Waste Isolation Pilot Plant

Compliance Certification Application

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Probability of Intercepting a Pressurized Brine Reservoir Under the WIPP

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ABSTRACT

Twenty-seven drillholes in the Delaware Basin are accepted as showing intercepts of pressurized brine in the Permian Castile Formation. Using an indicator function (brine = 1, no brine = 0) and location data for these and other drillholes in the area around WIPP, semi-variograms were constructed. Parameters from selected semi-variograms were input to an ordinary kriging algorithm to estimate the probabilities of intercepting brine in a drillhole within the Castile Formation beneath the WIPP site. For the area of the disposal panels, the estimated probabilities at computational nodes range between 0.078 and 0.084. For the shaft and access area, probabilities at nodes range between 0.078 and 0.221. Nodes within the experimental area ranged from 0.078 to 0.371. An areally-weighted average for the waste panel area is 0.080.

Structure contour and isopach maps of selected stratigraphic contacts and intervals over part of the nine township area around WIPP show deformed evaporites in areas where most brine occurrences are mapped. No data were obtained from a few drillholes where brine was encountered. The Castile is deformed at WIPP 12, the nearest brine encounter to the WIPP. Stratigraphic data from the Castile are few at WIPP, but there appears to be no significant deformation in the vicinity of the waste panels. This is consistent with generally low probabilities for a drillhole encountering brine as calculated by geostatistical techniques. The estimated thickness from base of Castile to base of Cowden Anhydrite at ERDA 9 is considerably less than the minimum thickness for any known brine encounter, indicating there may be a threshold value for reservoir formation.

1.0 INTRODUCTION

A scenario for the Waste Isolation Pilot Plant (WIPP) includes a drillhole intercept of pressurized brine in the Permian Castile Formation below WIPP underground workings. The analysis of this scenario requires estimates of the probability that a drillhole at WIPP will encounter pressurized Castile brine.

2.0 PURPOSE

This report describes the process that was followed to estimate the probability that a drillhole will intercept brine in the Castile below the underground workings at WIPP. This report also describes how geological data were acquired and analyzed as complementary evidence of the distribution of pressurized Castile brine.

3.0 APPROACH

Several steps were followed to estimate the probabilities of encountering brine in a drillhole:

1) The reported encounters of pressurized brine were listed, including relevant information about location, depth, drillhole name, and stratigraphic basis for assigning the encounter to the Castile.

2) A file of locations of oil and gas drillholes penetrating the Castile compiled by the Compliance Department of Westinghouse was provided by Westinghouse as a database for analysis. AUTOCAD software was used to establish locations and prepare data files for use. (See Appendix A).

3) The UNCERT geostatistics software package was used to prepare semi-variograms utilizing an indicator function (brine report = 1; no brine report =0) and location data for each drillhole. Rbase 5.5 and Excel 4.0 were used to format ASCII data files from AUTOCAD for use by UNCERT.

4) The semi-variograms were evaluated for sensitivity to data cluster effects and classification errors.

5) The ordinary kriging module of UNCERT was used to prepare comparable maps showing the estimated conditional probabilities of intercepting brine and to obtain nodal values for points within three defined areas including the underground workings at WIPP.

6) This analysis report was prepared to show data sources, techniques, estimated conditional probabilities, results and limitations.

Several steps were also followed to analyze how geological features or processes (mainly Castile deformation) are related to the distribution of Castile brine reservoirs:

1) Reported encounters of pressurized brine flow were listed to include information about location, depth, drillhole name, and stratigraphic basis for assigning the encounter to the Castile.

2) Stratigraphic data were derived from geophysical logs for many drillholes around the WIPP site where the geophysical logs were appropriate with respect to depth, location, and log coverage.

3) From the stratigraphic data, subsidiary tables of unit elevations (for structure maps) and thicknesses (for isopach maps) were prepared. These tables were used to prepare maps of structure and thickness for various horizons and intervals, respectively.

4) A general relationship apparently exists between the location of most brine encounters and areas where the Castile evaporites have been significantly deformed from original position. The structure data for the WIPP site are meager for the Castile, though it appears that the area of the waste panel is not significantly deformed.

5) The statistical relationship or association of structure and brine encounters is still being examined, as appropriate data have just been drawn together.

6) This analysis report discusses data sources, techniques, maps, results, and limitations of the geological analysis of the relationship between brine reservoirs and deformation.

3.1 Responsible Staff

The analysis has been conducted by:

Dennis Powers, mainly conducting geological research;

John Sigda, mainly conducting geostatistical analysis; and

Robert Holt, contributing to both geological and geostatistical analyses.

3.2 Schedule and Deliverables

The analysis report includes:

a) the estimated probabilities that a drillhole will encounter pressurized brine under 1) the waste panel area, 2) shaft and access areas, and 3) experimental area.

b) a discussion of the apparent relationship between Castile brine and Castile deformation.

The first request for assistance on this issue came in early February, 1996. An initial approach was outlined and followed before developing the broader analysis approach in April. An initial report and supporting data were scheduled for June 18, with a "final" report and data package required by about July 10, 1996.

4.0 DATA TYPES AND SOURCES

4.1 Geostatistical Analysis

The geostatistical methods used in this analysis for estimating probabilities require two related data sets:

a) a set of locations for drillholes, and

b) an indication of whether each drillhole intercepted Castile brine or not.

The location data set needed to be relatively comprehensive for the area in which brine encounters have been reported. Most of the drillholes that penetrate through most or all of the Castile should be represented. In addition, the data set needed to have a consistent coordinate system (e.g., NM State Plane coordinates) for computational purposes. The coordinates for each drillhole needs to be reasonably accurate relative to nearby drillholes, but long-range accuracy (over several miles) is not expected to be important and was not examined.

Two sources of a location data set were found. Petroleum Information Corporation (PI) maintains a large drillhole data set available for lease/purchase; location coordinates were available as an extra service. Through discussions with the Compliance Department, Westinghouse Electric Corporation, it became apparent that a partial set of drillhole data from PI already been purchased and was being used. L. Madl and D. Hughes provided two subsets of this data set. D. Hughes converted the original PI location data for each drillhole into equivalents to the NM State Plane coordinates (see Appendix A). L. Madl provided files that provided common elements with the location (State Plane coordinates) data and the standard locations (Township/Range system) generally available for geophysical data. We added useful WIPP drillholes not in the database using coordinates provided in Gonzales (1989).

The data set for brine occurrences (Table 4.1-1) was compiled from several sources.

Original studies and reports include Griswold (1977), Register (1981), Popielak et al. (1982), and Chaturvedi (1985). More recent summaries have been provided in unpublished documents by Kehrman (1994) and Silva (1996). Silva obtained summary data from a number of petroleum exploration companies active in the area. In addition, Powers examined files at the Oil Conservation Department (NM) in Artesia and Hobbs, NM, to develop additional data and verify some occurrences. Of the total apparent occurrences, several were eliminated as unlikely, usually because of the combination of 1) insufficient evidence of significant volume and/or pressure, and 2) being in the wrong stratigraphic unit. Twenty-seven reports of brine occurrence were accepted as Castile brine intercepts. The analysis is based on this set of encounters, though we demonstrate later (Section 6.3.2) that it is rather insensitive to adding or dropping encounters in areas where they are more common.

The data set for brine occurrences consists of reports of brine intercepts, which is a proxy for actual occurrences, and "non-reports". There is no requirement that all brine intercepts be reported. Some of the earliest known reports of brine came before modern drilling practices and resulted in loss of control of the drillhole and substantial surface flows. We cannot know if some drillholes intercepted a brine reservoir that went undetected because substantial pressure was depleted by other drillholes. Some companies declined to respond to Silva's survey. Other intercepts may have been quickly controlled, and no report was made or required. We accept the reports accumulated as a reasonable representation of the actual history of brine intercepts. In later discussion, we address alternatives.

Tables 4.1-1 and 4.1-2 include basic information about the drillholes included in this analysis as encountering brine within the Castile. Some excluded drillholes are also reported with justification for deciding they should not be in the data set.

The map area was selected to encompass the locations of all 27 Castile brine occurrences. We tried to make the area as small as practical to minimize the number of drillholes for which there is no report of a brine intercept. For the geostatistical analysis, the total number of drillholes, including appropriate WIPP drillholes, is 354.

4.2 Geological Analysis

The geological methods used in this analysis for understanding the relationship between brine reservoirs and geological features or processes (mainly evaporite deformation) require two related data sets:

a) stratigraphic and reference elevation data from drillholes (Appendix B), and

b) a locations (including State Plane coordinates) for those drillholes.

For most petroleum exploration drillholes in the area around WIPP, one or more geophysical logs have been made that can be purchased or examined. They vary in

Table 4.1-1

Location Data for Drillholes Considered to have Castile Brine

IDnum	T.	R.	Section	from section line (e.g.,n=north)		Drillhole Name
1104	21	31	35	2152s	910e	ERDA 6
1159	22	31	17	148s	84e	WIPP 12
5014	22	31	2	2310s	330e	Pogo State "2" No. 3
5128	23	30	1	1830n	1980w	Belco Hudson Federal No. 1
5275	21	32	31	1980n	660w	Phillips Luke Federal No. 1
5305	21	31	26	1980n	1980w	Pogo Federal No. 1
5306	21	31	35	660n	660w	Union Federal FI No. 1
5307	21	31	36	1980s	660e	Yates Lost Tank "AIS" State No. 1
5308	21	31	36	1980s	1980w	Yates Lost Tank "AIS" State No. 4
5326	22	31	1	660n	1980w	Phillips Molly State No. 1
5327	22	31	1	660n	660w	Phillips Molly State No. 3
5328	22	31	1	660n	1980e	Yates Unocal "AHU" Federal No. 1
5337	22	31	11	660s	1650e	Yates Martha "AIK" Federal No. 3
5338	22	31	11	1980s	1650e	Yates Martha "AIK" Federal No. 4
5339	22	31	12	330n	1650w	Pogo Federal 12 No. 8
5340	22	31	13	1980n	1980w	Texaco Federal Neff 13 No. 5
5348	22	32	5	660n	1580e	Getty Bilbrey Federal No. 1
5365	22	32	15	660s	1650w	Strata Lechuza Federal No. 4
5366	22	32	16	330s	330e	Yates Kiwi "AKX" State No. 1
5382	22	32	25	660n	1980w	Pogo Covington "A" Federal No. 1
5392	22	32	34	660n	1650e	Pogo Red Tank "34" Federal No. 1
5394	22	32	36	330n	1980w	Shell Bootleg Ridge Unit No. 1
5404	22	32	36	660n	660e	Richardson & Bass Tidewater No. 1
5405	22	32	36	1980n	1980e	Culbertson & Irwin Culbertson No. 1
5406	22	29	9	660s	660e	H & W Danford No. 1
5407	22	33	20	660s	1980e	Yates Mascho Cloyd No. 2
5408	22	33	20	660s	660e	Yates Mascho Cloyd No. 1

Data sources for this table include Popielak et al (1983), Register (1981), Kehrman (1994), Silva (1996), and information developed by Powers through visits to OCD offices in Artesia and Hobbs, NM.

Table 4.2-2
Brine Occurrence Depths and Unit Assignments

IDnum	Drillhole Name	Brine Depth (ft)	Depth* Data Source	Unit at Brine depth	Notes
1104	ERDA 6	2711	1,6,8,9	A2?	Uppermost anhydrite; may be A3
1159	WIPP 12	3017	1,7	A3	
5014	Pogo State "2" No. 3	3083	5	A3	May only be gas
5128	Belco Hudson Fed No. 1	2802	1	A3	
5275	Phillips Luke Fed No. 1	3050-57	3,4,5	A3	Lost Tank SWD#1-E
5305	Pogo Fed No. 1	3322	1	A2-A3?	A units coalesce?
5306	Union Fed Fl No. 1	2810	1	A3	
5307	Yates Lost Tank "AIS" State No. 1	2970	4	H2-A3	A3-H2 contact 2932
5308	Yates Lost Tank "AIS" State No. 4	3280	4	A2	Uppermost anhydrite? No A3?
5326	Phillips Molly State No. 1	3080	4	A3	
5327	Phillips Molly State No. 3	3023	4	A3	
5328	Yates Unocal "AHU" Fed No. 1	3068	3	A3	
5337	Yates Martha "AIK" Fed No. 3	3311	3,4	H2	A3-H2 contact 3267
5338	Yates Martha "AIK" Fed No. 4	3750, 3745	3,4	H1	H1 from 4170 to 3688
5339	Pogo Fed 12 No. 8	3050	3	A3	
5340	Texaco Fed Neff 13 No. 5	3340	4	A3	
5348	Getty Bilbrey Fed No. 1	3090; 2965-3066	1,5; 4	A3	
5365	Strata Lechuza Fed No. 4	3500	4	H2	H2 from 3700 to 3371
5366	Yates Kiwi "AKX" State No 1	TD(4535) ; 3400; 3360	3;5;4	A3	A3-H2 contact 3430
5382	Pogo Covington "A" Fed No. 1	3600	1,5	A3?	A3 in #5208 from 3385 to ?3650

IDnum	Drillhole Name	Brine Depth (ft)	Depth* Data Source	Unit at Brine depth	Notes
5392	Pogo Red Tank "34" Fed No. 1	3590-4489; 3000	3,5	A3-A1; Salado (3000)	
5394	Shell Bootleg Ridge No. 1	3671	1	A3 probably	A3-H2 not interpreted top A3 at 3466
5404	Tichardson & Bass Tidewater No. 1	3730	1	A3?	Compared to #5397
5405	Culbertson & Irwin Culbertson No. 1	3515	1,5	A3	Compared to #5210
5406	H & W Danford No. 1	1930; 2208	1;5	Cowden? @ 1952; A3 2150-2380	Scout report & NMBMMR well log report interpreted for Castile anhydrites/salt
5407	Yates Mascho Cloyd No. 2	3298; 3362	1;5	A3?	Unit inferred from maps, nearby wells
5408	Yates Mascho Cloyd No. 1	3322; 3362	1;5	A3?	Unit inferred from maps, nearby wells
	BOREHOLES NOT INCLUDED				
5315	Collins & Ware Lincoln Fed. No. 1	2000	3	Upper Salado	MB109 base 1926; top Vaca Triste 2106
5094	Phillips James A No. 9	7529	4	nd	Castile-BC contact at 3658 ft
5276	AEC 7	3918?	2,10	nd	gas blowout after well reached TD 3918

*References for Data Sources of Depths (see Reference list for complete citation):

1. Popielak et al, 1983
2. Register, 1981
3. Kehrman, 1994
4. Silva, 1996
5. Powers notes from OCD offices in Artesia and Hobbs, NM
6. Sandia National Laboratories and US Geological Survey, 1983
7. D'Applonia Consulting Engineers, Inc., 1982
8. Anderson and Powers, 1978
9. Jones, 1981
10. Sandia National Laboratories and D'Appalonia Consulting Engineers, Inc., 1983

Note: All stratigraphic unit assignments were reviewed by Powers based on reexamination of geophysical logs or by inferring units from nearby drillholes and contour maps of relevant units.

type (e.g., acoustic or neutron), drillhole conditions (open/cased), logged interval, and quality, which can be affected by unknowns such as hole diameter behind casing or by equipment development and improvement over the years. Where the geophysical log covers the appropriate interval and is at least partially interpretable, the principal data for geological analysis includes the elevation of the log reference or beginning point (commonly KB or kelly bushing) and the depth from the reference point to various stratigraphic markers.

With these basic data, two additional kinds of useful information are calculated:

> structure data - the elevation of any identifiable stratigraphic marker (Appendix C), obtained by subtracting the depth from the reference point elevation, and
>
> isopach (thickness) data - the thickness between any two identifiable stratigraphic markers (Appendix D), obtained by subtracting the depth to the uppermost marker from the depth to the deeper marker.

Both kinds of data are generally plotted on maps and then the elevations of the horizon for structure or the interval thickness values are contoured. The evaporite beds are expected to have been deposited essentially horizontal, and the upper surface of each unit was probably about horizontal when the overlying unit began to be deposited. Many of the units are expected to be reasonably uniform in thickness across significant areas, but there can also be differences if there was differential subsidence during deposition across the area.

The stratigraphic information is interpretive. Geophysical logs obtain data about rock characteristics indirectly. An example is natural gamma, a measurement of the natural radiation of the rocks the drillhole penetrates. The instrument is calibrated to a standard for the industry, and the display is scaled such that 100 API units (one full log cycle) would be the response from a hypothetical average mid-continent North American black shale. In a drillhole through unknown rocks, the natural gamma indicates the total gamma radiation from all sources, and it would be tentatively interpreted in terms of general expectations of the natural gamma of different rock types. Cuttings, other geophysical logs, or cores might be used to supplement the interpretation. In the area of WIPP, the evaporite units are well known in general from many thousands of drillholes and previous studies (e.g. Bachman, 1985), and their geophysical log characteristics are also well known (e.g., Jones et al., 1960; Holt and Powers, 1988; Powers and Holt, 1990). There is little difference in interpretation of the geophysical logs for many studies (see analysis in Appendix C of Powers and Holt, 1995). For this work, the main problem is that most geophysical logs for the Castile were taken in open holes. (See Limitations discussion below - section 5.5.)

The location data in standard township/range form were used to plot drillhole locations on preliminary maps and post values for structure and isopach maps. Such data are available from the geophysical logs and from Midland Map Company ownership maps used as convenient base map. State Plane coordinates were also assigned to each drillhole with stratigraphic data to examine statistical relationships between structural properties at drillhole locations and reports/nonreports of Castile brine. The statistical studies of this relationship are incomplete at this time.

5.0 CASTILE DEFORMATION

Early in the history of the WIPP project, pressurized Castile brines were considered to be related to deformation of the Castile (e.g., Griswold, 1977; Anderson and Powers, 1978; Register, 1981; Popielak et al., 1983). Popielak et al. (1983) proposed that brine resides in fractures created within anhydrite by deformation and that fewer large fractures provide vigorous initial flow when hit with a drillhole. Borns et al. (1983) reviewed basic information on evaporite deformation in the northern Delaware Basin, considered five hypotheses on the origin of deformation, and concluded that gravity foundering (due to denser anhydrite overlying halite) and gravity sliding were the most likely explanations. Nonetheless, the physical conditions for either mechanism exist over broad areas while deformation is apparently not widespread. Borns et al. (1983) suggest intergranular water may have varied areally, changing rock strength somewhat locally and leading to deformation in these areas. Petrofabrics in the deformed Castile are also consistent with pressure solution and intergranular fluids (e.g., Borns, 1987). It is possible that intergranular fluids contribute directly to deformation and are also the source of the pressurized brines, but this has not been established.

The analysis by Register (1981) reported 10 brine encounters from the 62 drillholes (existing at that time) into the Castile near the WIPP and inferred that nine of the 10 were associated with known anticlinal structures. There has been considerable drilling since 1981; in this section we report structural information from a much larger data base and examine whether we can still conclude that brine reservoirs are associated with Castile deformation.

Our data around Danford well (T.22S., R.29E., sec. 9) are so limited that we draw no conclusions about structure. Our maps for this analysis do not extend to the Danford well.

We use two main forms of structure information: structure contours on selected stratigraphic contacts and maps of thickness (isopachs) of selected intervals. We assume that the evaporites were deposited on generally planar, horizontal surfaces, though we also recognize that there may have been differential subsidence or tilting during some of the deposition. We also begin with a working assumption that most of the units were deposited with a reasonably uniform thickness; regional and local trends can be depositional, compensating for synsedimentary subsidence or tilting.

While the focus is on Castile deformation, we have examined some of the effects on higher units as background. There are two reasons for this. The structure and thickness of higher units help delineate or bound the extent and age range for deformation. In addition, there are many more data points on mid-Salado to Rustler stratigraphic units across the WIPP site. If brine is associated with Castile structure, but the effects of that structure can also be seen in higher units, it may be possible to better judge the possibilities that brine underlies parts of the WIPP. This possibility had not been adequately tested statistically at this time.

5.1 Methods

Data for structure and isopach maps were managed and computed using Rbase 5.5. Data were posted manually to maps and were contoured by Powers. All data were honored by contouring except some isolated points at the contour value (e.g., 1500) and some values at map edges, particularly along the northeast side of the map area where the Capitan reef underlies the area. Interpolation of values between data points is subjective but is generally roughly scaled. Dashes and dots for contour lines reflect decreasing confidence, generally in areas of fewer data points and at greater distance from data points.

Single hole anomalies that remain generally have not been reconfirmed or resolved with available data. They should be treated with caution at this time.

5.2 Structure Contours

Drillhole locations are identified on Figure 5.1-1 with identification numbers tied to data tables (e.g. ~~Table 4.2-2~~) Appendix B DWP

5.2.1 General

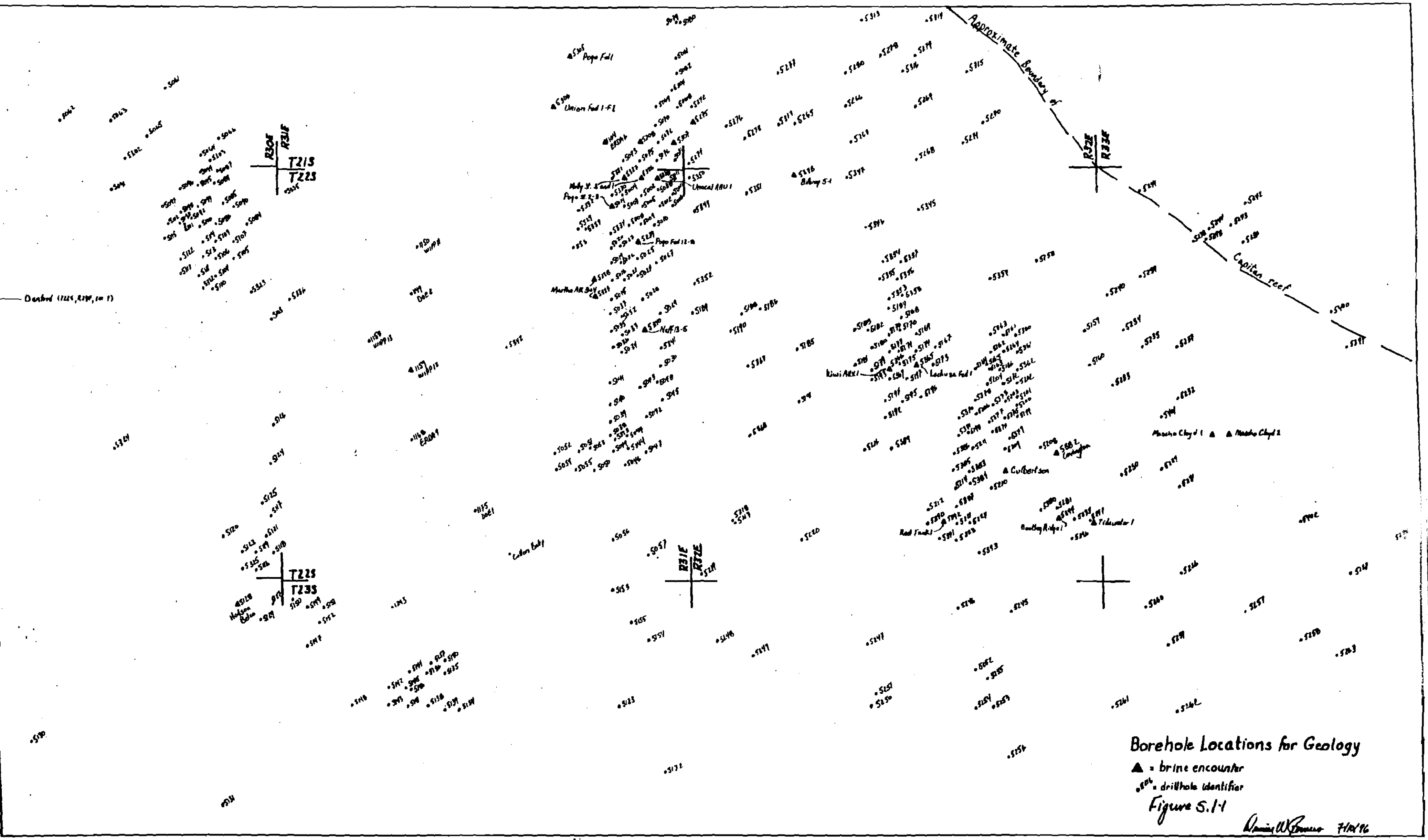
Over the area south of the study area, the top of the Delaware Mountain Group (DMG) displays relatively uniform strike slightly east of north and dips east about 75-100 ft/mile (about 1 degree) (Borns and Shaffer, 1985, fig. 16). This unit is the "basement" rock for our discussion.

For much of the study area, the DMG (Figure 5.2-1) continues the trends mapped by Borns and Shaffer (1985) for areas south of WIPP. Data for this contact are almost non-existent for the site area. We assume the NNE-SSW strike and modest east dip continues under the site.

In T.22S., R.32E., the contours indicate the DMG dips less than regional dip. Near the eastern edge of the map, some contours may be showing basin margin effects, though we include too few data to be certain.

While there are some differences from areas to the south, these are relatively minor. The structure of the DMG contrasts significantly with upper Castile horizons, as shown below.

Structure contours have been drawn for the top of the middle (A2) and upper A3) anhydrites of the Castile to demonstrate the main Castile features.



Borehole Locations for Geology

▲ = brine encounter

• = drillhole identifier

Figure 5.14

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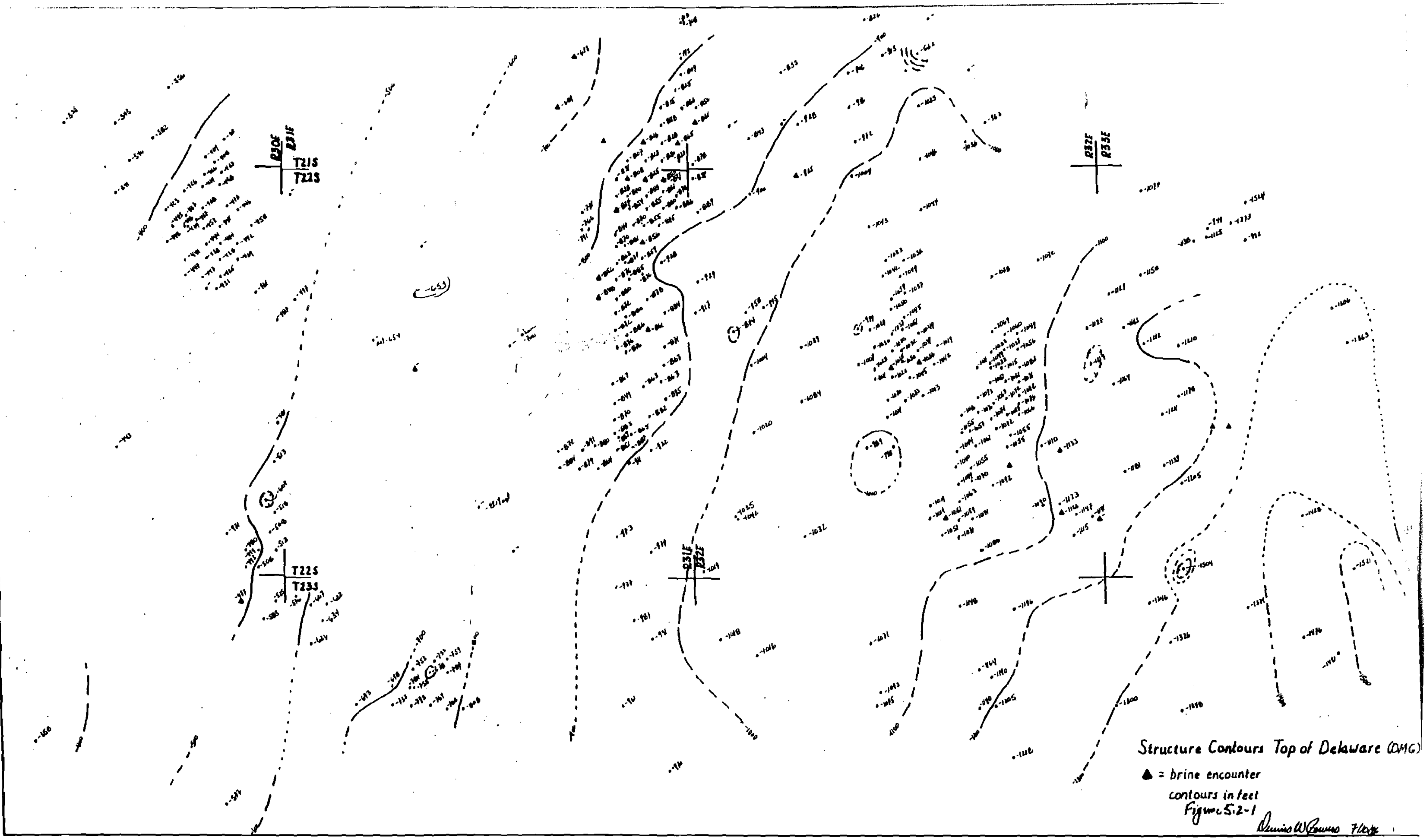

Structure Contours Top of Delaware (DWG)

▲ = brine encounter

contours in feet

Figure 5.2-1

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5.2.2 Anhydrite 2 (A2) (Figure 5.2-2)

Over the area south of the study area, A2 has strike and dip similar to the DMG (see figure 13 of Borns and Shaffer, 1985). The southern margin of our map study area appears to be the transition area to more complex structure to the north in the study area.

The few data points at the site area show deformation in the northern area and approximately "normal" structure in the southeastern site area (the vicinity of DOE 1). Near the southwest corner of the site, this unit in the Hudson Belco well appears also to be structurally high, though no nearby wells exist west of the Belco well to confirm closure. Near the northwest corner of the WIPP, it appears that the attitude of A2 is changing to more east-west strike. Three holes, each somewhat isolated, indicate structure lows. There are no known brine encounters in the cluster of drillholes near the northwest corner of WIPP

East and northeast of WIPP, A2 has been deformed into a major anticline trending about NW-SE. At least half of the known brine encounters closely relate to this major anticline, and several others are located along subsidiary structures. A structural low in east-central T22S., R.32E., interrupts part of this trend. Along the southeast corner of the map area, structure contours run approximately east-west, normal to the strike further south and west. Three brine encounters are in this area, 200 - 300 ft above projected contours from the south. The Mascho 1 and 2 brine encounters in T.22S., R.33E., are near deformed areas, but data near these wells are few.

Nearly all the brine encounters on the map appear to be related to areas deformed at the A2 level. More than half appear in areas where structural closure is demonstrable or very likely. Most of the rest are in areas where A2 differs considerably from contours projected from the south into the area.

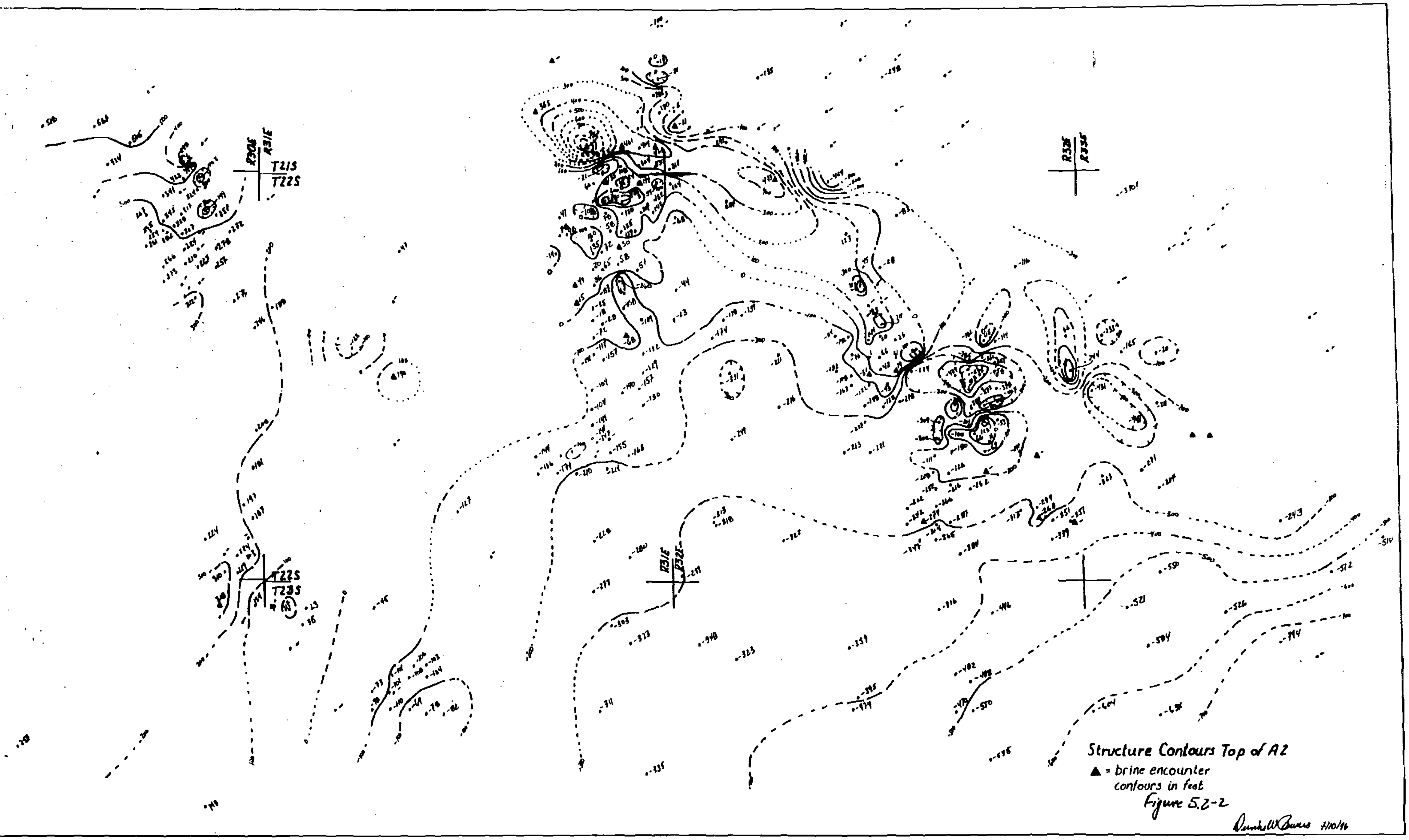
5.2.3 Anhydrite 3 (A3) (Figure 5.2-3)

In this area, the top of A3 is also the top of Castile. Most of the brine encounters are interpreted to flow from the lower part of this bed.

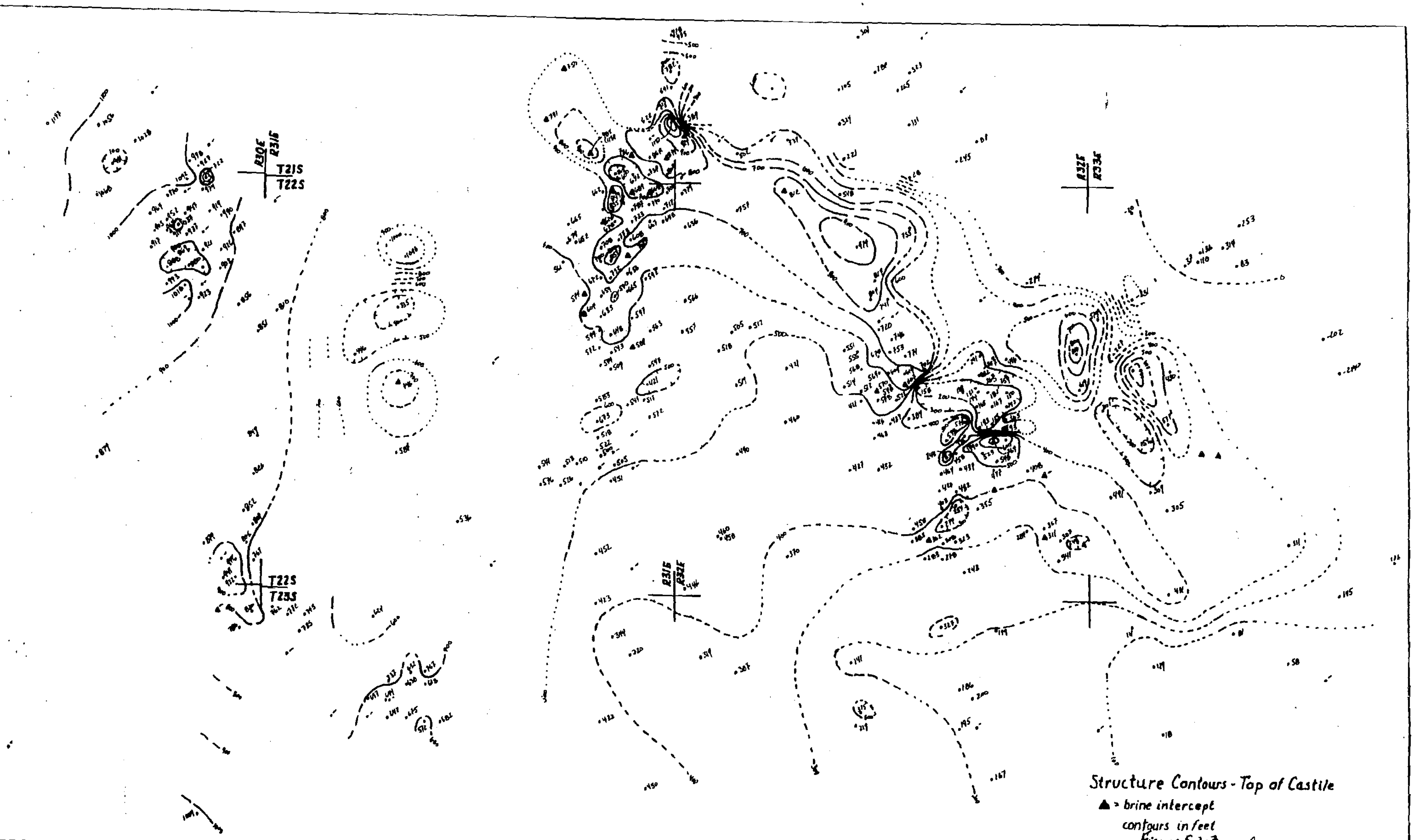
The major structures of A3 and associations with brine encounters are very similar to those described for A2. The top of A3 was uncertain in the Belco well, though other nearby wells indicate some local structure.

5.2.4 Comparison with Culebra Dolomite Member (Rustler Formation)

A recent structure contour map of the Culebra (Powers and Holt, 1995) shows that the main anticlinal structure north and east of WIPP persists to the level of the Culebra. Over the WIPP site, there are limited changes from regional trends that may be difficult to attribute to any process (Powers and Holt, 1995).



Structure Contours Top of A2
▲ = brine encounter
contours in feet
Figure 5.2-2



Structure Contours - Top of Castile
▲ = brine intercept
contours in feet
Figure 5.2-3

5.3 Isopach Information

5.3.1 General

Three intervals were chosen to represent the main value of thickness maps: 1) Castile thickness, 2) the combined thickness of both halite numbers (H1, H2) and anhydrite (A2) between these halites, and 3) the thickness from base of Castile to base of the Cowden Anhydrite (of the Salado Formation). For simplicity, we call the third interval the IsoCowden.

5.3.2 Castile Thickness (Figure 5.3-1)

In areas near the southern margin of the site, the undeformed Castile is generally 1300-1400 ft thick. South and west of the site, isopach data are not very helpful. There may be local relative thickening and thinning near Hudson Belco, but the data are few. Over the site, DOE 2 shows thinning of the Castile; Borns (1987) described deformation features from Castile cores. While other WIPP drillholes at the site show structure, they do not go as deep as the DMG, and we have not inferred thickness in such drillholes for this analysis.

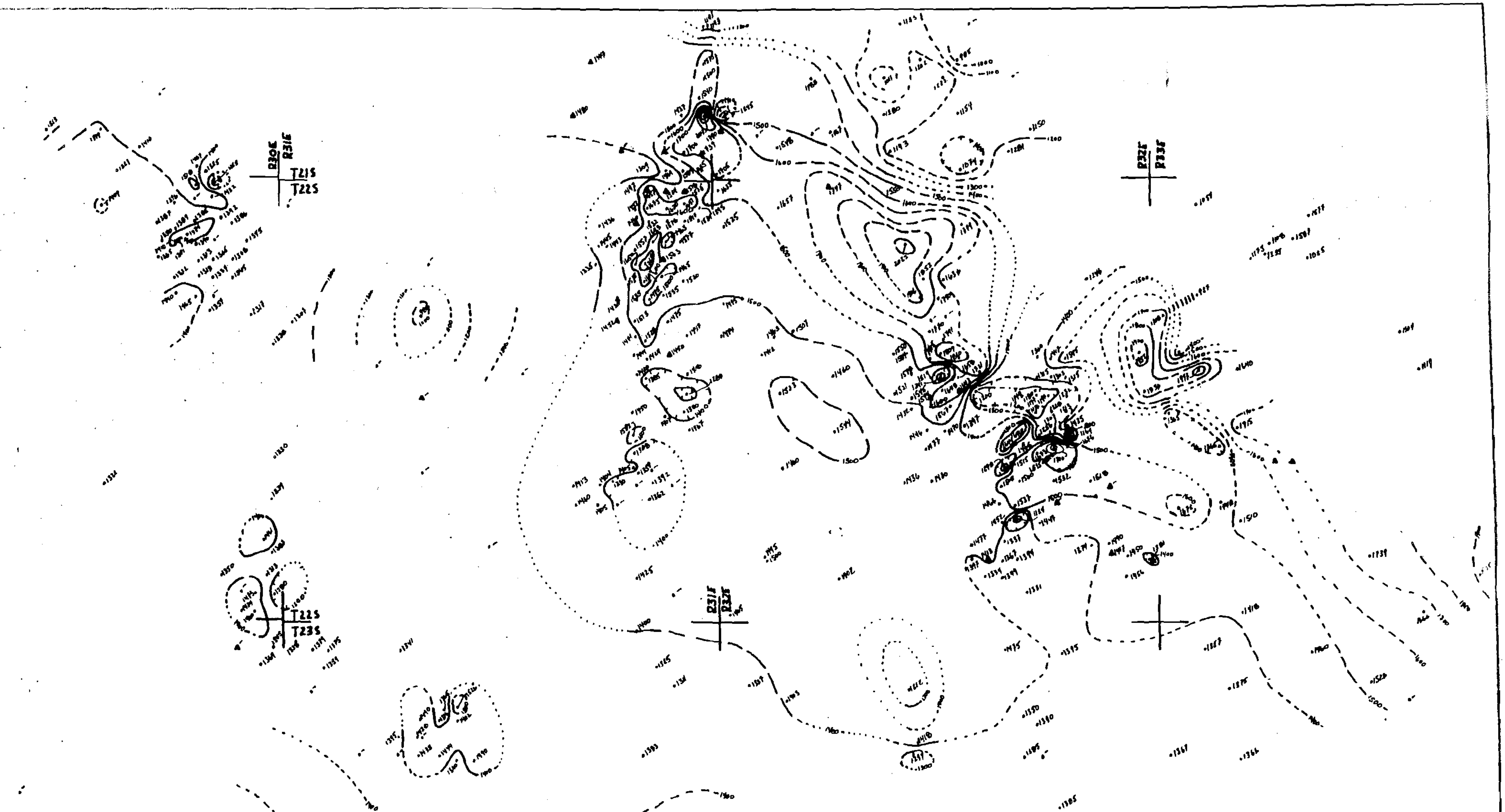
As expected, this map shows a strong thickening trend along the anticline north and east of WIPP. Just northeast of WIPP, there is an apparent minor thickening trend of about NNE-SSW. A localized thin area in east-central T.22S., R.32E. is consistent in location with a structural low along the anticline trend.

The apparent thickening of Castile northeast and east of WIPP is associated with many of the brine encounters. Nonetheless data are not available at several holes with brine, mainly because the DMG was not drilled or we cannot determine the stratigraphic contacts for the relevant beds. Some encounters east of WIPP are around areas of thickening or thinning, but thickness at the brine locations is not greatly different from undeformed areas.

5.3.3 Middle Castile (H1-A2-H2) Interval (Figure 5.3-2)

The main thickening and thinning trends and locations shown by the total Castile isopach are present in this map. There are more site details because more wells penetrated the relevant interval. Some local features show finer detail in this map compared to "smoother" contours for the thicker total Castile map. In "undeformed" areas south of the site, the thickness of the interval is about 600-700 ft.

In the northern part of the WIPP site a few drillholes are available that show the effects of deformation in the "disturbed zone" (see Powers et al., 1978). WIPP 12 and WIPP 11 show thickening, while WIPP 13 is much thinner. In the southeast part of WIPP, drillhole DOE 1 shows a "normal" thickness. The contours in these area are very approximate, and the thickness north of WIPP 12 is expected to be quite variable. While DOE 2 is difficult to interpret, there is almost no halite in the Castile at that location. If A2 was correctly identified, the thickness could be less than 150 ft.

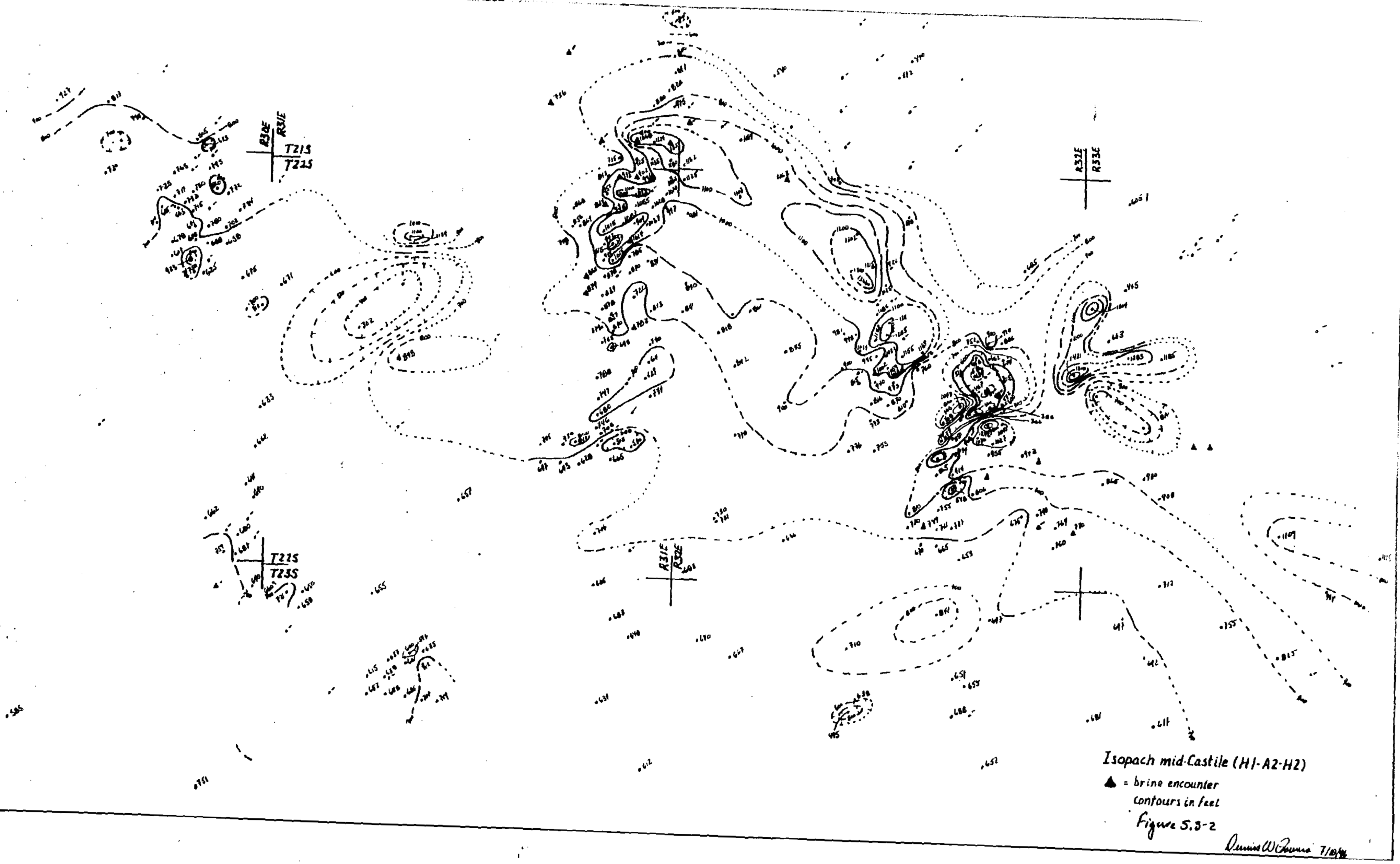


Isopach Castle Fm.

▲ - brine intercept
contours in feet

Figure 5.3-1

Dennis W. Powers 7/10/96



Isopach mid-Castile (H1-A2-H2)

Figure 5.3-2

Dennis W. Powers 7/10/96

Off the southwest corner of WIPP, there are some limited indications of thickening, but the interval was not definable at Hudson Belco. Off the northwest corner of WIPP, there is northward thickening.

Northeast and east of the site, a thick area trends along the anticlinal structure and zone of thickening for the entire Castile. The thinner area in east-central T.22S., R.32E., displays some apparent "fabric" of local thin zones approximately normal to the trend of the thick zone.

Most of the known brine occurrences can be associated with areas of thickening/thinning of this interval. There are several occurrences where data are inadequate and few where isopach changes are smaller or can be questioned.

5.3.4 IsoCowden (Figure 5.3-3)

This interval is very similar to the total Castile isopach, and it should be because it is the Castile plus the salt (commonly called the InfraCowden) between Castile and Cowden Anhydrite. The main structures are present, though there is some broadening across the main structure of the ERDA 6 anticline.

This map includes some estimated values noted by [ ]. The basis for the estimated values included on the map is provided in Appendix E. [Additional values for the thickness were generated from this map for later analysis in Section 8.0; only values that could be estimated independently from this map were included in this map.] The map was contoured in more detail than some others because this map has the most values, including estimates, of the thickness interval compared to other intervals.

While many of the brine intercepts occur in areas that are near the maximum thickness for the interval, some intercepts are not. While we think that most of the brine intercepts are in areas differing in thickness from regional trends, some are located in the mid-range of thickness for this map area.

5.3.5 Comparison of "Normal" and Thickened Zones

All three isopach maps show similar thickness differences between areas that are undeformed and deformed. This means that the thickening can principally be attributed to the halite members or the combined H1-A2-H2 interval. The basal (A1) and upper (A3) anhydrites included in the total Castile isopach differ much less from normal to deformed areas than does the interval with halite.

In order to examine further the relationship between various thickness intervals and the occurrence of brine, we plotted (Figure 5.3-4) the basic statistics (minimum, maximum, range of $\pm$ 1 standard deviation around the mean) for a number of intervals for comparison. Those intervals are:

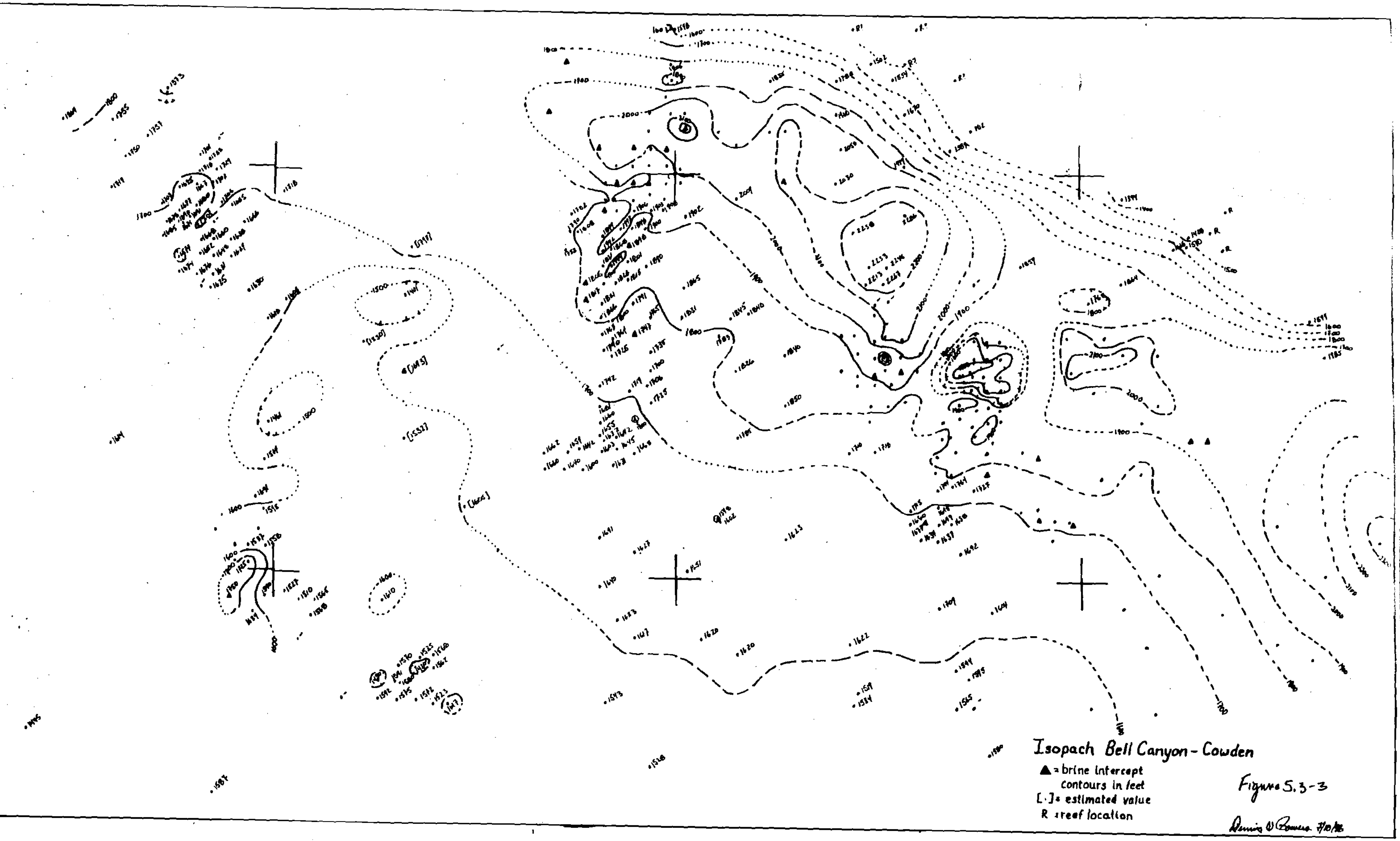

Isopach Bell Canyon - Cowden
▲ = brine intercept
contours in feet
[ ] = estimated value
R = reef location

Figure 5.3-3

IsoA1	top of Bell Canyon to top of A1
IsoH1	top of Bell Canyon to top of H1
IsoA2	top of Bell Canyon to top of A2
IsoH2	top of Bell Canyon to top of H2
H1A2H2	base of H1 to top of H2
IsoCas	top of Bell Canyon to top of Castile (A3)
IsoCow	top of Bell Canyon to base of Cowden Anhydrite
Iso124	top of Bell Canyon to base of MB 124
IsoRus	top of Bell Canyon to base of Rustler Formation
Cashal	sum to H1 and H2 thickness
IsoVT	top of Bell Canyon to base of Vaca Triste Sandstone Mbr
A1-Cow	top of A1 to base of Cowden Anhydrite

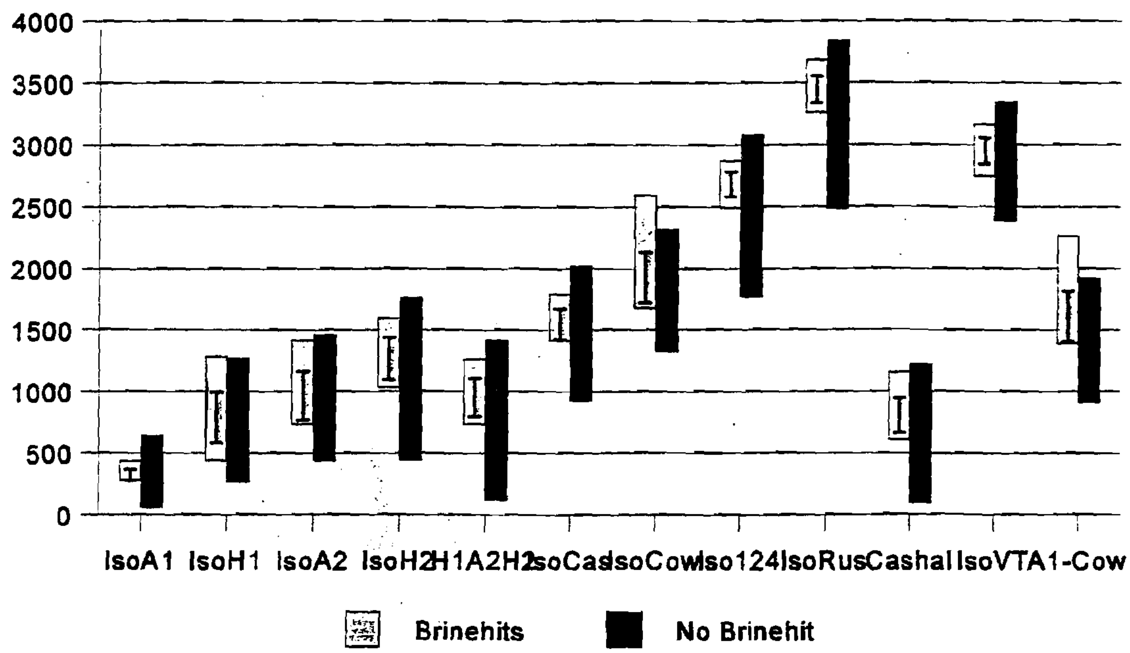


Figure 5.3-4 Color bars show range of thickness for each interval. Bars represent ± 1 standard devation around the mean.

We see that the thickness associated with brinehits tends to be greater than for the other drillholes. Each Cowden interval shows greater thickness for brine hits. The minimum thickness of IsoCow associated with a brine reservoir is 1677 ft; at ERDA 9, near the waste panels, the estimated thickness of the IsoCow is 1532 (± 25) ft. This interval is the most reliable of all listed above with respect to largest number of data points with direct thickness information at any drillhole

This is because the Bell Canyon structure is reasonably well understood and considered to be best for interpolation and because the Cowden could be interpreted reliably in more wells than the top of Castile. This interval is considered as a possible exclusionary indicator for brine reservoirs under the waste panel. The statistical data are further examined in Section 7.0.

5.4 Summary of Geological Relationship to Brine Encounters

The majority of reported occurrences of Castile brine are clearly associated with areas of deformed evaporites in the Castile. Geological information is too limited for one drillhole (Danford) to determine if the evaporites are deformed at that location. Several drillholes are located in the general area of deformation, but they are not on extreme features. Brine appears to be strongly related to structure in Castile.

Very limited data on the top of the Castile near the WIPP site indicate that there is little, if any, deformation under the waste panel area. From this, we would infer that there is low likelihood of intercepting a brine reservoir in a drillhole through the waste panel area. The thickness of some of the intervals, especially the IsoCowden (base Castile to base Cowden), at the waste panel is estimated to be about 145 ft less than the minimum thickness for this interval at any known brine encounter, suggesting there may be a threshold excluding the panel area as an area to expect brine encounters.

Though the association of brine to structure appears to be strong, we note that most drillholes in areas of structure do not report brine in the Castile. A drillhole that does not intercept brine is not a demonstration that brine does not exist within an area.

5.5 Limitations

Some of the limitations for the geological data are due to the nature of the data. The geophysical logs for this study are dominated by neutron and gamma logs taken through casing in the evaporite section. While many of the stratigraphic "picks" are relatively straightforward, some are not, requiring more subjective decisions based on experience. The posted values for the structure contour and isopach maps do not differentiate between such kinds of data. The contoured maps are themselves a means of checking the likelihood of any individual value by the surrounding values. Single hole anomalies should be reexamined regardless of the apparent quality of the original data.

Another limitation to the geological study is that several of the holes with brine encounters were drilled before modern geophysical logging and have such limited geological data available that we are unable to confidently interpret the stratigraphic horizons and structural features at the drillhole location. Because more reliable data from other drillholes demonstrates that the structure and isopachs can vary over short distances, we have limited our inferences/extrapolations about the structure at these hole locations.

Work has not been completed to examine possible statistical relationships between structure or isopachs and brine encounters. If there is found a relationship strong enough to be helpful, we expect to incorporate this later into a re-evaluation of the kriging estimates of intercepting brine under the WIPP site (see section 7.0).

6.0 GEOSTATISTICAL ANALYSIS

6.1 INTRODUCTION

We utilize a geostatistical approach to estimate the conditional probability of a brine reservoir intercept within the Castile Formation because geostatistics permits quantification of a phenomenon's spatial correlation and it provides robust estimation algorithms in kriging. The data are first examined with a suite of geostatistical tools to estimate the phenomenon's covariance function and then test the covariance estimate's robustness. This function quantifies how the phenomenon's observed values are correlated in space, in time, or in both. We can gain a better understanding of the scale of the phenomenon from the correlation scale, the distance over which the observed values appear to be correlated, of most estimated covariance functions. The data and the estimated covariance function are then input into a kriging algorithm to give a "best" unbiased, minimized least-squares error estimate of the phenomenon's value at unsampled locations while honoring the data exactly. For a binary phenomenon, such as the presence or absence of a brine reservoir intercept, kriging provides a direct estimate of the probability of the phenomenon at an unsampled location conditioned on the data locations and on the estimated covariance function (Deutsch and Journel, 1992). We can test the validity or appropriateness of the probability estimates by comparing the estimated covariance with covariance functions estimated from related phenomena, particularly those which may have created or influenced the spatial distribution of interest.

Our phenomenon of interest is whether a borehole will intercept a brine reservoir in the Castile Formation. We have observations of intercept/no-intercept from 354 wells distributed across roughly 645 km^2 (252 mi^2) of Delaware Basin. The WIPP site is roughly centered within this area. Taking on a value of either 1 or 0, binary variable observations are a type of categorical variable, which can represent phenomena such as rock types, counts of numbers of species, or whether a contaminant concentration exceeds a given threshold value. In contrast, continuous variables describe phenomena whose values vary more continuously than discretely; e.g., hydraulic conductivity, chemical concentration, temperature, etc. We seek the probability of a brine reservoir intercept at specific unsampled locations. Assuming the data set is representative and that classification errors are negligible, we can calculate a probability estimate for the unsampled locations which depends on the observed values: divide the 27 intercepts by 354, the total number of observations, to get a mean probability of 0.076. Although legitimate, this approach does not include information contributed by locations of the observed values relative to the unsampled locations of interest. It is equivalent to deciding that there is no spatial relationship between occurrences; the mean probability can be reduced by simply enlarging the study area, which will include more drillholes without evidence of brine occurrences.

We can treat the observed values as having originated from a random function (RF), a name which is applied to a collection of random variables distributed across a domain of interest. The spatial correlation of a RF Z is described by the (auto)covariance, $C_{Z(x),Z(x+h)}$, where E is the expectation operator, **x** is the location vector for an observation, and **h** is the distance between it and another observation.

$$C_{Z(\boldsymbol{x}),Z(\boldsymbol{x}+\boldsymbol{h})} = E\{[Z(\boldsymbol{x}) - E\{Z(\boldsymbol{x})\}][Z(\boldsymbol{x}+\boldsymbol{h}) - E\{Z(\boldsymbol{x}+\boldsymbol{h})\}]\} \qquad (Eqn. 6\text{-}1)$$

If we assume that the mean is constant and that the covariance is simply a function of the distance **h** separating the two values within the domain of interest, we can then simplify the covariance function:

$$C_z(\boldsymbol{h}) = E\{[Z(\boldsymbol{x})\,Z(\boldsymbol{x}+\boldsymbol{h})]\} - E\{Z(\boldsymbol{x})\}^2 \qquad (eqn.\ 6\text{-}2)$$

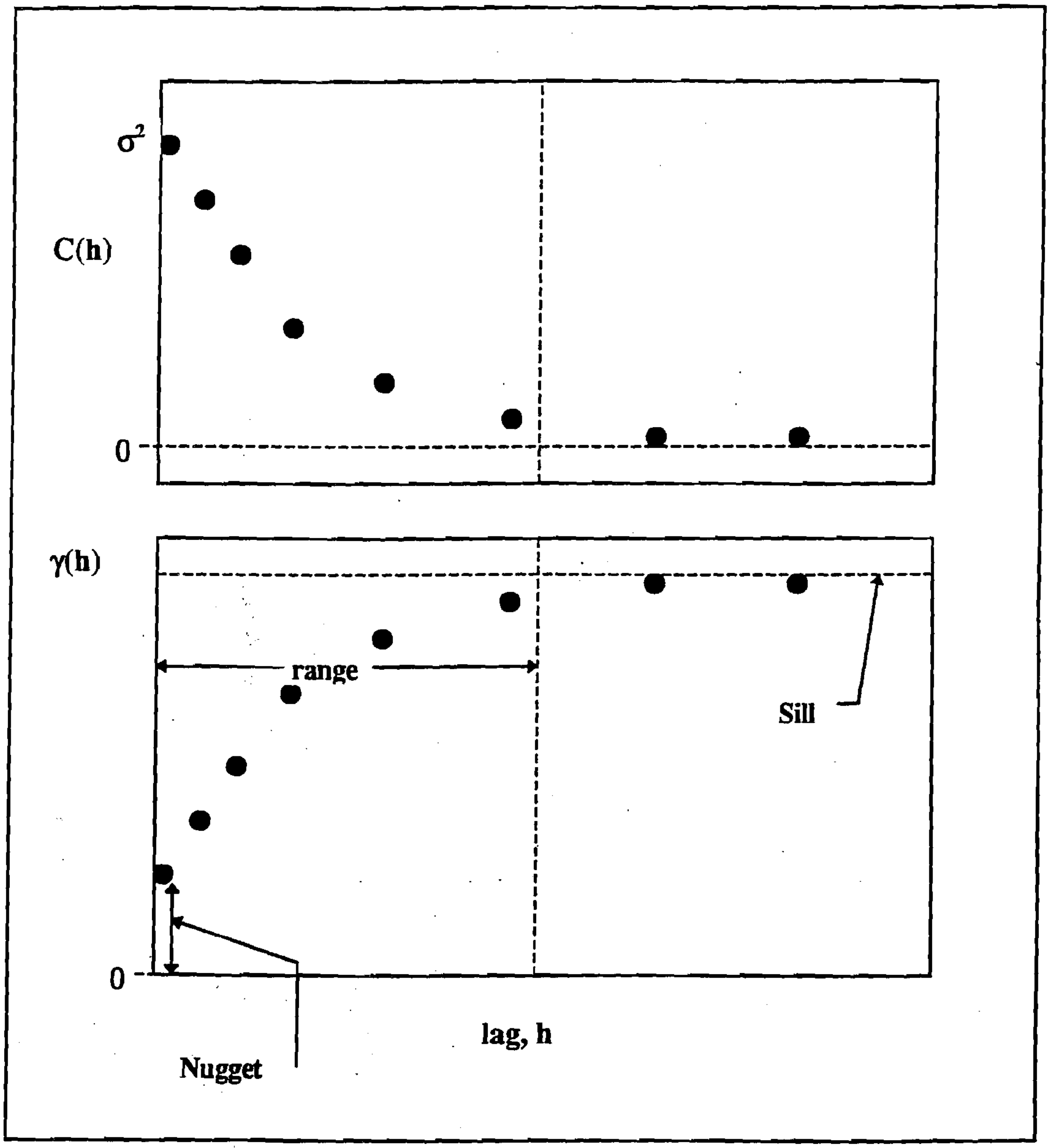
These assumptions are the result of deciding to treat the random function Z as a stationary RF. It is useful to decide an RF is stationary because we seldom can take repeated measurements of the phenomenon of interest at the same location, making it impossible to estimate the cumulative distribution function (cdf) at that point. Instead, by deciding to use a stationary random function model, we can use samples from other locations to estimate the cdf. It cannot be determined from the data whether the stationarity decision is valid . See Deutsch and Journel, 1992, p 12-13; Isaaks and Srivastava, 1989, p. 220-221; and Journel, 1986 for further discussion. This decision, however, permits us the use of a range of geostatistical tools, such as the semi-variogram, to estimate the covariance and thereby quantify the spatial variability.

The semi-variogram, g(**h**), is the variance of the difference between observations separated by a distance (or lag) **h**:

$$\gamma\ (\boldsymbol{h}) = \frac{Var\{Z(\boldsymbol{x}-\boldsymbol{h}) - Z(\boldsymbol{x})\}}{2} = C_Z(\boldsymbol{0}) - C_Z(\boldsymbol{h}) \qquad (Eqn.\ 6\text{-}3)$$

The covariance at separation distance **0** is simply the variance of Z. Equation 3 demonstrates the relationship between the variogram and the covariance function for a stationary RF. Their interrelationship is depicted in Figure 1. The

FIGURE 6-1
Interrelationship Between the Covariance
and Semi-Variogram Functions



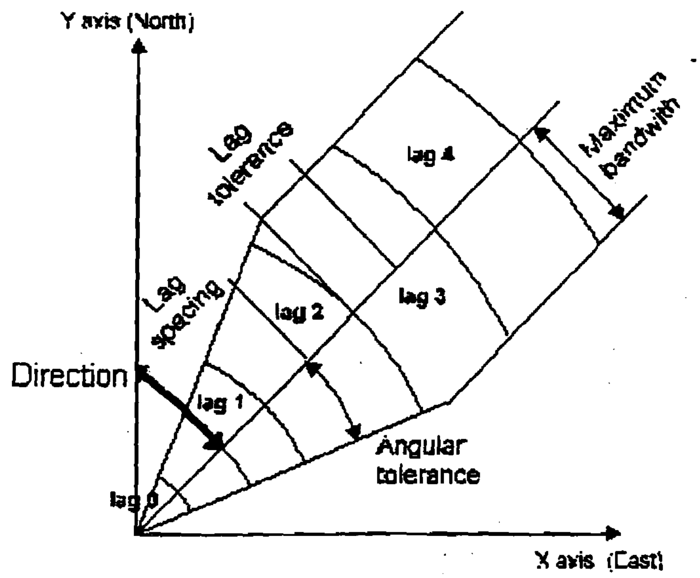
following discussion assumes a random function defined over a two-dimensional domain; generalization to a three-dimensional domain is straightforward. Most semi-variograms consist of three parameters: the range, defined as the lag at which the semi-variogram value levels out, i.e., the correlation between two observations decreases to zero; the sill, defined as the $\gamma(\mathbf{h})$ value at which the semi-variogram levels out; and the nugget, which refers to a discontinuity between the estimated semi-variogram's first point (nearest to a zero lag) and the origin. The range represents the length (or time) scale over which correlation between any two observations is still observed. The sill represents the population or sample variance of all the observations, and the nugget represents the sum of measurement errors and small-scale spatial variability not yet resolved. Each of these is depicted in Figure 6-1.

If, when calculated along a number of different directions, the sample semi-variograms show no significant changes in range, nugget, or sill values then the phenomenon is said to be isotropic; otherwise, it is anisotropic. Anisotropy in the directional semi-variograms is analogous to the major and minor axes of an ellipse (or ellipsoid in 3-D space). The directions corresponding to the major and minor axes can be thought of as the phenomenon's preferred or principal directions. Figure 6-2 demonstrates the relevant parameters for calculating a directional semi-variogram. To calculate an isotropic semi-variogram, which is also called an omni-directional semi-variogram, the search and bandwidth distances and half-angle should be set to their maxima, e.g., the length of the domain and 90 degrees, respectively.

A host of related geostatistical tools for describing spatial variability have been developed to complement the strengths and weaknesses of the semi-variogram (see Deutsch and Journel, 1992, p. 56). The correlogram and non-ergodic covariance functions can filter out trends in the variances and means for each lag group respectively. The relative semi-variograms and semi-rodogram are less susceptible to data clustering and outlier values than the semi-variogram. The semi-madogram is more robust to outliers than the semi-variogram. Prudent practice requires that one or more of these alternative measures of spatial variability be examined in addition to the traditional semi-variogram.

Estimation of the values at unsampled locations can begin once the spatial variability has been adequately characterized by a semi-variogram (or covariance) function with an estimated sill, nugget, and range. A very wide range of methods have been developed to solve the general interpolation problem (see Cressie, 1991), but only the kriging algorithms provide an unbiased, minimum error variance estimate, which exactly honors observed values, for an explicit covariance model. The kriged or predicted value is a function of the estimated covariance and of the locations, not the values, of the initial observations of the phenomenon. However, the value predicted for an unsampled location is conditional on the observed values, since they are

FIGURE 6-2
Parameters for Calculating Sample Semi-Variograms



Adapted from Y. Pannatier, VARIOWIN HELP.

reproduced exactly by the algorithms. When applied to a binary variable, such as the presence or absence of a rock type or a brine reservoir intercept, the most commonly used kriging algorithm, ordinary kriging, provides a direct estimate of the conditional probability of that variable (Journel, 1984; Deutsch and Journel, 1992, p. 73). As above, this probability estimate is a function of the covariance model adopted and of the data locations and is conditioned on the observations.

6.2 METHODS

6.2.1 Variography

Variography is the process of extricating a phenomenon's spatial correlation from a set of observed values. Also known as structural analysis, the process focuses on estimating a sample semi-variogram or related functions, which are proxies for the covariance function, and then critically examining the estimate for sensitivity to individual data points, data clustering, and extreme values (outliers). Values for the range, sill, and nugget are determined from a theoretical semi-variogram model which is fitted to the sample semi-variogram.

6.2.1.1 Sample Semi-Variogram Calculation

Semi-variograms are calculated according to

$$\gamma(\boldsymbol{h}) = \frac{1}{2N(\boldsymbol{h})}\sum_{i=1}^{N(\boldsymbol{h})}(x_i - y_i)^2 \qquad (Eqn.\ 6\text{-}4)$$

where **h** is the approximate or average lag distance for each lag class, N(**h**) is the number of pairs for each lag class, x_i is the initial or tail value, and y_i is the final or head value for the pair. All variographic calculations were carried out using the VARIO module of the public domain software package UNCERT (Wingle et al, 1994), available from the Colorado School of Mines in Golden, CO. Calculations for the final semi-variograms were compared with those from two other geostatistical software packages: GSLIB (Deutsch and Journel, 1992) and VARIOWIN (Pannatier, 1994).

Since the geological structure data were not available to help constrain the choice of geometric directions prior to this study's start, we calculated sample semi-variograms for the isotropic (omni-directional) case and for a full range of anisotropic geometric directions. This ensured there was no bias in the selection of sample semi-variogram directions. We did not consider zonal anisotropy in this analysis because we have assumed the Castile Formation, from which all of the observations were collected, has a homogeneous variance about the probability of a brine intercept. That is, the brine intercept probability variance is constant across the study area. Our results indicate the sill does not vary significantly compared to the ranges for the directional sample semi-variograms and therefore the anisotropy is better described by the geometric rather than the zonal approach.

The directional semi-variograms were estimated for azimuths 0, 20, 45, 70, 90, 110, 135, and 160 degrees measured clockwise from a 0 degree north. Lag spacings between 1000 ft and 2000 ft were examined because they bracketed the most common borehole spacings observed in the data. The maximum search distance, directional bandwidth, and horizontal half-angle were set to their maximum values of 150000 ft, 150000 ft and 90 degrees for the isotropic sample semi-variogram. The data were sufficient in number to restrict the horizontal half-angle to 15 degrees , maximum search distance to 50000 ft, and the directional bandwidth to 10000 ft and still have adequate numbers of observation pairs (>30) within each of the first 20 or more lags for all of the anisotropic sample semi-variograms.

Sample semi-variograms were judged significant if they exhibited a reasonably monotonic increasing structure within the first 25% of the lag classes with adequate numbers of pairs within each lag class. All significant sample semi-variograms were retained for fitting of theoretical semi-variogram model parameters (range, sill, and nugget variance). When an anisotropic sample semi-variogram was found significant, we calculated the sample semi-variogram along its orthogonal direction.

6.2.1.2 Sample Semi-Variogram Robustness

Clustering of the data locations can create apparent structure in sample semi-variograms (Deutsch and Journel, 1992; Isaaks and Srivastava, 1989, p. 162). Given the obvious clustering of borehole locations (see Figure 6-3), we tested the sample semi-variogram robustness to clustering using two different approaches. The first compares sample semi-variograms from the entire data set with those computed for two non-overlapping data subsets which have relatively uniform spatial distributions of boreholes and possess adequate numbers of brine reservoir intercepts. Subset 1 contains 81 boreholes, 15 of which had brine intercepts. Subset 2 holds 93 boreholes, 9 of which had evidence of brine intercepts. Figures 6-4 and 6-5 show the locations of the two data subsets. These two subsets were the only areas to possess both a relatively uniform distribution of boreholes and sufficient numbers of brine intercepts. Most of the boreholes in these two subsets were drilled to explore sand channels which underlie the Castile Formation. Correlation structures which appeared significant in each of the data subsets and in the complete data set were judged to be independent of the large scale data clustering evident in Figure 6-3.

Figure 6-3

All Borehole Locations

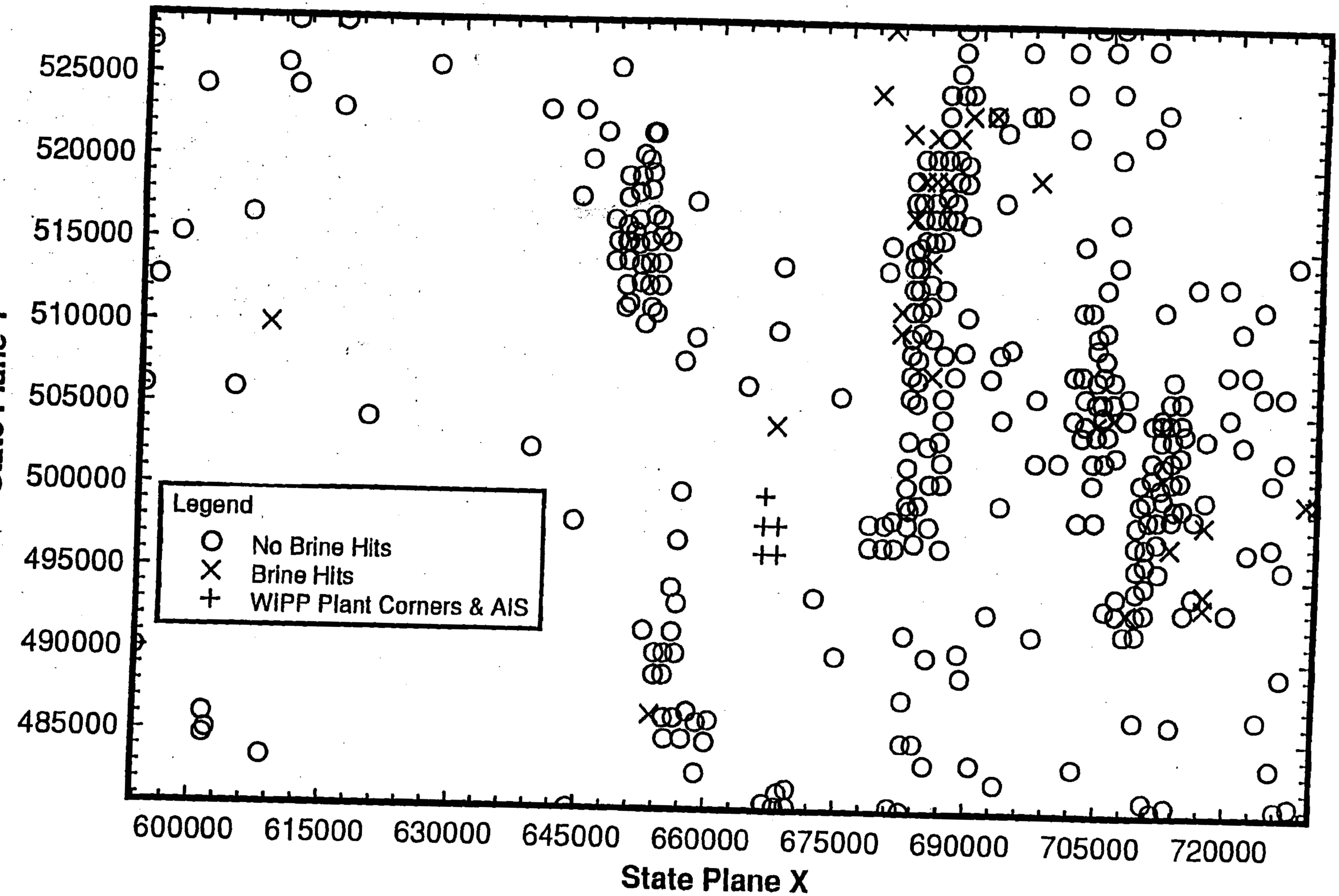


Figure 6-7

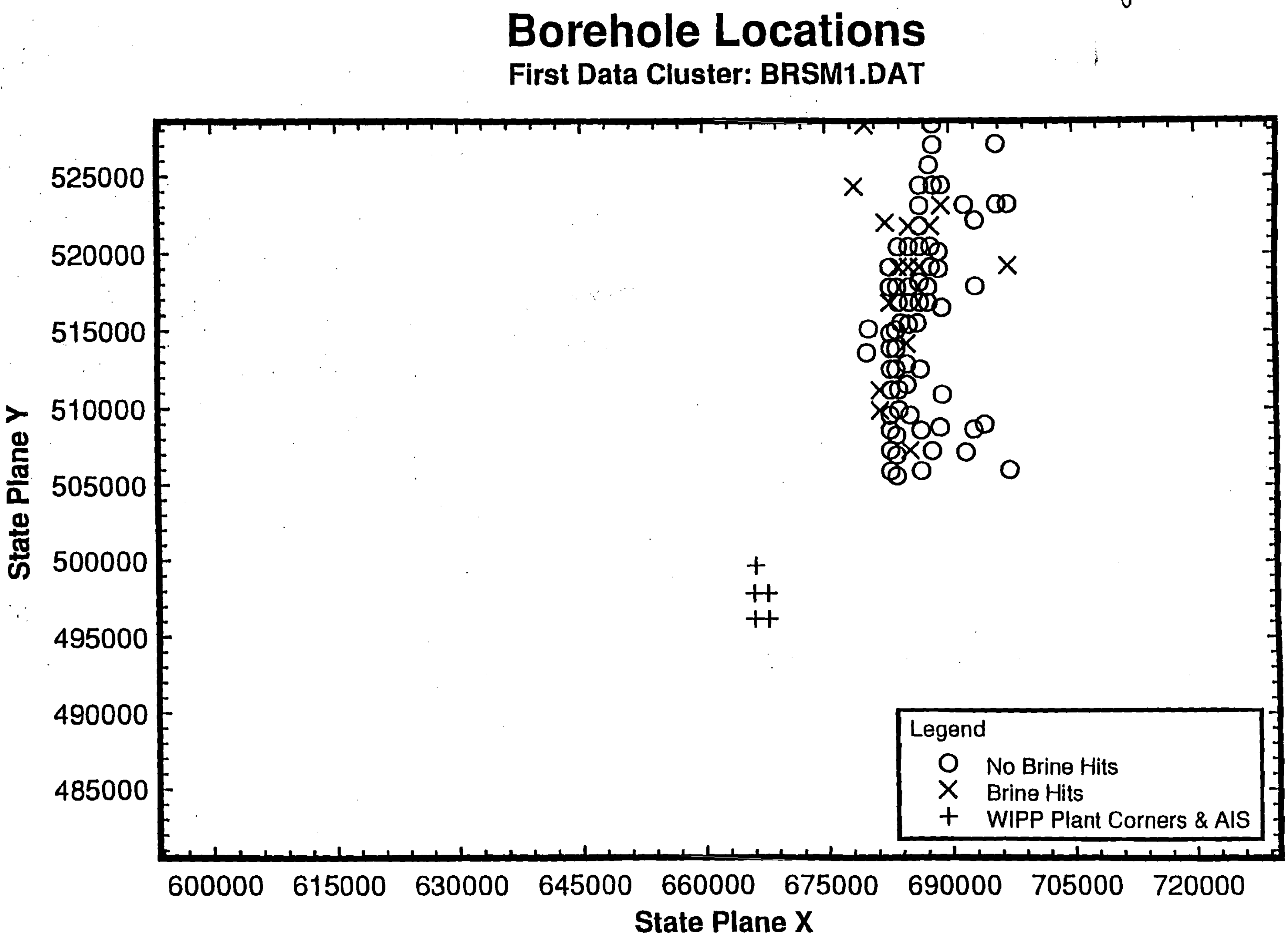
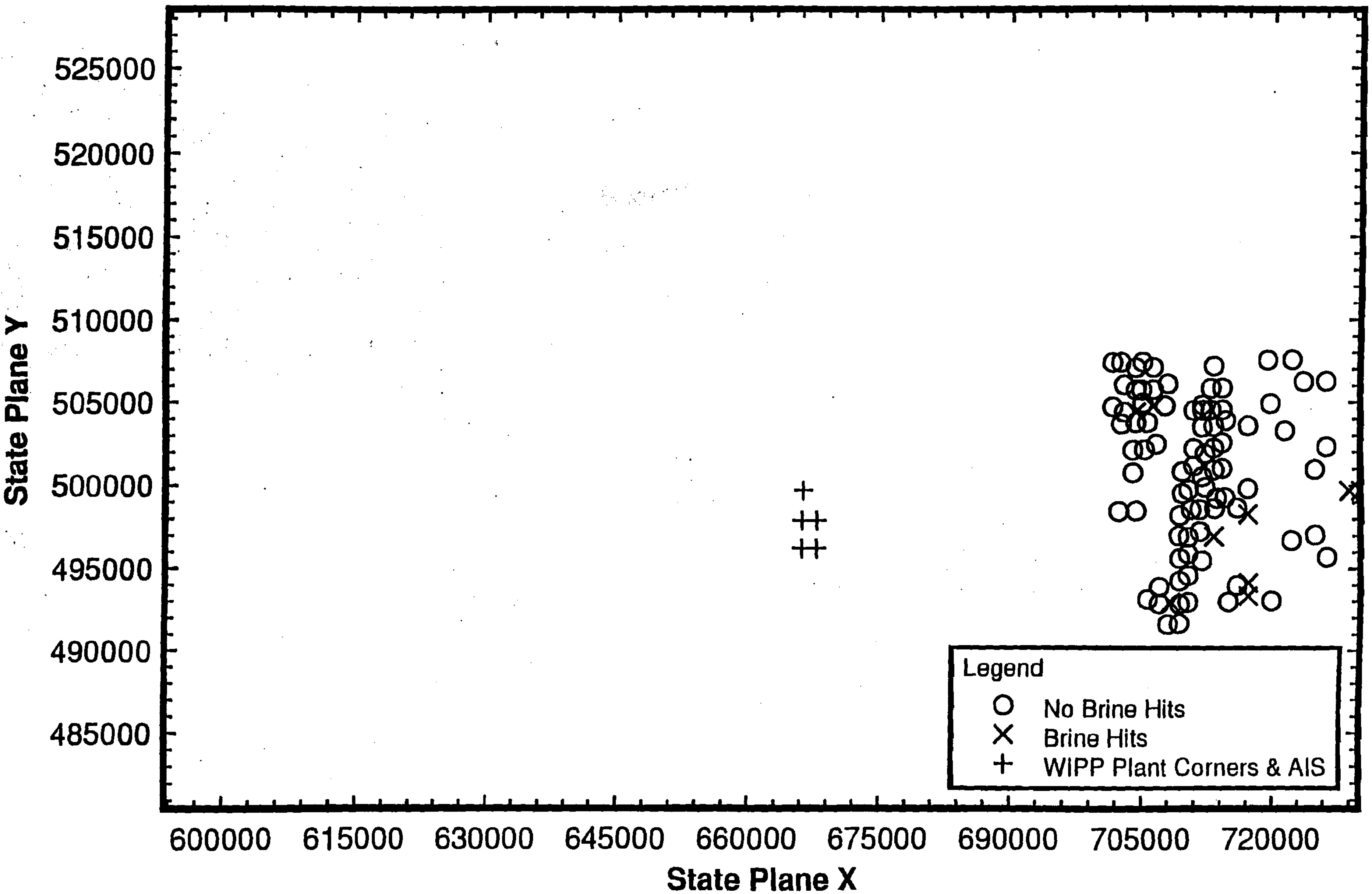

Borehole Locations
First Data Cluster: BRSM1.DAT
State Plane Y
525000
520000
515000
510000
505000
500000
495000
490000
485000
State Plane X
600000
615000
630000
645000
660000
675000
690000
705000
720000
Legend
No Brine Hits
Brine Hits
WIPP Plant Corners & AIS

Figure 6-5

Borehole Locations

Second Data Cluster: BRSM2.DAT



The second approach utilizes alternative measures of spatial continuity which are less sensitive to data clustering. The general and pairwise relative semi-variograms are typically less vulnerable to clustering because they normalize the semi-variogram value for each lag class by the squared mean of the data and the squared average of the paired values; however, they can only be computed for strictly positive data (Deutsch and Journel, 1992). Since our data were mainly zeros and a few ones, we added a value of one to each data point, shifting the data range from [0,1] to [1,2] and then calculated the relative semi-variograms. This shift preserves the maximum and minimum differences between any two data points, which are all that is required for calculation.

