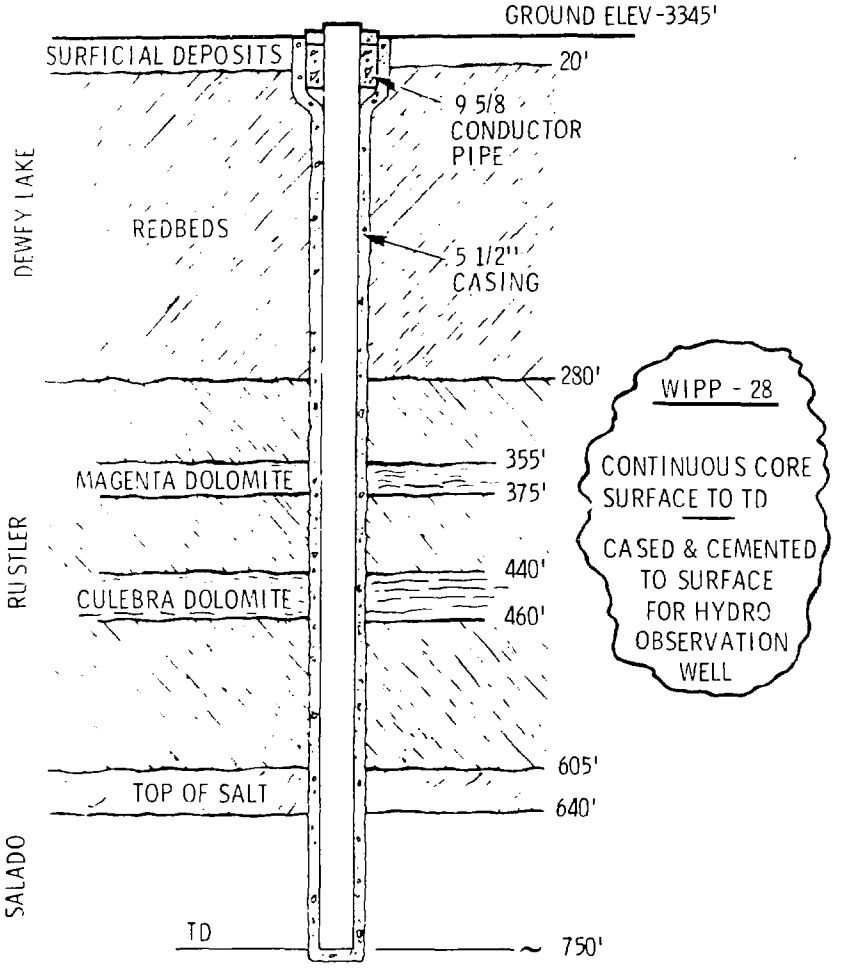
"Geologic Prognosis for Nash Draw Boreholes"
(Depth Intervals in Feet)

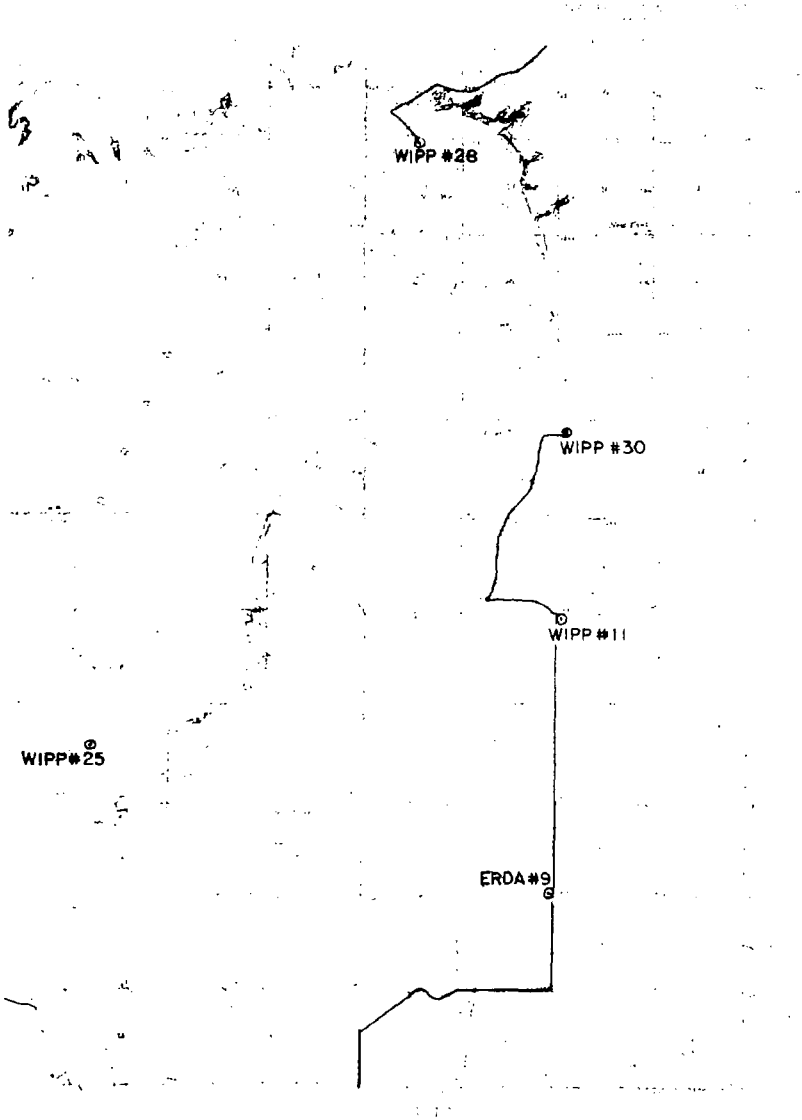
Rock Unit	WIPP 25	WIPP 26	WIPP 27	WIPP 28	WIPP 29	WIPP [illegible]
Surficial deposits	0-5	0-5	0-15	0-20	0-[illegible]	[illegible]
Gatuna Formation	5-50	NP*	15-[illegible]	NP	NP	NP
Santa Rosa Sandstone	NP	NP	NP	NP	NP	NP
Dewey Lake Red Beds	50-180	NP	50-130	20-280	NP	[illegible]
Rustler Formation	180-490	5-[illegible]	130-370	280-[illegible]	[illegible]	480-[illegible]
Magenta Dolomite	250-275	70-9[illegible]	130-150	355-[illegible]	NP	[illegible]
Culebra Dolomite	380-405	210-2[illegible]	[illegible]50-275	440-[illegible]	[illegible]	[illegible]
Salado Formation	490-600	350-470	370-[illegible]	605-[illegible]	[illegible]	[illegible]
Dissolution residue	490-500	350-[illegible]	370-440	605-[illegible]	[illegible]	NP
Top of salt	500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Core intervals: continuous surface to total depth of all holes.						
Total depth:	600	470	525	750	[illegible]	[illegible]

