NMED/DOE/AIP-96/3

Waste Isolation Pilot Plant Environmental Borehole Report 1996

Department of Energy Oversight Bureau
New Mexico Environment Department
P.O. Box 26110
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December 1996

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CONTENTS

ACRONYMS

AIP	Environmental Oversight and Monitoring Agreement Between the U.S. Department of Energy and the State of New Mexico, October 22, 1990
BCF	Billion Cubic Feet (of gas)
BWPM	Barrels of water per month
CAO	Carlsbad Area Office of the DOE
CH	Contact Handled TRU-waste
DOE-OB	New Mexico Environment Department DOE Oversight Bureau
DOE	U.S. Department of Energy
EMOP	1995 NMED/WIPP Environmental Monitoring and Oversight Plan
EMP	WIPP Environmental Monitoring Plan, DOE/WIPP 94-024
EPA	U.S. Environmental Protection Agency
LWB	Land Withdrawal Boundary
NMED	State of New Mexico Environment Department
NQA	Nuclear Quality Assurance
OCD	Oil Conservation Division
RCRA	Resource Conservation and Recovery Act
RH	Remote Handled TRU-waste
SWD	Salt Water Disposal
TD	Total Depth
TOC	Top of Cement
WIPP	Waste Isolation Pilot Plant

1.0 EXECUTIVE SUMMARY

The concern addressed by this investigation is the potential of a borehole to act as a conduit to release radioactive waste to the environment. State Engineer Regulations require that each water shall be confined to the aquifer in which it is encountered. The boreholes listed in Appendix V may not comply with regulations of the State Engineer Office presuming that the Dewey Lake, Magenta, Culebra, Salado, and Castile formations each encountered water. The investigation determined that 15 of 74 boreholes (see Appendix V) are suspected as non-compliant with 49 of 74 boreholes inconclusive due to inadequate information available to determine compliance (ref. AIP Borehole Database, Appendix IV; Jim Klaus/CAO letter dated 7-19-96).

Following the plugging of the above-described wells and according to the standards to date, all steps for protecting the environment in boreholes will have been taken. Please note that this investigation does not address the long term stability of the borehole but rather the current regulations which govern producing, plugging, and abandonment of boreholes. The life of the materials used in these boreholes may degrade in one hundred years (Stormont 84) but in theory the self-healing processes of salt will restrict movement of ground water or hazardous materials.

2.0 REASONS FOR INVESTIGATION

2.1 Introduction

The purpose of this investigation is to verify DOE borehole data, review the integrity of on site boreholes and their the ability to collect in-situ ground water free from interzone contamination, and evaluate the potential of boreholes as a pathway for radioactive waste from the stored underground waste repository to the environment. Creditable professionals were contracted to evaluate the off site "industry standard" cementing and cement evaluation methods which this investigation will employ as examples to apply to on site boreholes, since wells within the LWB were not logged to evaluate the cement integrity.

2.2 Water Levels

This investigation began with stakeholder concern that all the WIPP boreholes were connecting the underground aquifers, creating a potential pathway for radioactive waste release. The reasoning behind this concern was the rise in water levels in boreholes throughout the site. Of the thirty five wells measured, 71% recorded a rise (ref. Post 1988 Culebra Water Levels, Rick Beauheim, Sandia), the greatest rise of which was the P-18 well (90' from 1991 to 1995—attributed primarily from replacing 4" casing to 2 3/8" tubing) located 3/4 of a mile southeast of the LWB (section 26-22S-31E) and 2118' North of a water injection well (Yates #1 AIT Ross Federal). The rise in water level in several boreholes is a strong indication that unnatural recharge is occurring from an unknown source, since weather patterns have remained constant throughout the life of these boreholes. Other wells and boreholes with significant water level changes are:

Cabin Baby - Water level has dropped from 338' from surface in 1990 to 364' from surface in 1995.

H-14 - Water level has increased from the normal 345' from surface in 1991 to 337' from surface in 1995.

H-1, H2b2, H3b2, H-16, ERDA 9, WIPP 12, 18, 19, 21, and 22 - Water levels dropped beginning in 1993 due to leakage into the Air Intake Shaft (AIS) (ref. Beauheim June 1995). The Culebra water levels increased when the AIS was grouted in late 1993, but why did the Magenta zones in H-1 and H-16 increase? This may be an indication of cross contamination due to open hole conditions in the H-16 borehole and packer leakage in the H-1 borehole.

DOE-2 - Water levels have dropped since 1993.

2.3 Water Quality/Chemistry

Water Chemistry changes from the western portion of the site to the eastern portion.

1) Total Dissolved Solids (TDS) in the ***Culebra*** change drastically from 5,000 mg/L southwest of the site to >200,000 mg/l on the eastern edge of the site (ref. Crawley, 1988; Holt, 1992; and Siegel, 1991).
2) ***Dewey Lake*** TDS ranges from 673 mg/l in the Barn well southwest of the site to 3350 mg/l in the Fairview well southeast of the site.
3) ***Culebra*** $CaSO_4$ type water southwest of the site and NaCl type water in the eastern part of the site is a significant water chemistry change (ref. Crawley, 1988; Holt, 1992; and Siegel, 1991). It is not known whether the NaCl type water change occurs in the Dewey Lake since the wells in the eastern part of the site were not analyzed for Calcium and Sodium. Dewey Lake chloride levels also change from 81 mg/L in the Barn well southwest of the site to 140 mg/L in the Fairview well southeast of the site.
4) H-11b3 chlorides decreased to 56,000 PPM in 1990. Disposal of produced water began in 1991 in the AIT #1 Ross Federal (35-22S-31E) and analysis from 1992 to 1994 indicated an increase in chlorides to 65,500 PPM. Injection fluids in the Yates #1 AIT Ross Federal are 200,000 PPM. This change in chlorides is not significant since fluctuations in chlorides often range as much as 10,000-20,000 PPM from one measurement to the next.

These changes in water chemistry indicate that ground water on the western boundary of the site is intermixing with fresh water and/or that ground water on the eastern part of the site is intermixing with salt water.

2.4 Devon/Texas American Todd 26 F #3 Federal (NW 1/4 26-23S-31E)

Located four miles south of the LWB, this water injection well is the suspected cause of the water level rise in ground water in H-9. Deteriorated casing was replaced through the Rustler zone on November 22, 1993.

2.5 Yates #1 Ross AIT Federal (NE 1/4 35-22S-31E)

This salt water disposal well is located three quarters of a mile from the southeast corner of the LWB. The operator fractured the Delaware zone (below the base of the Castile), did not establish the necessary disposal rate, and fractured additional Delaware perforations so disposal of 67,000-104,000 BWPM could be accomplished (ref. OCD records 1991-95).

2.6 Grace #1 Cabin Baby Federal (NE 1/4 5-23S-31E)

This borehole is located 1980' south of the LWB. It was completed at a depth of 4150' and Temporarily Abandoned 2-8-75. Sandia performed slug injection tests in this borehole (ref. Sand87-7125) and DOE has long contended that this well may have a bridge plug failure and could be a possible cause to the rise in water levels in the southern portion of the LWB.

2.7 Casing and Cement Practices

2.7.1 Oil and Gas Industry Standard

Recently the Oil Conservation Division has required industry wells around WIPP to set surface casing to the base of the Rustler, intermediate casing to the top of the Delaware, and circulate both strings. In the past however, the Cotton Baby (34-22S-31E) completed in 1975 represents the industry standard. This well was cemented by plugs with the focus on the oil producing zones below the Delaware. Typically, the shallow water aquifers (Magenta, Culebra, Salado, and Castile) are commingled. It is worthwhile to note that it is difficult to seal zones in the Rustler, Salado, and Castile formations due to washout problems addressed in paragraph 3.7.2.

2.7.2 Problem Zones

Historically, water zones and salt/evaporite zones were considered problem zones while drilling and completing. Strong water zones resist good cement bonds and salt/evaporite zones washed out during drilling. The washouts create problems for cement volume calculations and, in some cases where cement is circulated to cover washouts, the pipe was pushed to the side of the hole allowing minimum cement bond between the pipe and formation. In many boreholes and industry wells, however, the salt/evaporite section which contains the Magenta and Culebra Aquifers was left uncemented (see notes Borehole Database H-2A, H3d1, H-16, I-377; Figure 1 - #1 Hargrove).

2.7.3 Pathway to the Environment

Of primary concern in this investigation is the potential pathway to the environment created by the boreholes. Assuming a migration of hazardous waste from the repository to a borehole (ref. Hartman #2 Bates had water injection flow through MB-141), waste could be transported to the surface or to the LWB through ground water flow and be consumed by animals, plants and humans (i.e. air, ingestion). Unsealed boreholes allow cross contamination from zone to zone, therefore potentially spreading the contamination.

2.7.4 Borehole Verification

Borehole verification consisted of listing the completion and plugging components of each borehole into a database format. Cement volume calculations were made using Halliburton/Western formulas to determine depth covered by the amount of cement used. Compliance was assessed based on the known zone levels (i.e. database intervals: Dewey Lake, Magenta, Culebra, Salado, and Castile) and the calculated cement covered intervals (i.e. database "Cement" column).

3.0 BOREHOLE INTEGRITY EVALUATION—OIL AND GAS WELLS

3.1 Oil and Gas History

The oil and gas picture surrounding WIPP has changed from its conception to the present. Four Control Zones were originally established to restrict activity that would affect the WIPP site. The outside or Control Zone IV restricted drilling activity approximately one mile beyond the 16-section LWB. These zones are now reduced to fit within the LWB (ref. WIPP Site Environmental Report 1995). Oil and gas reserves were thought to be of no economic consequence since the WIPP was located in a structural syncline. Today analogies can be drawn that show WIPP's 16-section boundary is structurally analogous to and on trend with the prolific Sand Dunes, Los Medanos, and Cabin Lake Fields. Ron Broadhead et al in 1995 calculated 12.3 million barrels of oil and gas condensate and 186 BCF gas recoverable by primary production methods from probable resources within the LWB and an additional one mile boundary surrounding WIPP. These reserves are very conservative due to calculations based on 150 barrels per month as the economic limit (industry uses 50-75 barrels per month), using 10% Discount rate calculated from Beta values (These Beta values are company wide and basin wide projections. Discount rates calculated from the surrounding WIPP Delaware play should be used. Note: There are no 1990's vintage dry holes surrounding WIPP, therefore, success ratios surrounding WIPP of greater than ninety five percent should replace the company wide variables for completion success in the Beta Value formula.), and market value projections for price per barrel are inconsistent with current prices (15.91 barrel 1996 was projected, current average for 1996 as of August is $20.30 per barrel). Possible resources which include undiscovered pools were not quantified. Even though the drilling activity has surpassed expectations surrounding WIPP, there is no reason why the two cannot coexist provided adequate control measures and regulations are enforced by the OCD, BLM, and the State Engineer Office.

3.2 Regulations

The following list of regulations are intended to convey requirements placed upon oil and gas industry activites occurring within the area now encompassed by the WIPP LWB:

Rule 1 - The Oil Conservation Division of the New Mexico Energy, Minerals and Natural Resources Department are to conserve the natural resources of the State of New Mexico, to prevent waste, to protect correlative rights of all owners of crude oil and natural gas, and to protect fresh waters.