The semi-rodogram, defined as

$$\gamma_R(\boldsymbol{h}) = \frac{1}{2N(\boldsymbol{h})}\sum_{i=1}^{N(\boldsymbol{h})}\sqrt{|x_i - y_i|} \qquad (Eqn.6\text{-}5)$$

is also more resistant to clustering than the semi-variogram (Deutsch and Journel, 1992, p. 56). However, this measure (and the related semi-madogram) is numerically identical to the semi-variogram when computed for a binary variable limited to differences of 1 and 0. While this may suggest the semi-variogram for a binary variable with the same maximum and minimum differences should be relatively indifferent to data clustering, it may simply be a numerical artifact. Accordingly, the semi-rodograms were not used in the analysis.

We examined the impact of classification error on the sample semi-variogram calculations. Initial variographic calculations had been made prior to reclassifying well AEC7 from a brine intercept to a non-intercept. We recalculated sample semi-variograms for each of the data subsets and for the entire data set and then compared them to the previous results.

Undue influence of outlier data values was not considered to be significant because the range of allowable values was strictly limited to 0 and 1.

6.2.1.3 Theoretical Variogram Model Fitting

The range, sill, and nugget variance were estimated for each of the final sample semi-variograms using UNCERT's VARIOFIT module. Fits of each of the most common theoretical semi-variogram models: spherical, exponential, and Gaussian, were made both with and without non-zero nugget variances. Model fit was evaluated subjectively with the objective of preserving the apparent smaller scale range and nugget as much as possible. Automated, non-linear curve fits of theoretical models to the sample semi-variograms were also examined to check for subjective bias in the initial manual fit.

6.2.2 Kriging of a Binary Categorical Variable

We estimated the conditional probabilities of a brine intercept at regularly-spaced grid nodes using ordinary point kriging for each of the selected theoretical semi-variogram models. An areally-averaged probability was then computed from the kriged point probabilities for the waste panel area.

Ordinary point kriging was carried out using UNCERT's GRID module for each theoretical semi-variogram model. Inputs include the estimated semi-variogram parameters, the intercept/no-intercept observations, grid definition parameters, and search parameters. We selected a 1000 ft grid node spacing along both the N-S and E-W axes. The kriged domain range included all of the data points and had an E-W range of [590000, 731000] and a N-S range of [480000, 530000] in NM state plane coordinates. We compared results from the normal search mode, with minimum and maximum number of data points set to 4 and 16, to those from the octant search mode, which had minimum and maximum number of data points set to 2 and 16 and a maximum per octant of 8 points.

The CONTOUR module from UNCERT was used to create color-coded maps of the conditional brine intercept probabilities for each of the semi-variogram models. Point-kriged probabilities for each node within the waste panel, the shaft pillar, and the experimental areas were pulled from the output files and noted. We estimated an average conditional probability for the entire waste panel area through weighting each nodal conditional probability by the percentage of the total waste panel area it influenced. These calculations were made using the EXCEL spreadsheet package.

We checked the point-kriged probabilities from UNCERT's GRID module against results from GSLIB's KTB3D algorithm using the same grid, search, and variogram model parameters.

6.3 RESULTS AND DISCUSSION

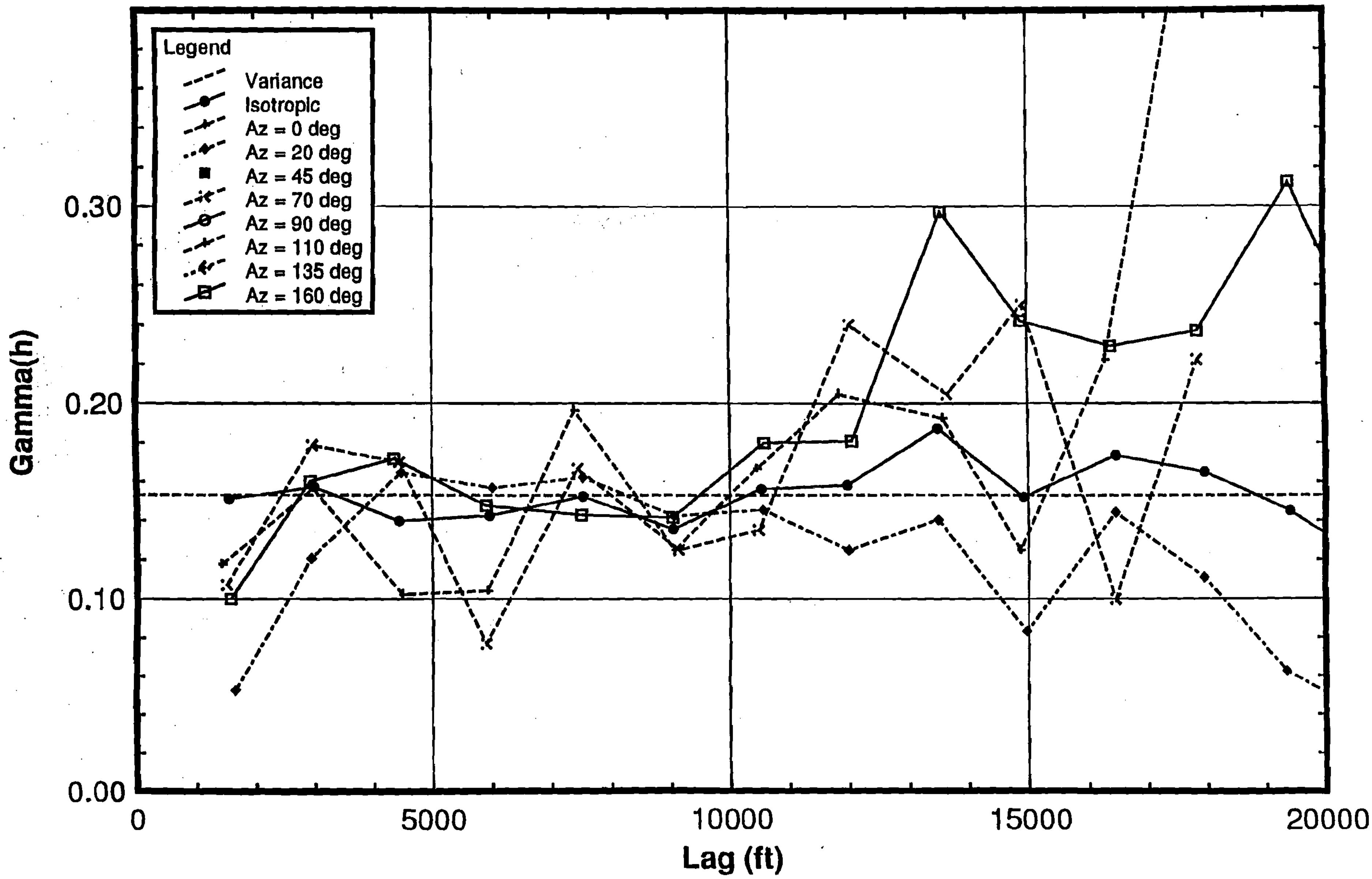
6.3.1 Variography

6.3.1.1 Sample Semi-Variogram Calculations

Figures 6-6ab and 6-7ab show all the sample semi-variograms for the first and second data subsets. Figure 6-6a depicts the most significant sample semi-variograms found in Subset 1: the isotropic case and azimuths 20 and 160 degrees together with their orthogonals (110 and 70 degrees, respectively). The remaining directional sample semi-variograms, shown in Figure 6-6b, demonstrate a pure nugget effect, i.e., there is no spatial correlation. Figure 6-7a shows that only the azimuth 160 directional semi-variogram clearly demonstrates any correlation structure. The isotropic case semi-variogram also

Castile Brine Reservoirs: BRSM1.DAT

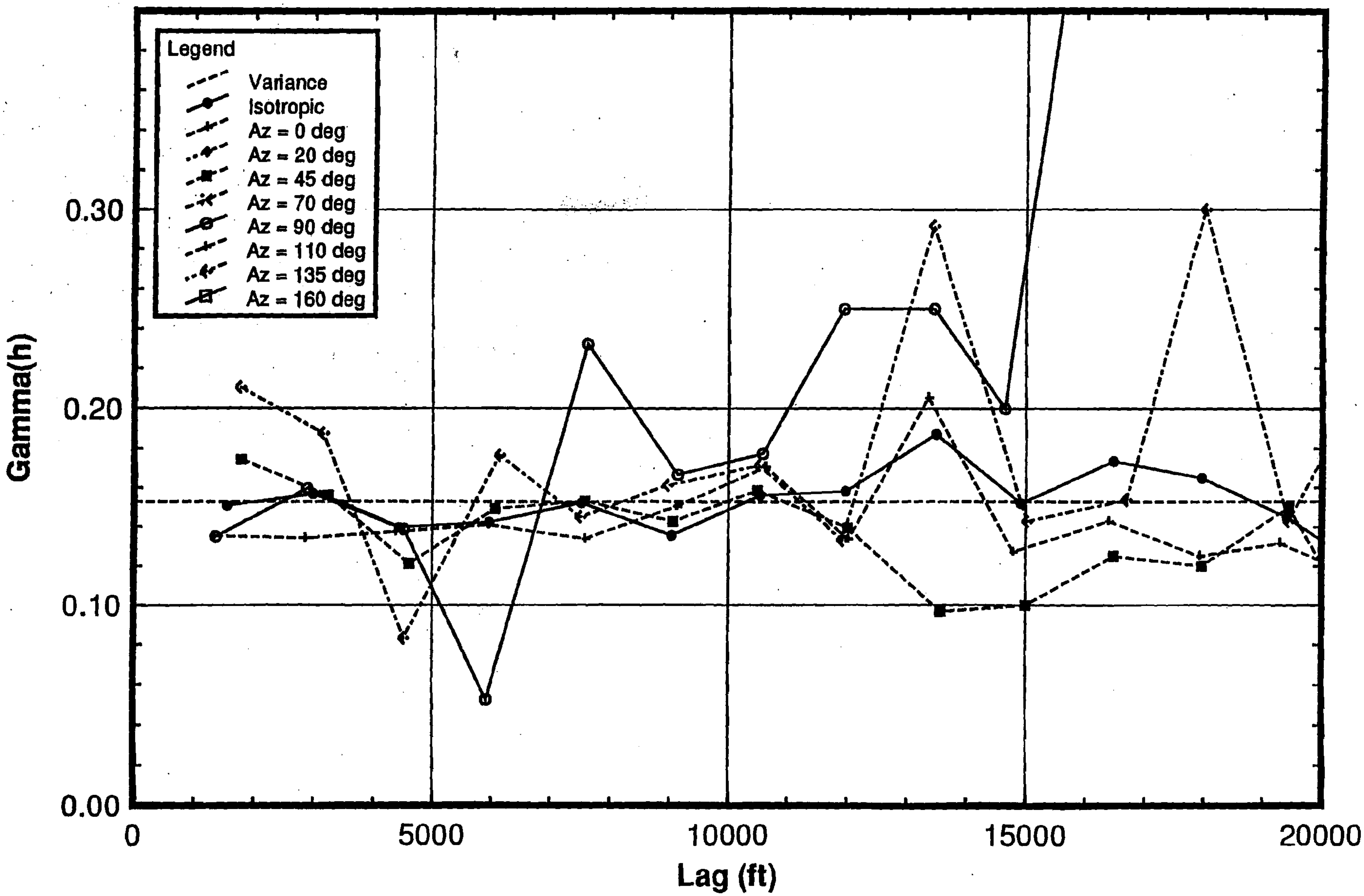
Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15



Castile Brine Reservoirs: BRSM1.DAT

Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15

Figure 6-6b



Castile Brine Reservoirs: BRSM2.DAT

Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15

Figure 6-7a

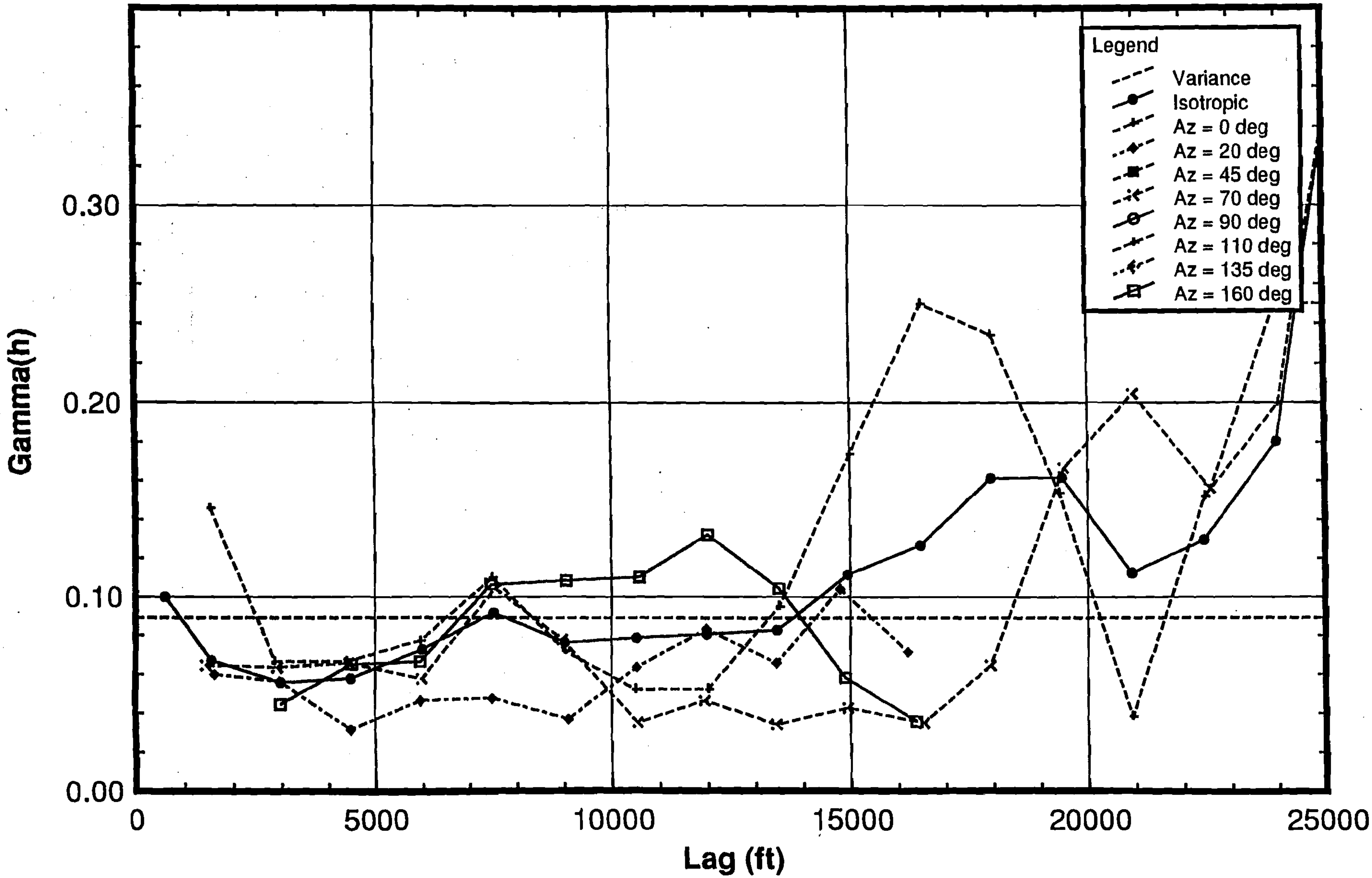
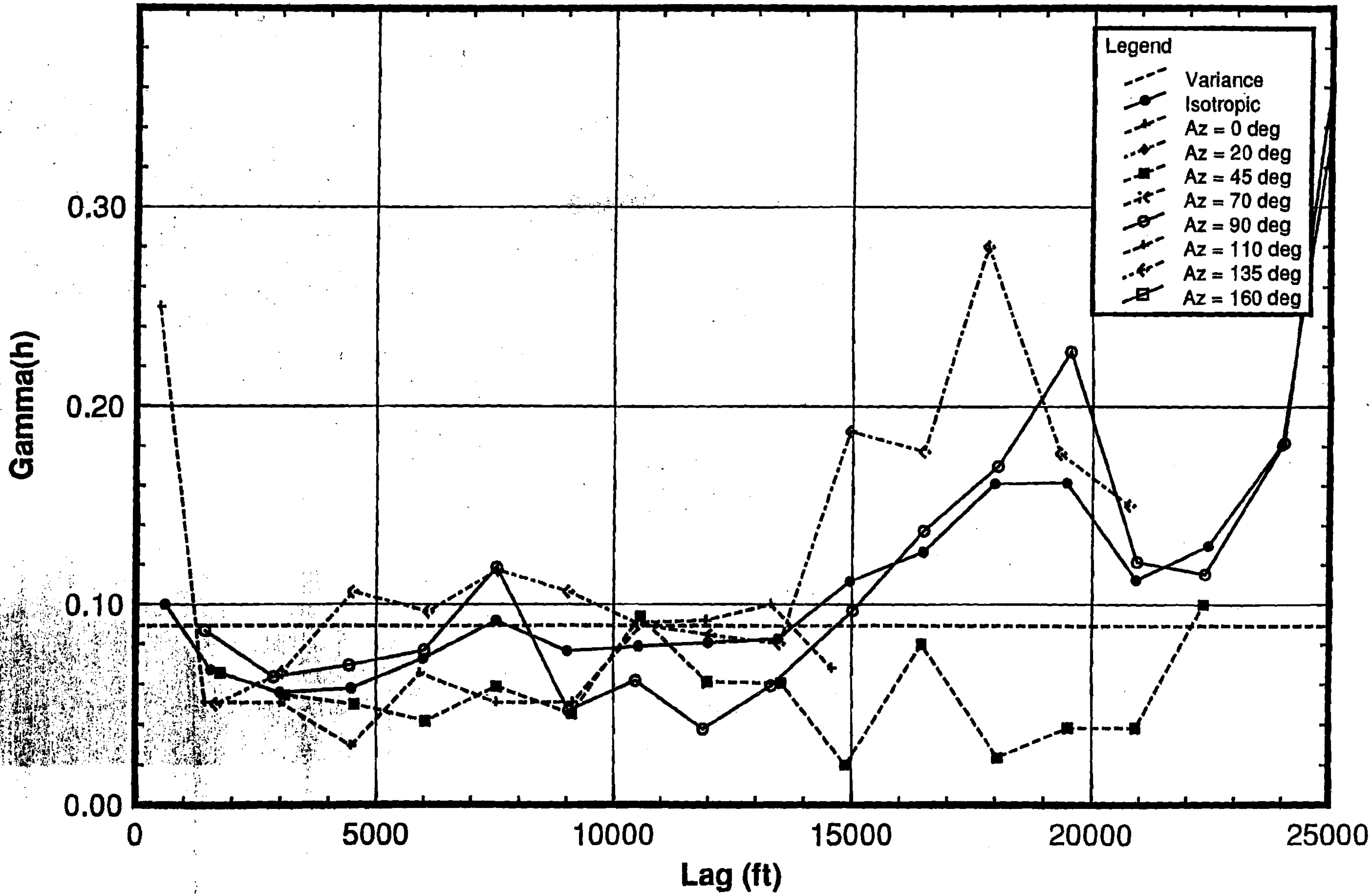


Figure 6-7b

Castile Brine Reservoirs: BRSM2.DAT

Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15



demonstrates correlation structure because its first lag spacing point has too few pairs to be considered a valid estimate. The 20 degree azimuth does not exhibit significant correlation structure. The same holds for all the remaining directions depicted in Figure 6-7b.

Figure 6-8a indicates that significant correlation structure can be found in the isotropic and 20, 70, and 160 degrees azimuth sample semi-variograms for the complete data set. Figure 6-8b shows that the remaining directions have no correlation structure and are best described by a pure nugget effect. The relatively large number of data points within the complete data set ensured that large numbers of pairs were found in all of the early lag classes, e.g., from 0 to 20000 ft lags. The semi-variogram values are typically less dependable for the later lag classes because the semi-variogram estimates become increasingly unstable as lag spacing increases beyond 25 to 40% of the maximum separation distance within the data set.

The only spatial correlation structures which appear consistently across the three data sets are the isotropic (omni-directional) and the anisotropic 160 degrees azimuth sample semi-variograms. The latter sample semi-variogram persisted across a fairly narrow range of azimuth angles: from 157 to 162 degrees azimuth. Although it exhibits some noise (or, potentially, cyclicity) at the fourth lag, the 70 degree azimuth sample semi-variogram was consistent across the three data sets. The correlation structures observed for the 160 and 70 degree azimuth and isotropic semi-variograms persisted when lag spacings were varied from the initial value of 1500 ft to 1000 and 2000 ft. This was not the case for the 20 degree azimuth semi-variogram, which was observed at 1500 and 2000 ft lags but not at the 1000 ft lag. Furthermore, its orthogonal semi-variogram (azimuth of 110 degrees) did not show any significant correlation structure in any of the data sets for any lag spacing. Consequently, the 20 degree azimuth model was not considered to be a significant sample semi-variogram.

The relative semi-variograms for the complete data set shifted from [0,1] to [1,2] (see Figures 6-9ab and 6-10ab) confirm the isotropic and 160 and 70 degree azimuth semi-variograms demonstrate significant correlation structure. Changing borehole AEC7 from an intercept to a no-intercept had a negligible impact on the estimated sample semi-variograms. We found an exact equivalence to four or more decimal places between the calculations made with UNCERT's VARIO and those made using the GSLIB and VARIOWIN variography routines. The calculation results for each package are presented in Appendix I.

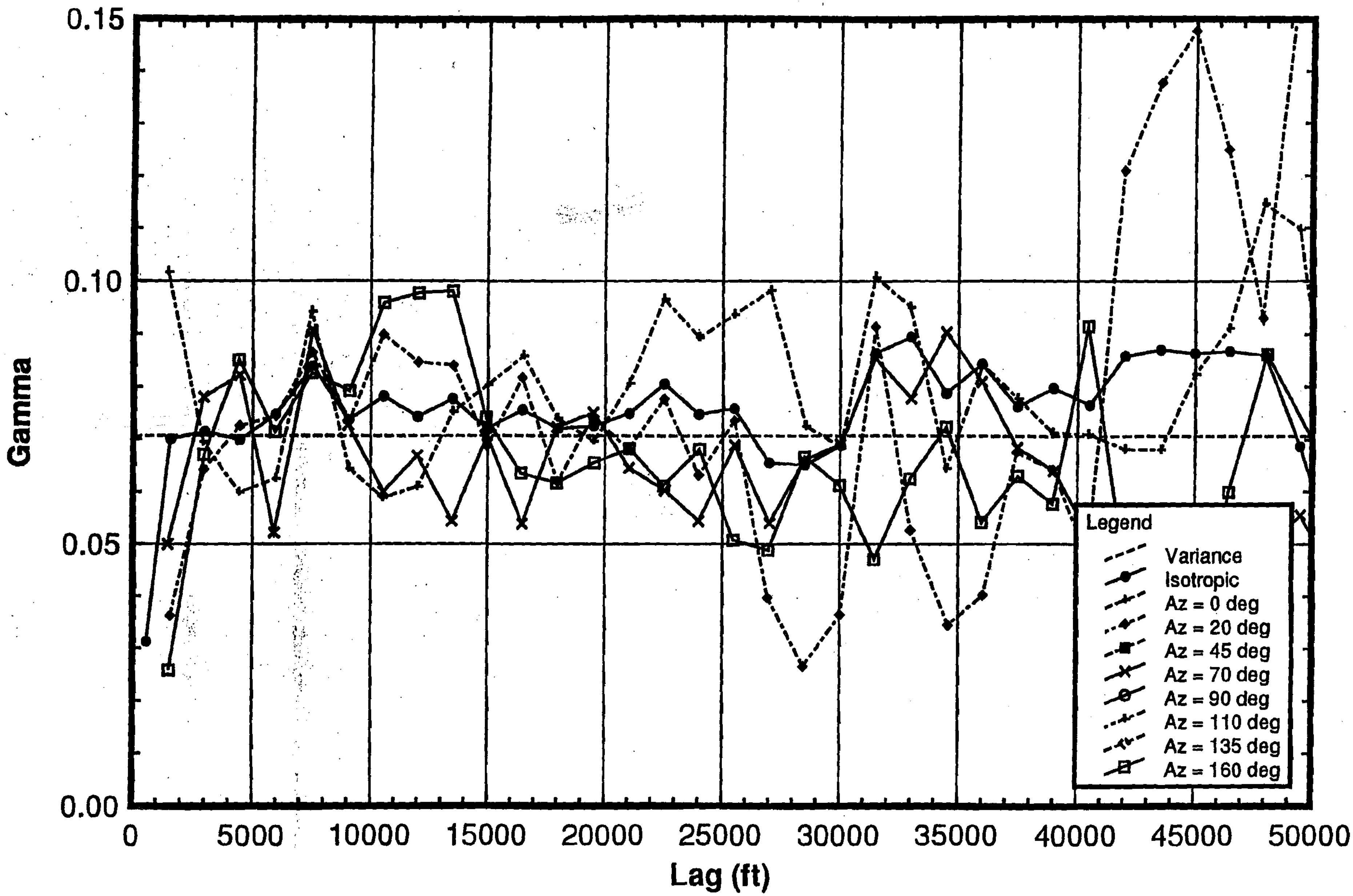
6.3.1.2 Theoretical Semi-Variogram Model Fitting

Table 6-1 presents the range, sill, and nugget variance parameters fitted for the

Figure 6-8a

Castile Brine Reservoirs: BRSM5.DAT

Semi-Variogram: Range = 1500 ft; BW = 10000; HA = 15



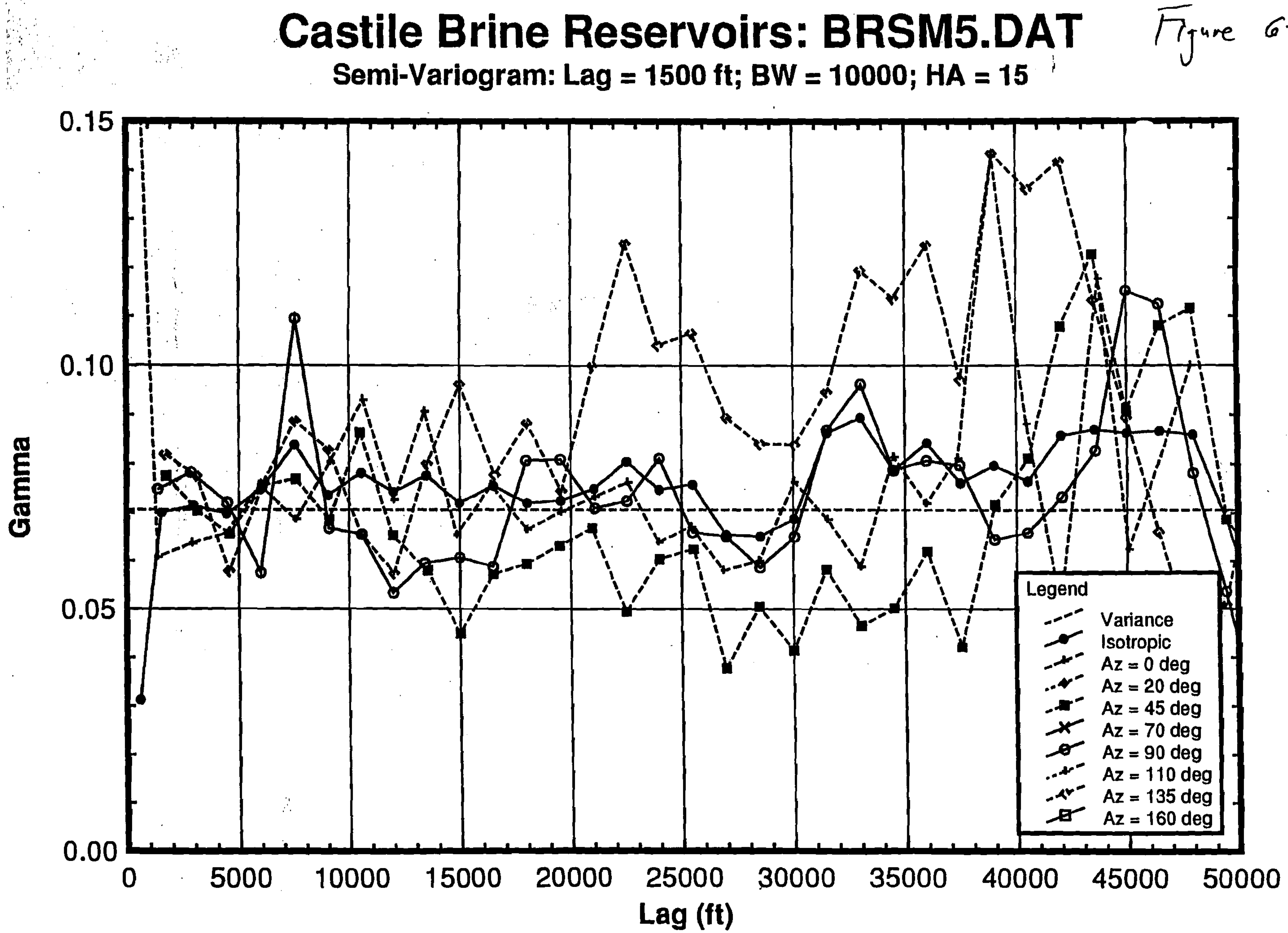

Castile Brine Reservoirs: BRSM5.DAT
Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Gamma
0.15
0.10
0.05
0.00
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Lag (ft)
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg

Figure 6-86

Castile Brine Reservoirs: BRSM512.DAT

Figure 6-9a

General Relative Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15

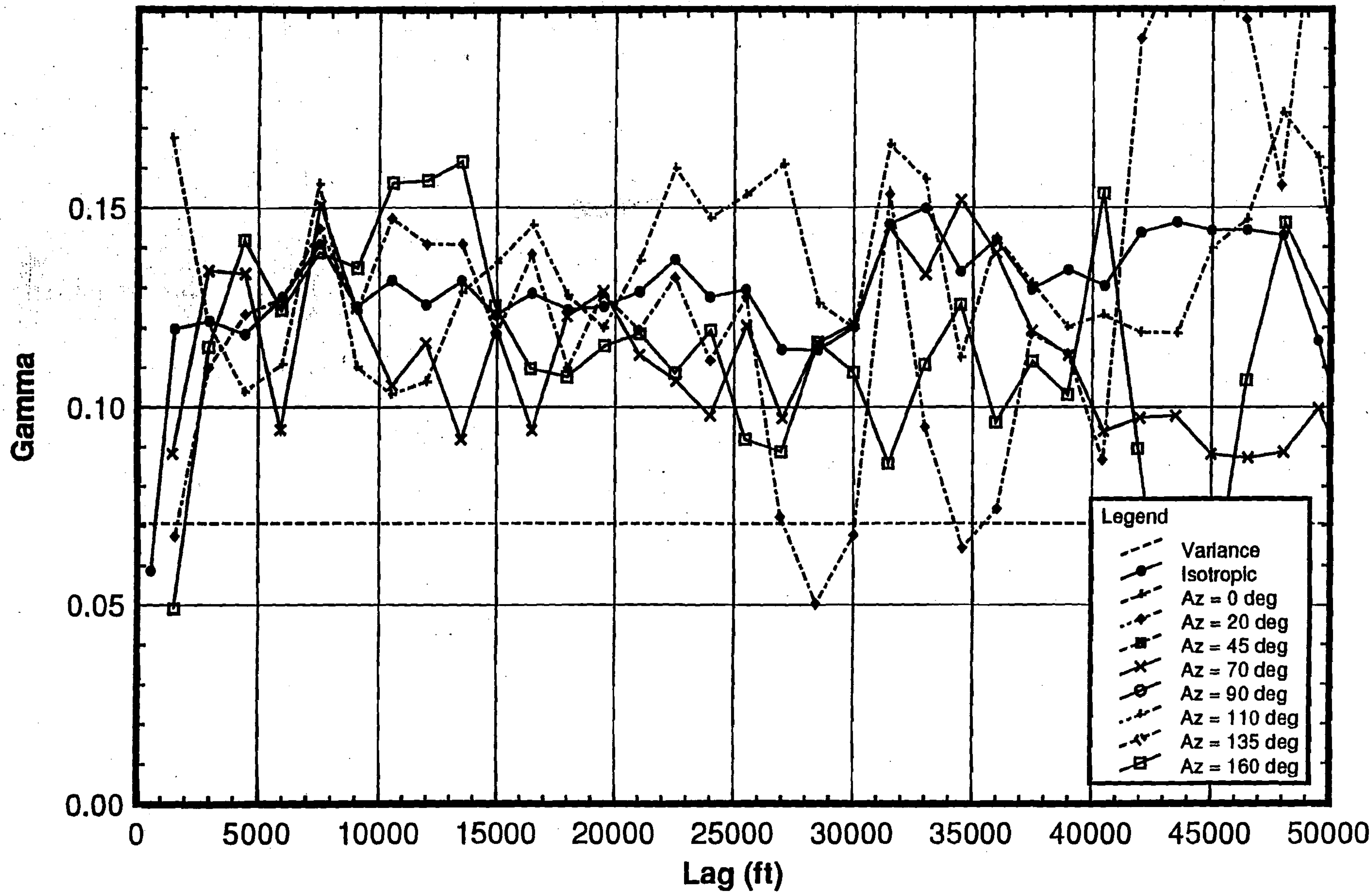


Figure 6-96

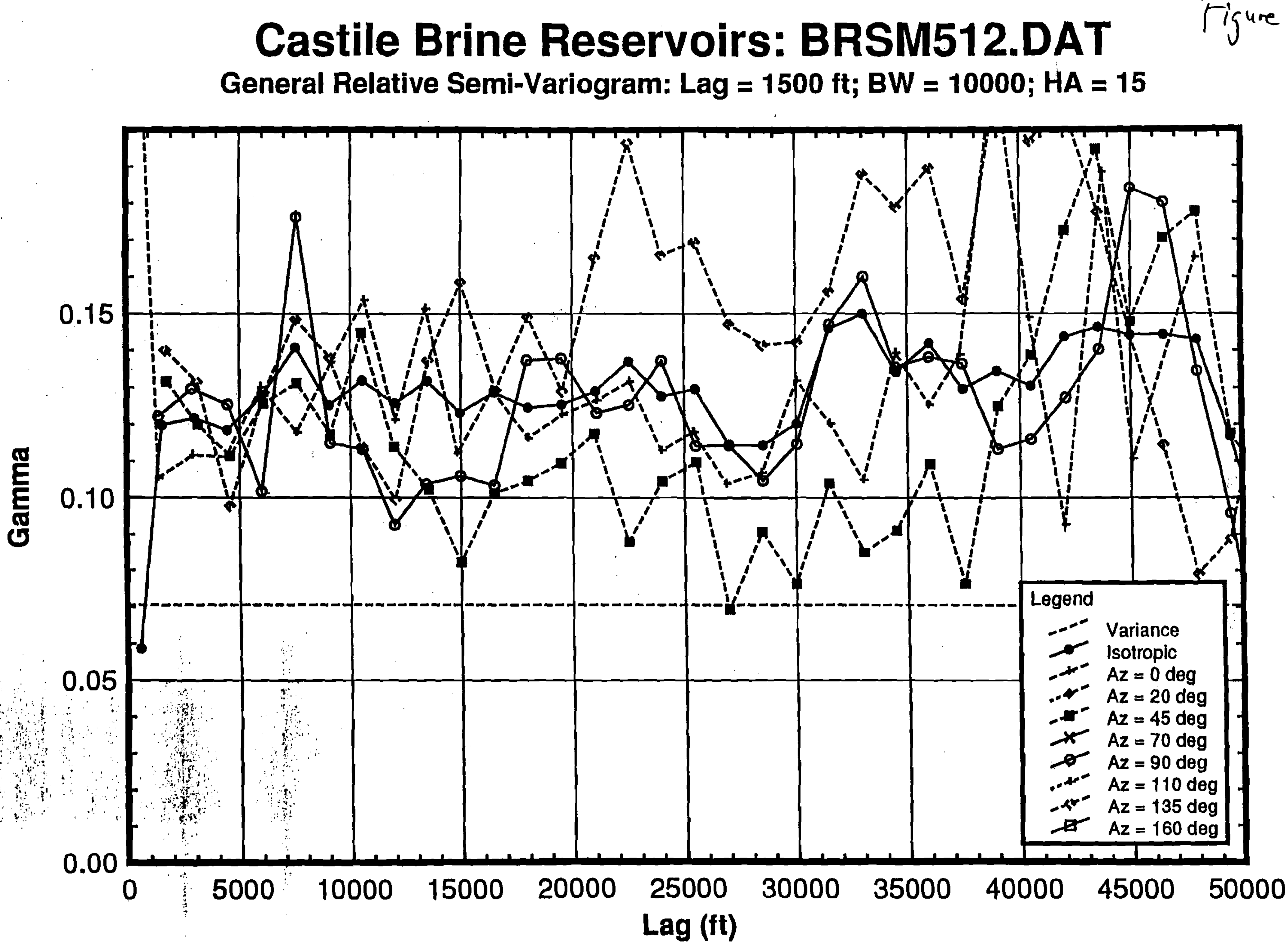

Castile Brine Reservoirs: BRSM512.DAT
General Relative Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Gamma
0.15
0.10
0.05
0.00
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Lag (ft)
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg

Figure 6-10a

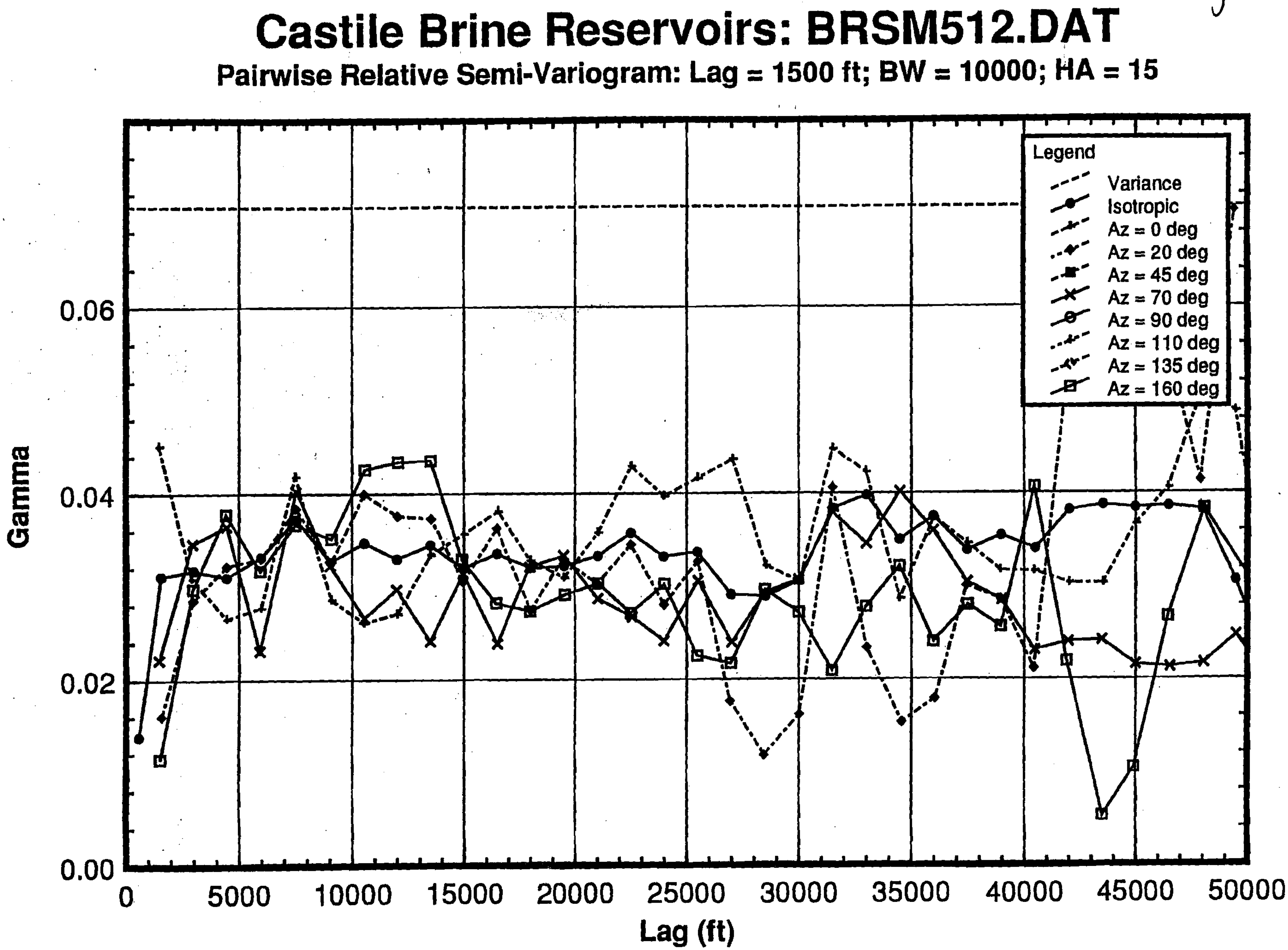
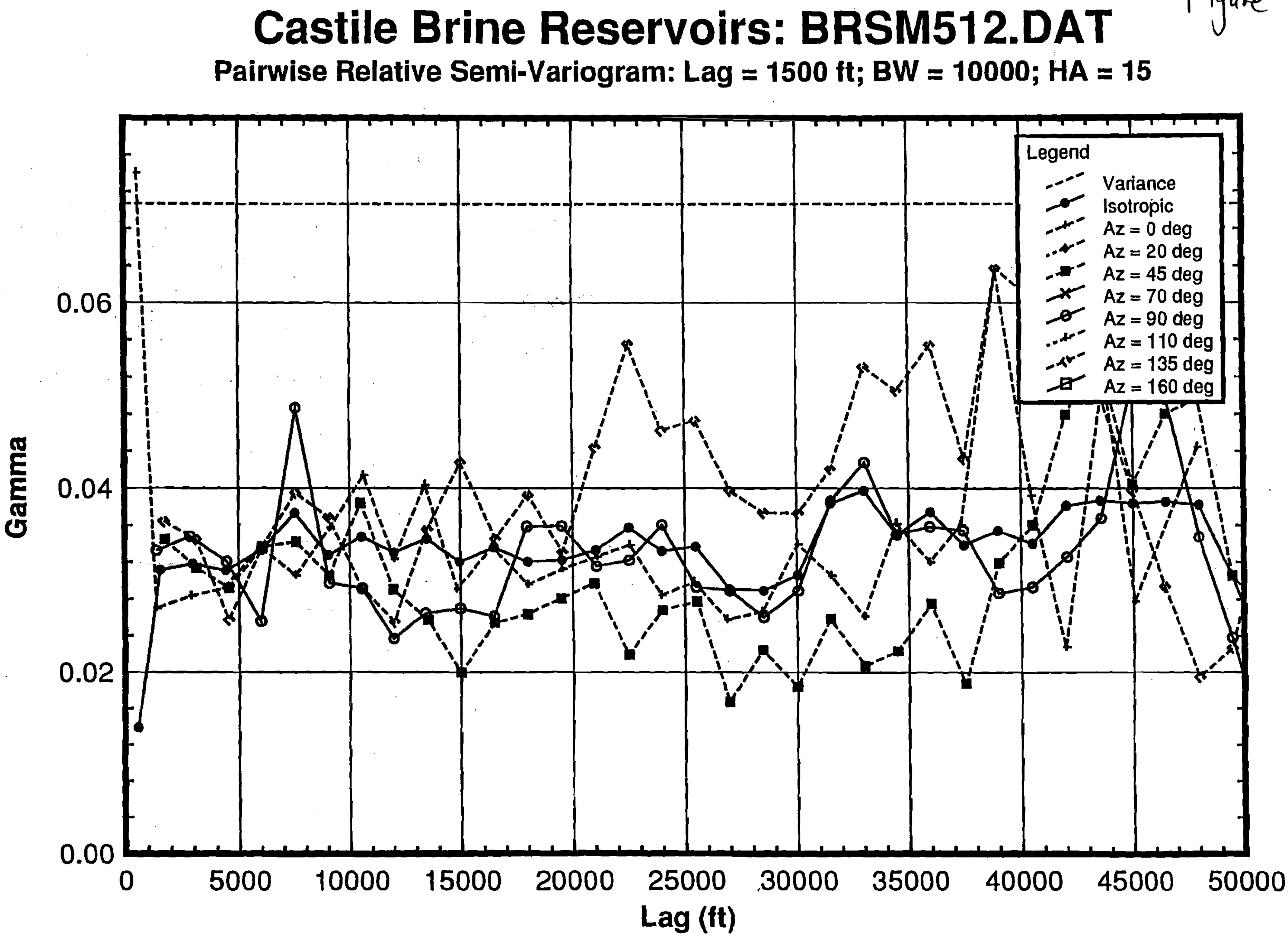

Castile Brine Reservoirs: BRSM512.DAT
Pairwise Relative Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg
Gamma
0.00
0.02
0.04
0.06
Lag (ft)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000

Figure 6-10b



Castile Brine Reservoirs: BRSM512.DAT
Pairwise Relative Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg
Gamma
0.00
0.02
0.04
0.06
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Lag (ft)

isotropic and two anisotropic sample semi-variograms. The "best" fits were made using the spherical theoretical variogram model, typically with zero nugget variance. The Gaussian theoretical variogram model allowed a non-zero nugget for the 160 degree azimuth sample semi-variogram. Figures 6-11abc show how the fitted spherical theoretical variograms match the sample semi-variograms.

It is important to note that the effective ranges of the various theoretical model types differ substantially. While the spherical model's range and effective range are equal, the effective range for the Gaussian model is $\sqrt{3}$ times its range. Similarly, multiply the exponential model's range by 3 to get its effective range. Only the effective ranges can be compared across model types.

Table 6-1
Fitted Model Variogram Parameters

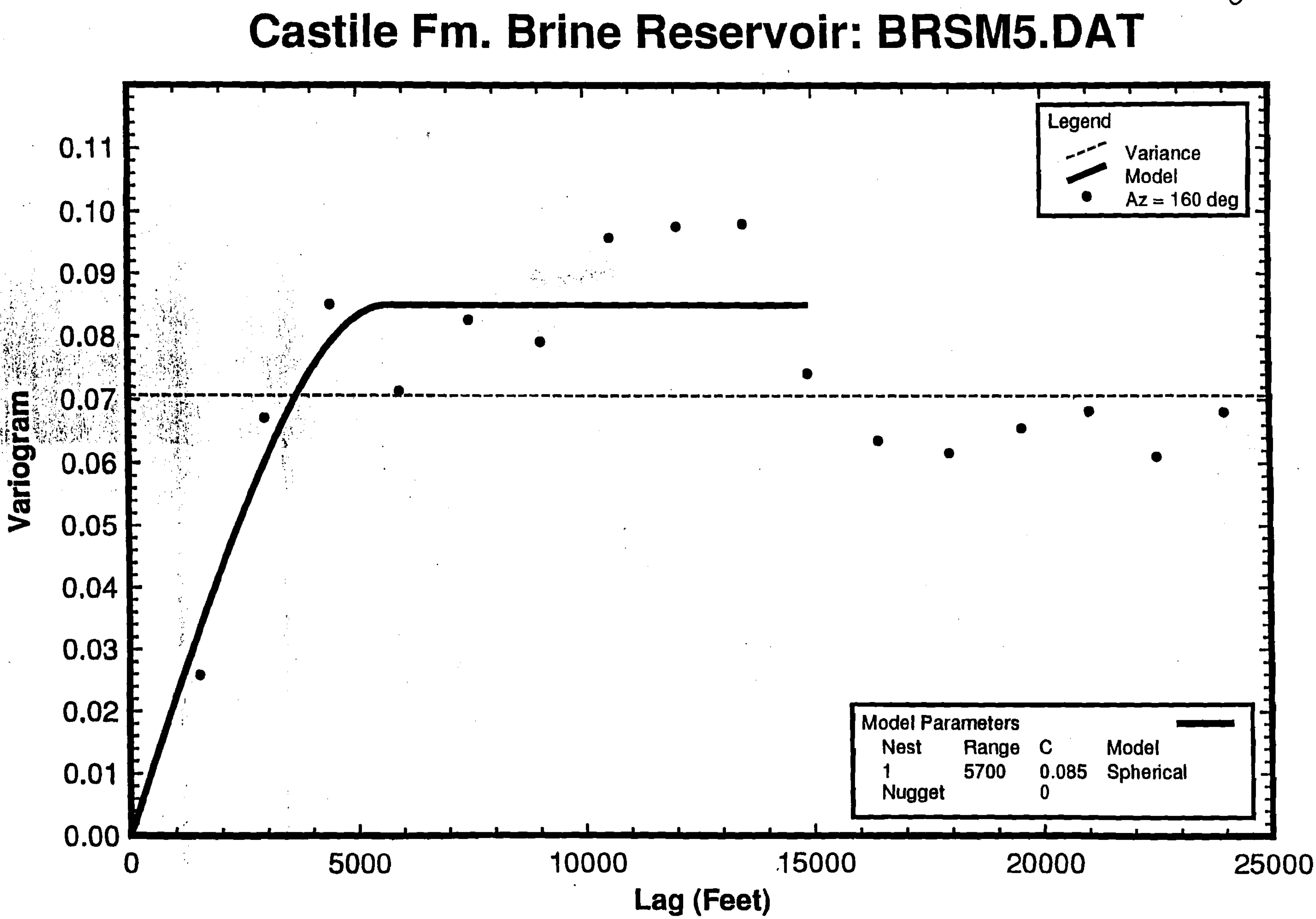
Sample Semi-Variogram	Theoretical Model Type	Nugget	Range (ft)	C (= Sill - Nugget)
Azimuth 160 degrees	Spherical	0.00	5700	0.085
	Gaussian	0.01	2500	0.074
Azimuth 70 degrees	Spherical	0.00	2880	0.080
	Gaussian	0.01	1400	0.068
Isotropic	Spherical	0.01	2500	0.065
	Exponential	0.00	800	0.076

6.3.2 Kriging

Figure 6-12 shows the point-kriged conditional probability of a brine reservoir intercept for the WIPP site and the surrounding vicinity using the 160 - 70 degree azimuth model semi-variograms. The waste panel centers are indicated by four crosses located in the center left of the map at roughly state plane coordinates [667000, 499000]. It is immediately south of the isolated brine reservoir hit shown as a high probability zone in yellow and orange. Note the anisotropic orientation of the probability contours: they are aligned along an azimuth corresponding to the 160 degree sample semi-variogram orientation. The contours form an ellipse because the 70 degree azimuth range is roughly half the range for the 160 degree orientation. The were no differences observed, to three or more decimal places, in point-kriged intercept probabilities within the site area footprints when results from the normal and octant search methods were compared. Figure 6-13 shows the individual nodal kriged probabilities within the site's three areas of interest: waste panel, shafts and access, and the experimental area. The kriged probabilities show an increasing trend moving from south to north as you approach the observed brine intercept at the WIPP-12 borehole.

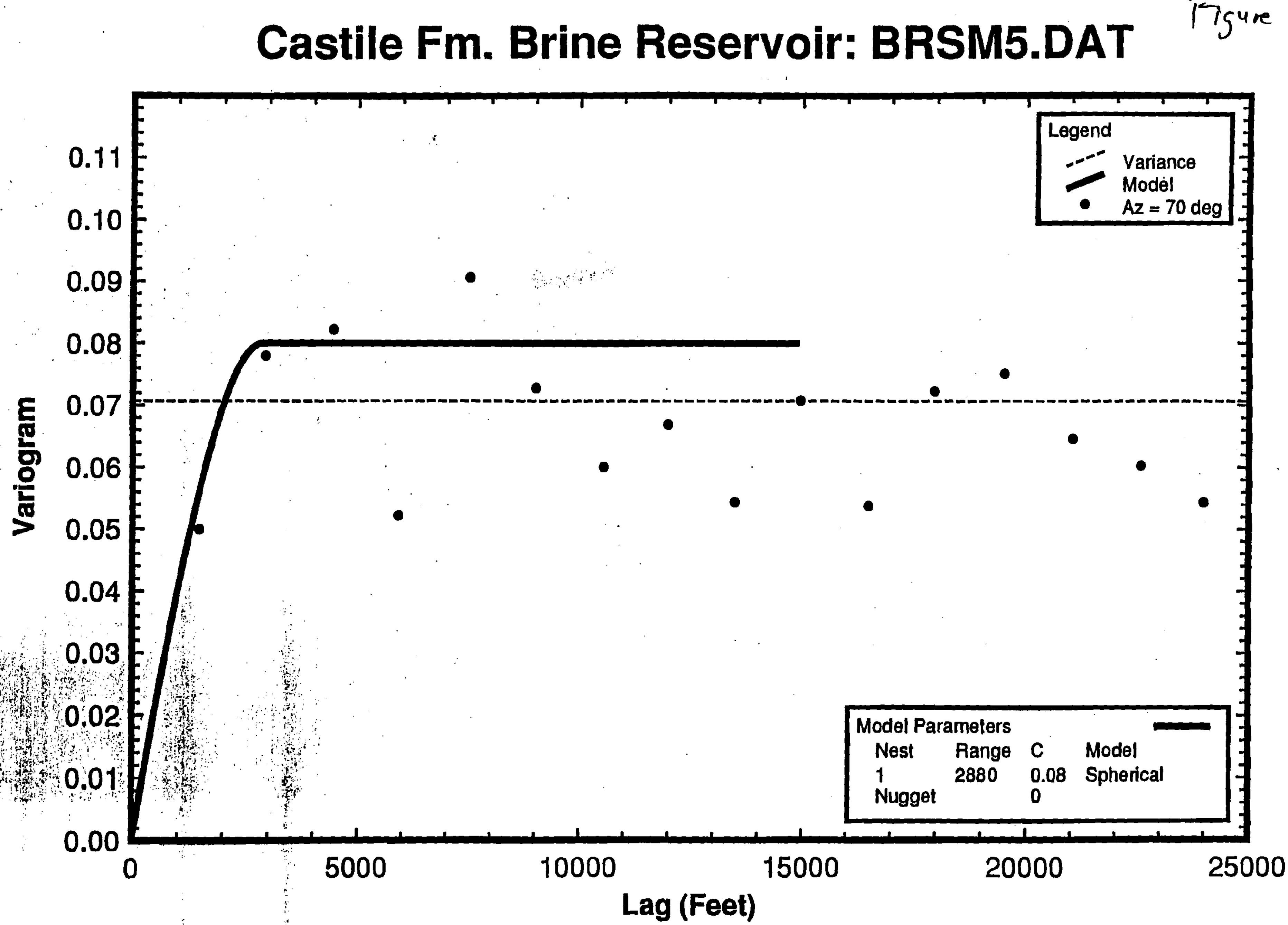
Within the waste panel area, however, the kriged probabilities range between

Figure 6-11a



Castile Fm. Brine Reservoir: BRSM5.DAT
Legend
Variance
Model
Az = 160 deg
Variogram
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
5000
10000
15000
20000
25000
Lag (Feet)
Model Parameters
Nest Range C Model
1 5700 0.085 Spherical
Nugget 0

Figure 6-11b



Castile Fm. Brine Reservoir: BRSM5.DAT
Legend
Variance
Model
Az = 70 deg
Model Parameters
Nest Range C Model
1 2880 0.08 Spherical
Nugget 0
Variogram
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
5000
10000
15000
20000
25000
Lag (Feet)

Figure 6-11c

Castile Fm. Brine Reservoir: BRSM5.DAT

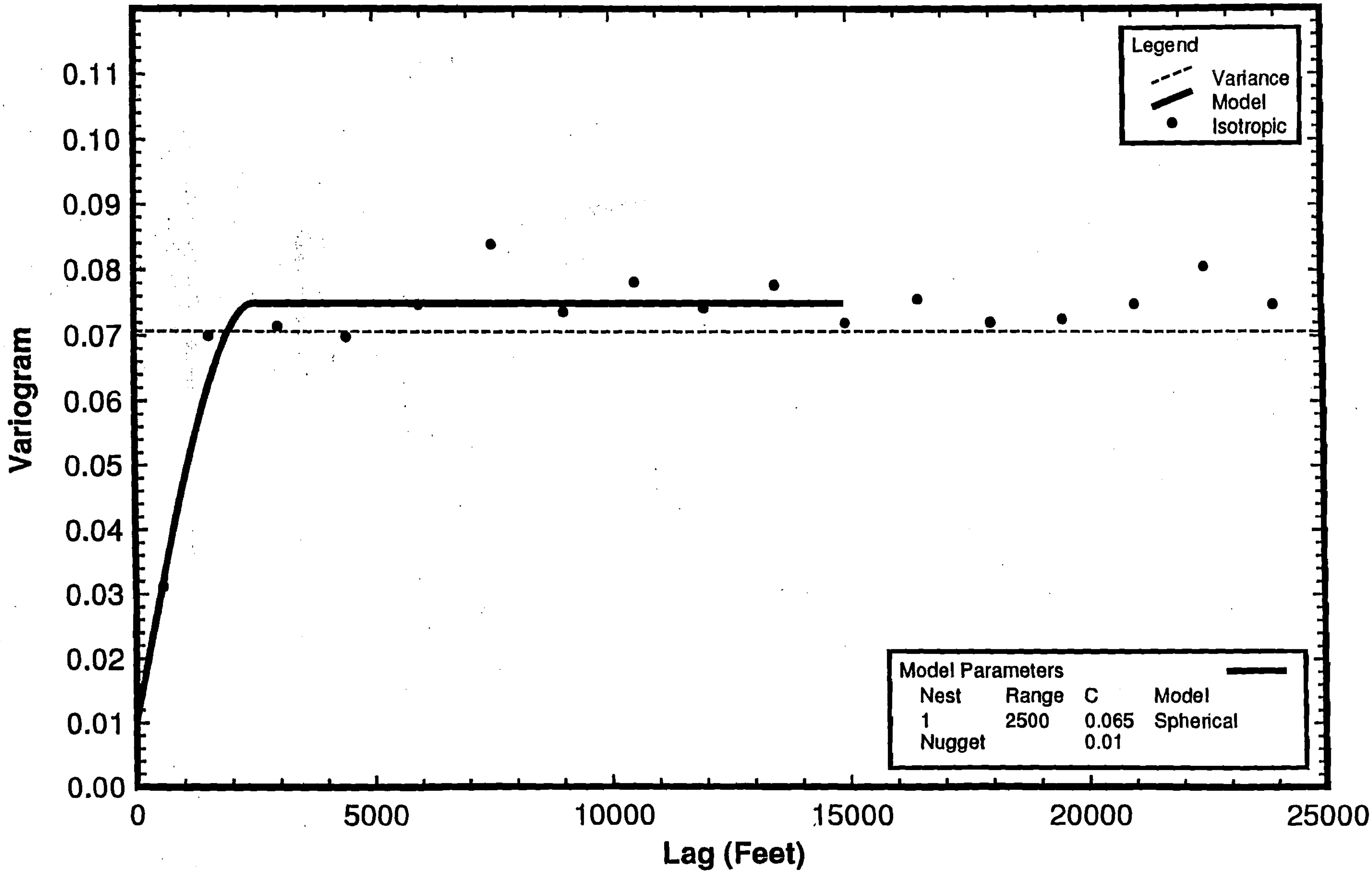


Figure 6-12

Probability of Encountering a Castile Brine Reservoir

Anisotropic Spherical Semi-Variogram: Azimuth = 160 deg; Range = 5700 ft; Nugget = 0

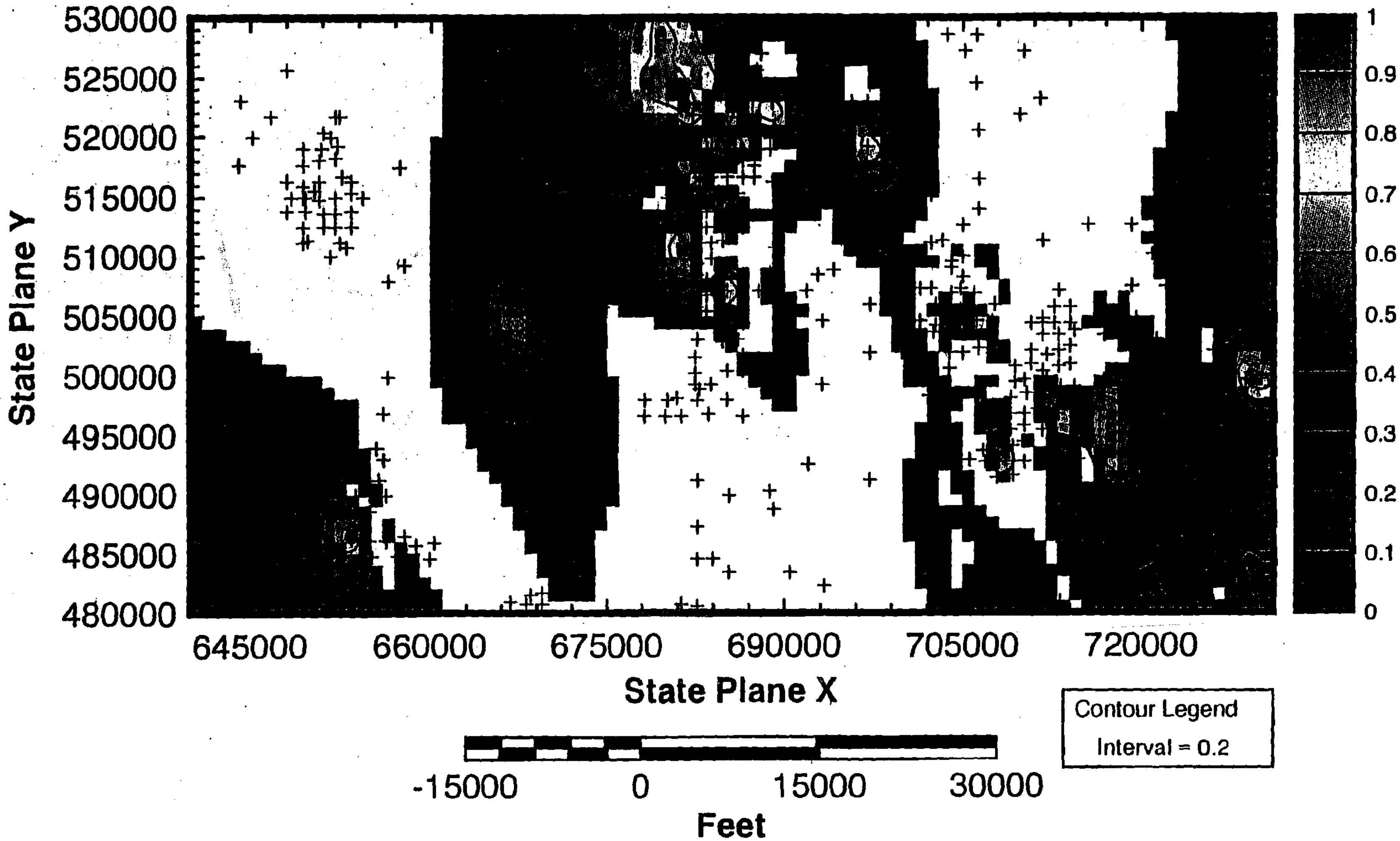
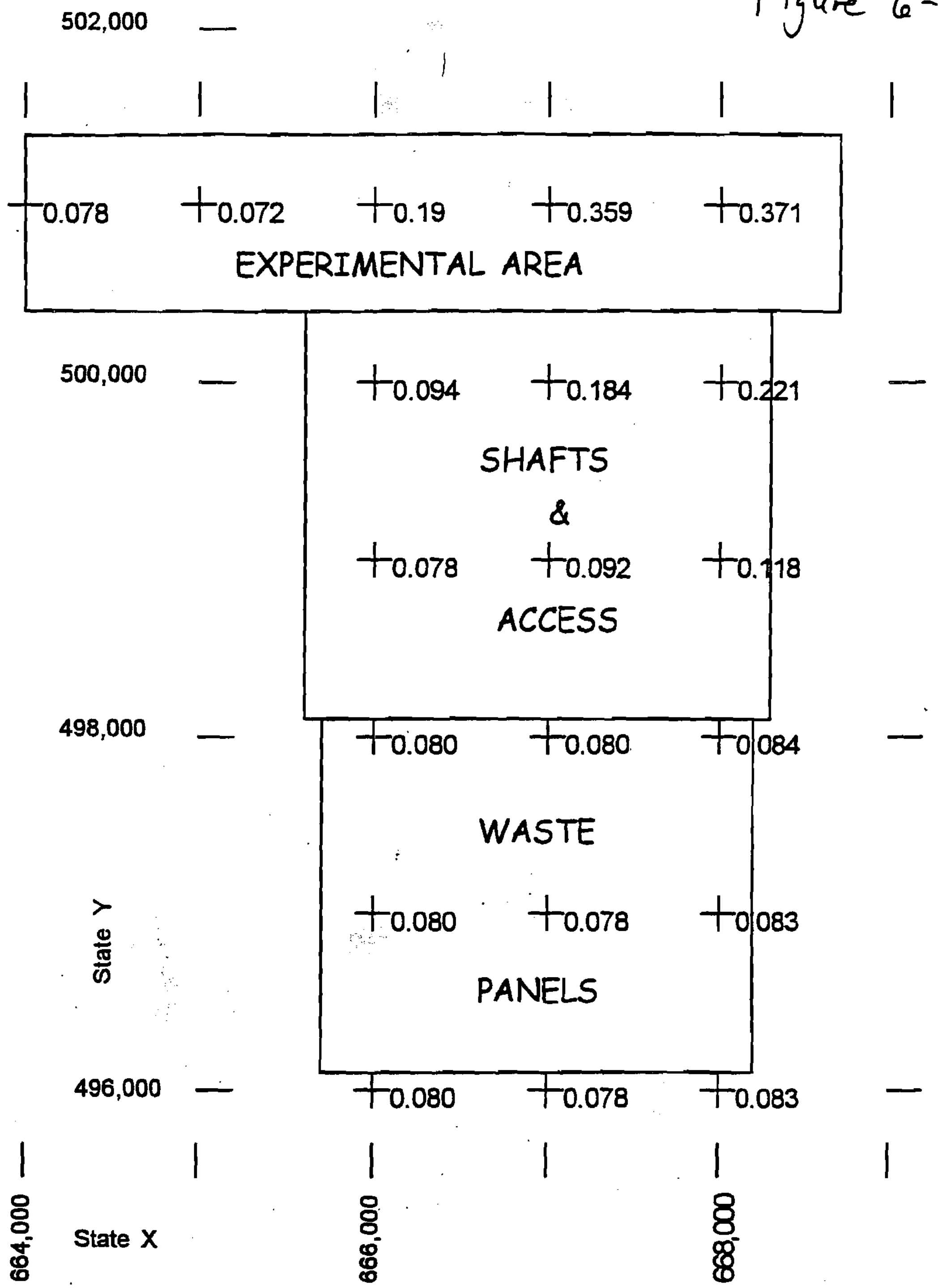


Figure 6-13



Nodal Probabilities of Intercepting Brine in Castile
(Anisotropic: az = 160; range 5700 ft, nugget = 0)

0.078 and 0.084. Each node is centered in a grid block which has dimensions of 1000 ft on each face. We calculated an areally-averaged probability of 0.080 for the entire waste panel site by weighting each point-kriged probability by the proportion of the waste panel area its grid block occupies. This weighted probability average is roughly equivalent to a 3x3 block-kriged probability if the block overlaid the waste panel area exactly.

The waste panel point-kriged probabilities calculated using the isotropic theoretical semi-variogram model were all less than 0.07. The lower probabilities were caused by the substantially shorter range (2500 vs 5700 ft). Figure 6-14 shows the point-kriged conditional probability map assuming the isotropic theoretical model semi-variogram.

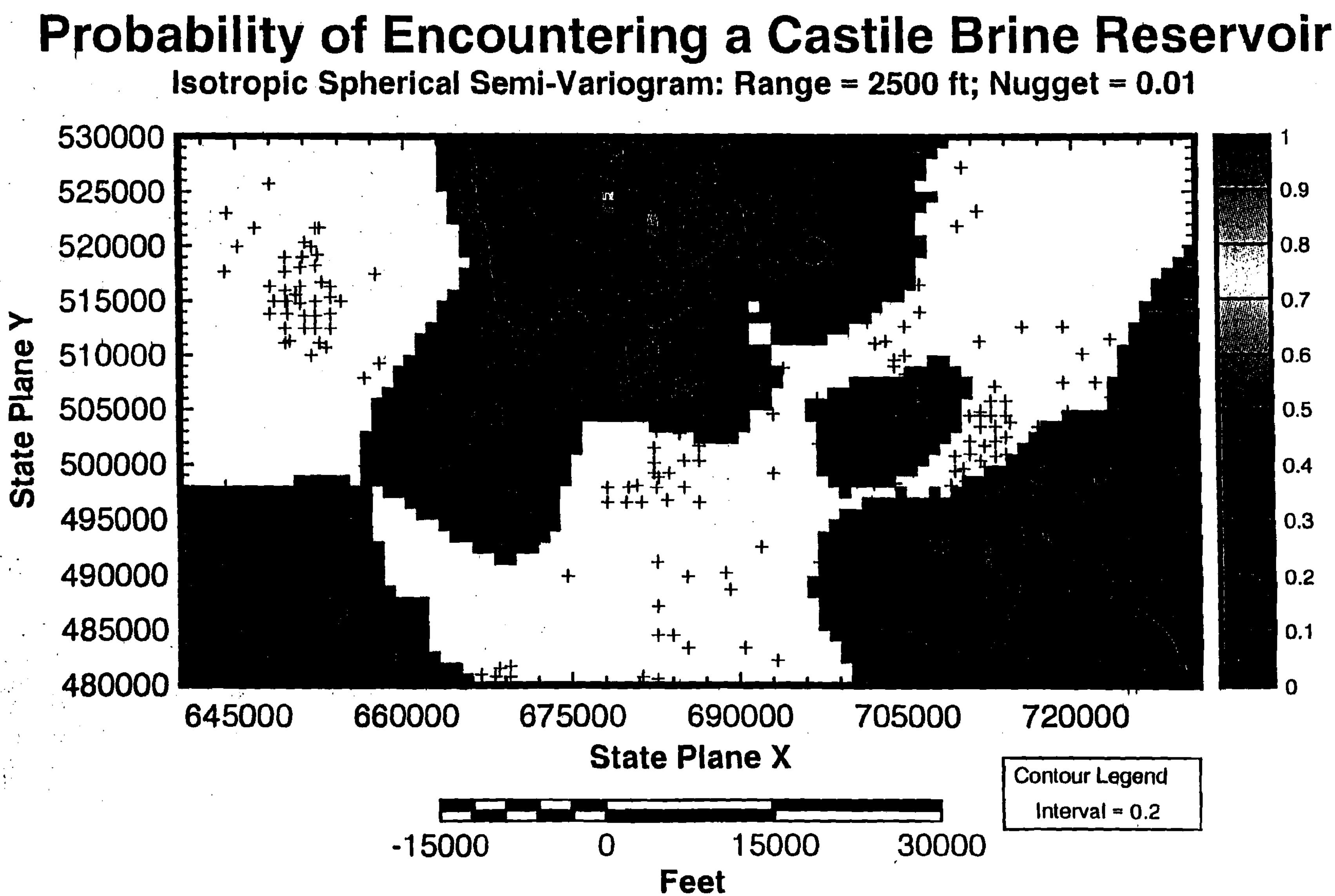
6.3.3 Variations in Kriging Results

We examined partially the effects of "errors" in classification equivalent to either missing a brine intercept in a drillhole or believing pressurized brine is present when it is not. Drillholes AEC 7 was included in our first analyses because it was included in some lists as a potential brine reservoir. After further review of the basic data report (Sandia National Laboratories and D'Appolonia Consulting Engineers, 1982), we have excluded it from the list (Table 4.1-2).

The kriging results were unchanged by the change in classification of borehole AEC 7 from an intercept to a no-intercept. The negligible impact of the classification error is attributable to the large distance (roughly 10 km), relative to the semi-variogram ranges observed, between the site and AEC 7's location. This suggests that classification errors must be considered with regard to the location of interest before their impact on the estimated probabilities can be understood. Individual misclassification errors will have continue to have a negligible impact on estimated intercept probabilities at the site unless those errors occur within one or two correlation lengths (ranges) of the site footprint and they are Type II errors. Type I errors are also known as false positives; Type II errors are known as false negatives. Thus, to create a significant change in the estimated site probabilities, one of the nearby no-intercept observations would have to reclassified as a brine intercept. It is unlikely such an error has occurred because most of the wells near the WIPP site were drilled by the Department of Energy, and conditions should have been quite favorable for detecting such Castile brine reservoirs. Our approach is robust with regard to individual misclassification errors located beyond several miles from the WIPP site.

Differences in the intercept probabilities estimated using UNCERT's GRID module and those estimated using the KT3B algorithm found in GSLIB (Deutsch and Journel, 1992) were 5% or less within the waste panel footprint. The GSLIB routine estimates for the shaft & access and experimental areas were less than

Figure 6-14



Probability of Encountering a Castile Brine Reservoir
Isotropic Spherical Semi-Variogram: Range = 2500 ft; Nugget = 0.01
State Plane Y
530000
525000
520000
515000
510000
505000
500000
495000
490000
485000
480000
645000
660000
675000
690000
705000
720000
State Plane X
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Contour Legend
Interval = 0.2
-15000
0
15000
30000
Feet

those calculated with GRID, which was based on the KT3B algorithm. This is attributed to the different search strategies utilized by the packages.

6.4 SUMMARY

- There is significant spatial correlation to the presence of brine reservoirs based on the available data. The physical cause of the correlation is, at present, unknown.
- The most significant correlation occurs along an azimuth of 160 degrees counterclockwise from north. It is anisotropic. This correlation structure does not appear to significantly influenced by data clustering. The main drilling trends are north-northeast.
- Another model of spatial correlation, along azimuth of 20 degrees, may be significant. However, it appears to be influenced by data clustering.
- The spatial correlation length scale of a brine reservoir hit, as described by the semi-variogram range, is relatively small: less than 6000 ft.
- The kriged point probability of a borehole encountering a brine reservoir in the Castile Formation within the waste panel footprint does not exceed 0.10, regardless of which spatial correlation model is chosen.
- The point-kriged probability estimates are insensitive to individual data classification errors located more than several miles from the WIPP site areas of concern.

7.0 GEOSTATISTICAL INVESTIGATION OF THE CASTILE FORMATION'S GEOLOGICAL STRUCTURE

7.1 INTRODUCTION

The objective of this investigation is to determine whether there are significant quantitative relationships between the brine reservoir intercepts and structural geologic data, particularly data that may be indicative of processes which created or influenced the observed brine intercept spatial distribution. Ideally, a geostatistical analysis will identify a random field's spatial correlation structure that is consistent with the processes which controlled the distribution of that random field. For example, the spatial variability of soil lead concentrations in fields surrounding a lead smelter should be consistent with the orientation of the prevailing winds and smelter operation patterns.

We believe brine reservoirs were caused by deformation of the uppermost units within the Castile Formation. We hypothesize that structural data, such as the thickness of these units, can provide insight into the amount and location of deformation. We began testing our hypothesis by 1) estimating the spatial variability of the structural data to compare with the brine intercept results from section 6.0 and 2) using statistics to examine potential interrelationships between geological structure and brine intercept data. Given our assumptions that structural data and brine reservoirs are functions of the amount of deformation in the upper Castile, any structural data similarities to the correlation scale and direction observed for brine intercepts adds greater weight to our conclusions about brine reservoir spatial variability. This investigation could potentially provide significant improvements in predicting the conditional probability of a brine reservoir intercept within the WIPP site.

For example, Figure 6-1 shows there are relatively few boreholes within 10000 ft of the WIPP site with information about brine intercepts/no-intercepts. There are, however, numerous boreholes across the site with information about the geologic structure of the Salado and Rustler Formations. If a strong association between brine intercepts/no-intercepts and geological structure data can be determined, then we could use the cokriging approach to get better-constrained estimates of the conditional probability of a Castile brine reservoir intercept within the site than can be estimated using brine hit/miss data alone. Cokriging extends the kriging algorithms by conditioning prediction of a random field at unsampled locations (e.g., brine hit probability) on observations of the original and a second, related, random field (e.g., brine hits/misses and amount of deformation). It also assumes knowledge of the random fields' autocovariance and cross-covariance functions, which are typically estimated from sample semi-variograms and cross-semivariograms. Cokriging can only improve on a standard kriging algorithm when observation locations of the second random field are more numerous within the area of interest than those for the first random field. At the WIPP site, this would require a strong relationship between brine hits and structural information for units above the Castile Formation, such as Marker Bed 124, since there are many more different observation locations for these units than for units within the Castile across the WIPP site.

We have some doubts whether the cokriging approach will work for the specific case of brine intercepts/no-intercepts and structural data since the cross-covariance (or cross-semivariogram) for each lag only receives a positive contribution from pairs which include brine intercepts (see Eqns 7-1 and 7-2 below). This suggests that the estimated cross-covariance is then a function of the ratio of brine intercepts to brine no-intercepts. However, cokriging may still provide significant improvements in the conditional probability estimates from Section 6 because it, like standard kriging and unlike many other interpolation algorithms, honors the data exactly.

We focused on the thickness between the top of the Bell Canyon and the base of the Cowden, which immediately overlies the presumed location of the brine reservoirs within the Castile's uppermost anhydrite (Anhydrite III) and halite (Halite II) zones. Measurements of this thickness, called here the Cowden isopach of IsoCowden, were made using geophysical logs for 352 boreholes. The dataset differs slightly from that used for geostatistical analysis of brine reservoir intercepts (Section 6.0). We estimated the Cowden isopach for five brine intercept boreholes and several drillholes without intercepts using information from nearby boreholes (section 5.0; Appendix E). As before, the 352 wells are distributed across roughly 645 km^2 (252 mi^2) of Delaware Basin. The WIPP site is roughly centered within this area.

In addition to estimating the spatial variability of the Cowden isopach, we examined the spatial cross-correlation between the Cowden isopach and brine intercept/no-intercepts. The cross-covariance between two random fields, Y and Z, is described by $C_{Y(x),Z(x+h)}$, where E is the expectation operator, **x** is the location vector for an observation, and **h** is the distance between it and another observation:

$$C_{Y(\mathbf{x}),Z(\mathbf{x}+\mathbf{h})} = E\{[Y(\mathbf{x}) - E\{Y(\mathbf{x})\}][Z(\mathbf{x}+\mathbf{h}) - E\{Z(\mathbf{x}+\mathbf{h})\}]\} \qquad (Eqn.7-1)$$

The cross-semivariogram, $\gamma_C(\mathbf{h})$, is the variance of the difference between observations of two variables separated by a distance (or lag) **h**:

$$\gamma_C(\mathbf{h}) = \frac{Var\{Z(\mathbf{x}-\mathbf{h}) - Y(\mathbf{x})\}}{2} \qquad (Eqn.\ 7.2)$$

7.2 METHODS

7.2.1 Exploratory Data Analysis

We examined differences in Cowden isopach measurements for two categories: boreholes with brine intercepts and boreholes with brine no-intercepts. Descriptive statistics, such as sample mean, standard deviation, skewness, etc., and sample cumulative frequency distributions for the two categories were compared.

Descriptive statistics and sample cumulative frequency distributions of Cowden isopach measurements were calculated for boreholes with and without brine intercepts. Graphs and calculations were made using the Excel spreadsheet program, version 4, from Microsoft and MathSoft's MathCad 6.0+ mathematical analysis program.

7.2.2 Variography

We quantified Cowden isopach spatial correlation through calculation of sample semi-variograms. We tested our estimates for sensitivity to data clustering and extreme values (outliers) by computing sample semi-variograms for subsets of the data and by examining more robust measures such as the semi-rodogram, general relative semi-variogram, and non-ergodic covariance function (see Section 6.1). Values for the range, sill, and nugget variance are determined by fitting a theoretical semi-variogram model to the sample semi-variogram.

7.2.1.1 Sample Semi-Variogram Calculation

Sample semi-variograms are calculated according to Eqn. 6-4 for the isotropic (omni-directional) case and for a range of anisotropic geometric directions: azimuths 0, 20, 45, 70, 90, 110, 135, and 160 degrees measured clockwise from a 0 degree north. All variographic calculations were carried out using the VARIO module of the public domain software package UNCERT (Wingle et al, 1994), available from the Colorado School of Mines in Golden, CO.