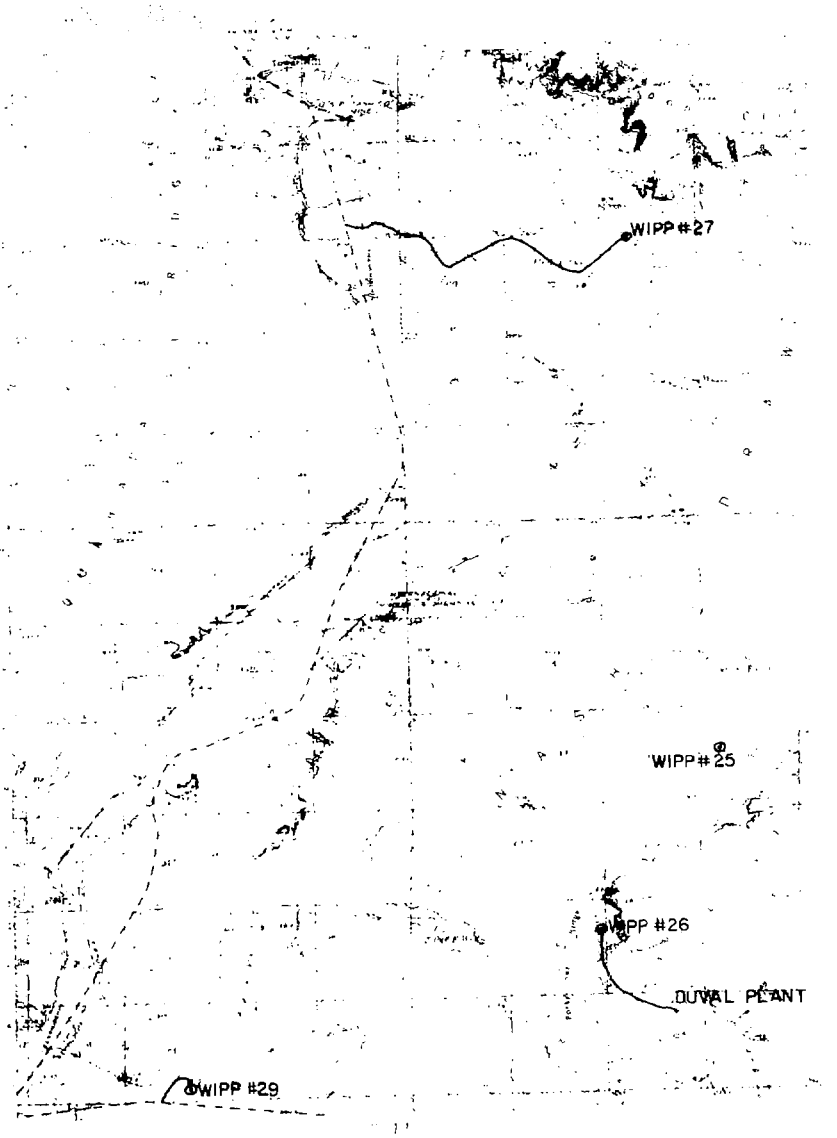
*NP = Not Present.

Some production of fluids as well as zones of lost circulation is expected in each location.

The following sketch of WIPP 28 is typical of all holes with the exception of depths to, and thicknesses of, formations.