Rule 106 - A. During the drilling of any oil well, injection well or any other services well, all oil, gas and water strata above the producing and/or injection horizon shall be sealed or separated in order to prevent their contents from passing into other strata.
B. All fresh waters and waters of present or probable value for domestic, commercial, or stock purposes shall be confined to their respective strata and shall be adequately protected by methods approved by the Division. Special precautions by methods satisfactory to the Division shall be taken in drilling and abandoning wells to guard against any loss of artesian water from the strata in which it occurs, and the contamination of artesian water by objectionable water, oil, or gas.
C. All water shall be shut off and excluded from the various oil- and gas-bearing strata which are penetrated. Water shut-offs shall ordinarily be made by cementing casing.

Rule 107 - A. Any well drilled for oil or natural gas shall be equipped with such surface and intermediate casing strings and cement as may be necessary to effectively seal off and isolate all water-, oil-, and gas-bearing strata and other strata encountered in the well down to the casing point.
B. Sufficient cement shall be used on surface casing to fill the annular space behind the casing to the top of the hole, provided however, that authorized field personnel of the Division may, at their discretion, allow exceptions to the foregoing requirement when known conditions in a given area render compliance impracticable.
G. Option 1 and 2 address cement curing times. Subparagraph "a" addressees curing "zone of interest". The "zone of interest" for surface and intermediate casing strings shall be the bottom 20 percent of the casing string, but shall be no more than 1000 feet nor less than 300 feet of the bottom-part of the casing unless the casing is set at less than 300 feet. The "zone of interest" for production casing strings shall include the interval or intervals where immediate completion is contemplated.

Rule 108 - Defective Casing or Cementing - If any well appears to have a defective casing program or faultily cemented or corroded casing which will permit or may create underground waste or contamination of fresh waters, the operator shall give written notice to the Division within five (5) working days and proceed with diligence to use the appropriate method and means to eliminate such hazard. If such hazard of waste or contamination of fresh water cannot be eliminated, the well shall be properly plugged and abandoned.

Rule 202 - B. Plugging - (1) Before any well is abandoned, it shall be plugged in a manner which permanently confine all oil, gas and water in the separate strata in which they are originally found. This may be accomplished by using mud-laden fluid, cement and plugs singly or in combination as approved by the Division on the notice of intention to plug.

Rule 203 - Temporary Abandonment - A. Wells Which May Be Temporarily Abandoned (1) The Division may permit any well which is required to be properly abandoned under these rules but which has potential for future beneficial use for enhanced recovery or injection, and any other well for which an operator requests temporary abandonment, to be temporarily abandoned for a period of up to five (5) years. Prior to the expiration of any approved temporary abandonment the operator shall return the well to beneficial use under a plan approved by the division, permanently plug and abandon said well or apply for a new approval to temporarily abandon the well.

Rule 204 - Wells To Be Used For Fresh Water (A) When a well to be plugged may safely be used as a fresh water well and the landowner agrees to take over said well for such purpose, the well need not be plugged above the sealing plug set below the fresh water formation. (B) The operator must comply with all other requirements contained in Rule 202 regarding plugging, including surface restoration and reporting requirements. (C) Upon completion of plugging operations, the operator must file with the Division a written agreement signed by the landowner whereby the landowner agrees to assume responsibility for such well. Upon the filing of this agreement and approval by the Division of well abandonment operations, the operator shall no longer be responsible for such well, and any bonds thereon may be released.

Rule-111-P This rule applies only to Oil and Gas wells and effective April 21, 1988.
Para. 16 - During the drilling of wells for oil and gas, measures should be taken to protect the salt-protection casing from internal pressures greater than the designed burst resistance plus a safety factor so as to prevent any possible entry of methane into the salt and potash interval.
Para. D 2 (a) - A surface casing string of new or used oil field casing in good condition shall be set in the "Red Bed" salt section, or in the anhydrite at the top of the salt section, as determined necessary by the regulatory representative approving the drilling operations, and the cement shall be circulated to the surface. (c) Casing and water-shut-off tests shall be made both before and after drilling the plug and below the casing seat as follows: (i) If rotary tools are used, the mud shall be displaced with water and a hydraulic pressure of six hundred (600) pounds per square inch shall be applied. If a drop of one hundred (100) pounds per square inch or more should occur within thirty (30) minutes, corrective measures shall be applied. (ii) If cable tools are used, the mud shall be bailed from the hole and if the hole does not remain dry for a period of one hour, corrective measures shall be applied.
Para. D 3 (a) - A salt protection string of new or used oil field casing in good condition shall be set not less than one hundred (100) feet nor more than six hundred (600) feet below the base of the salt section;... (b) (i) For wells drilled to the shallow zone, the string may be cemented with a nominal volume of cement for testing purposes only. If the exploratory test well is completed as a productive well, the string shall be re-cemented with sufficient cement to fill the annular space back of the pipe from the top of the first cementing to the surface or to the bottom of the cellar, or may be cut and pulled if the production string is cemented to the surface as provided in sub-section D (5) (a) (i) below. (ii) For wells drilled to the deep zone the string must be cemented with sufficient cement to fill the annular space back of the pipe from the casing seat to the surface or to the bottom of the cellar. (c) If the cement fails to reach the surface or the bottom of the cellar, where required, the top of the cement shall be located by a temperature, gamma ray or other survey and additional cementing shall be done until the cement is brought to the point required. (f) Casing tests shall be made both before and after drilling the plug and below the casing seat (same as para. D 2).
Para. D 4 (a) - In drilling wells to the deep zone for oil or gas, the operator shall have the option of running and intermediate string of pipe, unless the Division requires an intermediate string be run. (b) Cementing procedures and casing tests for the intermediate string shall be the same as provided under sub-sections D (3) (c), (e), and (f) for the salt protection string.
Para. D 5 (a) - A production string shall be set on top or through the oil or gas pay zone and shall be cemented as follows: (i) For wells drilled to the shallow zone the production string shall be cemented to the surface if the salt protection string was cemented only with a nominal volume for testing purposes, in which case the salt protection string can be cut and pulled before the production string is cemented; provided, that if the salt protection string was cemented to the surface, the production string shall be cemented with a volume adequate to protect the pay zone and the casing above such zone.
Para. F (1) - All wells heretofore and hereafter drilled within the Potash Area shall be plugged in a manner and in accordance with the general rules or field rules established by the Division that will provide a solid cement plug through the salt section and any water-bearing horizon and prevent liquids or gases from entering the hole above or below the salt section.

3.3 List of Boreholes and Area of Study

Appendix IV contains a list of boreholes within the LWB (P-18 outside of the LWB was added) that were examined during this study. This list is composed of seventy-four boreholes, all of which penetrate at least two aquifers (see also Appendix I - Map).

3.4 Examples of Potential Problem Wells

11-23S-31E - Devon Barkley #7 :
Good bond 150' down into the Bell Canyon Formation (perforation zone in the Yates #1 AIT Federal). 275' Poor bond at the Base of Castile Formation. Little or no bond between surface and 275' above the base of the Castile Formation

26-23S-31E - Devon/Texas American Todd 26 F #3:
In past literature this well was suspected to have a poor cement job and may have contaminated ground water zones with injection fluids. Records indicate a solid cemented interval through the salt section. There have, however, been problems with the 4 1/2" casing in the Rustler Formation. On November 22, 1993, the operator replaced eight joints of new casing at 338' and cemented to surface with 123 sacks of cement. This well represents what could happen to a well that reportedly cemented per OCD regulations.

5-23S-31E - Grace #1 Cabin Baby Federal:
Suspected bridge plug failure

3.5 Contractor Summary

35-22E-31E - Yates #1 AIT Ross Federal:
This well has been studied by the operator and Pecos Petroleum Engineering, Inc. It is a focal point due to its location 3/4 mile SE of the LWB and because it is injecting produced water into the Delaware Formation. Stakeholder concern led to the investigation of whether this injection water was the source of fluid level rise in P-18 and other wells within the WIPP boundary. Well integrity investigation shows 8 5/8" intermediate casing was set to 4465' with 1650 sacks of cement. Cement was circulated to the surface. 5 1/2" production casing was cemented to 4310' or 112' above the top of the Delaware Formation, which provides 155' of cement overlap into the 8 5/8" intermediate casing (see wellbore diagram Appendix III). Calculations of induced fracture geometry suggest vertical or horizontal magnitudes of 150-200' . The ability of the Bell Canyon and Cherry Canyon intervals to accept injected fluids was calculated using compressibility formulas assuming no oil or gas is present in the injection interval. These calculations suggest that an area of less than 1,000 acres could receive this volume of water.

EPA recommended that Yates conduct a tracer survey to determine if injection fluids were "going out of zone". While this test has limited resolution of vertical movement behind pipe, it is the most defensible technology to trace what zone the produced water is entering. Before this test was run induced vertical fracture calculations indicated that frac height could exceed the Top of Cement (TOC) at 4310'. The tracer test indicates that all of the injected water is entering the Delaware formation and that the top perforations 4500-90' are not receiving any fluid at all. A letter from Mr. Fant, Yates Petroleum Co., to the OCD dated December 5, 1995, indicated two build-up periods as proof of hydraulic connection between the Magenta and the Culebra as the reason for the P-18 water level increase. The two apparent build-ups are due to replacing the 4" monitoring casing with 2 3/8" tubing. The hydraulic connection assumption is in error since the well has never been perforated in the Magenta and the cement was circulated to surface behind the casing. The increasing water levels in 71% of the thirty five wells measured in the WIPP Site area is why EPA and not NMED wanted further proof that the Yates injection well is not contributing to this problem. The tracer survey was advised to protect Yates and the general public from this issue resurfacing in the future. So the question on P-18 remains: Why is the ground water head still rising above Culebra static levels?

Calculations conclude that this well has adequate mechanical integrity, is properly equipped for water disposal, and shows no indications that water is migrating from the injection zones to other zones in the wellbore. The injected reservoir is of the proper nature and has sufficient volume to provide adequate storage volume for the injected fluids. EPA suggested that the OCD require Yates to run a tracer survey as additional proof. The results of this survey revealed no vertical migration of fluids. Current technology and evaluation methods suggests that this well is compliant and disposing of water properly.

3.6 Borehole Integrity Tool Limitations

Borehole integrity tools are limited to cement bond logs and tracer surveys. The cement bond log lacks consistency to allow it to be comparable from well to well. For instance, the frequency, gating and bias levels are decided by each individual service company, and these have considerable affect on bond log response. Tracer surveys have limited horizontal resolution not to exceed 2-3' away from the wellbore. These tools, however, are the current technology and the only solution to evaluate borehole integrity.

4 .0 BOREHOLE INTEGRITY EVALUATION—TEST WELLS WITHIN THE LAND WITHDRAWAL BOUNDARY

4.1 Regulations (Boreholes and Shafts)

The following State Engineer Rules and Regulations apply to boreholes penetrating aquifers:

4-20 Test or Exploratory Wells - All test or exploratory wells shall be so constructed, maintained, and operated that each water shall be confined to the aquifer in which it is encountered. All test or exploratory wells penetrating artesian aquifers shall be cased, cemented, and tested as required for the construction of artesian wells (Article 4-15 through 4-19) and the casing shall be landed in the formation underlying the deepest artesian aquifer and cemented through all known artesian aquifers. The casing, as referred to in the artesian well specifications, is designated as the water protection string by the oil industry. If conductor pipe is used, it shall not be removed until after cementing of the casing has been completed. All casing, cementing, and testing programs shall be witnessed and approved by a representative of the State Engineer.