Lag spacing was set at 1500 ft to match the lag spacings from the analysis of brine intercept/no-intercept spatial variability. The maximum search distance, directional bandwidth, and horizontal half-angle were set to their maximum values of 150000 ft, 150000 ft and 90 degrees for the isotropic sample semi-variogram. The data were sufficient in number to restrict the horizontal half-angle to 15 degrees, maximum search distance to 150000 ft, and the directional bandwidth to 10000 ft for all of the anisotropic sample semi-variograms.

Sample semi-variograms were judged significant if they exhibited a reasonably monotonic increasing structure within the first 25% of the lag classes with adequate numbers of pairs within each lag class. Theoretical semi-variogram model parameters (range, sill, and nugget variance) were estimated for selected sample semi-variograms.

7.2.1.2 Sample Semi-Variogram Robustness

We tested the Cowden isopach sample semi-variogram robustness to clustering using two different approaches. The first compares sample semi-variograms from the entire data set with those computed for two non-overlapping data subsets which have relatively uniform spatial distributions of boreholes and possess adequate numbers of brine reservoir intercepts. Subset 1 contains 80 boreholes, 15 of which had brine intercepts. Subset 2 holds 93 boreholes, 9 of which had evidence of brine intercepts. These two subsets possess both a relatively uniform distribution of boreholes and sufficient numbers of brine intercepts to generate adequate numbers of observation pairs for each lag. Correlation structures which appeared significant in each of the data subsets and in the complete data set were judged to be independent of the large scale data clustering evident in Figure 6-3.

The second approach utilizes alternative measures of spatial continuity which are less sensitive to data clustering. The semi-rodogram and general and pairwise relative semi-variograms are typically less vulnerable to clustering because they normalize the semi-variogram value for each lag class by the squared mean of the data and the squared average of the paired values; Eqn. 6-5 defines the semi-rodogram and Eqn. 7-3 defines the general relative semi-variogram. We calculated sample semi-rodograms, general relative semi-variograms, and non-ergodic covariances for each data subset, their union, and the entire data set.

$$\gamma_{GR}(\boldsymbol{h}) = \frac{Var\{Z(\boldsymbol{x}-\boldsymbol{h}) - Z(\boldsymbol{x})\}}{\left[\frac{m_t m_h}{2}\right]^2} \qquad (Eqn.\ 7\text{-}3)$$

where m_t and m_h are the means of the tails and heads of each pair within a lag.

7.2.1.3 Sample Cross-Semivariogram Estimation

We estimated the sample cross-semivariograms for the brine intercept/no-intercept and Cowden isopach using

$$\gamma_C(\boldsymbol{h}) = \frac{1}{2N(\boldsymbol{h})}\sum_{i=1}^{N(\boldsymbol{h})}(z_i - y_i)^2 \qquad (Eqn.\ 7\text{-}4)$$

Sample cross-semivariograms were determined for the union of Subsets 1 and 2 for the isotropic case and along the same eight sample semi-variogram directions. Calculations were made with the GAM2V routine from the GSLIB library (Deutsch and Journel, 1992) because the Sun OS version of UNCERT's VARIO module does not yet support cross-semivariogram estimation.

7.2.1.3 Theoretical Variogram Model Fitting

We estimated range, sill, and nugget variance using UNCERT's VARIOFIT module for only a few selected sample semi-variograms because of a time limitation and because we did not need to krige Cowden isopach values. We estimated ranges by eye for the remaining sample semi-variograms, assuming a spherical theoretical semi-variogram model, to enable quick comparison with the ranges estimated for the brine intercept/no-intercept variable.

7.3 RESULTS AND DISCUSSION

7.3.1 Exploratory Data Analysis

Table 7-1 summarizes the descriptive statistics for Cowden isopach categorized by whether a brine intercept was observed (or not) in the borehole. Note that the mean, minimum, and maximum for the brine hit group are all larger than those for the brine miss group. Isopach standard deviations relatively close (coefficient of variation is 10% for each group). The brine intercept group is skewed to larger isopach values and is significantly kurtic, i.e., its probability density function (histogram) is more flat than peaked. In contrast, the brine no-intercept group shows relatively little skewness and kurtosis.

Table 7-1
Summary Statistics for Cowden Isopach by Brine Intercept/No-Intercept

Statistic	Brine Intercepts	Brine No-Intercepts
Mean	1905.77	1760.16
Standard Error	37.49	9.99
Median	1891.00	1726.00
Mode	1925.00	1660.00
Standard Deviation	191.16	180.31
Variance	36541.94	32511.90
Kurtosis	5.97	-0.02
Skewness	2.01	0.55
Range	919	944
Minimum	1677	1373
Maximum	2596	2317
Sum	49550	573812
Count	26	326

Figure 7-1 presents the sample cumulative relative frequency distributions for the two groups. Figure 7-2 depicts sample histograms for each group. Comparison of the intercept and no-intercept curves suggests there is a minimum Cowden isopach value of 1650 to 1680 ft below which brine reservoirs are not observed.

We attempted to fit a Poisson distribution to the sample relative frequency distribution for the brine intercepts. Results are shown in Figure 7-3. If we can assume the Cowden isopach for brine intercepts is governed by a Poisson process, then it is highly unlikely that brine intercepts will be observed when the Cowden isopach is less than 1670 ft. We attempted to fit several other distributions but met with no success.

7.3.2 Variography

7.3.2.1 Sample Semi-Variogram Calculations

Figures 7-4ab and 7-5ab show the sample semi-variograms for the first and second data subsets, which occupy the same locations used in Section 6.2. Appendix J contains printouts of the calculation log files. The results are less clear-cut than those presented for the brine intercept/no-intercept binary variable in Section 6.3. Locally-varying trends in Cowden isopach values keep both isotropic and anisotropic sample semi-variograms from leveling out near the sill. See, for example, the sample semi-variograms for azimuths 0, 20, 45, and 70 degrees, as well as the isotropic case, for Subset 1 (Figures 7-4ab). These thickening-thinning trends can be seen in Figure 5.3-3, which depicts the top of Bell Canyon to base of Cowden isopach contours. Note the especially strong north-south trend in isopach value across the center of the map. The sample semi-variograms for azimuths 90, 100, and 135 degrees appear to be mostly noise. While some evidence for trends in the sample semi-variograms for Subset 2 can be observed (e.g., azimuths 0 and 45 degrees), it is not as common as in the Subset 1 results. This is most likely attributable to the lack of strong trends within that data set (see Figure 5.3-3).

The sample semi-variogram for azimuth 160 degrees suggests the presence of a nested correlation structure under both data subsets. The small-scale correlation length (range) appears to fall between 4000 and 5000 ft. The azimuth 0, 20, and 135 degree sample semi-variograms for Subset 2 and the 0 degree azimuth sample semi-variogram for Subset 1 also indicate such a small-scale correlation structure. The large-scale correlation length may reach its sill somewhere near 15000 ft; however, this large-scale structure may be an artifact of the small number of pairs found within those largest lags.

Figures 7-6ab present the sample semi-variograms for the complete data set.

Figure 7-1

Estimated Cumulative Relative Frequency Distributions of Cowden Isopach Values

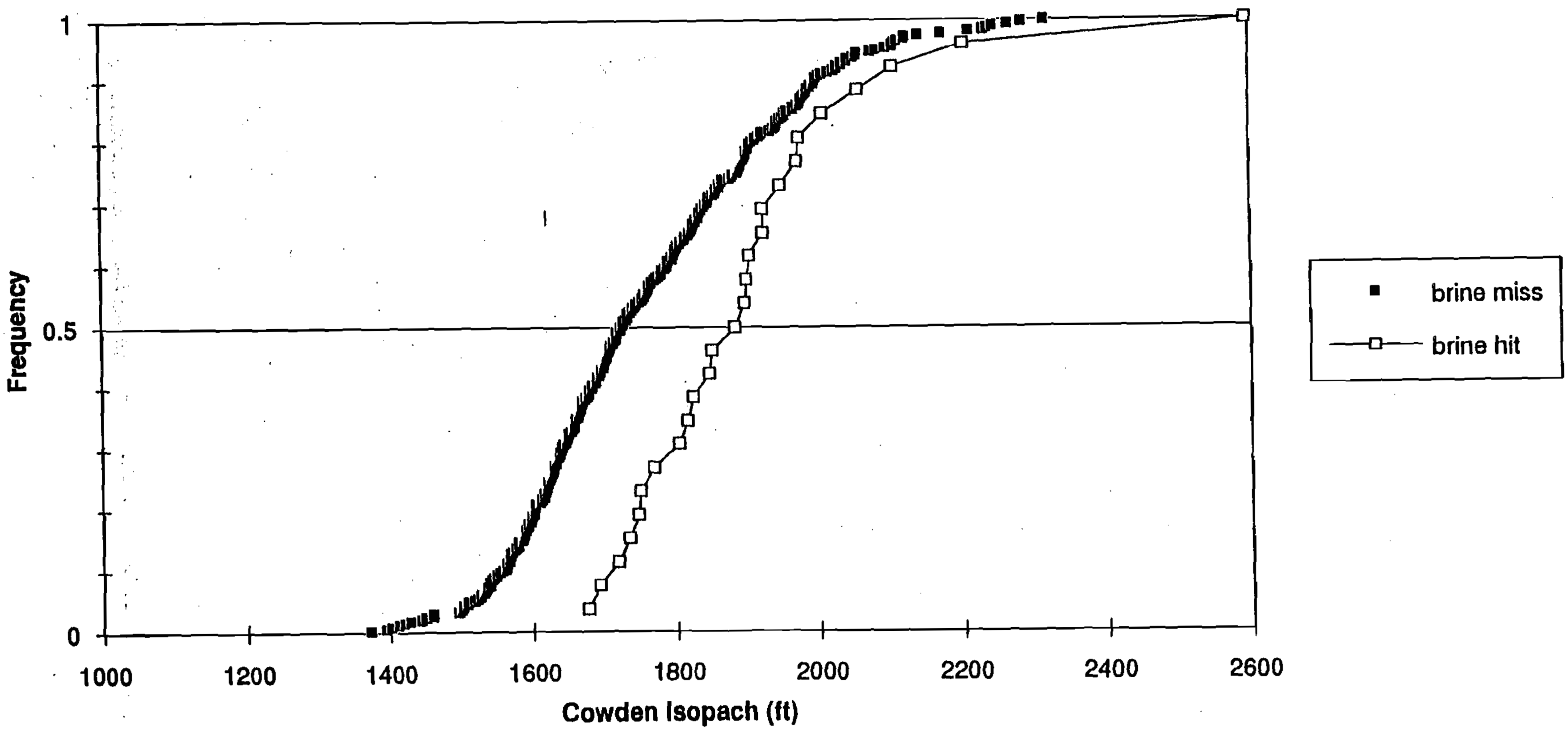


Figure 7-2

7/2/96

Sample Relative Frequency Distributions

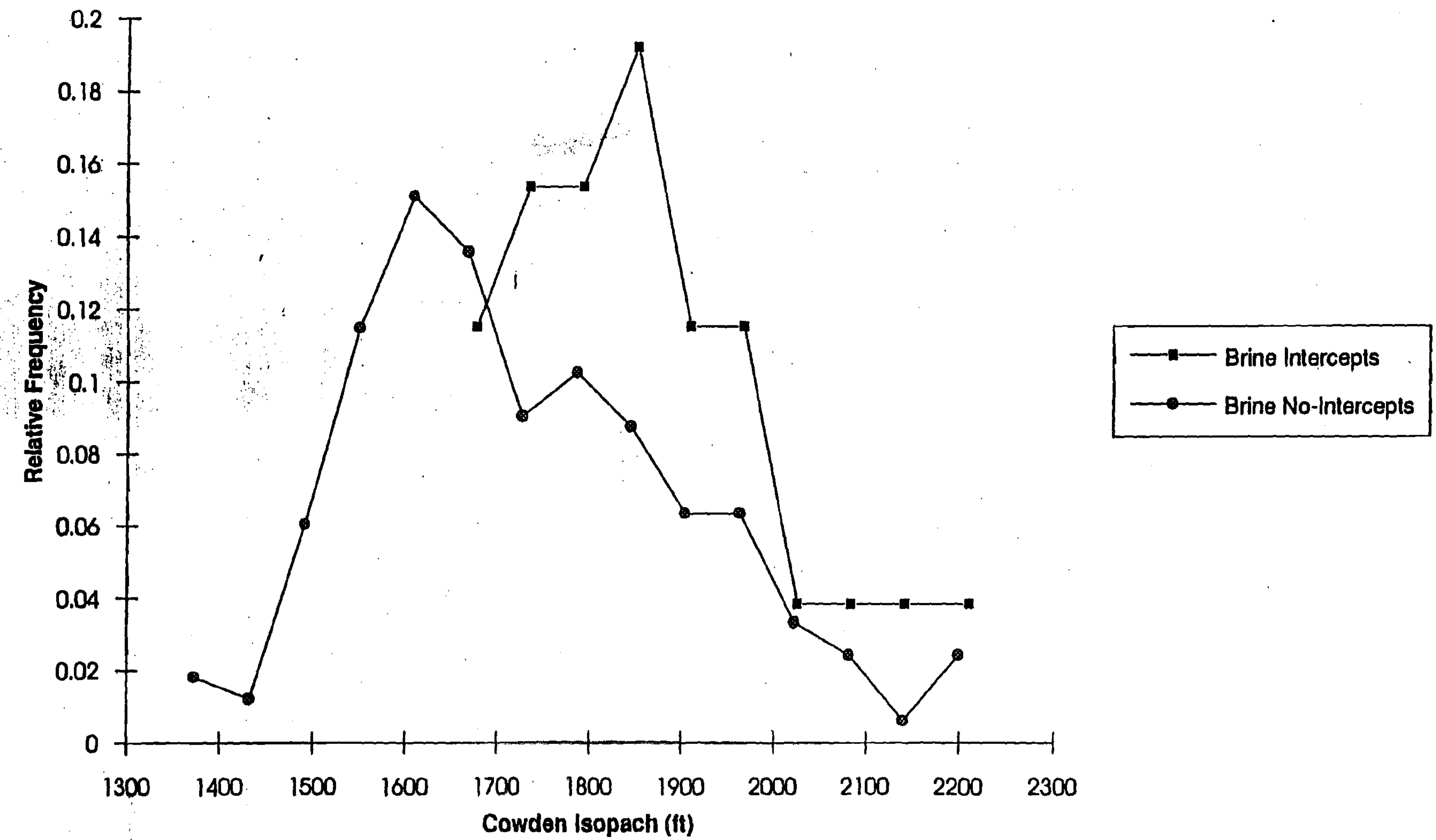


FIGURE 7-3

Estimated Cowden Isopach Probability Density Function (PDF) vs. Poisson PDF

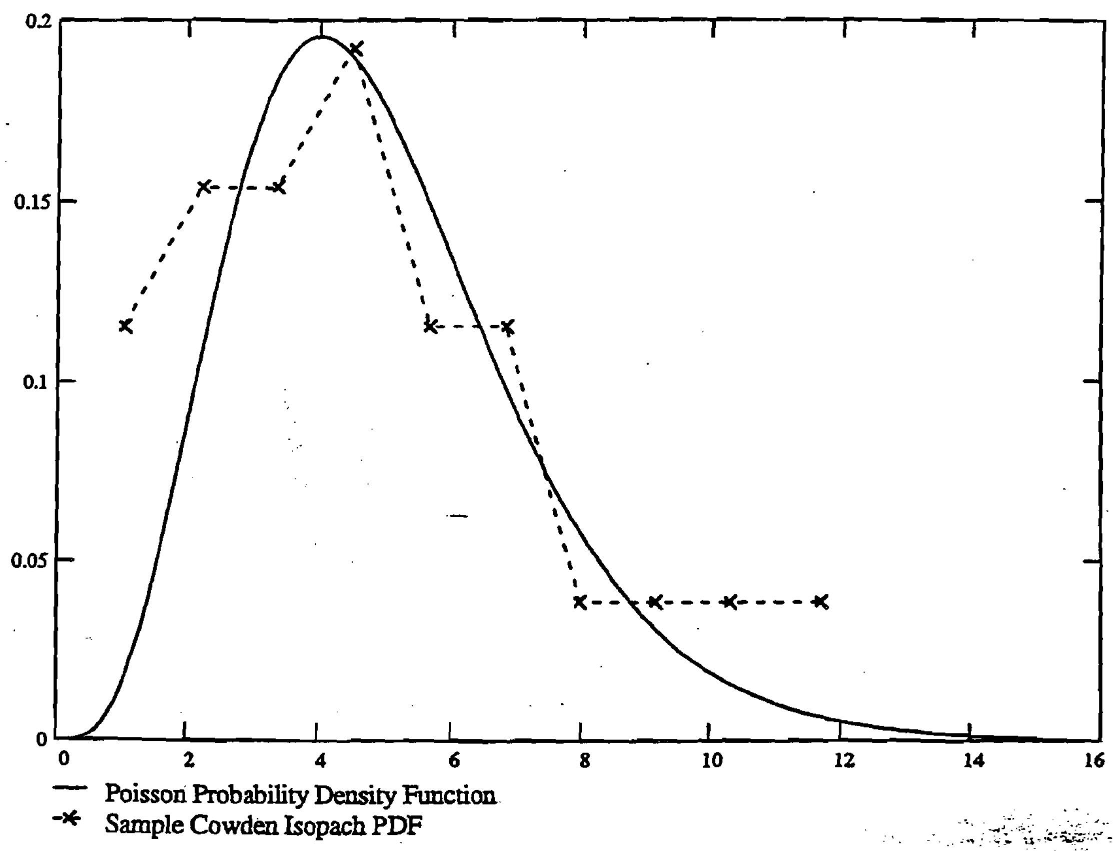
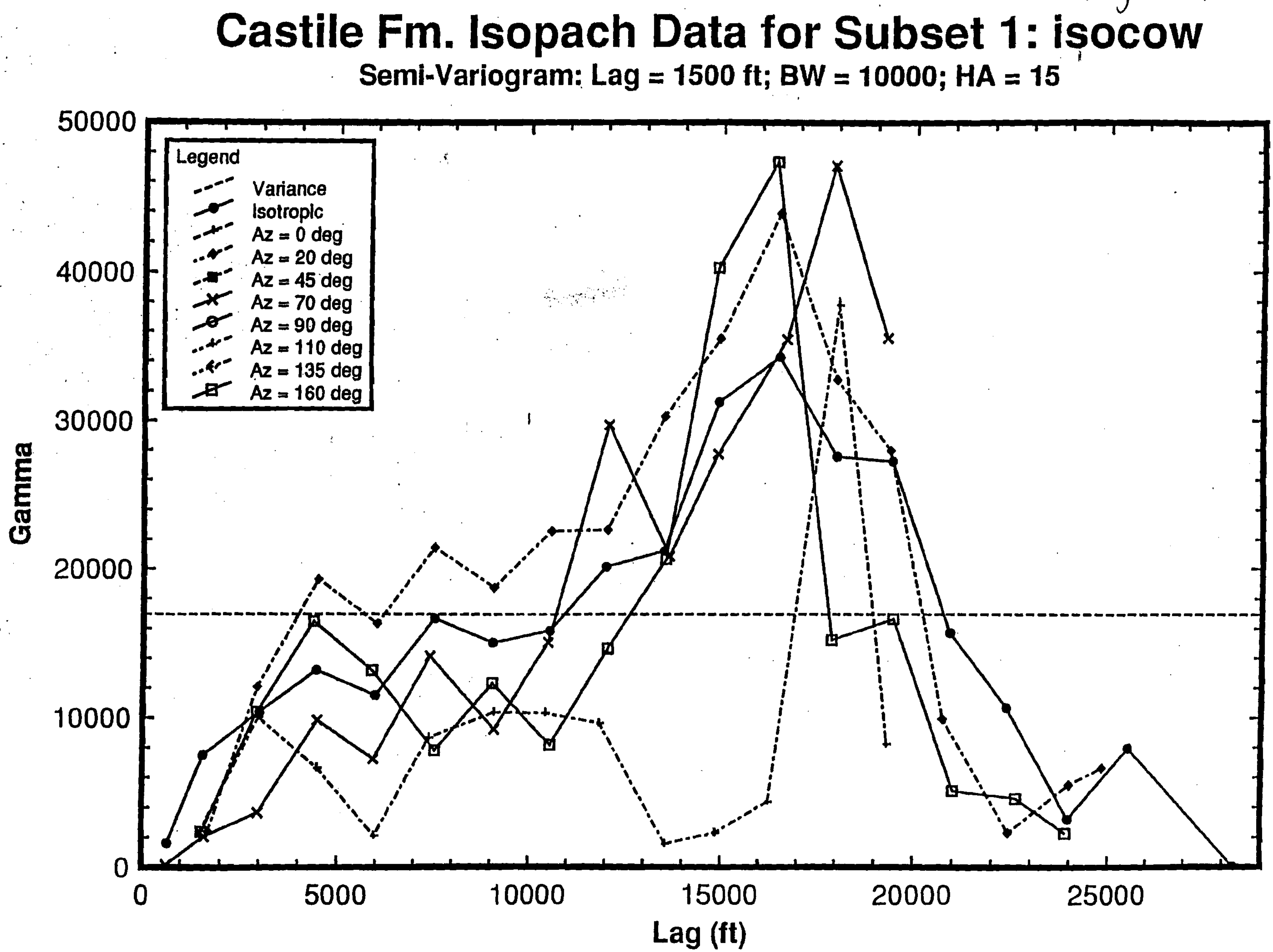


Figure 7-4a



Castile Fm. Isopach Data for Subset 1: isocow
Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg
Gamma
50000
40000
30000
20000
10000
0
0
5000
10000
15000
20000
25000
Lag (ft)

Figure 7-4b

Castile Fm. Isopach Data for Subset 1: isocow

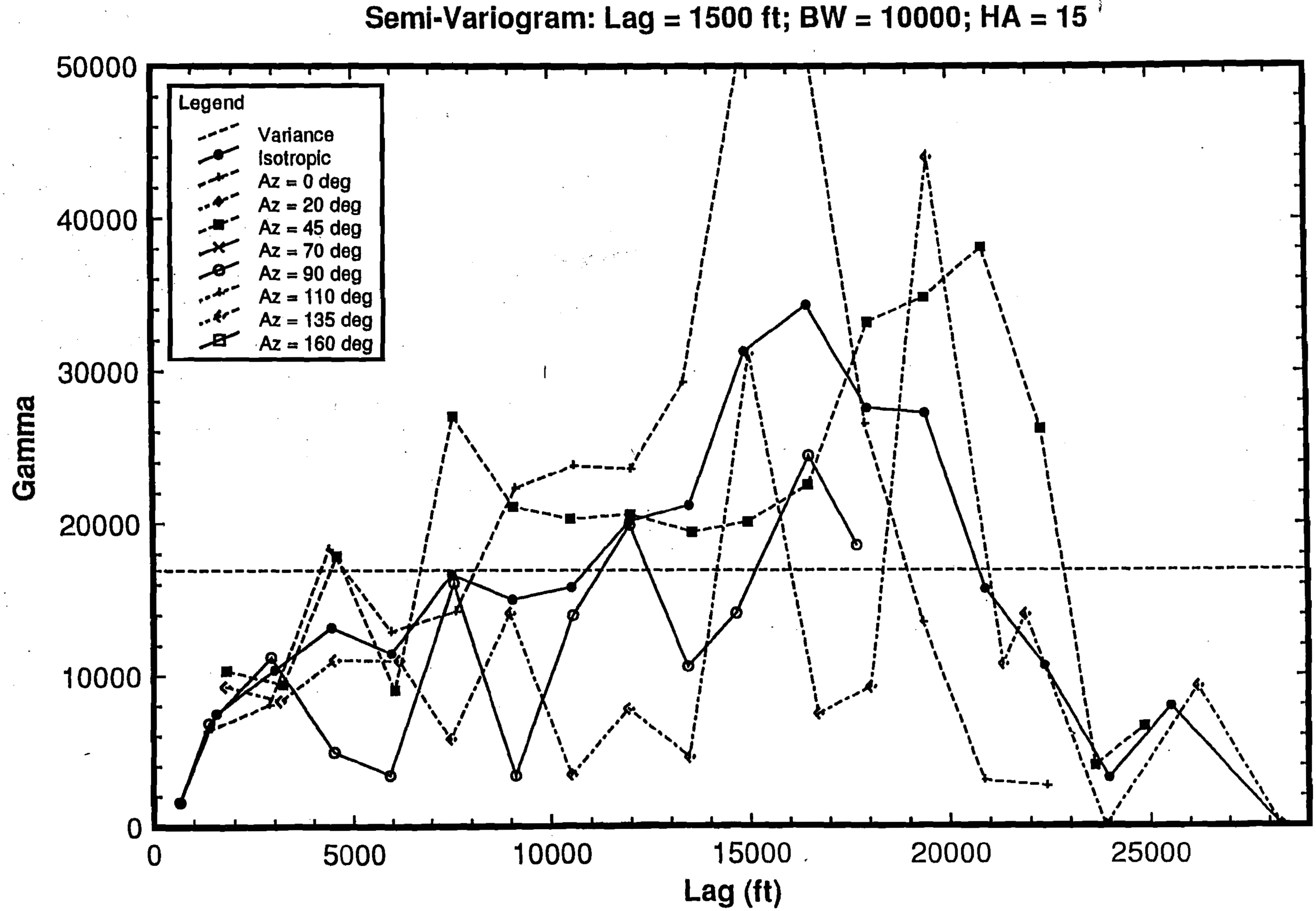
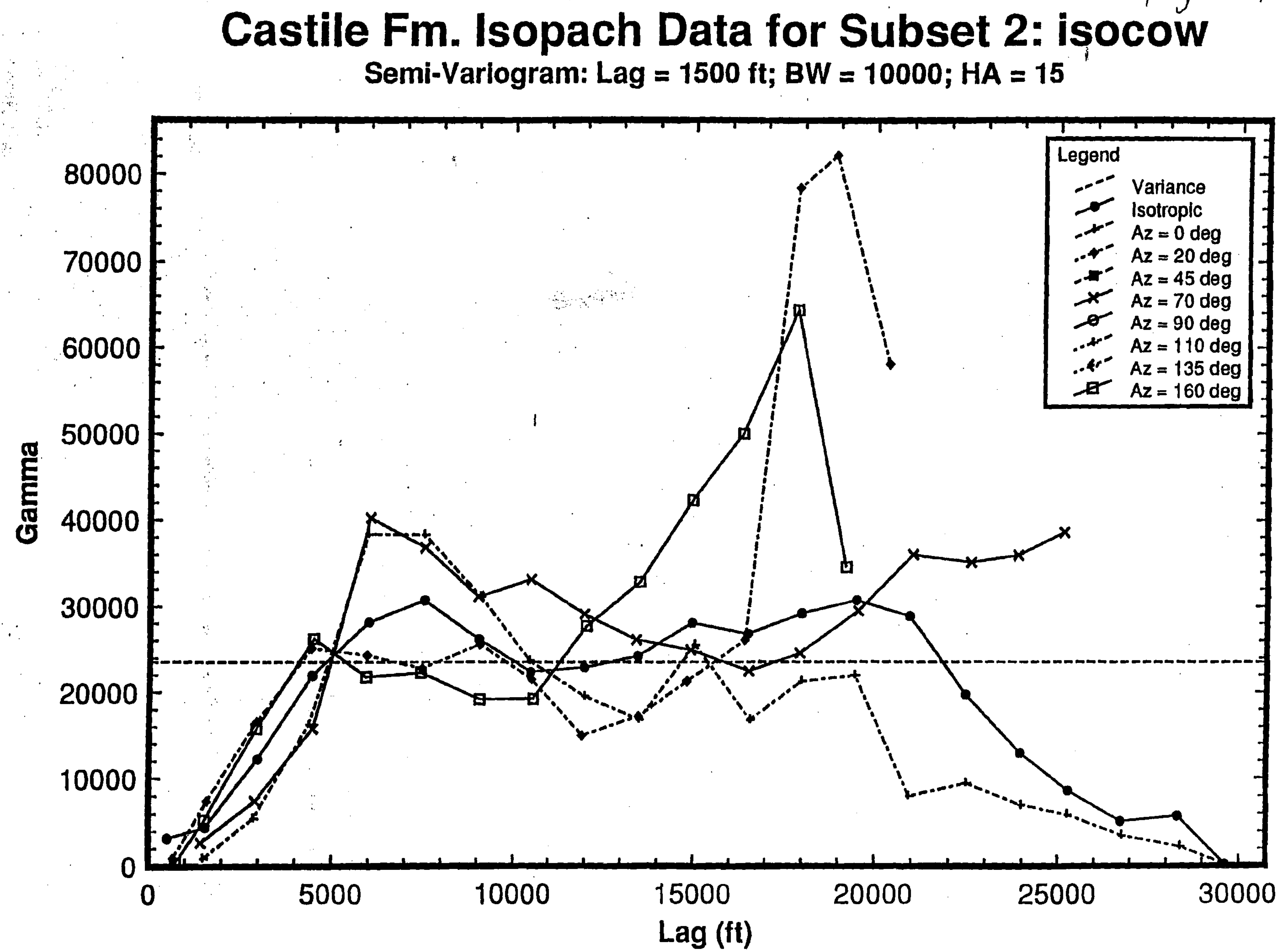


Figure 7-5a



Castile Fm. Isopach Data for Subset 2: isocow
Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Gamma
Lag (ft)
0
5000
10000
15000
20000
25000
30000
10000
20000
30000
40000
50000
60000
70000
80000
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg

Figure 7-5b

Castile Fm. Isopach Data for Subset 2: isocow

Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15

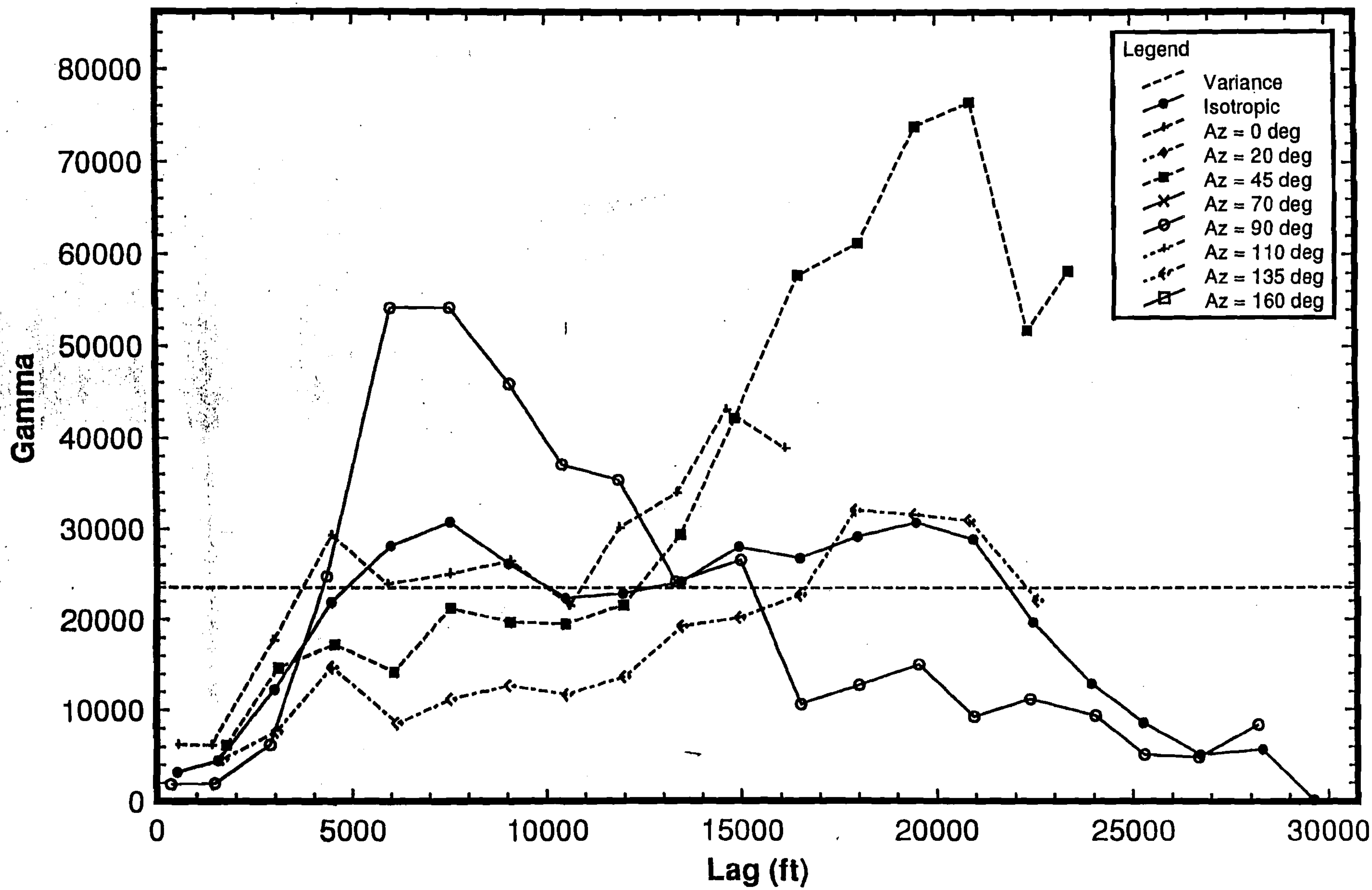


Figure 7-6a

Castile Fm. Isopach Data: icowr3

Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15

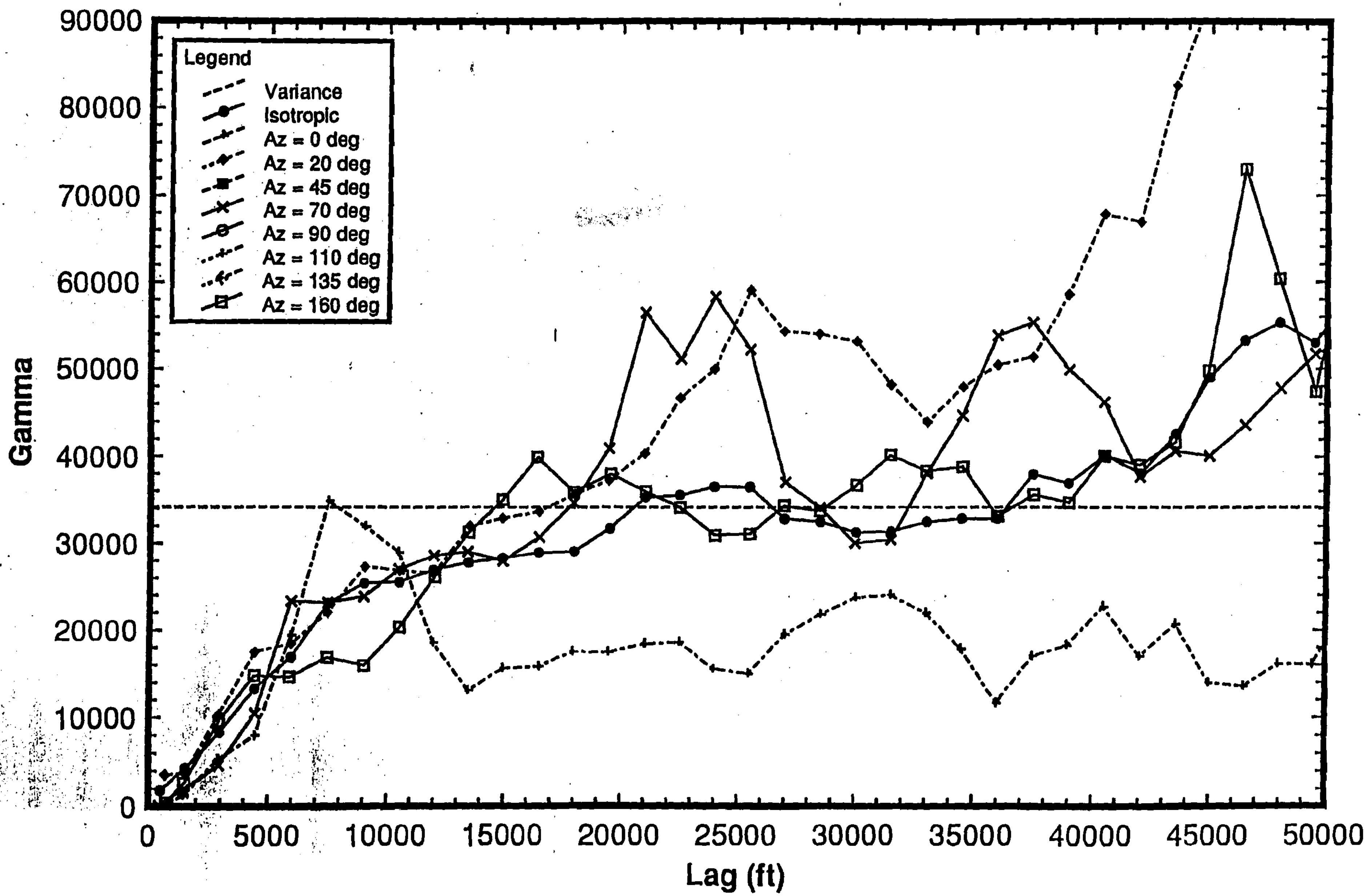
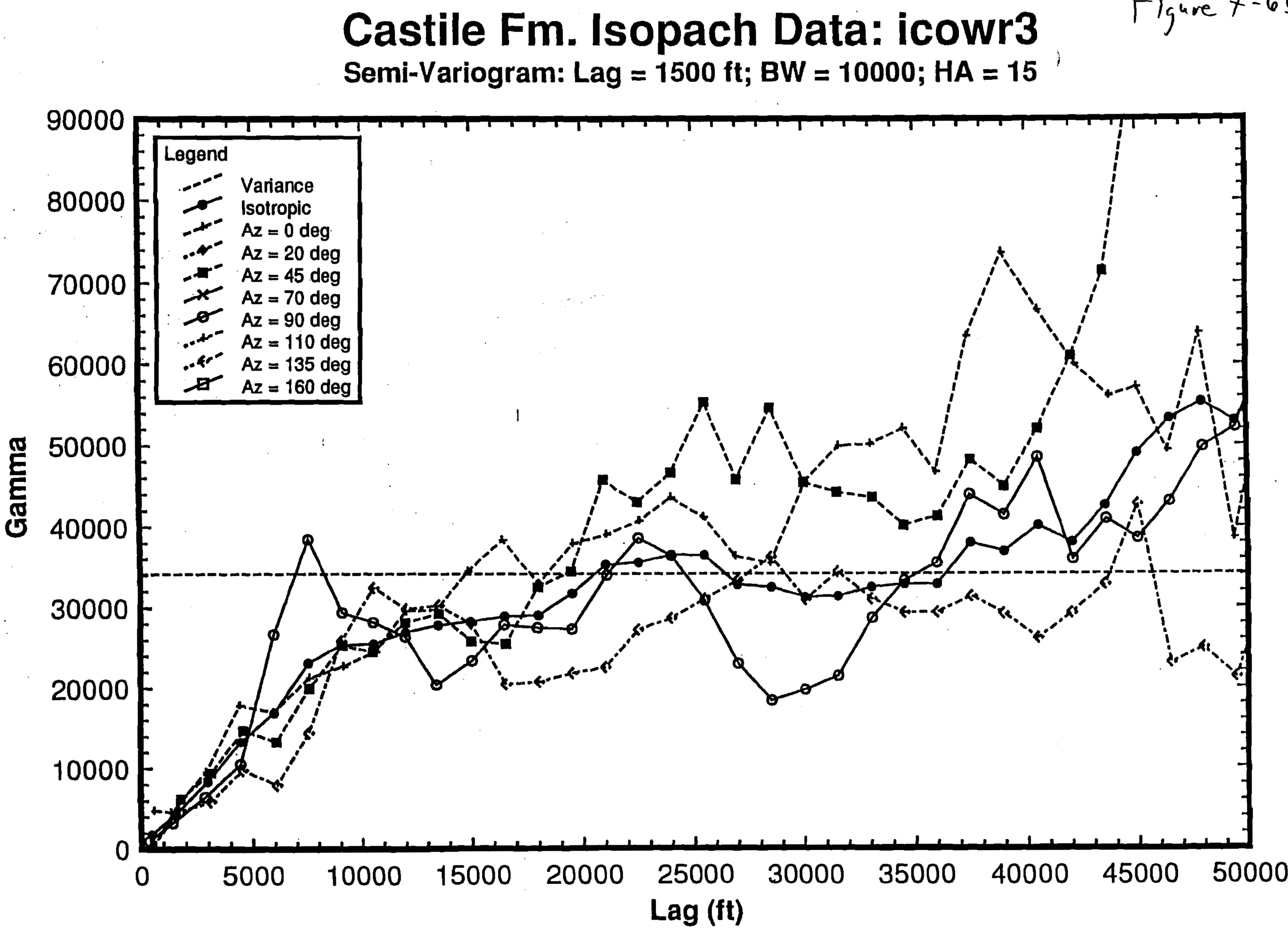


Figure 7-6b



Castile Fm. Isopach Data: icowr3
Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg
Gamma
Lag (ft)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
5000
15000
25000
35000
45000

Figure 7-7a

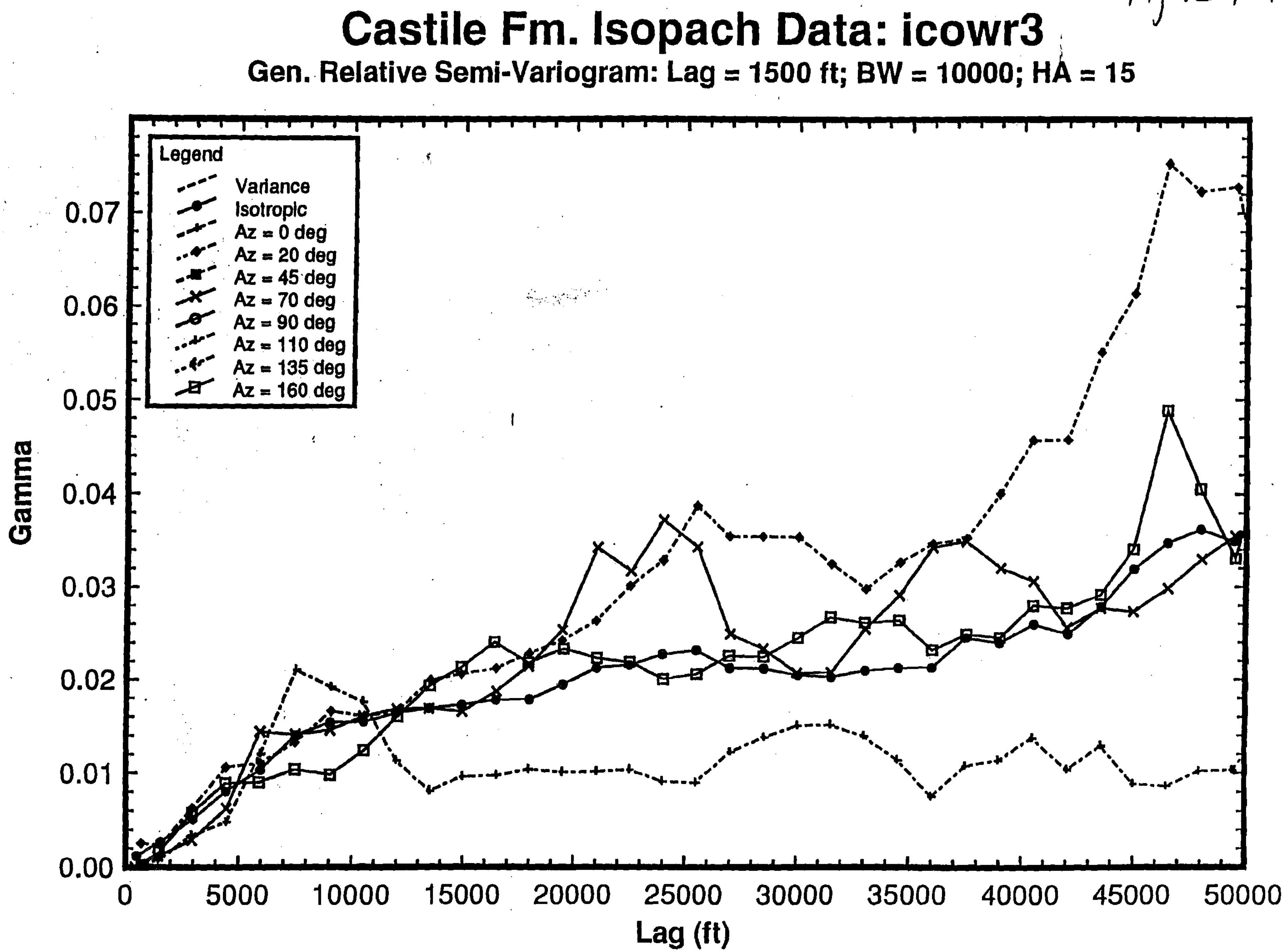
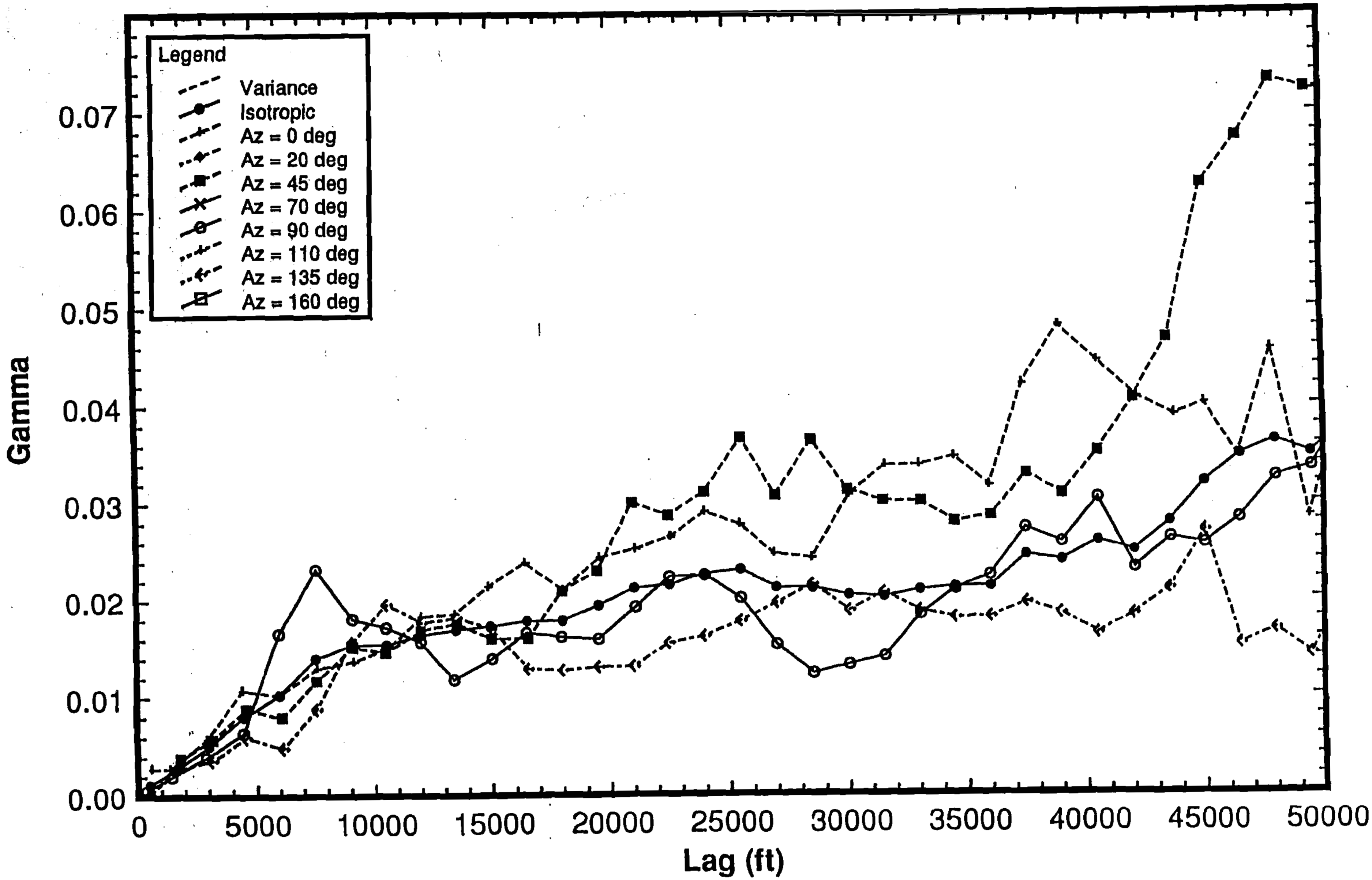

Castile Fm. Isopach Data: icowr3
Gen. Relative Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15
Legend
Variance
Isotropic
Az = 0 deg
Az = 20 deg
Az = 45 deg
Az = 70 deg
Az = 90 deg
Az = 110 deg
Az = 135 deg
Az = 160 deg
Gamma
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Lag (ft)

Figure 7-7b

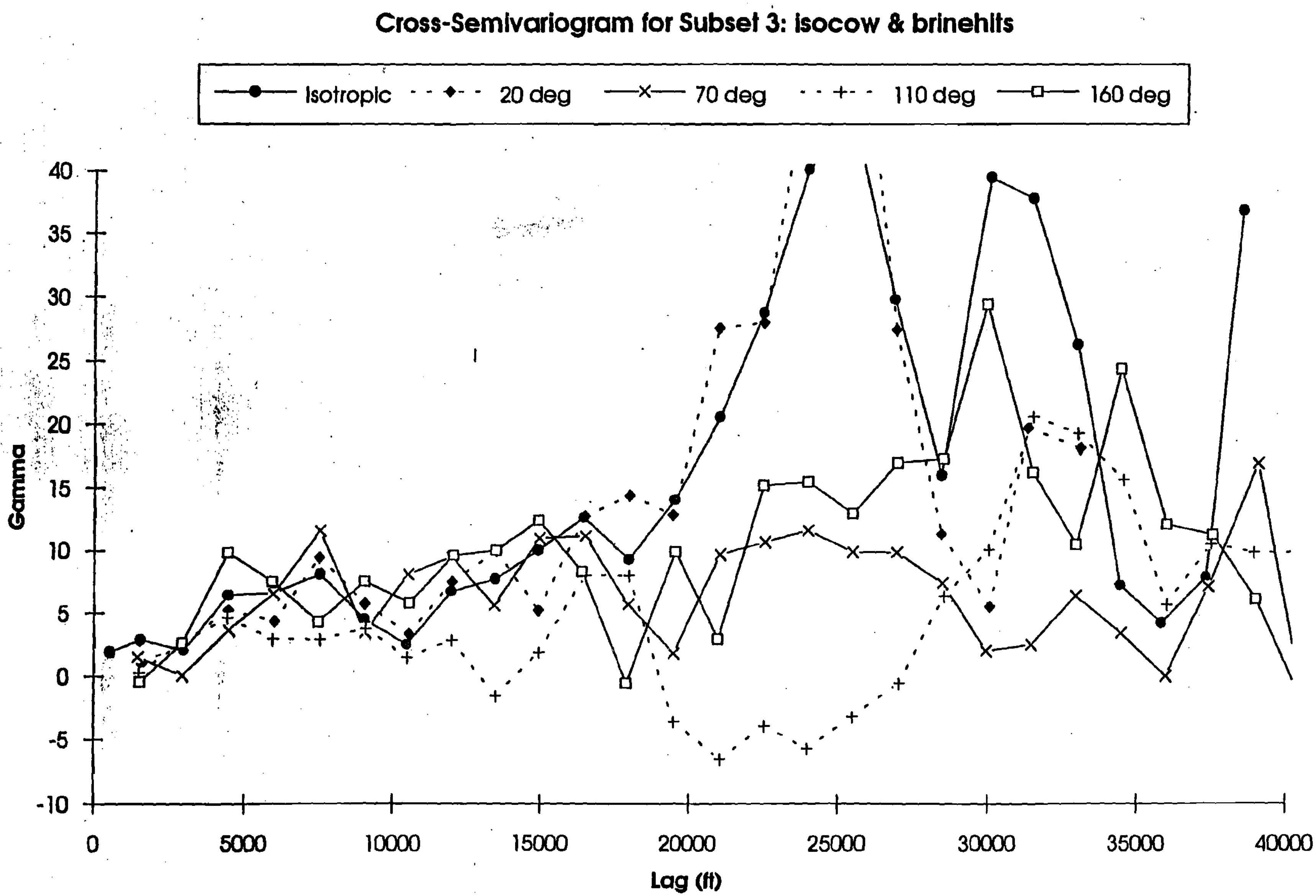
Castile Fm. Isopach Data: icowr3

Gen. Relative Semi-Variogram: Lag = 1500 ft; BW = 10000; HA = 15



7/2/96

Figure 7-8a



7/2/96

Figure 7-8b

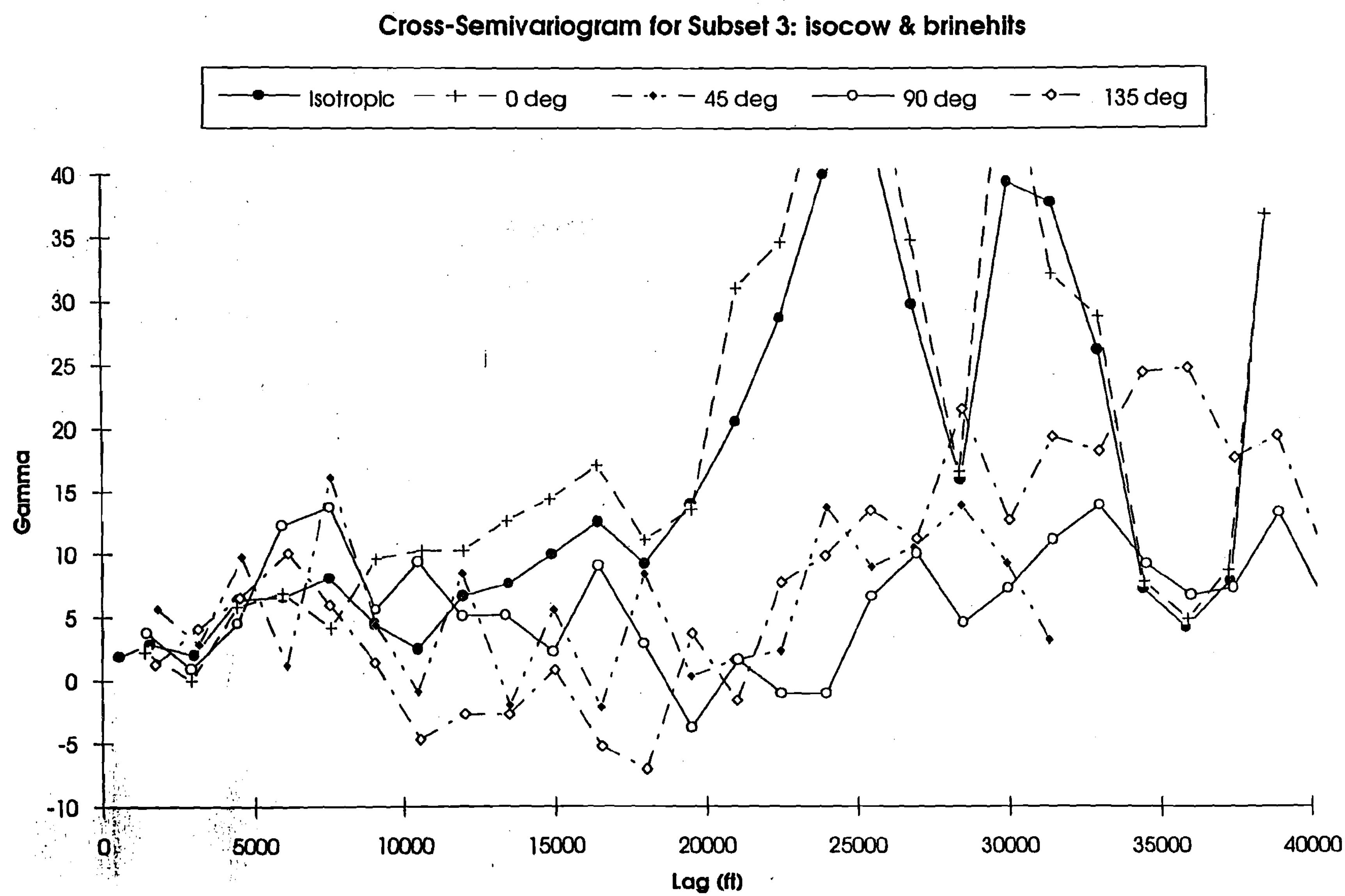
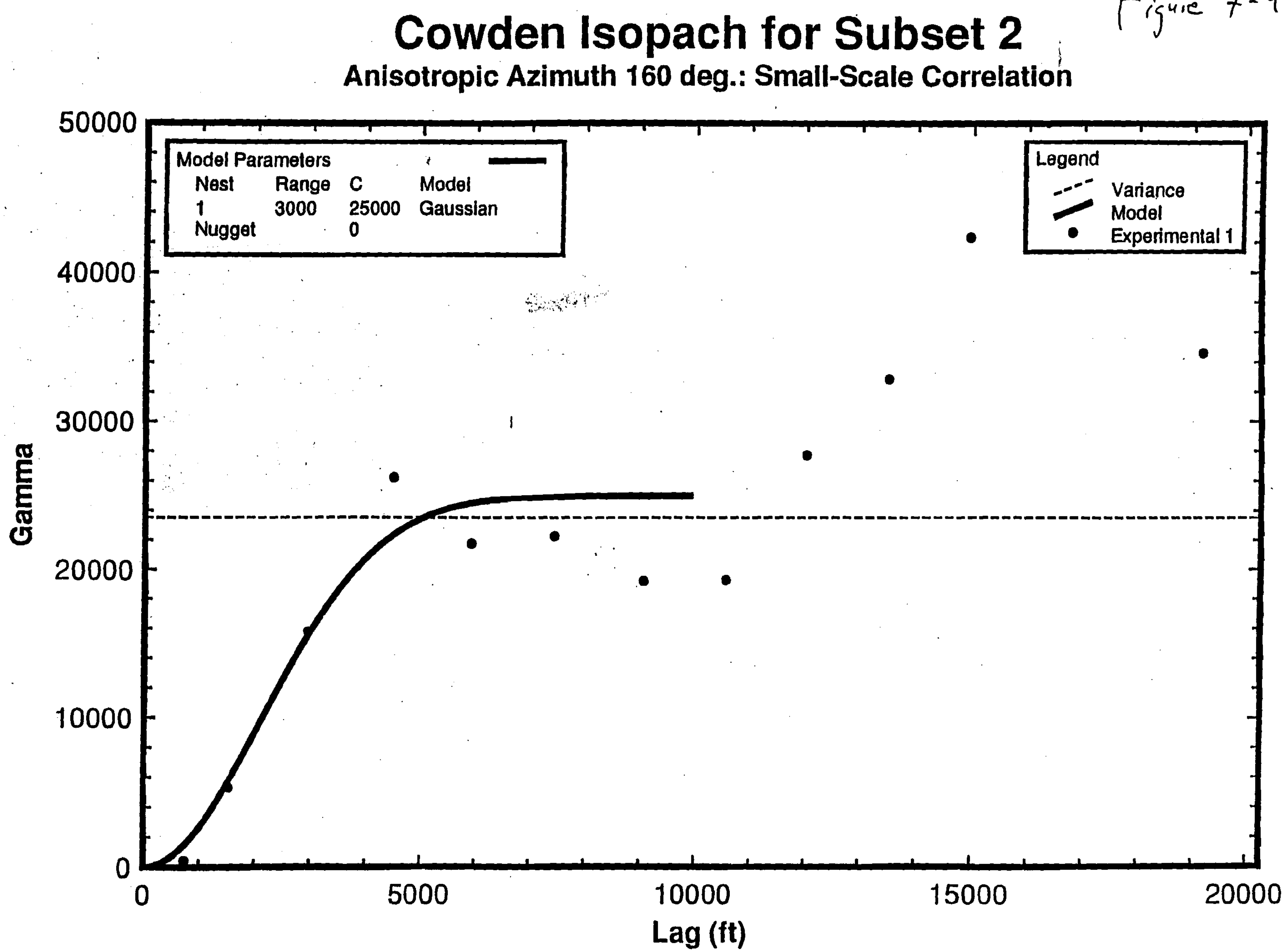


Figure 7-9a

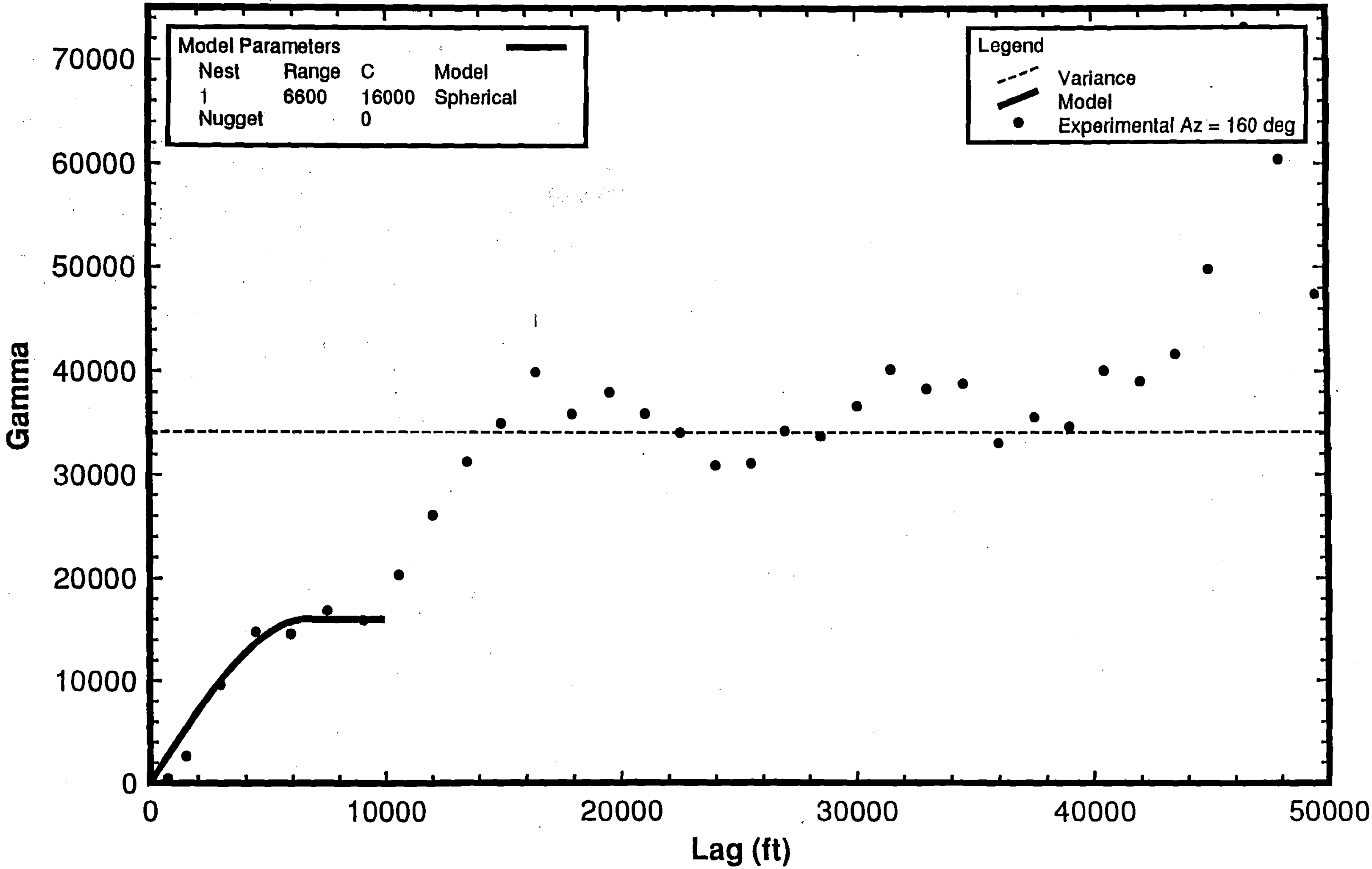


Cowden Isopach for Subset 2
Anisotropic Azimuth 160 deg.: Small-Scale Correlation
Model Parameters
Nest Range C Model
1 3000 25000 Gaussian
Nugget 0
Legend
Variance
Model
Experimental 1
Gamma
Lag (ft)
50000
40000
30000
20000
10000
0
5000
10000
15000
20000

Figure 7-9b

Cowden Isopach: icowr3

Anisotropic Azimuth 160 deg.: Small-Scale Correlation



Trends in isopach values are evident in the isotropic and azimuth 0, 20, 45, and 70 degree anisotropic sample semi-variograms. Small-scale correlation structures with effective ranges varying between 5000 and 6000 ft are shown most clearly in the azimuth 160, 135, and 70 degree sample semi-variograms. The 0, 20, and 45 degree directional semi-variograms also appear to possess this small-scale structure. Additional analyses indicated that the small-scale correlation features similar to that found in the azimuth 135 and 160 degree directions were observable along azimuths 140, 145, 150, and 155 degrees for the complete data set. This observation is by the orientation of the Cowden isopach maximum shown in Figure 5.3-3, which varies between azimuths 135 and 160 degrees.

Figures 7-6ab also demonstrate a significant large-scale correlation structure which has an effective range between roughly 10000 ft (for azimuth 135 deg.) and 18000 to 20000 ft (azimuths 70 and 160 deg.). The distance separating Subset 1 from Subset 2 closely corresponds to the upper end of the range estimate, possibly indicating the sample semi-variogram values are controlled by data clustering. However, the large-scale correlation structure is observable in the sample general relative semi-variograms for the same directions (see Figures 7-7ab), suggesting that data clustering is not the cause. Plots of the non-ergodic covariance and the semi-rodograms add support to this conclusion. The remaining directional sample semi-variograms demonstrate more trend effects than large-scale spatial correlation at larger lags.

7.3.2.2 Sample Cross-Semivariogram Calculation

Figures 7-8ab show the estimated cross-semivariograms for a combination of data Subsets 1 and 2. As above, there is consistent evidence for a small-scale correlation structure with an effective range of 5000 to 9000 ft (azimuths 0, 20, 70, 135, and 160 deg.). Several of the directional sample cross-semivariograms indicate the possibility of a large-scale correlation structure with an effective range of roughly 20000 ft. Although we have doubts about the impact of computing a cross-semivariogram using a binary variable, these results are consistent with the correlation structures observed along the azimuth 160 degree sample semi-variograms.

If there is a minimum Cowden isopach thickness for brine reservoirs and if the observed minimum is close to the actual threshold, it may be possible to define an indicator variable for the threshold Cowden isopach and then cokrige the brine intercept/no-intercept binary variable with the indicator variable.

7.3.2.3 Theoretical Semi-Variogram Model Fitting

Figures 7-9ab show the fitted theoretical variograms for the small-scale correlation structures observed in the azimuth 160 deg. sample semi-variograms for all data and for Subset 2. We fit a Gaussian model to the latter sample semi-variogram with an effective range of $\sqrt{3}$ x 3000 ft = 5200 ft (Figure 7-9a). The small-scale feature for the complete data set was fitted with a spherical model and an effective range of 6600 ft (Figure 7-9b). These range values matched those estimated by eye for the small-scale correlation structure observed in the other sample semi-variograms. We focused solely on estimating effective ranges because we had no need of kriging the Cowden isopach variable.

7.4 SUMMARY

- The Bell Canyon to base of Cowden thickness (Cowden isopach) shows significant spatial correlation along several directions. Several directions demonstrate both small and large scale correlation structures.
- The observed large-scale spatial correlation had an effective range on the order of 10000 to 20000 ft.
- Small-scale spatial correlation, with effective ranges between 5000 and 7000 ft, was observed in the azimuth 160, 70, and 135 degree directions.
- The most consistent, significant correlation occurs in a range of azimuths from 135 to 160 degrees counterclockwise from north. These correlation structure does not appear to significantly influenced by data clustering and are consistent with the direction and correlation lengths observed for the brine intercept/no-intercept binary variable analyzed in Section 6.0
- Sample cross-semivariograms also appear to share the same small-scale correlation structure observed in the azimuth 160 degree sample semi-variograms.
- The geostatistical analysis results for the Cowden isopach are consistent with those for brine intercept/no-intercept.
- There may be a threshold Cowden isopach value, roughly 1670 ft, below which brine reservoirs do not occur.

8.0 INTEGRATION AND CONCLUSIONS

The geological information clearly outlines the area where evaporites have been greatly deformed to the northeast of the WIPP. Both structure contour and isopach data also give indications for certain horizons and intervals that areas at WIPP 12 and the Hudson Belco well differ from the surrounding areas. Drillholes east of the WIPP site differ structurally from regional trends as well, but are less deformed than the maximum for our study areas. The geological information strongly suggest that brine encounters are related to deformation of Castile evaporites.

The geostatistical analysis of brine intercepts alone demonstrates there is a directional anisotropy for brine reservoir intercepts along an azimuth of 160 degrees. This direction is in general agreement with the orientation of the major structures revealed by geological analysis. Further analysis of the spatial correlation of thickness data shows similar anisotropy, and is consistent with an association between the structural deformation of the upper anhydrite zones and the presence of brine reservoirs within the Castile Formation. Analysis of one interval shows also that known brine occurrences are in areas where the interval is thicker than estimated for the WIPP site; there may be a threshold thickness related to degree of deformation. Further analysis of this approach is warranted before concluding that this kind of information limits the probability of brine encounters under the WIPP site.

Two models of spatial correlation for brine encounters were observed: one isotropic with a range of 2500 ft and one anisotropic with a longer range of 5700 ft. We recommend conditional probabilities of encountering a brine reservoir intercept be estimated using the anisotropic model because it yields the larger estimate, though differences are small. Using the anisotropic model, the area-weighted average of estimated conditional probabilities at computational nodes located over the waste panel is 0.08.

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Appendix A

Background for Borehole Location Data

Westinghouse Electric Corporation

Westinghouse
Electric Corporation

Government and Environmental
Services Company

WS:96:03002
DA:96:13041

Waste Isolation Division

Box 2078
Carlsbad New Mexico 88221

July 18, 1996

Ms. Margaret Chu
WIPP Deputy Project Management and Technical Integration Department
Sandia National Laboratories
P.O. Box 5800
Department 6801 MS-1335
Albuquerque, NM 87185

Subject: PROBABILITY OF INTERCEPTING A PRESSURIZED BRINE RESERVOIR UNDER THE WIPP SITE

Dear Ms. Chu:

Per your request, please find attached two data files to aid your research of brine reservoir occurrences in the area of the WIPP. The information was derived from our Delaware Basin Drilling Studies which will ultimately be included in appendix DEL of the CCA. The first file consists of drillhole locations from oil and gas exploration in the Delaware Basin (inside the Capitan Reef) from T.21-23S., R.29-33E. The second file consists of a set of locations for the underground (in State Plane coordinates) that you will need for the final geostatistical analysis being conducted in support of the WIPP Performance Assessment (PA). This set of locations includes the following:

a) the corners of the disposal area,
b) the corners of the area outlining the shafts and access area, and
c) the corners of the rectangular area outlining the experimental area and access to it.

Attached is the request for this data, information documenting the quality of the data, along with some additional supporting documentation. This information should be included in relevant PA data packages and records, as required.

If you have any further questions, please contact Mr. David Hughes of my staff at Extension 8175.

Sincerely,

R. J. Leonard, Manager
Compliance and Permitting

DH:hmp

Attachments

cc: Dennis Powers

Dennis W. Powers, Ph. D.
Consulting Geologist

July 15, 1996

FAX: (505) 234-8854

David Hughes
Westinghouse Compliance
WIPP Project
P.O. Box 2078
Carlsbad, NM 88221

Dear Dave:

On June 13, you forwarded to Mel Marietta (SNL) documentation of the background for drillhole location data analyzed as part of our geostatistics study of brine reservoirs in the northern Delaware Basin. Unfortunately, the documentation has fallen through the cracks somewhere between the time you sent it out and arriving in Albuquerque to be held for the report we were preparing.

Would you please recreate the documentation and forward it to:

Margaret Chu
Department 6801 MS 1335
WIPP Deputy Project Management and
Technical Integration Department
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

It will be Appendix A of our report "Probability of Intercepting a Pressurized Brine Reservoir Under the WIPP Site".

I would also appreciate a copy of the same documentation, if it's not too much trouble.

I apologize for not being able to track down the documentation, and I appreciate your willingness to recreate it for the report.

Sincerely,

(sent from computer)
Dennis W. Powers

US Postal Service: HC 12 Box 87, Anthony, TX 79821 Telephone: (915) 877-3929

WS:96:03001
DA:96:13035

Westinghouse Electric Corporation

Government and Environmental Services Company

Waste Isolation Division

Box 2078
Carlsbad New Mexico 88221

June 13, 1996

Mr. Mel Marietta, Manager
WIPP Project Compliance Department
Sandia National Laboratories
115 N. Main Street
Carlsbad, NM 88220

Subject: GEOSTATISTICAL ANALYSIS OF BRINE RESERVOIR OCCURRENCES IN THE AREA OF WIPP FOR WIPP PERFORMANCE ASSESSMENT (PA)

Dear Mr. Marietta:

Per your request, please fine attached two data files to aid your research of brine reservoir occurrences in the area of WIPP. The information was derived from our Delaware Basin Drilling Studies and will ultimately be included as an appendix to the Compliance Certification Application. The first file consists of drillhole locations from oil and gas exploration in the Delaware Basin (inside the Capitan Reef) from T.21-23S., R.29-33E. The second file consists of a set of locations for the underground (in State Plane coordinates) that you will need for the final geostatistical analysis being conducted in support WIPP PA:

a) the corners of the disposal area,
b) the corners of the area outlining the shafts and access area, and
c) the corners of the rectangular area outlining the experimental area and access to it.

Attached is the request for this data and pedigree for the source of the data along with some supporting documentation. This information should be included in relevant PA data packages and records, as required.

Should you have any question, please contact David Hughes of my staff at (505) 234-8175.

Sincerely,

R. J. Leonard, Manager
Compliance and Permitting

DLH:kds

Attachments

DATA RECORD PACKAGE FOR DRAWINGS SUPPLIED TO DENNIS POWERS USED IN THE GEOSTATISTICAL ANALYSIS OF BRINE RESERVOIR OCCURRENCES IN THE AREA OF WIPP FOR WIPP PERFORMANCE ASSESSMENT (PA).

POWERS.DWG

The software used to create the Powers map (see attached map) was AUTOCAD®, Release 11. This software package is currently being used by this user for several projects, including the making of maps and is recognized as an industry standard for this type of project.

The background information was purchased from Sylvan Ascent, Inc., P.O. Box 4792, Santa Fe, New Mexico 87502. The information on the maps of New Mexico and West Texas was derived from the U.S. census Bureau's TIGER/Line data, U.S. Geological Survey 3 Arc Second Digital Elevation Model (DEM) data, and USGS Geographical Names Information System (GNIS) data. This data was converted to DWG files and state plane coordinate systems for easy use in AutoCAD software. Map accuracy for the data varies for the different features, and for different geographical areas. Each type corresponds to National Map Accuracy standards for the original data from the US government. The State Plane Coordinate systems used in these maps were based on the North American Datum of 1927.

One electronic file was purchased, active.dxf (Drawing Interchange File),which consisted of all oil and gas well locations for southeastern New Mexico and west Texas, primarily that of the Delaware Basin. DXF files are standard ASCII text files. They can easily be translated to the formats of other CAD systems or submitted to other programs for specialized analysis. This file was purchased from Petroleum Information Corporation of Denver, Colorado and consisted of points and five-digit numbers for the hydrocarbon holes. The five-digit number was part of the API number associated with each hydrocarbon well and allowed for further information to be retrieved from PI's database utilizing that number. The DXF file was imported into AutoCAD and saved as a drawing. This drawing was then inserted into a map consisting of the information purchased from Sylvan Ascent. The oil well location drawing was scaled up and rotated to fit the state plane coordinates of the two dry holes located in the WIPP Site boundary. Symbology representing the different types of oil wells were inserted at the point location for each well.

The land grid data was purchased from Whitestar Corp, 333 West Hampden Avenue, Suite 604, Englewood, Colorado 80110 and consisted of the township, range, blocks, and section lines for Eddy and Lea Counties in New Mexico and seven counties in West Texas. This data was in a AutoCAD drawing file format. This drawing was inserted into the master map drawing at the proper state plane coordinates for Jeff Davis County in west Texas.

The next step in the process to create Powers.dwg was to Wblock (a command within AutoCAD that allows the user to write all or part of a drawing out to a new drawing file) the area desired.

The new drawing was given the name of Powers.dwg. The material that was not needed was erased, leaving only the desired material which consisted of the land grid, the symbol and location for each hydrocarbon hole, and the API number associated for each well. To properly locate the drawing to the state plane coordinate system, the state plane coordinates for the northeast corner of Sec. 15, Township 22 South, Range 31 East were looked up in the U.S.G.S. table located in SAND88-1065. The drawing was moved to that location and verified that the northeast corner of Sec. 15 was at the proper state plane coordinate.

A lisp routine (see attached) was written to extract the five-digit API number for the hydrocarbon holes and the x-y location of each number in the drawing. The x-y location is the same as state plane coordinates. The API number and x-y location was written to a file called dennis.txt (see attached).

The x-y locations as translated into state plane coordinates are as accurate as the information obtained from Petroleum Information and no claim is made as to the exactness of the locations. All hydrocarbon holes are reported in feet from line for the location of the hole and not in state plane coordinates.

POWERS1.DWG

WID Engineering drawing 1XMINE is maintained as an overlay for other engineering drawings that depict the underground conditions. This drawing (see attached) was inserted into Powers.dwg and all extraneous information was erased. The reason for using Powers.dwg was that it was already set up for state plane coordinates. The locations (in state plane coordinates) of the four shafts, exhaust, waste handling, salt handling, and air intake were taken from the tables in SAND95xxxx, Condensed Listing of Surface Boreholes at the Waste Isolation Pilot Plant Project through June 30, 1995. The drawing was moved to these locations and verified that the center of each shaft matched the location of that given in the above report. It was renamed to Powers1.dwg to distinguish it from Powers.dwg.

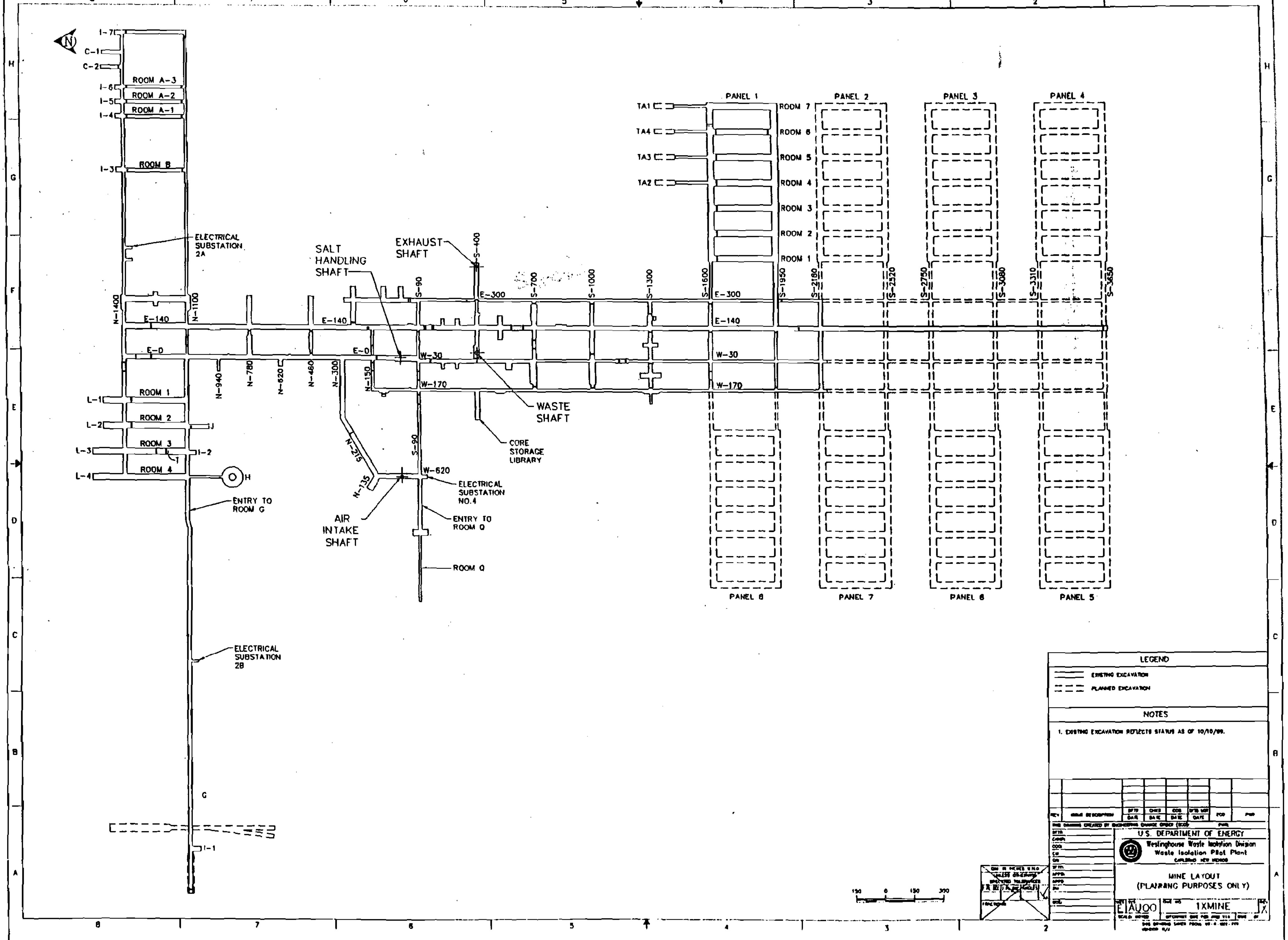
Three rectangles were located on the drawing (as requested) and the corners were identified in state plane coordinates and listed on the drawing.