GROUND ELEV-3345'
SURFICIAL DEPOSITS
20'
9 5/8
CONDUCTOR
PIPE
DEWEY LAKE
REDBEDS
5 1/2"
CASING
280'
WIPP - 28
CONTINUOUS CORE
SURFACE TO TD
CASED & CEMENTED
TO SURFACE
FOR HYDRO
OBSERVATION
WELL
355'
MAGENTA DOLOMITE
375'
RUSTLER
440'
CULEBRA DOLOMITE
460'
605'
TOP OF SALT
640'
SALADO
TD
750'


WIPP #28
WIPP #30
WIPP #11
WIPP#25
ERDA#9


WIPP #27
WIPP #25
WIPP #26
DUVAL PLANT
WIPP #29

C. Drilling Parameters and Expected Drilling Requirements

The following drilling program is intended to be typical for each of the six Nash Draw boreholes, WIPP 25 through 30. The diameters of the holes and drilling techniques will be basically similar, but the depths of formations and total depths will naturally vary according to location. For guidance on depth projection, refer to previous section containing geologic prognosis.

1. Level and prepare a suitable surface location compatible with local terrain and drilling equipment selected.

2. Locate borehole according to surveyed location and establish concrete monument with brass cap in the immediate vicinity of borehole such that it can be utilized as the datum point for all vertical measurements of the drilling, coring and logging activities. Once established, this marker should be surveyed by a certified land surveyor to establish vertical elevation of the benchmark within ± one foot of nearest National Geodetic Survey and the lateral coordinates within ± one foot with respect to nearest section corner.

3. Move in rig and rig up in a manner such that a continuous core can be taken from as near the surface as practicable to the total depth. The core should be at least 3-5/8" diameter or the largest practically obtainable in continuous coring operation. Utilize a drilling and circulating fluid best suited for promoting full core recovery. Use additives as required to control loss of circulation keeping in mind the desire to convert these boreholes into hydrologic observation wells. All core is to be logged, marked, and handled according to procedures outlined in Section III.A.

4. Duty geologist will closely monitor core production and establish total depth. Total depth is expected to be about 50 feet below the top of salt and past the evaporite residuum at the top of the Salado Formation.

5. Upon reaching total depth, borehole will be conditioned and made ready for geophysical logging by a commercial firm and USGS/WRD if they desire. Borehole may have to be opened to accommodate logging tools.

6. Geophysical logs are to be run to provide information for:

   a. Identifying rock types encountered

   b. Aiding the maintenance of stratigraphic control

   c. Aid in verifying core depths

   d. Identifying fluid bearing zones

e. Evaluate relative permeabilities

f. Up-hole sonic velocity

g. Determine elastic properties of rocks.

The actual commercial logs selected to produce the above information will be established at a later time after a better understanding of the hole conditions is known. Procedures for logging program will be found in Section IV.B.

7. After logging operations are completed, the borehole should be made ready for running casing and cementing. A string of 5-1/2", 15.5, J-55 casing (or reasonable equivalent) with centralizers will be stood and cemented to the surface. A prime reason for casing is to isolate aquifers from one another and procedures described in section III. must be followed.

8. Upon completion of casing and cementing, the well should be filled with fresh water and covered with a temporary, removable cap.

9. Clean up pad areas, fill in pits and leave hole temporarily [illegible] for hydrological testing.

[illegible] potential hazards

[illegible] are expected. Some small inert gas pockets may be [illegible] unlikely above the salt.

III. FIELD OPERATING PROCEDURES FOR QUALITY CONTROL REQUIREMENTS

Portions of this field activity are considered of such a significance that quality control measures have been established and these are subject to independent audit by Sandia Laboratory Quality Assurance personnel as well as NRC Field Audit Team. These activities are:

A. Measurement of Surface Location and Elevation

B. Core Logging and Handling and Storage

C. Geophysical Logging

D. Casing and Cementing.

The above activities will be monitored in detail or reviewed by a [illegible] quality control experts whose education, knowledge and/or experience make him qualified to assure adherence to operating procedures or to ascertain or certify that desired objectives have been met.

When designated, this individual shall take appropriate measures to negotiate with pertinent officials to whatever extent necessary to assure acceptable results.

A. Measurement of Surface Location and Elevation

The general location will be established by Division 5311 following a review of resistivity surveys, surface features, accessibility and other geo-political considerations. A preliminary land survey shall be conducted by a Registered Land Surveyor to establish access [illegible] set stakes for drill location and pad boundaries. Upon [illegible] the location will be established with nearest section [illegible] and [illegible] marked section corners to provide data necessary [illegible] permits. Drawings or sketches suitable for [illegible] submitted. After pad construction is complete and at the time of [illegible] spudding, a concrete monument with a brass cap will be set in the [illegible] vicinity of the borehole such that it can be used as the datum point [illegible] all borehole vertical measurements. Once this monument is established [illegible] the monument and its lateral relation to borehole axis is to be [illegible] by a Registered Land Surveyor to establish the vertical elevation within [illegible] ±1' of the nearest NGS monument and the lateral [illegible] within [illegible] with respect to nearest section boundaries and to [illegible]

Copies of all field notes utilized in [illegible] as well as a written description of [illegible] in making the survey shall be submitted along with [illegible] the stamp of the responsible surveyor.