4-20.2 Abandonment–Plugging - In the event that the test or exploratory well is to be abandoned, the State engineer shall be notified. Such well shall be plugged in accordance with Article 4-19.1 so that the fluids will be permanently confined to the specific strata in which they

were originally encountered.

Note: This study did not focus on the integrity of the shafts at the WIPP site. This should be evaluated at a later date, especially in light of the State Engineer determination dated September 1996. This determination states that shafts are considered boreholes and that it is necessary to confine ground waters to the zone in which they are encountered.

4.2 List of Boreholes and Area of Study

The primary focus of this investigation was the seventy-four boreholes listed in Appendix IV. The area of study was confined to the Land Withdrawal Boundary with the exception of the contractor reports which investigated the industry standard surrounding WIPP and P-18. The LWB is within the Carlsbad Basin as designated by the State Engineer.

4.3 Examples of Problem Wells

The following wells contain monitoring, maintenance or potential compliance problems in addition to the wells in Appendix V:

20-22S-31E - B-25:
Water inflow while drilling from 690-701'. Hole size, casing and cement information are needed to calculate whether this water has been isolated.

28-22S-31E - DOE #1:
No bond at the base of the intermediate casing (1130'). Cement volumes and casing information are needed to verify a suspected collapsed casing in lower hole. Culebra is known to have double porosity.

20-22S-31E - ERDA-9:
The Salado is uncemented in this hole from 1045-2425'. This is the repository level and the zone of stored waste. This well is less than 40' from the E-300 drift.

20-22S-31E - WQSP #1:
The Magenta Aquifer is sealed with bentonite clay from 550'-640'. Sand and gravel separate the bentonite clay plug and the Culebra. Consideration should be given to sealing the Magenta with cement to isolate the Magenta and Culebra ground water per State Engineer Regulations. At the very least, a variance should be obtained if DOE can demonstrate that the bentonite plug is less permeable than cement.

20-22S-31E - H-16:
This well is mentioned in Appendix V and is significant enough to list as a problem well. This borehole allows the Dewey Lake, Magenta, Culebra, and Salado to be commingled. If

contaminated waste migrates along a zone in the Salado (i.e. MB 139) and reaches this borehole (located next to the Air Intake Shaft) then it will likely contaminate all of the shallow water aquifers since they are not isolated or confined.

4.4 Borehole Sealing

The best method of short term seals for boreholes was detailed in SAND84-1057. This reports states "Before plugging, existing casing should be removed where seals are to be emplaced. Over long periods of time, iron casing could corrode, leaving a more permeable conduit through the plug. Further, casing cement should be removed to reestablish contact of the host rock with the new plugging material. The BCT 1-F mix or a comparable cement should be placed in the salt zones to preclude dissolution of the host rock by the cement water. On the other hand, the freshwater mix, BCT1-FF, is preferred in non-salt zones because of its slightly better performance characteristics (ref. Tremper 1966)."

OCD Rule-111-P (applies to all oil and gas wells in sections 27-34-22S-31E) gives a higher standard for sealing oil and gas wells and could be adopted for all boreholes in the future. This rule generally provides that surface and salt protection casing strings be circulated with cement so as to fill the annulus behind the casing with cement. Casing and water shut-off tests are to be run to test the cement job for pressure leaks. Plugged wells should provide a solid cement plug through the salt section to seal off the salt section and any water-bearing formations.

4.5 Contractor Summary

WIPP Bond Log Project:
The purpose of this study was to determine the probability of hydraulic communication within the annulus between the formation and the casing using bond logs. The following information was determined in this study:

20-22S-31E - WIPP-18: Good bond is reported from TD of 1046' to 108' using the vintage of logs available on this well. Radial logging techniques have replaced this log which makes it easier to detect channeling through cement in wells that have circulated the cement to surface as the WIPP-18 reported. Zones within this well show amplitude changes which indicate poor bond; however, a closer look at those changes reveal formation density differences and therefore shows a good bond.

ERDA-9: Good bond is reported from 208-996'. There is no cement and no bond reported from 996-2540'. Hydraulic communication is probable through this interval.

H-1: There is bond present between 654-798'. There is no certainty of hydraulic isolation from 0-754'. This well is definitely a candidate for additional evaluation in spite of hole history reports of cement circulated to surface.

5.0 CONCLUSION

This investigation has verified available DOE borehole data and offers substantial evidence that WIPP wells could be the cause of ground water fluctuations. The review of the integrity of on site boreholes and their ability to collect in-situ ground water free from interzone contamination, has indicated 15 of 74 boreholes may not comply with State Engineer Regulations. Information regarding the remaining 49 boreholes was inconclusive. In order to eliminate boreholes as a potential pathway to the environment it is recommended that DOE contact the State Engineer's Office to evaluate procedures which may be required to bring the boreholes into compliance with standards. The unknown causes of ground water fluctuations and the boreholes listed in Appendix V may have an effect on the Final Safety Analysis Report and the Performance Assessment of WIPP.

Practical solutions can eliminate these boreholes from environmental concerns by addressing casing and cement problems using a multi-stage approach. The first stage should include an assessment of the suspected "non compliant" and "problem boreholes" within the LWB. This may involve defining which boreholes have confirmed aquifers ("each water shall be confined"), verifying that subsequent information is not available, and determining whether shafts are compliant. Forms and reports should be provided to the State Engineer so a determination can be made whether the plugging or construction, operation, and maintenance of the drill hole are satisfactory.

The second stage should include monitoring of all oil and gas wells within a one-mile buffer to insure that operators are complying with R-111-P.

The third stage should include drilling and completing old and new boreholes consistent with the most stringent standards set by Rule-111-P. This involves re-entering the boreholes with a workover unit, logging cement integrity, pulling old casing, pumping cement across aquifers to isolate ground water, fully cementing the salt section including the annulus space behind the casing, and separating commingled perforations. All borehole workovers should be witnessed by a representative of the State Engineer.

From a practical standpoint, some of the boreholes within the LWB could be of valuable use for monitoring sources of radionuclides. This should include a frequent broad monitoring (during and after waste receipt) of the aquifers in boreholes near the repository and near the LWB.

6.0 REFERENCES

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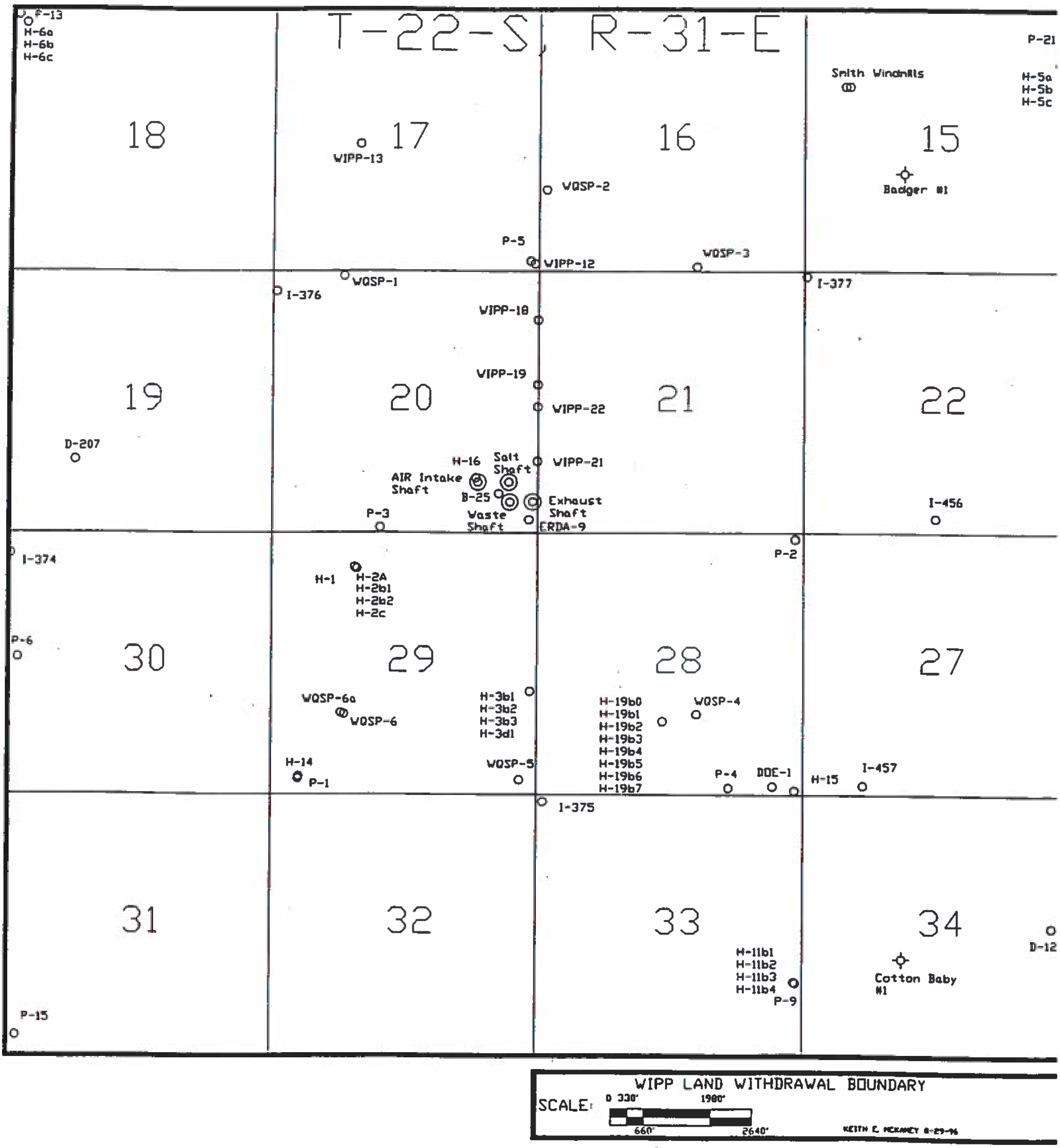
WIPP Environmental Monitoring Plan (EMP), DOE/WIPP 94-024