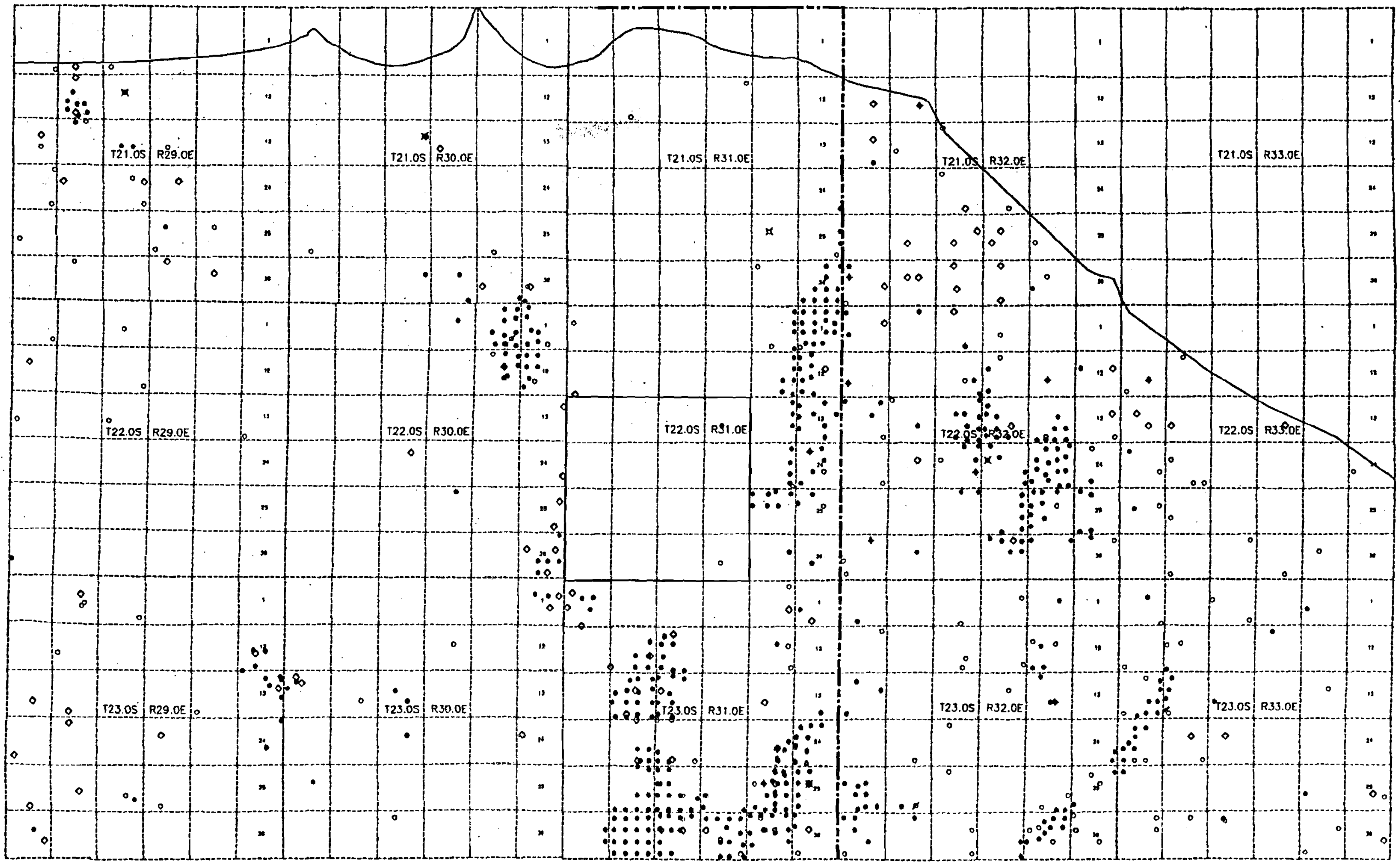
TEXTLOC.LSP

A lisp routine or program created using the programming language Autolisp that is resident within AutoCAD for this purpose.

```
(defun C:txtout  (/ fln f a n index e1 e txt)
  (setq fln (getstring "\nFile name:  "))
  (setq f (open fln "w"))
  (setq a (ssget))
  (setq n (sslength a))
  (setq index (- n 1))
  (repeat n
    (setq e1 (entget (ssname a index)))
    (setq index (- index 1))
    (setq e (assoc 0 e1))
    (if (= "TEXT" (cdr e))
      (progn
        (setq txt (cdr (assoc 1 e1)))
        (setq bcd (cdr(assoc 10 e1)))
        (setq text (list(cons txt bcd)))
        (print text f)
      )
    )
  )
  (close f)
)
```

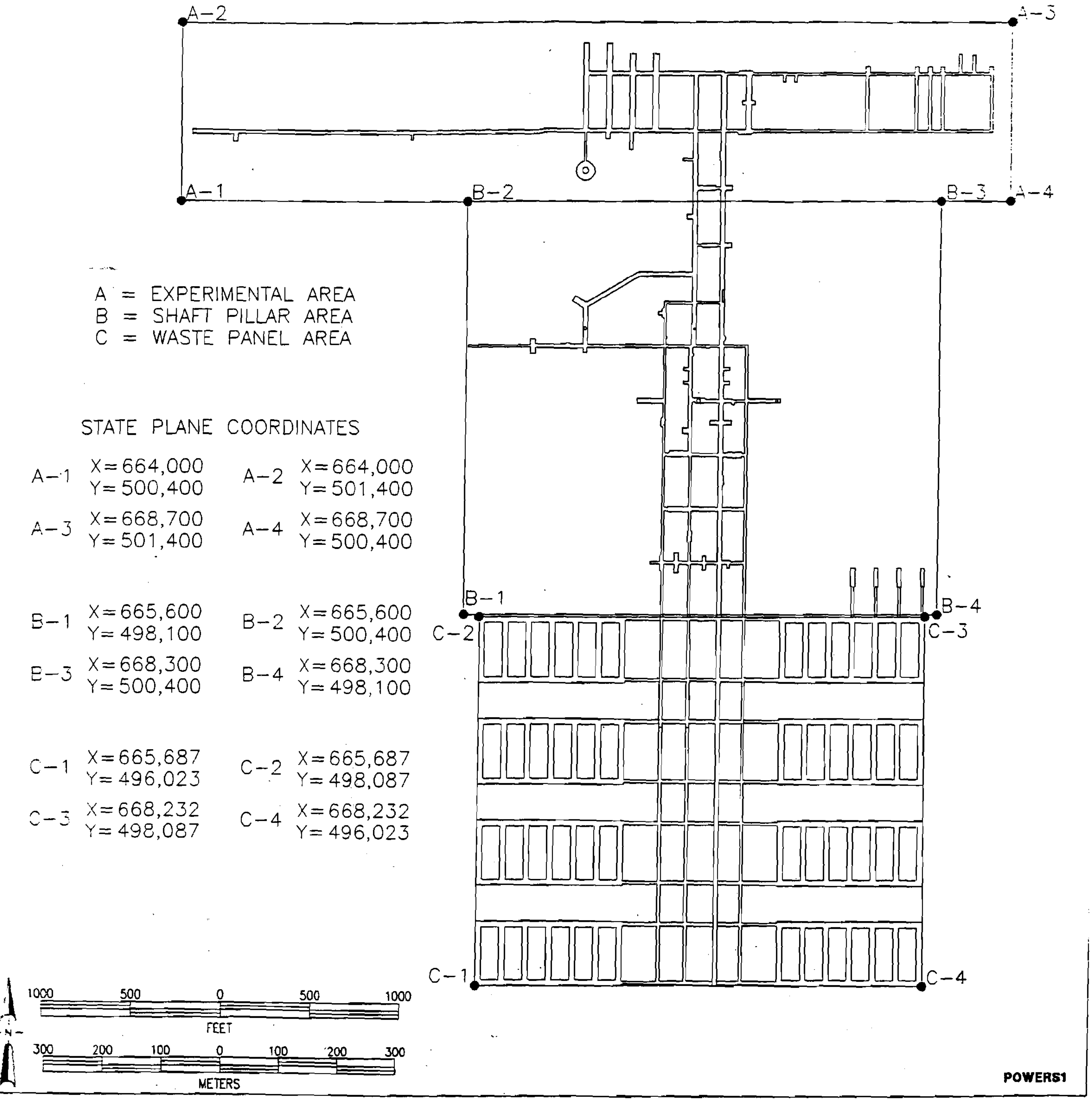
1XMINE


PANEL 1
PANEL 2
PANEL 3
PANEL 4
PANEL 5
PANEL 6
PANEL 7
PANEL 8
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
ROOM 7
TA1
TA4
TA3
TA2
ROOM A-3
ROOM A-2
ROOM A-1
ROOM B
ELECTRICAL SUBSTATION 2A
SALT HANDLING SHAFT
EXHAUST SHAFT
WASTE SHAFT
CORE STORAGE LIBRARY
AIR INTAKE SHAFT
ELECTRICAL SUBSTATION NO.4
ENTRY TO ROOM Q
ROOM Q
ENTRY TO ROOM G
ELECTRICAL SUBSTATION 2B
S-90
S-400
S-700
S-1000
S-1300
S-1600
S-1950
S-2180
S-2520
S-2750
S-3080
S-3310
S-3650
E-300
E-140
E-0
W-30
W-170
W-620
N-150
N-300
N-460
N-620
N-780
N-940
N-1100
N-1400
N-215
N-135
L-1
L-2
L-3
L-4
I-1
I-2
I-3
I-4
I-5
I-6
I-7
C-1
C-2
LEGEND
EXISTING EXCAVATION
PLANNED EXCAVATION
NOTES
1. EXISTING EXCAVATION REFLECTS STATUS AS OF 10/10/89.
U.S. DEPARTMENT OF ENERGY
Westinghouse Waste Isolation Division
Waste Isolation Pilot Plant
CARLSBAD, NEW MEXICO
MINE LAYOUT
(PLANNING PURPOSES ONLY)
1XMINE



T21.0S R29.0E
T21.0S R30.0E
T21.0S R31.0E
T21.0S R32.0E
T21.0S R33.0E
T22.0S R29.0E
T22.0S R30.0E
T22.0S R31.0E
T22.0S R32.0E
T22.0S R33.0E
T23.0S R29.0E
T23.0S R30.0E
T23.0S R31.0E
T23.0S R32.0E
T23.0S R33.0E

POWERS



A-2
A-3
A-1
B-2
B-3
A-4
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B = SHAFT PILLAR AREA
C = WASTE PANEL AREA
STATE PLANE COORDINATES
A-1 X=664,000 Y=500,400
A-2 X=664,000 Y=501,400
A-3 X=668,700 Y=501,400
A-4 X=668,700 Y=500,400
B-1 X=665,600 Y=498,100
B-2 X=665,600 Y=500,400
B-3 X=668,300 Y=500,400
B-4 X=668,300 Y=498,100
C-1 X=665,687 Y=496,023
C-2 X=665,687 Y=498,087
C-3 X=668,232 Y=498,087
C-4 X=668,232 Y=496,023
B-1
B-4
C-2
C-3
C-1
C-4
1000 500 0 500 1000
FEET
300 200 100 0 100 200 300
METERS
N
POWERS1

DENNIS.TXT

The following is the text file created with the AutoCAD lisp routine. The information in this file is the API number and x-y location of the oil and gas wells defined on the Powers.dwg.

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Appendix B

Location Data and Depth for

Drillholes with Interpreted Geophysical Data

Dennis W. Powers

Basic Stratigraphic Data - Locations

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
1104	21	31	35	2152s	910e	ERDA 6
1149	22	31	8	704s	128e	DOE 2
1150	22	31	9	712n	294w	WIPP 11
1153	22	31	11	935n	1979w	AEC 8
1158	22	31	17	2566s	1731w	WIPP 13
1159	22	31	17	148s	84e	WIPP 12
1168	22	31	20	267s	177e	ERDA 9
1175	22	31	28	182s	610e	DOE 1
1243	23	31	5	1980n	1980e	MP Grace Cabin Baby Federal No. 1
5000	22	31	1	1980n	990e	Hanagan No. 2 Unocal-HPC
5002	22	31	1	1980n	1980w	Phillips Molly State No. 2
5004	22	31	1	1980n	535w	Phillips Molly State No. 4
5005	22	31	1	2310s	1980w	Pogo Federa 1 No. 1
5006	22	31	1	2310s	990e	Pogo Federal 1 No. 3
5007	22	31	1	2310s	660w	Pogo 1 Federal No. 4
5008	22	31	1	990s	990w	Pogo Federal 1 No. 5
5009	22	31	1	900s	1880w	Pogo Federal 1 No. 6
5010	22	31	1	990s	2310e	Pogo Federal 1 No. 6
5011	22	31	1	660n	660e	Yates Unocal "AHU" Federal No. 2

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IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5012	22	31	1	2310s	1980e	Pogo Federal 1 No. 2
5014	22	31	2	2310s	330e	Pogo State "2" No. 3
5015	22	31	11	330s	430e	Yates Martha "AIK" Federal No. 1
5016	22	31	11	1980s	330e	Yates Martha "AIK" Federal No. 2
5019	22	31	11	1980n	330e	Yates Martha "AIK" Federal No. 5
5020	22	31	11	660n	330e	Yates Martha "AIK" Federal No. 6
5021	22	31	12	1980s	660w	Pogo Federal 12 No. 2
5022	22	31	12	1980n	330w	Pogo Federal 12 No. 4
5023	22	31	12	660n	330w	Pogo Federal 12 No. 5
5024	22	31	12	2310s	1650w	Pogo Federal 12 No. 6
5025	22	31	12	1650n	1650w	Pogo Federal 12 No. 7
5027	22	31	12	1980n	1980e	Pogo SCL Federal No. 2
5028	22	31	12	330s	1980w	Pogo Federal 12 No. 3
5029	22	31	13	1980n	660e	Texaco Federal Neff "13" No. 2
5030	22	31	13	660s	1980e	Texaco Neff 13 No. 3
5032	22	31	13	990n	330w	Texaco Federal Neff 13 No. 6
5033	22	31	13	2310n	330w	Texaco Federal Neff 13 No. 7
5034	22	31	13	1651s	330w	Texaco Federal Neff 13 No. 8
5035	22	31	14	1980n	430e	Yates Dolores "AIL" Federal No. 3
5036	22	31	14	1980s	430e	Yates Dolores "AIL" Federal No. 2

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5037	22	31	14	660n	430e	Yates Dolores "AIL" Federal No. 1
5038	22	31	23	660s	660e	Pogo Federal 23 No. 1
5039	22	31	23	1750s	660e	Pogo Federal "23" No. 2
5040	22	31	23	2310n	660e	Pogo Federal "23" No.3
5041	22	31	23	660n	510e	Pogo Federal 23 No. 5
5042	22	31	24	1980s	1980w	Texaco Getty Federal 24 No. 4
5043	22	31	24	990n	1652w	Texaco Getty Federal 24 No. 5 SWD
5044	22	31	24	660s	660w	Texaco Getty Federal 24 No. 2
5045	22	31	24	1980n	1980e	Getty Federal #24-1
5046	22	31	25	1650n	330w	Pogo Neff Federal No. 2
5047	22	31	25	660n	1980w	Pogo Federal Neff No. 1
5048	22	31	24	660n	2310e	Texaco Getty Federal 24 No. 3
5049	22	31	26	610n	510e	Pogo Federal 26 No. 1
5050	22	31	26	1980n	1980e	Pogo Federal 26 No. 2
5051	22	31	26	610n	2130w	Pogo Federal "26" No. 3
5052	22	31	26	600n	330w	Pogo Federal 26 No. 4
5053	22	31	26	330n	2230e	Pogo Federal 26 No. 5
5054	22	31	26	1980n	330w	Pogo Federal 26 No. 6
5055	22	31	26	1980n	1980w	Pogo Federal 26 No. 7
5056	22	31	35	1980n	660e	Yates David Ross "AIT" Federal No. 1

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IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5057	22	31	36	1980s	1980w	Union of CA Medano State Com. Well No. 1
5058	21	30	5	250n	1600w	Bass Big Eddy Unit No. 91
5059	21	30	16	1980n	660e	Bass Big Eddy Unit No. 44
5060	21	30	16	1980n	751e	Bass Big Eddy No. 45-Y
5061	21	30	26	660s	1980w	Phillips James "D" No. 1
5062	21	30	33	1980n	660e	Yates Kaleidoscope "AIO" Federal No. 1
5063	21	30	34	1980n	1980e	Yates Julia "AJL" Federal No. 4
5064	21	30	35	660s	330e	Phillips Peak View No. 1
5065	21	30	35	1980s	660w	Phillips James "C" No. 1
5066	21	30	36	1980s	990w	C. Grace Livingston Ridge No. 1-Y
5068	21	31	36	660n	330e	Yates Mary "AIV" State No. 5
5069	21	31	36	660n	1980e	Yates Mary "AIV" State No. 3
5070	21	31	36	1980n	1980e	Yates Mary "AIV" State No. 1
5071	21	31	36	660s	660e	Yates Lost Tank "AIS" State No. 8
5072	21	31	36	1980s	1980e	Yates Lost Tank "AIS" State No. 6
5073	21	31	36	660s	660w	Yates Lost Tank "AIS" State No. 5
5075	21	31	36	660s	1980w	Yates Lost Tank "AIS" State No. 3
5076	21	31	36	660s	1980e	Yates Lost Tank "AIS" State No. 2
5079	21	31	24	660s	330e	Yates "AJA" Federal No. 7
5080	21	31	24	660s	200e	Yates Bonneville "AKK" Federal No. 2

 Print Date: 07/10/1996

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5081	21	31	25	1980n	330e	Yates Wolf "AJA" Federal No. 5
5082	21	31	25	1980s	330e	Yates Wolf "AJA" Federal No. 4
5084	22	30	1	660s	2310e	Yates Jasmine "AJI" Federal No. 1
5085	22	30	1	2240s	1200w	Phillips Livingston Ridge No. 2
5086	22	30	1	660s	700w	Troporo Cabana No. 1
5087	22	30	1	430n	860w	:hillips Livingston Ridge No. 4
5088	22	31	1	1650n	1980e	Hanagan No. 1 Unocal-HPC
5089	22	30	1	1450n	660w	Phillips Livingston Ridge No. 3
5090	22	30	1	1980s	1980w	Phillips Livingston Ridge No. 6
5091	22	30	3	1980n	1980e	Yates Donell 3 Federal No. 1
5092	22	30	2	1250s	1150e	:hillips James "A" No. 12W
5093	22	30	2	660s	2310w	Phillips James A No. 10
5094	22	30	2	660n	500e	Phillips James A No. 9
5095	22	30	2	1650n	660e	Phillips James A No. 8
5096	22	30	2	1980n	1980e	Phillips James "A" No. 4
5097	22	30	2	1980s	1980w	Phillips James "A" No. 3
5098	22	30	2	1652s	1980e	Phillips James "A" No. 2
5099	22	30	2	1980s	660e	Phillips James "A" No. 6
5100	22	30	2	500s	660e	Phillips James A No. 7
5101	22	30	2	660s	1800e	Phillips James "A" No. 5

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5102	22	30	2	665s	2006e	Phillips James A No. 1
5103	22	30	13	1330n	330e	Mitchell Energy Apache "13" Federal No. 1
5104	22	30	12	1980s	995w	Phillips James E No. 15
5105	22	30	12	1980n	1980w	Phillips James "E" No. 14
5106	22	30	12	1980n	660w	Phillips James "E" No. 13
5107	22	30	12	660n	1980w	Phillips James "E" No. 12
5109	22	30	12	660n	660w	Phillips James "E" No. 11
5110	22	30	12	990s	330w	Bass James Ranch Unit No. 48
5111	22	30	11	2247s	1558e	Phillips James "E" No. 8
5112	22	30	11	1980s	1980e	Phillips James "E" No. 6
5113	22	30	11	1810n	330e	Phillips James "E" Federal No. 5
5114	22	30	11	760n	330e	Phillips James "E" Federal No. 4
5115	22	30	11	535n	2080w	Phillips James "E" No. 2
5116	22	30	36	660s	2009e	Shell James Ranch No. 1
5117	22	30	36	330n	660e	Enron James Ranch Unit No. 71
5118	22	30	36	1980s	660e	Enron James Rand Unit No. 37
5119	22	30	36	1980s	1980e	Enron James Ranch Unit No. 19
5120	22	30	36	1980n	920w	Belco James Ranch No. 11
5121	22	30	36	1980n	1100e	Enron James Ranch Unit No. 18
5122	22	30	11	1980n	1980e	Phillips James "E" No. 1

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5123	22	30	36	1980s	2310w	Bass James Ranch Unit No. 29
5124	22	30	25	1730n	660e	Mitchell Apache "25" Federal No. 1
5125	22	30	25	660s	1310e	Mitchell Apache "25" Federal Com. No. 2
5126	22	30	24	1200s	330e	Mitchell Apache "24" Federal No. 1
5127	23	30	1	1980n	660e	Belco (Bass?) Belco-James Ranch No. 10
5128	23	30	1	1830n	1980w	Belco Hudson Federal No. 1
5129	23	30	1	1980s	1658e	Belco James Ranch Unit No. 3
5130	23	30	16	2310n	1980w	Texaco Forty-Niner Ridge Unit No. 3
5131	23	30	24	1980n	660w	Phillips Sandy Unit No. 1
5132	23	31	13	760s	2080e	Devon Todd 13 'O' Federal No. 15
5133	23	31	11	660s	330e	Max M. Wilson Bauerdorf-Federal No. 1
5134	23	31	9	330s	1980e	Santa Fed North Pure Gold "9" No. 9
5135	23	31	9	1980n	1980w	Santa Fe North Pure Gold "9" Federal No. 7
5136	23	31	9	1980n	660w	Santa Fe North Pure Gold "9" Federal No. 4
5137	23	31	9	1140n	990w	Santa Fe North Pure Gold "9" Federal No. 5
5138	23	31	9	660s	660w	Santa Fe North Pure Gold "9" Federal No. 2
5139	23	31	9	330s	1980w	Santa Fe North Pure Gold "9" Federal No. 1
5140	23	31	9	900n	1980w	Santa Fe Pure Gold "4" Federal No. 1
5141	23	31	8	660s	860e	Santa Fe North Pure Gold "8" Federal No. 9
5142	23	31	8	1980s	2310e	Santa Fe North Pure Gold "8" Federal No. 6

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5143	23	31	8	660s	2310e	Santa Fe North Pure Gold "8" Federal No. 5
5144	23	31	8	1780n	660e	Santa Fe North Pure Gold "8" Federal No. 3
5145	23	31	8	1980s	860e	Santa Fe North Pure Gold "8" Federal No. 2
5146	23	31	8	1980s	660e	Santa Fe North Pure Gold "8" Federal No. 1
5147	23	31	6	100s	1980w	Belco James Ranch Unit 14
5148	23	31	8	660s	100w	Belco James Ranch Unit No. 15
5149	23	31	6	2080n	1980w	Enron James Ranch Unit No. 17
5150	23	31	6	1440n	860w	Bass James Ranch No. 13
5151	23	31	6	1980n	1980e	Continental James Ranch Unit No. 7
5152	23	31	6	1980s	2310e	Bass James Ranch Unit No. 30
5153	23	31	2	660n	660e	Continental State AA-2 No. 1
5154	23	31	1	660s	1980w	Union of CA Barclay Federal No. 1
5155	23	31	1	1980s	660w	Owens Union Federal No. 1
5158	22	32	12	1980n	600w	Maralo Prohibition Federal Unit No. 1
5159	22	32	13	1980n	990e	Pogo WBR Federal No. 1
5160	22	32	13	660s	660e	Ray Smith B&H Federal No. 1
5161	22	32	14	2310n	1980e	Maralo Prohibition Federal Unit No. 4
5162	22	32	14	1650s	2135w	Meridian Red Tank Federal No. 4
5163	22	32	14	330s	1980w	Meridian Red Tank Federal No. 1
5164	22	32	14	330s	990w	Meridian Red Tank Federal No. 3

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5165	22	32	14	660s	1980w	Carper Red Tank Unit No. 2 (SWD?)
5166	22	32	14	330s	2310e	Meridian Red Tank Federal No. 5 (SWD?)
5167	22	32	15	1980s	1980e	Superior No. 1 Connally Federal
5168	22	32	15	990n	660w	Strata Paisano Federal No. 3
5169	22	32	15	2310n	1650w	Strata Paisano Federal No. 2
5170	22	32	15	1980n	460w	Strata Paisano Federal No. 1
5171	22	32	15	1650s	330w	Strata Lechuza Federal No. 5
5173	22	32	15	660s	2310e	Strata Lechuza Federal No. 3
5174	22	32	15	1650s	1650w	Strata Lechuza Federal No. 2
5175	22	32	15	862s	458w	Strata Lechuza Federal No. 1
5176	22	32	16	2310n	330e	Yates Kiwi "AKX" State No. 3
5177	22	32	16	1650s	330e	Yates Kiwi "AKX" State No. 2
5179	22	32	16	330s	1650e	Yates Kiwi "AKX" State No. 4
5180	22	32	16	1980s	1650e	Yates Kiwi "AKX" State No. 5
5181	22	32	16	660s	2310w	Yates Kiwi "AKX" State No. 6
5182	22	32	16	1980n	1980e	Yates Kiwi "AKX" State No. 7
5183	22	32	16	1980n	2310w	Yates Kiwi "AKX" State No. 8
5184	22	32	16	330n	330e	Yates Kiwi "AKX" State No. 9
5185	22	32	17	1980s	1980e	Yates Cleary "AKC" Feceral No. 1
5186	22	32	17	330n	330w	Yates Cleary "AKC" Federal No. 2

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5188	22	32	18	660n	990e	Pogo Livingston Ridge Federal No. 1
5189	22	32	18	480n	330w	Pogo Livingston Ridge Federal No. 3 "ZAP"
5190	22	32	18	2130n	1980e	Pogo East Livingston Ridge Federal No. 3
5191	22	32	20	1980n	1980e	Zonne Federal No. 1
5192	22	32	21	1980s	660e	Union of CA Federal Gilmore No. 1 (Cerc Fed 1 SWD)
5193	22	32	21	390n	1980e	Strat Cercion Federal No. 3
5194	22	32	21	1990n	660e	Strat Cercion Federal No. 1
5195	22	32	22	1980n	660w	Trigg Federal Red Tank No. 1-22
5196	22	32	22	1650n	1980w	Strata Cercion Federal No. 4
5197	22	32	22	330n	990w	Strata Cercion Federal No. 2
5198	22	32	23	879s	403w	Meridian Checkerboard 23 Federal No. 6
5199	22	32	23	2110s	990e	Pogo Red Tank 23 Federal No. 2
5200	22	32	23	2310n	990e	Meridian Checkerboard 23 No. 16
5201	22	32	23	1650n	990e	Meridian Checkerboard 23 Federal No. 13
5202	22	32	23	660n	990e	Meridian Checkerboard 23 Federal No. 12
5203	22	32	23	1980n	1980e	Meridian Checkerboard 23 Federal No. 8
5204	22	32	23	690n	1980w	Meridian Checkerboard 23 Federal No. 4
5206	22	32	23	2310s	990w	Meridian Checkerboard 23 Federal No. 5
5208	22	32	25	330n	660w	Pogo Covington "A" Federal No. 2
5209	22	32	26	330n	1980e	Pogo Covington "A" Federal No. 18

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5210	22	32	26	1880s	1880w	Pogo Red Tank "26" Federal No. 1
5211	22	32	26	330n	660w	Pogo Red Tank "26" Federal No. 2
5212	22	32	27	330s	2310w	Pogo Federal 27 No. 1
5214	22	32	27	1980s	660e	Pogo Exxon Federal 27 No. 3
5216	22	32	28	330n	2310e	Pogo Red Tank 28 Federal No. 3
5217	22	32	31	660n	1980e	Bass Perry Federal No. 1
5218	22	32	31	660n	2085e	Pogo Proximity 31 No. 4
5219	22	32	31	660s	660w	Enron Silverton 31 Federal No. 1
5220	22	32	32	1980n	1980e	Yates Lotus "ALT" State No. 2
5221	22	32	34	760n	660e	Pogo Red Tank 34 Federal No. 3
5223	22	32	34	1980n	660e	Pogo Red Tank 34 Federal No. 2
5224	22	32	35	660n	330w	Pogo Red Tank 35 Federal No. 1
5226	22	33	32	660s	660w	Helbing & Podpechan Shell State No. 1-B
5227	22	33	34	660s	1980e	CP Miller Humble State No. 1
5228	22	33	35	1980n	1980w	Amoco Federal "BG" No. 1
5229	22	33	30	1980n	660e	Yates pronghorn Unit No. 2
5230	22	33	30	2310n	1650w	Mitchell Bighorn "30" State No. 2
5231	22	33	29	1980s	660w	Yates Pronghorn "ACZ" Federal No. 1
5232	22	33	20	1980n	660w	Davis & Collins Conoco Federal No. 1
5233	22	33	19	990n	990w	Santa Fe Bootleg Ridge 19 State No. 1

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5234	22	33	18	1980n	1864w	Pogo State NBR No. 2
5235	22	33	18	1980s	1980e	Pogo State NBR No. 1
5236	22	33	9	660n	660w	Dual Hudson Federal No. 1
5237	22	33	17	1980s	660w	Pogo EBR Federal No. 1
5238	22	33	8	660n	1980w	Meridian Dagger Lake "8" Federal No. 1
5239	22	33	7	1980s	1980e	Superior SST State 7 No. 1
5240	22	33	7	660s	660w	Cabot State "K" No. 1
5241	22	33	6	1980n	1980e	Superior San Simone State Com No. 1
5242	22	33	4	2310s	800w	Texas Pacific Reed Federal No. 1
5243	22	33	5	660s	330e	Dual Richardson & Bass State No. 1
5244	22	33	5	330s	1980e	Meridian Dagger Lake State No. 1
5245	23	32	2	2310n	1650e	Yates Saffron Unit No. 1
5246	23	32	3	1980n	660e	OB Kiel, Jr. Federal No. 1
5247	23	32	4	330s	2310e	Strata Aracanga Federal No. 1
5248	23	32	6	660s	1980w	Santa Fe Platinum 6 Federal No. 1
5249	23	32	7	510n	660e	JH Trigg Federal "WL" No. 5
5250	23	32	9	660s	1980e	McBee Continental Federal No. 1
5251	23	32	9	1650s	1650e	Strata Aracanga Federal No. 2
5252	23	32	11	1680n	660w	Exxon Central SW Oil Corp Federal No. 1
5253	23	32	11	660s	1980w	Superior Triste Draw Gulf Federal No. 1

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5254	23	32	11	560s	660w	Strata Urraca Federal No. 2
5255	23	32	11	2310n	1650w	Yates Amanda "AMN" Federal No. 1
5256	23	32	14	1980s	1980e	Superior Triste Draw Federal No. 1
5257	23	33	4	2310n	330w	Yates Jackal "ANJ" Federal No. 7
5258	23	33	4	660s	660e	Cabeen Continental Federal No. 1-P
5259	23	33	6	330s	330e	WA & ER Hudson Shell Federal No. 1
5260	23	33	6	1980n	1980e	Yates Pronghorn Unit No. 1
5261	23	33	7	660s	660w	Hudson Federal No. 1
5262	23	33	8	330s	330w	Yates Pronghorn AAP Federal No. 1
5263	23	33	10	660n	1980w	Amoco State "IK" No. 1
5264	21	32	12	1980s	660w	Belco Federal HM No. 1
5265	21	32	32	1980n	1980e	Getty State Com No. 1
5266	21	32	33	660n	1980w	Texaco Bilbrey Federal Com No. 1
5267	21	32	33	1980s	2310w	Texaco Bilbrey Federal No. 2
5268	21	32	34	660s	1980w	Phillips Bilbrey Federal No. 1
5269	21	32	34	660n	1980w	Maralo Bilbrey Federal No. 1
5270	21	32	35	1980n	1980w	Gulf Chaney Federal No. 1
5271	21	32	35	1980s	330w	Manzano Anderson No. 1
5272	21	32	31	660n	660w	Phillips Luke Federal No. 2
5273	21	32	31	2310s	660e	Pogo Federal No. 1

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5274	21	32	31	330s	330w	Collins & Ware BW Federal No. 1
5275	21	32	31	1980n	660w	Phillips Luke Federal No. 1
5276	21	32	31	2040n	2040e	AEC No. 7
5277	21	32	29	1980s	1980w	Getty Bilbrey Federal Com No. 1
5278	21	32	28	1980n	660e	Santa Fe Bilbrey Federal No. 1
5279	21	32	27	1980n	1980w	Santa Fe Bilbrey Federal No. 1-A
5280	21	32	28	1980s	1980w	Santa Fe Bilbrey Federal No. 1-A
5301	21	30	15	1980s	990w	WC Blanks Big Eddy Unit No. 67
5302	21	30	34	330s	990e	Yates Cabin Lake 34 Federal No. 1
5303	21	30	36	330s	330w	C Grace Salomeh No. 1
5304	21	31	25	660s	790e	Maralo MR "25" Federal No. 1
5305	21	31	26	1980n	1980w	Pogo Federal No. 1
5306	21	31	35	660n	660w	Union Federal FI No. 1
5307	21	31	36	1980s	660e	Yates Lost Tank "AIS" State No. 1
5308	21	31	36	1980s	1980w	Yates Lost Tank "AIS" State No. 4
5309	21	32	13	990n	1980w	Belco Federal "HM" No. 13-1
5310	21	32	18	660s	1980e	Collins & Ware N.L. Federal No. 2
5311	21	32	18	1980n	1980e	Getty North Bilbrey 18 Federal No. 1
5312	21	32	21	660n	660w	Skelly Salt Lake South Unit No. 1
5313	21	32	21	660s	1980e	Santa Fe Bilbrey "21" Federal Com. No. 1

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5314	21	32	22	660s	2310e	Santa Fe Bilbrey "22" Federal Com. No. 1
5315	21	32	26	1980s	660w	Collins & Ware Lincoln Federal No. 1
5316	21	32	27	1980s	990w	Santa Fe Bilbrey 27 Federal Com. No. 1
5317	21	32	32	1980n	1980w	Texaco Bilbrey 32 State Com. No. 1
5318	22	29	4	1980s	2240w	Bass Big Eddy Unit No. 90
5319	22	29	6	660s	660e	Hudson Federal No. 1
5320	22	29	16	1980s	660w	Bass Big Eddy Unit 96
5321	22	29	18	1980s	660w	Bass Big Eddy Unit No. 88
5322	22	30	11	1060s	10e	Phillips James E Federal No. 9
5323	22	30	12	660s	1980e	Bass James Ranch Unit No. 70
5324	22	30	27	660n	2003e	Richardson & Bass Federal Legg No. 1
5325	22	30	36	660s	2310w	Bass James Ranch Unit No. 41
5326	22	31	1	660n	1980w	Phillips Molly State No. 1
5327	22	31	1	660n	660w	Phillips Molly State No. 3
5328	22	31	1	660n	1980e	Yates Unocal "AHU" Federal No. 1
5329	22	31	2	660s	2310w	Yates Flora "AKF" State No. 1
5330	22	31	2	1980n	330e	Yates Graham "AKB" State No. 2
5331	22	31	2	660n	330e	Yates Graham "AKB" State No. 1
5332	22	31	2	1980s	2310w	Yates Flora "AKF" State No. 2
5333	22	31	2	660s	2310e	Pogo State 2 No. 2

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5334	22	31	2	330s	330e	Pogo State 2 No. 1
5335	22	31	6	1980n	660w	Bryon McKnight & Troporo Campana No. 1
5336	22	31	7	330s	950w	Yates Llama "ALL" Federal No. 1
5337	22	31	11	660s	1650e	Yates Martha "AIK" Federal No. 3
5338	22	31	11	1980s	1650e	Yates Martha "AIK" Federal No. 4
5339	22	31	12	330n	1650w	Pogo Federal 12 No. 8
5340	22	31	13	1980n	1980w	Texaco Federal Neff 13 No. 5
5341	22	31	13	1980s	1980e	Pogo Neff 13 No. 1
5342	22	31	15	1980s	1980w	Clayton W. Williams Badger Unit Federal No. 1
5343	22	31	23	330s	330e	Texas Crude Wright Federal 23 No. 1
5344	22	31	25	430n	760w	Pogo Neff Federal No. 3
5345	22	32	3	1980s	1980w	Siete Ottowa State No. 1
5346	22	32	4	660s	1980e	Santa Fe Trumpeter 4 State No. 1
5347	22	32	4	660n	1980w	Getty Bilbrey Federal Com. No. 1
5348	22	32	5	660n	1580e	Getty Bilbrey Federal No. 1
5349	22	32	6	1980s	660w	Yates Rosemary "AJB" Federal No. 1
5350	22	32	6	800n	330w	Pogo Federal 6 No. 1
5351	22	32	6	1980n	660e	Amoco Federal "CK" Com. No. 1
5352	22	32	7	1650s	660w	Strata Flamenco Federal No. 1
5353	22	32	9	330s	330e	Santa Fe White Swam "9" Federal No. 1

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5354	22	32	9	1980n	660e	Santa Fe White Swam "9" Federal No. 4
5355	22	32	9	1980s	990e	Maralo Wild Turkey "9" state No. 1
5356	22	32	10	1980s	330w	Maralo Wild Turkey "10" state No. 1
5357	22	32	10	1980n	660w	WTI Barr None Federal No. 1
5358	22	32	10	660s	660w	Phillips Emerald Federal No. 1
5359	22	32	11	1980s	2080w	Maralo Prohibition Federal No. 2
5360	22	32	14	2310n	990e	Maralo Prohibition Federal Unit No. 6
5361	22	32	14	1650s	990e	Meridian Redchecker 14 No. 2
5362	22	32	14	330s	990e	Meridian Redchecker 14 No. 1
5363	22	32	14	2310n	2155w	Meridian Prohibition Federal No. 5
5364	22	32	14	1650s	1980w	Meridian Red Tank Federal No. 6
5365	22	32	15	660s	1650w	Strata Lechuza Federal No. 4
5366	22	32	16	330s	330e	Yates Kiwi "AKX" State No. 1
5367	22	32	18	660s	660e	John H. Trigg Federal Jennings No. 1
5368	22	32	19	660s	660e	Ralph Lowe Bass Federal No. 1
5369	22	32	21	330n	330e	Strata Cercion Federal No. 5
5370	22	32	22	1980s	330e	Pogo Prize Federal No. 13
5371	22	32	22	660s	330e	Pogo Prize Federal No. 10
5372	22	32	23	660n	1980e	Meridian Checkerboard 23 Federal No. 11
5373	22	32	23	2310n	2295w	Meridian Checkerboard 23 Federal No. 3

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5374	22	32	23	330s	1650e	Meridian Checkerboard 23 Federal No. 2
5375	22	32	23	1980s	1980e	Meridian Checkerboard 23 Federal No. 1
5376	22	32	23	990s	2310w	Meridian Checkerboard 23 Federal No. 9
5377	22	32	23	1650s	1980w	Meridian Checkerboard 23 Federal No. 7
5378	22	32	23	1980n	990w	Meridian Checkerboard 23 Federal No. 10
5380	22	32	25	330s	660w	Pogo Covington "A" Federal No. 8
5381	22	32	25	480s	1980w	Pogo Covington "A" Federal No. 9
5382	22	32	25	660n	1980w	Pogo Covington "A" Federal No. 1
5383	22	32	26	1980n	330w	Pogo Red Tank "26" Federal No. 3
5384	22	32	26	2310s	330w	Pogo Red Tank "26" Federal No. 4
5385	22	32	27	1880n	760e	Pogo Prize Federal No. 4
5386	22	32	27	660n	660e	Pogo Prize Federal No. 5
5387	22	32	27	660s	660e	Pogo Exxon Federal 27-2
5389	22	32	28	330n	330e	Pogo Red Tank "28" Federal No. 1
5390	22	32	34	710n	2310w	Pogo Red Tank "34" Federal No. 14
5391	22	32	34	1980n	1980e	Pogo Red Tank "34" Federal No. 4
5392	22	32	34	660n	1650e	Pogo Red Tank "34" Federal No. 1
5393	22	32	35	2310s	990w	Pogo Red Tank "35" Federal No. 3 SWD
5394	22	32	36	330n	1980w	Shell Bootleg Ridge Unit No. 1
5395	22	32	36	330n	1980e	Meridian Mule Deer 36 State No. 1

IDNum	TWP	RGE	Section	fn,sl	fe,wl	Drillhole Name
5396	22	32	36	1980n	2310e	Meridian Mule Deer 36 State No. 2
5397	22	32	36	660n	860e	Meridian Mule Deer 36 State No. 4
5398	22	33	8	330n	2310e	Meridian Dagger Lake 8 Fed No. 2
5399	22	33	15	1980s	1980e	Getty Federal 15 No. 1
5400	22	33	15	660n	1980w	Getty Federal 15 Com "B" No. 1
5401	22	33	19	1980s	660e	Collins & Ware White Lightning Federal No. 1
5402	22	33	33	660n	660e	R.B. Farris Phillps State No. 1
5403	22	34	23	360s	660e	Pogo RI Federal 23 No. 1
5404	22	32	36	660n	660e	Richardson & Bass Tidewater No. 1
5405	22	32	26	1980n	1980e	Culbertson & Irwin Culbertson No. 1
5406	22	29	9	660s	660e	H & W Danford No. 1
5407	22	33	20	660s	1980e	Yates Mascho Cloyd No. 2
5408	22	33	20	660s	660e	Yates Mascho Cloyd No. 1

The source data table and this report were created by Dennis W. Powers using Rbase 5.5, a commercial relational database available from Microrim, Inc. Basic information has been checked. The relational column within the database is the idnum, an identifier unique to the drillhole. Data were checked for report setup.

Basic Stratigraphic Data - Depths *

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
1104	3540	4300		2733	2555	2401		2291	1525	1287	811
1149	3418	4071	3809	3801			3083	2670	1738	1456	961
1150	3439		3563	3512	3392	2424	2343	2242	1688	1434	964
1153	3541	4315	4038	3696	3555	3290	2980	2562	1747	1484	990
1158	3405		3809	3715	3626	3507	2959	2509	1633	1347	846
1159	3484		3914	3403	3294	3066	2738	2471	1715	1447	966
1168	3420						2836	2563	1653	1367	860
1175	3473		4032	3708	3600	3375	2937	2677	1785	1490	977
1243	3328	4045	3810	3480	3373	3155	2704	2435	1481	1184	653
5000	3607	4485	4188	3583	3445	3118	2890	2528	1738	1462	945
5002	3585	4428	4138	3360	3200	3015	2798	2482	1696	1431	917
5004	3575	4415	4115	3435	3272	3015	2740	2512	1624	1413	916
5005	3583	4438	4141	3619	3463	3086	2860	2532	1704	1426	917
5006	3604	4490	4195	3600	3462	3198	2956	2582	1746	1468	947
5007	3570	4424	4126	3645	3492	3178	2892	2555	1680	1411	920
5008	3568	4438	4142	3635	3510	3055	2795	2445	1682	1420	933
5009	3590	4445	4150	3610	3465	3241	2982	2597	1720	1447	956
5010	3600	4475	4182	3608	3483	3145	2898	2575	1752	1473	978
5011	3609	4480	4172	3945	3555	3110	2905	2535	1735	1460	950
5012	3599	4479	4183	3650	3490	3155	2932	2576	1746	1468	912

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5014	3564	4398	4104	3810	3664	3270	2938	2573	1693	1416	922
5015	3579	4459	4174	3746	3614	3335	2946	2662	1854	1580	1090
5016	3599	4475	4188	3712	3563	3310	2940	2644	1838	1566	1175
5019	3577	4440	4147	3700	3557	3188	2905	2558	1765	1500	1010
5020	3560	4430	4137	3567	3425	3145	2780	2488	1708	1452	972
5021	3595	4480	4198	3784	3647		3005	2652	1840	1566	1065
5022	3577	4454	4160	3645	3512	3145	2845	2510	1759	1496	1010
5023	3567	4448	4153	4038	3495	3300	2680	2580	1704	1450	970
5024	3605	4475	4195	4034	3865	3325	2940	2660	1846	1570	1070
5025	3604	4463	4179	3692	3546	3394	2998	2662	1805	1533	1036
5027	3642	4570	4234	3730	3585	3340	3050	2680	1880	1603	1098
5028	3607	4485	4120	3860	3715	3398	3010	2694	1890	1621	1105
5029	3626	4510	4240	3840	3755	3427	3063	2745	1955	1680	1153
5030	3586	4453	4115	3865	3715	3504	3165	2753	1848	1660	1137
5032	3582	4462	4185	3740	3610	3328	2934	2662	1878	1607	1105
5033	3576	4462	4240	3810	3687	3370	3033	2698	1894	1617	1118
5034	3569	4445	4168	3845	3726	3470	3060	2720	1908	1628	1120
5035	3570	4442	4162	3770	3642	3383	2998	2675	1877	1604	1107
5036	3569	4445	4160	3835	3710	3425	3025	2705	1895	1614	1113
5037	3572	4444	4163	3720	3590	3285	2973	2628	1856	1582	1092
5038	3592	4475	4210	3855	3733	3464	3070	2820	1990	1703	1185

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5039	3572	4442	4122	3845	3721	3442	3054	2782	1947	1660	1150
5040	3553	4402	4135	3783	3657	3387	2880	2721	1900	1620	1112
5041	3561	4428	4153	3775	3665	3365	2978	2686	1887	1612	1105
5042	3601	4483						2683		1712	1204
5043	3574	4437	4163	3844	3714	3423	3030	2718	1917	1646	1126
5044	3599	4464						2822		1709	1190
5045	3607	4502	4221	3860	3737	3447	3035	2767	1972	1697	1174
5046	3546	4457	4185	3875	3760	3520	3095	2826	1915	1696	1168
5047	3598	4520	4245	3885	3766	3675		2852	1941	1740	1214
5048	3580	4443	4093	3861	3737	3464	3063	2737	1935	1662	1142
5049	3610	4461						2858		1730	1208
5050	3556	4420	4158	3885	3766	3530		2820		1677	1153
5051	3576	4467	4205	3855	3735	3475	3063	2808	1966	1676	1162
5052	3556	4428	4173	3790	3700	3428	3015	2766	1915	1634	1124
5053	3585	4465	4204	3860	3640	3345	3075	2823	1985	1693	1177
5054	3526	4410	4150	3806	3692	3453	2950	2750	1891	1604	1090
5055	3546	4425	4163	3835	3720	3470	3020	2785	1936	1646	1137
5056	3482	4455	4166	3820	3710	3460	3030	2764	1882	1607	1082
5057	3488	4462	4210	3880	3768			2835	1932	1657	1127
5058	3566	3785								1262	857
5059	3324	3554								863	565

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5060	3315	3553	3207			2670	2115	1815	1140	870	510
5061	3250	3606						2233			465
5062	3149	3484	3207	2763	2631	2280	1972	1620	850	563	344
5063	3216	3559	3277	2810	2680	2460	2160	1804	1013	737	392
5064	3228	3637	3300	3010	2930	2495	2230	1936	1140	862	515
5065	3218	3600	3301	2844	2713	2503	2190	1843	1063	797	460
5066	3256	3667								930	594
5068	3671	4537	4160	3660	3535	3185	2520	2460	1765	1500	990
5069	3627	4442	4075	3645		3195	3005	2441	1716	1440	937
5070	3617	4455	4120					2430	1695	1431	948
5071	3603	4430	4160	3443	3273	2980	2795	2455	1706	1433	930
5072	3604	4442	4125	3310	3140	2906	2736	2445	1705	1436	940
5073	3567	4374	4065	4040	3778	3340	3065	2330	1590	1345	895
5075	3578	4405	4095	3710	3470	3170	2936		1637	1390	902
5076	3591	4441	4125	3460	3287	3090	2852	2530	1696	1418	915
5079	3650	4363	4025	3990	3750	3565	3172	2760	1947	1670	1160
5080	3655	4363					3170	2765	1950	1676	1170
5081	3682	4475	4100	3785	3665	3300	2900	2670	1917	1645	1145
5082	3709	4518	4220	4030	3780	3323	3018	2757	1910	1628	1120
5084	3352	3810	3544	3190	3080	2810	2455	2144	1406	1150	656
5085	3319	3792	3520	3250	3120	2700	2400	2086	1340	1073	582

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5086	3357	3798								1112	625
5087	3312	3745	3500	3200	3150		2590	2016	1265	1008	543
5088	3590	4451					2800	2482	1710	1438	925
5089	3314	3772	3495	3100	2990	2700	2340	2070	1304	1040	560
5090	3344	3790	3520	3100	2987	2748	2404	2105	1362	1103	612
5091	3203	3544	3268	3000		2530	2135	1825	1040	765	435
5092	3197	3634	3360	3008	2874	2627	2160	1943	1160	897	570
5093	3174	3620			2915	2670	2210	1930	1132	850	532
5094	3232	3658	3360	2935	2810		2140	1940	1159	898	560
5095	3228	3652	3345	3000				1985	1183	916	560
5096	3194	3620	3350	2973	2845	2585	2224	1925	1135	870	510
5097	3179	3602	3335	3043	2912	2610	2215	1895	1103	840	512
5098	3188	3625	3350	2965	2845	2633	2236	1928	1140	877	550
5099	3217	3655	3370	3018	2900	2640	2270	1975	1182	918	510
5100	3232	3685	3395	3040	2925	2680	2295	1982	1220	953	495
5101	3187	3621	3323	3028	2905	2660	2270	1950	1153	883	555
5102	3193	3640	3370	3055	2928	2675	2290	1962	1152	887	522
5103	3361	3848	3592	3220	3115	2880	2510	2230	1480	1216	735
5104	3330	3755	3495	3150				2124	1370	1105	610
5105	3336	3775	3510	3190	3080	2852	2430	2146	1393	1133	688
5106	3322	3760	3493	3170	3055	2810	2426	2112	1360	1092	595

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5107	3336	3778	3514	3170	3058	2812	2410	2140	1380	1115	628
5109	3321	3765	3540			2760	2400	2105	1350	1084	584
5110	3344	3775	3515	3140	3032	2790	2421	2150	1384	1120	630
5111	3238	3685	3423			2500	2220	2009	1245	906	600
5112	3228	3675	3282	3069	2955	2675	2235	2001	1228	958	640
5113	3300	3738	3478	3180	3090	2780	2420	2086	1321	1145	555
5114	3305	3748	3468	3260	3080	2797	2435	2080	1322	1057	560
5115	3187	3635	3370	3037	2926	2660	2270	1950	1150	874	560
5116	3327	3835	3582	3235	3108	2895	2405	2110	1308	1035	535
5117	3339	3857	3610	3255	3152	2920	2470	2262	1382	1102	615
5118	3327	3840			3120	2890	2560	2282	1350	1062	555
5119	3324	3823	3580	3240	3100	2900	2350	2286	1335	1054	548
5120	3324	3795	3552	3203	3100	2890	2445	2250	1335	1065	580
5121	3345	3853				3142	2540	2273	1365	1082	585
5122	3221	3665	3400	3064	2955	2722	2333	2000	1225	960	600
5123	3327	3807						2230	1320	1150	545
5124	3391	3904	3657	3315	3210	2995	2565	2340	1489	1208	710
5125	3362	3971	3625	3270	3165	2984	2510	2280	1416	1140	650
5126	3425	3906	3647	3322	3217	3014	2576	2445	1563	1270	790
5127	3315	3840	3654	3285	3181	2964	2495	2300	1328	1148	535
5128	3318	3795		3110	3000			2045	1220	968	486

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5129	3311	3894					2525	2260	1285	1020	508
5130	3137	3495	3265	2978	2880	2680		2050	1028	714	385
5131	3290	3867	3635	3240	3142	2884	2286	2280	1232	956	475
5132	3530	4500	4262	3965	3865	3650	3080	2972	2017	1737	1200
5133	3492	4453	4218	3905	3803	3584	3070	2910	1919	1645	1117
5134	3372	4180	3945	3558	3454	3226	2690	2563	1588	1310	795
5135	3366	4150	3962	3570	3470	3250	2748	2588	1595	1305	760
5136	3352	4030	3846	3562	3460	3245	2714	2610	1570	1278	750
5137	3362	4095	3858	3570	3468	3262	2730	2560	1580	1290	712
5138	3357	4126	3892	3528	3426	3207	2682	2554	1570	1286	766
5139	3372	4160	3927	3552	3450	3220	2800	2637	1587	1308	778
5140	3372	4131	3895	3580	3475	3260	2605	2563	1604	1316	782
5141	3322	4115	3878	3535	3432	3230	2680	2540	1554	1270	740
5142	3317	4015	3782	3490	3390	3167	2620	2565	1510	1219	675
5143	3322	4430	3797	3520	3420	3145		2463	1525	1234	690
5144	3327	4080	3843	3530	3428	3206	2590	2510	1535	1246	720
5145	3329	4482	3850	3530	3430	3212	2685	2522	1540	1251	725
5146	3360	4115						2535	1553	1266	725
5147	3327	3953									
5148	3339	4034							1472	1197	670
5149	3327	3934	3696	3315	3210	2975	2555	2424	1403	1106	585

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5150	3332	3908	3668	3348	3242	3008	2570	2381	1382	1100	570
5151	3338	3970	3735	3425	3315	3085	2595	2405	1442	1155	630
5152	3330	3954	3712	3399	3295	3054	2595	2386	1429	1138	612
5153	3453	4430	4185	3840	3730	3500	3030	2790	1872	1600	1070
5154	3517	4508	4268	3945	3840	3620	3197	2891	1976	1705	1125
5155	3494	4475	4233	3905	3797	3550	3150	2852	1949	1676	1145
5158	3664	4736	4215	3970	3780	3530	3390	2877	2112	1812	1250
5159	3678	4815	4445	3900	3612	3345	2862	2770	2075	1817	1301
5160	3644	4861	4517	3594	3400	3196	3025	2753	2032	1775	1276
5161	3725	4785	4431	3918	3680	3458	3368	3074	2159	1856	1295
5162	3742	4775	4448	4155	4027	3990	3460	3267	2176	1830	1235
5163	3756	4789	4462	4372	4350	4338	3612	3240	2134	1845	1307
5164	3766	4777	4471	4340	4195	3955	3637	3280	2118	1840	1308
5165	3731	4780	4450				3600	3320	2140	1840	1292
5166	3745	4760	4430	4224			3563	3192	2185	1870	1300
5167	3749	4768	4452	3766	3508	3283	3047	2763	2001	1756	1240
5168	3796	4841	4494	3740	3585	3283	3050	2728	1974	1718	1201
5169	3771	4820		3920	3745	3280	3000	2713	1982	1730	1220
5170	3803	4854	4557	3990	3783	3272	3050	2744	1986	1736	1223
5171	3746	4778	4420	3840	3680	3388	3137	2790	1978	1718	1202
5173	3718	4760	4450	4226	4052	3690	3560	2866	2020	1754	1236

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5174	3743	4782	4460	3870	3682	3305	3124	2784	1980	1723	1205
5175	3733	4783	4455	3847	3690	3396	3135	2784	1976	1716	1195
5176	3780	4817	4483	3795	3636	3335	3102	2780	1975	1712	1190
5177	3754	4784	4415	3910	3753	3470	3185	2815	1992	1726	1206
5179	3717	4751		3985	3825	3500	3205	2860	2020	1754	1228
5180	3744	4774	4462	3984	3820	3448	3176	2820	1982	1704	1182
5181	3708	4715	4420	4000	3840	3520	3194	2878	2012	1745	1212
5182	3783	4812	4495	4112	3929	3497	3228	2855	1996	1719	1193
5183	3761	4760	4455	4047	3875	3474	3210	2855	1976	1702	1166
5184	3795	4845	4500	3755	3612	3414	3075	2748	1956	1693	1173
5185	3701	4740	4441	4055	3912	3606	3280	2900	1996	1718	1200
5186	3727	4722	4424	4000	3866	3563	3215	2882	2003	1701	1170
5188	3727	4685	4455	3990	3845	3540	3222	2840	1982	1700	1178
5189	3646	4564	4268	3807	3670	3427	3090	2733	1940	1670	1158
5190	3726	4620	4370	4010	3900	3552	3208	2837	2010	1732	1210
5191	3640	4724	4440	4000	3856	3540	3180	2874	2040	1770	1440
5192	3678	4692	4393	4060	3905	3620	3215	2920	2075	1810	1280
5193	3709	4720	4413	4030	3872	3598	3288	2906	2041	1776	1255
5194	3702	4732	4423	4018	3860	3607	3286	2910	2058	1790	1255
5195	3687	4720	4410	3982	3815	3540	3250	2895	2067	1795	1265
5196	3709	4722	4415	4168	3987	3605	3325	2960	2080	1815	1274

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5197	3709	4754	4433	3910	3752	3460	3187	2833	2016	1754	1230
5198	3703	4760	4455	3965	3803	3605	3245	2955	2103	1850	1333
5199	3740	4806	4490	3926	3793	3450	3130	2909	2087	1830	1317
5200	3758	4834	4515	4331			3665	2975	2105	1836	1320
5201	3773	4845	4522	4280	4180	3950	3410	3148	2156	1870	1332
5202	3762	4833	4421	4240	4140	3940	3620	3245	2195	1890	1330
5203	3763	4835	4518	4340	4170	4130	3628	3025	2106	1833	1315
5204	3767	4818	4497	4428	4280	4030	3642	3110	2111	1840	1315
5206	3732	4802	4488	4380			3337	2952	2097	1833	1320
5208	3793	4903	4593	4100	3984	3650	3385	3060	2250	1993	1463
5209	3747	4802	4495	3983	3816	3540	3270	2966	2170	1923	1410
5210	3723	4815	4521	4132	3985	3715	3368	3088	2271	2023	1495
5211	3694	4755	4452	4028	3874	3553	3255	2928	2106	1860	1393
5212	3653	4672	4390	3985	3855	3582	3195	2957	2140	1902	1385
5214	3671	4720	4430	4065	3923	3630	3268	2976	2143	1902	1380
5216	3637	4626	4386	3993	3850	3610	3210	2916	2080	1822	1285
5217	3538	4580	4317	3975	3856	3586	3080	2978	2080	1780	1292
5218	3540	4575	4313	3972	3853	3583	3080	2977	2074	1782	1243
5219	3501	4520	4258	3910	3800	3575	3055	2869	1963	1704	1174
5220	3550	4582	4316	3997	3877	3650	3180	2959	2085	1814	1280
5221	3696	4755	4475	4150	4010	3754	3388	3106	2282	2020	1495

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5223	3703	4774	4495	4204	4068	3830	3425	3137	2324	2065	1535
5224	3723	4794	4510	4158	4010	3773	3400	3136	2316	2061	1586
5226	3726	5008	4712	4406	4276	4000	3590	3280	2483	2228	1707
5227	3571	5092	4758	4245	4083	3764	3426	3039	2190	1910	1365
5228	3566	5070	4675	4255	4080	3560	3135	2753	1990	1725	1230
5229	3696	4835	4573	4134	3967	3643	3387	3056	2220	1902	1440
5230	3746	4927	4617	4232	4073	3752	3255	3107	2290	2035	1515
5231	3681	4886	4581	4045	3885	3673	3376	3051	2206	1932	1410
5232	3645	4823	4185	4050	3856	3314	3108	2805	2030	1757	1230
5233	3719	4883	4555	4320	4150	3865	3518	2890	2080	1805	1304
5234	3652	4813	4448	4105	3885	3785	3425	2830	2050	1705	1240
5235	3640	4852	4493	4350	3805	3210	2855	2709	2070	1795	1260
5236	3643	4585					3560	3223	2492	2200	1632
5237	3630	4840	4475	3908	3650	3290	3100	2852	2152	1786	1260
5238	3632	4770					3595	3104	2386	2112	1557
5239	3614	4772	4475				3845	2908	2195	1900	1340
5240	3631	4760	4356				3052	2992	2185	1845	1240
5241	3680	4754	4490	4220	4050	3885	3700	3360	2520	2230	1656
5242	3661	4985					3408	3187	2490	2245	1720
5243	3659	4932					3345	3190	2472	2097	1650
5244	3661	4633	4150	3750			3525	3205	2490	2202	1685

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5245	3754	4950	4665	4325	4200	3966	3555	3346	2482	2224	1702
5246	3727	4875	4606	4167	4043	3765	3400	3166	2327	2083	1585
5247	3691	4762	4505	4166	4050	3795	3550	3140	2222	2015	1500
5248	3542	4560	4312	4075	3890	3672	3223	2940	2020	1765	1243
5249	3552	4568	4315	3985	3875	3648	3165	2948	2035	1775	1250
5250	3699	4774	4520	4280	4173	4025	3480	3240	2300	2052	1546
5251	3697	4790	4535	4195	4092	3897	3372	3271	2290	2040	1541
5252	3736	4900	4635	4338	4218	3976	3550	3306	2442	2180	1655
5253	3750	4955	4690	4450	4300		3182		3182	2208	1693
5254	3735	4925	4660	4320	4205	3972	3540	3360	2432	2127	1665
5255	3740	4930	4655	4343	4228	4000	3540	3335	2460	2206	1690
5256	3732	4950	4697	4377	4267	4045	3565	3370	2470	2207	1700
5257	3711	5090	4795	4360	4237	4040	3630	3315	2495	2238	1710
5258	3636	5112	4820	4628	4430	3995	3586	3263	2450	2184	1655
5259	3704	5030	4748	4408	4288	4056	3655	3395	2550	2300	1772
5260	3734	4980	4705	4370	4245	4008	3623	3332		2322	1800
5261	3722	5022	4756	4440	4326	4075	3655	3436	2583	2272	1760
5262	3728	5076	4803	4482	4362	4126	3710	3450	2593	2325	1803
5263	3616	5107	4820					3272	2422	2152	1620
5264	3835							3070		2471	1993
5265	3780	4708	4337	3750			3241	2585	1852	1417	1090

idnum	refelev	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5266	3734	4680	4215	3961			3400	2720	1935	1656	1130
5267	3771	4743	4336	4100			3550	2685	1852	1591	1082
5268	3758	4804	4570	4240			3730	2825	1970	1682	1140
5269	3707	4730	4350	3980			3576	3060	2130	1837	1290
5270	3687	4650					3500	3238	2490	2003	1430
5271	3685	4721						3132	2162	1875	1310
5272	3691	4547	4178	3780			3302	2490	1803	1530	1038
5273	3687	4530	4192	3685	3395	3115	2982	2541	1790	1507	1000
5274	3619	4497	4182	3462	3302	3020	2792	2460	1720	1458	946
5275	3659	4520	4172	3780	3680		2730	2315	1786	1505	994
5276	3662							2533	1788	1507	1000
5277	3705	4538	4080	4080	3840	3540	3055	2683	1953	1680	1167
5278	3697	4610	4300				3418	3108	2168	1891	1350
5279	3723	4385	3980			3540	3400	3061	2260	1985	1444
5280	3709	4615					3604	2827	1985	1718	1208
5301	3281										
5302	3214	3560	3280	2910	2790	2603	2133	1810	1060	798	484
5303	3267	3675	3355	2938	2823	2682	2340	1952	1190	932	578
5304	3675	4500	4108	3480	3390	3280	2960	2583	1795	1518	1024
5305	3553	4250	3812	3612			2803	2402	1606	1336	855
5306	3515	4204	3778	3765	3150	3042	2724	2228	1550	1300	828

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5307	3629	4494	4166	3335	3161	2932	2755	2435	1711	1445	948
5308	3590	4406	4076	3288	3129	2808		1810	1610	1373	898
5309	3929								2790	2550	2060
5310	3640							2838	2104	1826	1333
5311	3661										
5312	3679							3017	2258	1970	1455
5313	3712	4538					3405	3087	2244	1960	1420
5314	3736	4740						3070	2348	2070	1538
5315	3735							3150	2422	2121	1556
5316	3712	4674	4292	4130	4010	3700	3447	3120	2202	1929	1370
5317	3768	4645						2560	1857	1587	1088
5318	3435	3265	2986	2386	2248	1960	1630	1350			620
5319	3304	2980	2710	2480	2343			1120			500
5320	3330	3170									
5321	3268	2930									
5322			3520	3122	3022	2770	2400	2132	1367	1108	610
5323	3359	3820	3559	3226	3083	2884	2503	2190	1444	1188	702
5324	3309	3752	3436				2430	2138	1308	1018	530
5325	3310	3803	3562	3107	3000	2803	2369	2175	1273	1009	512
5326	3584	4419	4122	3736	3560	3220	2895	2535	1672	1404	898
5327	3572	4380	4082	3610	3440	3090	2723	2475	1635	1367	890

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5328	3588	4438	4140	3550	3394	3148	2920	2537	1712	1438	930
5329	3544	4310	4026	3600	3466	3170	2865	2520	1715	1446	960
5330	3569	4397	4102	3732	3489	3150	2945	2640	1666	1403	922
5331	3562	4393	4093	3680	3502	3200	2900	2487	1632	1367	886
5332	3545	4316	4025	3639	3504	3157	2880	2534	1692	1427	940
5333	3537	4328	4033	3574	3439	3164	2885	2520	1700	1438	947
5334	3564	4413	4120	3540	3404	3105	2856	2514	1680	1428	950
5335		3880						2162	1442	1190	710
5336	3378	3875	3616	3302	3190	2945	2568	2272	1513	1252	763
5337	3579	4427	4146	3693	3564	3267	2975	2610	1827	1563	1079
5338	3599	4455	4170	3688	3555	3335	3025	2650	1832	1567	1078
5339	3590	4446	4162	3700	3560	3135	2883	2548	1747	1485	990
5340	3592	4453	4175	3790	3660	3392	3003	2706	1910	1645	1140
5341	3622	4493	4220	3882	3754	3510	3075	2758	1957	1690	1173
5342	3496										
5343	3596	4455	4188	3865	3743	3480	3096	2823	2000	1715	1190
5344	3585	4472	4200	3856	3740	3495	3080	2827	2000	1710	1189
5345	3807	4851	4321	4073	3890	3503	3082	2565	1837	1583	1070
5346	3809	4852	4482	4000	3686	3280	2830	2614	1858	1591	1080
5347	3816	4820	4437	4437	4240	3734	3268	2790	1955	1645	1080
5348	3730	4665	4320	3380	3247		2918	2558	1792	1502	980

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5349	3625	4514	4210	3858	3693	3226	2989	2612	1778	1500	980
5350	3619	4478	4170	3727	3495	3045	2845	2500	1724	1454	947
5351	3655	4555	4222	3550	3371	3115	2898	2546	1740	1450	935
5352	3656	4585	4283	3840	3700	3393	3090	2720	1898	1628	1119
5353	3806	4865	4516	4124							
5354	3805	4838	4485	4025	3760	3270	2986	2605	1884	1625	1105
5355	3818	4860	4523	3614	3458	3157	2954	2647	1902	1650	1130
5356	3806	4855	4500			3475	3065	2588	1898	1650	1140
5357	3810	4846	4480	4020	3838	3554	3210	2600	1872	1631	1112
5358	3805	4842									
5359	3759	4827									
5360	3746	4795	4446	3960	3860	3560	3250	3003	2060	1860	1317
5361	3749	4805	4474	4206	4100	3800	3490	3302	2265	1946	1345
5362	3760	4842	4510	4305	4218	3995	3610	3220	2295	1941	1350
5363	3718	4787	4422	3950	3900	3670	3427	3198	2170	1845	1250
5364	3751	4788	4452	4137	4057	3790	3486	3176	2251	1913	1318
5365	3719	4755	4439	3875	3700	3371	3112	2782	1992	1731	1215
5366	3716	4740	4432	3903	3747	3430	3146	2791	2003	1738	1220
5367	3696	4700	4408	4178	4027	3556	3177	2874	2032	1750	1230
5368	3620	4640	4366	4000	3869	3588	3180	2857	2041	1768	1243
5369	3708	4730	4420	3950	3830	3480	3130	2838	2022	1753	1228

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5370	3711	4757	4438	4340	4020	3530	3113	2873	2093	1831	1318
5371	3688	4743	4433	4160	3990	3756	3445	3030	2104	1842	1320
5372	3757	4818	4510	4312	4130	3880	3590	3278	2161	1875	1310
5373	3759	4822	4514	4239	4148		3566	2927	2082	1824	1315
5374	3748	4803	4497	3910	3737	3470	3200	2924	2159	1904	1386
5375	3739	4796	4482	3750	3616	3240	2970	2870	2091	1823	1314
5376	3718	4790	4490	3810	3692	3420	3195	2866	2100	1850	1344
5377	3729	4803	4364	4070	3930	3396	3130	2908	2093	1834	1324
5378	3753	4826	4507	4000	3830	3410	3180	2880	2084	1829	1315
5380	3764	4854	4493	4222	4077	3818	3480	3150	2364	2117	1600
5381	3777	4900	4600	4220	4076	3810	3410	3154	2372	2118	1603
5382	3789	4922						3070	2244	1988	1461
5383	3694	4749	4454	3973	3820	3540	3212	2947	2155	1902	1382
5384	3684	4754	4194	4050	3900	3646	3330	2990	2182	1936	1412
5385	3672	4712	4418	3940	3800	3553	3246	2922	2113	1858	1332
5386	3676	4720	4420	3940	3787	3398	3212	2896	2110	1857	1320
5387	3684	4747	4460	4094	3950	3705	3410	3052	2208	1962	1444
5389	3642	4640	4347	4024	3873	3594	3210	2922	2093	1821	1290
5390	3666	4680	4400	4037	3908	3670	3283	3020	2200	1945	1428
5391	3683	4734	4460	4167	4030	3790	3400	3100	2283	2023	1492
5392	3686	4737	4455	4100	3960	3706	3324	3060	2250	1996	1480

idnum	refelev *	topBC	topA1	topH1	topA2	topH2	topA3	baseCow	base124	baseVT	baseRus
5393	3739	4827	4545	4252	4123	3892	3496	3185	2388	2122	1602
5394	3777	4883	4554	4185	4040		3466	3164	2377	2128	1608
5395	3773	4920	4620	4270	4124	3856	3470	3188	2390	2141	1614
5396	3761	4876	4592	4240	4100	3832	3420	3192	2400	2162	1648
5397	3766	4907	4610	4262	4120	3840	3526	3172	2378	2134	1612
5398	3645	4770					3535	3230	2441	2150	1580
5399	3572	4935					3816	2950	2270	2008	1476
5400	3572	4878					3774	3279	2400	2091	1508
5401	3664	4875	4575	4315	4124	3943	3510	2938	2114	1852	1330
5402	3587	5015	4690	3992	3830	3581	3276	2986	2168	1890	1340
5403	3773	4860	4540	3950	3771	3474	3260	2964	2192	1930	1415
5404											
5405											
5406											
5407											
5408											

*The source data table and this report were created by Dennis W. Powers using Rbase 5.5, a commercial relational database available from Microrim, Inc. Reference elevations and depths to stratigraphic horizons are given in feet. The relational column within the database is the idnum, an identifier unique to the drillhole. Data were checked corrected with checkprints.

Appendix C

Structural Elevation Data for

Drillholes with Geophysical Data

Dennis W. Powers

Structure Data - Brine Reservoir Area

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
1104	-760		807	985	1139		1249	2015	2253	2729
1149	-653	-391	-383			335	748	1680	1962	2457
1150		-124	-73	47	1015	1096	1197	1751	2005	2475
1153	-774	-497	-155	-14	251	561	979	1794	2057	2551
1158		-404	-310	-221	-102	446	896	1772	2058	2559
1159		-430	81	190	418	746	1013	1769	2037	2518
1168						584	857	1767	2053	2560
1175		-559	-235	-127	98	536	796	1688	1983	2496
1243	-717	-482	-152	-45	173	624	893	1847	2144	2675
5000	-878	-581	24	162	489	717	1079	1869	2145	2662
5002	-843	-553	225	385	570	787	1103	1889	2154	2668
5004	-840	-540	140	303	560	835	1063	1951	2162	2659
5005	-855	-558	-36	120	497	723	1051	1879	2157	2666
5006	-886	-591	4	142	406	648	1022	1858	2136	2657
5007	-854	-556	-75	78	392	678	1015	1890	2159	2650
5008	-870	-574	-67	58	513	773	1123	1886	2148	2635
5009	-855	-560	-20	125	349	608	993	1870	2143	2634
5010	-875	-582	-8	117	455	702	1025	1848	2127	2622
5011	-871	-563	-336	54	499	704	1074	1874	2149	2659
5012	-880	-584	-51	109	444	667	1023	1853	2131	2687

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5014	-834	-540	-246	-100	294	626	991	1871	2148	2642
5015	-880	-595	-167	-35	244	633	917	1725	1999	2489
5016	-876	-589	-113	36	289	659	955	1761	2033	2424
5019	-863	-570	-123	20	389	672	1019	1812	2077	2567
5020	-870	-577	-7	135	415	780	1072	1852	2108	2588
5021	-885	-603	-189	-52		590	943	1755	2029	2530
5022	-877	-583	-68	65	432	732	1067	1818	2081	2567
5023	-881	-586	-471	72	267	887	987	1863	2117	2597
5024	-870	-590	-429	-260	280	665	945	1759	2035	2535
5025	-859	-575	-88	58	210	606	942	1799	2071	2568
5027	-928	-592	-88	57	302	592	962	1762	2039	2544
5028	-878	-513	-253	-108	209	597	913	1717	1986	2502
5029	-884	-614	-214	-129	199	563	881	1671	1946	2473
5030	-867	-529	-279	-129	82	421	833	1738	1926	2449
5032	-880	-603	-158	-28	254	648	920	1704	1975	2477
5033	-886	-664	-234	-111	206	543	878	1682	1959	2458
5034	-876	-599	-276	-157	99	509	849	1661	1941	2449
5035	-872	-592	-200	-72	187	572	895	1693	1966	2463
5036	-876	-591	-266	-141	144	544	864	1674	1955	2456
5037	-872	-591	-148	-18	287	599	944	1716	1990	2480
5038	-883	-618	-263	-141	128	522	772	1602	1889	2407

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5039	-870	-550	-273	-149	130	518	790	1625	1912	2422
5040	-849	-582	-230	-104	166	673	832	1653	1933	2441
5041	-867	-592	-214	-104	196	583	875	1674	1949	2456
5042	-882						918		1889	2397
5043	-863	-589	-270	-140	151	544	856	1657	1928	2448
5044	-865						777		1890	2409
5045	-895	-614	-253	-130	160	572	840	1635	1910	2433
5046	-911	-639	-329	-214	26	451	720	1631	1850	2378
5047	-922	-647	-287	-168	-77		746	1657	1858	2384
5048	-863	-513	-281	-157	116	517	843	1645	1918	2438
5049	-851						752		1880	2402
5050	-864	-602	-329	-210	26		736		1879	2403
5051	-891	-629	-279	-159	101	513	768	1610	1900	2414
5052	-872	-617	-234	-144	128	541	790	1641	1922	2432
5053	-880	-619	-275	-55	240	510	762	1600	1892	2408
5054	-884	-624	-280	-166	73	576	776	1635	1922	2436
5055	-879	-617	-289	-174	76	526	761	1610	1900	2409
5056	-973	-684	-338	-228	22	452	718	1600	1875	2400
5057	-974	-722	-392	-280			653	1556	1831	2361
5058	-219								2304	2709
5059	-230								2461	2759

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5060	-238	108			645	1200	1500	2175	2445	2805
5061	-356						1017			2785
5062	-335	-58	386	518	869	1177	1529	2299	2586	2805
5063	-343	-61	406	536	756	1056	1412	2203	2479	2824
5064	-409	-72	218	298	733	998	1292	2088	2366	2713
5065	-382	-83	374	505	715	1028	1375	2155	2421	2758
5066	-411								2326	2662
5068	-866	-489	11	136	486	1151	1211	1906	2171	2681
5069	-815	-448	-18		432	622	1186	1911	2187	2690
5070	-838	-503					1187	1922	2186	2669
5071	-827	-557	160	330	623	808	1148	1897	2170	2673
5072	-838	-521	294	464	698	868	1159	1899	2168	2664
5073	-807	-498	-473	-211	227	502	1237	1977	2222	2672
5075	-827	-517	-132	108	408	642		1941	2188	2676
5076	-850	-534	131	304	501	739	1061	1895	2173	2676
5079	-713	-375	-340	-100	85	478	890	1703	1980	2490
5080	-708					485	890	1705	1979	2485
5081	-793	-418	-103	17	382	782	1012	1765	2037	2537
5082	-809	-511	-321	-71	386	691	952	1799	2081	2589
5084	-458	-192	162	272	542	897	1208	1946	2202	2696
5085	-473	-201	69	199	619	919	1233	1979	2246	2737

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5086	-441								2245	2732
5087	-433	-188	112	162		722	1296	2047	2304	2769
5088	-861					790	1108	1880	2152	2665
5089	-458	-181	214	324	614	974	1244	2010	2274	2754
5090	-446	-176	244	357	596	940	1239	1982	2241	2732
5091	-341	-65	203		673	1068	1378	2163	2438	2768
5092	-437	-163	189	323	570	1037	1254	2037	2300	2627
5093	-446			259	504	964	1244	2042	2324	2642
5094	-426	-128	297	422		1092	1292	2073	2334	2672
5095	-424	-117	228				1243	2045	2312	2668
5096	-426	-156	221	349	609	970	1269	2059	2324	2684
5097	-423	-156	136	267	569	964	1284	2076	2339	2667
5098	-437	-162	223	343	555	952	1260	2048	2311	2638
5099	-438	-153	199	317	577	947	1242	2035	2299	2707
5100	-453	-163	192	307	552	937	1250	2012	2279	2737
5101	-434	-136	159	282	527	917	1237	2034	2304	2632
5102	-447	-177	138	265	518	903	1231	2041	2306	2671
5103	-487	-231	141	246	481	851	1131	1881	2145	2626
5104	-425	-165	180				1206	1960	2225	2720
5105	-439	-174	146	256	484	906	1190	1943	2203	2648
5106	-438	-171	152	267	512	896	1210	1962	2230	2727

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5107	-442	-178	166	278	524	926	1196	1956	2221	2708
5109	-444	-219			561	921	1216	1971	2237	2737
5110	-431	-171	204	312	554	923	1194	1960	2224	2714
5111	-447	-185			738	1018	1229	1993	2332	2638
5112	-447	-54	159	273	553	993	1227	2000	2270	2588
5113	-438	-178	120	210	520	880	1214	1979	2155	2745
5114	-443	-163	45	225	508	870	1225	1983	2248	2745
5115	-448	-183	150	261	527	917	1237	2037	2313	2627
5116	-508	-255	92	219	432	922	1217	2019	2292	2792
5117	-518	-271	84	187	419	869	1077	1957	2237	2724
5118	-513			207	437	767	1045	1977	2265	2772
5119	-499	-256	84	224	424	974	1038	1989	2270	2776
5120	-471	-228	121	224	434	879	1074	1989	2259	2744
5121	-508				203	805	1072	1980	2263	2760
5122	-444	-179	157	266	499	888	1221	1996	2261	2621
5123	-480						1097	2007	2177	2782
5124	-513	-266	76	181	396	826	1051	1902	2183	2681
5125	-609	-263	92	197	378	852	1082	1946	2222	2712
5126	-481	-222	103	208	411	849	980	1862	2155	2635
5127	-525	-339	30	134	351	820	1015	1987	2167	2780
5128	-477		208	318			1273	2098	2350	2832

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5129	-583					786	1051	2026	2291	2803
5130	-358	-128	159	257	457		1087	2109	2423	2752
5131	-577	-345	50	148	406	1004	1010	2058	2334	2815
5132	-970	-732	-435	-335	-120	450	558	1513	1793	2330
5133	-961	-726	-413	-311	-92	422	582	1573	1847	2375
5134	-808	-573	-186	-82	146	682	809	1784	2062	2577
5135	-784	-596	-204	-104	116	618	778	1771	2061	2606
5136	-678	-494	-210	-108	107	638	742	1782	2074	2602
5137	-733	-496	-208	-106	100	632	802	1782	2072	2650
5138	-769	-535	-171	-69	150	675	803	1787	2071	2591
5139	-788	-555	-180	-78	152	572	735	1785	2064	2594
5140	-759	-523	-208	-103	112	767	809	1768	2056	2590
5141	-793	-556	-213	-110	92	642	782	1768	2052	2582
5142	-698	-465	-173	-73	150	697	752	1807	2098	2642
5143	-1108	-475	-198	-98	177		859	1797	2088	2632
5144	-753	-516	-203	-101	121	737	817	1792	2081	2607
5145	-1153	-521	-201	-101	117	644	807	1789	2078	2604
5146	-755						825	1807	2094	2635
5147	-626									
5148	-695							1867	2142	2669
5149	-607	-369	12	117	352	772	903	1924	2221	2742

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5150	-576	-336	-16	90	324	762	951	1950	2232	2762
5151	-632	-397	-87	23	253	743	933	1896	2183	2708
5152	-624	-382	-69	35	276	735	944	1901	2192	2718
5153	-977	-732	-387	-277	-47	423	663	1581	1853	2383
5154	-991	-751	-428	-323	-103	320	626	1541	1812	2392
5155	-981	-739	-411	-303	-56	344	642	1545	1818	2349
5158	-1072	-551	-306	-116	134	274	787	1552	1852	2414
5159	-1137	-767	-222	66	333	816	908	1603	1861	2377
5160	-1217	-873	50	244	448	619	891	1612	1869	2368
5161	-1060	-706	-193	45	267	357	651	1566	1869	2430
5162	-1033	-706	-413	-285	-248	282	475	1566	1912	2507
5163	-1033	-706	-616	-594	-582	144	516	1622	1911	2449
5164	-1011	-705	-574	-429	-189	129	486	1648	1926	2458
5165	-1049	-719				131	411	1591	1891	2439
5166	-1015	-685	-479			182	553	1560	1875	2445
5167	-1019	-703	-17	241	466	702	986	1748	1993	2509
5168	-1045	-698	56	211	513	746	1068	1822	2078	2595
5169	-1049		-149	26	491	771	1058	1789	2041	2551
5170	-1051	-754	-187	20	531	753	1059	1817	2067	2580
5171	-1032	-674	-94	66	358	609	956	1768	2028	2544
5173	-1042	-732	-508	-334	28	158	852	1698	1964	2482

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5174	-1039	-717	-127	61	438	619	959	1763	2020	2538
5175	-1050	-722	-114	43	337	598	949	1757	2017	2538
5176	-1037	-703	-15	144	445	678	1000	1805	2068	2590
5177	-1030	-661	-156	1	284	569	939	1762	2028	2548
5179	-1034		-268	-108	217	512	857	1697	1963	2489
5180	-1030	-718	-240	-76	296	568	924	1762	2040	2562
5181	-1007	-712	-292	-132	188	514	830	1696	1963	2496
5182	-1029	-712	-329	-146	286	555	928	1787	2064	2590
5183	-999	-694	-286	-114	287	551	906	1785	2059	2595
5184	-1050	-705	40	183	381	720	1047	1839	2102	2622
5185	-1039	-740	-354	-211	95	421	801	1705	1983	2501
5186	-995	-697	-273	-139	164	512	845	1724	2026	2557
5188	-958	-728	-263	-118	187	505	887	1745	2027	2549
5189	-918	-622	-161	-24	219	556	913	1706	1976	2488
5190	-894	-644	-284	-174	174	518	889	1716	1994	2516
5191	-1084	-800	-360	-216	100	460	766	1600	1870	2200
5192	-1014	-715	-382	-227	58	463	758	1603	1868	2398
5193	-1011	-704	-321	-163	111	421	803	1668	1933	2454
5194	-1030	-721	-316	-158	95	416	792	1644	1912	2447
5195	-1033	-723	-295	-128	147	437	792	1620	1892	2422
5196	-1013	-706	-459	-278	104	384	749	1629	1894	2435

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5197	-1045	-724	-201	-43	249	522	876	1693	1955	2479
5198	-1057	-752	-262	-100	98	458	748	1600	1853	2370
5199	-1066	-750	-186	-53	290	610	831	1653	1910	2423
5200	-1076	-757	-573			93	783	1653	1922	2438
5201	-1072	-749	-507	-407	-177	363	625	1617	1903	2441
5202	-1071	-659	-478	-378	-178	142	517	1567	1872	2432
5203	-1072	-755	-577	-407	-367	135	738	1657	1930	2448
5204	-1051	-730	-661	-513	-263	125	657	1656	1927	2452
5206	-1070	-756	-648			395	780	1635	1899	2412
5208	-1110	-800	-307	-191	143	408	733	1543	1800	2330
5209	-1055	-748	-236	-69	207	477	781	1577	1824	2337
5210	-1092	-798	-409	-262	8	355	635	1452	1700	2228
5211	-1061	-758	-334	-180	141	439	766	1588	1834	2301
5212	-1019	-737	-332	-202	71	458	696	1513	1751	2268
5214	-1049	-759	-394	-252	41	403	695	1528	1769	2291
5216	-989	-749	-356	-213	27	427	721	1557	1815	2352
5217	-1042	-779	-437	-318	-48	458	560	1458	1758	2246
5218	-1035	-773	-432	-313	-43	460	563	1466	1758	2297
5219	-1019	-757	-409	-299	-74	446	632	1538	1797	2327
5220	-1032	-766	-447	-327	-100	370	591	1465	1736	2270
5221	-1059	-779	-454	-314	-58	308	590	1414	1676	2201

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5223	-1071	-792	-501	-365	-127	278	566	1379	1638	2168
5224	-1071	-787	-435	-287	-50	323	587	1407	1662	2137
5226	-1282	-986	-680	-550	-274	136	446	1243	1498	2019
5227	-1521	-1187	-674	-512	-193	145	532	1381	1661	2206
5228	-1504	-1109	-689	-514	6	431	813	1576	1841	2336
5229	-1139	-877	-438	-271	53	309	640	1476	1794	2256
5230	-1181	-871	-486	-327	-6	491	639	1456	1711	2231
5231	-1205	-900	-364	-204	8	305	630	1475	1749	2271
5232	-1178	-540	-405	-211	331	537	840	1615	1888	2415
5233	-1164	-836	-601	-431	-146	201	829	1639	1914	2415
5234	-1161	-796	-453	-233	-133	227	822	1602	1947	2412
5235	-1212	-853	-710	-165	430	785	931	1570	1845	2380
5236	-942					83	420	1151	1443	2011
5237	-1210	-845	-278	-20	340	530	778	1478	1844	2370
5238	-1138					37	528	1246	1520	2075
5239	-1158	-861				-231	706	1419	1714	2274
5240	-1129	-725				579	639	1446	1786	2391
5241	-1074	-810	-540	-370	-205	-20	320	1160	1450	2024
5242	-1324					253	474	1171	1416	1941
5243	-1273					314	469	1187	1562	2009
5244	-972	-489	-89			136	456	1171	1459	1976

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5245	-1196	-911	-571	-446	-212	199	408	1272	1530	2052
5246	-1148	-879	-440	-316	-38	327	561	1400	1644	2142
5247	-1071	-814	-475	-359	-104	141	551	1469	1676	2191
5248	-1018	-770	-533	-348	-130	319	602	1522	1777	2299
5249	-1016	-763	-433	-323	-96	387	604	1517	1777	2302
5250	-1075	-821	-581	-474	-326	219	459	1399	1647	2153
5251	-1093	-838	-498	-395	-200	325	426	1407	1657	2156
5252	-1164	-899	-602	-482	-240	186	430	1294	1556	2081
5253	-1205	-940	-700	-550		568		568	1542	2057
5254	-1190	-925	-585	-470	-237	195	375	1303	1608	2070
5255	-1190	-915	-603	-488	-260	200	405	1280	1534	2050
5256	-1218	-965	-645	-535	-313	167	362	1262	1525	2032
5257	-1379	-1084	-649	-526	-329	81	396	1216	1473	2001
5258	-1476	-1184	-992	-794	-359	50	373	1186	1452	1981
5259	-1326	-1044	-704	-584	-352	49	309	1154	1404	1932
5260	-1246	-971	-636	-511	-274	111	402		1412	1934
5261	-1300	-1034	-718	-604	-353	67	286	1139	1450	1962
5262	-1348	-1075	-754	-634	-398	18	278	1135	1403	1925
5263	-1491	-1204					344	1194	1464	1996
5264							765		1364	1842
5265	-928	-557	30			539	1195	1928	2363	2690

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5266	-946	-481	-227			334	1014	1799	2078	2604
5267	-972	-565	-329			221	1086	1919	2180	2689
5268	-1046	-812	-482			28	933	1788	2076	2618
5269	-1023	-643	-273			131	647	1577	1870	2417
5270	-963					187	449	1197	1684	2257
5271	-1036						553	1523	1810	2375
5272	-856	-487	-89			389	1201	1888	2161	2653
5273	-843	-505	2	292	572	705	1146	1897	2180	2687
5274	-878	-563	157	317	599	827	1159	1899	2161	2673
5275	-861	-513	-121	-21		929	1344	1873	2154	2665
5276							1129	1874	2155	2662
5277	-833	-375	-375	-135	165	650	1022	1752	2025	2538
5278	-913	-603				279	589	1529	1806	2347
5279	-662	-257			183	323	662	1463	1738	2279
5280	-906					105	882	1724	1991	2501
5301										
5302	-346	-66	304	424	611	1081	1404	2154	2416	2730
5303	-408	-88	329	444	585	927	1315	2077	2335	2689
5304	-825	-433	195	285	395	715	1092	1880	2157	2651
5305	-697	-259	-59			750	1151	1947	2217	2698
5306	-689	-263	-250	365	473	791	1287	1965	2215	2687

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5307	-865	-537	294	468	697	874	1194	1918	2184	2681
5308	-816	-486	302	461	782		1780	1980	2217	2692
5309								1139	1379	1869
5310							802	1536	1814	2307
5311										
5312							662	1421	1709	2224
5313	-826					307	625	1468	1752	2292
5314	-1004						666	1388	1666	2198
5315							585	1313	1614	2179
5316	-962	-580	-418	-298	12	265	592	1510	1783	2342
5317	-877						1208	1911	2181	2680
5318	170	449	1049	1187	1475.	1805	2085			2815
5319	324	594	824	961			2184			2804
5320	160									
5321	338									
5322										
5323	-461	-200	133	276	475	856	1169	1915	2171	2657
5324	-443	-127				879	1171	2001	2291	2779
5325	-493	-252	203	310	507	941	1135	2037	2301	2798
5326	-835	-538	-152	24	364	689	1049	1912	2180	2686
5327	-808	-510	-38	132	482	849	1097	1937	2205	2682

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5328	-850	-552	38	194	440	668	1051	1876	2150	2658
5329	-766	-482	-56	78	374	679	1024	1829	2098	2584
5330	-828	-533	-163	80	419	624	929	1903	2166	2647
5331	-831	-531	-118	60	362	662	1075	1930	2195	2676
5332	-771	-480	-94	41	388	665	1011	1853	2118	2605
5333	-791	-496	-37	98	373	652	1017	1837	2099	2590
5334	-849	-556	24	160	459	708	1050	1884	2136	2614
5335										
5336	-497	-238	76	188	433	810	1106	1865	2126	2615
5337	-848	-567	-114	15	312	604	969	1752	2016	2500
5338	-856	-571	-89	44	264	574	949	1767	2032	2521
5339	-856	-572	-110	30	455	707	1042	1843	2105	2600
5340	-861	-583	-198	-68	200	589	886	1682	1947	2452
5341	-871	-598	-260	-132	112	547	864	1665	1932	2449
5342										
5343	-859	-592	-269	-147	116	500	773	1596	1881	2406
5344	-887	-615	-271	-155	90	505	758	1585	1875	2396
5345	-1044	-514	-266	-83	304	725	1242	1970	2224	2737
5346	-1043	-673	-191	123	529	979	1195	1951	2218	2729
5347	-1004	-621	-621	-424	82	548	1026	1861	2171	2736
5348	-935	-590	350	483		812	1172	1938	2228	2750

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5349	-889	-585	-233	-68	399	636	1013	1847	2125	2645
5350	-859	-551	-108	124	574	774	1119	1895	2165	2672
5351	-900	-567	105	284	540	757	1109	1915	2205	2720
5352	-929	-627	-184	-44	263	566	936	1758	2028	2537
5353	-1059	-710	-318							
5354	-1033	-680	-220	45	535	819	1200	1921	2180	2700
5355	-1042	-705	204	360	661	864	1171	1916	2168	2688
5356	-1049	-694			331	741	1218	1908	2156	2666
5357	-1036	-670	-210	-28	256	600	1210	1938	2179	2698
5358	-1037									
5359	-1068									
5360	-1049	-700	-214	-114	186	496	743	1686	1886	2429
5361	-1056	-725	-457	-351	-51	259	447	1484	1803	2404
5362	-1082	-750	-545	-458	-235	150	540	1465	1819	2410
5363	-1069	-704	-232	-182	48	291	520	1548	1873	2468
5364	-1037	-701	-386	-306	-39	265	575	1500	1838	2433
5365	-1036	-720	-156	19	348	607	937	1727	1988	2504
5366	-1024	-716	-187	-31	286	570	925	1713	1978	2496
5367	-1004	-712	-482	-331	140	519	822	1664	1946	2466
5368	-1020	-746	-380	-249	32	440	763	1579	1852	2377
5369	-1022	-712	-242	-122	228	578	870	1686	1955	2480

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5370	-1046	-727	-629	-309	181	598	838	1618	1880	2393
5371	-1055	-745	-472	-302	-68	243	658	1584	1846	2368
5372	-1061	-753	-555	-373	-123	167	479	1596	1882	2447
5373	-1063	-755	-480	-389		193	832	1677	1935	2444
5374	-1055	-749	-162	11	278	548	824	1589	1844	2362
5375	-1057	-743	-11	123	499	769	869	1648	1916	2425
5376	-1072	-772	-92	26	298	523	852	1618	1868	2374
5377	-1074	-635	-341	-201	333	599	821	1636	1895	2405
5378	-1073	-754	-247	-77	343	573	873	1669	1924	2438
5380	-1090	-729	-458	-313	-54	284	614	1400	1647	2164
5381	-1123	-823	-443	-299	-33	367	623	1405	1659	2174
5382	-1133						719	1545	1801	2328
5383	-1055	-760	-279	-126	154	482	747	1539	1792	2312
5384	-1070	-510	-366	-216	38	354	694	1502	1748	2272
5385	-1040	-746	-268	-128	119	426	750	1559	1814	2340
5386	-1044	-744	-264	-111	278	464	780	1566	1819	2356
5387	-1063	-776	-410	-266	-21	274	632	1476	1722	2240
5389	-998	-705	-382	-231	48	432	720	1549	1821	2352
5390	-1014	-734	-371	-242	-4	383	646	1466	1721	2238
5391	-1051	-777	-484	-347	-107	283	583	1400	1660	2191
5392	-1051	-769	-414	-274	-20	362	626	1436	1690	2206

IDNUM	Bell Cnyn	Top A1	Top H1	Top A2	Top H2	Top A3	Base Cwdn	Base MB124	Base VT	Base Rstlr
5393	-1088	-806	-513	-384	-153	243	554	1351	1617	2137
5394	-1106	-777	-408	-263		311	613	1400	1649	2169
5395	-1147	-847	-497	-351	-83	303	585	1383	1632	2159
5396	-1115	-831	-479	-339	-71	341	569	1361	1599	2113
5397	-1141	-844	-496	-354	-74	240	594	1388	1632	2154
5398	-1125					110	415	1204	1495	2065
5399	-1363					-244	622	1302	1564	2096
5400	-1306					-202	293	1172	1481	2064
5401	-1211	-911	-651	-460	-279	154	726	1550	1812	2334
5402	-1428	-1103	-405	-243	6	311	601	1419	1697	2247
5403	-1087	-767	-177	2	299	513	809	1581	1843	2358
5404										
5405										
5406										
5407										
5408										

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The source data table and this report were created by Dennis W. Powers using Rbase 5.5, a commercial relational database available from Microrim, Inc. Elevation data for each horizon is given in feet. The relational column within the database is the idnum, an identifier unique to the drillhole. Data were partially checked for basic computations and report setup.