B. Core Logging and Handling and Storage

A duty geologist will log and measure core as it is removed from core barrel. When drill cuttings are required, duty geologist will see they they have been taken, washed and dried. They should then be tied in 100' bundles, boxed, and marked with well identity, and interval taken. Cuttings will then be taken to core storage in Carlsbad along with core.

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

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

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

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

3. Log, identify and measure all core pieces, mark to the nearest foot relative to measurements of drill pipe, express to closest 1 10th of foot. Note: all depth measurements are from the top side of the Kelly Bushing unless otherwise specified.

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

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

6. [illegible] will be responsible for assuring [illegible] the [illegible] all core boxes, [illegible] and making entries into the Daily Core Logging Record (sample follows) as to quantities and date of core delivery to core storage.

Page ____ of ____

DAILY CORE LOGGING RECORD

[illegible] _____ DUTY GEOLOGIST _____

[illegible]

[illegible]

[illegible] WIPP No. _____

[illegible] County _____ State New Mexico

[illegible]

[illegible] _____ Township _____ Range

[illegible] Elevations: K.B.

[illegible] From _____ D.F.

G.L. _____

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

July 26, 1978

Geophysical Logging

1. Prior to logging, a Sandia representative will meet with the logging engineer, present "Instructions to Logging Co" as shown on following pages, and discuss:

   a. The entire logging program and any special requirements

   b. Hole conditions that may cause problems

   c. Zones of special interest.

2. The equipment will be "warmed up" for the adequate amount of time and tools will be checked to see that they are functioning properly upon arrival at the location.

3. Rw, Rmf, and Rmc will be measured on mud samples. Estimated values are not acceptable. The service company should run the sample through a mud press.

4. Proper scales will be used on each log.

5. All Sidewall and Compensated Neutron logs and all density porosity curves will be run on limestone matrix over the zones of interest, regardless of the lithology.

6. Equipment will be tested while running in hole.

7. Before and after log calibrations will be shown for all curves.

8. Panel calibrations will be shown for all density and neutron logs. Integration checks will be shown for all integrated Acoustic logs.

9. In addition to caliper rings the caliper calibration should show "tool full open" and casing readings.

10. A minimum 20% test repeat must be shown.

11. Overlap previous runs by at least 200 feet.

12. Headings on routine will be completely filled out.

13. "Log Quality Report" such as is shown on following pages will be completed by qualified Sandia representative.

LOG QUALITY REPORT

Hole _____ Log Date _____ Current Date _____

Log _____ Run # _____ Engr. _____

Field Print [ ] Final Print [ ] Log Analyst _____

CHECK ALL BOXES – ACCEPTABLE YES OR UNACCEPTABLE NO

Sections not applicable to a particular service, Leave Blank.

	YES	NO
A. HEADING		
1. Correct Heading Used		
2. Heading Data Properly Completed		
3. Equipment Used Section Completed		
4. Equipment Data Section Completed		
5. Scale Changes Noted on Heading		
6. Are all abnormal conditions explained in the remarks section		
B. CALIBRATIONS AND SCALES		
1. Scales Correct for Area		
2. Scales Labelled		
3. Scale Changes Labelled		
4. Zeroes Recorded		
5. Before Log Calibrations		
6. After Log Calibrations		
7. Repeat Section Recorded		
8. Repeat Section Acceptable		
C. VALIDITY OF LOG		
1. Curves Functioning Correctly		
2. Do Log values fall within reasonable limits		
3. Curves on Depth		
4. Logging Speed Indicated		
5. Logging Speed Correct		
D. APPEARANCE		
1. Printing or Typing Neat		
2. Printing or Typing Accurate		
3. Grid and Pen Traces		
4. Splices Straight and Clean		
5. Film Correctly Processed		
6. General Print Quality		

REMARKS. Code Remarks with the proper Section Number. For Example: Remarks concerning [illegible] calibrations would be noted B-5.

[illegible] FLOWERS, [illegible]

Page [illegible]

[illegible]

[illegible] Carrier [illegible]

[illegible] Carrier Invoice [illegible]

Attention By [illegible]

[illegible]

[illegible] [illegible]

[illegible] [illegible]

[illegible] [

July 26, 1978

D. Casing and Cementing

1. Inspect casing to be run. Sand blast if necessary to remove severe rust flakes. Pits of rust without flakes may actually enhance bonding.

2. Condition hole, ream if necessary to remove tight places.

3. Condition fluid until mostly free of cuttings.

4. Install a combination float shoe.

5. Stand casing with centralizer. Utilize logs to determine locations as well as routine spacing of 60-90 feet apart.

6. Begin pumping and displace well fluid with mud flush, then [illegible], and cement slurry. Use 70-30 poz mix, salt to saturation, [illegible] 2% bentonite gel.