APPENDIX

LIST OF APPENDICES

APPENDIX I


T-22-S, R-31-E
18
17
16
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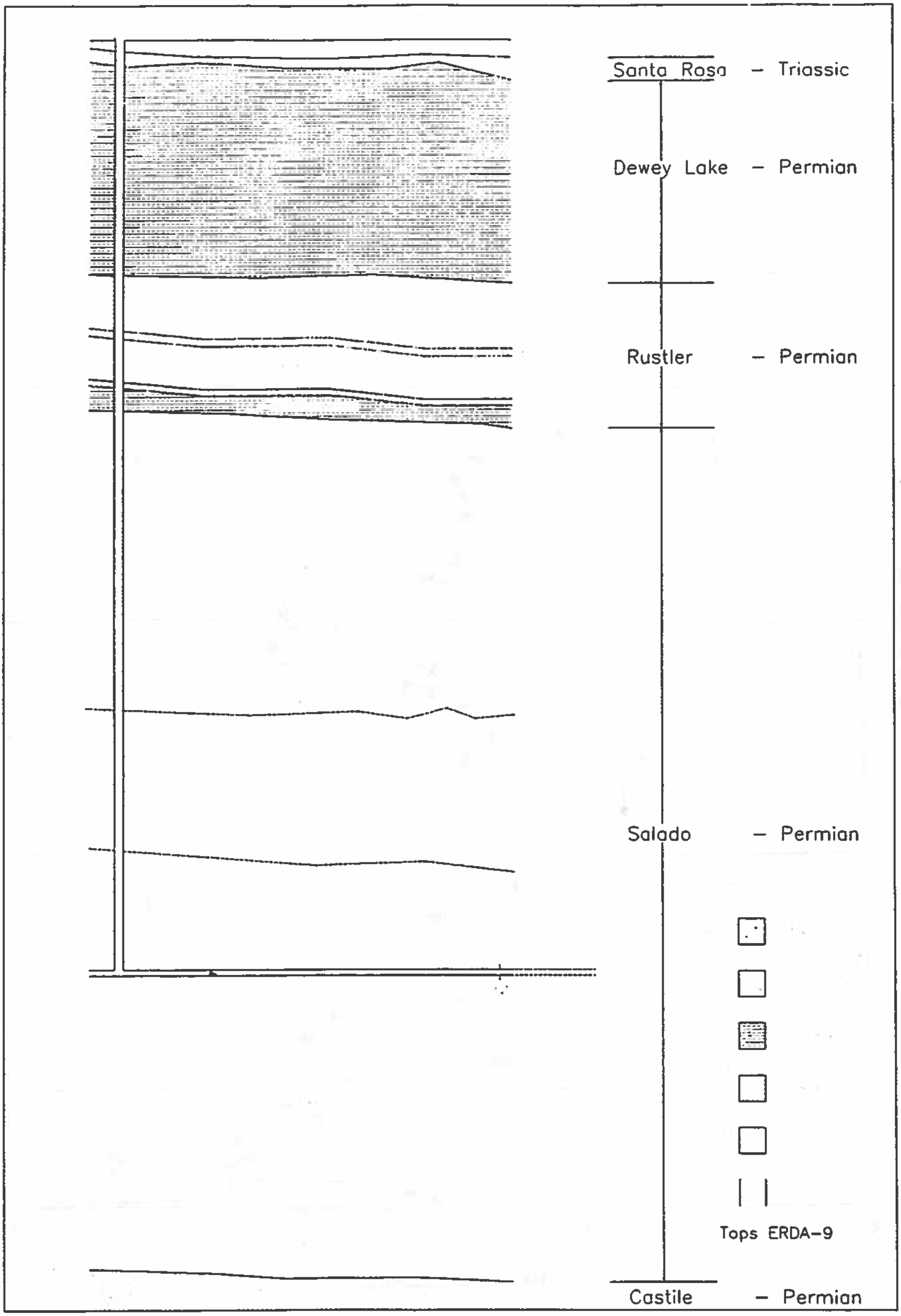
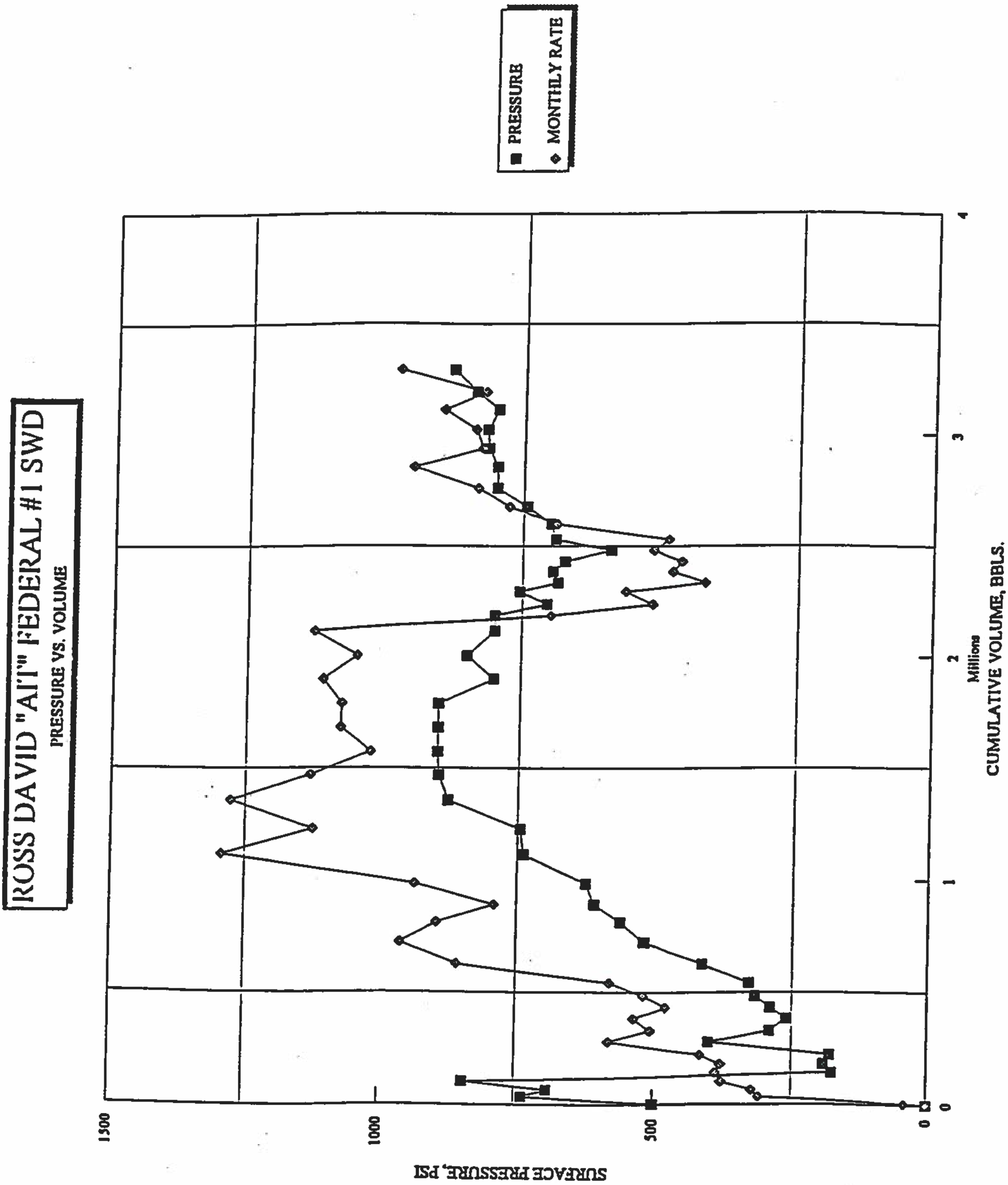
31
32
33
34
P-13
H-6a
H-6b
H-6c
WIPP-13
WQSP-2
Smith Windmills
P-21
H-5a
H-5b
H-5c
Badger #1
P-5
WIPP-12
WQSP-3
WQSP-1
I-376
I-377
WIPP-18
WIPP-19
WIPP-22
D-207
H-16
Salt Shaft
WIPP-21
AIR Intake Shaft
B-25
Exhaust Shaft
I-456
P-3
Waste Shaft
ERDA-9
I-374
P-2
H-1
H-2A
H-2b1
H-2b2
H-2c
P-6
WQSP-6a
WQSP-6
H-3b1
H-3b2
H-3b3
H-3d1
H-19b0
H-19b1
H-19b2
H-19b3
H-19b4
H-19b5
H-19b6
H-19b7
WQSP-4
H-14
P-1
WQSP-5
P-4
DOE-1
H-15
I-457
I-375
H-11b1
H-11b2
H-11b3
H-11b4
P-9
Cotton Baby #1
D-12
P-15
WIPP LAND WITHDRAWAL BOUNDARY
SCALE:
0 330'
1980'
660'
2640'
KEITH E. MCKANEY 8-29-96

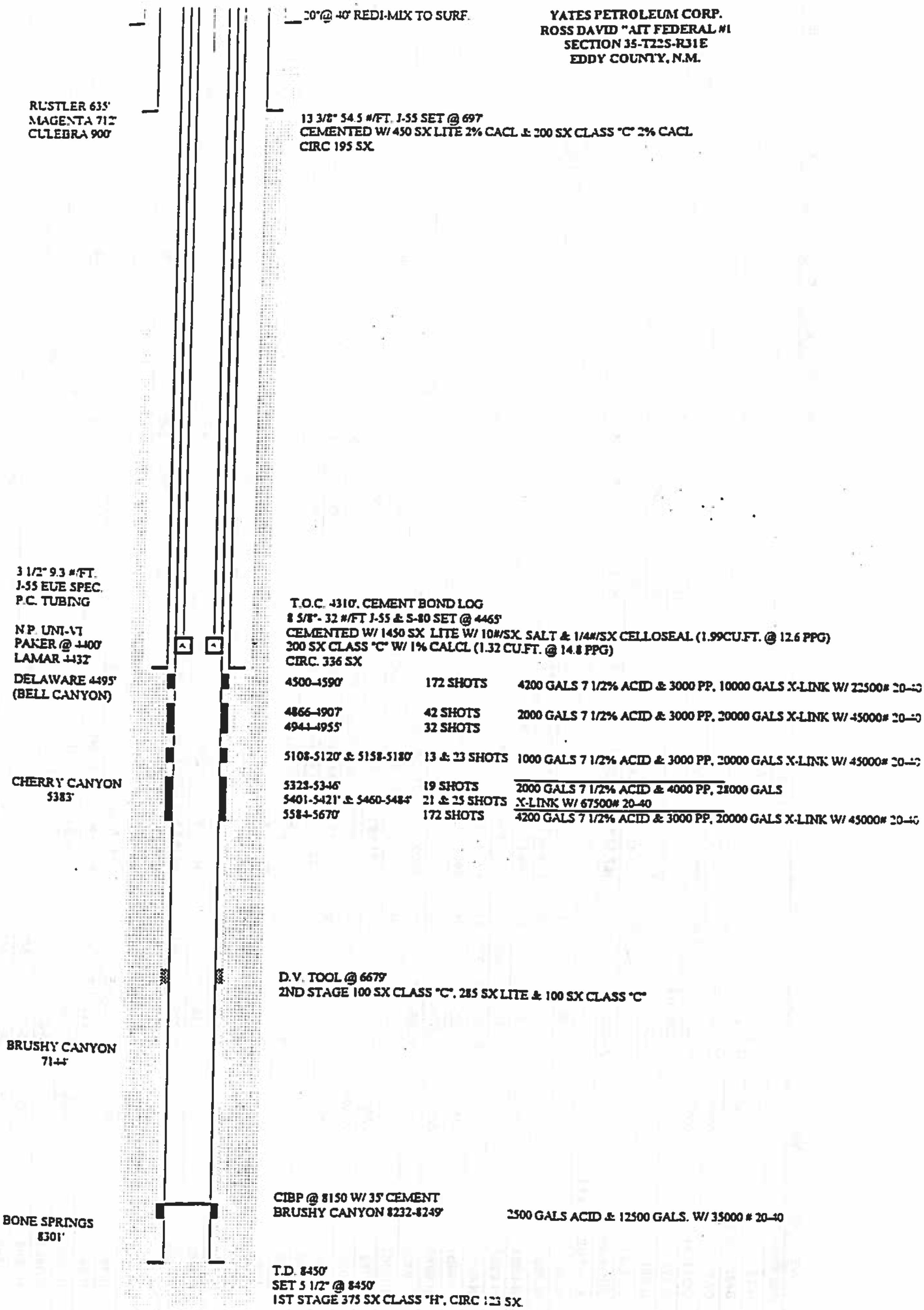
APPENDIX II


Santa Rosa – Triassic
Dewey Lake – Permian
Rustler – Permian
Salado – Permian
Tops ERDA-9
Castile – Permian


ROSS DAVID "AIT" FEDERAL #1 SWD
PRESSURE VS. VOLUME
PRESSURE
MONTHLY RATE
SURFACE PRESSURE, PSI
0
500
1000
1500
CUMULATIVE VOLUME, BBLS.
Millions
0
1
2
3
4

APPENDIX III

YATES PETROLEUM CORP.
ROSS DAVID "AIT FEDERAL #1
SECTION 35-T22S-R31E
EDDY COUNTY, N.M.