Appendix D

Thickness (Isopach) Data for

Drillholes with Geophysical Data

Dennis W. Powers

Basic Stratigraphic Data - Isopachs *

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
1104	1		1567	1745	1899				2009		2775	3013	3489
1149	0	262	270					988	1401	1139	2333	2615	3110
1150	0					1139	1019			1321			
1153	0	277	619	760	1025	748	607	1335	1753	1476	2568	2831	3325
1158	0					302	213			1300			
1159	1					848	739			1443			
1168	0												
1175	0					657	549			1355			
1243	0	235	565	672	890	655	548	1341	1610	1375	2564	2861	3392
5000	0	297	902	1040	1367	1070	932	1595	1957	1660	2747	3023	3540
5002	0	290	1068	1228	1413	1123	963	1630	1946	1656	2732	2997	3511
5004	0	300	980	1143	1400	1100	937	1675	1903	1603	2791	3002	3499
5005	0	297	819	975	1352	1055	899	1578	1906	1609	2734	3012	3521
5006	0	295	890	1028	1292	997	859	1534	1908	1613	2744	3022	3543
5007	0	298	779	932	1246	948	795	1532	1869	1571	2744	3013	3504
5008	0	296	803	928	1383	1087	962	1643	1993	1697	2756	3018	3505
5009	0	295	835	980	1204	909	764	1463	1848	1553	2725	2998	3489

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5010	0	293	867	992	1330	1037	912	1577	1900	1607	2723	3002	3497
5011	0	308	535	925	1370	1062	672	1575	1945	1637	2745	3020	3530
5012	0	296	829	989	1324	1028	868	1547	1903	1607	2733	3011	3567
5014	1	294	588	734	1128	834	688	1460	1825	1531	2705	2982	3476
5015	0	285	713	845	1124	839	707	1513	1797	1512	2605	2879	3369
5016	0	287	763	912	1165	878	729	1535	1831	1544	2637	2909	3300
5019	0	293	740	883	1252	959	816	1535	1882	1589	2675	2940	3430
5020	0	293	863	1005	1285	992	850	1650	1942	1649	2722	2978	3458
5021	0	282	696	833				1475	1828	1546	2640	2914	3415
5022	0	294	809	942	1309	1015	882	1609	1944	1650	2695	2958	3444
5023	0	295	410	953	1148	853	310	1768	1868	1573	2744	2998	3478
5024	0	280	441	610	1150	870	701	1535	1815	1535	2629	2905	3405
5025	0	284	771	917	1069	785	639	1465	1801	1517	2658	2930	3427
5027	0	336	840	985	1230	894	749	1520	1890	1554	2690	2967	3472
5028	0	365	625	770	1087	722	577	1475	1791	1426	2595	2864	3380
5029	0	270	670	755	1083	813	728	1447	1765	1495	2555	2830	3357
5030	0	338	588	738	949	611	461	1288	1700	1362	2605	2793	3316
5032	0	277	722	852	1134	857	727	1528	1800	1523	2584	2855	3357

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ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5033	0	222	652	775	1092	870	747	1429	1764	1542	2568	2845	3344
5034	0	277	600	719	975	698	579	1385	1725	1448	2537	2817	3325
5035	0	280	672	800	1059	779	651	1444	1767	1487	2565	2838	3335
5036	0	285	610	735	1020	735	610	1420	1740	1455	2550	2831	3332
5037	0	281	724	854	1159	878	748	1471	1816	1535	2588	2862	3352
5038	0	265	620	742	1011	746	624	1405	1655	1390	2485	2772	3290
5039	0	320	597	721	1000	680	556	1388	1660	1340	2495	2782	3292
5040	0	267	619	745	1015	748	622	1522	1681	1414	2502	2782	3290
5041	0	275	653	763	1063	788	678	1450	1742	1467	2541	2816	3323
5042	0								1800			2771	3279
5043	0	274	593	723	1014	740	610	1407	1719	1445	2520	2791	3311
5044	0								1642			2755	3274
5045	0	281	642	765	1055	774	651	1467	1735	1454	2530	2805	3328
5046	0	272	582	697	937	665	550	1362	1631	1359	2542	2761	3289
5047	0	275	635	754	845	570	451		1668	1393	2579	2780	3306
5048	0	350	582	706	979	629	505	1380	1706	1356	2508	2781	3301
5049	0								1603			2731	3253
5050	0	262	535	654	890	628	509		1600	1338		2743	3267

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5051	0	262	612	732	992	730	610	1404	1659	1397	2501	2791	3305
5052	0	255	638	728	1000	745	655	1413	1662	1407	2513	2794	3304
5053	0	261	605	825	1120	859	639	1390	1642	1381	2480	2772	3288
5054	0	260	604	718	957	697	583	1460	1660	1400	2519	2806	3320
5055	0	262	590	705	955	693	578	1405	1640	1378	2489	2779	3288
5056	0	289	635	745	995	706	596	1425	1691	1402	2573	2848	3373
5057	0	252	582	694					1627	1375	2530	2805	3335
5058	0											2523	2928
5059	0											2691	2989
5060	0	346			883	537		1438	1738	1392	2413	2683	3043
5061	0								1373				3141
5062	0	277	721	853	1204	927	795	1512	1864	1587	2634	2921	3140
5063	0	282	749	879	1099	817	687	1399	1755	1473	2546	2822	3167
5064	0	337	627	707	1142	805	725	1407	1701	1364	2497	2775	3122
5065	0	299	756	887	1097	798	667	1410	1757	1458	2537	2803	3140
5066	0											2737	3073
5068	0	377	877	1002	1352	975	850	2017	2077	1700	2772	3037	3547
5069	0	367	797		1247	880		1437	2001	1634	2726	3002	3505

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ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5070	0	335							2025	1690	2760	3024	3507
5071	0	270	987	1157	1450	1180	1010	1635	1975	1705	2724	2997	3500
5072	0	317	1132	1302	1536	1219	1049	1706	1997	1680	2737	3006	3502
5073	0	309	334	596	1034	725	463	1309	2044	1735	2784	3029	3479
5075	0	310	695	935	1235	925	685	1469			2768	3015	3503
5076	0	316	981	1154	1351	1035	862	1589	1911	1595	2745	3023	3526
5079	0	338	373	613	798	460	220	1191	1603	1265	2416	2693	3203
5080	0							1193	1598		2413	2687	3193
5081	0	375	690	810	1175	800	680	1575	1805	1430	2558	2830	3330
5082	0	298	488	738	1195	897	647	1500	1761	1463	2608	2890	3398
5084	0	266	620	730	1000	734	624	1355	1666	1400	2404	2660	3154
5085	0	272	542	672	1092	820	690	1392	1706	1434	2452	2719	3210
5086	0											2686	3173
5087	0	245	545	595				1155	1729	1484	2480	2737	3202
5088	0							1651	1969		2741	3013	3526
5089	0	277	672	782	1072	795	685	1432	1702	1425	2468	2732	3212
5090	0	270	690	803	1042	772	659	1386	1685	1415	2428	2687	3178
5091	0	276	544		1014	738		1409	1719	1443	2504	2779	3109

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5092	0	274	626	760	1007	733	599	1474	1691	1417	2474	2737	3064
5093	0			705	950			1410	1690		2488	2770	3088
5094	0	298	723	848				1518	1718	1420	2499	2760	3098
5095	0	307	652						1667	1360	2469	2736	3092
5096	0	270	647	775	1035	765	637	1396	1695	1425	2485	2750	3110
5097	0	267	559	690	992	725	594	1387	1707	1440	2499	2762	3090
5098	0	275	660	780	992	717	597	1389	1697	1422	2485	2748	3075
5099	0	285	637	755	1015	730	612	1385	1680	1395	2473	2737	3145
5100	0	290	645	760	1005	715	600	1390	1703	1413	2465	2732	3190
5101	0	298	593	716	961	663	540	1351	1671	1373	2468	2738	3066
5102	0	270	585	712	965	695	568	1350	1678	1408	2488	2753	3118
5103	0	256	628	733	968	712	607	1338	1618	1362	2368	2632	3113
5104	0	260	605						1631	1371	2385	2650	3145
5105	0	265	585	695	923	658	548	1345	1629	1364	2382	2642	3087
5106	0	267	590	705	950	683	568	1334	1648	1381	2400	2668	3165
5107	0	264	608	720	966	702	590	1368	1638	1374	2398	2663	3150
5109	0	225			1005	780		1365	1660	1435	2415	2681	3181
5110	0	260	635	743	985	725	617	1354	1625	1365	2391	2655	3145

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ID #	Brine	BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
		Thickness of Units*											
5111	0	262			1185	923		1465	1676	1414	2440	2779	3085
5112	0	393	606	720	1000	607	493	1440	1674	1281	2447	2717	3035
5113	0	260	558	648	958	698	608	1318	1652	1392	2417	2593	3183
5114	0	280	488	668	951	671	491	1313	1668	1388	2426	2691	3188
5115	0	265	598	709	975	710	599	1365	1685	1420	2485	2761	3075
5116	0	253	600	727	940	687	560	1430	1725	1472	2527	2800	3300
5117	0	247	602	705	937	690	587	1387	1595	1348	2475	2755	3242
5118	0			720	950			1280	1558		2490	2778	3285
5119	0	243	583	723	923	680	540	1473	1537	1294	2488	2769	3275
5120	0	243	592	695	905	662	559	1350	1545	1302	2460	2730	3215
5121	0				711			1313	1580		2488	2771	3268
5122	0	265	601	710	943	678	569	1332	1665	1400	2440	2705	3065
5123	0								1577		2487	2657	3262
5124	0	247	589	694	909	662	557	1339	1564	1317	2415	2696	3194
5125	0	346	701	806	987	641	536	1461	1691	1345	2555	2831	3321
5126	0	259	584	689	892	633	528	1330	1461	1202	2343	2636	3116
5127	0	186	555	659	876	690	586	1345	1540	1354	2512	2692	3305
5128	1		685	795					1750		2575	2827	3309

ID #	Brine	BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
		Thickness of Units*											
5129	0							1369	1634		2609	2874	3386
5130	0	230	517	615	815	585	487		1445	1215	2467	2781	3110
5131	0	232	627	725	983	751	653	1581	1587	1355	2635	2911	3392
5132	0	238	535	635	850	612	512	1420	1528	1290	2483	2763	3300
5133	0	235	548	650	869	634	532	1383	1543	1308	2534	2808	3336
5134	0	235	622	726	954	719	615	1490	1617	1382	2592	2870	3385
5135	0	188	580	680	900	712	612	1402	1562	1374	2555	2845	3390
5136	0	184	468	570	785	601	499	1316	1420	1236	2460	2752	3280
5137	0	237	525	627	833	596	494	1365	1535	1298	2515	2805	3383
5138	0	234	598	700	919	685	583	1444	1572	1338	2556	2840	3360
5139	0	233	608	710	940	707	605	1360	1523	1290	2573	2852	3382
5140	0	236	551	656	871	635	530	1526	1568	1332	2527	2815	3349
5141	0	237	580	683	885	648	545	1435	1575	1338	2561	2845	3375
5142	0	233	525	625	848	615	515	1395	1450	1217	2505	2796	3340
5143	0	633	910	1010	1285	652	552		1967	1334	2905	3196	3740
5144	0	237	550	652	874	637	535	1490	1570	1333	2545	2834	3360
5145	0	632	952	1052	1270	638	538	1797	1960	1328	2942	3231	3757
5146	0								1580		2562	2849	3390

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5147	0												
5148	0										2562	2837	3364
5149	0	238	619	724	959	721	616	1379	1510	1272	2531	2828	3349
5150	0	240	560	666	900	660	554	1338	1527	1287	2526	2808	3338
5151	0	235	545	655	885	650	540	1375	1565	1330	2528	2815	3340
5152	0	242	555	659	900	658	554	1359	1568	1326	2525	2816	3342
5153	0	245	590	700	930	685	575	1400	1640	1395	2558	2830	3360
5154	0	240	563	668	888	648	543	1311	1617	1377	2532	2803	3383
5155	0	242	570	678	925	683	575	1325	1623	1381	2526	2799	3330
5158	0	521	766	956	1206	685	495	1346	1859	1338	2624	2924	3486
5159	0	370	915	1203	1470	1100	812	1953	2045	1675	2740	2998	3514
5160	0	344	1267	1461	1665	1321	1127	1836	2108	1764	2829	3086	3585
5161	0	354	867	1105	1327	973	735	1417	1711	1357	2626	2929	3490
5162	0	327	620	748	785	458	330	1315	1508	1181	2599	2945	3540
5163	0	327	417	439	451	124	102	1177	1549	1222	2655	2944	3482
5164	0	306	437	582	822	516	371	1140	1497	1191	2659	2937	3469
5165	0	330						1180	1460	1130	2640	2940	3488
5166	0	330	536					1197	1568	1238	2575	2890	3460

ID #	Brine	BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
		Thickness of Units*											
5167	0	316	1002	1260	1485	1169	911	1721	2005	1689	2767	3012	3528
5168	0	347	1101	1256	1558	1211	1056	1791	2113	1766	2867	3123	3640
5169	0		900	1075	1540			1820	2107		2838	3090	3600
5170	0	297	864	1071	1582	1285	1078	1804	2110	1813	2868	3118	3631
5171	0	358	938	1098	1390	1032	872	1641	1988	1630	2800	3060	3576
5173	0	310	534	708	1070	760	586	1200	1894	1584	2740	3006	3524
5174	0	322	912	1100	1477	1155	967	1658	1998	1676	2802	3059	3577
5175	0	328	936	1093	1387	1059	902	1648	1999	1671	2807	3067	3588
5176	0	334	1022	1181	1482	1148	989	1715	2037	1703	2842	3105	3627
5177	0	369	874	1031	1314	945	788	1599	1969	1600	2792	3058	3578
5179	0		766	926	1251			1546	1891		2731	2997	3523
5180	0	312	790	954	1326	1014	850	1598	1954	1642	2792	3070	3592
5181	0	295	715	875	1195	900	740	1521	1837	1542	2703	2970	3503
5182	0	317	700	883	1315	998	815	1584	1957	1640	2816	3093	3619
5183	0	305	713	885	1286	981	809	1550	1905	1600	2784	3058	3594
5184	0	345	1090	1233	1431	1086	943	1770	2097	1752	2889	3152	3672
5185	0	299	685	828	1134	835	692	1460	1840	1541	2744	3022	3540
5186	0	298	722	856	1159	861	727	1507	1840	1542	2719	3021	3552

ID #	Brine	Thickness of Units* BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5188	0	230	695	840	1145	915	770	1463	1845	1615	2703	2985	3507
5189	0	296	757	894	1137	841	704	1474	1831	1535	2624	2894	3406
5190	0	250	610	720	1068	818	708	1412	1783	1533	2610	2888	3410
5191	0	284	724	868	1184	900	756	1544	1850	1566	2684	2954	3284
5192	0	299	632	787	1072	773	618	1477	1772	1473	2617	2882	3412
5193	0	307	690	848	1122	815	657	1432	1814	1507	2679	2944	3465
5194	0	309	714	872	1125	816	658	1446	1822	1513	2674	2942	3477
5195	0	310	738	905	1180	870	703	1470	1825	1515	2653	2925	3455
5196	0	307	554	735	1117	810	629	1397	1762	1455	2642	2907	3448
5197	0	321	844	1002	1294	973	815	1567	1921	1600	2738	3000	3524
5198	0	305	795	957	1155	850	688	1515	1805	1500	2657	2910	3427
5199	0	316	880	1013	1356	1040	907	1676	1897	1581	2719	2976	3489
5200	0	319	503					1169	1859	1540	2729	2998	3514
5201	0	323	565	665	895	572	472	1435	1697	1374	2689	2975	3513
5202	0	412	593	693	893	481	381	1213	1588	1176	2638	2943	3503
5203	0	317	495	665	705	388	218	1207	1810	1493	2729	3002	3520
5204	0	321	390	538	788	467	319	1176	1708	1387	2707	2978	3503
5206	0	314	422					1465	1850	1536	2705	2969	3482

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5208	0	310	803	919	1253	943	827	1518	1843	1533	2653	2910	3440
5209	0	307	819	986	1262	955	788	1532	1836	1529	2632	2879	3392
5210	0	294	683	830	1100	806	659	1447	1727	1433	2544	2792	3320
5211	0	303	727	881	1202	899	745	1500	1827	1524	2649	2895	3362
5212	0	282	687	817	1090	808	678	1477	1715	1433	2532	2770	3287
5214	0	290	655	797	1090	800	658	1452	1744	1454	2577	2818	3340
5216	0	240	633	776	1016	776	633	1416	1710	1470	2546	2804	3341
5217	0	263	605	724	994	731	612	1500	1602	1339	2500	2800	3288
5218	0	262	603	722	992	730	611	1495	1598	1336	2501	2793	3332
5219	0	262	610	720	945	683	573	1465	1651	1389	2557	2816	3346
5220	0	266	585	705	932	666	546	1402	1623	1357	2497	2768	3302
5221	0	280	605	745	1001	721	581	1367	1649	1369	2473	2735	3260
5223	0	279	570	706	944	665	529	1349	1637	1358	2450	2709	3239
5224	0	284	636	784	1021	737	589	1394	1658	1374	2478	2733	3208
5226	0	296	602	732	1008	712	582	1418	1728	1432	2525	2780	3301
5227	0	334	847	1009	1328	994	832	1666	2053	1719	2902	3182	3727
5228	0	395	815	990	1510	1115	940	1935	2317	1922	3080	3345	3840
5229	0	262	701	868	1192	930	763	1448	1779	1517	2615	2933	3395

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5230	0	310	695	854	1175	865	706	1672	1820	1510	2637	2892	3412
5231	0	305	841	1001	1213	908	748	1510	1835	1530	2680	2954	3476
5232	0	638	773	967	1509	871	677	1715	2018	1380	2793	3066	3593
5233	0	328	563	733	1018	690	520	1365	1993	1665	2803	3078	3579
5234	0	365	708	928	1028	663	443	1388	1983	1618	2763	3108	3573
5235	0	359	502	1047	1642	1283	738	1997	2143	1784	2782	3057	3592
5236	0							1025	1362		2093	2385	2953
5237	0	365	932	1190	1550	1185	927	1740	1988	1623	2688	3054	3580
5238	0							1175	1666		2384	2658	3213
5239	0	297						927	1864	1567	2577	2872	3432
5240	0	404						1708	1768	1364	2575	2915	3520
5241	0	264	534	704	869	605	435	1054	1394	1130	2234	2524	3098
5242	0							1577	1798		2495	2740	3265
5243	0							1587	1742		2460	2835	3282
5244	0	483	883					1108	1428	945	2143	2431	2948
5245	0	285	625	750	984	699	574	1395	1604	1319	2468	2726	3248
5246	0	269	708	832	1110	841	717	1475	1709	1440	2548	2792	3290
5247	0	257	596	712	967	710	594	1212	1622	1365	2540	2747	3262

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5248	0	248	485	670	888	640	455	1337	1620	1372	2540	2795	3317
5249	0	253	583	693	920	667	557	1403	1620	1367	2533	2793	3318
5250	0	254	494	601	749	495	388	1294	1534	1280	2474	2722	3228
5251	0	255	595	698	893	638	535	1418	1519	1264	2500	2750	3249
5252	0	265	562	682	924	659	539	1350	1594	1329	2458	2720	3245
5253	0	265	505	655				1773			1773	2747	3262
5254	0	265	605	720	953	688	573	1385	1565	1300	2493	2798	3260
5255	0	275	587	702	930	655	540	1390	1595	1320	2470	2724	3240
5256	0	253	573	683	905	652	542	1385	1580	1327	2480	2743	3250
5257	0	295	730	853	1050	755	632	1460	1775	1480	2595	2852	3380
5258	0	292	484	682	1117	825	627	1526	1849	1557	2662	2928	3457
5259	0	282	622	742	974	692	572	1375	1635	1353	2480	2730	3258
5260	0	275	610	735	972	697	572	1357	1648	1373		2658	3180
5261	0	266	582	696	947	681	567	1367	1586	1320	2439	2750	3262
5262	0	273	594	714	950	677	557	1366	1626	1353	2483	2751	3273
5263	0	287							1835	1548	2685	2955	3487
5264	0												
5265	0	371	958					1467	2123	1752	2856	3291	3618

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5266	0	465	719					1280	1960	1495	2745	3024	3550
5267	0	407	643					1193	2058	1651	2891	3152	3661
5268	0	234	564					1074	1979	1745	2834	3122	3664
5269	0	380	750					1154	1670	1290	2600	2893	3440
5270	0							1150	1412		2160	2647	3220
5271	0								1589		2559	2846	3411
5272	0	369	767					1245	2057	1688	2744	3017	3509
5273	0	338	845	1135	1415	1077	787	1548	1989	1651	2740	3023	3530
5274	0	315	1035	1195	1477	1162	1002	1705	2037	1722	2777	3039	3551
5275	1	348	740	840				1790	2205	1857	2734	3015	3526
5276	0												
5277	0	458	458	698	998	540	300	1483	1855	1397	2585	2858	3371
5278	0	310						1192	1502	1192	2442	2719	3260
5279	0	405			845	440		985	1324	919	2125	2400	2941
5280	0							1011	1788		2630	2897	3407
5301	0												
5302	0	280	650	770	957	677	557	1427	1750	1470	2500	2762	3076
5303	0	320	737	852	993	673	558	1335	1723	1403	2485	2743	3097

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5304	0	392	1020	1110	1220	828	738	1540	1917	1525	2705	2982	3476
5305	1	438	638					1447	1848	1410	2644	2914	3395
5306	1	426	439	1054	1162	736	121	1480	1976	1550	2654	2904	3376
5307	1	328	1159	1333	1562	1234	1060	1739	2059	1731	2783	3049	3546
5308	1	330	1118	1277	1598	1268	1109		2596	2266	2796	3033	3508
5309	0												
5310	0												
5311	0												
5312	0												
5313	0							1133	1451		2294	2578	3118
5314	0								1670		2392	2670	3202
5315	0												
5316	0	382	544	664	974	592	472	1227	1554	1172	2472	2745	3304
5317	0								2085		2788	3058	3557
5318	0	279	879	1017	1305	1026	888	1635	1915	1636			2645
5319	0	270	500	637					1860	1590			2480
5320	0												
5321	0												

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5322	0					750	650			1388			
5323	0	261	594	737	936	675	532	1317	1630	1369	2376	2632	3118
5324	0	316						1322	1614	1298	2444	2734	3222
5325	0	241	696	803	1000	759	652	1434	1628	1387	2530	2794	3291
5326	1	297	683	859	1199	902	726	1524	1884	1587	2747	3015	3521
5327	1	298	770	940	1290	992	822	1657	1905	1607	2745	3013	3490
5328	1	298	888	1044	1290	992	836	1518	1901	1603	2726	3000	3508
5329	0	284	710	844	1140	856	722	1445	1790	1506	2595	2864	3350
5330	0	295	665	908	1247	952	709	1452	1757	1462	2731	2994	3475
5331	0	300	713	891	1193	893	715	1493	1906	1606	2761	3026	3507
5332	0	291	677	812	1159	868	733	1436	1782	1491	2624	2889	3376
5333	0	295	754	889	1164	869	734	1443	1808	1513	2628	2890	3381
5334	0	293	873	1009	1308	1015	879	1557	1899	1606	2733	2985	3463
5335	0								1718		2438	2690	3170
5336	0	259	573	685	930	671	559	1307	1603	1344	2362	2623	3112
5337	1	281	734	863	1160	879	750	1452	1817	1536	2600	2864	3348
5338	1	285	767	900	1120	835	702	1430	1805	1520	2623	2888	3377
5339	1	284	746	886	1311	1027	887	1563	1898	1614	2699	2961	3456

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5340	1	278	663	793	1061	783	653	1450	1747	1469	2543	2808	3313
5341	0	273	611	739	983	710	582	1418	1735	1462	2536	2803	3320
5342	0												
5343	0	267	590	712	975	708	586	1359	1632	1365	2455	2740	3265
5344	0	272	616	732	977	705	589	1392	1645	1373	2472	2762	3283
5345	0	530	778	961	1348	818	635	1769	2286	1756	3014	3268	3781
5346	0	370	852	1166	1572	1202	888	2022	2238	1868	2994	3261	3772
5347	0	383	383	580	1086	703	506	1552	2030	1647	2865	3175	3740
5348	1	345	1285	1418				1747	2107	1762	2873	3163	3685
5349	0	304	656	821	1288	984	819	1525	1902	1598	2736	3014	3534
5350	0	308	751	983	1433	1125	893	1633	1978	1670	2754	3024	3531
5351	0	333	1005	1184	1440	1107	928	1657	2009	1676	2815	3105	3620
5352	0	302	745	885	1192	890	750	1495	1865	1563	2687	2957	3466
5353	0	349	741										
5354	0	353	813	1078	1568	1215	950	1852	2233	1880	2954	3213	3733
5355	0	337	1246	1402	1703	1366	1210	1906	2213	1876	2958	3210	3730
5356	0	355			1380	1025		1790	2267	1912	2957	3205	3715
5357	0	366	826	1008	1292	926	744	1636	2246	1880	2974	3215	3734

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5358	0												
5359	0												
5360	0	349	835	935	1235	886	786	1545	1792	1443	2735	2935	3478
5361	0	331	599	705	1005	674	568	1315	1503	1172	2540	2859	3460
5362	0	332	537	624	847	515	428	1232	1622	1290	2547	2901	3492
5363	0	365	837	887	1117	752	702	1360	1589	1224	2617	2942	3537
5364	0	336	651	731	998	662	582	1302	1612	1276	2537	2875	3470
5365	1	316	880	1055	1384	1068	893	1643	1973	1657	2763	3024	3540
5366	1	308	837	993	1310	1002	846	1594	1949	1641	2737	3002	3520
5367	0	292	522	673	1144	852	701	1523	1826	1534	2668	2950	3470
5368	0	274	640	771	1052	778	647	1460	1783	1509	2599	2872	3397
5369	0	310	780	900	1250	940	820	1600	1892	1582	2708	2977	3502
5370	0	319	417	737	1227	908	588	1644	1884	1565	2664	2926	3439
5371	0	310	583	753	987	677	507	1298	1713	1403	2639	2901	3423
5372	0	308	506	688	938	630	448	1228	1540	1232	2657	2943	3508
5373	0	308	583	674				1256	1895	1587	2740	2998	3507
5374	0	306	893	1066	1333	1027	854	1603	1879	1573	2644	2899	3417
5375	0	314	1046	1180	1556	1242	1108	1826	1926	1612	2705	2973	3482

ID #	Brine	Thickness of Units*											
		BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
5376	0	300	980	1098	1370	1070	952	1595	1924	1624	2690	2940	3446
5377	0	439	733	873	1407	968	828	1673	1895	1456	2710	2969	3479
5378	0	319	826	996	1416	1097	927	1646	1946	1627	2742	2997	3511
5380	0	361	632	777	1036	675	530	1374	1704	1343	2490	2737	3254
5381	0	300	680	824	1090	790	646	1490	1746	1446	2528	2782	3297
5382	1								1852		2678	2934	3461
5383	0	295	776	929	1209	914	761	1537	1802	1507	2594	2847	3367
5384	0	560	704	854	1108	548	398	1424	1764	1204	2572	2818	3342
5385	0	294	772	912	1159	865	725	1466	1790	1496	2599	2854	3380
5386	0	300	780	933	1322	1022	869	1508	1824	1524	2610	2863	3400
5387	0	287	653	797	1042	755	611	1337	1695	1408	2539	2785	3303
5389	0	293	616	767	1046	753	602	1430	1718	1425	2547	2819	3350
5390	0	280	643	772	1010	730	601	1397	1660	1380	2480	2735	3252
5391	0	274	567	704	944	670	533	1334	1634	1360	2451	2711	3242
5392	1	282	637	777	1031	749	609	1413	1677	1395	2487	2741	3257
5393	0	282	575	704	935	653	524	1331	1642	1360	2439	2705	3225
5394	1	329	698	843				1417	1719	1390	2506	2755	3275
5395	0	300	650	796	1064	764	618	1450	1732	1432	2530	2779	3306

ID #	Brine	BC-A1	BC-H1	BC-A2	BC-H2	H1A2H2	Castile halite	Total Castile	BC-Cow	A1-Cow	BC-124	BC-VT	BC-Rust
		Thickness of Units*											
5396	0	284	636	776	1044	760	620	1456	1684	1400	2476	2714	3228
5397	0	297	645	787	1067	770	628	1381	1735	1438	2529	2773	3295
5398	0							1235	1540		2329	2620	3190
5399	0							1119	1985		2665	2927	3459
5400	0							1104	1599		2478	2787	3370
5401	0	300	560	751	932	632	441	1365	1937	1637	2761	3023	3545
5402	0	325	1023	1185	1434	1109	947	1739	2029	1704	2847	3125	3675
5403	0	320	910	1089	1386	1066	887	1600	1896	1576	2668	2930	3445
5404	1												
5405	1												
5406	1												
5407	1												
5408	1												

Checkprint for computational setup, report format

* The source data table and this report were created by Dennis W. Powers using Rbase 5.5, a commercial relational database available from Microrim, Inc. Thickness of each interval is given in feet. The relational column within the database is the idnum, an identifier unique to the drillhole. Data computations were checked partially for correct setup of data tables and report.

Appendix E

Thickness Data for Bell Canyon to Cowden Interval with Estimates and Justification

Dennis W. Powers

Bell Canyon to Base Cowden Data And Estimated Thickness

ID num	Brinehit	State X	State Y	Isocow	Justification
1104	1	682279	521970	2009	Est BC elev to calc thickness. Prob + or - 25 ft.
1149	0	667317	509876	1401	
1150	0	667700	513751	1797	Est elev of BC about - 600 ft used to estimate depth and thickness. Prob + or -
1153	0	679951	513567	1753	
1158	0	663885	506464	1550	Add 250 ft est A1 thickness to A1toCow. Prob + or - 50 ft.
1159	1	667371	504068	1693	Add 250 ft est A1 thickness to A1toCow. Prob + or - 50 ft.
1168	0	667301	498887	1532	Est elev BC -675 to calc thickness. Prob + or - 50 ft.
1175	0	672206	493563	1605	Add d250 ft est A1 thickness to A1toCow. Prob + or - 50 ft.
1243	0	665559	486111	1610	
5000	0	687453	517817	1957	
5002	0	685143	517807	1946	
5004	0	683697	517798	1903	
5005	0	685149	516803	1906	
5006	0	687459	516799	1908	
5007	0	683829	516803	1869	
5008	0	684173	515489	1993	
5009	0	685062	515399	1848	
5010	0	686144	515490	1900	

ID num	Brinehit	State X	State Y	Isocow	Justification
5011	0	687775	519132	1945	
5012	0	686469	516801	1903	
5014	1	682845	516790	1825	
5015	0	682796	509554	1797	
5016	0	682885	511198	1831	
5019	0	682877	512529	1882	
5020	0	682869	513845	1942	
5021	0	683872	511208	1828	
5022	0	683537	512529	1944	
5023	0	683529	513841	1868	
5024	0	684860	511537	1815	
5025	0	684852	512857	1801	
5027	0	686504	512529	1890	
5028	0	685202	509565	1791	
5029	0	687857	507261	1765	
5030	0	686552	504607	1700	
5032	0	683563	508250	1800	
5033	0	683570	506937	1764	
5034	0	683579	505578	1725	
5035	0	682803	507264	1767	

ID num	Brinehit	State X	State Y	Isocow	Justification
5036	0	682812	505893	1740	
5037	0	682796	508580	1816	
5038	0	682604	499315	1655	
5039	0	682601	500402	1660	
5040	0	682599	501631	1681	
5041	0	682744	503275	1742	
5042	0	685241	500628	1800	
5043	0	684906	502953	1719	
5044	0	683925	499308	1642	
5045	0	686559	501978	1735	
5046	0	683605	497005	1631	
5047	0	685247	497996	1668	
5048	0	686227	503289	1706	
5049	0	682760	498050	1603	
5050	0	681299	496693	1600	
5051	0	680158	498061	1659	
5052	0	678359	498083	1662	
5053	0	681039	498331	1642	
5054	0	678367	496708	1660	
5055	0	680015	496696	1640	

ID num	Brinehit	State X	State Y	Isocow	Justification
5056	0	682660	491396	1691	
5057	0	685311	490031	1627	
5059	0	640217	538905	-999	DELETE. Off main map area, no nearby wells.
5060	0	640127	538904	1738	
5061	0	648187	525723	1373	
5062	0	640263	523060	1864	
5063	0	644237	523079	1755	
5064	0	651176	520437	1701	
5065	0	646880	521743	1757	
5066	0	652480	521752	1700	Nearby wells extrapolated, not constrained to N. + or - 50 ft.
5068	0	688075	524406	2077	
5069	0	686429	524399	2001	
5070	0	686437	523087	2025	
5071	0	687770	520448	1975	
5072	0	686445	521756	1997	
5073	0	683807	520428	2044	
5075	0	685127	520435	1980	Based on nearby wells. Prob + or - 25 ft.
5076	0	686453	520440	1911	
5079	0	688026	531008	1603	
5080	0	688186	530998	1598	

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ID num	Brinehit	State X	State Y	Isocow	Justification
5081	0	688045	528376	1805	
5082	0	688059	527034	1761	
5084	0	654502	515157	1666	
5085	0	652656	516740	1706	
5086	0	652168	515145	1680	Based on nearby wells. Prob + or - 25 ft.
5087	0	652292	519352	1729	
5088	0	686461	518138	1969	
5089	0	652115	518300	1702	
5090	0	653438	516467	1685	
5091	0	644112	517803	1719	
5092	0	650327	515728	1691	
5093	0	648433	515137	1690	
5094	0	650945	519123	1718	
5095	0	650793	518134	1667	
5096	0	649478	517807	1695	
5097	0	648081	516451	1707	
5098	0	649489	516124	1697	
5099	0	650807	516458	1680	
5100	0	650818	514982	1703	
5101	0	649679	515140	1671	

ID num	Brinehit	State X	State Y	Isocow	Justification
5102	0	649472	515142	1678	
5103	0	656517	507932	1618	
5104	0	652468	511180	1631	
5105	0	653458	512523	1629	
5106	0	652138	512516	1648	
5107	0	653460	513839	1638	
5109	0	652140	513832	1660	
5110	0	651813	510184	1625	
5111	0	649916	511440	1676	
5112	0	649501	511172	1674	
5113	0	651144	512689	1652	
5114	0	651151	513733	1668	
5115	0	648211	513943	1685	
5116	0	654924	488781	1725	
5117	0	656248	493126	1595	
5118	0	656263	490090	1558	
5119	0	654945	490094	1537	
5120	0	652484	491463	1545	
5121	0	655815	491378	1580	
5122	0	649498	512506	1665	

ID num	Brinehit	State X	State Y	Isocow	Justification
5123	0	653880	490100	1577	
5124	0	656234	497001	1564	
5125	0	655598	494097	1691	
5126	0	656552	499922	1461	
5127	0	656055	486279	1540	
5128	1	653563	486310	1750	
5129	0	655287	484839	1634	
5130	0	637575	475238	1445	
5131	0	652320	470288	1587	
5132	0	686664	473054	1528	
5133	0	683072	478191	1543	
5134	0	670866	477804	1617	
5135	0	669534	480782	1562	
5136	0	668207	480778	1420	
5137	0	668532	481620	1535	
5138	0	668221	478099	1572	
5139	0	669545	477786	1523	
5140	0	669525	481862	1568	
5141	0	666705	478105	1575	
5142	0	665259	479417	1450	

ID num	Brinehit	State X	State Y	Isocow	Justification
5143	0	665254	478108	1592	Orig BC top prob error, alt pick used.
5144	0	666887	480967	1570	
5145	0	666707	479421	1591	Orig BC pick prob in error, alt pick used.
5146	0	666896	479418	1580	
5147	0	658934	482782	1570	Based on nearest wells, not well constrained. Prob + or - 50 ft.□
5148	0	662386	478118	1500	Based on nearest wells, not well constrained. Prob + or - 100 ft.□
5149	0	658924	485883	1510	
5150	0	657800	486514	1527	
5151	0	660269	485996	1565	
5152	0	659943	484664	1568	
5153	0	682702	487402	1640	
5154	0	685369	483466	1617	
5155	0	684036	484770	1623	
5158	0	715576	512845	1859	
5159	0	719299	507585	2045	
5160	0	719651	504941	2108	
5161	0	713055	507207	1711	
5162	0	711890	505887	1508	
5163	0	711774	504537	1549	

ID num	Brinehit	State X	State Y	Isocow	Justification
5164	0	710784	504523	1497	
5165	0	711772	504864	1460	
5166	0	712743	504551	1568	
5167	0	707811	506124	2005	
5168	0	705128	508426	2113	
5169	0	706130	507124	2107	
5170	0	704937	507436	2110	
5171	0	704824	505759	1988	
5173	0	707493	504806	1894	
5174	0	706145	505775	1998	
5175	0	704962	504975	1999	
5176	0	704158	507100	2037	
5177	0	704170	505751	1969	
5179	0	702868	504415	1891	
5180	0	702851	506059	1954	
5181	0	701542	504730	1837	
5182	0	702509	507416	1957	
5183	0	701519	507402	1905	
5184	0	704139	509067	2097	
5185	0	697249	506004	1840	

ID num	Brinehit	State X	State Y	Isocow	Justification
5186	0	694250	508981	1840	
5188	0	692941	508635	1845	
5189	0	688841	508765	1831	
5190	0	691960	507160	1783	
5191	0	697274	502059	1850	
5192	0	703873	500772	1772	
5193	0	702536	503708	1814	
5194	0	703864	502131	1822	
5195	0	705188	502158	1825	
5196	0	706503	502505	1762	
5197	0	705507	503807	1921	
5198	0	710224	499756	1805	
5199	0	714066	501040	1897	
5200	0	714102	501921	1859	
5201	0	714068	502597	1697	
5202	0	714475	503927	1588	
5203	0	713073	502259	1810	
5204	0	711784	503533	1708	
5206	0	710807	501189	1850	
5208	0	715786	498671	1843	

ID num	Brinehit	State X	State Y	Isocow	Justification
5209	0	713148	498645	1836	
5210	0	711731	495498	1727	
5211	0	710485	498569	1827	
5212	0	706900	493891	1715	
5214	0	709193	495630	1744	
5216	0	702247	498452	1710	
5217	0	692059	492737	1602	
5218	0	691954	492737	1598	
5219	0	689284	488859	1651	
5220	0	697351	491465	1623	
5221	0	709225	492852	1649	
5223	0	709223	491671	1637	
5224	0	710208	492972	1658	
5226	0	726303	489144	1728	
5227	0	739511	489206	2053	
5228	0	743432	491880	2317	
5229	0	724919	497052	1779	
5230	0	722064	496705	1820	
5231	0	726246	495713	1835	
5232	0	726170	502337	2018	

ID num	Brinehit	State X	State Y	Isocow	Justification
5233	0	721313	503306	1993	
5234	0	722146	507594	1983	
5235	0	723492	506273	2143	
5236	0	731330	514213	1362	DELETE. Prob over reef.
5237	0	726123	506282	1988	
5238	0	727370	514213	1666	
5239	0	723435	511549	1864	
5240	0	720922	510222	1768	
5241	0	723435	518149	1394	
5242	0	731495	517159	1798	DELETE. Prob over reef.
5243	0	730365	515509	1742	DELETE. Prob over reef.
5244	0	728715	515179	1428	
5245	0	713552	486079	1604	
5246	0	709293	486352	1709	
5247	0	702426	483394	1622	
5248	0	690620	483483	1620	
5249	0	693473	482355	1620	
5250	0	702718	478364	1534	
5251	0	703103	479385	1519	
5252	0	710648	481391	1594	

ID num	Brinehit	State X	State Y	Isocow	Justification
5253	0	711983	478484	1670	Based on nearest wells, not well constrained. Prob + or - 50 ft.
5254	0	710666	478366	1565	
5255	0	711612	480841	1595	
5256	0	713292	474527	1580	
5257	0	731282	486206	1775	
5258	0	735569	483904	1849	
5259	0	725384	483523	1635	
5260	0	723696	486489	1648	
5261	0	721203	478534	1586	
5262	0	726068	478256	1626	
5263	0	738219	482615	1835	
5264	0	715700	543100	-999	DELETE. Out of map area, behind reef.
5265	0	697111	523186	2123	
5266	0	701049	524549	1960	
5267	0	701403	521883	2058	
5268	0	706351	520629	1979	
5269	0	706324	524620	1670	
5270	0	711605	523380	1412	
5271	0	709968	522005	1589	
5272	0	689062	524415	2057	

ID num	Brinehit	State X	State Y	Isocow	Justification
5273	0	693156	522136	1989	
5274	0	688762	520119	2037	
5275	1	689070	523103	2205	
5276	0	691829	523133	1979	Est BC elev from map to calc thickness. Isopach contour est 2025. + or - 25 ft
5277	0	695745	527104	1855	
5278	0	703668	528559	1502	
5279	0	706307	528583	1324	DELETE? May be over reef.
5280	0	701038	527167	1788	
5301	0	641866	537582	-999	DELETE. Off map area.□
5302	0	645242	520102	1750	
5303	0	651831	520109	1723	
5304	0	687611	525719	1917	
5305	1	679839	528315	1848	
5306	1	678521	524326	1976	
5307	1	687762	521764	2059	
5308	1	685122	521752	2596	
5309	0	716900	540250	-999	DELETE. Prob over reef.
5310	0	691747	536332	-999	DELETE. Prob over reef.
5311	0	691724	538989	-999	DELETE. Prob over reef.

ID num	Brinehit	State X	State Y	Isocow	Justification
5312	0	699664	535095	-999	DELETE. Prob over reef.
5313	0	702335	531157	1451	DELETE. Prob over reef.
5314	0	707257	531208	1670	DELETE. Prob over reef.
5315	0	710253	527301	-999	DELETE. Prob over reef.
5316	0	705323	527224	1554	
5317	0	695776	523170	2085	
5318	0	605975	516526	1915	
5319	0	597850	515250	1860	
5320	0	604394	505900	-999	DELETE. Off main map area to west near Danford.□
5321	0	593929	506028	-999	DELETE. Off main map area to west near Danford.□
5322	0	651450	510150	1650	From isopach map. No control to south. Prob + or - 25 ft.□
5323	0	654900	510000	1630	
5324	0	644179	498036	1614	
5325	0	653887	488787	1628	
5326	1	685129	519123	1884	
5327	1	683812	519115	1905	
5328	1	686455	519124	1901	
5329	0	680237	515105	1790	
5330	0	682839	517800	1757	
5331	0	682828	519113	1906	

ID num	Brinehit	State X	State Y	Isocow	Justification
5332	0	680200	516400	1782	
5333	0	680850	515250	1808	
5334	0	682863	514819	1899	
5335	0	657463	517615	1718	
5336	0	657789	509389	1603	
5337	1	681576	509860	1817	
5338	1	681568	511172	1805	
5339	1	684844	514173	1898	
5340	1	685216	507264	1747	
5341	0	686544	505923	1735	
5342	0	674707	505867	-999	No BC or Cowden data. No nearby wells.□
5343	0	682933	498982	1632	
5344	0	684027	498226	1645	
5345	0	706377	516673	2286	
5346	0	702432	515309	2238	
5347	0	701090	519263	2030	
5348	1	697134	519223	2107	
5349	0	689111	516479	1902	
5350	0	688768	519007	1978	
5351	0	693182	517875	2009	

ID num	Brinehit	State X	State Y	Isocow	Justification
5352	0	689152	510880	1865	
5353	0	704165	509787	2125	Est from isopach contours. Prob + or - 25 ft.□
5354	0	703788	512676	2233	
5355	0	703458	511356	2213	
5356	0	704823	511448	2267	
5357	0	705090	512723	2246	
5358	0	705153	510128	2175	Est from isopach contours. Prob + or - 50 ft.□
5359	0	711819	511456	1950	Est from isopach contours. Prob + or - 100 ft.□
5360	0	714045	507207	1792	
5361	0	714051	505880	1503	
5362	0	714060	504564	1622	
5363	0	711910	507207	1589	
5364	0	711735	505887	1612	
5365	1	706154	504786	1973	
5366	1	704185	504435	1949	
5367	0	693293	504667	1826	
5368	0	693314	499351	1783	
5369	0	704183	503788	1892	
5370	0	709485	500842	1884	
5371	0	709491	499529	1713	

ID num	Brinehit	State X	State Y	Isocow	Justification
5372	0	713074	503575	1540	
5373	0	712107	501921	1895	
5374	0	713409	499262	1879	
5375	0	713126	500954	1926	
5376	0	712130	499893	1924	
5377	0	711795	500552	1895	
5378	0	710800	502232	1946	
5380	0	715772	493995	1704	
5381	0	717086	494153	1746	
5382	1	717041	498309	1852	
5383	0	710172	496920	1802	
5384	0	710179	495917	1764	
5385	0	709089	497007	1790	
5386	0	709176	498222	1824	
5387	0	709212	494256	1695	
5389	0	704225	498483	1718	
5390	0	706913	492866	1660	
5391	0	707918	491618	1634	
5392	1	708236	492940	1677	
5393	0	710868	490662	1642	

Bell Canyon to Base Cowden Data And Estimated Thickness

ID num	Brinehit	State X	State Y	Isocow	Justification
5394	1	717094	493357	1719	
5395	0	718414	493357	1732	
5396	0	718084	491707	1684	
5397	0	719534	493027	1735	
5398	0	728360	514543	1540	
5399	0	739333	506351	1985	
5400	0	738013	508991	1599	
5401	0	724872	500986	1937	
5402	0	735512	493164	2029	
5404	1	719791	493060	1735	Adjacent drillhole thickness 1735. Prob + or - 20 ft.□
5405	1	713107	496962	1770	Interpol from nearby drillholes, contours. Prob + or - 20 ft.□
5406	1	608294	509896	-999	DELETE? No direct data, off map, no nearby drillholes.□
5407	1	728806	499702	1925	Est fro contours and nearest drillholes. Prob + or - 25 ft.□
5408	1	730127	499712	1925	Est fro contours and nearest drillholes. Prob + or - 25 ft.

 Date Printed: 07/10/1996

The source data table and this report were created by Dennis W. Powers using Rbase 5.5, a commercial relational database available from Microrim, Inc. The thickness of each interval is given in feet. The rlational column within the database is the idnum, and identifier unique to the drillhole. Data without justification are directly from geophysical log interpretations. Other data have been modified or estimated according to the notes. DELETE indicates a drillhole that should be eliminated from use in maps or geostatistics.

Values of -999 are defaults indicating no estimate made.

Appendix F

Letter Report on Brine Occurrences

R.F. Kehrman (Westinghouse)

RECEIVED
JUL 27 1994
6307/KA

A. Lappin

Westinghouse Electric Corporation
Government Operations

WS:94:03255
DA:94:11100

Waste Isolation Division

Box 2078
Carlsbad New Mexico 88221

July 20, 1994

Mr. Wendell Weart
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-1345

Subject: RECENT OCCURRENCES OF PRESSURIZED BRINE IN THE CASTILE FORMATION

Dear Mr. Weart:

Within the last month members of my staff completed a review of records on oil and gas wells drilled within an 864 square mile area surrounding the WIPP. The records that were review are maintained by the New Mexico Oil Conservation Division offices located in Artesia and Hobbs. One of the areas examined by this review, that may be of interest to Sandia, are occurrences of pressurized brine in the Castile formation that were not previously referenced in **Brine Pocket Occurrences in the Castile Formation, Southeastern New Mexico** (TME 3080) or **Brine Reservoirs in the Castile Formation, Southeastern New Mexico** (TME 3153). A table and map detailing the locations of these new occurrences and copies of the drilling records documenting the occurrences are attached.

The Bureau of Land Management Form 3160-5, Sundry Notice and Reports on Wells, was the record used to identify the occurrence of brine flow. There is no requirement for a driller to report occurrences of pressurized brine on this form and therefore this list of new occurrences of pressurized brine can not be considered all inclusive.

The Environmental Evaluation Group (EEG) recently identified the occurrence of a brine flow at 2000 feet for Lincoln Federal No. 1 in Section 26, T21S, R32E. This well was not identified in our review of records. The driller did not report the occurrence of brine on the Sundry Notice. The EEG identified the occurrences of this brine flow by reviewing the driller's daily drilling logs. The OCD does not have the daily driller's logs on file. They stated that the Petroleum Information Corporation in Midland, Texas could be a source of more detailed information if required.

Should you have any question please call Mr. Larry Madl of my staff at (505) 234-8400.

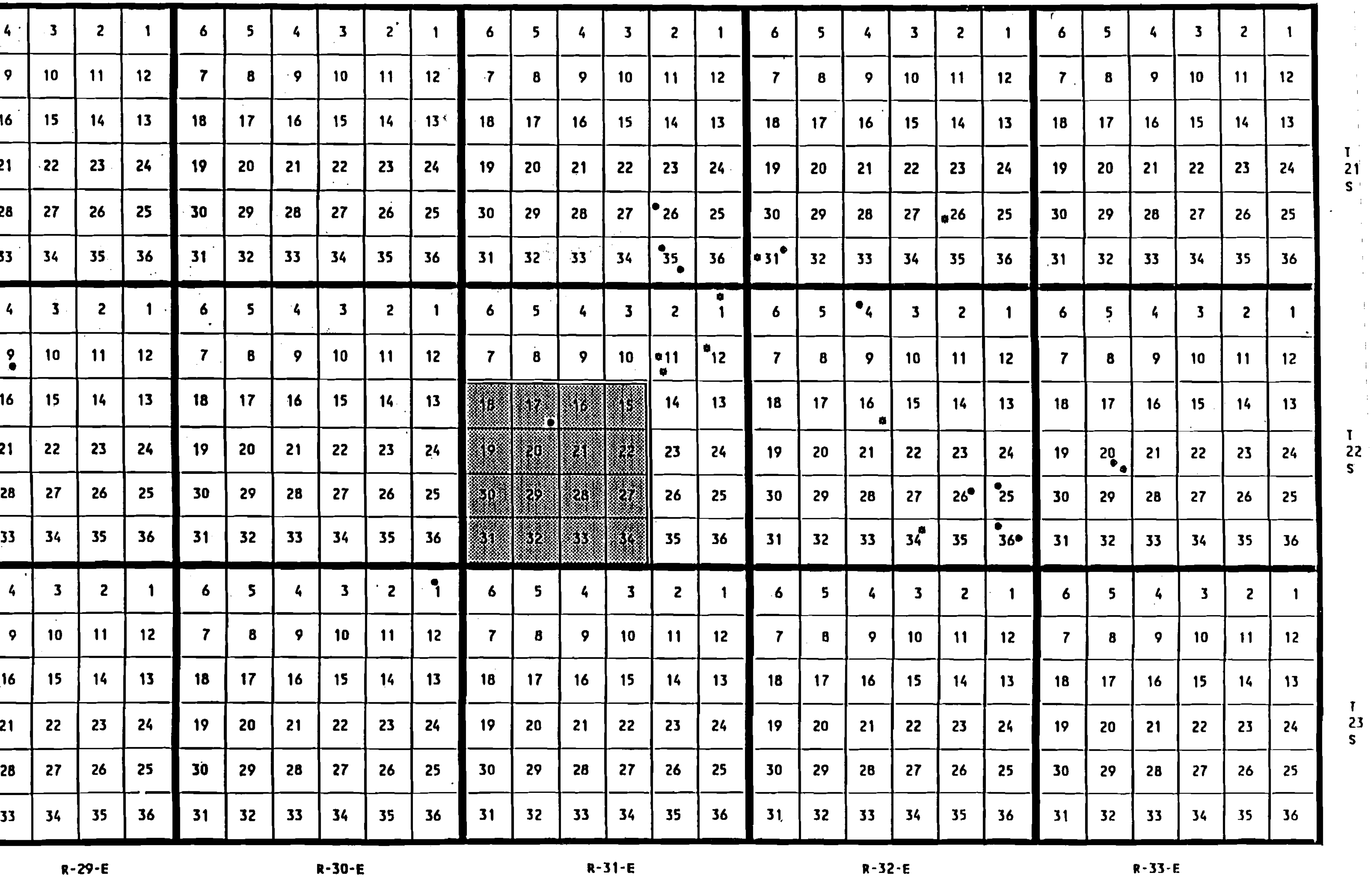
Sincerely,

R.F. Kehrman, Manager
Regulatory Compliance

LJM:kds

cc: R. A. Bills - CAO
P. A. Davis - SNL
P. Davies - SNL
A. Lappin - SNL
J. A. Mewhinney - CAO
D. Powers - IT

OCCURRENCES OF PRESSURIZED BRINE IN THE CASTILE FORMATION



- ● Pressurized Brine in the Castile Formation (THE 3080 and THE 3153)
- ● Recent Occurrences of Pressurized Brine in the Castile Formation

NEW OCCURRENCES OF PRESSURIZED BRINE
IN THE CASTILE FORMATION

OPERATOR	LEASE NAME	LOCATION	COMMENTS
Yates Petroleum Corp.	Martha "AIK" Federal #3	SEC.11 T-22-S, R-31-E 660 FSL, 1650 FEL	Drilling 3311' encountered 80 ppm H2S bearing water flow
Yates Petroleum Corp.	Martha "AIK" Federal #4	SEC.11 T-22-S, R-31-E 1980 FSL, 1650 FEL	Encountered water flow at 3750'
Yates Petroleum Corp.	Unocal AHU Federal #1	SEC.1 T-22-S, R-31-E 660 FNL, 1980 FEL	Drilling 3068' encountered 100+ ppm H2S bearing water flow
Pogo Producing Corp.	Federal "12" #8	SEC.12 T-22-S, R-31-E 330 FNL, 1650 FWL	Hit water flow at 3050'; flow contained a max of 1700 ppm H2S; rate of flow: between 1-2 BPM
Yates Petroleum Corp.	Kiwi AKX State #1	SEC.16 T-22-S, R-32-E 330 FSL, 330 FEL	Well was flowing ~40/bbls/hr while running casing and prior to running casing
Pogo Producing Corp.	Red Tank 34 Federal #1	SEC.34 T-22-S, R-32-E 660 FNL, 1650 FEL	Hit water flow at 3590'-4489' at a max rate of 240 bbls per hour and 700 ppm H2S at shaker; water flow lasted 45 hours
Phillips Petroleum Corp.	Lost Tank SWD #1	SEC.31 T-21-S, R-32-E 1980 FNL, 660 FWL	Water flow encounter at approximately 3050'
Collins & Ware, Inc.	Lincoln Federal #1	SEC. 26 T-21-S, R-32-E 1980 FNL, 660 FWL	Brine flow encountered at 2000'

m 3160-5
ne 1990)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
Budget Bureau No. 1004-0135
Expires: March 31, 1993

SUNDRY NOTICES AND REPORTS ON WELLS

Do not use this form for proposals to drill or to deepen or reentry to a different reservoir.
Use "APPLICATION FOR PERMIT—" for such proposals

SUBMIT IN TRIPLICATE

5. Lease Designation and Serial No.: NM 65417

6. If Indian, Allottee or Tribe Name: N/A

7. If Unit or CA, Agreement Designation: N/A

Type of Well: [X] Oil Well [ ] Gas Well [ ] Other

8. Well Name and No.: Martha AIK Federal #

Name of Operator: YATES PETROLEUM CORPORATION

9. API Well No.: 30-015-26723

Address and Telephone No.: 105 South 4th St., Artesia, NM 88210 (505) 748-1471

10. Field and Pool, or Exploratory Area: Livingston Ridge De

Location of Well (Footage, Sec., T., R., M., or Survey Description): Unit O, 660' FSL & 1650' FEL, Sec. 11-T22S-R31E

11. County or Parish, State: Eddy, NM

CHECK APPROPRIATE BOX(s) TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION	
[ ] Notice of Intent	[ ] Abandonment	[ ] Change of Plans
[X] Subsequent Report	[ ] Recompletion	[ ] New Construction
[ ] Final Abandonment Notice	[ ] Plugging Back	[ ] Non-Routine Fracturing
	[ ] Casing Repair	[ ] Water Shut-Off
	[ ] Altering Casing	[ ] Conversion to Injection
	[X] Other Report H_2S Encounter	[ ] Dispose Water

(Note: Report results of multiple completion on Completion or Recompletion Report and Log fo

Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

5-13-91. Drilling 3311' encountered 80 ppm H_2S bearing water flow. Shut well in. Raised mud weight to 11 ppg. Kill well. Resumed drilling.
Reported to Shannon Shaw, BLM, Carlsbad, NM, by Tim Bussell, Yates Petroleum Corporati
5-13-91.

I hereby certify that the foregoing is true and correct

Signed [signature] Title Production Supervisor Date 5-13-91

(This space for Federal or State office use)

Approved by ______ Title ______ Date
Conditions of approval, if any:

ACCEPTED FOR RECORD

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements

Form 3160-5
(June 1990)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
Budget Bureau No. 1004-0135
Expires: March 31, 1993

5. Lease Designation and Serial No.
NM 65417

6. If Indian, Allottee or Tribe Name

SUNDRY NOTICES AND REPORTS ON WELLS

Do not use this form for proposals to drill or to deepen or reentry to a different reservoir.
Use "APPLICATION FOR PERMIT—" for such proposals

RECEIVED
SEP 2 ? 1991
ARTESIA OFFICE

SUBMIT IN TRIPLICATE

7. If Unit or CA, Agreement Designation

1. Type of Well
[XX] Oil Well [ ] Gas Well [ ] Other

8. Well Name and No.
Martha AIK Federal

2. Name of Operator
YATES PETROLEUM CORPORATION ✓

9. API Well No.
30-015-26724

3. Address and Telephone No.
105 South 4th St., Artesia, NM 88210 (505) 748-1471

10. Field and Pool, or Exploratory Area
Livingston Ridge Del

4. Location of Well (Footage, Sec., T., R., M., or Survey Description)
Unit J, 1980' FSL & 1650' FEL, Sec. 11-T22S-R31E

11. County or Parish, State
Eddy, NM

12. CHECK APPROPRIATE BOX(s) TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION	
[ ] Notice of Intent	[ ] Abandonment	[ ] Change of Plans
[ ] Subsequent Report	[ ] Recompletion	[ ] New Construction
[ ] Final Abandonment Notice	[ ] Plugging Back	[ ] Non-Routine Fracturing
	[ ] Casing Repair	[ ] Water Shut-Off
	[ ] Altering Casing	[ ] Conversion to Injection
	[XX] Other Report water flow.	[ ] Dispose Water

(Note: Report results of multiple completion on Well Completion or Recompletion Report and Log

13. Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

Per conversation on 9-9-91 between Shannon Shaw, BLM, Carlsbad, NM, and Rex Gates, Yates Petroleum, intermediate casing set at 4302' (B. of salt at 4165'). Encountered water flow at 3750'. Water flow (10 spm) was killed with 10.6 ppg mud after reaching casing point. Casing was cemented in 2 stages with DV tool at 2898'. Circulated 250 sx cement on 1st stage and 275 sx cement on 2nd stage.

14. I hereby certify that the foregoing is true and correct

Signed [signature] Title Production Supervisor Date 9-16-91

(This space for Federal or State office use)

Approved by ____________ Title ____________ Date ____________
Conditions of approval, if any:

ACCEPTED FOR RECORD
SEP 20 1991

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
Budget Bureau No. 1004-0135
Expires: March 31, 1993

SUNDRY NOTICES AND REPORTS ON WELLS

se this form for proposals to drill or to deepen or reentry to a different reservoir.
Use "APPLICATION FOR PERMIT—" for such proposals

SUBMIT IN TRIPLICATE

MAY 1 4 1991

5. Lease Designation and Serial No.: NM 43556

6. If Indian, Allottee or Tribe Name: N/A

7. If Unit or CA, Agreement Designation: N.A

ell: ☐ Gas Well ☐ Other

8. Well Name and No.: Unocal AHU Federal #1

perator: PETROLEUM CORPORATION

9. API Well No.: 30-015-26698

d Telephone No.: uth 4th St., Artesia, NM 88210 (505) 748-1471

10. Field and Pool, or Exploratory Area: Undes. Livingston Ridge-Dela

f Well (Footage, Sec., T., R., M., or Survey Description): ' FNL & 1980' FEL, Sec. 1-T22S-R31E

11. County or Parish, State: Eddy, NM

CHECK APPROPRIATE BOX(s) TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION	
☐ Notice of Intent	☐ Abandonment	☐ Change of Plans
☐ Subsequent Report	☐ Recompletion	☐ New Construction
☐ Final Abandonment Notice	☐ Plugging Back	☐ Non-Routine Fracturing
	☐ Casing Repair	☐ Water Shut-Off
	☐ Altering Casing	☐ Conversion to Injection
	☒ Other Report H_2S encounter	☐ Dispose Water

(Note: Report results of multiple completion on Completion or Recompletion Report and Log

roposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally ubsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

91. Drilling 3068' encountered H_2S bearing water flow (100+ ppm H2S).
oximately 40-50 BPH while drilling. Raised mud weight to 10.4 ppg to control
.0 ppm H2S. At casing point raised mud weight to 12.3 ppg to run casing.
nd cemented casing.
ied Shannon Shaw, BLM, Carlsbad, NM, of H2S encounter.

hat the foregoing is true and correct

Title Production Supervisor Date 4-30-91

ederal or State office use)

Title

oval, if any:

ACCEPTED FOR RECORD
Date MAY 13 1991

1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent ... any matter within its jurisdiction.

*See Instruction on Reverse Side

Form 3160-5
(June 1990)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVE
Budget Bureau No. 100-
Expires: March 31,

SUNDRY NOTICES AND REPORTS ON WELLS

Do not use this form for proposals to drill or to deepen or reentry to a different reservoir.
Use "APPLICATION FOR PERMIT—" for such proposals

SUBMIT IN TRIPLICATE

CONFIDENTIAL

1. Type of Well
[XX] Oil Well [ ] Gas Well [ ] Other

2. Name of Operator
Pogo Producing Co.

3. Address and Telephone No.
P.O. Box 10340, Midland, TX 79702-7340 (915-682-6822)

4. Location of Well (Footage, Sec., T., R., M., or Survey Description)
330' FNL, 1650' FWL, Section 12, T-22-S, R-31E

5. Lease Designation and Seri
NM-29233

6. If Indian, Allottee or Tribe
APR 2

7. If Unit or CA, Agreement D

8. Well Name and No.
Federal "12" #8

9. API Well No.
30-015-26942

10. Field and Pool, or Exploratory
Livingston Ridge

11. County or Parish, State
Eddy Co., NM

12. CHECK APPROPRIATE BOX(s) TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION	
[ ] Notice of Intent	[ ] Abandonment	[ ] Change of Plans
[XX] Subsequent Report	[ ] Recompletion	[ ] New Construction
[ ] Final Abandonment Notice	[ ] Plugging Back	[ ] Non-Routine Fracturing
	[ ] Casing Repair	[ ] Water Shut-Off
	[ ] Altering Casing	[ ] Conversion to Injection
	[ ] Other Water flow	[ ] Dispose Water

(Note: Report results of multiple complet Completion or Recompletion Report and

13. Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is direction give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

Hit water flow while drl 11" intermediate hole @ 3050' 3-31-92. Flow contain maximum 1 PPm H_2S @ Flowline. Rate of water flow was between 1 & 2 BPM. Indian Fire & Safety ha all monitoring and safety equipment. Pogo continued drilling 11" hole to a T.D. of 430 w/ a rotating packoff. 8 5/8" csg was set & cmt'd 4-2-92. Flow ceased.

14. I hereby certify that the foregoing is true and correct

Signed [signature] Title Div. Operations Supvr. Date 4-24-92

(This space for Federal or State office use)

Approved by ____ Title ____ Date ____
Conditions of approval, if any:

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent

...s Copies ...ppropriate ...ct Office

...RICT I
...Box 1980, Hobbs, NM 88240
...RICT II
...Drawer DD, Artesia, NM 88210
...RICT III
...Rio Brazos Rd., Aztec, NM 87410

Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO. 30-025-31576

5. Indicate Type of Lease STATE [X] FEE [ ]

6. State Oil & Gas Lease No. VB 134

SUNDRY NOTICES AND REPORTS ON WELLS

...O NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name: Kiwi AKX State

Type of Well: OIL WELL [X] GAS WELL [ ] OTHER

Name of Operator: ...ATES PETROLEUM CORPORATION

8. Well No. 1

Address of Operator: ...05 South 4th St., Artesia, NM 88210

9. Pool name or Wildcat: East Livingston Ridge Delaware

Well Location
Unit Letter P : 330 Feet From The South Line and 330 Feet From The East Line
Section 16 Township 22S Range 32E NMPM Lea County

10. Elevation (Show whether DF, RKB, RT, GR, etc.) 3704' GR

Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:

...FORM REMEDIAL WORK [ ] PLUG AND ABANDON [ ]
...PORARILY ABANDON [ ] CHANGE PLANS [ ]
...L OR ALTER CASING [ ]
...ER: [ ]

SUBSEQUENT REPORT OF:

REMEDIAL WORK [ ] ALTERING CASING [ ]
COMMENCE DRILLING OPNS. [ ] PLUG AND ABANDONMENT [ ]
CASING TEST AND CEMENT JOB [ ]
OTHER: Intermediate Casing [X]

. Describe Proposed or Completed Operations *(Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work)* SEE RULE 1103.

TD 11" hole 4:30 AM 5-5-92. Ran 102 jts 8-5/8" 32# S-80 and J-55 casing set 4535'. Guide shoe set 4535'. Float collar set 4491'. DV tool set 3175'. Cmtd' in 2 stages: Stage 1: 205 sx PSL w/1/4# Celloseal, 10# salt, 5# Gilsonite (yield 1.94, wt 12.9).Tailed in w/200 sx "C" with 2% CaCl2 (yield 1.33, wt 14.8). PD 2:30 PM 5-5-92. Circulated 200 sacks. Sta 900 sx PSL w/1/4# Celloseal, 10# salt, 5# Gilsonite (yield 1.94, wt 12.(). Tailed in w/1C sx "C" with 2% CaCl2 (yield 1.33, wt 14.8). PD 5:00 PM 5-5-92. Circulated 144 sacks. WOC. NOTE: Well was flowing 40±/bbls/hr while running casing and prior. Dead after 1st and afterward. Notified Joan with NMOCD, Hobbs, NM, prior to cementing. Did not witness. Drilled out 8:00 AM 5-6-92. WOC 17 hrs and 30 minutes. Reduced hole to 7-7/8" and resume drilling.

...hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE *Juanita Goodlett* TITLE Production Supervisor DATE 5-12-92

TYPE OR PRINT NAME Juanita Goodlett TELEPHONE NO. 505/748-1

(This space for State Use) ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR

MAY 13 '92

APPROVED BY ______ TITLE ______ DATE ______

CONDITIONS OF APPROVAL, IF ANY:

RECEIVED
APR 28 10 05 AM '93

Form 3160-5
(June 1990)

N. M. OIL CONS. COMMISSION
P. O. BOX 1980
HOBBS, NEW MEXICO 88240

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
Budget Bureau No. 1004-0135
Expires: March 31, 1993

5. Lease Designation and Serial No.
NM-77060

6. If Indian, Allottee or Tribe Name

SUNDRY NOTICES AND REPORTS ON WELLS

Do not use this form for proposals to drill or to deepen or reentry to a different reservoir.
Use "APPLICATION FOR PERMIT—" for such proposals

7. If Unit or CA, Agreement Designation

SUBMIT IN TRIPLICATE

1. Type of Well
☐ Oil Well ☒ Gas Well ☐ Other

8. Well Name and No.
Red Tank 34 FEDERAL WELL N

2. Name of Operator
POGO PRODUCING COMPANY

9. API Well No.
30-025-31720 ✓

3. Address and Telephone No.
P. O. BOX 10340, MIDLAND, TEXAS 79702

10. Field and Pool, or Exploratory Area
WILDCAT

4. Location of Well (Footage, Sec., T., R., M., or Survey Description)
660' FNL AND 1650' FEL OF Unit B
SEC.34, T-22-S, R-32-E, N.M.P.M.

11. County or Parish, State
LEA COUNTY, NEW MEXIC

12. CHECK APPROPRIATE BOX(s) TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION	
☐ Notice of Intent	☐ Abandonment	☐ Change of Plans
☒ Subsequent Report	☐ Recompletion	☐ New Construction
☐ Final Abandonment Notice	☐ Plugging Back	☐ Non-Routine Fracturing
	☐ Casing Repair	☐ Water Shut-Off
	☐ Altering Casing	☐ Conversion to Injection
	☒ Other Water Flow	☐ Dispose Water

(Note: Report results of multiple completion on Well Completion or Recompletion Report and Log form.)

13. Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

Water Flow

Encountered water flow on 9/29/92 F/3590'-4489' at a maximum rate of 240 bbls per hour and H_2S with 700 PPM at shaker. Water flow lasted 45 hours.

J. Sara
JUN 3 1993

14. I hereby certify that the foregoing is true and correct
Signed [signature] Title Richard L. Wright, Division Operations Manager Date January 19, 1993

(This space for Federal or State office use)

Approved by ______ Title ______ Date ______
Conditions of approval, if any:

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

Formerly 9-331 DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

SUNDRY NOTICES AND REPORTS ON WELLS

(Do not use this form for proposals to drill or to deepen or plug back to a different reservoir. Use "APPLICATION FOR PERMIT—" for such proposals.)

5. NM-(14332) 86710

6. IF INDIAN, ALLOTTEE OR TRIBE NAME

7. UNIT AGREEMENT NAME

1. OIL WELL [X] GAS WELL [ ] OTHER

2. NAME OF OPERATOR
Phillips Petroleum Company

8. FARM OR LEASE NAME
Lost Tank (SWD)
Luke Federal

3. ADDRESS OF OPERATOR
4001 Penbrook St., Odessa, Texas 79762

9. WELL NO.
1

4. LOCATION OF WELL (Report location clearly and in accordance with any State requirements.* See also space 17 below.)
At surface

Unit E, 1980' FNL & 660' FWL

10. FIELD AND POOL, OR WILDCAT
N.E. Livingston Ridge (De

11. SEC., T., R., M., OR BLK. AND SURVEY OR AREA
Sec. 31, T-21-S, R-

14. PERMIT NO.
30-025-31443

15. ELEVATIONS (Show whether DF, RT, GR, etc.)
3646' GR

12. COUNTY OR PARISH
Lea

13. STATE
NM

16. Check Appropriate Box To Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:				SUBSEQUENT REPORT OF:			
TEST WATER SHUT-OFF	[ ]	PULL OR ALTER CASING	[ ]	WATER SHUT-OFF	[ ]	REPAIRING WELL	[ ]
FRACTURE TREAT	[ ]	MULTIPLE COMPLETE	[ ]	FRACTURE TREATMENT	[ ]	ALTERING CASING	[ ]
SHOOT OR ACIDIZE	[ ]	ABANDON*	[ ]	SHOOTING OR ACIDIZING	[ ]	ABANDONMENT*	[ ]
REPAIR WELL	[ ]	CHANGE PLANS	[ ]	(Other)			[ ]
(Other)			X				

(NOTE: Report results of multiple completion on Well Completion or Recompletion Report and Log form.)

17. DESCRIBE PROPOSED OR COMPLETED OPERATIONS (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

DUE TO A WATER FLOW ENCOUNTER AT APPROXIMATELY 3050' THE 8-5/8" CASING CEMENT PROGRAM WILL BE REVISED AS FOLLOWS TO MINIMIZE THE POSSIBILITY OF LOST CIRCULATION INTO THE WATER FLOW ZONE WHILE CEMENTING.

18. I hereby certify that the foregoing is true and correct

SIGNED [signature] TITLE Supervisor Reg/Proration (915) 368-1488 DATE 11-21-91

(This space for Federal or State office use)

APPROVED BY ______ TITLE ______ DATE 11/25/91

CONDITIONS OF APPROVAL, IF ANY:

8 5/8" CSG IS TO BE CEMENTED TO THE SURFACE.

*See Instructions on Reverse Side

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency

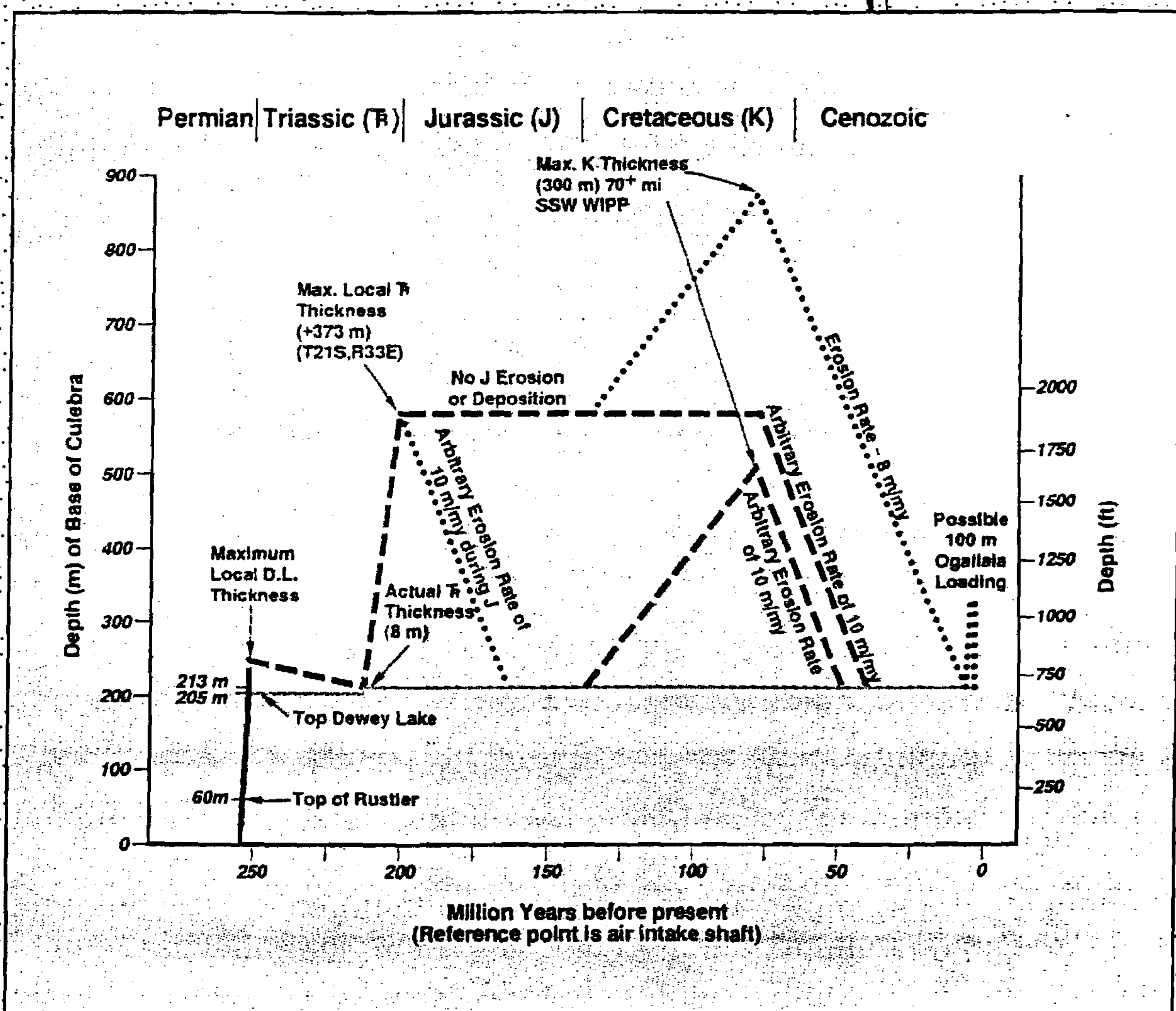
Appendix G

Regional Geological Processes Affecting Rustler Hydrogeology

Dennis W. Powers
and
Robert M. Holt

(report by IT Corporation)

Regional Geological Processes Affecting Rustler Hydrogeology



REGIONAL GEOLOGICAL PROCESSES AFFECTING RUSTLER HYDROGEOLOGY

Prepared for:

Westinghouse Electric Corporation
P.O. Box 2078
Carlsbad, New Mexico 88221

Prepared by:

Dennis W. Powers
Consulting Geologist
HC 12, Box 87
Anthony, Texas 79821

Robert M. Holt
IT Corporation
5301 Central Avenue NE, Suite 700
Albuquerque, New Mexico 87108

April 1995

EXECUTIVE SUMMARY

This executive summary is prepared for the general reader rather than as a strict summary of the technical material. The executive summary includes broader information about the context of the study and general implications. It also includes limited explanations of the technical approach not included in the abstract. While this report was written mainly for the professional geologist, the technical community at large should be able to follow the thrust of the arguments with occasional reference to the American Geological Institute Glossary of Geology to understand some technical terms.

The Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico is being constructed to isolate transuranic radioactive waste from U.S. defense programs from the environment by emplacing it within the bedded salt of the Permian Salado Formation. The Culebra Dolomite Member of the Permian Rustler Formation is the most significant hydrological unit overlying the Salado. Geological processes operating since Rustler deposition have contributed to the evolution of Culebra hydrological properties. These properties are being extensively evaluated.

This report addresses the timing, magnitude, and areal extent of these regional geological processes with respect to the Culebra. In another document, we will more directly address the relationship between hydrological properties and factors such as overburden or thickness of halite in the Rustler. While these geological processes have been considered at one level or another in previous reports for the WIPP, we address some in much more detail, and all are cast in terms of their effects on the Culebra.

Evaporites in the Delaware Basin have partially been dissolved, and Culebra hydrological properties have commonly been associated with dissolution of halite from either the Rustler or the Salado. The analyses have not always been provided in detail, and we have reexamined both the Salado and the Rustler.

The upper half of the Salado was subdivided into intervals for comparison of geophysical logs from the area. From the WIPP site to the southeast, the intervals change little in thickness and represent the depositional sequence. West of the WIPP site, the upper interval of the Salado (from Marker Bed 103 to the top of the Salado) declines greatly in thickness across a horizontal distance of about 2 miles (about 3 kilometers). The zone of thinning underlies Livingston Ridge, the eastern boundary of Nash Draw, and very closely parallels its trend. The zone then runs to the southeast. Several of the Nash Draw drillholes used for hydrological monitoring lie on this trend or west of it, and they show the effects of subsidence after dissolution. Along the southern part of the mapped area, highly variable thicknesses signify considerable Salado dissolution in the Big Sinks and Phantom Banks areas. Furthermore, the dissolution in the southern part of the map area has reversed the eastward dip on the Culebra and created an anticline (the "Remuda Basin anticline") that trends from the Remuda Basin to the southeast.

The structure contour map of the Culebra indicates some of the tectonic activity that has affected the unit and can change hydrologic characteristics. The Culebra shows a general eastward dip like the formations under the evaporites, but it is further deformed locally. Northeast of the WIPP site, at the location of drillhole ERDA 6, the Castile Formation has been deformed, and the Culebra has been arched into an anticline. The effects of this deformation extend to the northeastern corner and to the eastern side of the WIPP site. South of the WIPP site, the Remuda Basin anticline formed from a combination of regional eastward dip and westward reversal of dip caused by subsidence over an area of Salado dissolution. More subtle structural changes across the WIPP site have been isolated by comparing the present Culebra structure to the estimated regional structure—a regular eastward dip of about 1°. The main feature is a negative deviation, along the north side of the WIPP site, from this estimated regional structure. The feature is larger than can be accounted for by halite dissolution, and the Dewey Lake is thicker in the same area, indicating that it apparently down-warped moderately before late-Cenozoic erosion. This analysis, comparing structure to an estimate of regional structure, is limited because of assumptions, but it also has power to delineate subtle activity superimposed on regional structure.

Geophysical logs of the Rustler were carefully interpreted to map the presence of halite within three members of the formation. In contrast to some earlier studies, the unnamed lower member was separated into two mudstone/halite units to emphasize the location of halite immediately under the Culebra. Some earlier studies depended more on cuttings and core for information. Our work may indicate halite when it is absent, whereas studies depending on cuttings and core may miss some halite. There is general agreement, however, between the two methods. By mapping the areal extent of halite in the Rustler members, we will be able in a later document to determine how well halite thickness correlates with hydrologic parameters. In past studies, we have reported the results from shaft mapping, core descriptions, and geophysical log interpretations of the Rustler. On the basis of these studies, we concluded that halite was mainly distributed according to sedimentary processes rather than later dissolution. If so, this would minimize the effects of Rustler halite dissolution on Culebra hydrology.

The rocks at the WIPP were buried more deeply in the past, but part of the overburden has been removed by erosion. These stress changes can create or enhance fracture porosity within beds such as the Culebra. We have reconstructed some possible loading and unloading histories based on the geology of the site and region. The most likely sequence is that Triassic rocks loaded about 400 meters (about 1,300 feet) more before a lengthy period with some erosion and little deposition. Near mid-Cenozoic time, the rocks in the basin were tilted to the east. After that, the rocks across the site were eroded to a wedge-like shape, during what was likely the highest rate of unloading. Surrounding areas have thick deposits of Cretaceous rocks, but there is little to indicate thick Cretaceous deposits across the WIPP site. Data from hydrocarbon maturation more weakly indicate greater burial as well.

In this report, different regional geological processes were examined in some detail with respect to the Culebra. In a later report, these and other data will be integrated to try to correlate Culebra hydrology more closely with pertinent geological factors.

PREFACE

Through our studies of the Permian Rustler Formation (Holt and Powers, 1988; Powers and Holt, 1990), we began to discern different processes contributing to the development of Rustler hydrogeology. We proposed (e.g., Beauheim and Holt, 1990) some alternatives for Rustler hydrology that emphasized a history to this development. To better understand Rustler hydrology, we also believed it necessary to understand better both the underlying and overlying units and the geological history of the units since the Permian.

We began several specific studies of geology and hydrology related to the Rustler and attempted to integrate the information into a single, comprehensive volume. Like some other documents for the Waste Isolation Pilot Plant project, this volume has been cited while in draft (commonly as Holt et al., in preparation), and various figures have been used or modified for use in other documents. Several topics included in the draft have now been published or made available in other formats (e.g., Beauheim and Holt, 1990). As a result, the main topics not yet available are the geology and paleohydrology related to the Gatuña (Powers et al., in review), regional geological processes affecting Rustler hydrology (this report), and a summary paper on Rustler hydrogeology. These are being prepared and printed as separate documents, and all are expected to be available during the first half of 1995.

Besides depositional processes and features, we recognize several other processes that may contribute to the pattern of Rustler hydrogeology. This report broadly assesses several of these processes, based on new or additional information.

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Abstract

The Culebra Dolomite Member of the Permian Rustler Formation is a hydrological unit that significantly affects performance analysis of the Waste Isolation Pilot Plant (WIPP). Regional geological processes following deposition of the Culebra contributed to its hydrological properties. We focused on dissolution, tectonics, and loading/unloading to determine the area, magnitude, and timing of their effects on the Culebra.

Though the Salado Formation has been extensively dissolved in the western Delaware Basin, drillhole data in the area around the WIPP show that the site has not been affected. The upper Salado thins more abruptly to the west of the WIPP, along the margin of Nash Draw, and to the southeast. Several Nash Draw boreholes have been drilled on this zone of thinning.

The Culebra has been deformed by regional tectonics, evaporite deformation, and dissolution of underlying rocks. The eastward dip (approximately 1°) is its main tectonic feature. At ERDA 6, a drillhole northeast of the site, the underlying evaporites have deformed, arching the Culebra well above the regional trend and forming an anticline. South of the WIPP, an anticline (the "Remuda Basin anticline") has formed where dissolution of the Salado to the west reversed the eastward regional dip. Across the WIPP site, more subtle changes in structural position of the Culebra are believed to have formed from variations in regional tectonics or from evaporite deformation, rather than from dissolution of Rustler halite.

Geophysical logs were interpreted to determine the areal extent of halite in various Rustler members in the vicinity of the WIPP. In contrast to some earlier studies, the unnamed lower member was divided into two separate mudstone/halite units. Though we believe halite in the Rustler is mainly distributed according to depositional processes, the data will permit the hydrologic parameters of the Culebra to be compared more directly with variations in thickness and other factors.

The Culebra has been physically perturbed by loading and unloading since the Permian. It is most likely that approximately 400 meters (approximately 1,300 feet) of rocks were added during the Triassic. Little, if any, additional load was added until the late Cenozoic. The bevelled edges of the Dewey Lake and Santa Rosa Formations suggest that they were eroded since regional tilting occurred about mid-Cenozoic, which may have been the most rapid

period of unloading experienced by the Culebra. Evidence based on hydrocarbon formation in formations below the evaporites suggests greater loading and unloading.

1.0 Introduction

The Permian Rustler Formation (Figure 1) of southeastern New Mexico overlies Permian evaporite beds of the Salado Formation. The Waste Isolation Pilot Plant (WIPP) is a facility designed to dispose of transuranic wastes (from U.S. defense programs) in the Salado. The Rustler has been intensely studied (e.g., Beauheim and Holt, 1990; Beauheim et al., 1991; Reeves et al., 1991) as a potential pathway for waste should any mechanism release waste upward from the disposal horizon.

Most of the available field work on Rustler hydrology has focused on determining in situ properties of water-bearing units (mainly the Culebra Dolomite Member) through various borehole tests. There are continuing efforts to try to understand how well the hydrologic data at boreholes represent the formation or individual units. Last, but not least, the data and generalizations about the hydrology of the Culebra have been used to assess the performance of the WIPP in isolating waste, given certain assumptions about failure scenarios.

Studies of Rustler geology mainly began from the need to describe the geology of WIPP shafts and were accelerated by differences in interpretation of the distribution of halite in the formation. Depositional features were studied and interpreted (Holt and Powers, 1988), and we began to recognize additional geological processes that contributed to the development of Rustler hydrology. Here we will concentrate on those processes, exclusive of deposition, that we believe most contribute to Rustler hydrology.

A number of regional processes likely have affected the hydrogeology of the Rustler by developing or enhancing the fracture permeability of water-bearing units, especially the Culebra. Pervasive processes, such as regional tilting, may have introduced areally extensive and relatively uniform strain, and regionally extensive processes, such as dissolution of the Salado, may have local consequences around the WIPP. In the analysis that follows, we emphasize the regional processes likely to have some local effect on hydrologic characteristics of the Culebra. In order of discussion, these are dissolution of the Salado, tectonic or other deformation of the Culebra, dissolution of Rustler halite, and the unloading history of the Culebra.

Only a few stratigraphic units are discussed in this report (Figure 1). The Salado and Rustler are considered in more detail, and some additional stratigraphic information is presented in

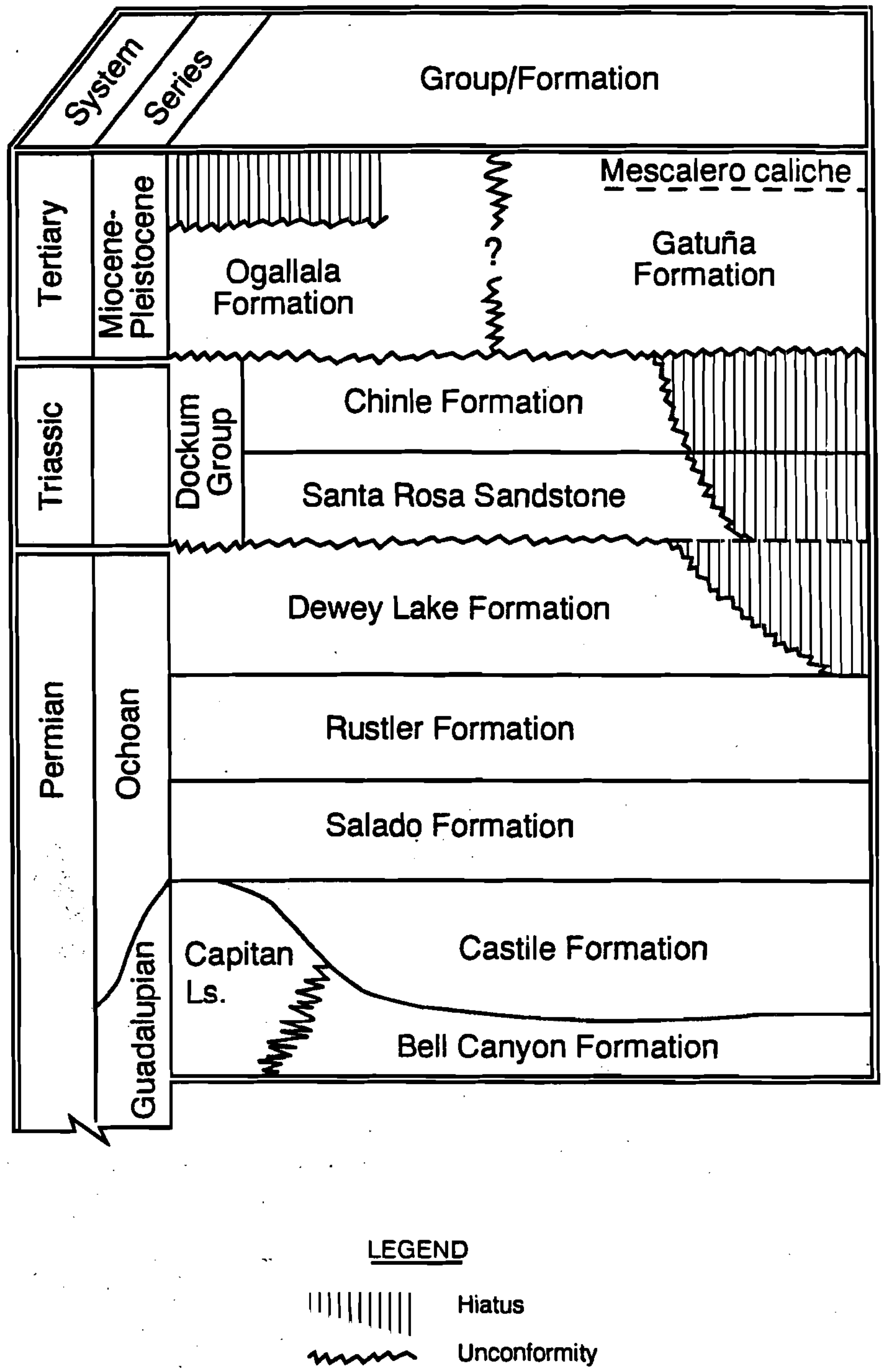
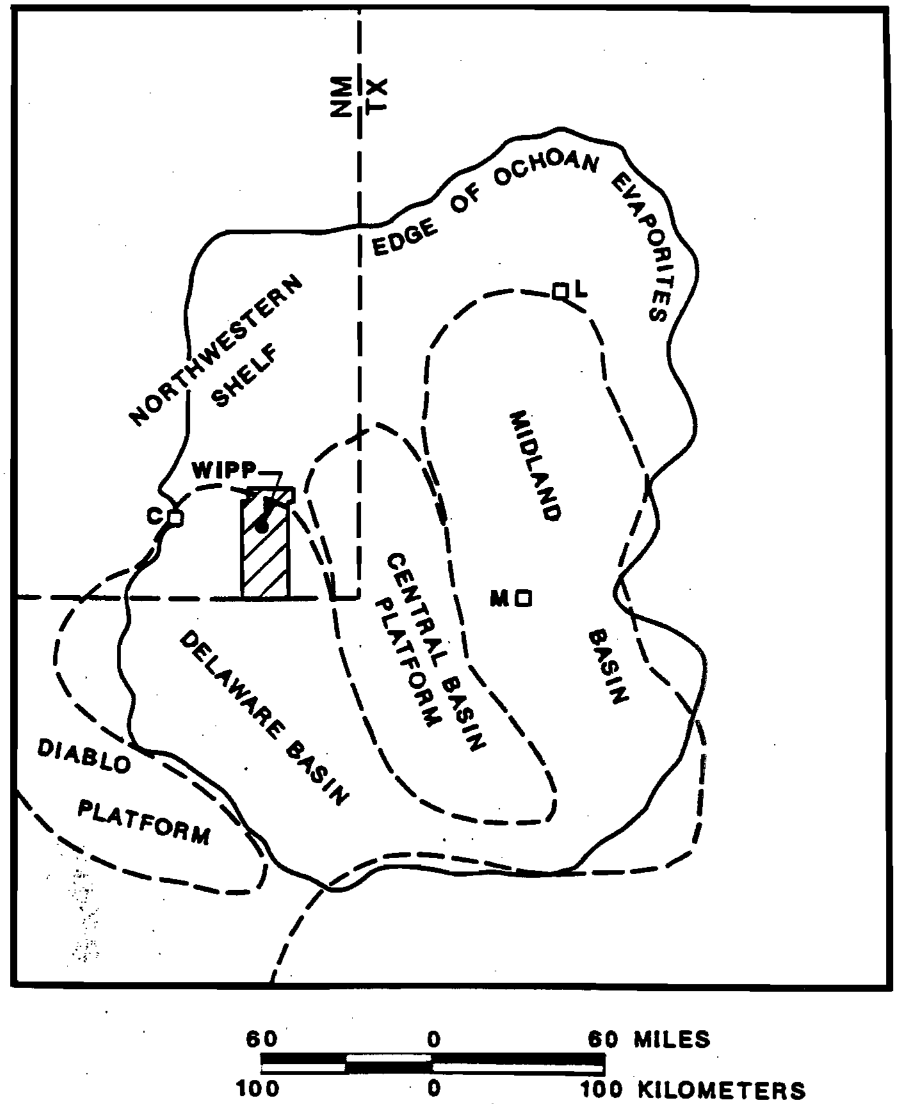


Figure 1
General Stratigraphic Column Northern Delaware Basin

later sections, as needed. (For further information on the background of the stratigraphic nomenclature, refer to Powers and LeMone [1990]. Lucas and Anderson [1993a,b] have proposed some changes in stratigraphic nomenclature for this area that we are not using until their utility is established.) Within the Delaware Basin (Figure 2), the Salado overlies the Permian Castile Formation, also an evaporite deposit, and underlies the Rustler Formation, a mixed clastic and evaporite unit (Holt and Powers, 1984, 1986a, 1986b, 1988; Powers and Holt, 1990). The overlying Permian Dewey Lake Formation and Triassic Santa Rosa Sandstone (also referred to in reports respectively as the Dewey Lake Red Beds and the Dockum Group or the Triassic undivided) are considered briefly for certain processes, especially unloading. The Mio-Pliocene Ogallala Formation of the High Plains is useful for estimating some bounds to erosion and unloading. The Miocene to Pleistocene Gatuña Formation is also briefly referred to, though it is considered separately as it relates to geological history and possible recharge (Powers and Holt, 1995). The Rustler Formation has been evaluated in detail in Holt and Powers (1988).

Data developed for this report and existing data sets used to supplement our work have varying metric and English units. The units used in differing sources are generally adopted as primary units, and conversions are provided. Conversions may be rounded, especially if an estimate is the beginning point. Thus, 300 m may show a conversion of 1,000 ft. Not all units, however, are converted. A contour line value may not be converted, and some repetitive values have been deliberately left without a conversion.

Drillhole data used in and developed for this report have a history that is demonstrated by the appendix organization. Many drillholes were initially interpreted for the Rustler study (Holt and Powers, 1988), and these drillholes provide a substantial part of our database. Appendix A presents this database, supplemented by some additional drillholes and interpreted for additional stratigraphic units. Appendix A-1 presents basic identification and location data for each drillhole. Appendices A-2, A-3, and A-4 present depth data, respectively, for the Salado, Rustler, and Dewey Lake and Santa Rosa. Appendix B reports similar location and identification data (B-1) and depths for Rustler units (B-2) provided by Richey (1989). Appendix C is a comparison of the Rustler data between the Holt and Powers data set (Appendix A-3) and the Richey data set (Appendix B-2). Topics are not introduced in the text exactly in the order of appendix information.



Ochoan Series: Dewey Lake Formation
Rustler Formation
Salado formation
Castile Formation

Modified from Jones (1972). C, M, L are Carlsbad, Midland, and Lubbock.
Study Area is Hachured

Figure 2
Approximate Edge of Ochoan
Evaporites Superimposed on Broad Tectonic Elements.

2.0 Salado Dissolution

It has long been recognized that the Salado Formation has been variably dissolved, with the greatest effects occurring west of the Pecos River. Removing the thick salt deposits of the Salado significantly disrupts the overlying units, including the Rustler Formation. Within this section, we review the general geology of the Salado, including WIPP information bearing on the depositional history of the unit. Specific data on the thickness of the Salado have been developed and help to ascertain both the location of, and the potential for, disruption of the overlying units by dissolution.

2.1 Background Information on the Salado

The Permian Salado Formation of southeastern New Mexico and west Texas is well known as the major domestic source of potash used as fertilizers in the United States. The Salado was deposited over a large area of the Permian Basin in New Mexico and west Texas (Figure 2), and Lowenstein (1988) considers the Salado a saline giant because of its areal extent. Over much of the area, Salado strata are readily traceable. The dominant mineral is halite, but marker beds are mainly sulfate minerals. These marker beds, consisting of anhydrite and polyhalite (or gypsum at shallow depths), are continuous over large areas. The U.S. Geological Survey (Jones et al., 1960) numbered the more prominent of these marker beds downward from 100 to 144.

The Salado displays features that have been interpreted to have formed in shallow water in a desiccating basin (Gard, 1968; Jones, 1972; Lowenstein, 1982, 1988; Holt and Powers, 1990, 1991). Depositional features from WIPP shafts have been described and interpreted by Holt and Powers (1990, 1991), indicating that water-table levels changed frequently while beds were being deposited. Argillaceous beds and features are analogous to young evaporites exposed at Death Valley, California.

2.2 Salado Stratigraphy

The Castile and Rustler Formations were named by Richardson (1904) for outcrops at Castile Spring and the Rustler Hills, respectively, in Culberson County, Texas. The principal evaporite rocks are below the Rustler and were divided by Cartwright (1930) into two units: the lower and upper Castile Formations. Lang (1935) later proposed that the upper Castile Formation of Cartwright should be called the Salado Formation after Salado Wash in northern Loving County, Texas. Lang (1935) restricted the name Castile to the lower section.

Pre-Rustler evaporites belonging to the Salado were noted by Lang (1935) to generally have more than 1 percent K_2O, as well as polyhalite. Adams (1944) states that the Salado was defined by Lang (1935) ". . . to include all pre-Rustler evaporites containing more than 0.5 of 1 percent of potash," though this limit is not in various publications by Lang (1935, 1937, 1939, 1942) covering the Salado. A stratotype of the Salado was designated (Lang, 1935) in the Pinal Dome Means No. 1 well (southeast corner, Section 23, Block C-26, P.S.L.) in eastern Loving County, Texas. Lang (1939) considered the difficulties in designating the base of the Salado on any of several criteria:

- The base of salt over the Capitan reef
- The base of potash, including polyhalite
- The top of banded anhydrite
- The contact between anhydrite and Capitan limestones.

This was, at least partially, resolved when Lang (1942) described the anhydrite overlying Capitan reef rocks and defined the contact as the base of the Salado. Lang named this basal member of the Salado the Fletcher Anhydrite after the U.S. Potash Fletcher No. 1 core test (Section 1, T.21S., R.28E.) in Eddy County, New Mexico. By this definition, the Castile Formation was restricted to the Delaware Basin area inside the Capitan reef. Later investigators (Jones et al., 1973, p. 15; Bachman, 1984) suggest that the Fletcher Anhydrite Member may interfinger with anhydrites normally considered part of the Castile Formation elsewhere in the Delaware Basin. In a recent paper, Madsen and Raup (1988) agree with earlier proposals (e.g., Bachman, 1984) that the Castile was exposed along the western margin of the Delaware Basin before the Salado was deposited.

Several additional members or beds within the Salado have been formally or informally proposed and are used with varying frequency (Figure 3). Kronlein (1939) named the McNutt potash zone after the 250-foot (ft) (76-meter [m]) thick interval with soluble potash salts first demonstrated in the Snowden-McSweeny V.N. McNutt No. 5 drillhole. The Cowden Anhydrite Member was included in the lower Salado by Lang (1942); the Cowden was designated by Giesey and Fulk (1941) in a well in the North Cowden field in Ector County, Texas. In the northern Delaware Basin, a zone of halite below the Cowden has informally been called the infra-Cowden. Within this salt unit, Lang (1942) designated the La Huerta Siltstone Member for a 5-foot-thick (about 1.5-m-thick) red siltstone that Lang felt is common over the Capitan reef area. The name comes from La Huerta townsite, north of Carlsbad, where Lang expected the siltstone would crop out if present at the surface. In the northern Delaware Basin, a widespread unit was named the Vaca Triste Sandstone Member (Adams,

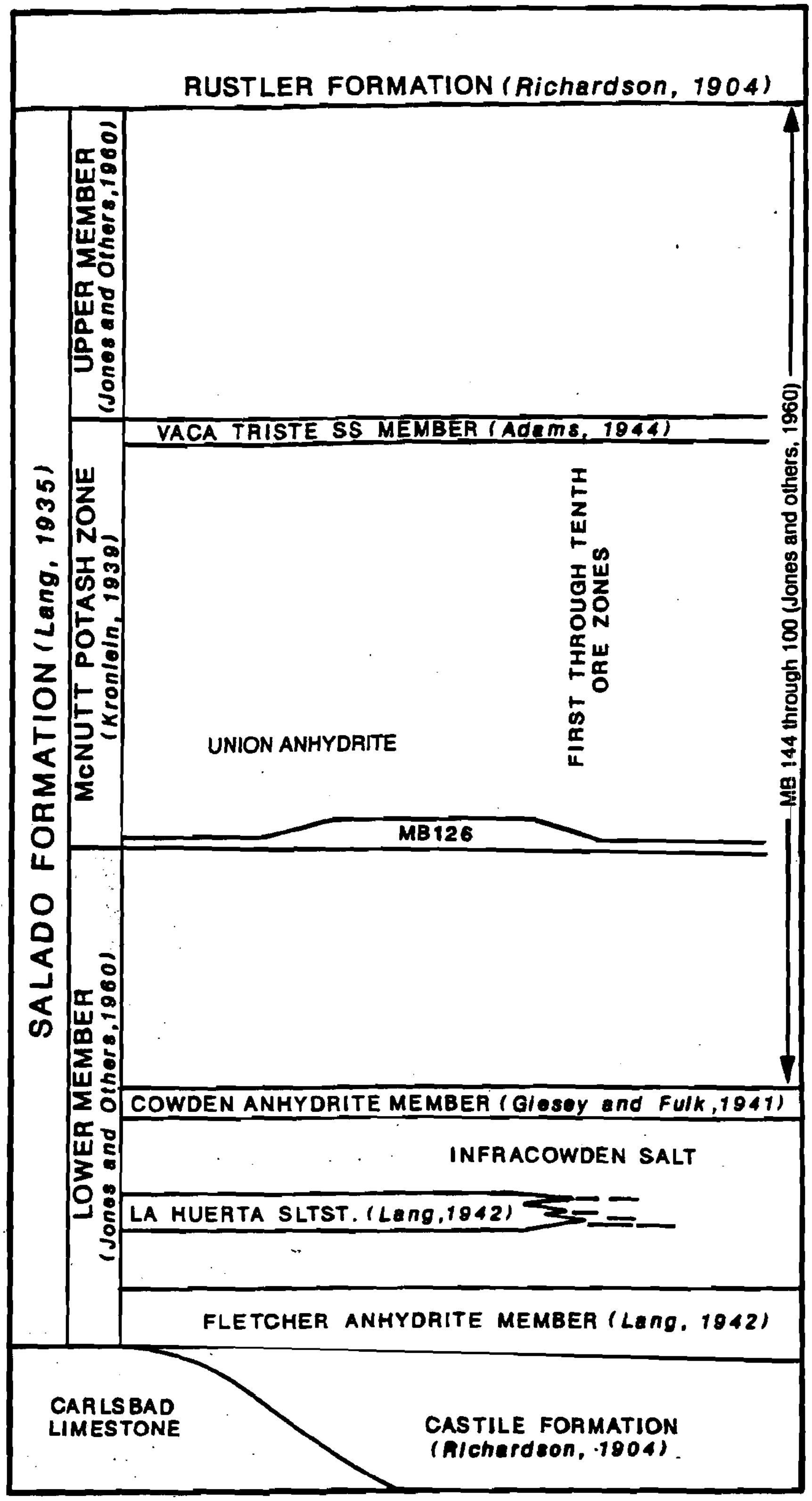


Figure 3
Salado Stratigraphy

1944) for Vaca Triste Draw. The type section was designated at depths between 1,555 and 1,565 ft (474 and 477 m) in the Continental King No. 1 well (Section 26, T.25S., R.32E.) in Lea County, New Mexico. Adams (1944) reports 15 ft (4.6 m) of anhydrite immediately underlying the Vaca Triste. Geophysical logs from the vicinity of Continental King No. 1 display a prominent siltstone bed at about the same depth, but there is no discernible anhydrite or sulfate unit beneath it (Figure 4). These geophysical log signatures provide a standard for the Vaca Triste, though it cannot be conclusively demonstrated to be the Vaca Triste as described by Adams (1944). The log signatures provided are similar in form and stratigraphic position to the Vaca Triste as identified in other areas (e.g., Jones et al., 1960).

Kronlein (1939) introduced a numbering system for halitic and sulfatic units within the upper Castile (Salado), but this scheme was not specifically adopted. Jones et al. (1960) provide general geophysical log responses and corresponding lithologic logs for the Salado in the potash resource area in the northern Delaware Basin and on the Northwestern Shelf. Jones et al. (1960) clarified and established informal marker bed and ore zone terminology (Figure 3) that has become standard and is used here. In addition, Jones et al. (1960) commented on the variability of marker bed thickness and lithology on the shelf north of the Delaware Basin and in the northern Delaware Basin area.

2.3 General Salado Geology in the Northern Delaware Basin

The total Salado section in the eastern part of the Delaware Basin (Figure 2) consists of about 2,000 ft (600 m) of evaporites. The Salado is about the same thickness at the WIPP site in the northern part of the basin. The Salado can be considerably thinner (1,000 ft [300 m]) northwest of the WIPP site, near the potash mines.

Over the western part of the Delaware Basin, however, the Salado consists of yellowish-brown to reddish-brown, poorly consolidated argillaceous and silty sediment and blocks of gypsum that are commonly bright reddish brown. The gypsum blocks are attributed informally to incongruent solution of polyhalite beds, as most polyhalite beds are orange to reddish-brown from disseminated iron oxide. The blocks also are considered to be alteration products of one or another of the major marker beds of the Salado. These outcrops are thin, and they have been studied little because they are usually considered a residue from nearly complete dissolution of the Salado.

Between these extremes, the Salado may be thinner than it normally is in or near the depocenter, varying due to deposition, dissolution, or some combination of the two. Holt and

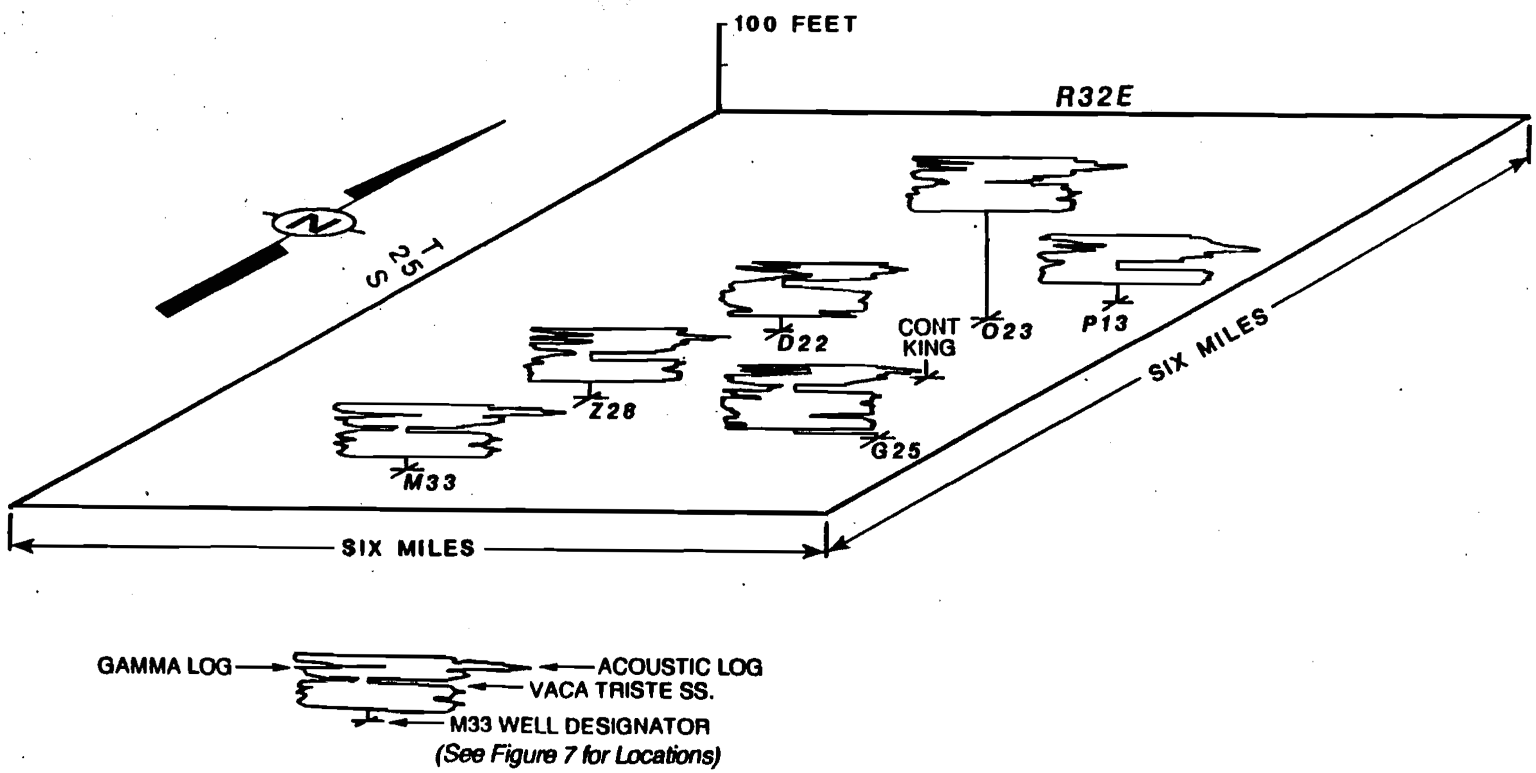


Figure 4
Vaca Triste Log Signatures near Continental King Well, Paduca Field.

Powers (1988), following Bachman (1974), demonstrated that in the Nash Draw area, dissolution removed as much as 180 ft (55 m) of upper Salado, causing collapse upward that has affected the overlying units, including the Culebra Dolomite Member of the Rustler Formation. The inference by Bachman (1974) that this occurred since formation of the Mescalero caliche is no longer maintained as correct (Bachman, 1980, p. 85), while the removed thickness is likely underestimated. The hydrologic character of the Culebra has been altered by this process in the Nash Draw area.

For this study, the upper Salado is more systematically examined over a larger area, and the objective is to assess the amount of soluble minerals that may have been removed from the upper Salado in the vicinity of the WIPP site. The objective requires that we estimate the reasonable variation in original deposition that may have occurred and the relative time of removal.. A series of isopach maps of selected upper Salado beds and intervals between them demonstrates the variable thickness. Combined with analysis of geophysical log signatures and selected structure contour maps, these isopachs permit an initial assessment of how past and/or future dissolution of the upper Salado may affect Rustler hydrogeology.

From the general vicinity of the Pecos River eastward, the subsurface Salado thickens toward an area near the eastern margin of the Delaware Basin. Additional sulfate marker beds can also be distinguished in the upper Salado in the eastern Delaware Basin. Jones et al. (1960) and Bachman (1974) described how, from east to west, the Rustler lies on successively deeper marker beds of the Salado. Vine (1963) attributed the relationship to dissolution of the upper Salado. Jones et al. (1973) note that a solution residue of the Salado would probably be lumped with basal Rustler mudstones on the basis of geophysical logs. Holt and Powers (1984, 1988) recognize erosion and channeling in basal mudstones of the Rustler at the WIPP site. At least some pre-Rustler erosion and dissolution of the upper Salado probably have occurred. Based on outcrops, Adams (1944) considered the Salado/Rustler contact to be erosional.

The present relationship of the upper Salado to the basal Rustler was developed apparently both by pre-Rustler solution and erosion (that continued as the basal Rustler was being deposited) and later episodes of dissolution (that may be largely Cenozoic and are probably continuing at some level today). We are still unable to separate basinwide the relative contributions of these two episodes, and we generally ascribe the effects to later dissolution, though this overestimates the effects during this time.

Between sulfate marker beds, intervals of halite are mixed variously with polyhalite, anhydrite, siliciclastics, and some potash minerals. In this study, siliciclastic beds, mudstones, or argillaceous halite were distinguished by geophysical log responses (mainly natural gamma ray and sonic or acoustic velocity logs). These argillic rocks are commonly continuous over the width of the basin like the numbered sulfatic marker beds (Powers et al., 1988), although early mapping in the WIPP underground ([TSC-D'Appolonia], 1983; Powers and Hassinger, 1985) and more recent mapping in a shaft (Holt and Powers, 1991) demonstrated that the argillaceous units are laterally disrupted on a scale of 1 m or less (about 3 ft) by syndepositional processes. The argillaceous units have not been numbered or named, probably because they are not as distinctive individually in cores or cuttings, with the exception of the Vaca Triste Sandstone Member (Adams, 1944) that is taken as the upper boundary of the McNutt potash zone. The siliciclastic beds are also helpful in diagnosing the effects of dissolution and the extent of lateral facies changes within the Salado.

Within Nash Draw, much of the upper Salado has been removed by dissolution (Bachman, 1974; Holt and Powers, 1988). Erosional features in the basal Rustler mudstones, however, also suggest that the upper Salado section in the central to western parts of the Delaware Basin may have been lost through erosion and/or solution before the Rustler was deposited. The section may not have been reduced simply due to dissolution in the more recent geological past. Three separate processes may contribute to the generally observed contact relationships between Rustler and Salado: dissolution, pre-Rustler erosion and dissolution, or Salado facies/depositional changes. Dissolution has been considered as the significant process (e.g., Jones et al., 1973; Bachman, 1974; Anderson, 1978; Vine, 1963; Lambert, 1983), though Adams (1944) reported a nonconformity at the Salado/Rustler contact. The prevailing assumption has been that upper Salado marker beds, lithofacies, and thickness were deposited uniformly through the area of the Pecos River Valley. This assumption tends to maximize the volume estimate of halite and other rocks removed by dissolution.

As rock is dissolved in the subsurface, void space is created, and the overlying rocks tend to collapse and fracture (see review in Holt and Powers, 1988). Such fracturing and collapse has been hypothesized to contribute to the hydrologic characteristics of the Culebra Dolomite Member of the Rustler Formation (e.g., Gonzalez, 1983; Mercer, 1983; Beauheim, 1988). Holt and Powers (1988) suggest that rocks overlying a dissolution zone are affected in proportion to the thickness of dissolved rock. A realistic estimate of the thicknesses of removed Salado and Rustler rocks may correlate with present hydrologic properties (and predict future characteristics) of the Culebra better than conservative estimates. Holt and

Powers (1988) reconstructed depositional environments of the Rustler, providing a more realistic (and lower) estimate of the extent of recent Rustler dissolution. Most of the Rustler halitic units were affected by synsedimentary dissolution much more than by dissolution after the Rustler was deposited. The upper Salado needs to be reexamined as well to provide a more realistic estimate of recent dissolution.

In this study, the upper Salado relationships to the Rustler are reexamined to provide insight into possible effects of facies changes and pre-Rustler erosion and solution, as well as more recent or post-Rustler dissolution. For an initial approach, the loss of upper Salado is estimated from the change in thickness from the base of the Rustler to specific marker beds (e.g., Marker Bed [MB] 103). Jones et al. (1960) indicated how geophysical logs could be used in the study of the Delaware Basin evaporites, and they concluded that some marker beds vary considerably in thickness and composition, based on cores and geophysical logs. A database was not established by Jones et al. (1960). A more recent study (Adams, 1970) of the Salado based on geophysical logs and cores provided some information similar to this study and demonstrated the utility of using geophysical logs.

Facies changes in the Salado are estimated first by carefully examining marker beds and intermarker beds in areas near the Salado depocenter, southeast of the WIPP site. Closely spaced and numerous geophysical logs permit us to study continuity of marker beds, thickness and log character variability, and lithologic changes of intermarker beds. Logs from the depocenter and margins serve as a beginning point and standard of comparison for logs in the critical area to the west where the upper Salado begins to thin.

Syndepositional erosion and dissolution may be the most difficult to assess. Larger, mappable channel forms, similar to those mapped in the Salado in shafts at the WIPP (Holt and Powers, 1986b), may or may not exist throughout the area; we are unlikely to interpret them using geophysical logs in the rest of the basin. Truncated marker beds at the top of the Salado need to be evaluated for evidence of dissolution and erosion. Elsewhere, Salado sulfates crop out, having apparently survived extensive solution. We might, therefore, expect sulfate to accrete to the base of the residue unit; erosion should remove and truncate beds. Sulfates could be dissolved completely, and the result may be indistinguishable from erosion. Carefully reconstructed cross section and log signatures should provide better evidence of the extent of facies changes, pre-Rustler erosion and solution, as well as more recent dissolution of the Salado in the northern Delaware Basin.

2.4 General Methods to Evaluate Salado Dissolution

Isopachs and cross sections are based mainly on geophysical log data and are tied stratigraphically to the marker bed system within the Salado (Jones et al., 1960). Marker beds of the upper Salado are dominantly sulfatic (anhydrite and polyhalite, or gypsum where altered near the surface). In the deeper subsurface, anhydrite dominates, though polyhalite [$K_2MgCa_2(SO_4)_4 \cdot 2H_2O$] is also a common mineral. These two rock types, for example, have high acoustic velocities and densities (Table 1). Polyhalite has a high natural gamma signature from the decay of ^{40}K, and the hydrogen absorbs neutrons. Gamma ray and acoustic logs are relatively common in the Delaware Basin through the upper Salado and Rustler. Because of their characteristics and abundance, gamma ray logs combined with acoustic (sonic), density, or neutron logs were chosen, in that order of preference.

Table 1
Typical Log Responses for Salado Rocks

Rock Type	Natural Gamma (API Units)[a]	Acoustic Travel Time (in microseconds per ft)	Density (in grams per cubic centimeter)	Neutron
Halite	10[b]	~70	2.0–2.1	High
Argillaceous halite	10–30	70–80	<2.1	Low–Medium
Mudstone	20–50	>80	<2.0	Low
Gypsum	10[b]	60–70	~2.4	Low
Anhydrite	10[b]	~55	~2.9	High
Polyhalite	10–100[b]	~55	~2.8	Low

[a]API (American Petroleum Institute) units for natural gamma are normalized to 100 API units as the log response for a North American mid-continent black shale.
[b]Reflects baseline value on most logs.

The alleged dissolution residues of the upper Salado consist in large part of sulfates and insoluble silicates. Facies changes in the interbeds between marker beds may be inferred if the natural gamma in thick halites is insufficient to account for the thickness of the laterally equivalent silicate "residue." There are too few data to provide quantitative calibration of log responses, but some empirical notions of log response are useful (Doveton, 1986). The gamma reading from the "residue" times the thickness of the "residue" should be similar to the product of the "undissolved" lateral equivalent and its thickness, assuming natural gamma in "undissolved" halite units is entirely due to insoluble silicates. A 10-ft (3-m) "residue" registering 40 API units should have an "original" equivalent of, for example, 20 ft (6 m) at 20 API units, or 40 ft (13 m) at 10 API units. [Because ^{40}K in polyhalite or sylvite can contribute natural gamma in the "undissolved" unit, these assumptions can lead to overestimating silicates in the undissolved section. A spectral gamma log would help distinguish ^{40}K from other mineral sources of natural gamma.] Some of the Salado beds near the WIPP facility horizon have been analyzed in the laboratory, indicating low acid-insoluble content (e.g., average of 0.6 weight percent; Stein, 1985). These samples could be compared to log responses if additional calibration is desired. This study provides the first known examination of possible facies changes of the upper Salado across this area.

For baseline data, MB 103, MB 109, MB 123/124, Union anhydrite, and Vaca Triste Sandstone Member were identified on logs. [MB 123 and MB 124, and any distinguishable interval between them, are considered a single unit in this report and will be written as MB 123/124. The base of the combined unit is also referred to as the base of MB 124.] The base and top of each unit were selected on the basis of combined gamma ray and sonic or density logs. The sonic and density are most responsive to the sharp basal contact that most marker beds display. The upper contact may be less sharp than the base; reference signatures of selected contacts (Figure 5) provide a standard. From these data, isopach maps of selected marker beds, interbeds, or combined units were constructed. The intervals from the Salado/Rustler contact to different marker beds are also of principal concern, as the upper Salado is the area believed initially attacked by dissolution. Several cross sections were constructed to show systematic log changes, or the lack thereof, to indicate possible facies changes. Data from selected areas were examined statistically to highlight expectable variations in thickness in units like these (Table 2).

The Salado study was confined to approximately 35 townships around the WIPP site (Figures 6 and 7). The suite of geophysical logs used to interpret the Rustler Formation for this area (Holt and Powers, 1988) was supplemented with some additional logs to fill in areas with sparse coverage. The interpretive methods and the quality assurance procedures are similar to those for the Rustler (Holt and Powers, 1988). All logs were interpreted by one individual (D. W. Powers). Data were transferred to data sheets and verified independently. Commercial software (Rbase 3.1, a product of Microrim, Inc.) was used by Powers to create a

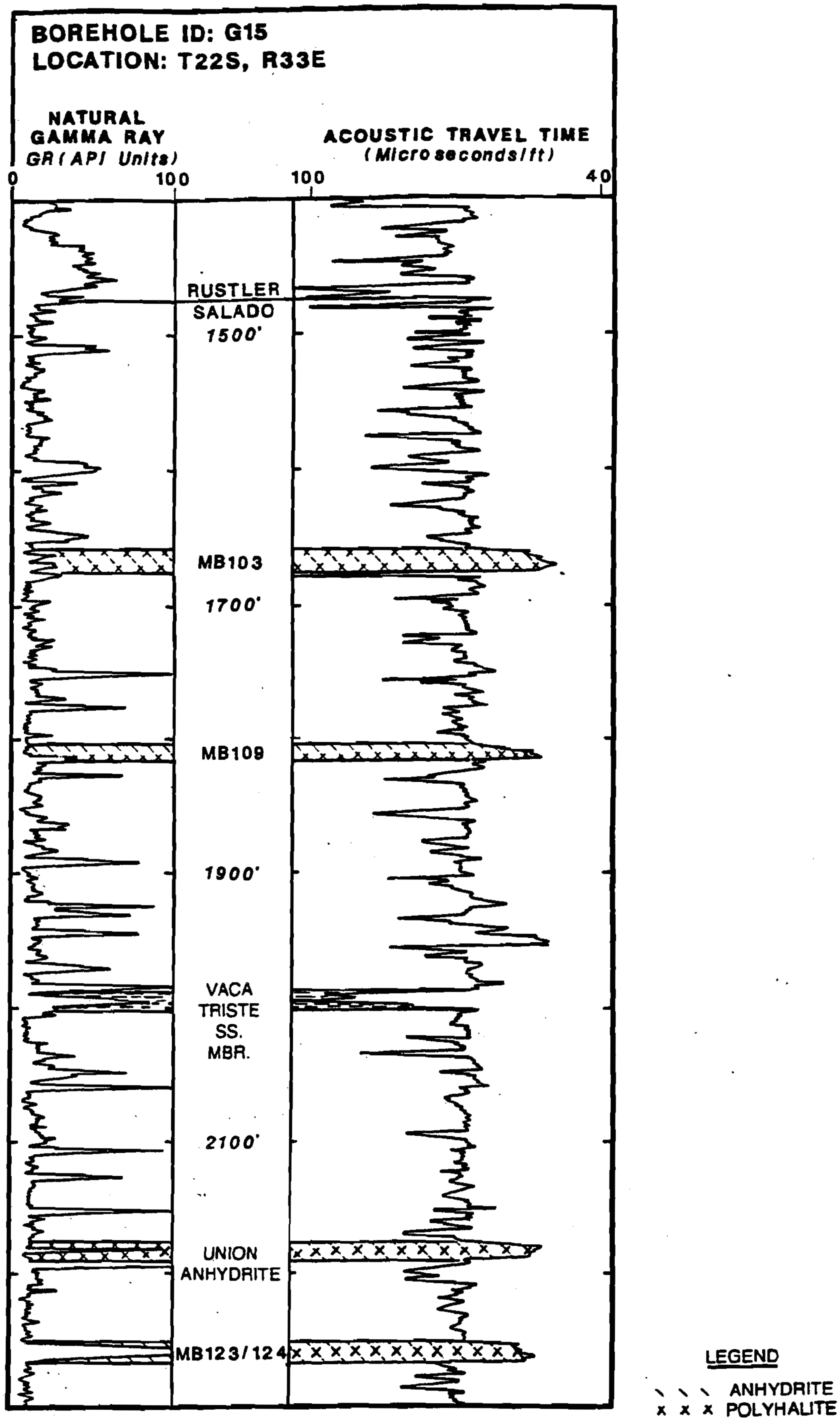


Figure 5
Reference Geophysical Signatures and Selected Contacts for Upper Salado Formation Near the WIPP Site

Table 2

Statistics Regarding Thickness of Interval from the Top of Vaca Triste to the Top of Salado[a]

T.23S., R.32E. $n = 28$ $\bar{x} = 520$ ft $\sigma_{n-1} = \pm19$ ft	T.23S., R.33E. $n = 13$ $\bar{x} = 507$ ft $\sigma_{n-1} = \pm9$ ft
T.24S., R.32E. $n = 28$ $\bar{x} = 577$ ft $\sigma_{n-1} = \pm35$ ft	T.24S., R.33E. $n = 19$ $\bar{x} = 562$ ft $\sigma_{n-1} = \pm34$ ft
For all four townships: $n = 88$ $x = 546$ ft $\sigma_{n-1} = \pm39$ ft	

[a]Refer to Figure 6 for township locations and isopach contours. Refer to Figure 5 for the stratigraphic interval. There are 107 drillholes within these townships; not all have data on this interval.

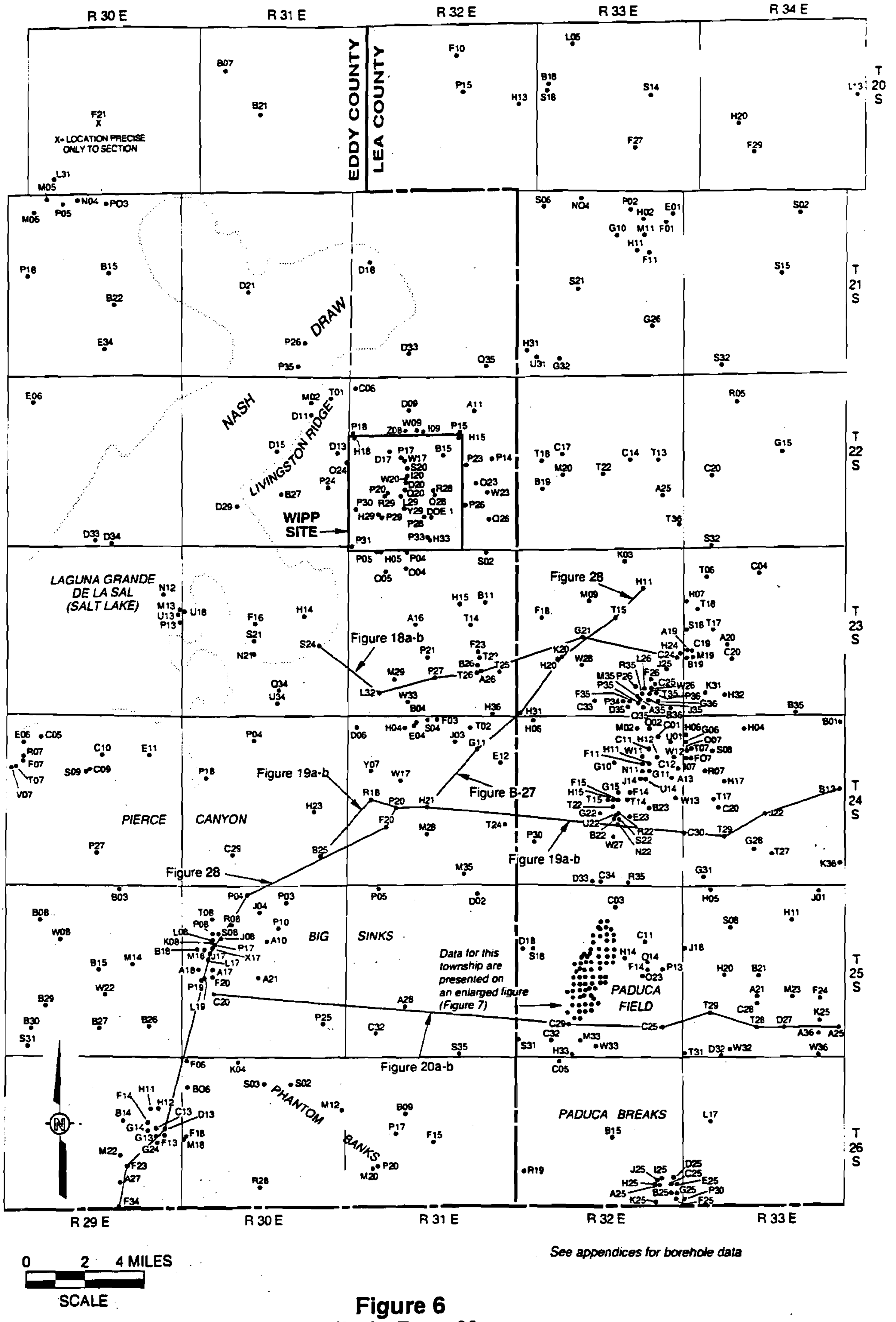
relational database and to manipulate basic data to formats required for various maps. Maps and data were verified independently as well. The data are presented in Appendix A.

2.5 Salado Thickness (Isopach) Information

To understand the patterns of thickness variations of the Salado in the area around the WIPP site, we compare first the broad patterns from two thick intervals (the upper and middle parts) of the Salado. We later describe in more detail the changes in thickness by comparing thinner subintervals of the Salado defined by intervals between some significant marker beds. There is no difference in methods for these comparisons.

2.5.1 Broad Patterns

Two isopach maps illustrate the broader patterns of upper Salado thickness. An isopach map from the top of the Vaca Triste to the top of the Salado expresses the broad patterns of thinning that are of interest for the Rustler geohydrology. An isopach map from the base of MB 124 to the base of the Vaca Triste shows the middle of the Salado quite well. The



See appendices for borehole data

Figure 6
Drillhole Base Map

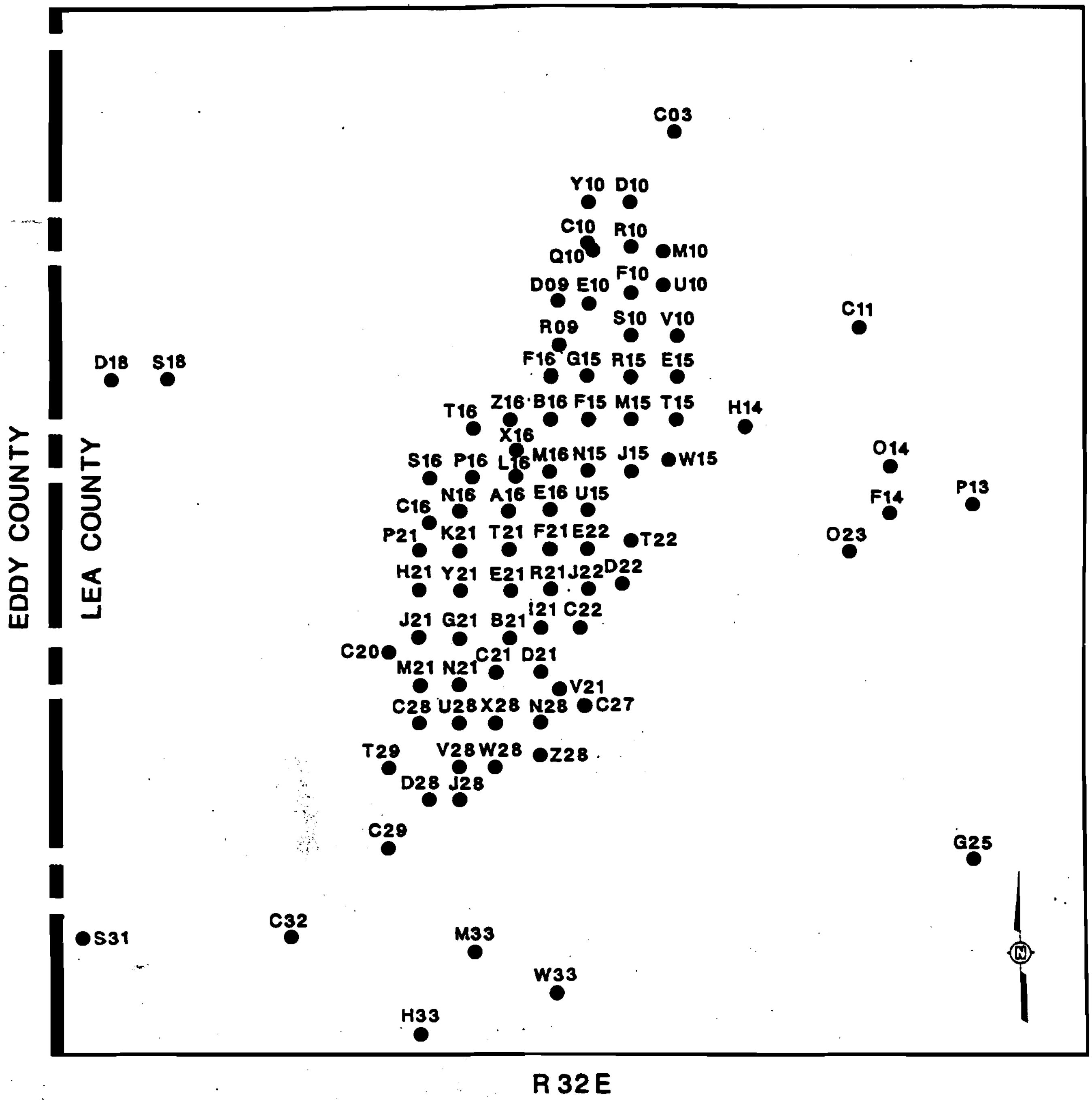


Figure 7
Drillhole Base Map
of the Paduca Field

isopach map of this lower unit, in comparison to the upper Salado, shows a larger region less affected by dissolution and indicates depositional variations in thickness as a pattern for the Salado. Maps of specific interbeds (e.g., MB 109 to MB 103) have also been constructed to provide additional detail in support of these broader patterns.

The isopach of the interval from the base of MB 123/124 to the base of Vaca Triste (Figure 8) shows that this interval is approximately 250 to 300 ft (76 to 91 m) thick under the WIPP site area. This interval thickens to the southeast, toward an apparent depocenter, at a rate of approximately 10 ft/township (approximately 3 m/10 kilometers [km]). In the apparent depocenter, in the area of T.24-26S., R.32-33E., the MB 123/124 to Vaca Triste interval is generally over 300 ft (91 m) thick. In the northeast corner of the map area, over and behind the Capitan reef margin, the MB 123/124 to Vaca Triste interval is slightly thinner (less than 250 ft [76 m]). Small areas of this interval in the vicinity of Big Sinks and Phantom Banks are significantly thinner than either the depocenter or site areas. Higher units in this same area are more seriously disrupted, as described in following sections. Within the map area, the best defined and sharpest thinning of the MB 123/124 to Vaca Triste interval occurs in the southwest corner of T.25S., R.32E., at the southwest end of the Paduca oil field. This thinning trend is also generally observed southwest of the oil field in stratigraphically higher intervals.

The interval from the top of the Vaca Triste to the top of the Salado (Figure 9) is approximately 450 to 520 ft (137 to 158 m) thick in the vicinity of the WIPP site. The interval may be starting to thin approximately 50 ft/mile (mi) (9.5 m/km) off the northwest corner of the site, but the data are relatively few. In general, the Vaca Triste to Salado interval thickens to the southeast of the site toward a probable depocenter in the area of T.24-26S., R.33E. As in the MB 123/124 to Vaca Triste interval, the rate of thickening is of the order of 10 ft/township (3 m/10 km). In the depocenter, the interval is commonly greater than 550 ft (168 m) thick. As in the MB 123/124 to Vaca Triste interval, the Vaca Triste to Salado interval also is thinner in the northeastern part of the map area, over and behind the Capitan reef margin. In the southwest part of the map, in the Phantom Banks and Big Sinks areas, the Vaca Triste to Salado interval is usually less than 300 ft (91 m) thick, though there are a few exceptions. The Vaca Triste to Salado interval thins sharply northwest-southeast from the Paduca oil field area (T.25S., R.32E.) through the southeast arm of Nash Draw. The interval thins through this zone at an apparent rate of approximately 50 ft/mi (9.5 m/km); this

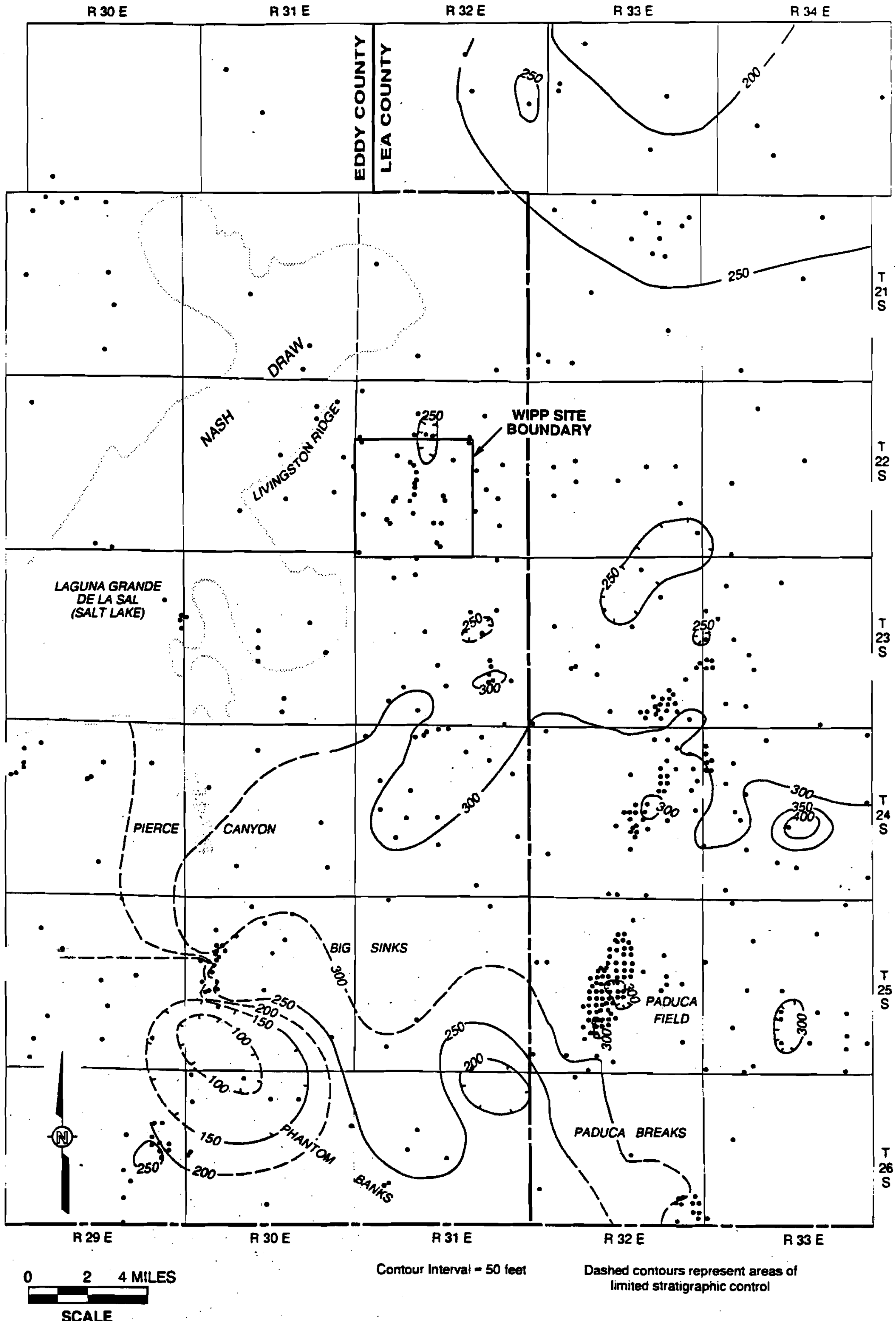
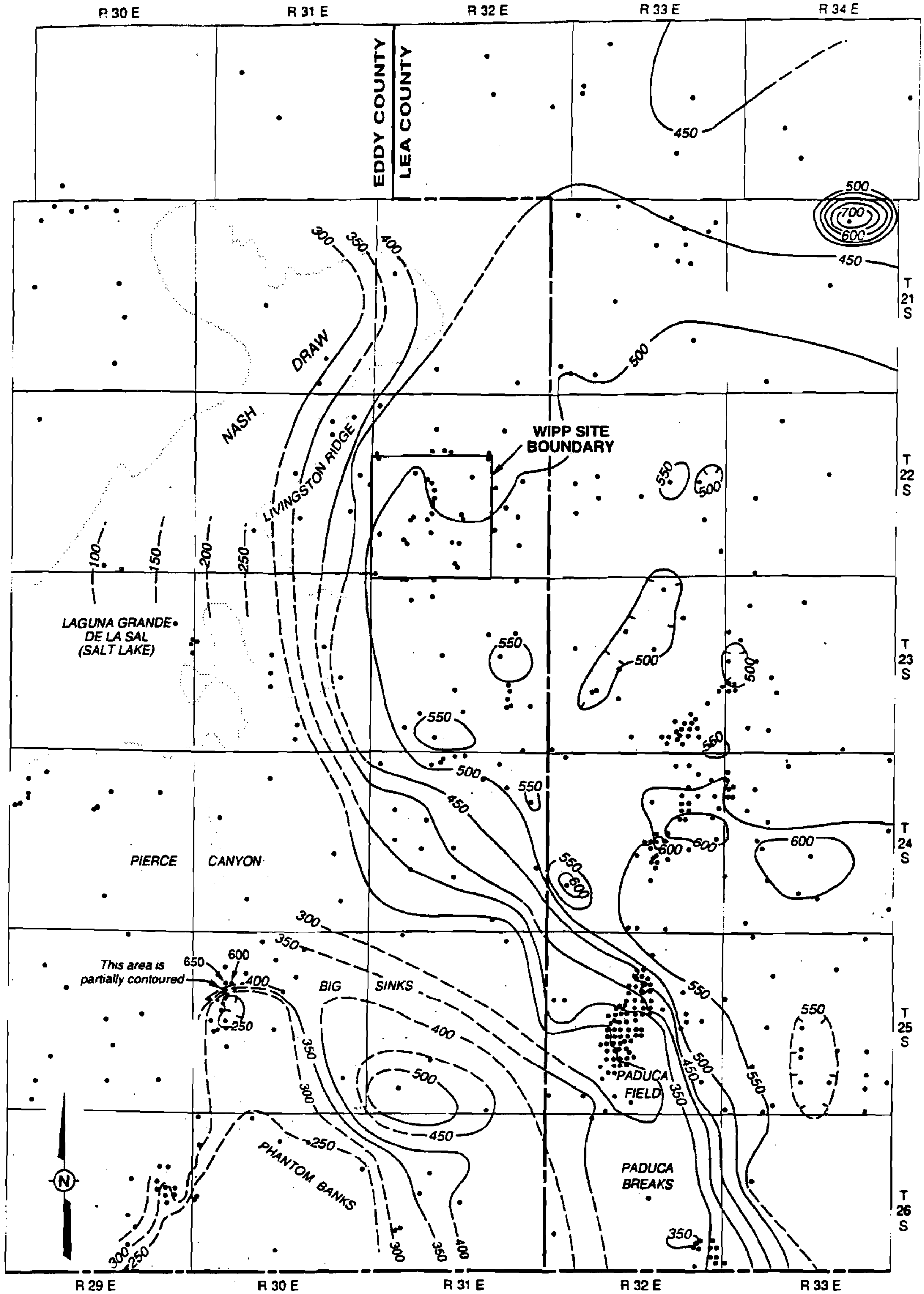


Figure 8
Isopach from the Base of MB 123/124 to the Base of the Vaca Triste



Contour Interval = 50 feet

Dashed contours represent areas of limited stratigraphic control

Figure 9
Isopach from the Top of the Vaca Triste to the Top of the Salado

rate differs markedly from the rate of thickening from the site area towards the apparent depocenter (about 0.3 m/km).

2.5.2 Subintervals of the MB 123/124 to Vaca Triste Interval

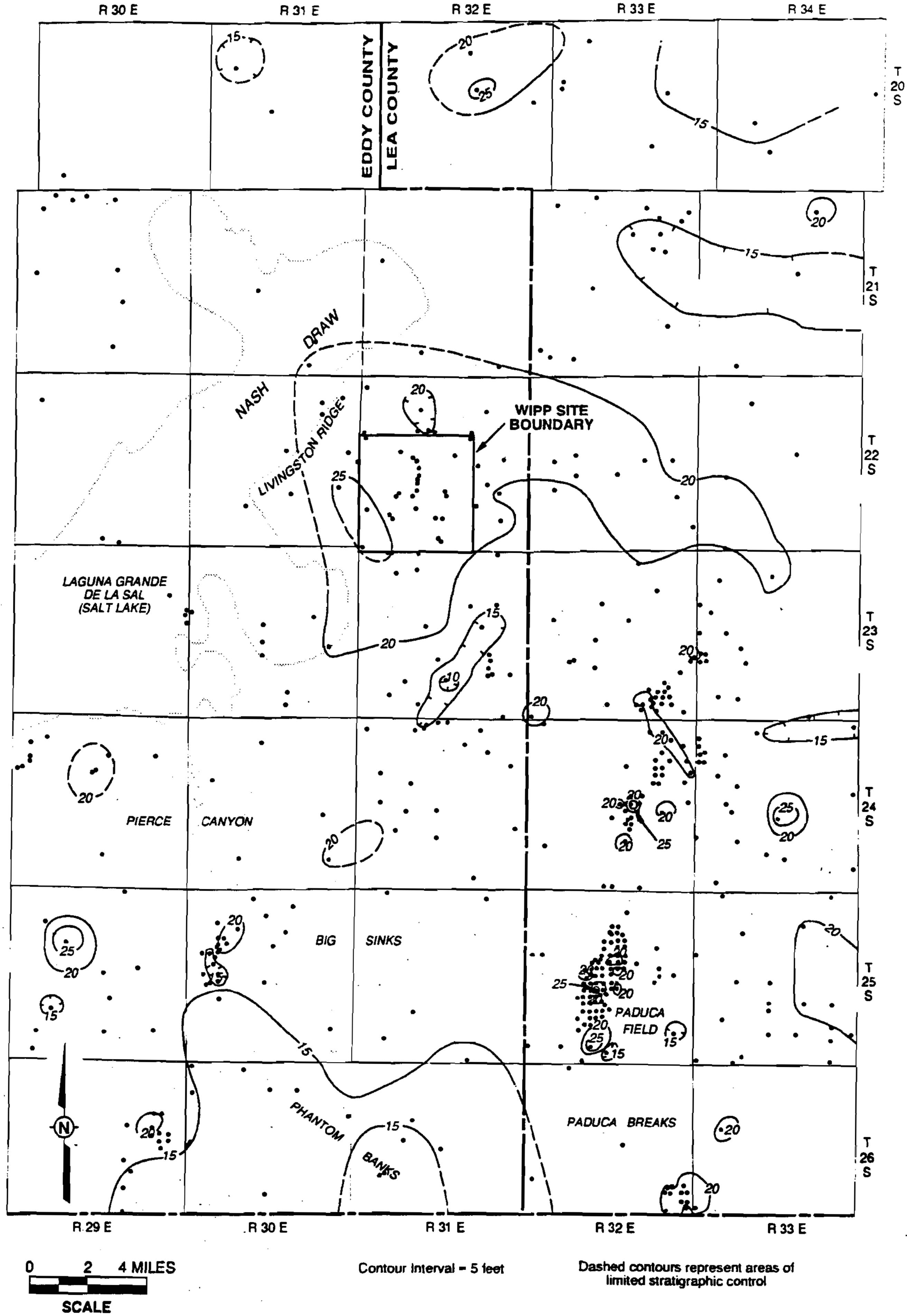
Within the MB 123/124 to Vaca Triste interval, two subintervals were examined for thickness trends. The combined MB 123/124 interval (Figure 10) is approximately 15 to 20 ft (4.6 to 6 m) thick in much of the map area; the most prominent variation is a slightly thicker (greater than 20 ft [6 m]) area in and around the WIPP site. In the southern part of the map area near Phantom Banks, MB 123/124 appears to be thinner, though the data are neither extensive nor very consistent in this area. Many of the other map patterns, where the thickness exceeds 20 ft (6 m), are areally quite limited and may not be significant departures from the "normal" thickness, given limits to precision of these data (see Holt and Powers, 1988, for a discussion of limits to log data).

The interval from the top of MB 123/124 to base of Union anhydrite (Figure 11) is broadly similar to the MB 123/124 interval. Much of the central map area ranges from 50 to 60 ft (15 to 18 m) thick. The WIPP site area and an area east-northeast of the site are thicker (60 to 70 plus ft [18 to 21 plus m]). A small area near the southeastern side of the map area also exceeds 60 ft (18 m) thickness. A thinner area (less than 40 ft [12 m]) dominates the south central margin of the mapped area, and it appears more reliable than, though similar to, the thinning in that area of MB 123/124.

2.5.3 Subintervals of the Vaca Triste to Salado Interval

Several subintervals of the Vaca Triste to Salado interval reveal additional details of the trends previously discussed.

The isopach from the top of Vaca Triste to the base of MB 109 (Figure 12) is approximately 160 to 180 ft (49 to 55 m) thick in the WIPP site area. Thickness increases slightly immediately south of the site as well as in the southeastern part of the map (from about 180 ft to more than 200 ft locally [about 55 to 61 m]). North and northeast of the site, the Vaca Triste to MB 109 interval thins slightly across the reef margin. The isopach data are not very systematic in the southwestern part of the map area. Overall, there is no well-defined southeast-northwest thinning trend as observed in the broader Vaca Triste to Salado interval (Figure 9) that includes Vaca Triste to MB 109.



Contour Interval = 5 feet

Dashed contours represent areas of limited stratigraphic control

Figure 10
Isopach of the Combined MB 123/124 Interval

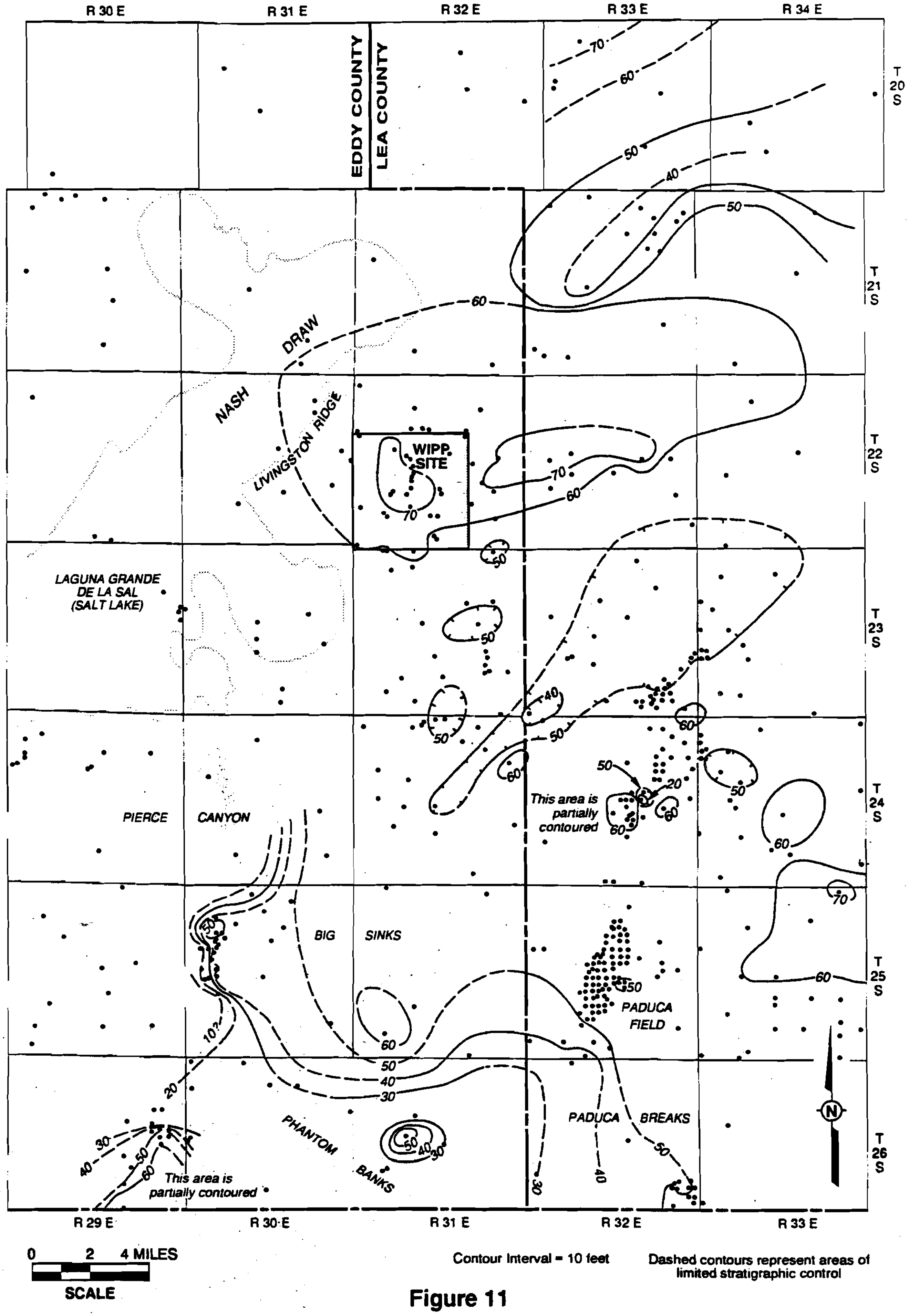
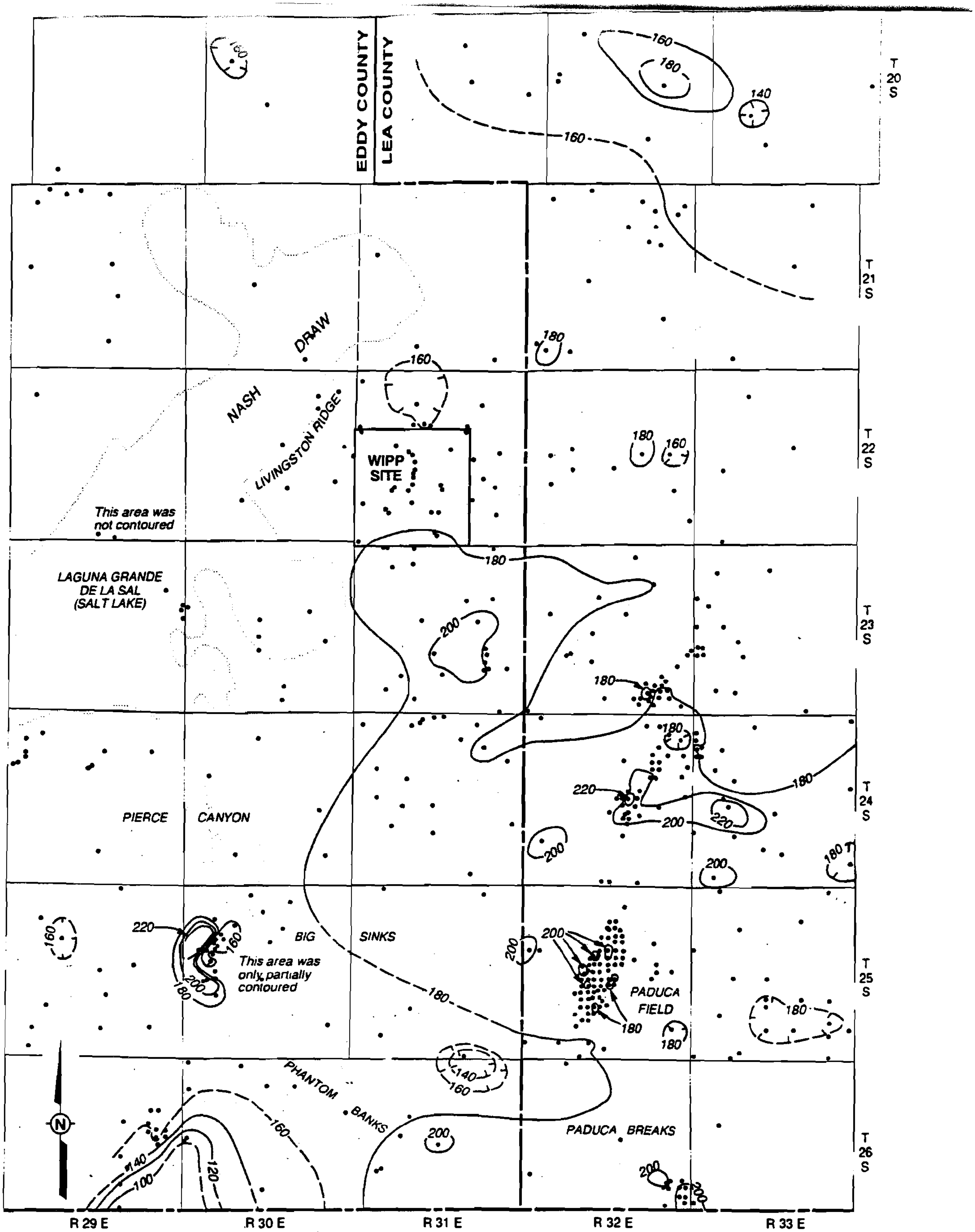


Figure 11
Isopach from the Top of MB 123 to the Base of the Union Anhydrite



0 2 4 MILES

SCALE

Contour Interval = 20 feet

Dashed contours represent areas of limited stratigraphic control

Figure 12
Isopach from the Top of the Vaca Triste to the Base of MB 109

The isopach of the interval from the top of MB 109 to the base of MB 103 (Figure 13) ranges from approximately 100 to 125 ft (30 to 38 m) thick in the vicinity of the WIPP site. This interval generally thickens from the site to the southeast. Most of T.24-26S., R.32-33E. is approximately 125 to 150 ft (38 to 46 m) thick, with a few exceptions. A slightly thicker area in T.24S., R.32E. exceeds 200 ft (61 m), while the immediately surrounding boreholes exceed 150 ft (46 m). The northeastern part of the map area is thinner than the site area, as in many other isopach maps, but the amount of thinning is not great. The southern and southwestern parts of the map are also thinner, though local variability is great. Some "normal" thicknesses of the MB 109 to MB 103 interval border much thinner areas of this interval. The sharply defined thinning zone trends northwest-southeast across the map, as it does on the map (Figure 9) of the thicker Vaca Triste to Salado interval, which includes MB 109 to MB 103. The zone of thinning also trends across the northern half of the Paduca oil field (T.25S., R.32E.). The MB 109 to MB 103 interval thins approximately 25 to 50 ft/mi (4.7 to 9.5 m/km) across this zone.

MB 103 varies little throughout the map area (Figure 14). It is generally 10 to 20 ft (3 to 6 m), and the variations appear neither systematic nor particularly meaningful.

The interval from the base of MB 103 to the top of Salado is approximately 175 to 200 ft (56 to 61 m) thick in the site vicinity (Figure 15). A few data points indicate that the interval thins immediately west and northwest of the site. As in previous interbed intervals, MB 103 to Salado thickens from the site vicinity to the southeast (T.24S., R.32-33E.; T.25S., R.33E.), where the MB 103 to Salado exceeds 200 ft (61 m). The southwestern end of the map area reveals a much thinner interval, as does part of the southeastern boundary. There is also slight thinning of the MB 103 to Salado interval from the site to the north and northeast across the Capitan reef margin. The northwest-southeast trending zone of rapid thinning of the MB 103 to Salado parallels the similar zone in MB 109 to MB 103 interval, but it is displaced further northeast. As in other intervals for which isopachs were constructed, the thinning occurs at approximately 50 ft/mi (9.5 m/km).