7. Displacement rate approximately 2-1/2 barrels per minute.

8. Bump plug with approximately 500 psi over pumping-mixing rate. Mix 1000 psi, close in head.

9. WOC 48 hours.

10. Nipple up after 36 hours.

[illegible] regulations issued by State Engineer; in particular, [illegible] statement that "Casing shall not be installed or cemented without prior notification to the State Engineer Office."

July 26, 1978

IV. REPORTS

Distribution Instructions:

A. Daily Report
F&S, Carlsbad, shall provide to Sandia, Carlsbad, a copy of the daily report. Sandia, Carlsbad, will telefax weekdays to D. Schueler, [illegible], and [illegible] Hill, 5311, Albuq., who will mail copies to McFarling, [illegible], Seward, 1133, and Statler, 1133. A copy of the daily report is to be kept by Sandia, Carlsbad.

B. Hole History
Compiled by F&S, Carlsbad, and Las Vegas, NV. Send copy to R. D. Statler, 1133, for Sandia, Albuquerque, distribution.

C. Geophysical Logs
F&S, Carlsbad, shall obtain nine copies of field prints and make general distribution, to include the following:

1 - Sandia, Carlsbad
1 - [illegible] Jones, USGS, Spec. Proj. Div., Denver, CO
1 - [illegible] Mercer, USGS/WRD, Albuq., NM
1 - G. O. Bachman, USGS/WRD, Albuq., NM
1 - D. W. Powers - 5311, SLA
4 - F&S, Carlsbad

F&S, Carlsbad, shall order by Final Copies for distribution as follows:

1 - F&S, Carlsbad
1 - F&S, Las Vegas
1 - Sandia, Carlsbad
1 - [illegible] Jones, USGS, Spec. Proj. Div., Denver, CO
1 - G. O. Bachman, USGS/WRD, Albuq., NM
1 - [illegible] Lambert, 5311, SLA
8 - D. W. Powers, 5311, SLA
1 - [illegible] Archives, w/original, tape and film
1 - State Engineer, Roswell, NM
1 - USGS Area Geologist, Roswell, NM
1 - West Texas Electric Log Service

D. Miscellaneous Records shall be provided by F&S, Carlsbad, including the following, with original to be kept on file at F&S, Carlsbad, and one copy to Sandia, Carlsbad:

Drillers Logs, Bit Records, Drill Fluid Recaps
Equipment Certification
Drilling History Chart
Cost Records (copies to R. D. Statler, 1133, Albuq.)

Sandia Laboratories

Albuquerque New Mexico
Livermore California

date August 18, 1978

to Distribution

from R. D. Statler:1133

subject Supplement #1 to Field Operating Program WIPP #25 thru #30

The following additions and modifications to the Field Operating Program for the Nash Draw Exploratory Wells, WIPP #25 thru #30 are forwarded for your use and information:

A. Fourteen (14) copies of the As Built Survey of the hole location should be distributed as follows:

1. Fenix & Scisson-Carlsbad
2. Fenix & Scisson-Las Vegas
3. Sandia-Carlsbad
4. Sandia-R. D. Statler:1133 (2 copies)
5. Sandia-P. D. Seward:1135
6. C. Jones-USGS, Special Project Div., Denver, CO
7. G. O. Bachman, USGS-WRD
8. J. Mercer, USGS-WRD
9. S. J. Lambert:5311, SLA-ALB
10. Archives:5310 (2 copies)
11. New Mexico State Engineer, Roswell, NM
12. USGS Area Geologist, Roswell, NM

B. 1. Run Geophysical Logs up to the highest level that will hold fluid. Estimated to be ±220-feet.

Logs to be run as follows:

1. Densilog
2. BHC Acoustilog
3. Micro Laterolog
4. Dual Laterolog
5. Compensated Neutron
6. "Up Hole Velocity"

2. Add J. Mercer, USGS-WRD to distribution of all logs.

3. Core Logging, Handling and Storage procedures are modified to include photography of core at the drill site as soon as it has been logged and identified by the Duty Geologist and before it is sleeved for storage.

Five copies of all core photographs are to be made by Sandia Laboratories and distributed as follows:

3 Copies - Division 5311
1 Copy - C. L. Jones, USGS, Denver, CO
1 Copy - G. O. Bachman, USGS-WRD

INTRODUCTION TO APPENDIX C, HOLE HISTORY

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

FENIX & SCISSON, INC.

HOLE HISTORY DATA

11-16-78

HOLE NO. WIPP #30	W.O. No.	I.D. No.
OPER. Sandia Lab	TYPE HOLE Exploratory	
LOCATION New Mexico	COUNTY Eddy	AREA WIPP
GRADE STORE NATED * 665.01' FNL, 174.92' FWL		GROUND ELEVATION *
PROJECT LOCATION	SPUDDED 9-8-78	COMPLETED 10-2-78
CIRCULATION MEDIA Salt base mud		
NO. OF COMPRESSORS & SIZE		

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	I.D.	WT. FT.	WALL	GRADE	CPL'G	FROM	TO	[illegible]
0'	246'	0-3/4"								
246'	913'	7-7/8"	4.950"	15.50#		J-55	ST&C	+ 1.3'	912'	46[illegible]