APPENDIX IV

REC_NO	WELL_NAME	WELL_NO	SEC_T_R	CAS_ELEV	BDB_LOC	BDB_ELEV	TD	COMP_DATE	CEMENT	[illegible]	HOLE_A_DEP	CAS_A_DIA	CAS_A_DEP
1	AIS SHAFT	WW1	20-22S-31E	?	1025.2'FSL-1204'FEL	?	?	?	?	?	?	?	?
2	B-25	WW2	20-22S-31E	3408.19	796.0'FSL-777.0'FEL	3408.74	901.8	01/18/79	?	11	?	9.625	0-18
3	BADGER-1	WW3	15-22S-31E	3496 KB	1980.0'FSL-1980.0'FWL	3496.00	15225	11/17/73	0-11990	?	0-804	20	0-804
4	C&SH SHAFT	WW4	20-22S-31E	?	1025.2'FSL-579.1'FEL	3411.00	?	?	?	?	?	?	?
5	COTTON BABY	WW5	34-22S-31E	3455 KB	1980'FSL-1980'FWL	3445.00	6651	12/15/75	ref. plugs	15	?	13.375	0-680.76
6	D-123	WW6	34-22S-31E	?	?	3432.00	1880	08/07/53	692-880	6.25	0-934	4	692-880
7	D-207	WW7	19-22S-31E	?	?	3406.00	1613	07/03/58	0-470	?	?	Pulled	0
8	DOE-01	WW8	28-22S-31E	3465.22	182.4'FSL-607.8'FEL	3465.22	4057.3	07/28/82	0-1123	>20 ?	0-49	20	0-49
9	ERDA-09	WW9	20-22S-31E	3410.10	287.17'FSL-176.74'FEL	3410.10	2886	06/26/76	2425-2883	20	5-40	16	0-40
10	EXHAUST SHAFT	WW10	20-22S-31E	?	625.2'FSL-103.6'FEL	3409.90	?	?	?	?	?	?	?
11	H-01	WW11	29-22S-31E	3399.53	623.2'FNL-1083.1'FWL	3399.53	856	06/10/76	0-848	18	0-40	10.125	0-48
12	H-02a	WW12	29-22S-31E	3378.09	728.86'FNL-1697.64'FWL	3378.09	654	02/21/77	0-613	18	4-33	10.75	0-33
13	H-02b1	WW13	29-22S-31E	3378.46	695.87'FNL-1660.57'FWL	3378.46	661	02/14/77	0-609	18	4-33	10.75	0-33
14	H-02b2	WW14	29-22S-31E	3378.31	700.6'FNL-1690.8'FWL	3378.31	649	05/03/84	?	18"	0-20'	9.625	0-20
15	H-02c	WW15	29-22S-31E	3378.41	637.18'FNL-1708.62'FWL	3378.41	795	02/05/77	0-742	18	4-33	10.75	0-33
16	H-03b1	WW16	29-22S-31E	3390.64	2085.31'FSL-138.10'FEL	3390.64	902	08/12/76	0-891	13.75	0-38	10.75	0-38
17	H-03b2	WW17	29-22S-31E	3390.03	2122.15'FSL-231.29'FEL	3390.03	725	11/14/83	0-672.7?	?	0-34	?	?
18	H-03b3	WW18	29-22S-31E	3388.67	2022.35'FSL-217.30'FEL	3388.67	693	01/30/84	50-670.5?	7.875	0-673	5.5	.50-670.5
19	H-03d1	WW19	29-22S-31E	3390.01	2067.3'FSL-164.3'FEL	3390.01	554	04/22/87	0-39	12.25	0-39	8.625	0-39
20	H-05a	WW20	15-22S-31E	3506.44	1091.98'FNL-185.03'FEL	3506.19	930	06/20/78	0-774	18	5-38	9.625	0-38
21	H-05b	WW21	15-22S-31E	3506.04	1008.30'FNL-236.22'FEL	3506.04	925	06/13/78	0-887	18	5-38	9.625	0-36
22	H-05c	WW22	15-22S-31E	3506.04	1005.55'FNL-134.96'FEL	3506.04	1076	06/03/78	0-1024	18	5-38	9.625	0-38
23	H-06a	WW23	18-22S-31E	3347.83	283.30'FNL-274.34'FWL	3347.83	637	07/11/78	0-478	18	5-38	9.625	0-38
24	H-06b	WW24	18-22S-31E	3348.25	196.34'FNL-332.96'FWL	3348.25	640	07/05/78	0-590	18	5-38	9.625	0-38
25	H-06c	WW25	18-22S-31E	3348.52	281.06'FNL-374.47'FWL	3348.52	741	06/26/78	0-699	18	5-38	9.625	0-38
26	H-11b1	WW26	33-22S-31E	3411.62	1510.9'FSL-173.9'FEL	3411.62	785	09/02/83	0-735?	18	0-37	9.625	0-35
27	H-11b2	WW27	33-22S-31E	3411.64	1436.3'FSL-168.7'FEL	3411.64	776	11/28/83	0-733.39?	18	0-37	9.625	0-37
28	H-11b3	WW28	33-22S-31E	3412.42	1501.7'FSL-105.2'FEL	3412.42	788.7	01/84	0-734?	18	0-37	9.625	0-34
29	H-11b4	WW29	33-22S-31E	3410.89	1514.7'FSL-320.2'FEL	3410.89	765	03/15/88	0-714	16	0-27	8.625	0-27
30	H-14	WW30	29-22S-31E	3347.11	372.2'FSL-562.4'FWL	3347.11	589	10/23/86	0-532?	12.25	0-39.5	8.625	0-39
31	H-15	WW31	28-22S-31E	3481.63	88.7'FSL-174.3'FEL	3481.63	900	11/14/86	0-863?	12.25	0-39.5	8.625	0-39
32	H-16	WW32	20-22S-31E	3406.77	1112.6'FSL-1241.3'FEL	3406.77	850.9	08/18/87	0-469	18	0-36.5	10.75	0-36.5
33	H-18	WW33	20-22S-31E	3414.21	984.8'FNL-448.6'FWL	3414.21	840	11/16/87	0-673	18	0-39.5	10.75	0-39.5
34	H-19b0	WW34	28-22S-31E	3418.38	1484.6'FSL-2460.4'FWL	3417.11	778.7	04/23/95	0-731.9	24	0-38	20	0-38
35	H-19b1	WW35	28-22S-31E	?	1535.0'FSL-2460.6'FWL	3417.43	732.6	03/19/95	N/A	24	0-38	20	0-38
36	H-19b2	WW36	28-22S-31E	3419.01	1434.3'FSL-2459.6'FWL	3417.13	785.4	08/28/95	0-732.4	18	0-37	14	0-37
37	H-19b3	WW37	28-22S-31E	3419.09	1509.2'FSL-2503.9'FWL	3417.28	785	08/29/95	0-734.0	18	0-38	14	0-38

= Need info. (not available in Borehole notebook or Hole History data)

= Non-Compliant (ref. Borehole Data Notebook, 1065-88, Hole History

Updated 9-3-96

= Odd information...ref. Borehole Data Notebook

= Odd information...ref. Hole History Reports (Sandia)

= All sources differ (ref. Borehole Data Notebook, Sand. 1065-88, Hole History)

APPENDIX IV

REC_NO	WELL_NAME	WELL_NO	SEC_T_R	CAS_ELEV	BDB_LOC	BDB_ELEV	TD	COMP_DATE	CEMENT	[illegible]	[illegible]	[illegible]	CAS_A_DEP
38	H-19b4	WW38	28-22S-31E	3419.03	1510.6'FSL-2417.1'FWL	3417.03	781.5	08/22/95	0-736.7	18	0-38	14	0-38
39	H-19b5	WW39	28-22S-31E	3418.63	1466.3'FSL-2420.4'FWL	3416.89	783.4	08/26/95	0-734.0	18	0-38	14	0-38
40	H-19b6	WW40	28-22S-31E	3419.07	1554.4'FSL-2472.6'FWL	3417.25	785	08/24/95	0-733.0	18	0-39	14	0-39
41	H-19b7	WW41	28-22S-31E	3418.99	1455.6'FSL-2464.1'FWL	3416.94	785	08/19/95	0-734.0	18	0-38	14	0-38
42	I-374	WW42	30-22S-31E	?	324.0'FNL-48.0'FWL	3340.00	1538	04/27/65	?	6.25	0-714	4	437-714
43	I-375	WW43	33-22S-31E	?	344.0'FNL-24.0'FWL	3390.00	1746	05/13/65	?	6.25	0-520	4	129-817
44	I-376	WW44	20-22S-31E	?	300.0'FNL-78.0'FWL	3410.00	1702	06/23/65	?	6.25	0-640	pulled	0
45	I-377	WW45	22-22S-31E	?	106.01'FNL-48.0'FWL	3490.00	1876	07/16/65	?	6.25	0-996	pulled	0
46	I-456	WW46	22-22S-31E	?	300.0'FSL-2650.0'FEL	3520.00	1975	N/A	?	6.25	0-940	pulled	0
47	I-457	WW47	27-22S-31E	?	200.0'FSL-1200.0'FWL	3460.00	1885	N/A	?	6.25	0-940	pulled	0
48	P-01	WW48	29-22S-31E	?	327.0'FSL-551.0'FWL	3345.00	1200	09/02/76	0 -1591	8.75	0-32	0	0
49	P-02	WW49	28-22S-31E	?	125.0'FNL-172.0'FEL	3478.00	1895	09/02/76	? -1895	8.75	0-20	0	0
50	P-03	WW50	20-22S-31E	?	103.0'FSL-3122.0'FEL	3382.00	1676	09/07/76	0 -1676	8.75	0-30	0	0
51	P-04	WW51	28-22S-31E	?	146.0'FSL-1487.0'FEL	3441.00	1857	09/04/76	0 -1857	8.75	0-23	0	0
52	P-05	WW52	17-22S-31E	?	202.0'FSL-165.0'FEL	3472.00	1420	09/21/76	0 -1830	8.75	0-25	0	0
53	P-06	WW53	30-22S-31E	?	2767.0'FSL-199.0'FWL	3354.00	1573	09/16/76	0 -1573	8.75	0-18	0	0
54	P-09	WW54	33-22S-31E	?	1493.0'FSL-143.0'FEL	3409.00	1796	09/25/76	0 -1796	8.75	0-23	0	0
55	P-13	WW55	18-22S-31E	?	125.0'FNL-116.0'FWL	3345.00	1576	09/23/76	0 -1576	8.75	0-18	0	0
56	P-15	WW56	31-22S-31E	?	410.8'FSL-192.32'FWL	3309.70	1465	10/14/76	0 -1465	8.75	0-20	8.625	0-20
57	P-18	WW57	26-22S-31E	?	138.5'FSL-732.7'FEL	3479.00	1998	11/05/76	0 - 1998	8.75	0-18	8.625	0-18
58	P-21	WW58	15-22S-31E	?	852.0'FNL-150.0'FEL	3510.00	1915	10/26/76	0 -1915	8.75	0-23	0	0
59	SMITH WINDMILL	WW59	15-22S-31E	3454.70	819'FWL-1547'FNL	?	161	02/19/59	?	?	?	6.625	?
60	SMITH WINDMILL	WW60	15-22S-31E	3456.60	905'FWL-1547'FNL	?	169	02/19/59	?	?	?	12.75	?
61	WASTE SHAFT	WW61	20-22S-31E	?	625.2'FSL-554.1'FEL	3409.00	?	N/A	?	?	?	4	?
62	WIPP-12	WW62	17-22S-31E	3472.06	149.4'FSL-80.4'FEL	3472.06	3927.5	12/07/78	0-1015	18	4-38.6	13.375	4-38.6
63	WIPP-13	WW63	17-22S-31E	3405.71	2565.68'FSL-1730.59'FWL	2565.68	3868	10/05/79	0-1035	16	5-36	13.375	0-35.5
64	WIPP-18	WW64	20-22S-31E	3458.76	983.58'FNL-11.85'FEL	3458.70	1060	04/03/78	0	8.75	0-16	7	0-16
65	WIPP-19	WW65	20-22S-31E	3435.14	2288.5'FNL-12.7'FEL	3435.14	1038	05/08/78	0	8.75	0-8	7	0-8
66	WIPP-21	WW66	20-22S-31E	3418.96	1450.6'FSL-11.7'FEL	3418.96	1045	05/26/78	0	8.75	0-15	7	0-15
67	WIPP-22	WW67	20-22S-31E	3428.12	2544.9'FSL-10.82'FEL	3428.12	1450	05/24/78	0	8.75	0-20	7	0-20
68	WQSP-01	WW68	20-22S-31E	?	101.0'FNL-1422.0'FWL	3575.00	737	09/16/94	0-550	15	0-25	10.75	0-25
69	WQSP-02	WW69	16-22S-31E	?	1646.0'FSL-142.0'FWL	3400.00	846	09/10/94	1-770	15	0-25	10.75	0-25
70	WQSP-03	WW70	16-22S-31E	?	96.0'FSL-2162.0'FEL	N/A	879	10/26/94	0-8007	15	0-25	10.75	0-25
71	WQSP-04	WW71	28-22S-31E	?	1632.0'FSL-2136.0'FEL	N/A	800	10/07/94	?	15	0-25	10.75	0-25
72	WQSP-05	WW72	29-22S-31E	?	300.0'FSL-340.0'FEL	N/A	681	10/13/94	1-613	15	0-25	10.75	0-25
73	WQSP-06	WW73	29-22S-31E	?	1626.0'FSL-1461.0'FWL	3350.00	617	09/30/94	1-560	15	0-25	10.75	0-25
74	WQSP-06a	WW74	29-22S-31E	?	1653.0'FSL-1395.0'FWL	N/A	225	10/31/94	0-152	15	0-25	10.75	0-25