None of the isopach intervals previously discussed includes the Vaca Triste Sandstone Member of the Salado. A separate isopach (Figure 16) for the Vaca Triste shows that the unit is generally between 10 to 20 ft (3 to 6 m) thick. In the vicinity of the WIPP site and area to the north of the site, the Vaca Triste is less than 10 ft (3 m) thick, but some additional explanation is appropriate. These data are mostly from the potash holes drilled for the WIPP project (Jones, 1978). The logs used for this information are natural gamma and an

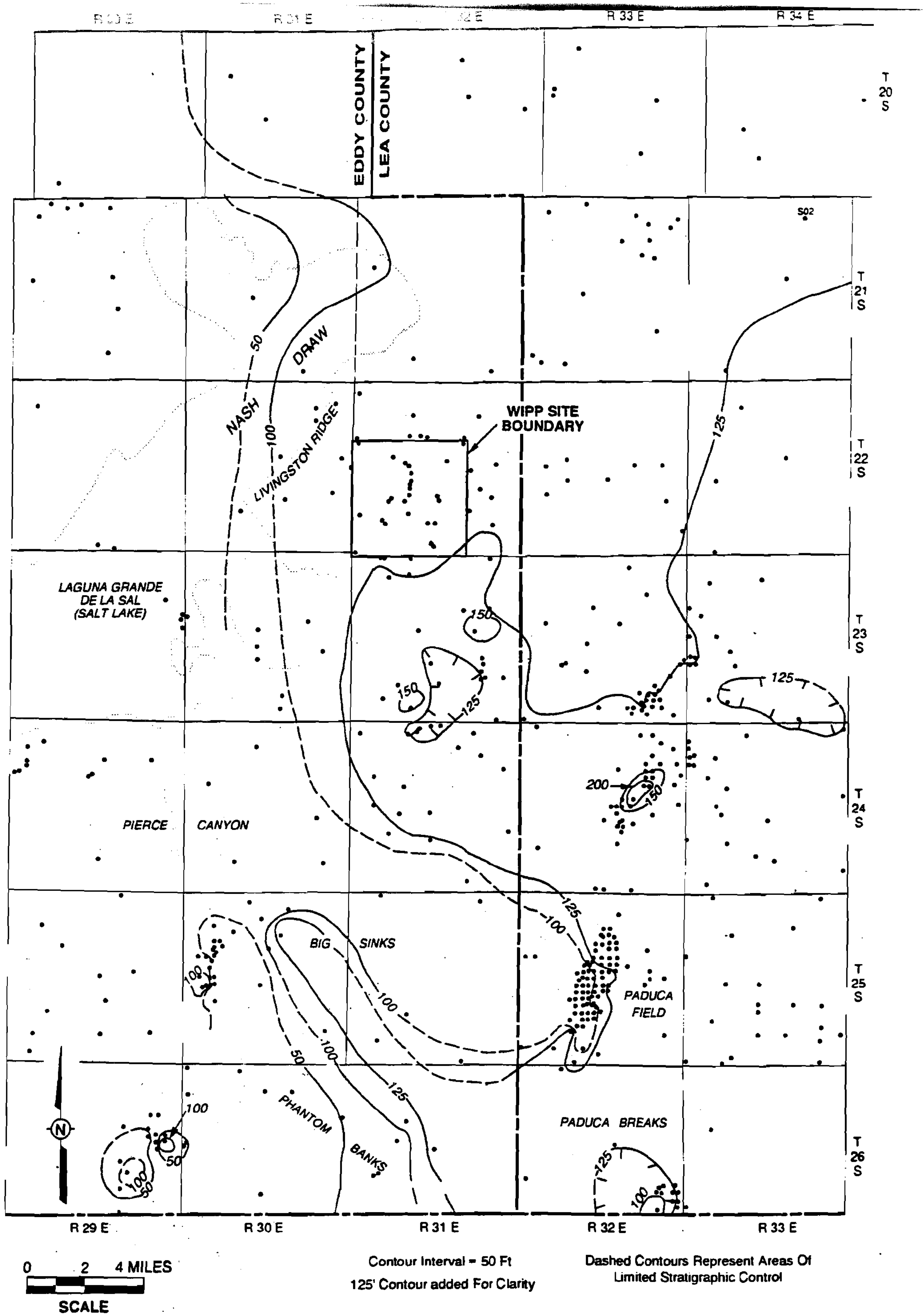


Figure 13
Isopach from the Top of MB 109 to the Base of MB 103

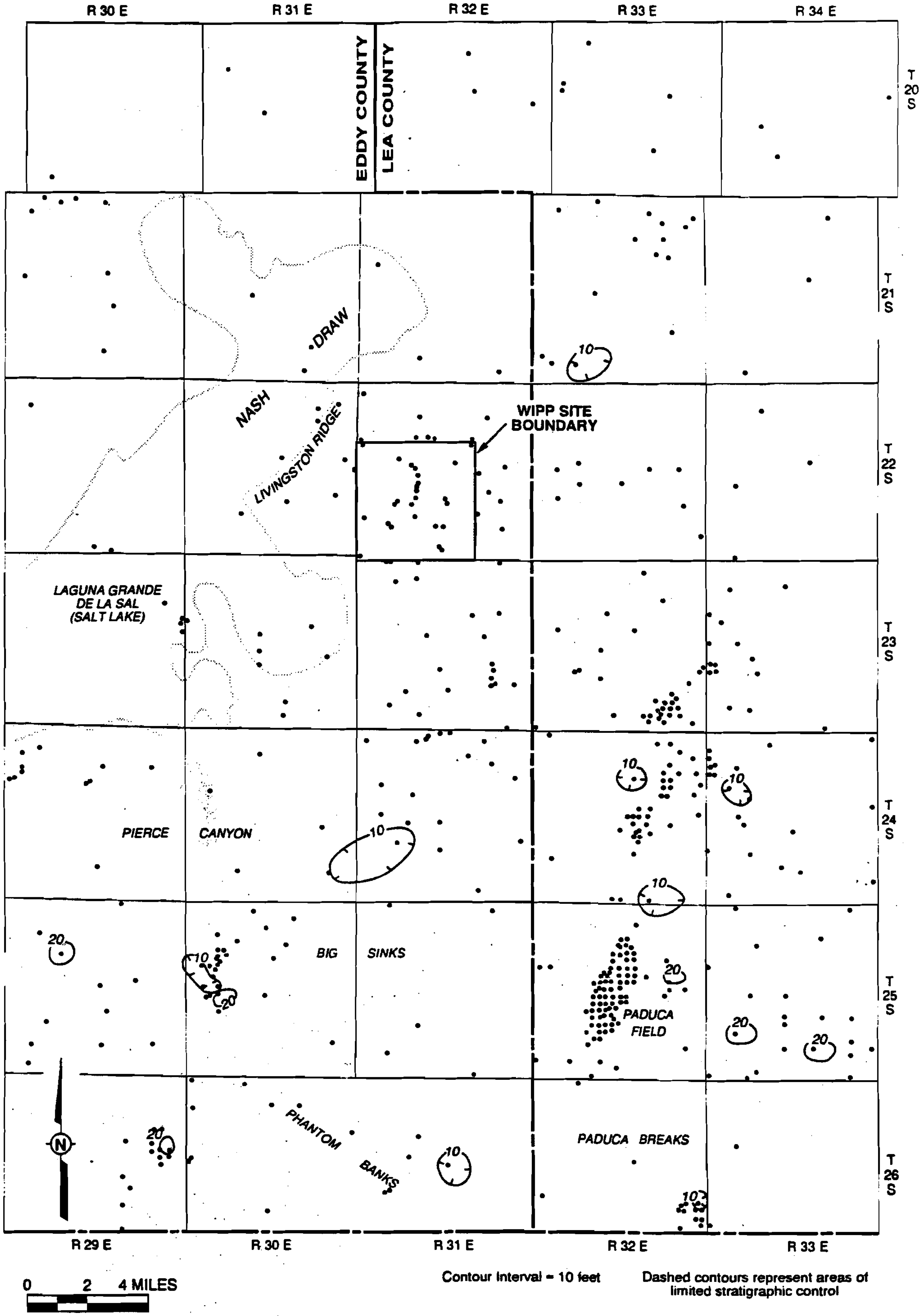


Figure 14
Isopach of MB 103

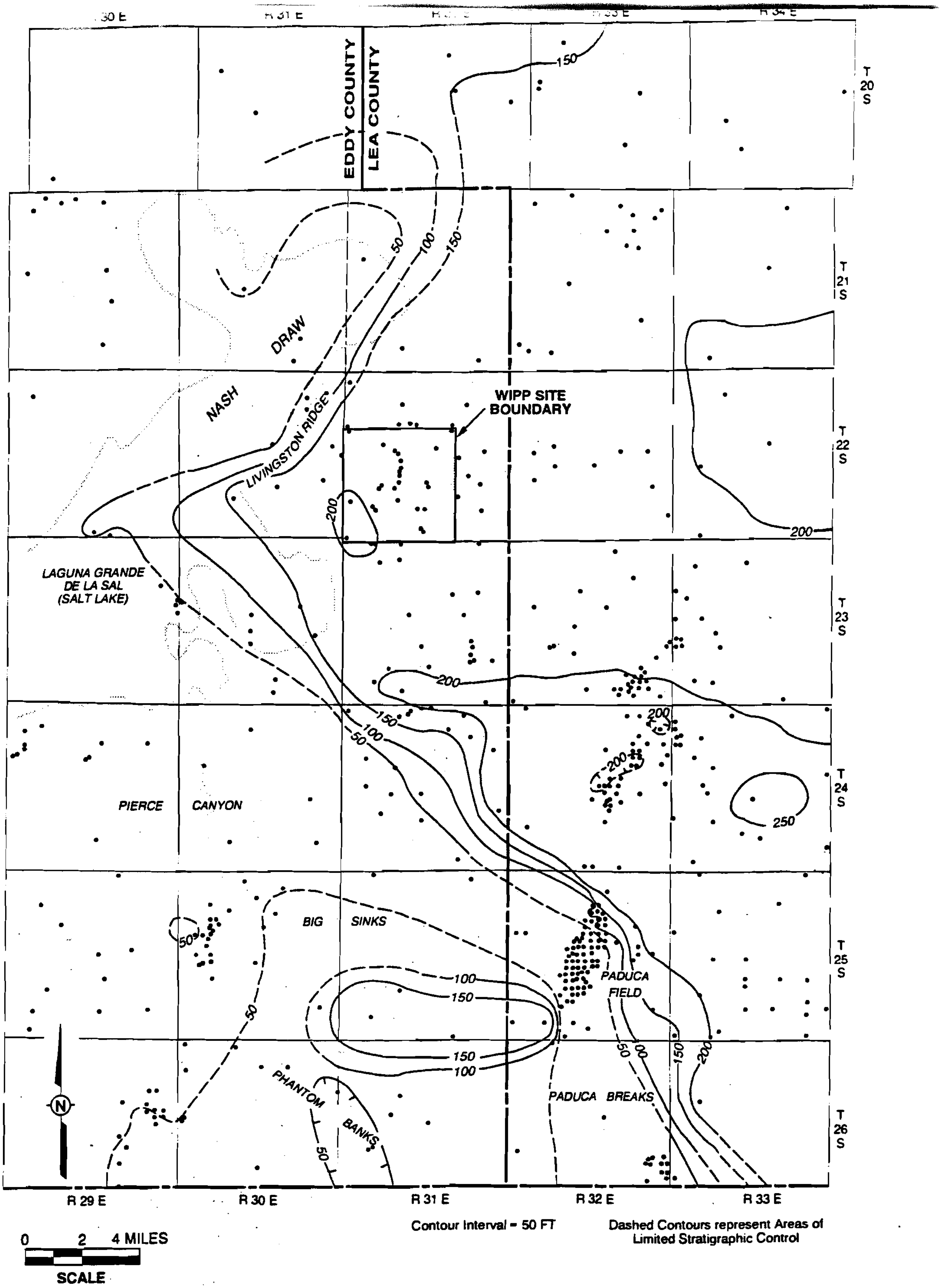


Figure 15
Isopach from the Base of MB 103 to the Top of the Salado

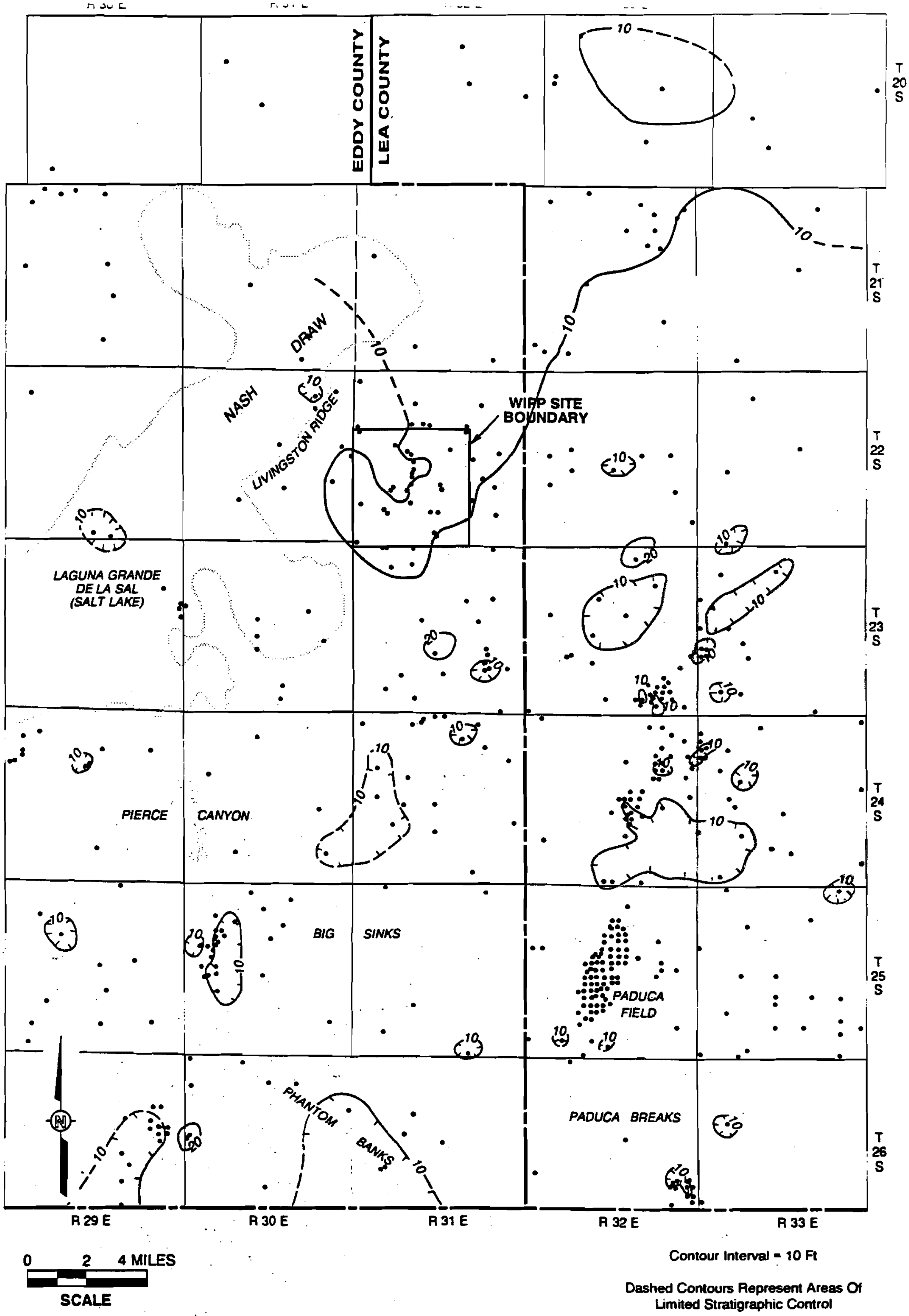


Figure 16
Isopach of the Vaca Triste Sandstone

uncalibrated density log. The density log does not display the same signature as commercial acoustic logs for this interval, and it appears that the Vaca Triste is underestimated on the density log relative to the commercial acoustic or sonic logs used for the rest of the area. Not enough overlapping logs of both types are available to truly demonstrate this possible explanation. The Vaca Triste is an important marker unit. Among other things, it demonstrates the great areal continuity of some clastic-rich units within the Salado Formation.

2.5.4 Discussion of Thickness Data

Isopach maps are traditionally valued because variations in the thickness of an individual unit can reveal information about the tectono-sedimentary regime during deposition of the unit and about events such as erosion before the overlying beds are deposited. The value of such maps is diminished when soluble evaporites are included in isopach units, because the thickness may be greatly reduced by dissolution long after overlying units are deposited. The maps included in this report still appear to contain information about some depositional trends that are useful in estimating the areas affected by dissolution and volumes removed.

We first observed generally that most of the mapped intervals are thickest in the east to southeast part of the map area. The same halitic intervals are also slightly thinner over and behind the Capitan reef margin to the north. The thickest area is interpreted as a depocenter because it is thickest and because it is located in approximately the same position as the Rustler depocenter (Holt and Powers, 1988). These same upper Salado units in the WIPP site area are slightly thinner but show no evidence of recent or continuing dissolution (Holt and Powers, 1984, 1986b, 1988, 1991) based on shaft descriptions and core observations.

Compared to halitic units of the Rustler, the upper Salado depocenter appears to be broader and flatter. In the northern and northeastern part of the map area, over the Capitan reef, thinner upper Salado intervals seem to show some effects of this boundary.

Upper Salado intervals show a relatively narrow (generally approximately 1 to 3 mi [1.5 to 5 km]) zone where the interval thins dramatically compared to the broader depocenter. The width and rate of thinning compare reasonably well to a similar zone of the Tamarisk Member of the Rustler Formation (Holt and Powers, 1988). The major difference is that cores of the Rustler show evidence of a large facies tract of synsedimentary dissolution without collapse of overlying units. Cores from Nash Draw, where this zone of thinning upper Salado occurs, show fracturing and collapse of overlying sediments, demonstrating post-Rustler dissolution. This margin of the upper Salado appears to be dominated by dissolution; we assume the rest of the margin southeast of the WIPP site is similar, though textural evidence is not available to confirm this assumption.

The upper Salado dissolution margin from the WIPP site to the southeast (Figure 15) trends subparallel to the strike line of the Culebra (Holt and Powers, 1988, figure 4.17; see Figure 22 in this report). If this margin of upper Salado salt is attacked further by dissolution, the Culebra transmissivities should be disturbed (increased) along strike to slightly downdip to the south-southeast of the site. This could provide a considerably different path for fluid transport than is usually assumed, as in the Final Environmental Impact Statement (U.S. Department of Energy, 1980).

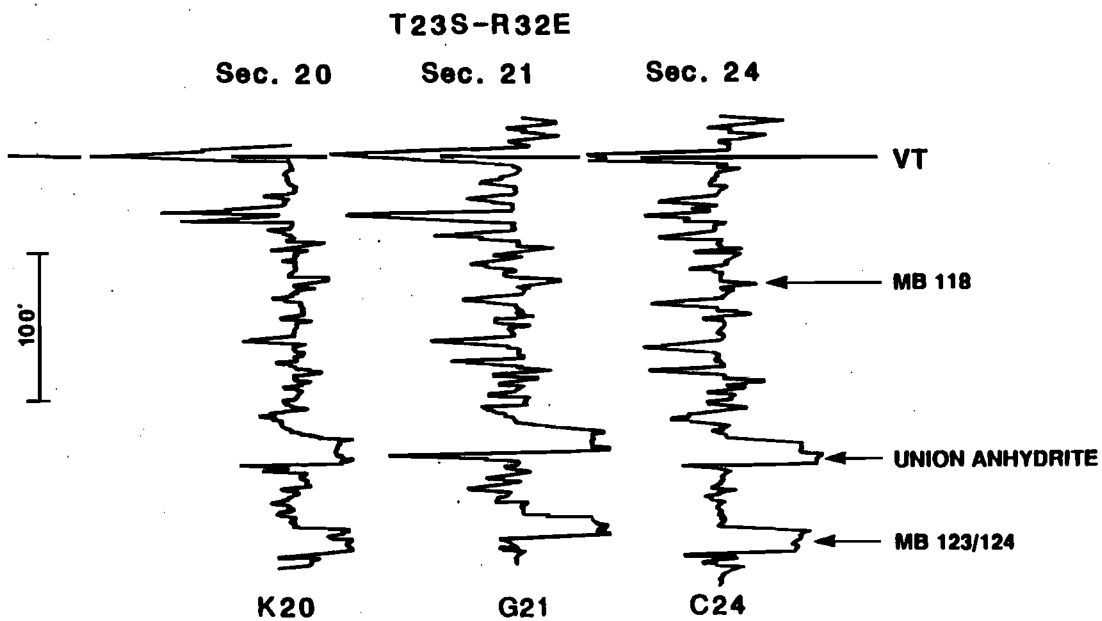
The third major observation and discussion point is that the Salado logs are often not interpretable in the west and southwest section of the map area. Where an individual geophysical log is interpretable, it is generally difficult to interpret the resultant isopachs. This western and southwestern section is disturbed by dissolution, including karst. Erosion before, during, and after deposition of the Miocene to Pleistocene Gatuña Formation has also affected the Rustler in this area.

2.6 Cross Section Data

Cross sections have been constructed from geophysical logs to evaluate continuity of major marker beds and lesser interbeds and to evaluate any possible facies changes within the Salado halite interbeds. Major marker beds clearly are continuous over large areas, as is easily shown on acoustic logs (e.g., Figure 17a-c). This is a necessary basis for using marker beds to establish changes in thickness of various intervals, as described in the previous section. Thin clastic beds, such as those between MB 117 and the Vaca Triste (Figure 17b-c), are continuous on the same general scale as the sulfate marker beds (Powers et al., 1988). Major facies changes, if present in the halitic units between marker beds, could greatly change the estimated effects of evaporite dissolution in the upper Salado. Cross sections incorporate both natural gamma and sonic/acoustic measurements; these data permit major lithologic changes to be discriminated. The upper Salado is emphasized, as the most important changes in thickness for our evaluation occur above MB 109. Middle Salado beds provide a reference by which to judge upper Salado changes.

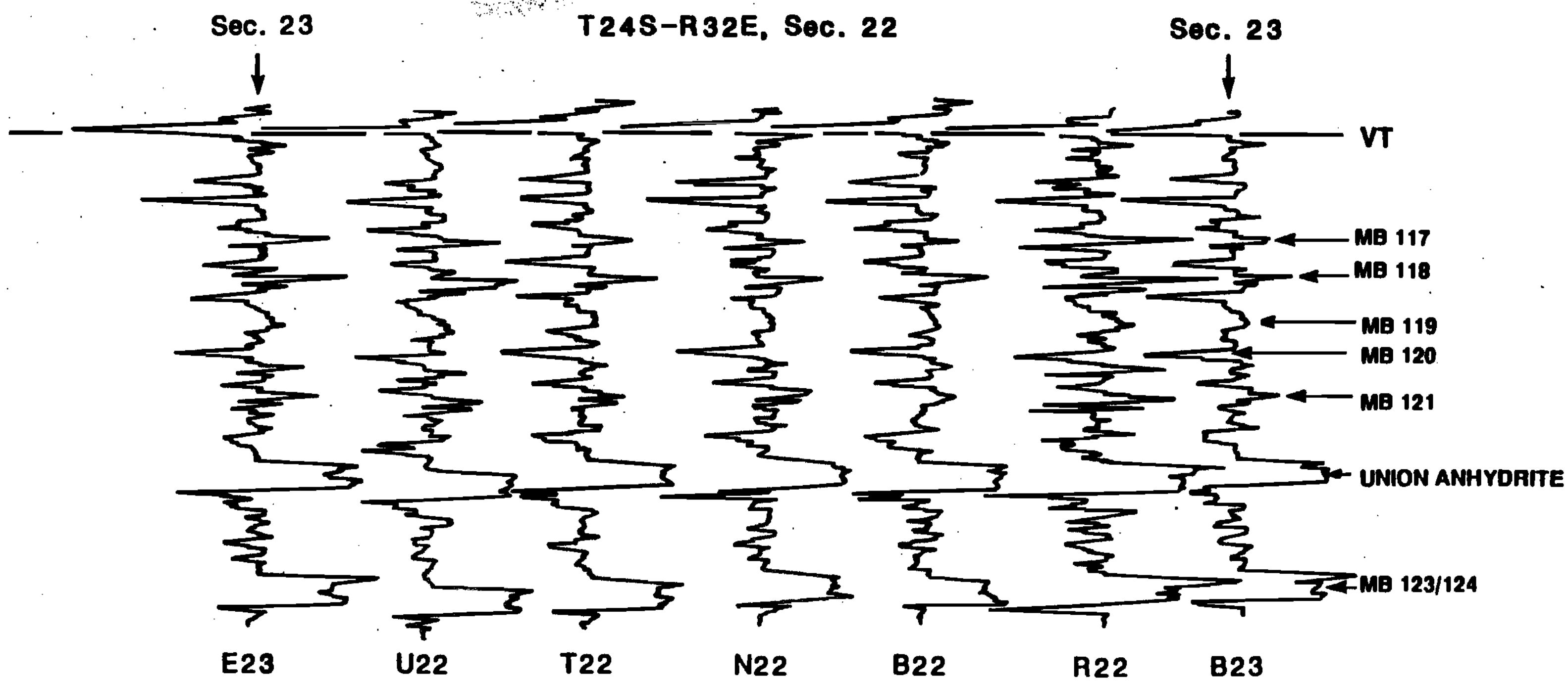
2.6.1 Cross Section Details

The intervals from MB 123/124 to Union anhydrite and from the Union to the Vaca Triste, including marker beds, in east-west cross sections (Figures 18, 19, and 20; locations on



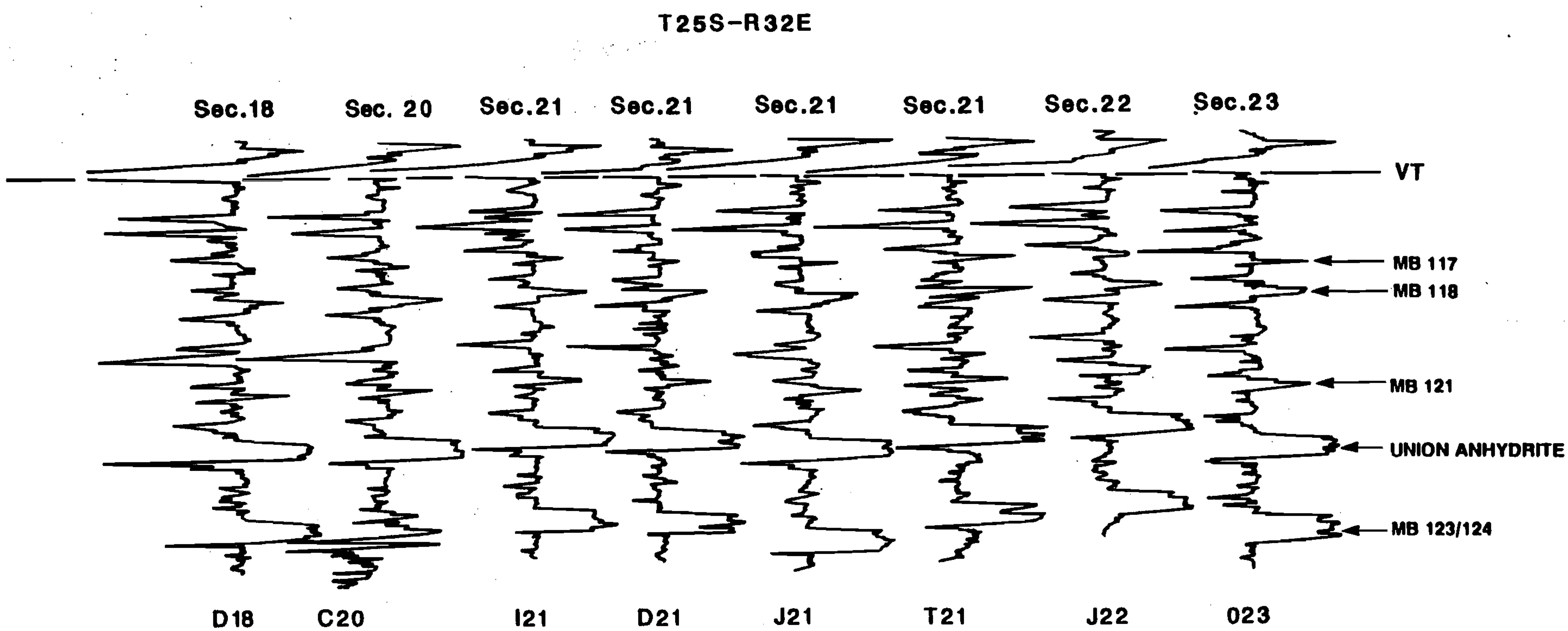
See Figure 6 for Drillhole Locations

Figure 17a
Selected Acoustic Logs T23-25S



See Figure 6 for Drillhole Locations

Figure 17b
Selected Acoustic Logs T23-25S



See Figure 6 for Drillhole Locations

Figure 17c
Selected Acoustic Logs T23-25S

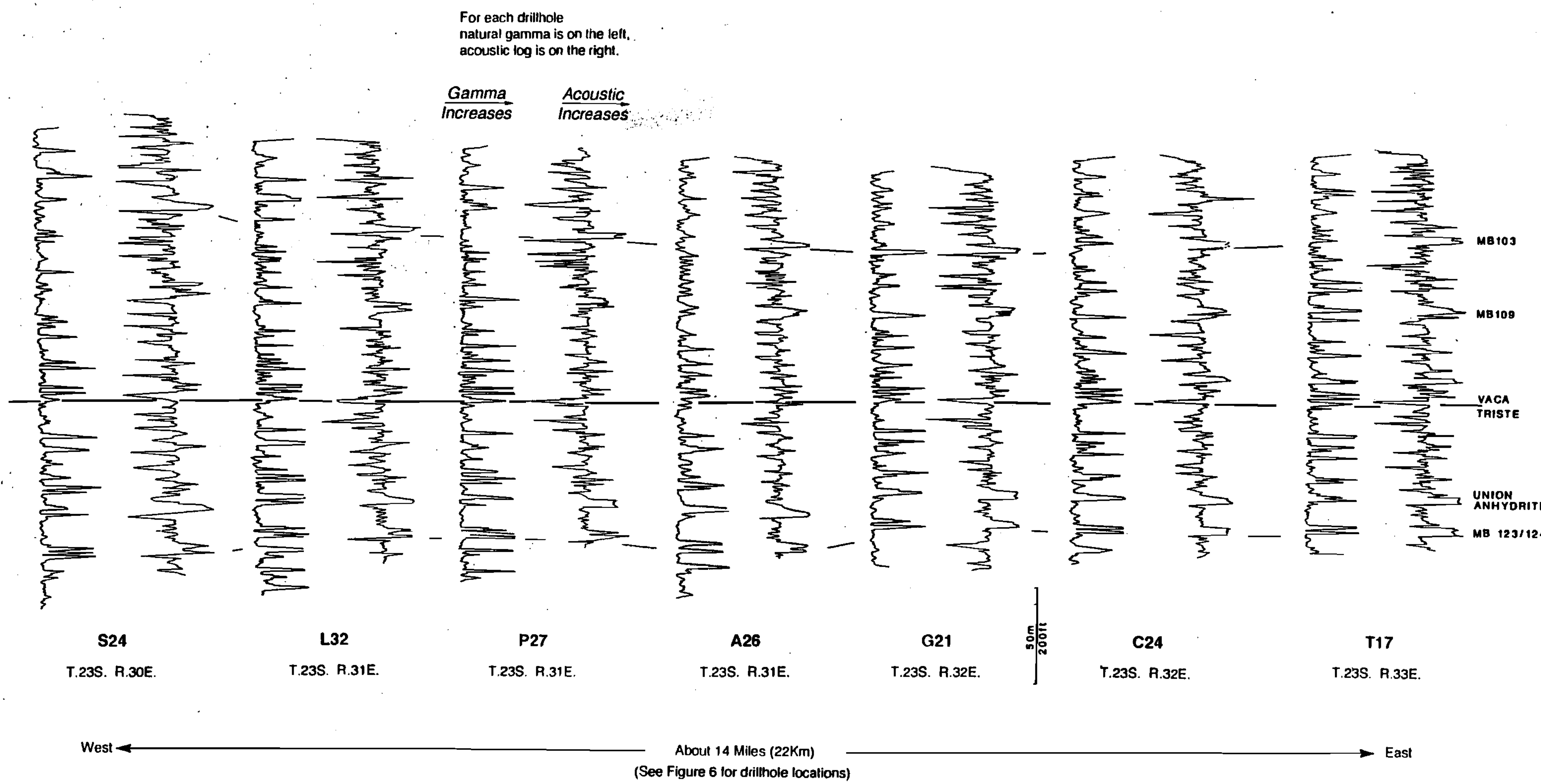


Figure 18
Acoustic and Natural Gamma Logs
(T23S)

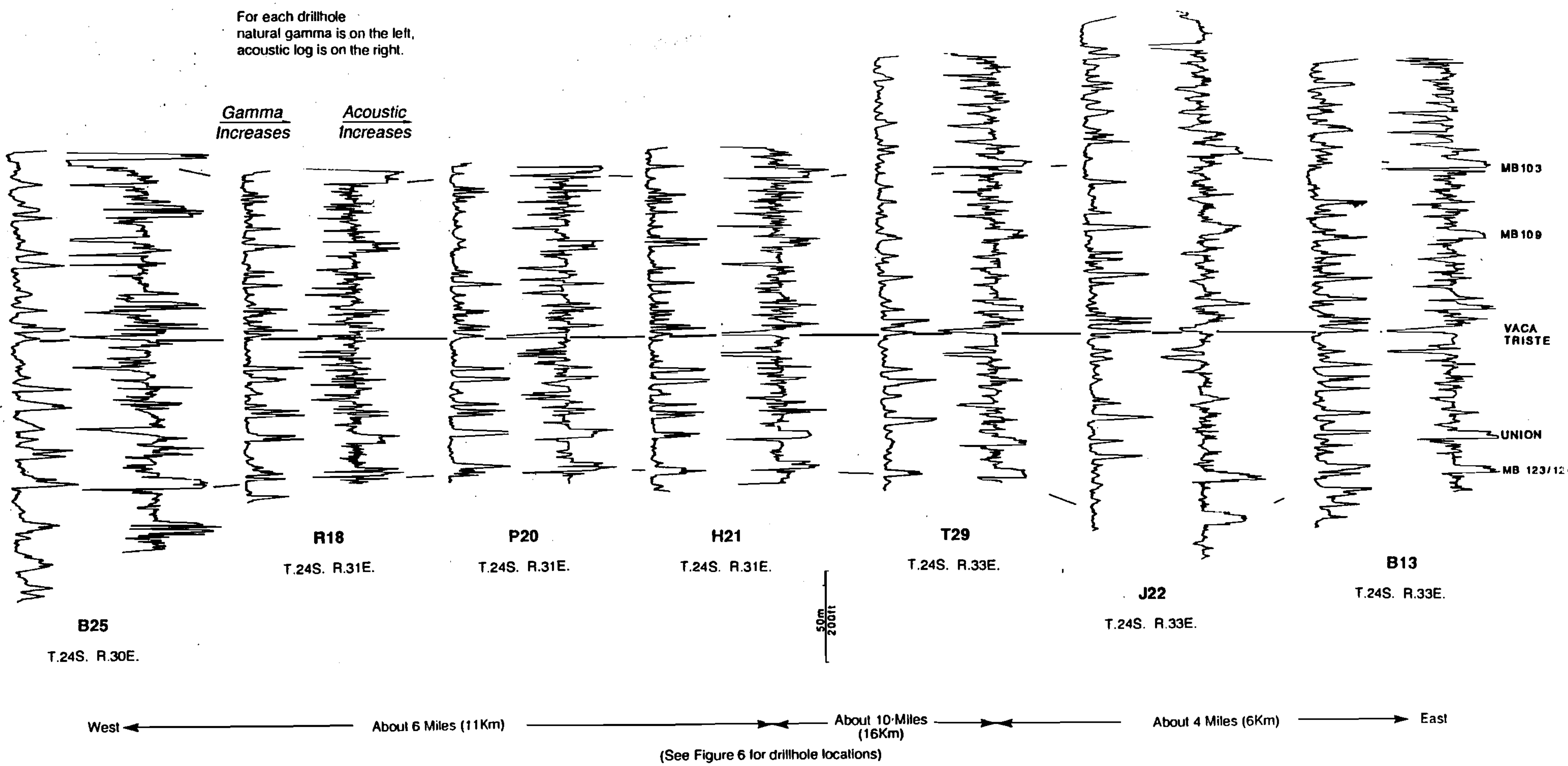


Figure 19
Acoustic and Natural Gamma Logs
(T24S)

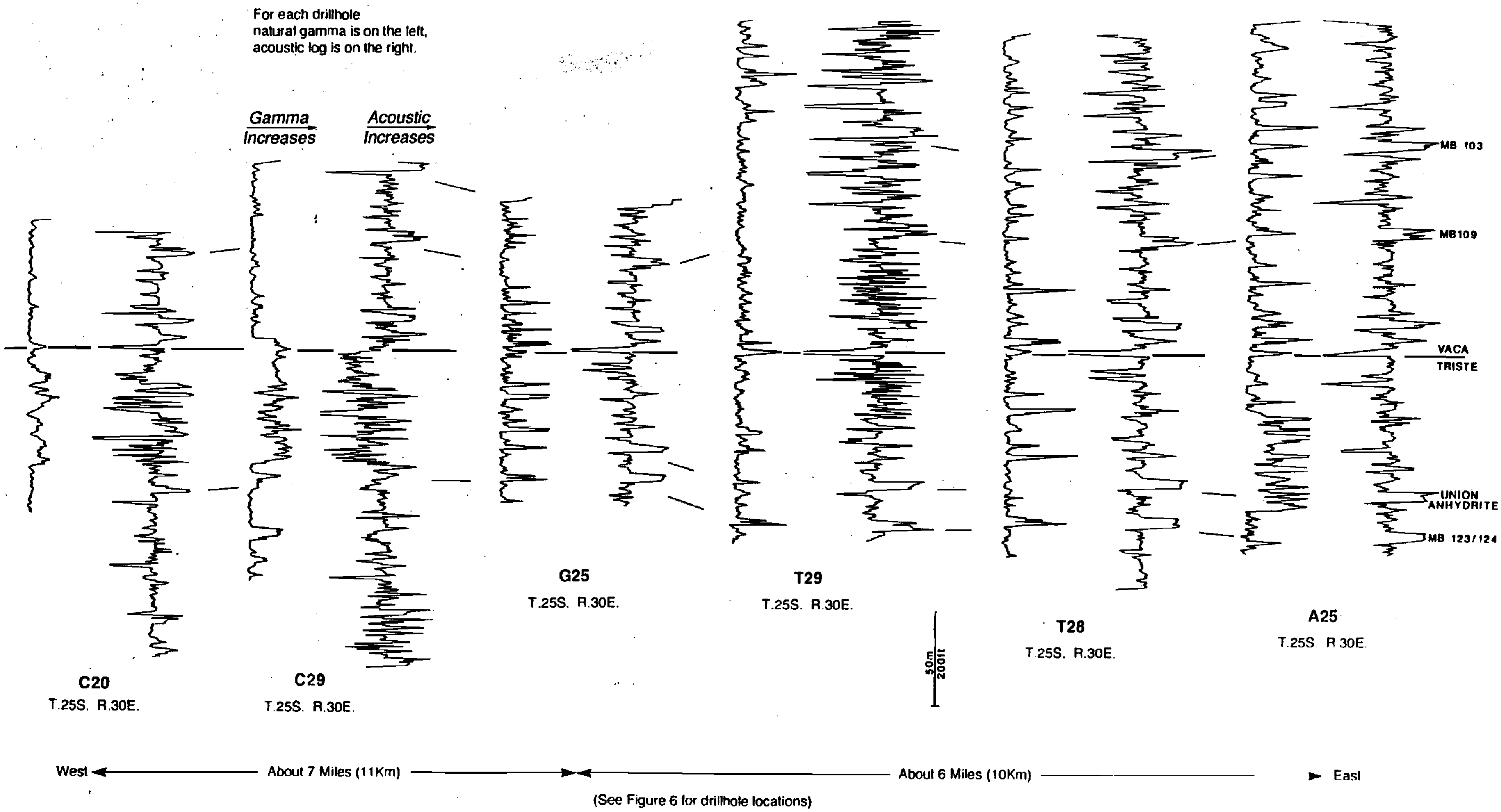


Figure 20
Acoustic and Natural Gamma Logs
(T25S)

Figures 6 and 7) vary little in thickness or lithology, except at the western end of each cross section. Thin clastic units below the Vaca Triste are traceable just as the main marker beds are. The main difference is that the western end of the section through Paduca field (Figure 20; T.25S., R.32E.) is not interpretable below the Vaca Triste as a continuous section of anhydrite marker beds and interbeds. Gamma is much increased through the entire interval up to about the position of the Vaca Triste, probably indicating increasing siliciclastic content. There is no particular evidence to suggest the increased gamma is due to potassium mineralization. Lower marker beds appear to be unaffected. A broader interval, including this high gamma section, appears to have a normal thickness, indicating the high gamma section is not a recently formed solution residue. The high gamma rock section appears to substitute for the normal sulfate and halite units below the Vaca Triste. The initial data are consistent with a depositional feature rather than recent dissolution because the overall section is not reduced in thickness.

The intervals from the Vaca Triste to MB 109 and from MB 109 to MB 103 (Figures 18, 19, and 20) do not vary greatly except in thickness from east to west. Thin clastic beds are traceable in the intervals, but it does not appear that clastic content is changing greatly from east to west. Nor does there appear to be any particular concentration of insoluble siliciclastic residues in the interval as it becomes thinner toward the west. The geophysical log data seem to favor equally either deposition or dissolution as the causes of thinning of the interval across these areas.

The interval from MB 103 to the Salado (Figures 18, 19, and 20) does thin markedly to the west in the southern cross sections. The interval is thinning from the top down. Some material should be accreting to the base of the Rustler, as postulated by Jones et al. (1973), if the section is being reduced by dissolution. An additional gamma bulge, seemingly at the base of the Rustler, occurs on some logs not in cross sections, but there is no identified systematic signature associated with the accreted material. In addition, a few interpreted logs not in cross sections show polyhalite in MB 103 at about the position where there is no discernible halite above MB 103. It is more common to find that MB 103 has lost all sign of polyhalite, while there is a complete, or at least thick, section of halite between MB 103 and the Salado/Rustler contact. MB 103, probably as gypsum, persists over a large area where halite is absent above the marker bed.

Overall, the cross sections indicate no significant, or at least not interpretable, facies changes in the halitic interbeds that might strongly favor depositional processes as an explanation of larger lateral thickness changes. The best defined lateral lithologic change is the lack of polyhalite in MB 103 away from the depocenter area.

2.6.2 Discussion of Cross Section Information

A major objective for drawing cross sections was to examine the evidence for facies changes and to compare or contrast this evidence with thickness changes. Facies changes are recognized when a distinguishable and interpretable lithologic change occurs laterally within a rock unit. Depositional systems everywhere display beds that attenuate away from the depocenter, more or less dramatically (e.g., alluvial fans versus some carbonate shelf regimes). Erosion can significantly affect thickness of beds that are subaerially deposited or exposed. Thickness changes in evaporites cannot be attributed uniquely to dissolution any more than to deposition or erosion. Lithofacies are, however, a universal consequence of depositional systems, and under appropriate conditions, evaporite lithofacies may be properly attributed to depositional systems rather than postdepositional dissolution. For example, Holt and Powers (1988) believe that textural and geophysical log evidence establish that large facies tracts of the Rustler Formation were unaffected by post-Rustler dissolution, contradicting earlier interpretations of thinning Rustler halitic/mudstone beds due to dissolution of halite. As core of the Salado is not available beyond the vicinity of the WIPP site, log signatures in cross sections are used to investigate the possibility of facies changes in the upper Salado.

The most important evidence of facies changes would consist of systematic changes in the halitic units of the Salado, indicating a depositional margin and/or depositional thinning. A lateral increase in clay content without change in bed thickness would be reasonable evidence of depositional variations. Depositional facies can also be signalled in halitic beds if the <u>cumulative</u> thickness of argillaceous material increases in areas that are thin compared to areas where the same bed is thicker. (Natural gamma logs can be used to assess cumulative thickness of argillaceous material.) Although such evidence is consistent with a facies change, it would not rule out dissolution as a factor. A situation like this would be inconsistent with the assumption that little or no lateral change occurs, which is used to justify the single working hypothesis of dissolution.

In the upper Salado, some facies changes do occur. It is clear, for example, that potassium is not uniformly distributed laterally within Salado beds. Adams (1970) showed the general distribution of potassium minerals in different ore zones, although he did not call these facies changes. Within our data, potassium is unevenly distributed in sulfate marker beds (Figures 18, 19, and 20).

MB 103 is more polyhalitic toward the east in log cross sections from T.23S. (Figure 18). (Polyhalite is inferred from combined high acoustic velocities and high natural gamma.) Marker beds in general appear to be somewhat more polyhalitic toward the thicker parts of interbeds (toward the inferred depocenter). This characteristic might be related to deposition/ early diagenesis, and it should be examined further, as polyhalite may also be construed as an indicator that dissolution has not occurred.

Polyhalite is locally to regionally absent from marker beds, while anhydrite or gypsum remain. Polyhalite should dissolve incongruently while halite is dissolving, leaving anhydrite or, more likely, gypsum. Incongruent solution of polyhalite probably does account for lateral changes in some marker beds from polyhalite to gypsum or anhydrite. Blocks of orange to reddish gypsum crop out in the western Delaware Basin; these blocks are attributed informally to incongruent solution of polyhalite.

MB 103 (Figures 18, 19, and 20) demonstrates that incongruent solution is not a unique origin for these lateral changes, as the polyhalitic to nonpolyhalitic anhydrite occurs where the marker bed is overlain by a thick halitic uppermost Salado. Because halite is still present, it is very doubtful this change is the result of post-Salado dissolution. Elsewhere, the margin of salt between MB 103 and the Rustler is near the transition in MB 103 from anhydrite to polyhalitic anhydrite. These latter occurrences show only that the "loss" of polyhalite may indicate either postdepositional incongruent dissolution or some early diagenetic process; it is not unique to either process.

At this time, there is little evidence to be derived from the geophysical log cross sections that shows lithofacies in the upper Salado varying in the areas where the halitic beds dramatically thin. The physical situation overall is quite similar to that in the Rustler, but without physical evidence such as core textures, Salado halite dissolution remains the simplest concept consistent with available data. To the west of the WIPP site, especially in Nash Draw, physical evidence from cores proves brittle collapse of upper Salado and lower Rustler coincides with abruptly thinning zones; there it should be concluded that the upper Salado has been partially dissolved to provide space for the collapse of overlying beds and solution residues.

By extension from the Nash Draw evidence, it is reasonable at this time to assume the zone of abrupt thinning of the upper Salado has been affected by dissolution. Perhaps more important, this zone should be the present and future point of attack on the upper Salado salt, resulting in proportional collapse of the overlying Salado/Rustler rocks. The Culebra should be expected to show an attendant change in hydrologic properties along this margin.

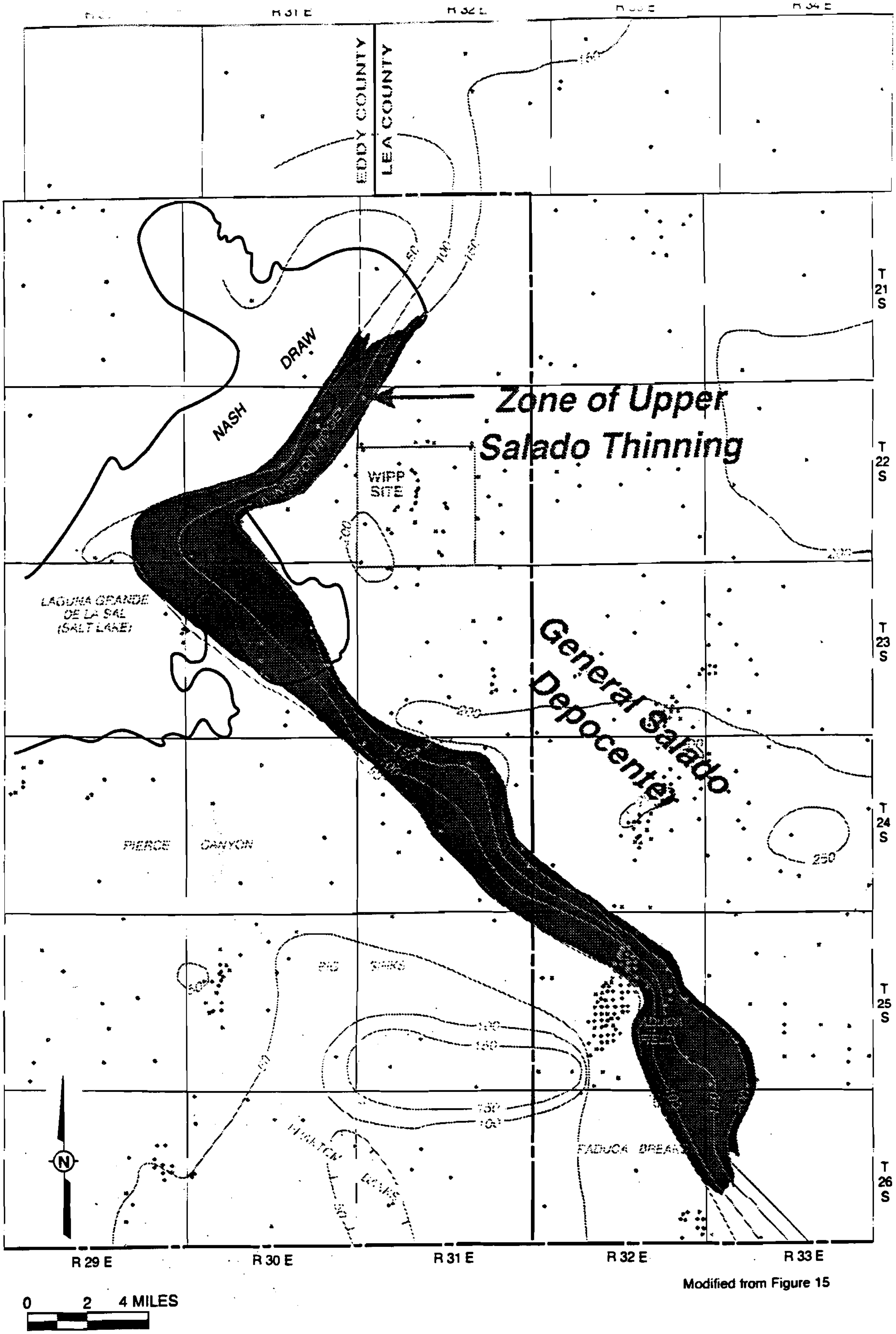
2.7 Summary of Evidence About Salado Dissolution

Geophysical logs of the upper Salado were correlated and interpreted to provide the data for isopach maps of several intervals between marker beds or other prominent contacts. Cross sections were constructed from geophysical logs so that possible facies changes could be identified. The study area covers approximately 35 townships that include the WIPP site.

The isopach maps reveal a broad depocenter for the Salado located in the eastern to southeastern part of the study area (Figure 21). Away from the depocenter, upper Salado units thin gradually; the shafts at the WIPP site are located in these thinner zones. A more sharply defined region of thinning of the upper Salado trends from the Nash Draw area, west of the WIPP site, to the south-southeast (Figure 21). This zone is most likely attributable to dissolution, as cores of the upper Salado from Nash Draw in this zone reveal collapse and brecciation of overlying units. Without textural evidence, we cannot discount totally the possibility that this margin also represents a depositional margin similar to the Tamarisk Member of the Rustler Formation. We assume that it is due to dissolution because of the Nash Draw evidence. The eastern margin of Nash Draw along Livingston Ridge closely parallels the contours of upper Salado thickness (Figures 13 and 21), and we believe that upper Salado dissolution controls much of the ridge shape in that area.

The cross sections display little evidence of lithofacies changes within halitic beds of the upper Salado. Closely spaced, as well as dispersed, data points show continuity of major marker beds, as well as of thin clastic beds.

The apparent dissolution margin of the upper Salado units is the most likely continuing and future point of attack for dissolution. The overlying Culebra should be affected by significant dissolution, causing collapse and fracturing that are expected to increase transmissivities along the zone. The path for transport of radionuclides may be affected by this process.



Modified from Figure 15

Figure 21
Zone of Upper Salado Thinning

3.0 Structural Disturbance of the Culebra

3.1 Background Information

The hydrologic character of Rustler units, especially the Culebra Dolomite Member, may be strongly affected by deformation due to tectonic or dissolution processes. In this chapter, we examine the existing structure of the Culebra, describing the basic structural features regardless of origin. In addition, other units are compared for thickness and structure to try to sort out, as much as possible, the timing of events and features related to tectonics from those caused by evaporite dissolution. The data on areal distribution of Rustler halite are presented in Chapter 4.0, however, where the contrasting concepts of dissolution and syndepositional processes are examined.

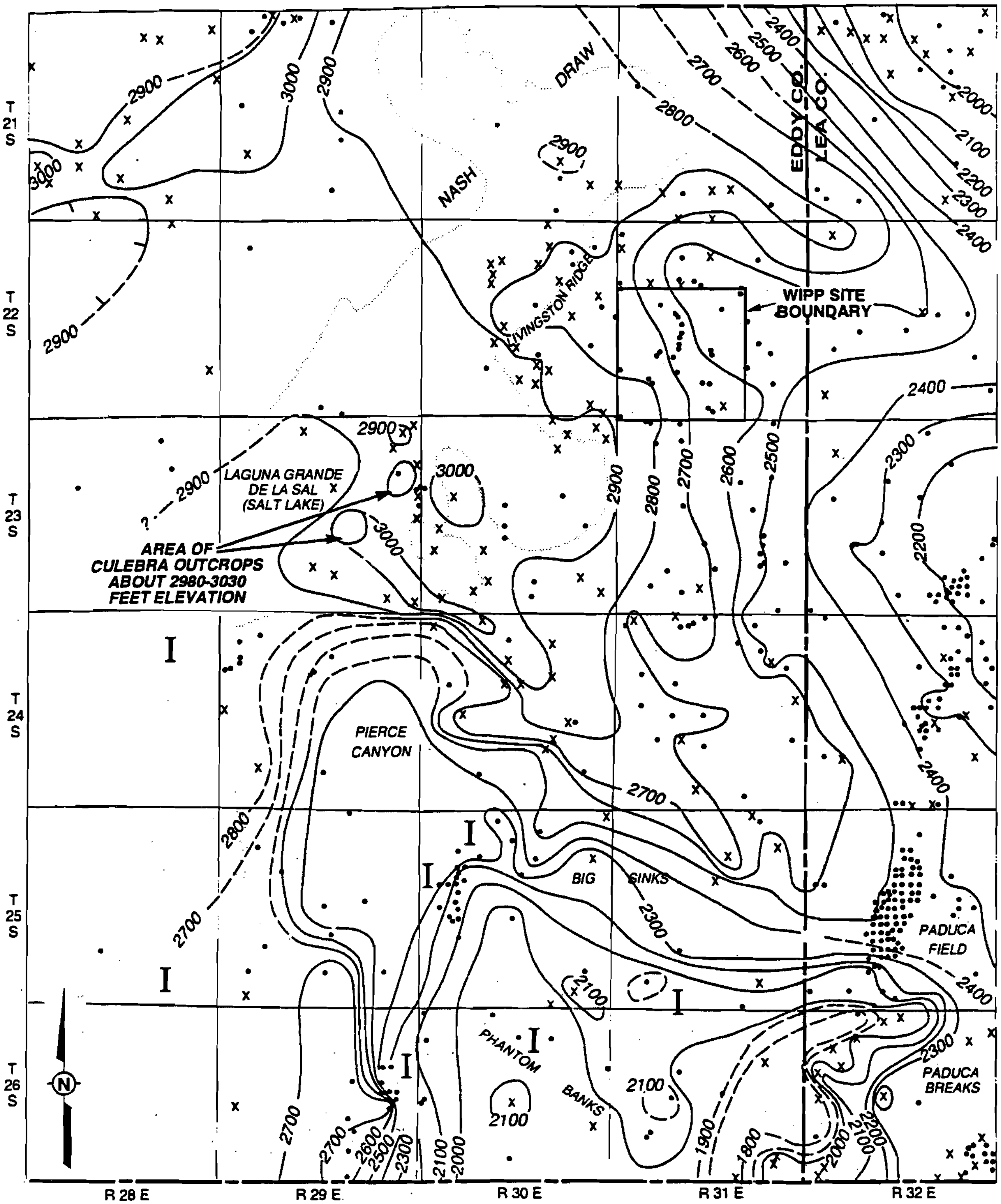
3.2 Data Sets and Methods

The structure contour map of the base of the Culebra Dolomite Member (Figure 22) presented here is based on the data from Holt and Powers (1988), some additional data acquired for this work, and data from Richey (1989) that clarifies important areas, especially in R.29E. and R.30E. The data are differentiated because the procedures followed for the Richey (1989) data are not known to us. (See Appendix A for a discussion of the data sources and Appendix C for a comparison of data sets.) The data set provided by Richey (1989) has been prepared as tables in Appendix B.

The broad regional structure of units below and above the Rustler are a beginning point for determining tectonic effects. To estimate the changes in Culebra structure due to either dissolution or tectonic processes, it is necessary to reconstruct the earlier configuration of the Culebra and underlying units. Key assumptions and data guide this reconstruction. The effects of dissolution are assessed based on two analyses: (1) the determinable facts of changes in thickness of halite-bearing units and (2) the independent (of thickness) interpretation of whether salt was deposited and, if so, when the evidence suggests it was removed (Chapter 4.0). In a third paper, we will examine directly the strength of the relationship between thickness changes in Rustler salt (commonly attributed to dissolution) and changes in hydrologic parameters in the Rustler Formation.

3.3 General Culebra Structure Elements

Though the structural features of the Delaware Basin have developed through time and have affected many geological units, we focus here on the Culebra Dolomite Member. It is the



I Marks general areas of incomplete contouring

Dashed Contours Represent Areas Of Limited Stratigraphic Control

See Figure 24 For Borehole Identifiers

• Represents Borehole and Data as Reported in Holt and Powers (1988) or interpreted from additional geophysical log data

x Represents Borehole and Data as Reported in Richey (1989)

Contour Interval = 100'

Figure 22
Structure Contour Map of Culebra Dolomite Base

main hydrological unit of interest overlying the Salado Formation, and it displays the broad structural elements (Figures 22, 23, and 24) relevant here:

1. Structure that approximates regional structure of sub-Castile units (i.e., north-south strike, east dip of approximately 100 ft/mi or 20 m/km) in the area at and south of the WIPP site

2. An anticline at ERDA 6 (southeast part of T.21S., R.31E.) plunging to the southeast

3. An anticline (the "Remuda Basin anticline") from the Remuda Basin area (southeast part of T.23S., R.29E.) plunging southeast toward the Paduca field

4. The steep and regular structural gradient on the southwest flank of the Remuda Basin anticline

5. Flat to chaotic to closed structures at the southern margin of the map (and into Texas).

In our earlier work on the Rustler (Holt and Powers, 1988, figure 4.17), the data were more restricted in some areas. We were only able to show the ERDA 6 anticline and the normal site structure (similar to regional dip). The other features (items 3, 4, and 5 above) coincided with too few data points to reliably interpret their existence. With sparse data on a regional map of the top of the Rustler Formation, Hiss (1976) shows the broad outlines of all of the features named above. Borns and Shaffer (1985), also using a somewhat restricted regional data set for southeastern New Mexico, show the first four features on structure contour maps of the top of Salado and the top of the Rustler. As their maps are truncated at the southern edge of T.25S., some of the area of the flat to chaotic closed structures was not considered by Borns and Shaffer (1985).

Using the data set from Richey (1989), Davies (1989, figure 15) also shows the same features, though his map includes some areas in which data points are not properly contoured. The structure contour map of the Culebra by Brinster (1991, figure II-17) is also based on data from Richey (1989). It more broadly reflects the same structural features, but the map is so flawed by errors in data placement and contouring, especially in the western part, that it should not be used for any interpretive or modeling purpose. A set of replacement maps has been provided as an addendum by Brinster to correct earlier flaws.

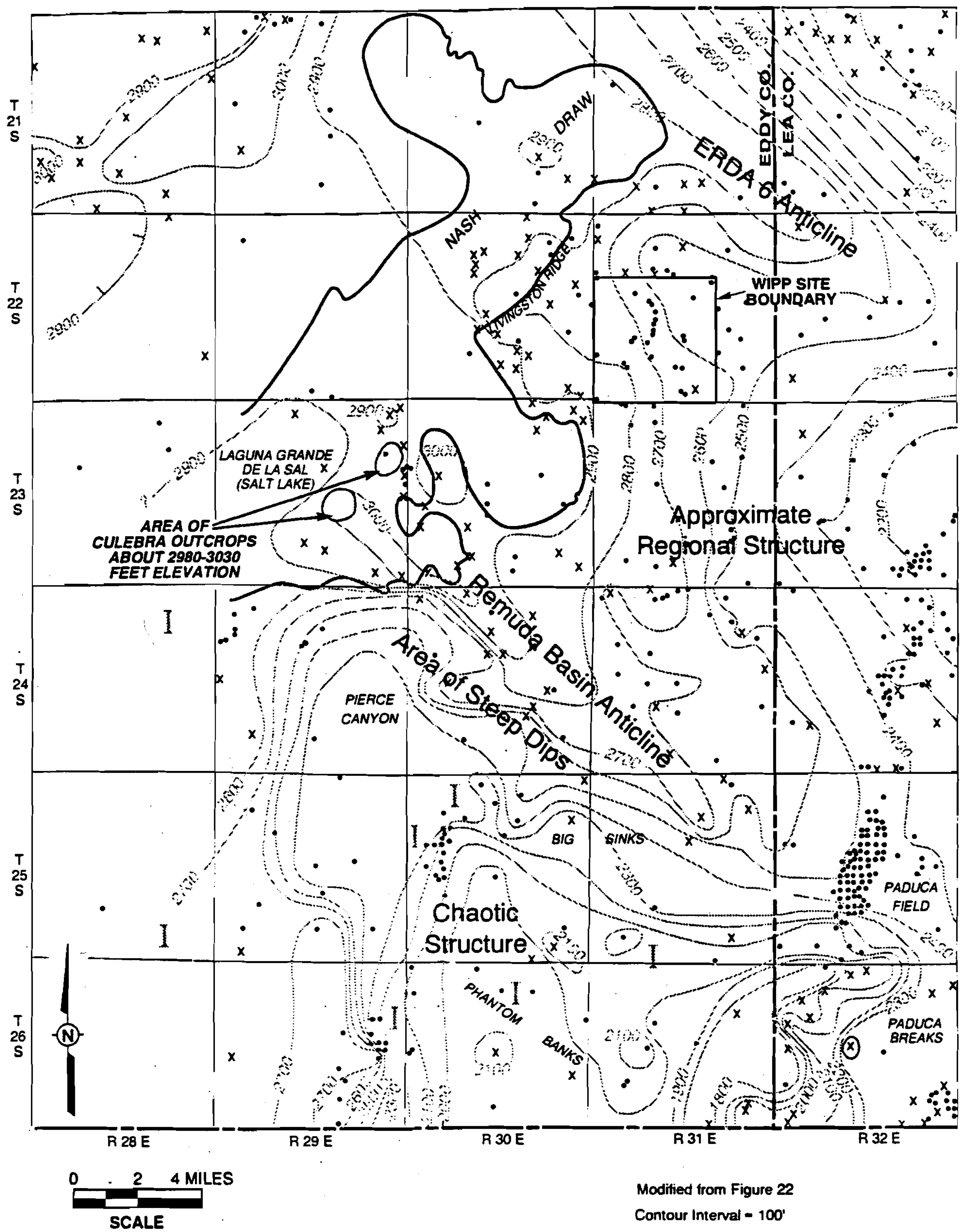
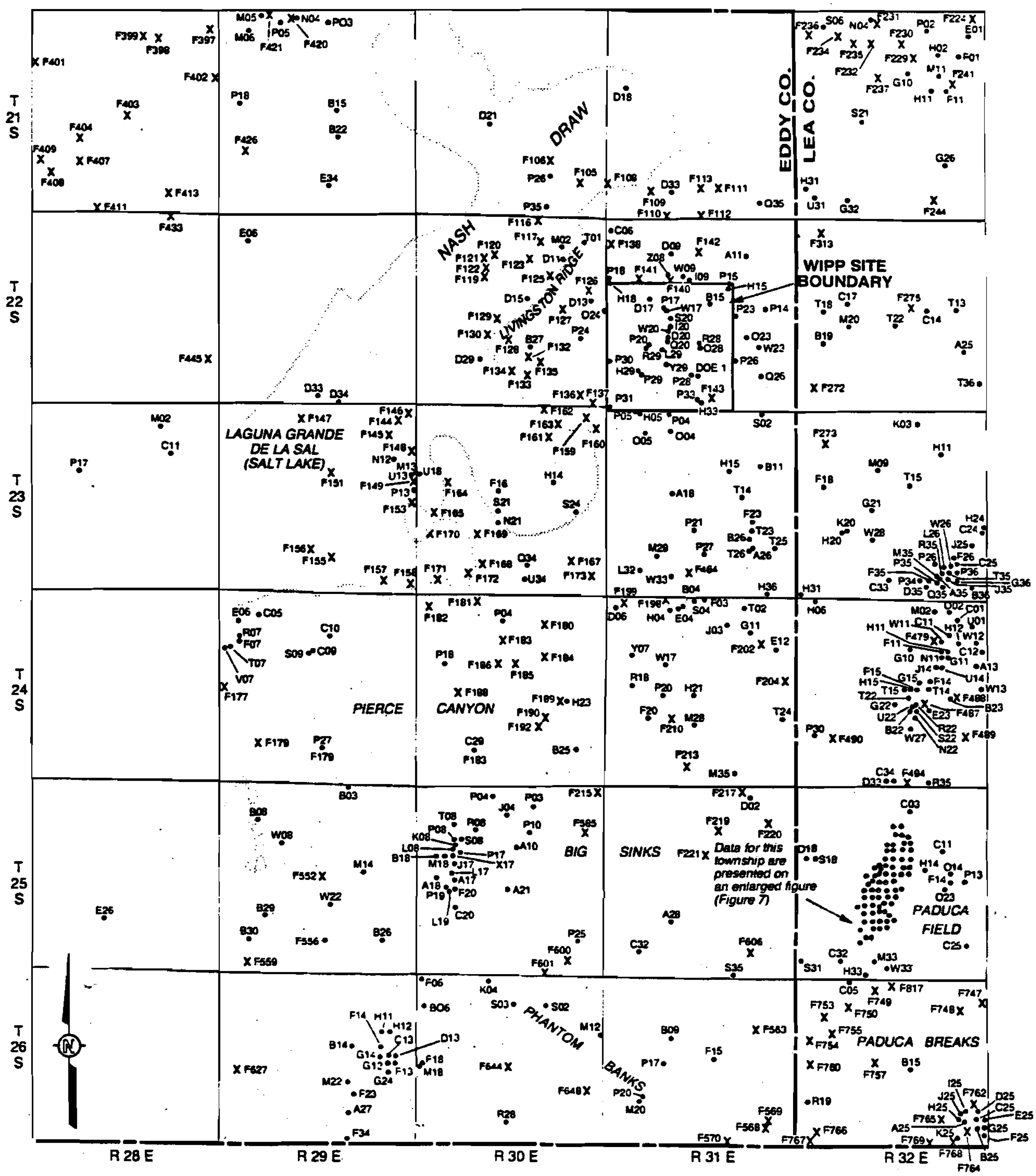


Figure 23
Main Structural Elements of Culebra Dolomite



0 2 4 MILES

SCALE

• Represents Borehole and Data as Reported in Holt and Powers (1988) or interpreted from additional geophysical log data

x Represents Borehole and Data as Reported in Richey (1989)

Modified from Figure 6

Figure 24
Drillhole Base Map for Culebra Data

3.4 Discussion of Culebra Structural Features

Throughout much of the northern Delaware Basin, stratigraphic units underlying the evaporite section consistently strike nearly north-south and dip to the east at a rate of approximately 100 ft/mi (approximately 20 m/km). The Bell Canyon to Castile contact is the best known example. In the eastern part of the basin, the evaporite units generally mirror this structure. All pre-Cenozoic units show the effects, leading to the interpretation that the broad basinal dip postdates the Paleozoic rocks. We expect, therefore, that disruptions of this pattern in the Rustler Formation around the WIPP site should be clues to postdepositional effects such as dissolution and deformation.

On the basis of these assumptions, estimated regional structure contour lines on the base of the Culebra Dolomite Member have been constructed to reflect an earlier configuration with a dominantly north-south strike and eastward dip (Figure 25). Areas of presently equal elevation north and south of the WIPP site have been used as "anchor points" for these structure contours. South of the WIPP site, these anchor points are located where the Salado does not display any significant thinning (Figures 9 and 15). North of the WIPP site, the anchor points are less secure, because the evaporites are deformed in some areas and the upper Salado is thinner. The data further north are generally consistent with the estimated regional structural trend (Figure 25), and the strike lines are generally consistent with subevaporite strike. We recognize the limitations in these assumptions.

The difference between the present elevation of the Culebra base and the estimated regional structural trend has been calculated for each borehole in the WIPP site area where data are available. The structural changes are estimated to the nearest 10 ft (3 m), as there is no justification for any additional precision, given the initial assumptions about the regional structure. The difference has been contoured to emphasize areas that may have undergone more recent changes or deformation differing from uniform eastward dip.

The Rustler displays increasing thickness from west to east across the site area, and the thickness changes are closely related to the amount of halite in three members of the formation (Snyder, 1985; Holt and Powers, 1988). Holt and Powers (1988) have previously attributed the lateral thickness and mineralogical changes to nondeposition and synsedimentary dissolution of halite during the Permian. Depositional patterns would not greatly change the later dip superimposed on the Rustler and surrounding units, while it is

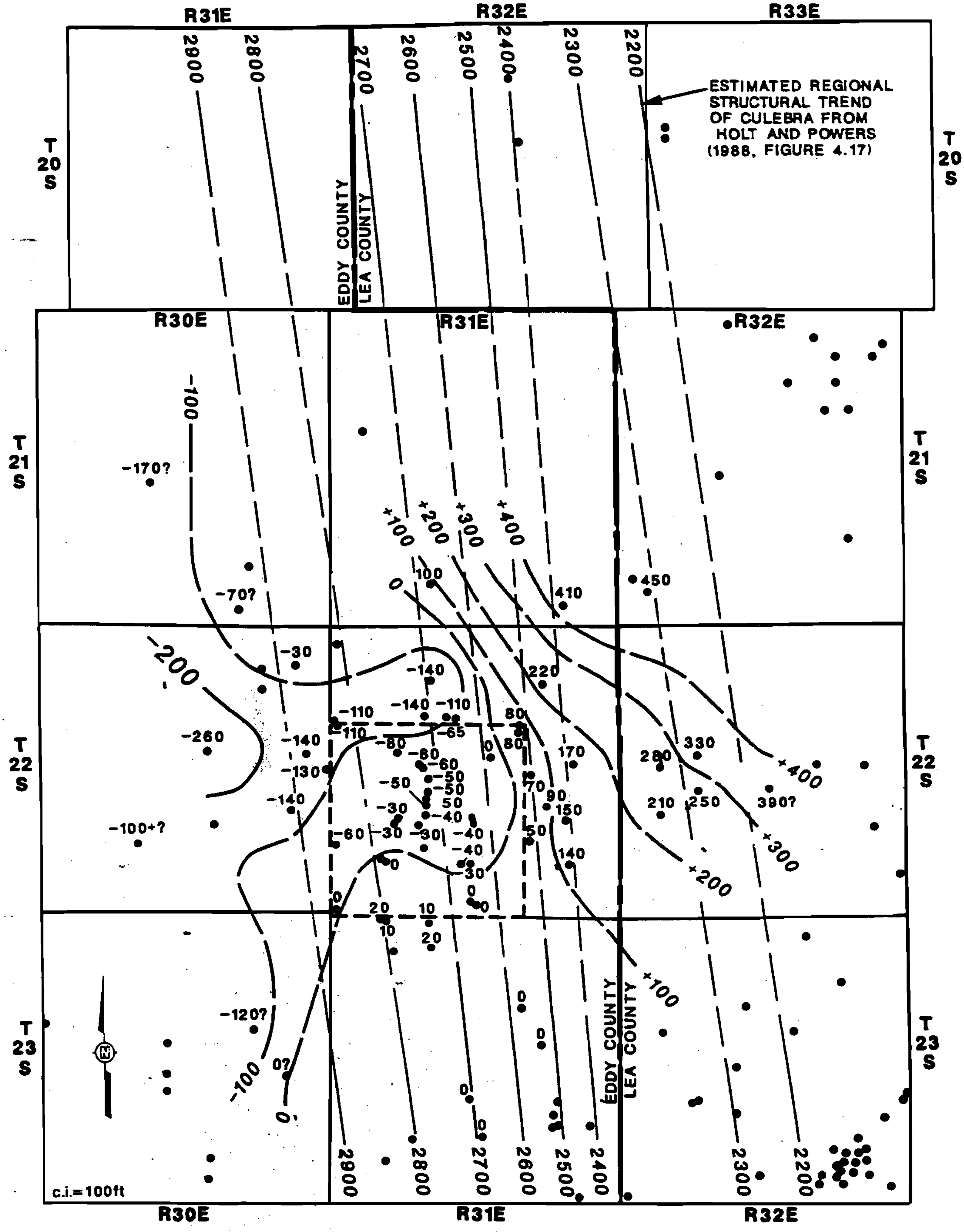


Figure 25
Difference in Elevation Between Present Culebra Base and Estimated Regional Structural Trend

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expected that later events, including dissolution, would be reflected. The patterns of this map (Figure 25) are interesting and require careful thought.

Across the WIPP site area, the estimated regional structure contour lines on the Culebra (Figure 25) show a general north-south trend, though the azimuth is slightly west of north. The departures from the estimated regional structure range from minus 200 ft along the edge of Nash Draw to plus 450 ft at ERDA 6.

The center of the WIPP site shows slightly depressed structure, but most of this is not expected to be significant, given the assumptions to estimate the regional structure. It may be that several tens of feet positive or negative are not significant. The underlying Salado is not thinner under this area (e.g., Figure 15). The lower part (M-1/H-1) of the unnamed lower member has halite (see Chapter 4.0, Figure 31). The upper part (M-2/H-2) of the unnamed lower member does not have halite across this area of slightly depressed structure; neither does the area south of the WIPP boundary, where the southern "anchor points" for regional structure are located. If the central depressed structure was interpreted as due to dissolution of the halite below the Culebra, it would have to be later than the area to the south or both areas would have been affected equally. Another problem is that the difference in thickness of the M-2/H-2 interval between the shafts (e.g., Holt and Powers, 1991) and borehole P-18 to the east is only approximately 20 to 25 ft (see Jones, 1978, for P-18 data) and for many boreholes could account for less than half the estimated structural difference. The range of differences between estimated regional structure and present structure in this central area is generally minus 30 to minus 60 ft and is marginal for drawing significant conclusions.

Northeast of the site, the Culebra appears to have been lifted as much as 450 ft (137 m) above estimated regional structure. The change in structure trends northwest-southeast, and it maps the flank of the anticlinal structure due to the intense deformation of the Castile and overlying formations observed in ERDA 6 (Anderson and Powers, 1978; Jones, 1981a; Sandia National Laboratories and U.S. Geological Survey, 1983). The effects of the deformation at ERDA 6 are evident to the northeast corner of the WIPP area and possibly along the eastern boundary. (In a rectangular 10 mi^2 area just east of the WIPP boundary, there are estimated to be 60 additional oil or gas wells that are not included in our data, and these could greatly enhance the available information on this area if suitable geophysical logs were obtained by the companies.)

A large negative feature, exceeding minus 100 ft (minus 30 m) departure from the estimated regional structure, occurs west of the WIPP site. A salient, with minus 110 to minus 140 ft (minus 34 to minus 43 m) difference, extends across the northwestern corner of the site to include WIPP 11 and DOE 2. There is little doubt that dissolution and collapse of the upper Salado have affected the westernmost data points in this negative area, as the cores from Nash Draw holes show varying degrees of brecciation in the lower to middle Rustler. The uppermost Salado (MB 103 to the top of Salado, Figure 15) shows 150 ft (46 m) or more of thinning along Livingston Ridge. The Salado is not thinner in the area of the salient feature, and the lower unnamed member has far too little halite to account for it, even if all halite within M-2/H-2 was dissolved. Another explanation is needed.

In the area of the salient, Castile structure has been significantly disturbed by evaporite deformation (Powers et al., 1978; Borns et al., 1983; Borns, 1987). It seems likely that the Culebra has been lowered locally as part of these structural disturbances. A structure contour map on selected Salado marker beds could probably clarify this possibility. Thickness maps of the overlying units, the Dewey Lake and Santa Rosa Formations (Figures 26 and 27), may also help explain this salient. The Dewey Lake isopach displays a "reverse salient" where the 500-ft isopach trends to the west over part of the same area as the salient shown on Figure 25. The Santa Rosa isopach shows a broader westward bulge in the same general area. These two formations help resolve the change in structure on the Culebra.

The Dewey Lake is not an evaporite deposit, and its thickness is not going to be diminished by dissolution. In addition, the Dewey Lake, in general, shows relatively uniform change in thickness from east to west, with isopach contours roughly north-south. Both units thin to the west like a wedge. Based on available data, the approximate western margin of the Santa Rosa is also approximately the eastern margin where the Dewey Lake begins to thin. The units have been bevelled in response to erosion after the units were tilted downward to the east. The eastward dip on these formations is approximately 100 ft/mi (19 mi/km), and the westward rate of thinning is similar.

The westward salient on the 500-ft isopach for the Dewey Lake indicates that the structural depression on the Culebra occurred prior to erosion. The units appear to have been warped differently in that area and not uniformly tilted to the east. The subsequent beveling results in slightly thicker deposits being preserved in the area of the Culebra depression. This interpretation would be enhanced with additional structure contour maps on these units.

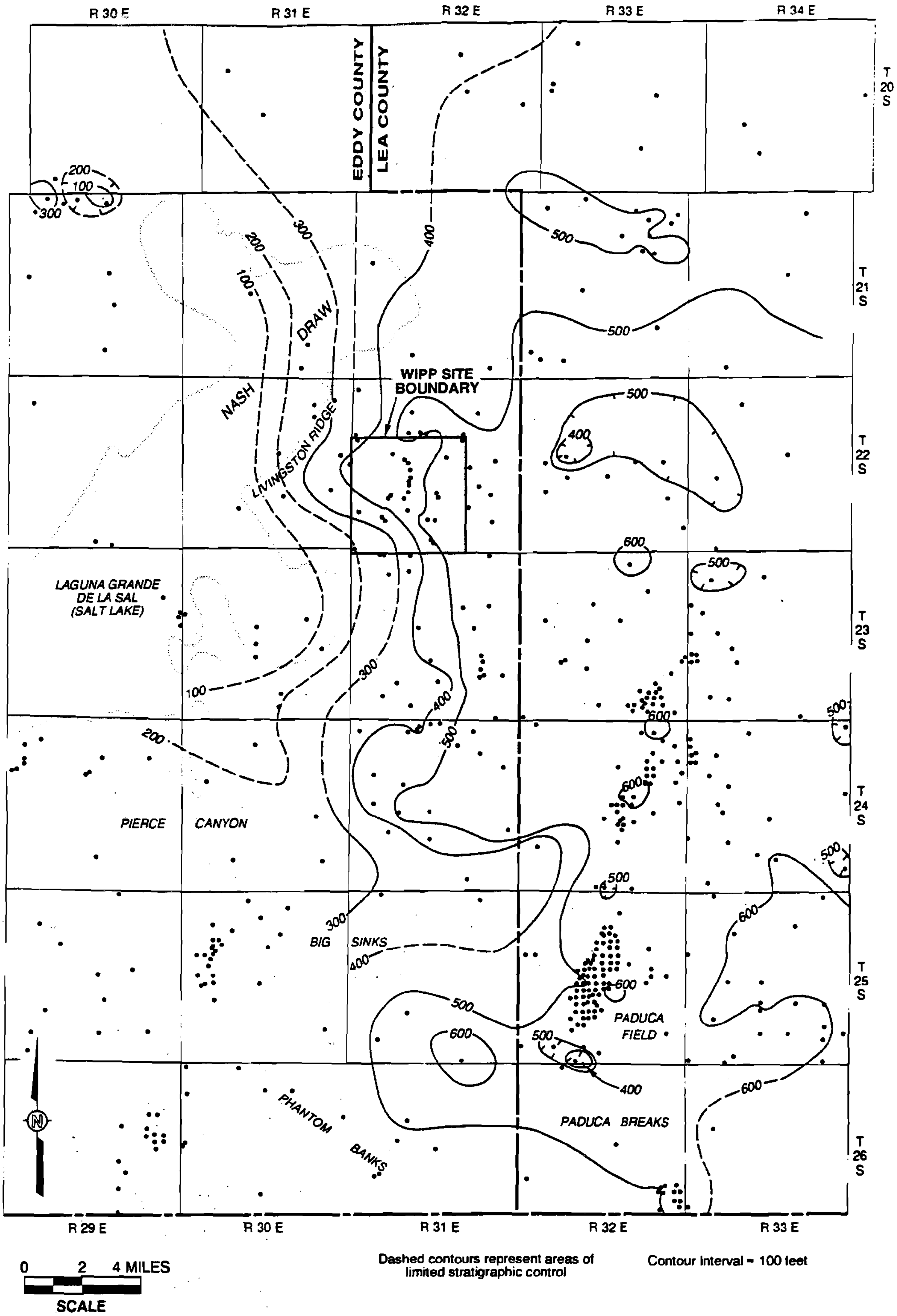


Figure 26
Isopach of the Dewey Lake Formation

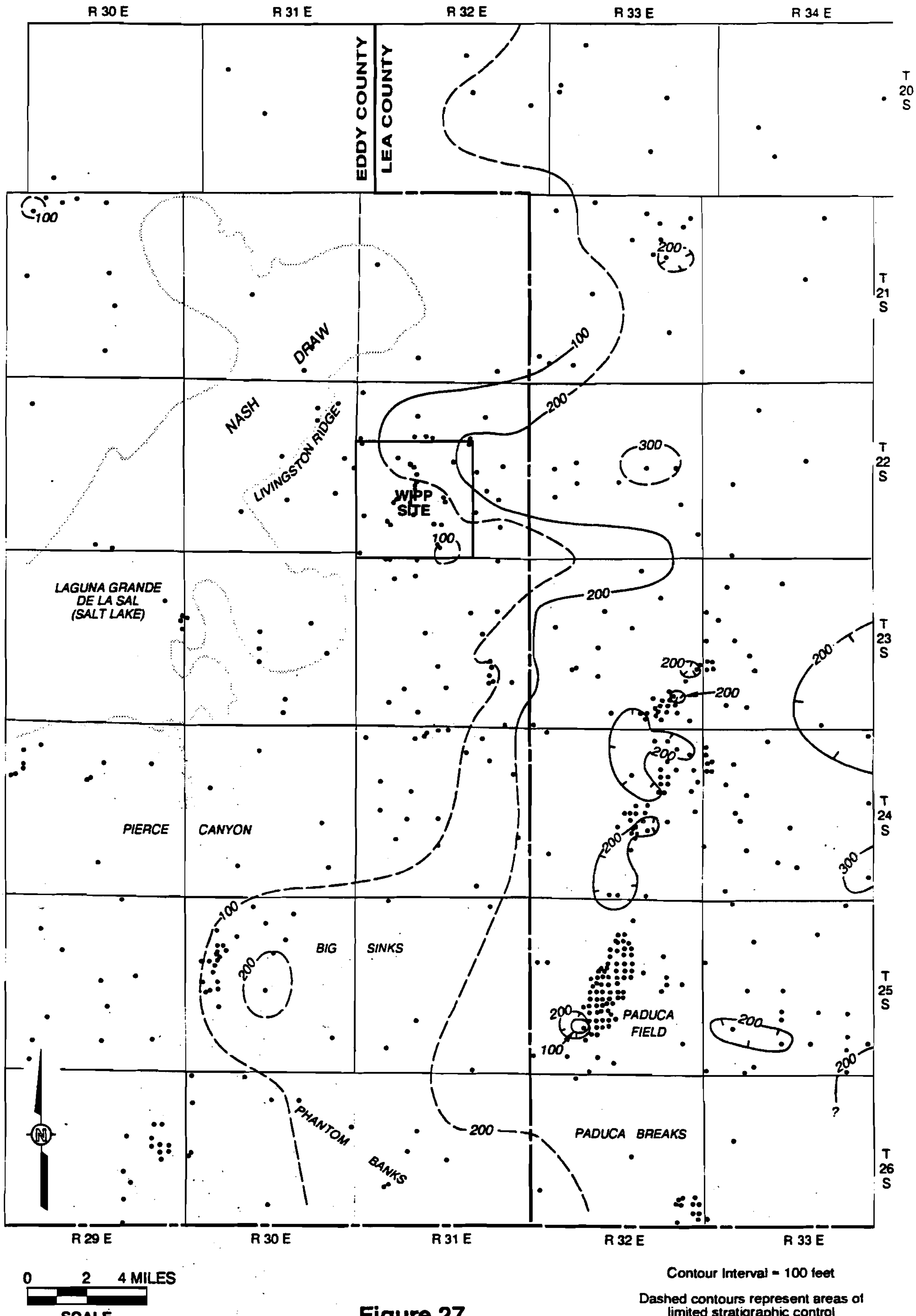


Figure 27
Isopach of the Santa Rosa Formation

There may be alternate explanations required in the area of Big Sinks and Phantom Banks, though the disturbance of the entire section in that area makes detailed inferences suspect.