TOTAL DEPTH 913'	MANDREL DEPTH	PLUGS
[illegible]		
[illegible] DATA Page [illegible]	SURVEYS PAGE	[illegible]
[illegible]		REFERENCE

NON OPERATIONAL TIME		OPERATIONAL DELAY TIME		WORKING TIME	
Move Rig & Aux.	days	Equipment Repair	0.07 days	Drilling Time, Reaming	1.24
[illegible]	7.78 days	Caving	days	Trip Time	
[illegible] Mangle	days	Lost Circ.	days	Single Shot Survey Time	
[illegible]	0.83 days	Fishing	0.13 days	Coring	11.05
[illegible]	days	W.O. Equipment	days	Total	12.29
[illegible]	0.35 days	W.O. Weather	0.10 days	Total Suspended Time	
[illegible]	0.56 days	Mix & Condition Mud	0.89 days	Non-Operational Time	9.73
[illegible]	days	Free Stuck Drill Pipe	0.74 days	Operational Delay Time	1.93
Run & Pull 7 casing	0.21 days		days	Working Time	12.29
TOTAL	9.73 days	TOTAL	1.93 days	TOTAL ELAPSED TIME	23.95

SUMMARY

* Brass Monument location: 660.79' FNL, 173.63' FWL, Sec. 33, T21S, R31E. Elevation 3427.54'.

Rig No.	Name	Type	
1	Penn. Drilling Co.	Failing 2000	23.95 days

WDS:it

WIPP #30
HOLE HISTORY

9-8-78	Moved in Pennsylvania Drilling Company's rig #1 and rigged up. Cut core #1 thru #3 using 3" O.D. Shelby tubes from 0' to 6' - 6' and stuck tube, left in the hole. Mixed up salt base mud. Ran a tapered tap in the hole ans washed 6" inside the tube.
9-9-78	Recovered the Shelby tube with a tapered tap. Made up 3" x 2' core bit on an Ace core barrel and cut core #4 and #5 from 6' - 6' to 17'. Opened 3" hole to 6-1/8" from 0' to 17'. Made up 6-1/8" x 3-1/2" core bit and cut core #6 thru #10 from 17' to 61' with 10' split core barrel.
9-11-78	Rig secured from 9-9-78 to 9-11-78. Cut core #11 thru #16 from 61' to to 138'. Changed out to a 25' core barrel at 81'.
9-12-78	Completed core #16 from 138' to 156'. Started losing fluid at 139' and had 75% returns at 156'. Mixed mud and lost circulation materials. Cut core #17 thru #21 from 156' to 198'. Had 40% to 50% returns after 166'.
9-13-78	Completed core #21 from 198' to 204'. Cut core #22 thru #25 from 204' to 259' with 50' to 20% returns. Opened 6-1/8" hole to 8-3/4" from 0' to 239', had 95% returns at 190' while reaming.
9-14-78	Opened 6-1/8" hole to 8-3/4" from 239' to 246'. Ran 7" O.D. casing to 246' and packed off. Cut core #26 thru #29 from 246' to 336'.
9-15-78	Completed core #29 from 336' to 348' and cut core #30 thru #31 from 348' to 398'.
9-16-78	Completed core #32 from 398' to 419'. Cut core #33 thru #35 from 419' to 487'.
9-18-78	Rig secured from 9-16-78 to 9-18-78. Cut core #36 thru #38 from 487' to 567'.
9-19-78	Completed core #39 from 567' to 577'. Cut core #40 and #41 from 577' to 632'.
9-20-78	Completed core #41 from 632' to 633'. Changed out to 10' split core barrel and cut core #42 thru #46 from 633' to 685'.
9-21-78	Completed core #46 from 685' to 704'. Cut core #47 thru #53 from 704' to 762'. Started losing fluid at 740'. Lost approximately 100 barrels of mud and regained 90% returns.
9-22-78	Cut core #50 thru #53 from 762 to 862' with 95% returns.
9-23-78	Cut core #54 and #55 from 862' to 912'. Ran USGS logs. Pulled the 7" O.D. casing out of the hole. Opened 6-1/8" hole to 8-3/4" from 246' to 368' with 90% returns.

9-29-78 Rig secured from 9-23-78 to 9-29-78. Opened 6-1/8" hole to 7-7/8" from 368' to 912' and drilled to 912'. Pulled out of hole, stuck drill pipe at 700' and worked free. Pulled to 640' and could not work free.

9-30-78 Made up jars and overshot, jarred drill pipe free. Stuck pipe again at 480' and worked free. Made trip with 7-7/8" bit and cleaned out 6' of fill. Conditioned hole for logs. Ran Dresser Atlas logs.

10-1-78 Ran Seismic Reference Service's seismic survey. Secured rig at 0615 hours.