= Need info. (not available in Borehole notebook or Hole History data)
= Non-Compliant (ref. Borehole Data Notebook, 1065-88, Hole History

Updated 9-3-96

= Odd Information...ref. Borehole Data Notebook
= Odd information...ref. Hole History Reports (Sandia)
= All sources differ (ref. Borehole Data Notebook, Sand. 1065-88, Hole History)

APPENDIX IV

REC_NO	WELL_NAME	[redacted]		HOL_SZ_B	HOL_B_DEP	CAS_B_DIA	CAS_B_DEP	CAS_B_TYPE	CEM_B
1	AIS SHAFT	?	?	?	?	?	?	?	?
2	B-25	?	?	?	?	6.25	18-901.8	?	?
3	BADGER-1	?	1478cu	?	?	13.375	0-4240	?	3854cu
4	C&SH SHAFT	?	?	?	?	?	?	?	?
5	COTTON BABY	61#	170 sks	7.875	?	2.875	3980-4634	6.50#	325 sks
6	D-123	?	45 sks	?	934-1880	?	?	?	73 sks
7	D-207	NA	25 sks	?	?	?	?	?	?
8	DOE-01	?	? cu	14.75	49-1130.5	10.75	49-1126.2	40.50# J-55	?
9	ERDA-09	?	95cu	15	51-1049	10.75	0-1045	40.50# J-55	1159cu
10	EXHAUST SHAFT	?	?	?	?	?	?	?	?
11	H-01	40.50# used	51cu	9.875	40-856	7	0-848	26.00# K-55	192cu
12	H-02a	used	54cu	8.75	33-513	6.625	0-513	24.00# J-55	260 cu
13	H-02b1	used	54cu	8.75	33-611	6.625	0-609	24.00# J-55	282cu
14	H-02b2	36.00# J-55	?	7.875	20-660	5.5	0-620	15.50# J-55	?
15	H-02c	used	54cu	8.75	33-743	6.625	0-742	24.00# J-55	339cu
16	H-03b1	40.50#	54cu	8.75	38-902	6.625	0-897.25	24.00# J-55	625cu
17	H-03b2	15.5# J-55	?	7.875	0-673	5.5	0-672.7	15.5# J-55	Circ. ?
18	H-03b3	15.5# J-55	? cu	4.5	673-693	?	?	?	?
19	H-03d1	28.00# H-40	27cu	7.875	39-553.9	OH	OH	OH	?
20	H-05a	36.00# J-55	72cu	7.875	38-775	5.5	0-774	15.50# J-55	192cu
21	H-05b	36.00# J-55	72cu	7.875	38-882	5.5	0-887	15.50# J-55	336cu
22	H-05c	36.00# J-55	72cu	7.875	38-1025	5.5	0-1024	15.50# J-55	416cu
23	H-06a	36.00# J-55	72cu	7.875	38-475	5.5	0-475	15.50# J-55	155cu
24	H-06b	36.00# J-55	72cu	7.875	38-592	5.5	0-590	15.50# J-55	210cu
25	H-06c	36.00# J-55	72cu	7.875	38-700	5.5	38-726	15.50# J-55	335cu
26	H-11b1	40.00# H-40	27cu	7.875	37-733	5.5	0-735	15.50# J-55	Cu. ?
27	H-11b2	40.00# H-40	N/A	7.875	37-734	5.5	0-733.39	15.50# J-55	Cu. ?
28	H-11b3	40.00# H-40	27cu	7.875	34-734	5.5	0-733	15.50# J-55	Cu. ?
29	H-11b4	28.00# H-40	18cu	7.875	27-714	5.5	0-714	15.50# J-55	263 Cu.
30	H-14	28.00# H-40	27cu	7.875	39.5-533	5.5	0-532	15.50# J-55	Circ. Cu. ?
31	H-15	28.00# H-40	27cu	7.875	39.5-854	5.5	0-853	15.50# J-55	circ. Cu. ?
32	H-16	40.50# H-40	35cu	9.625	36.5-479.73	7	0-469	23.00# J-55	411 Cu.
33	H-18	40.50# H-40	37cu	9.625	39.5-674	7	0-673	23.00# J-55	303 Cu.
34	H-19b0	53.00# H-40	50cu	14.75	38-735.5	9.625	0-731.9	5.7# Centron DHC-350	794cu
35	H-19b1	53.00# H-40	? cu	12.25	38-658	?	?	?	?
36	H-19b2	42.00# H-40	35cu	12.25	37-734	7	0-732.40	5.7# Centron DHC-300	606cu
37	H-19b3	42.00# H-40	35cu	12.25	38-734	7	0-732.04	5.7# Centron DHC-300	606cu

= Need Info. (not available in Borehole notebook or Hole History data)

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= Odd information...ref. Borehole Data Notebook

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APPENDIX IV

REC_NO	WELL_NAME	[redacted]	[redacted]	HOL_SZ_B	HOL_B_DEP	CAS_B_DIA	CAS_B_DEP	CAS_B_TYPE	CEM_B
38	H-19b4	42.00# H-40	35cu	12.25	38-734	7	0-730.7	5.7# Centron DHC-300	606cu
39	H-19b5	42.00# H-40	35cu	12.25	38-734.2	7	0-730.7	5.7# Centron DHC-300	606cu
40	H-19b6	42.00# H-40	35cu	12.25	39-732.8	7	0-730.1	5.7# Centron DHC-300	606cu
41	H-19b7	42.00# H-40	35cu	12.25	38-733.6	7	0-731.01	5.7# Centron DHC-300	606cu
42	I-374	?	? cu	3.88	714-1536	NA	NA	NA	? cu
43	I-375	?	? cu	3.88	620-1746	NA	NA	NA	? cu
44	I-376	0.00	? cu	3.88	840-1702	NA	NA	NA	? cu
45	I-377	0.00	? cu	3.88	996-1530	NA	NA	NA	? cu
46	I-456	0.00	? cu	3.88	840-1580	NA	NA	NA	?
47	I-457	0.00	? cu	3.88	840-1665	NA	NA	NA	?
48	P-01	?	0	6.25	32-794	4.5	591-794	[illegible]	310cu
49	P-02	?	0	5.875	20-1038	?	?	?	0
50	P-03	?	0	6.25	30-826	4.5	490-826	[illegible]	0
51	P-04	?	0	5.875	23-958	?	?	?	0
52	P-05	?	0	6.25	25-1000	4.5	435-1003	[illegible]	0
53	P-06	?	0	5.875	18-703	?	?	?	0
54	P-09	?	0	5.875	23-1023	?	?	?	0
55	P-13	?	0	5.875	18-785	?	?	?	0
56	P-16	?# Used	0	7.875	20-637	4.5	0-635	9.50# J-55	266cu
57	P-18	?# Used	0	7.875	18-1139	4.5	0-1139	9.50# J-55	427 Cu.
58	P-21	?	0	5.875	23-1105	?	?	?	0
59	SMITH WINDMILL	?	?	?	?	?	?	?	?
60	SMITH WINDMILL	?	?	?	?	?	?	?	?
61	WASTE SHAFT	?	?	?	?	?	?	?	?
62	WIPP-12	48.00# H-40	81cu	12.25	38.6-1015	9.625	0-1015	36.00# J-55 / 32.30# H-40	478cu
63	WIPP-13	?	108cu	12.25	36-1035	9.625	0-1035	36.00# O.D.	665cu
64	WIPP-18	20.00# O.D.	0	6.125	16-1060	NA	NA	NA	?
65	WIPP-19	?	0	6.125	8-1038	NA	NA	NA	?
66	WIPP-21	23.00# J-55	0	6.125	15-1045	NA	NA	NA	?
67	WIPP-22	?	0	6.125	20-1450	NA	NA	NA	?
68	WQSP-01	?	?	9.875	25-746	5	0-746	Fiberglass	?
69	WQSP-02	?	?	9.875	25-855.2	5	0-855.2	Fiberglass	?
70	WQSP-03	?	?	9.875	25-889	5	0-889.2	Fiberglass	?
71	WQSP-04	?	?	9.875	25-809.2	5	0-809.2	Fiberglass	?
72	WQSP-05	?	?	9.875	25-690.2	5	0-690.2	Fiberglass	?
73	WQSP-06	?	?	9.875	25-626.2	5	0-626.2	Fiberglass	?
74	WQSP-06a	?	?	9.875	25-234.2	5	0-234.2	Fiberglass	?