10-2-78 Rig secured to 0 hours. Ran 23 joints (929.05') of 5-1/2" O.D., 15.50#, J-55 casing and set at 912'. Cemented annulus using Dowell with 1000 gallons of mud wash ahead of 75 sacks of RFC cement and 270 sacks of 70% class "C" cement, 30% Litepoz 3 with 19.4 #per sack of salt, 2% gel and 0.1% salt dispersant. Total slurry volume was 403 ft^3. Lost circulation after 32 barrels of slurry was pumped. Displaced cement with 22 barrels of water and regained partial circulation after pumping 6 barrels. Cement circulated to surface and fell back when pumping stopped. Cement in place at 1020 hours. Cut off casing at 1.3'. Ran Bennet temperature survey. Rigged down. Hole completed.

LOG INDEX SHEET

TYPE LOG	DATE	RUN NO.	DEPTH DRILLER	DEPTH LOGGER	LOGGED FROM	LOGGED TO
DRESSER ATLAS LOGS						
BHC Acoustilog	9-30-78	1	912	910	10	903
Compensated Densilog	9-30-78	1	912	910	5	900
Micro-Laterolog	9-30-78	1	912	910	30	907
Dual Laterolog	9-30-78	1	912	909	10	905
Compensated Neutron Gamma	9-30-78	1	912	910	0	908
SEISMIC REFERENCE SERVICE LOG						
Seismic Survey	9-30-78	1	912	910	10	907

NOTE: Logs furnished F&S/Mercury.

WIPP #30

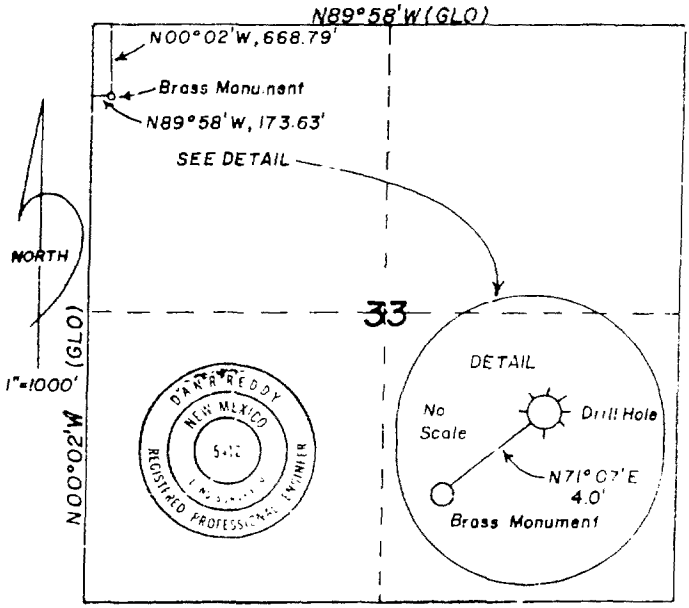
CORE NO.	INTERVAL	(IN FT.)	RPM	WOB	CIRC. PRESS PSI	FT.CORED	FT. REC.	% REC.	
9/8/78									
1	0	2' 2"	USING SHELBY TUBES			2' 2"	2' 2"	100%	
2	2' 2"	4' 4"	0	200	0	2' 2"	2' 2"	100%	[illegible]
3	4' 4"	6' 6"	0	[illegible]	0	2.2	2' 2"	100%	[illegible]
9/9/78									
4	6' 6"	12.0	85	1000	150	5.5	3	55%	[illegible]
5	12.0	17.0	85	1000	150	5.0	2	40%	2
6	17.0	21	70	5000	200	4	2.6	65%	3
7	21	31	70	6000	200	10	9.3	93%	4,5,6,7
8	31	41	75	6000	200	10	7.3	73%	8,9,10
9	41	51	75	6000	200	10	8.1	81%	11,12,13,14,1[illegible]
10	51	61	75	6000	200	10	9.3	93%	16,17,18,1[illegible]
9/11/78									
11	61	71	75	6000	200	10	10.2	102%	1[illegible],20,21,22,[illegible]
12	71	81	75	6000	200	10	10	100%	24 - 27
13	81	102	78	8000	200	21	15.2	72%	28 - 33
14	102	121	78	8000	200	19	14.2	75%	34 - 39
15	121	131	75	8000	200	10	8.1	81%	40 - 42
9/12/78									
16	131	156	75	8000	225	25	18.6	74.4%	43 - 50
17	156	166	75	5000	500	10	0	0%	51
18	166	176	70	7000	250	10	1.0	10%	52
19	176	184	60	5000	250	8	2.0	25%	53 - 56
20	184	194	85	5000	175	10	8.2	82%	57 - 60
21	194	204	85	5000	175	10	10	100%	61 - 64
22	204	214	85	5000	200	10	9.0	90%	65 - 68
23	214	224	85	5000	200	10	9.6	96%	69 - 72
24	224	234	85	5000	200	10	9.55	95%	
25	234	259	85	9000	150	25	22.8	91.2%	
9/14/78									
26	[illegible]	284	104	12,000	250	25	26	104%	
27	284	307	108	12,000	250	23	23.5	102%	
28	307	332	80	12,000	200	25	25	100%	
29	332	347.5	80	12,000	250	16	13.1	79.4%	
30	348	369	80	14,000	300	21	22.7	108%	
31	369	394	100	14,000	250	25	26.2	105%	
32	394	419	75	14,000	250	25	24	96%	
33	419	444	95	14,000	250	25	23.5	94%	
34	444	467	95	15,000	200	23	25.2	109%	
35	467	487	95	15,000	200	20	17.3	86.5%	