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APPENDIX IV

REC_NO	WELL_NAME	HOL_SZ_C	HOL_C_DEP	CAS_C_DIA	CAS_C_DEP	CAS_C_TYPE	CEM_C	DWY_LAKE	MAG	CUL	SAL	CAST
1	AIS SHAFT	?	?	?	?	?	?	?	?	?	?	?
2	B-25	NA	NA	NA	NA	NA	NA	45.0-533.0	592.7-617.0	704.1-728.0	842.9-901.8	NA
3	BADGER-1	12.25	4240-11990	9.625	0-11970	?	2640cu	?	?	?	?	?
4	C&SH SHAFT	?	?	?	?	?	?	?	?	?	?	?
5	COTTON BABY	?	?	?	?	?	?	80.0-575.0	652.0-682.0	732.0-774.0	970.0-2940.0	2940.0-4320.0
6	D-123	NA	NA	NA	NA	NA	NA	?	?	?	?	NA
7	D-207	NA	NA	NA	NA	NA	NA	?	?	?	?	NA
8	DOE-01	7.875	1126.2-4003.6	?	?	?	?	133.0-667.5	722.0-745.0	828.6-850.5	976.5-2936-5	2936.5-4057.3
9	ERDA-09	9.875	1049-2888	7	0-2889.66	23.00# J-55	122cu	63.0-550.0	608.0-632.0	716.0-739.0	860.0-2836.0	2836.0-2889.0
10	EXHAUST SHAFT	?	?	?	?	?	?	?	?	?	?	NA
11	H-01	NA	NA	NA	NA	NA	NA	35.0-502.0	563.0-589.0	676.0-699.0	824.0-856.0	NA
12	H-02a	5.75	513-625	4.5	0-623	9.50# J-55	?	38.0-457.0	515.0-543.0	623.0-645.0	NA	NA
13	H-02b1	4.75	611-661	OH	OH	OH	OH	38.0-457.0	515.0-543.0	623.0-645.0	NA	NA
14	H-02b2	4.75	620-649	4.5	614.3-648	?	?	38.0-457.0	515.0-543.0	623.0-645.0	NA	NA
15	H-02c	4.75	743-795	OH	OH	OH	OH	34.0-457.0	515.0-540.0	624.0-642.0	764.0-795.0	NA
16	H-03b1	NA	NA	NA	NA	NA	NA	22.0-502.0	559.0-584.0	672.0-694.0	821.0-902.0	NA
17	H-03b2	4.75	673-725	OH	OH	OH	OH	65.0-565.7	564.0-590.0	676.0-700.0	NA	NA
18	H-03b3	?	693-730	OH	OH	OH	OH	?	563.0-588.0	673.0-696.0	NA	NA
19	H-03d1	NA	NA	NA	NA	NA	NA	420.0	424.0-448.0	545.0-554	NA	NA
20	H-05a	4.75	775-824	OH	OH	OH	OH	225-732	783-810	897-920	NA	NA
21	H-05b	4.75	881-925	OH	OH	OH	OH	225.0-732.0	785.0-805.0	897.0-920.0	NA	NA
22	H-05c	4.75	1025-1076	OH	OH	OH	OH	225.0-732.0	788.0-812.0	899.0-924.0	1041.0-1076.0	NA
23	H-06a	4.75	475-525	OH	OH	OH	OH	225-432?	429-511	604-627?	NA	NA
24	H-06b	4.75	592-640	OH	OH	OH	OH	38.0-427.0	492.0-511.0	604.0-627.0	NA	NA
25	H-06c	4.75	700-741	OH	OH	OH	OH	38.0-427.0	490.0-514.0	604.0-627.0	721.0-741.0	NA
26	H-11b1	4.75	733-785	OH	OH	OH	OH	63.0-558.0	611.0-638.0	730.0-756.0	NA	NA
27	H-11b2	4.75	734-776	OH	OH	OH	OH	62.0-560.0	618.0-644.0	733.0-757.0	NA	NA
28	H-11b3	4.75	734-788.7	OH	OH	OH	OH	59.5-560.2	616.0-644.0	734.0-759.0	NA	NA
29	H-11b4	4.75	715-765	OH	OH	OH	OH	60.0-554.0	614.0-642.0	723.2-746.1	NA	NA
30	H-14	4.75	533-589	OH	OH	OH	OH	40.0-360.0	424.0-448.0	545.0-572.0	NA	NA
31	H-15	4.75	854-900	OH	OH	OH	OH	168.0-692.0	748.0-773.0	861.0-883.0	NA	NA
32	H-16	6.125	469.73-850.9	OH	OH	OH	OH	52.0-531.9	590.2-615.6	702.5-724.4	841.5-850.9	NA
33	H-18	6.125	674-840	OH	OH	OH	20 sacks	20.0-506.1	571.2-594.2	688.6-712.8	820.9-840.0	NA
34	H-19b0	7.75	735.5-778.7	OH	OH	OH	OH	53.0 ?-567.0	628.0-652.0	740.1-764.4	NA	NA
35	H-19b1	4.835	658-732.6	OH	OH	OH	OH	53.0 ?-567.0	625.0-650.3	740.1-?	NA	NA
36	H-19b2	5.875	734-785.4	5.5"	764-784	3.9# PVC	?	58.0 ?-567.0	628.0-653.0	741.6-766.0 ?	NA	NA
37	H-19b3	5.875	734-785	5.5"	762-782	3.9# PVC	?	60.0 ?-568.0	629.0-654.0	740.0-765.0 ?	NA	NA

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REC_NO	WELL_NAME	HOL_SZ_C	HOL_C_DEP	CAS_C_DIA	CAS_C_DEP	CAS_C_TYPE	CEM_C	DWY_LAKE	MAG	CUL	SAL	CAST
38	H-19b4	5.875	734-781.5	5.5"	761-781	3.9# PVC	?	58.0 ?-566.0	628.0-653.0	738.5-761.8	NA	NA
39	H-19b5	5.875	734.2-783.4	5.5"	763-783	3.9# PVC	?	58.0 ?-565.0	623.0-649.0	736.7-761.2	NA	NA
40	H-19b6	5.875	732.8-785	5.5"	766-786	3.9# PVC	?	63.0 ?-566.0	623.0-649.0	739.0-763.8 ?	NA	NA
41	H-19b7	5.875	733.6-785	5.5"	764-784	3.9# PVC	?	60.0 ?-567.0	627.0-652.0	739.5-764.0 ?	NA	NA
42	I-374	N/A	N/A	N/A	N/A	N/A	N/A	0-357.0	417.0-443.0	537.0-560.0	659.0-1538.0	NA
43	I-375	N/A	N/A	N/A	N/A	N/A	N/A	?	?	?	?	?
44	I-376	N/A	N/A	N/A	N/A	N/A	N/A	?	?	?	?	?
45	I-377	N/A	N/A	N/A	N/A	N/A	N/A	?	?	?	?	?
46	I-456	N/A	N/A	N/A	N/A	N/A	N/A	?	?	?	?	?
47	I-457	N/A	N/A	N/A	N/A	N/A	N/A	?	?	?	?	?
48	P-01	3.375	794-1200	NA	NA	NA	310 Cu.	40.0-358.0	423.0-448.0	538.0-565.0	677.0-1591.0	NA
49	P-02	3.9375	1038-1895	NA	NA	NA	274cu	164.0-690.0	748.0-773.0	857.0-883.0	1008.0-1895.0	NA
50	P-03	3.9375	826-1676	NA	NA	NA	302cu	41.0-468.0	529.0-553.0	642.0-665.0	759.0-1668.0	NA
51	P-04	3.9375	958-1857	NA	NA	NA	360cu	99.0-609.0	662.0-686.0	775.0-802.0	930.0-1857.0	NA
52	P-05	3.875	1000-1420	NA	NA	NA	336cu	146.0-623.0	686.0-711.0	804.0-827.0	947.0-1830.0	NA
53	P-06	3.9375	703-1573	NA	NA	NA	374cu	18.0-357.0	417.0-443.0	537.0-560.0	659.0-1573.0	NA
54	P-09	3.9375	1023-1796	NA	NA	NA	410cu	66.0-562.0	617.0-644.0	734.0-757.0	881.0-1796.0	NA
55	P-13	3.9375	785-1576	NA	NA	NA	338cu	38.0-427.0	490.0-514.0	604.0-627.0	721.0-1573.0	NA
56	P-15	4	637-1038	NA	NA	NA	108cu	32.0-231.0	294.0-321.0	413.0-435.0	542.0-1465.0	NA
57	P-18	3.875	1139-1998	NA	NA	NA	130cu	87.0-626.0	704.0-730.0	909.0-938.0	1088.0-2000.0	NA
58	P-21	3.9375	1105-1915	NA	NA	NA	425cu	225.0-734.0	788.0-812.0	899.0-924.0	1043.0-1918.0	NA
59	SMITH WINDMILL	?	?	?	?	?	?	?	?	?	?	?
60	SMITH WINDMILL	?	?	?	?	?	?	?	?	?	?	?
61	WASTE SHAFT	?	?	?	?	?	?	?	?	?	?	?
62	WIPP-12	7.875	1015-2790	OH	OH	OH	OH	167.0-640.0	703.9-727.0	822.0-846.8	966.0-2337.5	2337.0-3927.5
63	WIPP-13	7.875	1035-3868	OH	OH	OH	OH	66.0-517.0	565.0-583.0	703.0-726.0	846.0-2971	2971.6-3856.0
64	WIPP-18	NA	NA	NA	NA	NA	NA	138.0-613.0	672.0-696.0	787.0-808.0	928.0-1060.0	NA
65	WIPP-19	NA	NA	NA	NA	NA	NA	96.0-590.0	647.0-672.0	756.0-779.0	895.0-1038.2	NA
66	WIPP-21	NA	NA	NA	NA	NA	NA	73.0-560.0	618.0-642.0	729.0-753.0	868.0-1046.0	NA
67	WIPP-22	NA	NA	NA	NA	NA	NA	81.0-574.0	630.0-654.0	742.0-764.0	885.0-1450.0	NA
68	WQSP-01	NA	NA	NA	NA	NA	NA	40-522	591-612	NA	NA	NA
69	WQSP-02	NA	NA	NA	NA	NA	NA	143-169	692-714	811-833	NA	NA
70	WQSP-03	NA	NA	NA	NA	NA	NA	156-569	727-749	846-871	NA	NA
71	WQSP-04	NA	NA	NA	NA	NA	NA	78-566	652-672	770-790	NA	NA
72	WQSP-05	NA	NA	NA	NA	NA	NA	25-475	630-654	848-869	NA	NA
73	WQSP-06	NA	NA	NA	NA	NA	NA	68-409	474-497	586-606	NA	NA
74	WQSP-06a	NA	NA	NA	NA	NA	NA	85-220	NA	NA	NA	NA