CORE NO.	INTERVAL	(IN FT.)	RPM	WOB	CIRC. PRESS PSI	FT.CORED	FT. REC.	% REC.
[illegible] 18/78								
[illegible]	487	512	85	12,000	150	25	22.4	89.6%
[illegible]	512	537	85	12,000	175	25	24.9	99.6%
38	537	562	90	14,000	200	25	25	100%
9/19/78								
39	562	587	90	14,000	200	25	24.85	99.4%
40	587	612	95	14,000	200	25	19.1	76.4%
9/20/78								
41	612	633	90	14,000	200	21	23.6	112.4%
42	633	643	90	14,000	200	10	9.7	97%
43	643	654	90	14,000	200	11	11	100%
44	654	663	90	10,000	200	9	3.75	41.7%
45	663	679	90	10,000	200	16	15.8	98.[illegible]
9/21/78								
46	679	704	80	10,000	200	25	6.5	26%
47	704	727	80	10,000	200	23	8.1	[illegible]
48	727	744	75	8,000	200	17	8	[illegible]
49	744	762	50/65	7-8,000	200	18	16.[illegible]	[illegible]
9/22/78								
[illegible]	762	787	65	8,000	200	25	29.3	101%
51	787	812	100	12,000	200	25	24.7	[illegible]
52	812	837	100	12,000	150	25	25.3	101%
9/23/78								
53	837	862	100	12,000	150	25	25	100%
54	862	887	85	12,000	150	25	25	100%
[illegible]	887	912	85	12,000	150	25	25.1	100.4%
9/[illegible]/78								

SURVEY MONUMENT "AS BUILT"
W.I.P.P. 30

SECTION 33, TOWNSHIP 21S, RANGE 31E N.M.P.M.
EDDY COUNTY, NEW MEXICO

ELEVATION OF BRASS MONUMENT 3427.54'
668.79' FNL & 173.63' FWL

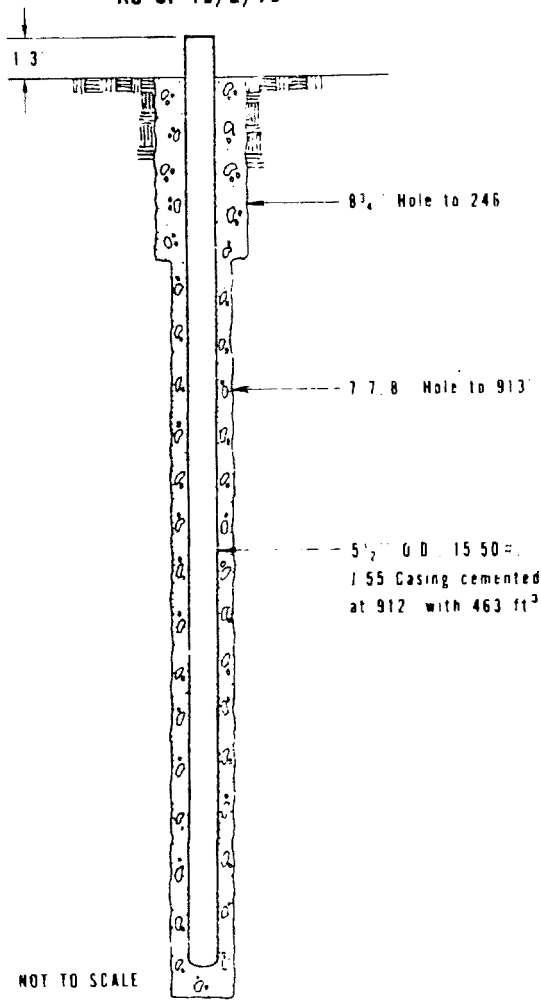


This is to certify that the foregoing plat was made from field notes of a bonafide survey made by me and is true and correct to the best of my knowledge and belief.

Dan R. Reddy

Dan R. Reddy
N.M.P.E. & L.S. #5412

WIPP #30
AS BUILT HOLE CONDITIONS
AS OF 10/2/78



WIPP 30 Logs[1]

Log	Company	ELSI#[2]	Top of Logged Interval[3] (feet)	Bottom Logged Interval (feet)	Date
BHC Acoustilog	Dresser Atlas	W7467W	10	903	9/30/78
Compensated Densilog	Dresser Atlas	W7467S	5	908	9/30/78
Compensated Neutron/Gamma Ray	Dresser Atlas	W7466Z	Surf.	908	9/30/78
Dual Laterolog	Dresser Atlas	W7467X	10	908	9/30/78
Digital Velocity Conversion	Seismic Reference Service, Inc.[4]	N/A	10	904	10/19/78
Micro-Laterolog	Dresser Atlas	W7467Y	30	907	9/30/78

[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 Avenue, Midland, TX.

[3]Depth measured from ground surface; elevation officially 3427.54' above MSL.

[4]Seismic Reference Service, Inc., Tulsa, OK.