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APPENDIX IV

REC_NO	WELL_NAME	NOTES
1	AIS SHAFT	No footage location info. In any of the three following sources:BDN, 1065-88, H.H.
2	B-25	Wash out and water inflow from 690'-701'. Need casing & hole sizes, cement volumes (reports prior to #41)
3	BADGER-1	Need Drilling report for cement
4	C&SH SHAFT	No footage location info. In any of the three following sources:BDN, 1065-88, H.H.
5	COTTON BABY	OH Salado & Castile
6	D-123	DL, Mag., and Sal. OH
7	D-207	DL, Mag. OH
8	DOE-01	Need cement volumes and casing info.; Salado OH
9	ERDA-09	1045-2425 Salado and U. Cast. OH
10	EXHAUST SHAFT	No footage location info. In any of the three following sources:BDN, 1065-88, H.H.
11	H-01	
12	H-02a	Mag. & Cul. OH; Hole started making water @ 186'. Collected sample with bailer. Need cementing info.
13	H-02b1	Check location info.
14	H-02b2	No Hole History information
15	H-02c	Salado OH; Water from 80' - 181'.
16	H-03b1	Mag., Cul., & Sal. commingled-perfs. ?, Possible BP below Mag. ; Water @ 570'.
17	H-03b2	
18	H-03b3	TDs on this well do not match.
19	H-03d1	D.L., Mag., & Cul. OH; Gained 400 barrels of brine at 390'. Water flow @ 165.5 @ .3 gpm.
20	H-05a	Mag. & Cul. dual completed, isolated through packer @594'
21	H-05b	
22	H-05c	Culebra & Sal. dual completed; BP @ 935'; Water in hole. Fluid level @ 400'.
23	H-06a	Mag. and Cul. dual completed, isolated through packer @ 594'
24	H-06b	None of the locations matched for KEM3, Hole history, Sandia, or BH Notebook.
25	H-06c	Culebra and Sal. dual completion; BP @ 641' Water @ 493'.
26	H-11b1	
27	H-11b2	Need drilling report for H11b2
28	H-11b3	
29	H-11b4	
30	H-14	Need complete cement info.
31	H-15	
32	H-16	D. L., Mag., Cul., & Salado commingled OH
33	H-18	
34	H-19b0	
35	H-19b1	AIP staff notified DOE (8-95) that H-19b1 needed to be plugged per regulations
36	H-19b2	Culebra 734-766 OH
37	H-19b3	Culebra 734-762 OH

REC_NO	WELL_NAME	NOTES
38	H-19b4	Culebra 734-761 OH
39	H-19b5	Culebra 734.2-763 OH
40	H-19b6	Culebra 732.8-766 OH
41	H-19b7	Culebra 733.6-766 OH
42	I-374	DL and Mag. Commingled, Need Cement Volumes
43	I-375	
44	I-376	Need cement volumes to verify isolated aquifers
45	I-377	Mag. and Cul. commingled, need cement volumes
46	I-456	
47	I-457	
48	P-01	30% cement excess
49	P-02	2% cement excess
50	P-03	56% cement excess
51	P-04	27% cement excess
52	P-05	62% cement excess
53	P-06	Hole size and casing depth don't match. 43% cement excess
54	P-09	35% cement excess
55	P-13	Water @630'. 35% Cement excess.
56	P-15	Water @225'. 42/33% Cement excess.
57	P-18	Salado OH; '37/46% cement excess
58	P-21	33% cement excess
59	SMITH WINDMILL	Water level 129'. Not pumping.
60	SMITH WINDMILL	Water level 133.32. Located 100 yds. East of windmill.
61	WASTE SHAFT	No footage location info. in any of the three following sources:BDN, 1065-88, H.H.
62	WIPP-12	Plug set at 2784-3000' isolates Castile; pressurized brine @ 3016
63	WIPP-13	Sal. & Cas. OH
64	WIPP-18	D. L., Mag., Cul. communicated ref. well files; cement circ. ref. Bond Log
65	WIPP-19	D. L., Mag., Cul. communicated ref. well files
66	WIPP-21	D. L., Mag., Cul. communicated ref. well files
67	WIPP-22	D. L., Mag., Cul. communicated ref. well files
68	WQSP-01	Need cement volume all casing strings and plugs; 275 gal. Bentonite seal 550'-640'
69	WQSP-02	Need cement volume all casing strings and plugs
70	WQSP-03	Need cement volume all casing strings and plugs
71	WQSP-04	Need cement volume all casing strings and plugs
72	WQSP-05	Need cement volume all casing strings and plugs
73	WQSP-06	Need cement volume all casing strings and plugs
74	WQSP-06a	Need cement volume all casing strings and plugs

APPENDIX IV

BDB_LOC	BOREHOLE DATABASE LOCATION
BDB_ELEV	BOREHOLE DATABASE ELEVATION
TD	TOTAL DEPTH
COMP_DATE	COMPLETION DATE
CEMENT	CEMENT (total depth of cementing)
[redacted]	HOLE SIZE A (for first string of casing)
	HOLE A DEPTH
	CASING A DIAMETER
	CASING A DEPTH
	CASING A TYPE
	CEMENT A (type & amount)
HOL_SZ_B	HOLE SIZE B (for second string of casing
HOL_B_DEP	HOLE B DEPTH
CAS_B_DIA	CASING B DIAMETER
CAS_B_DEP	CASING B DEPTH
CAS_B_TYPE	CASING B TYPE
CEM_B	CEMENT B (type & amount)
HOL_SZ_C	HOLE SIZE C (for third string of casing)
HOL_C_DEP	HOLE C DEPTH
CAS_C_DIA	CASING C DIAMETER
CAS_C_DEP	CASING C DEPTH
CAS_C_TYPE	CASING C TYPE
CEM_C	CEMENT C (type & amount)
DWY_LAKE	DEWEY LAKE interval
MAG	MAGNETA interval
CUL	CULEBRA interval
SAL	SALADO interval
CAST	CASTILE interval
NOTES	NOTES

APPENDIX V

	Well Name	Commingled formations	Comments
1	Cotton Baby	Salado, Castile	Plugging does not cover the listed commingled formations
2	D-123	Dewey Lake, Magenta, Salado	Cement volume does not cover commingled formations
3	D-207	Dewey Lake, Magenta	Plugging does not cover the listed commingled formations
4	ERDA-9	Salado, U. Castile	Plugged from 0-2425; repository zone not cemented
5	H-1	Dewey Lake, Magenta, Culebra *	Bond Log indicates possible hydraulic connection
6	H-02a	Magenta, Culebra	OH 513-654'
7	H-03d1	Dewey Lake, Magenta, Culebra	OH 39-554'
8	H-16	Dewey Lake, Magenta, Culebra, Salado	OH 460-851'
9	I-374	Dewey Lake, Magenta	AIP suspects more commingled formations but lacks cement record information
10	I-377	Magenta, Culebra	AIP suspects more commingled formations but lacks cement record information
11	WIPP-13	Salado, Castile	OH 1035-3868'
12	WIPP-18	Dewey Lake, Magenta, Culebra **	Cement records indicate OH through commingled formations; Bond Log on this well indicates cement circulated to surface
13	WIPP-19	Dewey Lake, Magenta, Culebra **	Cement records indicate OH through commingled formations; SAND87-0039 reports cement circulated to surface
14	WIPP-21	Dewey Lake, Magenta, Culebra **	Cement records indicate OH through commingled formations; SAND87-0039 reports cement circulated to surface
15	WIPP-22	Dewey Lake, Magenta, Culebra **	Cement records indicate OH through commingled formations; SAND87-0039 reports cement circulated to surface

* H-1 reported circulating cement to surface in hole history reports. This information conflicts with cement bond log interpretation.

** WIPP 18-22 reported circulating cement to surface in SAND87-0039. This information conflicts with well records and Basic Data Reports. AIP staff suspects that these wells are compliant but sundry notices are needed to confirm this report.

FIGURE 1

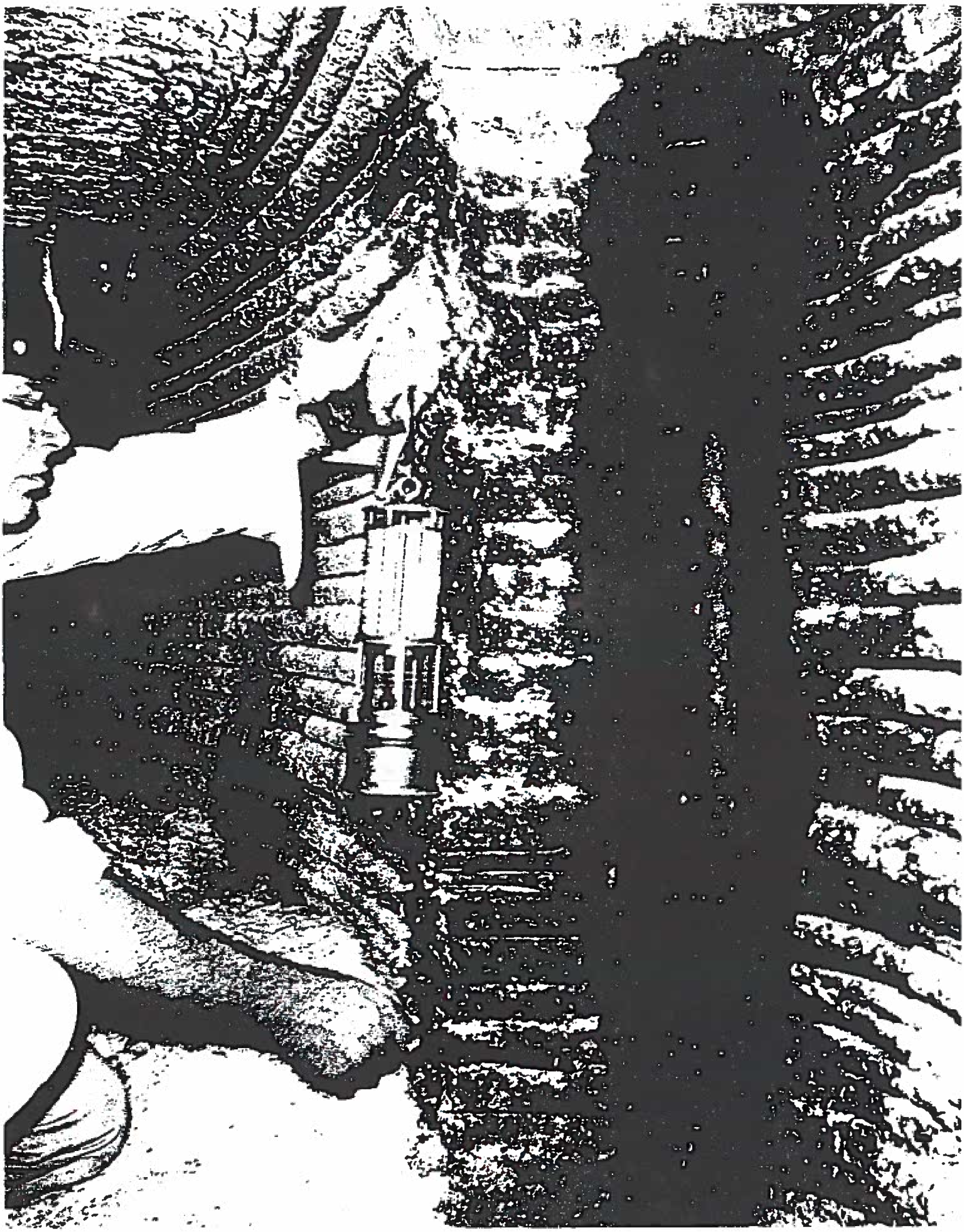

FIGURE 2

FIGURE 3