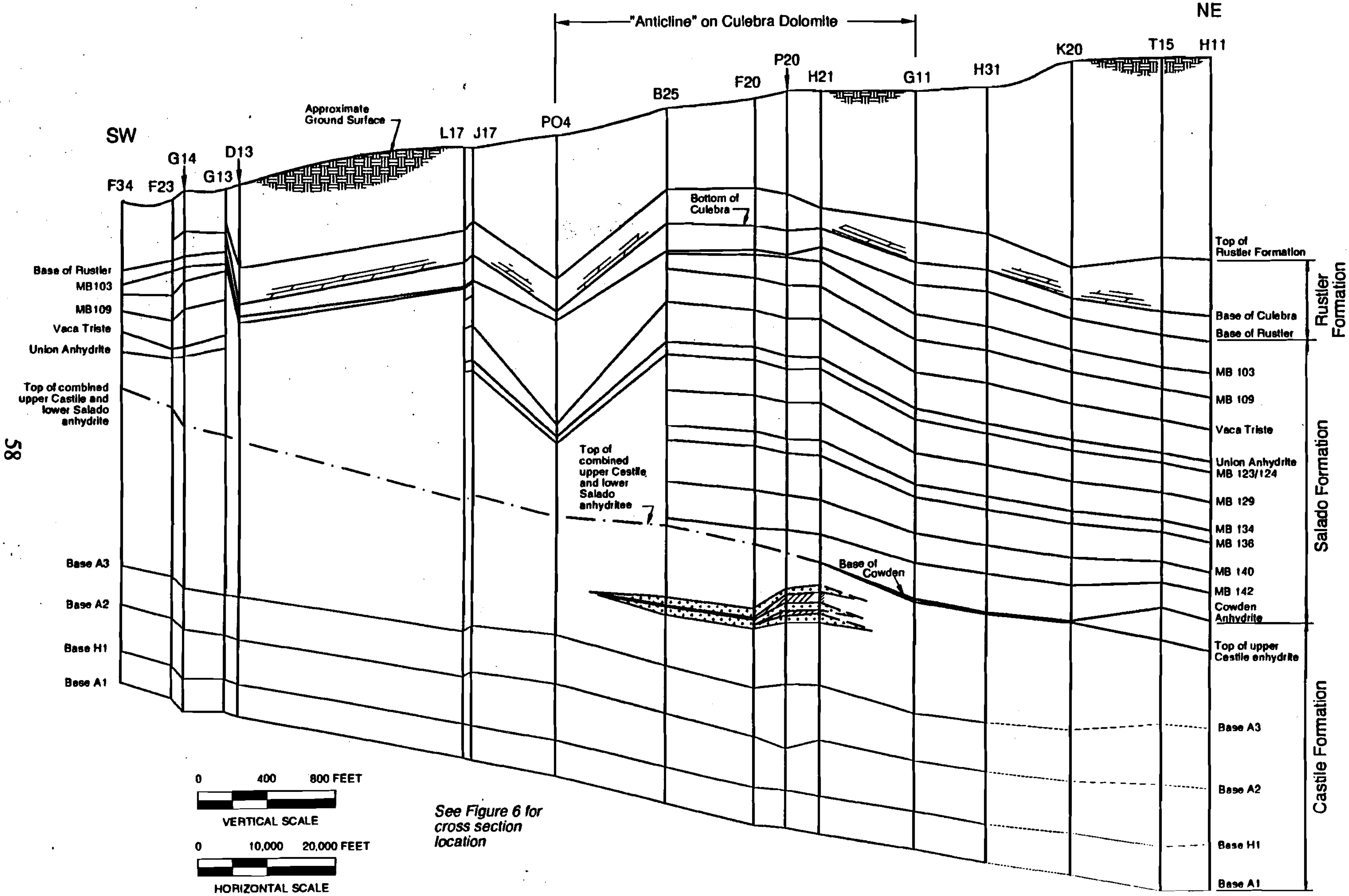
The Remuda Basin anticline trends southeast from the Remuda Basin area toward Paduca field. In this report, no structure contours were constructed on units within the Salado Formation. Borns and Shaffer (1985) present maps with somewhat sparse data in this area, which could be interpreted to show this anticline present in various units within the Salado. It is not visible in the structure of the top of the Bell Canyon (Delaware Mountain Group), indicating it is confined to the evaporite formations. The data on Castile Formation units are too sparse to decide if the structure is or is not present in that formation.

A cross section has been constructed perpendicular to the Remuda Basin anticline to show the structural relationship to lower units (Figure 28). The northwest flank of the anticline shows the regional dip to the east from the base of the Castile to the top of the Rustler. The northwest to southeast trend to the anticline is caused by the zone where the upper Salado is thinned along a similar trend. The southwest flank of the anticline is formed mainly by changes in thickness of the Salado. The base of Castile dips uniformly to the east through this area, and the thickness changes are probably mostly due to dissolution.

Flat to chaotic structure in the southern map area, south of the Remuda Basin anticline, is consistent with an area undergoing dissolution, and the cross section demonstrates that the Salado is the main unit being dissolved.

3.5 Summary of Evidence about Culebra Structure

The Culebra shows gross structural changes northeast of the WIPP because of evaporite deformation. Across the site, subtle structural changes from regional background exist that can best be explained as a response to evaporite deformation rather than dissolution of Rustler and Salado evaporites. Further south, the Remuda Basin anticline formed from a combination of eastern regional dip, dissolution along the upper Salado, and greater dissolution of Salado to the southwest to reverse the regional dip.



See Figure 6 for cross section location

Figure 28
NE-SW Cross Section through "Remuda Basin Anticline"

4.0 Rustler Halite Dissolution

4.1 Background Information and History

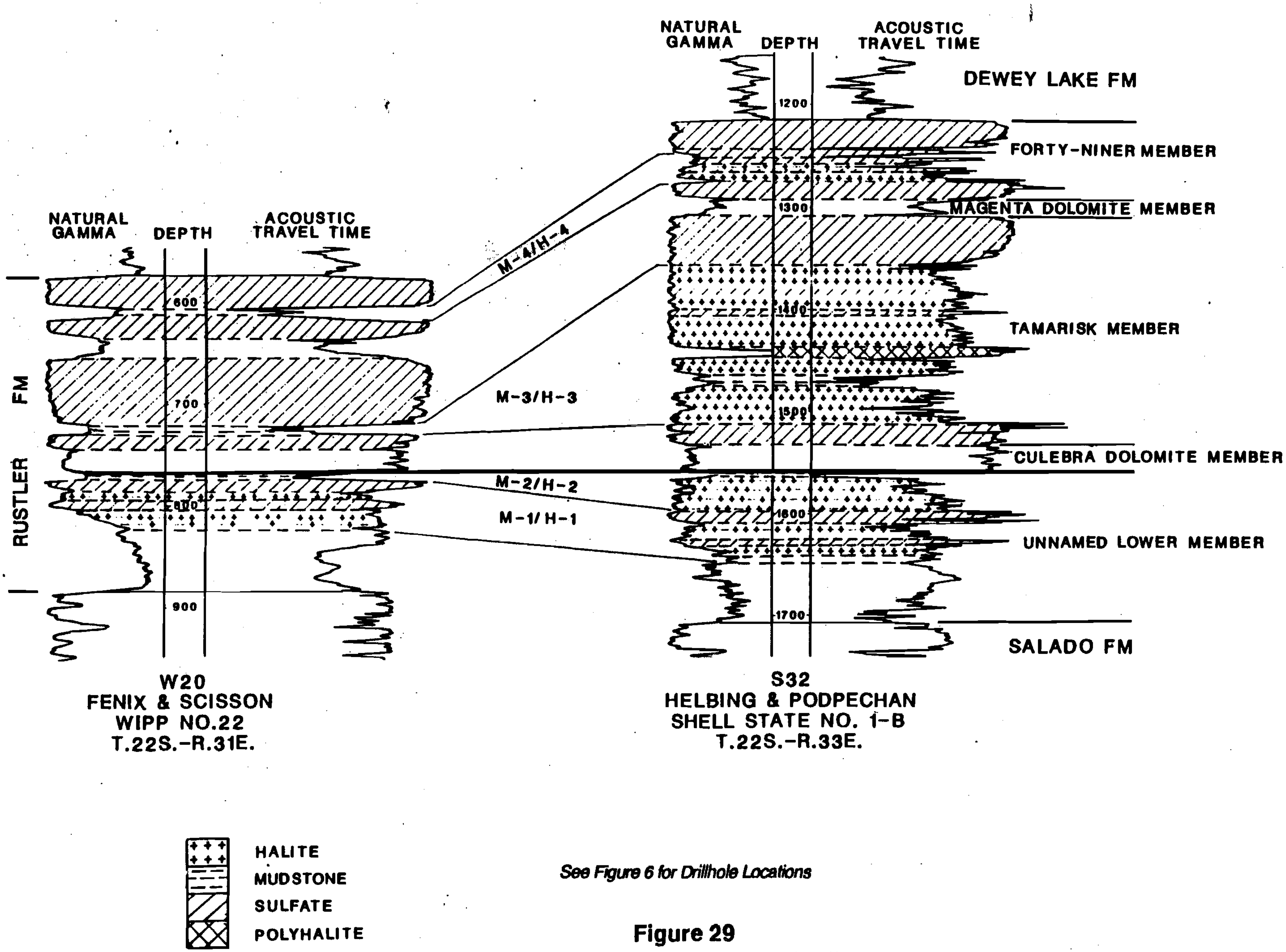
The three nondolomite members of the Rustler Formation have beds of halite (Figure 29) in an area east and south of the WIPP site. Some halite exists in both the unnamed lower member and in the Tamarisk Member within the WIPP site; the Forty-niner Member is devoid of halite within the WIPP site. Halitic parts of all three members are thicker than equivalent nonhalitic beds. Was halite dissolved after the Rustler was deposited to produce thinner, nonhalitic beds? Or are these beds lacking halite because of different depositional conditions?

Here we reconsider briefly the principal arguments that have already been presented, and we present maps of existing halite margins. From this information, we can hypothesize generally what effects dissolution may have, or may have had, on Rustler hydrology. The final report in this series (see Preface) will explicitly examine the correlation between Rustler hydrological parameters and the thickness of halitic members, as well as other factors.

Project history and studies regarding shallow dissolution in southeastern New Mexico have been extensively analyzed by Powers (in review). That evaluation is helpful in understanding how the WIPP has recognized and approached issues related to shallow dissolution, but it does not propose that the project should adopt one conceptual model of Rustler halite distribution over another.

4.1.1 Alternate Hypotheses of Halite Distribution

The prevailing hypothesis has been that halite was deposited relatively uniformly in each member of the Rustler across the WIPP area, and that the halite was later removed from some areas by dissolution. Jones et al. (1960, figure 1) considered each halitic unit to have a laterally equivalent residue after dissolution of halite. Vine (1963) and Jones et al. (1973) also proposed that halite was dissolved from the Rustler, and Jones et al. (1973) believed most of the halite was dissolved in later Cenozoic times. Powers et al. (1978) reviewed the information and previous work available for the WIPP project, following the line of thinking established in previous work. Lambert (1983) also reviewed the available information on, and hypotheses about, dissolution of the evaporite formations of the Ochoan Series, revising some of the proposed mechanisms for dissolution.



See Figure 6 for Drillhole Locations

Figure 29
Log Character of Rustler Mudstone/Halite Intervals

Through this period, the principal evidence for dissolution of halite was lack of halite in thinner units. To be sure, Jones et al. (1960) and Vine (1963) report residues and solution breccias in these members, but in little detail. Outcrops and near-surface parts of the Rustler in Nash Draw and further south exhibit karst and collapse features from solution of Rustler and Salado rocks. Near-surface sulfatic rocks are hydrated, and both the Culebra and Magenta Dolomite Members yield some water of varying salinity. Taken together, the pieces of evidence have convinced a number of geologists and hydrologists that water has percolated into or through the Rustler and that halite has been removed extensively from the Rustler since it was deposited.

As the Rustler was exposed, mapped, and described in detail in the waste handling shaft (Holt and Powers, 1984), bedding and sedimentary structures were revealed in units previously attributed to dissolution residues at the site (e.g., Jones, 1981b). During a more extended study of shafts, cores, and geophysical logs through the Rustler, Holt and Powers (1988) found considerable stratigraphic, textural, and diagenetic evidence indicating that halite pan to saline mudflats existed during deposition. Halite and gypsum grew displacively in facies tracts adjacent to the halite pan, and halite, especially, was removed syndepositionally from areas more distal to the halite pan at the depocenter. Incipient soil textures and probable fluvial deposits characterize the more distal facies tracts. At the site, facies tracts that had no halite deposited, or that had halite removed syndepositionally, show little or no fracturing or brecciation of overlying units. In Nash Draw, the upper Salado has been attacked by dissolution, causing collapse and brecciation of the overlying units. Holt and Powers (1988) show that this brecciation overprints synsedimentary dissolution in the Rustler; halite no longer existed in that part of the Rustler by the time the sediments were lithified. They concluded that little halite has been removed from the WIPP site area since the Rustler was deposited.

By this hypothesis of deposition and syndepositional dissolution, the Rustler Formation developed facies tracts with halite margins at about the present limits to halite. The depositional margins are the likely places, then, where halite might be modified by dissolution. Significant dissolution could further strain or result in collapse and fracturing of the overlying beds, affecting the hydrology of units such as the Culebra and Magenta. To further determine the areas of the Culebra and Magenta most likely to be affected if there were dissolution along these halite margins, the margins as they now exist were plotted in more detail.

4.1.2 Reported Halite Distributions

Mercer (1983) reported, on a map, the extent of halite beds within the Rustler Formation around the WIPP site area based on information from R. P. Snyder. Mercer (1983) interpreted the thickness changes of the Rustler Formation as due to both depositional and dissolution processes, following the interpretation of Jones et al. (1973). Depositional changes were considered by Jones as the source of lesser thickness changes from north to south in the eastern part of the area. Later, Snyder (1985) prepared a map (presented here as Figure 30) of a smaller area around the WIPP site that appears very similar to part of the map in Mercer (1983). The map shows halite margins within the Rustler Formation based mainly on the evidence of the interpretation of geophysical logs for unit thicknesses and presence of halite. These two maps, based on work by Snyder, are sources for some of the variety of figures in documents presenting and interpreting margins of Rustler halite.

The other source of maps of halite margins is traced to the map of Beauheim (1987) in which he combined information from Snyder (1985; also cited by Beauheim as personal communication from Snyder) and Powers (cited by Beauheim as personal communication). The map by Powers differs in some areas from Snyder and covers much of southeastern New Mexico. The geophysical logs used for that effort have been reexamined and newly interpreted to provide the map of halite margins in this report. The basis for interpreting the geophysical logs is the same as for the earlier map, and the results are very similar. In this report, the interpretive rationale and data are presented, and the map is based only on these data.

There is no question that the interpreted significance of halite margins in the Rustler Formation differs greatly between Snyder and Powers, as traced through related publications. Snyder (1985) clearly attributes the major changes in thickness of the Rustler and areas of no halite as due to post-Rustler dissolution. Holt and Powers (1984, 1986b, 1988) first question the extent of post-Rustler dissolution and then attribute the major changes in thickness to synsedimentary precipitation and dissolution along the halite pan margin. The general positions of the margins are similar for both investigators, and the differences in details are not the source of differences in interpretation.

4.2 Methods

Geophysical logs, mainly natural gamma and acoustic logs, were inspected to interpret the thicknesses of halite, sulfate, and mudstone of four intervals within the Rustler. Log characteristics of these lithologies were reviewed in Holt and Powers (1988). The acoustic

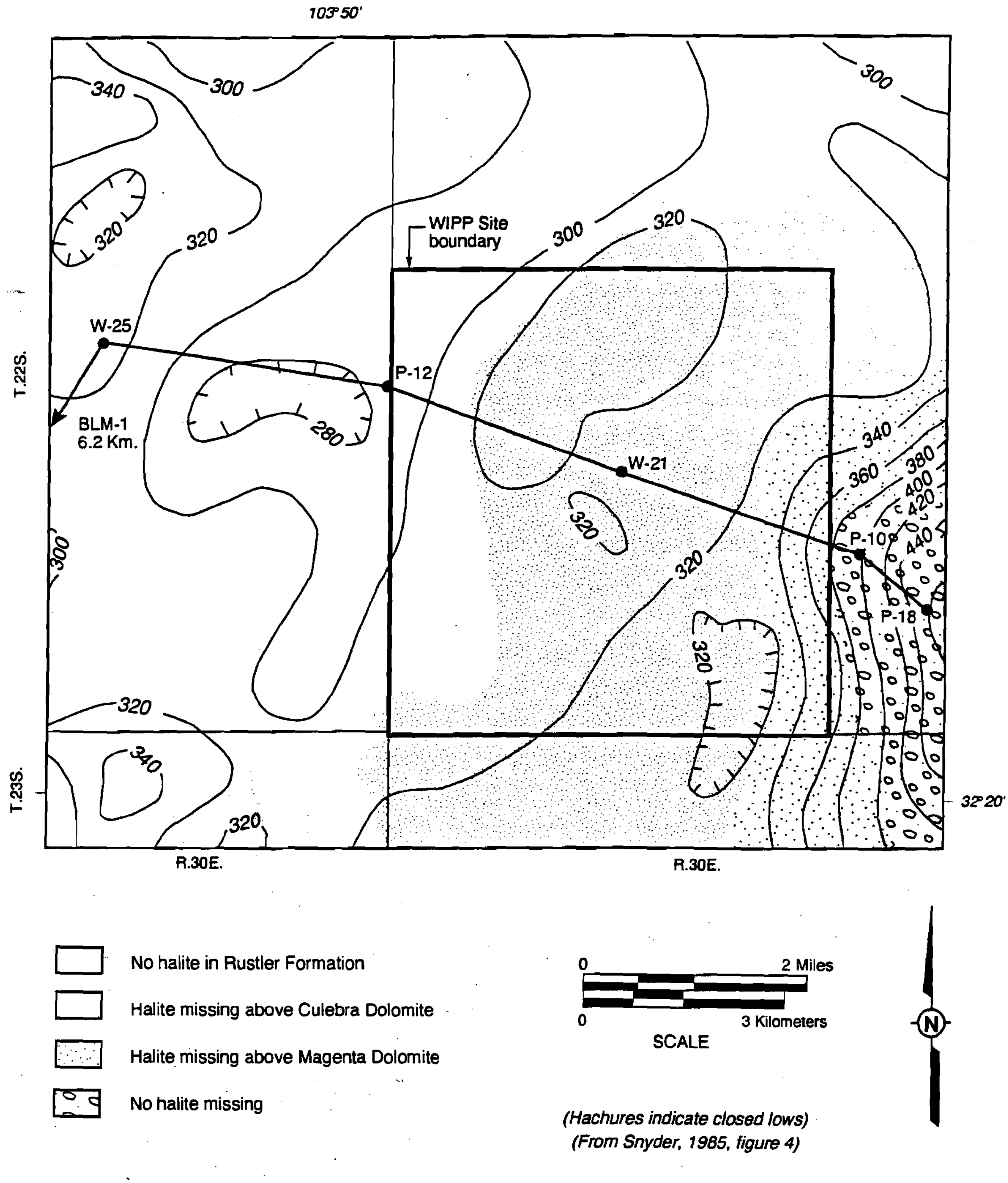


Figure 30
Isopach Map of the Rustler Formation in the Vicinity of the WIPP Site Showing Dissolution Zones

and natural gamma logs from one borehole at WIPP (WIPP 22) and a commercial well a few miles east demonstrate some of the halite to mudstone relationships (Figure 29). The thicknesses were estimated because the log characteristics do not provide a unique identification and proportion of minerals in mixed lithologies. Mixed halite and mudstone has been examined in core and compared to logs to provide a basic estimate of proportions, and the remaining logs were interpreted by Powers on the basis of this somewhat subjective standard. The estimates were plotted on a base map, and the present margins for halite in various members were based on these interpretations. The lower unnamed member was divided into two mudstone/halite units based on position above or below the first anhydrite below the Culebra (Figure 29). The lower unit has also been designated as H-1/M-1 in some of our reports, because halite is common across the site area in the unit. Mercer (1983) and Snyder (1985) do not divide the lower unnamed member; their margin is more nearly equivalent to our lower unit (M-1/H-1). The amount of halite was estimated for the M-1/H-1, M-2/H-2, Tamarisk mudstone (M-3/H-3), and Forty-niner mudstone (M-4/H-4) intervals (Figure 29).

Our method produces margins that are probably more extended in some areas than are margins based on a method that requires a bed of relatively pure halite to be present to be counted or a method that requires return of cuttings or core with observable halite. Our method probably interprets some areas as having halite in which none is present. Conversely, it also includes areas with halite that are overlooked by a very conservative method.

We note, as in other chapters, that many holes have been drilled around the WIPP site for oil and gas exploration in recent years, and geophysical logs from these drillholes have not been acquired and interpreted to extend our information. There may be relevant details to be gleaned, especially east of the WIPP site.

4.3 Halite Margins in the Rustler Formation

The halite margin for M-1/H-1 broadly parallels the other Rustler halite margins, but it is several miles west of the other margins (Figure 31). The halite margin in M-1/H-1 also generally parallels the zone of abrupt thinning of the upper Salado (MB 103 to Salado interval) (Figure 15). The M-1/H-1 halite margin is closer to the thinning margin of the Salado than to the halite margins of higher units in the Rustler.

The halite margins for units M-2/H-2, Tamarisk mudstone, and Forty-niner mudstone are generally closely spaced over the map study area (Figure 31). The M-2/H-2 margin is

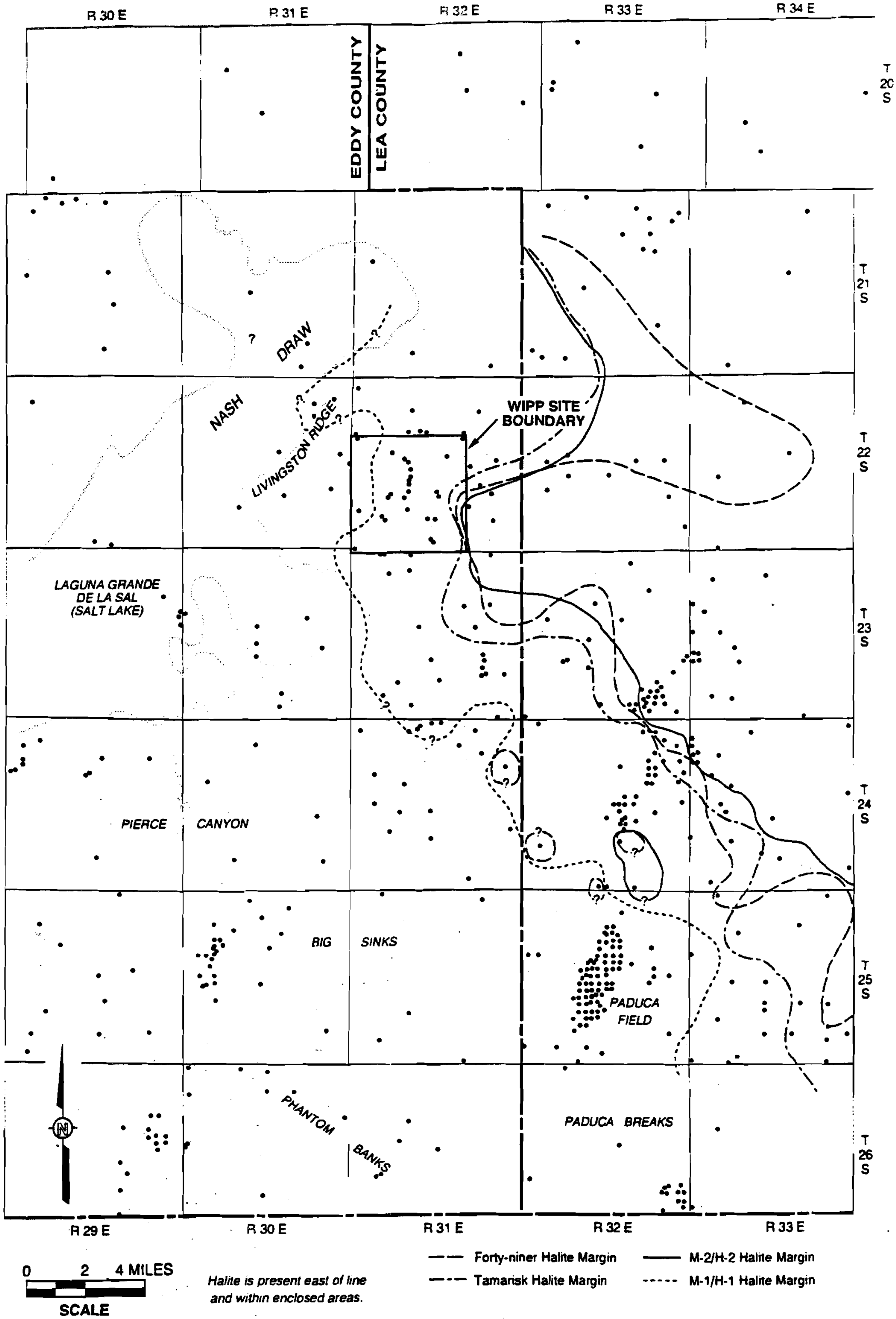


Figure 31
Halite Margins in Rustler

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generally the westernmost, and the Forty-niner halite margin is easternmost. At some locations, margins from higher units will "cross over" the margins of lower units. Though the margins are both closely spaced and generally parallel, there is a major difference between the Tamarisk and the other two units. The Tamarisk mudstone (and equivalent halitic units) has a much greater range of thickness, and, within the map area, may include 180 ft (55 m) of halite. The margin appears correspondingly much more abrupt in transition.

There is a final caution to overinterpreting the data on halite in the Rustler based on more detailed evidence. WIPP 19 was drilled just north of the center of the WIPP site (I20 on Figure 6). Neither geophysical logs interpreted here nor data summarized in Snyder (1985) indicate that halite is present in the Forty-niner. Nonetheless, a thin section prepared from core of the Forty-niner mudstone in WIPP 19 shows that halite is still present at that location (see Holt and Powers, 1988, plate 23). Gross methods used here and elsewhere are clearly not the best indications of halite in small quantities.

4.4 Discussion

The significant question about these margins is whether they are due to dissolution or limits to deposition. Snyder (1985) follows much of the earlier discussion of halite in the Rustler, concluding that thinning and absence of halite in the different members is largely a consequence of post-Rustler dissolution of halite. Snyder (1985) also concludes that the Rustler section was subsequently locally inflated by expansion of anhydrite to gypsum during hydration accompanying dissolution. The interpretation is based largely on thickness changes and the physical evidence of dissolution in the area of Nash Draw.

From shaft, core, and geophysical log data of the Rustler, Holt and Powers (1988) concluded that the halitic units of the Rustler were deposited in halite pan and adjacent environments. The Forty-niner Member mudstone (M-4/H-4) at the WIPP shows cross-cutting relationships as evidence of current transport. The same unit in drillhole DOE-2 includes beds described as "claystone and siltstone . . . alternating very thin beds, wavy bedding and scour and fill structures" (Mercer et al., 1987, p. 270). These are the most distant facies (in terms of depositional environments) from the halite pan that are represented in cores from the Rustler mudstones. The Tamarisk Member mudstone (M-3/H-3) exhibits smeared intraclast textures from synsedimentary dissolution of halite in halitic mudflat deposits where exposure is greater and solution more intense than in depositional environments closer to the halite pan. This facies tract is extensive. In the site area, the Tamarisk mudstone is generally unfractured, and the overlying beds are largely undisturbed, consistent with synsedimentary dissolution. In the

Nash Draw area, the mudstones in the Rustler are considerably disturbed and fractured, as are lower units including the Culebra. There, upper Salado has been dissolved, causing fracture and collapse of much of the Rustler and overprinting the earlier, syndepositional textures.

Holt and Powers (1988) interpreted limited and equivocal evidence from some cores of the Rustler as possible indicators of continuing or more recent dissolution of Rustler halite. Beauheim and Holt (1990) showed small map areas consistent with Holt and Powers (1988). Based on mapping of the Tamarisk and Culebra in the air intake shaft (Holt and Powers, 1991), we believe these core features are synsedimentary and do not interpret the halite margins at the WIPP site to have been affected by significant post-Permian dissolution of Rustler halite. Areas of Rustler halite have been or are being attacked where Salado halite has been or is being attacked.

Structural patterns for units of the Rustler (Figure 22) (see also Holt and Powers, 1988, figures 4.16, 4.17, 4.19) are similar in some areas to patterns of Rustler member halite margins, as well as to isopachs of the entire Rustler (Holt and Powers, 1988, figure 4.15) and unnamed lower member and Tamarisk Member mudstone/halite (Holt and Powers, 1988, figures 4.7 and 4.11, respectively). In particular, margins of the upper three Rustler halite members (Figure 31) northeast of the WIPP site swing around an area that coincides with the structural deformation at ERDA 6. Is this coincidence, dissolution controlled by structure, or structure controlled by halite distribution? Several lines of evidence are relevant.

All units of the Rustler are structurally deformed in this area (northeast corner, T.22S., R.31E.). The base and top of the Rustler (Holt and Powers, 1988, figures 4.16 and 4.19, respectively) are similarly deformed, both in areal extent and vertical uplift. The Culebra (Figure 22) is relevant here and representative of the structure within the Rustler. The structural high trends from northwest to southeast approximately along the topographic high known as the Divide and Antelope Ridge. The structure plunges to the southeast and is generally indistinguishable or greatly subdued in the vicinity of the southern half of T.22S., R.34E.

The thickness of the Forty-niner Member is not apparently affected over the main part of the structure. It thickens modestly on the northeast flank of the anticline. The Forty-niner Member thickens towards the depocenter, which is located in the area of San Simon Swale and Sink.

The Tamarisk mudstone/halite unit is approximately 100 ft (30 m) thinner over the area of the ERDA 6 structure as compared to the thicker depocenter to the southeast. In addition, the isopach contour lines of this unit also follow the form of the plunging anticline.

The isopach map (Holt and Powers, 1988, figure 4.7) of the unnamed lower member shows thinning, of the order of 50 ft (15 m), in an area that cuts across the structure at ERDA 6 and also shows some similarity in form along the plunging southeast end of the structure.

The total Rustler isopach shows a change of 100 plus ft (30 plus m) from the top of the structure to the nose to the southeast (Holt and Powers, 1988, figure 4.15).

Dissolution after deformation is probably limited, at most, to the nose of the anticline, as core from AEC 8 (Section 11, T.22S., R.31E.) indicates predeformation synsedimentary loss of halite from upper Rustler units, while the lower Rustler still includes halite. The original halite margin may have trended near AEC 8 and ERDA 6. The pattern of parallel structure contours could be developed either by deformation of a unit with lateral facies changes or through partial solution of halite across the structure. The evidence at the location of AEC 8 suggests that part of the structure very likely developed where halite was missing syndepositionally from the Rustler. The area of the nose of the structure, east of the WIPP site, may have undergone postdepositional dissolution. We have no core data from the area to differentiate between dissolution and syndepositional processes.

The Dewey Lake Formation (Figure 26) shows no thickness pattern apparently related to the structure at ERDA 6. Any change in Rustler thickness was fully compensated either during the deposition of the Rustler or the change in thickness occurred after the Dewey Lake was deposited. (Basic data for the Dewey Lake and Santa Rosa are presented in Appendix A-4.)

The Santa Rosa (Dockum Group) (Figure 27) shows thinning that partially mimics the structure of the underlying rocks at ERDA 6. Data are insufficient to decide whether this indicates erosion partially as a result of uplift or whether the thinning is part of the general erosional truncation of the unit from east to west. As with the Dewey Lake, there is no indication of thicker Santa Rosa that would imply sedimentary compensation for dissolution of the underlying Rustler prior to or during deposition of the Santa Rosa.

It seems most likely that the general pattern of the halite margins developed more or less coincidentally like the structural deformation pattern at ERDA 6. Core evidence of halite cement in the upper Rustler north of the WIPP site is most helpful; such features are not always detectable by geophysical logs, but they offer further evidence that late-stage dissolution is limited in that area. More recent dissolution may have occurred to conform the halite margin to the structure pattern around the nose of the anticline; we have no direct evidence either way. It seems unlikely, given the evidence of extensive deformation much deeper in the evaporites (Anderson and Powers, 1978; Jones, 1981a), that the structural deformation was controlled in any way by the distribution of halite in the Rustler.

There may be hydrologic consequences to the Rustler from evaporite deformation, but they are not determinable with our data. We do not at this time interpret the halite patterns in the Rustler near ERDA 6 as being due to post-Rustler dissolution, nor do we expect hydrologic consequences at that location due to dissolution. The area of the structural nose, nearer the center of T.22S., R.32E., is a more likely location for changes in hydrologic parameters, but there are no hydrologic data from that area.

From T.23S., R.31E., to the southeast, the halite margins in all Rustler units generally trend from northwest to southeast. This trend parallels the Remuda Basin anticline (Figure 23) as well as the trend of isopachs of the upper Salado units in this area. By analogy to the similar tract at the WIPP site, we would argue that this area southeast of the WIPP site lacks halite mainly due to syndepositional processes while the Rustler was being deposited. For the most part, this area does not exhibit signs of thickness inflation related to dissolution of the underlying Salado, as in Nash Draw and southwest in the Big Sinks to Phantom Banks area.

The trends of Rustler halite margins (Figure 31) are diverted in an area from the northeast quarter of T.24S., R.31E., to near the center of T.23S., R.32E. (near Bootleg Ridge). The southwestern end of this trend is located near Engle's Well.

There is no known structure underlying this trend of Rustler halite margin that appears related. In this same location, the isopachs on the interval from the top of MB 103 to top of Salado (Figure 15) show similar but muted diversions from their trends in the area.

There are no cores from this location where Rustler halite margins are diverted from their broader trend, and the change in upper Salado thickness is small. We do not rule out post-Permian dissolution of halite in this area, but we discount it considerably based on our experience.

4.5 Summary of Evidence About Rustler Halite Distribution

There is good agreement between the differing methods used here to determine halite distribution in various members of the Rustler and the methods used earlier by Snyder (1985) for the same purpose. The methods used here are more likely to result in interpreting some halite where there may not be any; we believe Snyder's methods might miss halite where there is some. Both interpretations have limits, as indicated by the fact that the Forty-niner mudstone in WIPP 19 cores has halite not detected by either approach. Different investigators (e.g., Ferrall and Gibbons, 1979; Barrows et al., 1983) have attempted to use WIPP 19 as evidence of Rustler dissolution of various kinds..

We differ from Snyder's distribution in a few areas, especially in the unnamed lower member around the northwest corner of the site area. We distinguished two separate mudstone/halite units and separated the distributions of halite. Our lower unit (M-1/H-1) indicates halite much further west, near the western boundary of the WIPP site and part of Livingston Ridge. Our second unit (M-2/H-2) is distributed very much like higher units. Snyder (1985) mapped halite in the lower unnamed unit as a whole, and his distribution is similar to our distribution for M-1/H-1 in the western part of the site. In the northeast corner of T.22S., R.30E., we suggest that halite in M-1/H-1 may be present at the Livingston Ridge boundary. This extends over the zone of thinning of the upper Salado (Figure 15). We cannot further resolve this based on the available data, though this is an area where geophysical log interpretation may exaggerate the presence of halite.

How the Rustler halite distribution is or is not relatable to measured and inferred point values of hydrological parameters of the Culebra Dolomite Member will be examined in the final report of this series. Other factors, including those discussed in this document, will also be examined in that final report to try to provide a comprehensive picture of Rustler hydrogeology.

5.0 Loading and Unloading History of the Culebra

5.1 Background Information

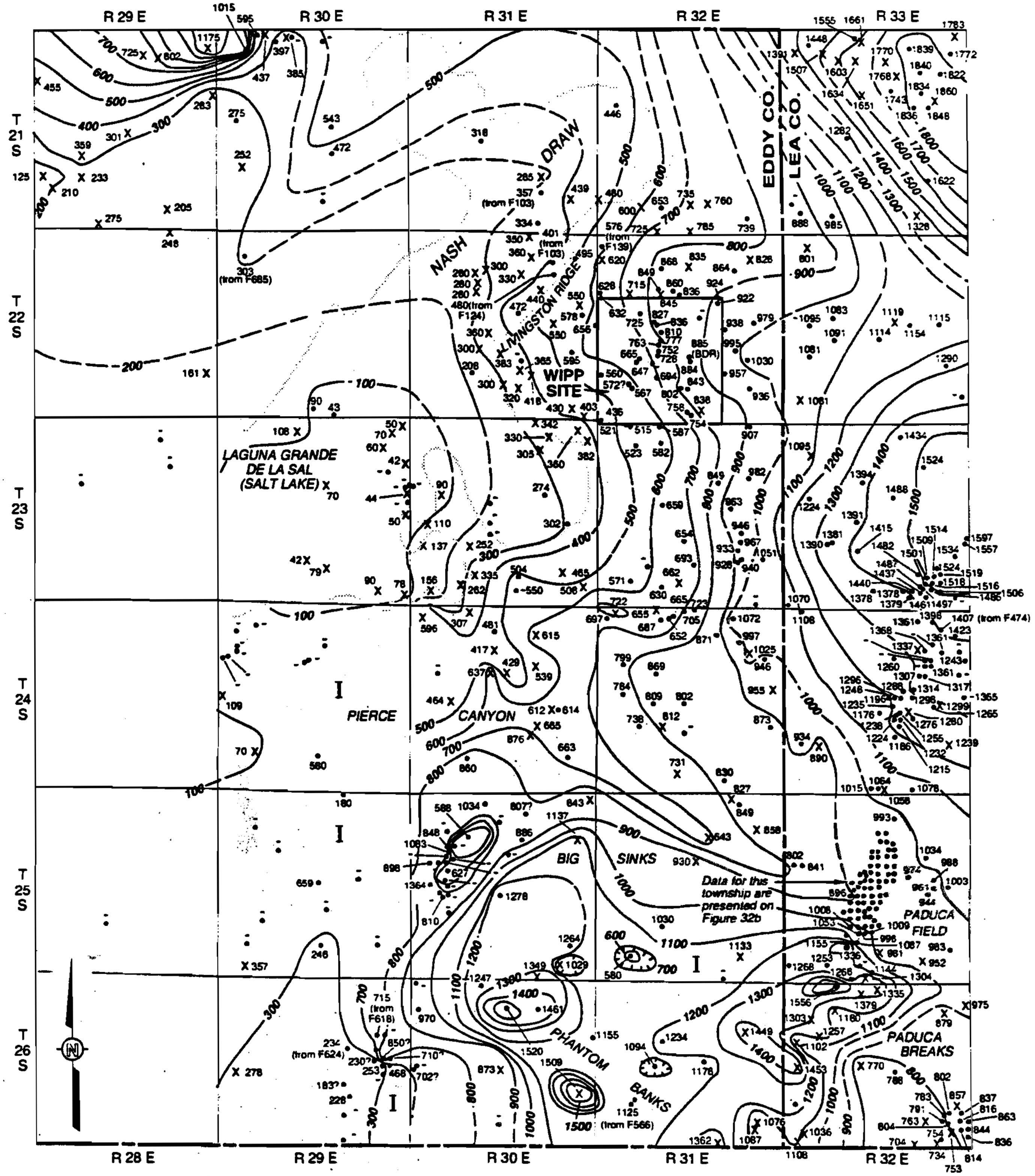
The last regional process being considered as an influence on the hydrology of the Culebra is loading and unloading during the geological history since deposition of the unit. Loading and unloading may have had considerable and variable effect on the fracture permeability of the unit through time. The highly variable present depth to the Culebra is an indicator of the modern effects of unloading. In addition, the history of loading and unloading of the Culebra at the vicinity of the WIPP site has been estimated to provide a guide to when permeability features may have developed. Differential loading and unloading of the unit are expected to create different fracturing systems, affecting the local to regional hydrogeologic characteristics of the Culebra. The sedimentary loading, depth of total burial, and erosion events combine in a complex history that we try here to reconstruct from regional geological trends and local data.

A similar, though simpler, loading history was constructed by Borns (1985, figure 10) to assist his interpretation of the features of MB 139 within the Salado Formation. His loading history is based mainly on stratigraphic history within Powers et al. (1978). We have re-examined the basic stratigraphic data and indicate alternatives we are unable to dismiss.

5.2 Present Depth to Base of Culebra

An additional form of an isopach map displays the depth, from the surface, to the base of the Culebra (Figure 32a-b). The map was created by plotting and contouring the log depth to the base of the Culebra from the log reference point, which is usually the Kelly bushing of the drilling rig. The map is not quite a true representation of depth, as the reference point may vary from ground surface to a point as much as approximately 20 ft (6 m) above ground surface. The trends will vary little if the data are corrected, but the reader should be aware of this difference.

In the site area, and to the south and southeast for approximately two townships, the depth contours are relatively uniformly spaced and trend from north to south to southeast to northwest. These reflect the general eastward dip on the Culebra in much of this area (see Holt and Powers, 1988, figure 4.17) combined with the general westward slope of the surface. The outline of the 600-ft contour of depth corresponds generally to the shape of the 3,500-ft elevation contour on the topographic surface (Figure 33). Relatively close spacing between



0 2 4 MILES

SCALE

I Area of incomplete contouring

• Represents Borehole and Data as Reported in Holt and Powers (1988) or interpreted from additional geophysical log data

x Represents Borehole and Data as Reported in Richey (1989)

Figure 32a
Depth to Base of Culebra

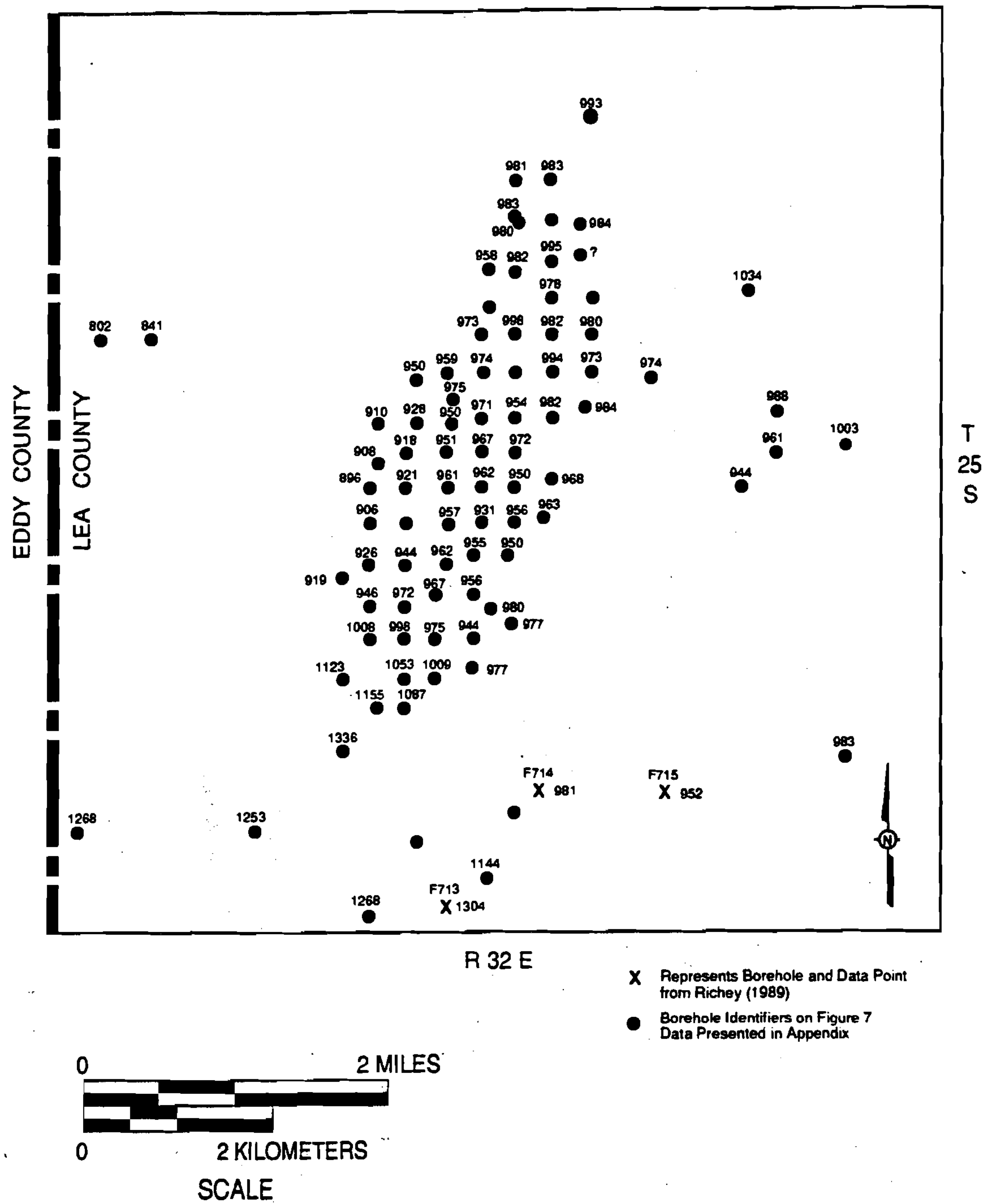


Figure 32b
Depth to Base of Culebra at Paduca Field

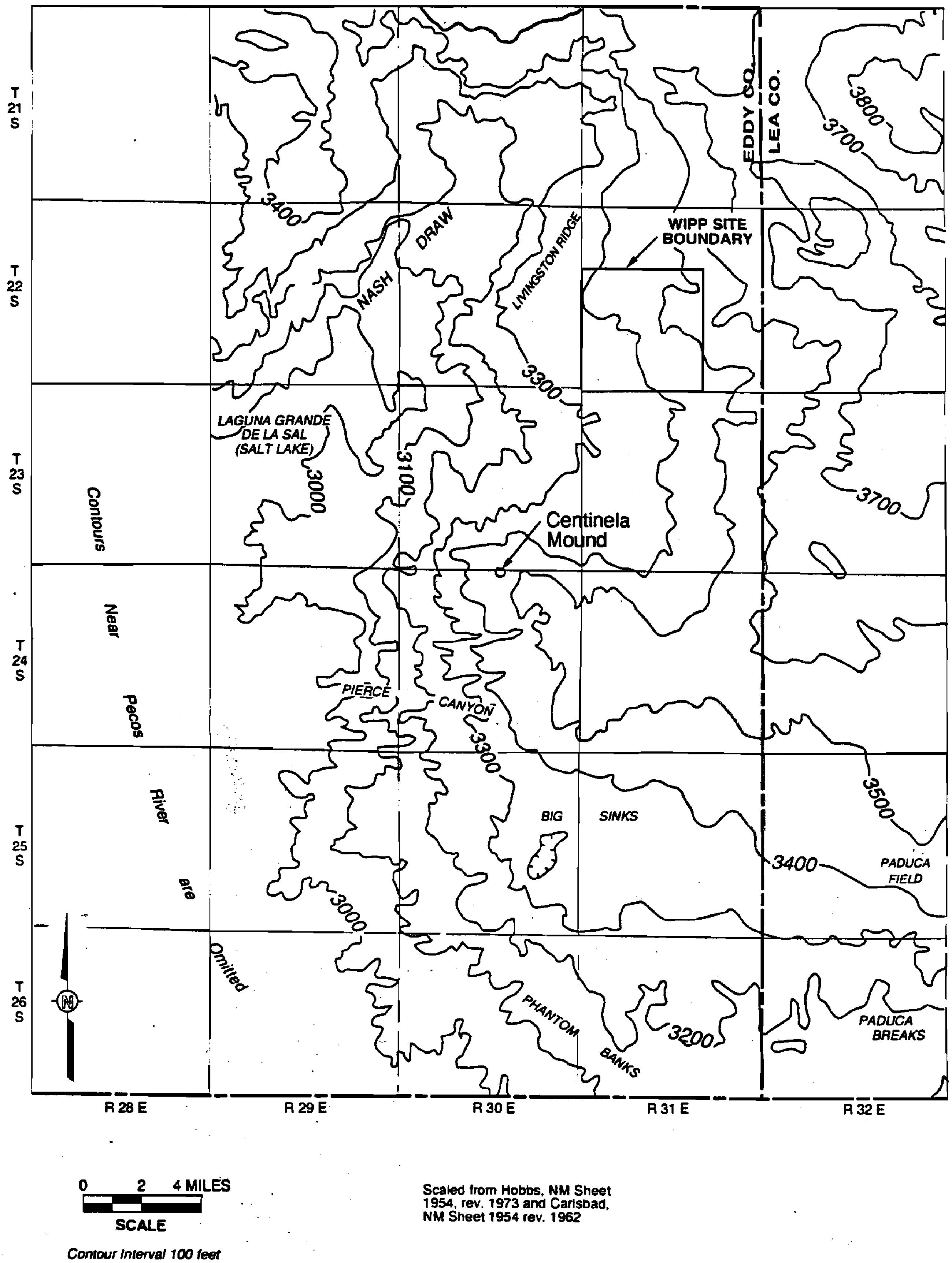


Figure 33
General Topography of the Study Area

700- and 800-ft depth contours and wide spacing between 800- and 900-ft depth contours at the WIPP site result from the increasing thickness of the Tamarisk Member of the Rustler Formation from west to east.

In T.24S., R.30-31E., the depth to the base of Culebra (Figure 32a) has been altered by structural and topographic changes. A topographic ridge trending from the northwest to the southeast from Centinela Mound through Twin Wells ranch area (central part of T.24S., R.31E.) causes a westward bulge in the 700- and 800-ft depth contours and a separation from the 900-ft depth contour. Slightly further west, the depth contours at 700- and 800-ft wrap around back to the northwest. These depth contours correspond to the Remuda Basin anticline (Figures 22 and 23). Lesser depths at the southeastern corner of the map area (Figure 32a) are the result of combined lower topography and northward dip on the Culebra into the Rustler depocenter. Very deep Culebra in the Phantom Banks area (T.26S., R.30E.) is apparently related to the Balmorhea-Loving trough (Maley and Huffington, 1953), salt dissolution, and extensive deposits of the Gatuña Formation (Powers and Holt, 1995).

5.3 History of Loading and Unloading of the Culebra

The loading and unloading history of the Culebra since deposition has been estimated as overburden based on inferences from various local and regional geological trends and data (Figure 33). The history is presented with several alternatives, depending on the inferences that are drawn, ranging from minimal to upper bound estimates. The estimates are made with a reference point and depth to the Culebra at the air intake shaft (AIS) (Holt and Powers, 1991).

The present depth to the Culebra from the top of the Dewey Lake at the AIS is 205 m (672 ft). The overlying Triassic rocks are 8-m (26-ft) thick at the AIS; together with the Dewey Lake, these sediments indicate a minimum of approximately 213 m (698 ft) of load on the Culebra. It is highly unlikely that the Culebra at the site has a history of rather constant loading of this 213-m (698-ft) thickness, with very little change since the Permian (Figure 33).

Given the maximum local thickness of the Dewey Lake, the maximum early load (end of Permian) was no more than approximately 240 m (787 ft). Approximately 35 m (115 ft) of Dewey Lake might then have been eroded during the early Triassic before additional sediments were deposited. The actual Triassic thickness at the AIS is approximately 8 m (26 ft). Northeast of the WIPP site (T.21S., R.33E.), Triassic rocks (Dockum Group) have a maximum local thickness of approximately 373 m (1,233 ft). This thickness is a reasonable estimate of the maximum thickness also attained at the WIPP site prior to the Jurassic Period. At the end of the Triassic, the total thickness at the WIPP site may have then attained approximately 586 m (1,863 ft) in two similar loading stages of a few million years each, over a period of approximately 50 million years.

The Jurassic outcrops nearest to the WIPP site are in the Malone Mountains of west Texas. There is no evidence that Jurassic rocks were deposited at or in the vicinity of the WIPP site. As a consequence, the Jurassic is considered a time of erosion or nondeposition at the site, though erosion is most likely. The Jurassic is not considered a time of major eustatic sea level changes (e.g. Vail et al., 1977), and a broad erosional plain apparently developed in this area without major relief. An arbitrary erosion rate averaging approximately 10 m/million years is sufficient to erode the inferred thickness of 365 m of additional Triassic rocks from the WIPP site. The Jurassic is the first possible period of significant unloading of the area at and west of the WIPP site.

This much erosion during the Jurassic obviously cannot be broadly inferred for the area or there would not be thick Triassic rocks still preserved. Triassic rocks of this thickness are preserved nearby, indicating either pre-Jurassic tilting or that erosion did not occur until later (but still after tilting to preserve the Triassic rocks near the WIPP site). It is also possible that the immediate site area had little Triassic deposition or erosion, but very limited Triassic deposition (i.e., 8 m [26 ft]) at the WIPP site seems unlikely.

Lang (1947) reported fossils from Lower Cretaceous rocks in the Black River Valley southwest of the WIPP site. Bachman (e.g., 1980) also reported similar patches of probable Cretaceous rocks near Carlsbad and south of Whites City. From these reports, it is likely that some Cretaceous rocks were deposited at or in the vicinity of the WIPP site. Approximately 70 mi (approximately 110 km) south southwest of the WIPP site, significant Cretaceous outcrops of both early and late Cretaceous age have a total maximum thickness of approximately 300 m (about 1,000 ft). Southeast of the WIPP, the nearest Cretaceous outcrops are thinner and represent only the lower Cretaceous. North of the WIPP site, Cretaceous outcrops in the Sierra Blanca (New Mexico) area are thick. Based on these reported outcrops, a maximum thickness of 300 m (1,000 ft) of Cretaceous rocks could be estimated for the WIPP site. Compared to the estimate of Triassic rock thickness, it is less likely that Cretaceous rocks were this thick at the site.

The uppermost lines of Figure 34 summarize the assumptions of maximum thickness of these units.

A more likely alternative is that virtually no Cretaceous rocks were deposited, followed by erosion of remaining Triassic rocks during the late Cretaceous to the late Cenozoic. Such erosion may also have taken place over an even longer period, beginning with the Jurassic Period. Ewing (1993) favors Early Cretaceous uplift and erosion for the Trans-Pecos Texas area, but he does not analyze later uplift and erosional patterns.

In the general vicinity of the WIPP site, there are outcrops of Cenozoic rock from the late Miocene (Gatuña and Ogallala Formations). Early Cenozoic (probable Paleocene) rocks in the Capitan Mountains region (west of Roswell, New Mexico) are the closest outcrops of the earliest Cenozoic. Cenozoic volcanics and interbedded sediments crop out south of the site in areas such as the Davis Mountains, and bolson fill of later Cenozoic age is common. There is little reason to infer any significant early Cenozoic sediment accumulation at the WIPP site, and we do not. Erosion is the main process inferred to have occurred during this period. Toward the end of the Cenozoic, more relief may have developed. The Cenozoic-age Gatuña is treated in more detail in Powers and Holt (1993, 1995). Maximum known Gatuña in the area around the WIPP is approximately 100 m (328 ft); at the WIPP site the Gatuña is very thin to absent.

An average erosion rate of approximately 11 m/million years is sufficient during the Cenozoic to erode the maximum inferred Triassic and Cretaceous thickness prior to Gatuña and Ogallala deposition. We do not believe that significant thicknesses of Cretaceous rocks were deposited, however, and average erosion rates could have been small.

Ogallala deposits are known from The Divide east of the WIPP site, as well as from the High Plains further east and north. On the High Plains northeast of the WIPP, the upper Ogallala surface slopes to the southeast at a rate of approximately 4 m/km (approximately 20 ft/mi). A straight projection of the 4,100-ft contour line from this High Plains surface intersects the site area, which is at an elevation slightly above 3,400 ft (1,036 ft). This difference of 700 ft (213 m) in elevation represents one estimate, probably near an upper bound, of possible unloading subsequent to deposition of the Ogallala Formation. Similar straight line projections of the 3,900- and 3,800-ft contour lines from the High Plains to The Divide would suggest the divide area has been lowered by 100 to 200 ft (30 to 61 m). Alternative

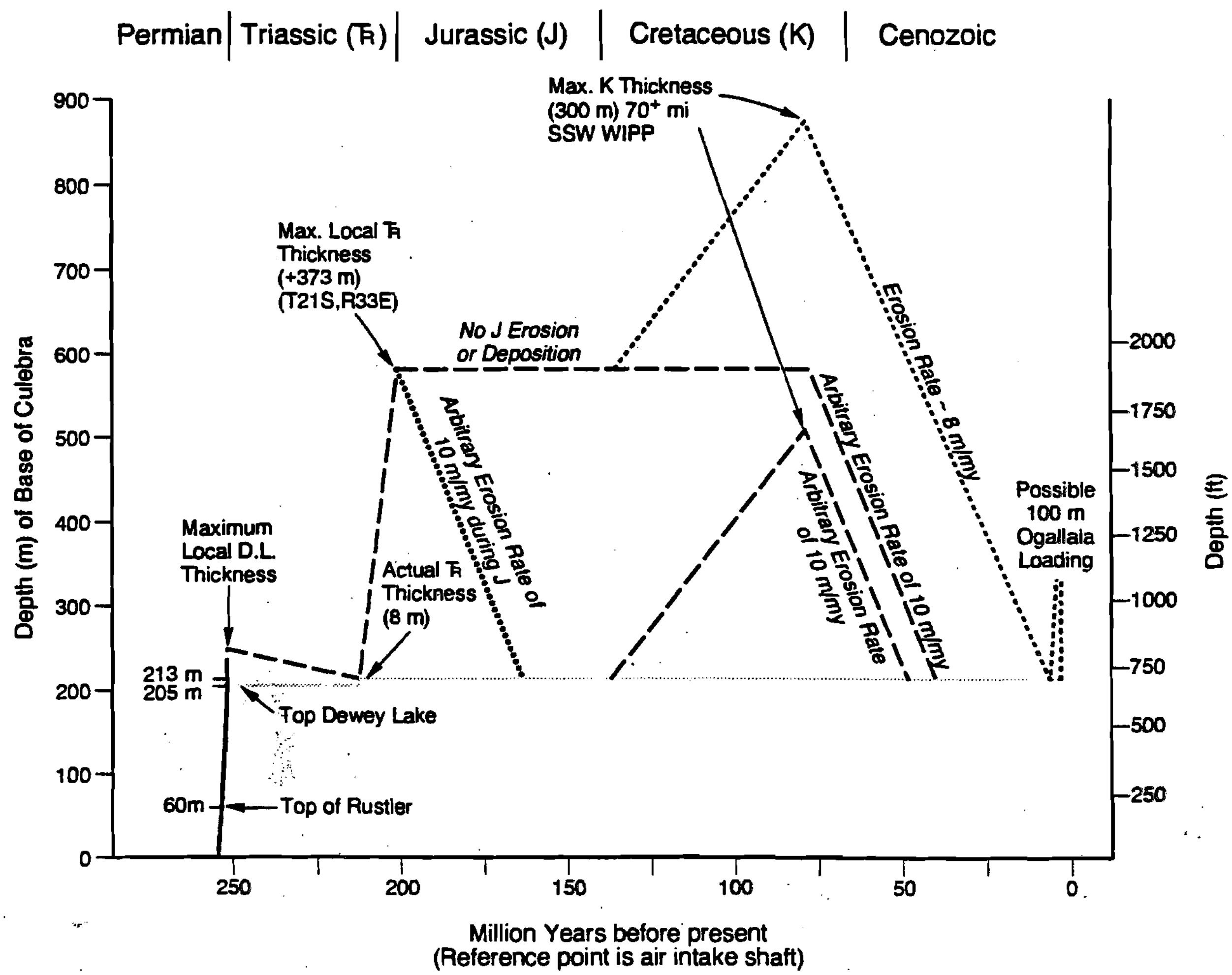


Figure 34
Loading and Unloading History Estimated for Base of Culebra

explanations could include halite dissolution, since the Ogallala was deposited or that the High Plains surface did not extend so uniformly to The Divide.

The Ogallala at The Divide may be at the same relative elevation as when it was deposited. Salado units do not indicate salt dissolution totalling 100 to 200 ft (30 to 61 m) at this location. The Rustler units are equivocal, with the total Rustler isopach (Holt and Powers, 1988) indicating the area of The Divide as being approximately 100 ft (30 m) thinner than the maximum at the depocenter. Other isopachs indicate part of this could be attributed to each of the unnamed lower member, the Tamarisk Member, and the Forty-niner Member of the Rustler Formation. The Dewey Lake indicates a possible slight thickening of about the same magnitude. The Triassic rocks appear not to show any general thickness changes at this locality, although one borehole was interpreted to have a thinner Triassic section. Taken as a whole, these features suggest the section under The Divide does not indicate any post-Ogallala dissolution and lowering of the surface rocks. The Divide can reasonably be inferred to not have changed elevation relative to other Ogallala deposits since the end of the Ogallala. On this basis, the High Plains surface could be inferred to swing more to the west through The Divide and the site area at an elevation of approximately 3,800 ft (1,158 m). The difference between this inferred Ogallala slope and the present elevation at the WIPP site is approximately 400 ft (122 m) or less. The loading and unloading of the Ogallala could have been approximately 100 m (30 m) and would have occurred as a short-lived pulse over a few million years at most.

While the above inferences about greater unit thicknesses and probable occurrence are permissible, a realistic assessment suggests a more modest loading and unloading history.

It is likely the Dewey Lake accumulated to near local maximum thickness of approximately 240 m (787 ft) before being slightly eroded prior to the Triassic rocks being deposited. It also is most probable that the Triassic rocks accumulated at the site to near local maximum thickness. In two similar cycles of rapid loading, the Culebra was buried to a depth of approximately 650 m (2,132 ft) by the end of the Triassic.

It also seems unlikely that a significant thickness of Cretaceous rock accumulated at the WIPP site. Erosion probably began during the Jurassic, slowed or stopped during the early Cretaceous as the area was nearer or at base level, and then accelerated during the Cenozoic, especially in response to uplift as Basin and Range tectonics encroached on the area and the basin was tilted more. Erosional bevelling of Dewey Lake and Santa Rosa (Chapter 3.0) suggest considerable erosion since tilting in the mid-Cenozoic. Erosion rates for this shorter period could have been relatively high, resulting in the greatest stress relief on the Culebra and surrounding units. Some filling occurred during the late Cenozoic as the uplifted areas to the west formed an apron of Ogallala sediment across much of the area, but it is not clear how much Gatuña or Ogallala was deposited in the site area. From our general reconstruction of Gatuña history in the area (Powers and Holt, 1995), we infer that Gatuña or Ogallala deposits likely were not much thicker at the WIPP site than they are now. The loading and unloading "spike" (Figure 34) representing Ogallala thickness probably did not occur. Cutting and headward erosion by the Pecos River has created local relief and unloading by erosion.

At the WIPP site, this history is little complicated by dissolution, though locally (e.g., Nash Draw) the effects of erosion and dissolution are more significant. The underlying evaporites have responded to foundering of anhydrite in less dense halite beds. These have caused local uplift (as at ERDA 6) but little change in the overburden at the WIPP. Areas east of the WIPP site are likely to have a similar history to the site. West of the site, the final unloading is more complicated by dissolution and additional erosion leading to exposure of the Culebra along stretches of the Pecos River Valley.

5.4 Other Inferences About Loading and Unloading History

The burial depth around the WIPP site can also be estimated on the basis of hydrocarbon generation and temperature gradients. Hills (1984) takes the temperature of 149°F (65°C) as the temperature to form oil and 257°F (125°C) as the "oil floor" or temperature of gas formation. The Bell Canyon Formation is an exploration target, yielding oil in some fields. A minimum temperature of 149°F may be used to estimate burial. At AEC 8, the upper Bell Canyon at a depth of 4,343 ft (1,324 m) has a temperature of approximately 90°F (32°C) (Mansure and Reiter, 1977). Hills estimates the thermal gradient below 6,500 ft as 1.54°F/100 ft. The 59°F difference between present temperature and the temperature to generate oil could be accounted for by increasing the overburden by approximately 3,800 ft (59°F/[1.54°F/100 ft]), or nearly 1,200 m. This estimate is approximately 1,000 to 1,150 ft (300 to 350 m) more than the maximum thickness estimated here from regional geological relationships. The estimate of 1,200 m would be 800 m more overburden than we consider more likely based on local thickness of Triassic rocks. Recent drilling prospects around the WIPP site have projected oil at greater depths than the Bell Canyon, suggesting this estimate may exaggerate burial depth because the "oil floor" may be deeper.

Barker and Pawlewicz (1993) measured vitrinite reflectance from drill cuttings in the Delaware Basin. They interpret higher thermal maturation gradients and higher (stratigraphically) positions of key vitrinite reflectance values in the western Delaware Basin as evidence of higher paleogeothermal gradients caused by igneous intrusions and Basin and Range development. We are not aware of comparable data from the WIPP area, which is approximately 8 mi (12.8 km) southeast of a mid-Cenozoic dike at its closest approach.

5.5 Summary of Loading and Unloading History

The Culebra loading and unloading history could be fairly complex, but the more likely history is relatively simple. Two main pulses of loading are apparent, the first ending Permian deposition and the second during the Triassic. Some unloading through erosion probably occurred during the Jurassic through the early Cenozoic. The major unloading through erosion likely is associated with regional tilting, which is generally placed at approximately mid-Cenozoic. Arbitrary erosion rates in the range of approximately 10 m/million years (about 33 ft/million years) may have been exceeded if most of the overburden survived until mid-Cenozoic or later and was then eroded. Within the WIPP site there are some variations in unloading reflecting in differing depths. Nash Draw, with combined erosion and dissolution, is much more complicated, and the loading/unloading history may be insignificant compared to the disruption due to both dissolution/subsidence and erosion.

Hydrocarbon maturation data are roughly consistent with geological inferences about overburden, but both methods have considerable room for uncertainty. Hydrocarbon data suggest greater overburden. Geological data are better able to distinguish various episodes and place them in geological history.

6.0 Conclusions

Following deposition of the Rustler, the formation in the area of the WIPP site has been affected by tectonic events, dissolution, and erosion leading to unloading. Each of these processes has contributed to the evolution of the current hydrological properties of the Culebra Dolomite Member. They have been individually analyzed to identify their general magnitude and history preliminary to relating processes more directly to the hydrology of the Culebra in another report in preparation.

The upper Salado is relatively uniform in thickness from the WIPP site to the southeast. South and west of the WIPP, beds of the upper Salado abruptly thin across a horizontal distance of 2 or 3 mi (approximately 3 to 5 km). We attribute the thinning mainly to subsurface dissolution of halite in the upper Salado. Rustler units have subsided in this area relative to areas to the east. Livingston Ridge, the eastern margin of Nash Draw, is closely associated with this zone of thinning, as is the southeastern extension of Nash Draw. Erosion thus reflects the dissolution of the upper Salado around Nash Draw. Several Nash Draw drillholes fall on or near this zone of thinning, and it is an important contributor to developing hydrologic characteristics of the Rustler as well.

The Culebra has been structurally deformed by tectonic events as well as dissolution of underlying rocks. The regional attitude of beds underlying evaporites is an approximate north-south strike with east dip approximating 1°. Northeast of the WIPP, evaporites in the Castile Formation deformed, arching the Culebra in the same area (the ERDA 6 anticline). South of the WIPP, the regional dip combined with dissolution of the Salado to the south, forming the Remuda Basin anticline. More subtle indicators of structural changes of the Culebra at the WIPP site are attributed to tectonics, because there has not been sufficient salt dissolution to account for the apparent changes.

There is general agreement about the distribution of halite in the Rustler in the WIPP site area. We extended map margins of halite in various members through a larger area and separated the unit immediately under the Culebra (M-2/H-2) from the remainder of the unnamed lower member (M-1/H-1). The potential for sub-Culebra halite dissolution at the WIPP site is limited, because M-1/H-1 has salt throughout much of the site and because the thickness change in M-2/H-2 is 20 to 25 ft (approximately 6 to 7 m). Nonetheless, we believe, based on extensive work mapping in the shafts, describing cores, and interpreting geophysical logs, that little, if any, halite has been dissolved from the Rustler at the WIPP site since deposition. We attribute most of the lateral differences to depositional facies changes in a halite pan to mudflat environment. Relationships between thickness differences and other parameters will be compared in a further work in preparation.

The Culebra has been subjected to loading by sedimentation and unloading due to erosion since being deposited. It is most likely that the Triassic rocks were deposited at the site about as thick as in adjacent areas and that little more sediment was added afterwards. Exposure and erosion predominated from the end of the Triassic until late Cenozoic; there are thick Cretaceous deposits in the region, but remnants are scarce in the general area around WIPP. Wedge-like margins to the Dewey Lake and Santa Rosa suggest that erosion postdated regional tilting about mid-Cenozoic. The time from tilting to the beginning of Gatuña and Ogallala is likely to have been the most intense period of unloading at the WIPP site.

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APPENDIX A

DATA FOR DRILLHOLES IN HOLT AND POWERS (1988) PLUS ADDITIONAL DRILLHOLES INTERPRETED BY POWERS

APPENDIX A
DATA FOR DRILLHOLES IN HOLT AND POWERS (1988) PLUS ADDITIONAL DRILLHOLES INTERPRETED BY POWERS

This appendix includes the drillhole data from an appendix in Holt and Powers (1988) as well as some additional boreholes more recently interpreted by Powers for eventual use in interpreting Rustler geology.

A location table (Appendix A-1) lists basic identification and location data for the boreholes. A uniform (in format) and a unique numerical identifier (ID #) has been assigned to each borehole for ease in manipulation. Another identifier (Hole ID) was used in Holt and Powers (1988), based on the system used by Borns and Shaffer (1985). That system did not produce unique identifiers and is not as easily manipulated during database management. It is included here (column 2) in order to refer back to these earlier references. Standard township, range, section, and distance (in feet) from section boundaries are included, as they are the common means of locating these drillholes. A drillhole name has been included based generally on an entry on one or more geophysical logs. *These drillhole names may differ slightly from source to source.* Some common words have been abbreviated to shorten the borehole name. A last column includes any revisions or notes that may be helpful to the reader.

The remainder of the appendix presents tables of depth data for relevant stratigraphic units: Salado—Appendix A-2, Rustler—Appendix A-3, Dewey Lake and Santa Rosa—Appendix A-4. Drillhole sources are referenced by ID # to Appendix A-1. The reference elevation is the point from which depth was measured, and it was frequently the Kelly bushing (KB) of the drill rig. A correction (KB) to surface elevation is given where it is known, but some geophysical logs did not include this number. For most uses in this report, the KB correction is unnecessary.

The basic data from Holt and Powers (1988) were prepared under quality assurance procedures and check provided by IT Corporation. The additional drillholes added to this data set were prepared under similar procedures. Some typographical errors have been corrected, as noted, from the Holt and Powers data set. One borehole was reinterpreted, as noted in other appendices.

APPENDIX A-1
LOCATIONS FOR RUSTLER FORMATION DATA POINTS

Rustler Formation Location Data

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name**	Revisions
1001	W04	18	29	4	1980n	1980w	Roach Drilling, Western Development Miller No. 1	
1002	T19	18	29	19	660s	1980e	Martin Yates III and S.P. Yates, Travis Fed. 2	
1003	L18	18	30	18	1650n	924w	Newmont Oil Co., Loco Hills 21-B-6	
1004	C25	18	30	25	990n	330e	Yates Petroleum Corp., Creek "AL" #1	
1005	G26	18	30	26	990s	330e	Hanson Oil Corp., Ginsberg Fed. No. 11	
1006	M27	18	30	27	990n	1651w	Texaco, Inc., L.R. Manning "B" NCT-1 Well #20	
1007	R28	18	30	28	330s	1491e	Texaco, Inc., L.R. Manning Fed. "B" (NCT_1) #4	
1008	MO2	18	31	2	330s	660w	W.S. Montgomery, Magnolia St. #1	
1009	S11	18	31	11	660s	660w	Hudson & Hudson Inc., Shugart B-1	
1010	M16	18	31	16	660s	1980e	M.R. Voltz, Magnolia St. #2	
1011	F22	18	31	22	660s	660w	Gulf Oil Corp., Fed. Littlefield #1	
1012	F28	18	31	28	1980n	660w	Gulf Oil Corp., Fed. Keohane et al "B" No. 1	
1013	K28	18	31	28	1980n	1980w	Gulf Oil Corp., Fed.-Keohane et al "B" #3	
1014	C31	18	31	31	1980n	1980e	Campana Petroleum Co., Pure Fed. #1	
1015	H31	18	31	31	330n	844w	Ray M. Hall, Pure-Fed. #1	
1016	M32	18	31	32	1980n	1980w	Chambers and Kennedy, Monterey St. #4	
1017	S32	18	31	32	1650n	2310e	Sunray Mid-Continent Oil Co., St. "Y" #1	
1018	P32	18	31	32	330n	330w	L.T. Pate, Monterrey St. #5	
1019	W33	18	31	33	330n	330w	V.S. Welch [indet] No. 2, Shugart No. 5-B	
1020	J04	18	32	4	1650n	990e	B.M. Jackson, Fed. No. 2	
1021	G16	18	32	16	1980n	1980w	Gulf Oil Corp., Lea St. "HS" #3	
1022	J20	18	32	20	2310s	990w	John M. Beard, Young Fed. #5	
1023	C28	18	32	28	1980n	660w	Texaco, Inc., Cotton Draw Unit No. 53	
1024	C10	18	33	10	1980n	660e	Carper Drilling Co., Corbin R #1	
1025	B12	18	33	12	660n	1980e	P.W. Miller Drilg. & Prod. Co., Brit. Am. St. #2	
1026	D13	18	33	13	1650s	2310w	J.I. O'Neill, Jr., Dorothy Swigart #1	
1027	S28	18	33	28	1980s	660e	Sunray Mid-Continent Oil Co., Fed. "E" #1	Rev loc ctr, NE1/4, SE1/4
1028	H30	18	33	30	1980s	1980w	Penzoil United Inc., Hudson "29" Fed. #3	
1029	N01	18	34	1	560n	760w	Texaco, Inc., St. of New Mexico "M" #5	
1030	L06	18	34	6	989n	330w	Phillips Petroleum Co., Lea No. 17	
1031	B07	18	34	7	660s	660e	Richardson & Bass, St. of New Mexico #1	
1032	S22	18	34	22	1980s	1980w	Continental Oil Co., St. V-22 #2	
1033	T22	18	34	22	330s	1980w	Continental Oil Co., St. V-22 #1	
1034	M33	18	34	33	330s	1980w	Tom Brown Drilling Co., Marathon St. #1	
1035	F03	18	35	3	2310s	330e	Phillips Petroleum Co., Santa Fe No. 114	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1036	V04	18	35	4	1980n	660w	Standard Oil Co. of Texas, Vac Edge Unit #2	
1037	F05	18	35	5	1650n	990e	Phillips Petroleum Co., Santa Fe No. 111	
1038	S05	18	35	5	1650n	2285e	Phillips Petroleum Co., Santa Fe No. 93	
1039	V05	18	35	5	990s	990e	Standard Oil Co. of Texas, Vac Edge Unit #19	
1040	W06	18	35	6	330s	913w	The Ohio Oil Co., St. Waren Account 2 #9	
1041	A07	18	35	7	330n	990e	Tidewater Oil Co., St. AN #1	
1042	C29	18	35	29	1980n	660w	Carper Drilling Co., Carper-Luthy No. 1	
1043	C01	18	36	1	1980s	1980e	Cactus Drilling Corp., Catron "B" No. 2	
1044	P11	18	36	11	1980s	1980w	John M. Kelly, St. PE #1	
1045	K11	18	36	11	660s	660e	John M. Kelly, St. J.J. #1	
1046	C12	18	36	12	660n	1980w	Cactus Drilling Co., Amerada St. #1	
1047	A14	18	37	14	1650s	2310w	Amerada Petroleum Corp., St. W.H. "B" #2	
1048	W31	18	37	31	1980n	660w	Amerada Petroleum Corp., St. WM "E" #3	
1049	A03	18	38	3	1980s	1980e	O.D. Alsabrook, Saunders #1	
1050	M19	18	38	19	2310s	1650e	Shell Oil Co., Shell et al McKinley A-19 #1	
1051	N06	19	29	6	1980s	1765w	Shamrock Drilling Co., Nix & Curtis #1	
1052	S21	19	29	21	2015n	1880e	Wayne J. Spears, Stout St. #1	
1053	U26	19	29	26	660n	660w	Wayne J. Spears, Union St. #1	Rev loc NW1/4, NW1/4
1054	P05	19	30	5	1980n	330w	Yates Petroleum Corp., Perkins "AD" #3	
1055	U06	19	31	6	330n	1650w	Texaco, Inc., USA Fed. #1	
1056	S13	19	31	13	660s	1980e	Phillips Petroleum Co., Simon "A" No. 1	
1057	S14	19	31	14	660s	660e	Phillips Petroleum Corp., Simon "A" #2	
1058	T21	19	31	21	1980s	660e	Texas Crude Oil Co., Tennessee-Fed. #1-21	
1059	E29	19	32	29	1980n	660e	El Paso Natural Gas Co., Southern Cal. Fed. #1	
1060	C12	19	34	12	660n	660w	Carper Drilling Co., U.S. Smelting St. #1	
1061	A14	19	35	14	660s	660w	Atlantic Refining Co., St. AU #1	
1062	S27	19	35	27	1980n	660e	Shell Oil Co., Allen ESt. A #1	
1063	C28	19	35	28	1980s	660w	Cabot Carbon Co., St. G #1	
1064	L33	19	35	33	1980n	660e	Gulf Oil Corp., Lea St. BG #8	
1065	P01	19	36	1	1980n	330e	Pan American Petroleum Corp., St. "B" #1	
1066	H11	19	36	11	660s	1980w	Humble Oil and Refining Co., New Mex. St. "AO" #1	
1067	S18	19	36	18	1980n	1980w	Tom Brown Drilling Co., Sunray-Bryan #1	
1068	A25	19	36	25	660n	1980w	Amerada Petroleum Corp., St. "T" No. 4	Rev loc NE1/4, NW1/4
1069	A32	19	37	32	1980s	1980e	Amerada Petroleum Corp., May Love Unit #1	
1070	F21	20	30	21			Amoco Prod., Fed. Gas Com No. 1-G	Log lacks loc data

ID No.	Hole ID	T.	R.	Sec	fn,sl	fe,wl	Drillhole Name	Revisions
		Location Data*						
1071	L31	20	30	31	1980n	760e	Texas International Petrol. Corp., Lowe Fed. #1	
1072	B07	20	31	7	1650s	660e	Pan American Petroleum Corp., Big Eddy Unit #11	
1073	B21	20	31	21	660n	660w	Pennzoil United, Big Eddy Unit No. 12	
1074	F10	20	32	10	330n	990w	Shell Oil Co., Perry Fed. #1	
1075	H13	20	32	13	660s	1980w	Flag-Redfern Oil Co., Hanson St. #1	
1076	P15	20	32	15	1980s	1980w	Phillips Petroleum Co., Plata Deep Unit #1	
1077	L05	20	33	5	660s	1980w	Pan American Petroleum Corp., Little Eddy Unit #1	
1078	S14	20	33	14	2310s	990w	Carl Engwall, Sinclair Fed. #1	
1079	B18	20	33	18	660n	2080w	Randall F. Montgomery, Bass St. #1	
1080	S18	20	33	18	1650n	1650w	Randall F. Montgomery, Bass St. #2	
1081	F27	20	33	27	1980n	1650e	Amoco Prod. Co., API #30-025-26241, Fed."Y" Com #1	
1082	L13	20	34	13	1980s	1980e	Marathon Oil Co., Lea Unit #3	
1083	H20	20	34	20	2310n	1650w	Burk Royalty, Hanson Fed. B #2	
1084	F29	20	34	29	1980s	330e	Earl G. Colton, Fed. #1	
1085	B28	20	35	28	660n	660e	W.H. Black, Phillips St. No. 1	
1086	S02	20	36	2	660n	1980e	The Superior Oil Co., St. "A" No. 2	
1087	U30	20	36	30	660n	660w	Union Oil Co. of California, Sims St. 1-30	
1088	H01	20	37	1	990n	1650w	Humble Oil and Refining Co., N.M. St. "AG" No. 6	
1089	W27	20	38	27	660s	660w	Continental Oil Co., Warren Unit "BT" No. 26	
1090	P03	21	29	3	1980n	1980w	Pan American Petroleum Corp., Big Eddy Unit #18	
1091	N04	21	29	4	4620s	1980w	Union Oil Co. of California, Cowden Fed. #1	
1092	P05	21	29	5	1980n	660e	Meadco Properties, Ltd., Harris-Bell #1	
1093	M05	21	29	5	980n	1880w	Meadco Properties Ltd., Harris Bell #2	
1094	M06	21	29	6	3147n	660e	Meadco Properties Ltd., Harris "6" #1	
1095	B15	21	29	15	1980s	1980w	Perry R. Bass, Big Eddy Unit #61	
1096	P18	21	29	18	1980s	1980e	Pan American Petroleum Corp., Big Eddy Unit #16	
1097	B22	21	29	22	1980n	1980e	Perry R. Bass, Big Eddy Unit No. 40	
1098	E34	21	29	34	660n	1980w	Bass Enterprises Prod. Co., Big Eddy Unit No. 38	
1099	D21	21	30	21	90n	1485w	WIPP 27	
1100	P26	21	30	26	660s	1980w	Phillips Petroleum Co., James "D" 1	
1101	P35	21	30	35	1980s	660w	Phillips Petroleum Co., James "C" #1	
1102	D18	21	31	18	99n	2401e	WIPP 28	
1103	D33	21	31	33	668n	177w	WIPP 30	Ref El from SAND79-0284
1104	Q35	21	31	35	2152s	910e	ERDA 6	
1105	E01	21	32	1	3255n	1972e	Phillips Petroleum Co., ETZ Fed. #1	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1106	F01	21	32	1	660s	1980w	Kimball Production Co., Fed. #1	
1107	H02	21	32	2	660s	1980e	Phillips Petroleum Co., Hat Mesa "A" #1	
1108	P02	21	32	2	3300n	660w	Amini Oil Co., Pubco Fed. #1	
1109	N04	21	32	4	1683n	1650w	Amini Oil Co., New Mexico Fed. #1	
1110	S06	21	32	6	2189n	500e	Holly Energy, Inc., Salt Lake Deep No. 1	
1111	G10	21	32	10	1980n	1980e	The Superior Oil Co., Government "H" Com. #1	
1112	F11	21	32	11	660s	660e	Gackle Drilling Co., Fed. #1	Rev loc SE1/4, SE1/4
1113	H11	21	32	11	660s	1980w	Phillips Petroleum Co., Hat Mesa 2-#2	
1114	M11	21	32	11	1980n	1980e	Phillips Petroleum Co., Hat Mesa #1	
1115	S21	21	32	21	660n	660w	Skelly Oil Co., Salt Lake South Unit #1	
1116	G26	21	32	26	1980n	660e	Gulf Oil Corp., San Simon #1	
1117	H31	21	32	31	660n	1980w	Gulf Oil Corp., H.T. Mattern (NCT) #10	
1118	U31	21	32	31	2040n	2040e	Union Carbide Corp., AEC #7; also Fenix & Scisson, AEC #7	
1119	G32	21	32	32	1980n	1980e	Getty Oil Co., Getty "32" St. Com #1	
1120	S02	21	33	2	2310s	2310w	Charles Read, Sinclair St. #1	
1121	W01	21	35	1	660n	660e	Amerada Petroleum Corp., St. WE "F" #3	Surf El from log
1122	N04	21	35	4	1902n	660w	British American Oil Prod. Co., N.M. St. "F" #1	
1123	C16	21	35	16	660s	660e	Cosden Petroleum Co., Cosden Petr. St. D #1	
1124	R32	21	35	32	1650n	660e	Resler & Sheldon, Phillips "C" No. 2	
1125	C17	21	36	17	990n	1650w	Atlantic Refining Co., Coleman #1	
1126	A21	21	36	21	660s	1980w	Gulf Oil Corp., Arnott Ramsey "C" No. 5	Rev loc SE1/4, SW1/4; log elev
1127	H26	21	36	26	1980n	1980w	Humble Oil & Refining Co., N.M. St. "G" #14	
1128	A27	21	36	27	1980s	1980e	Gulf Oil Corp., Arnott Ramsey "C" No. 5; ?DUP 1126***	Rev loc SE1/4, SW1/4
1129	G27	21	36	27	650n	1980e	Gulf Oil Corp., W.A. Ramsey NCT A #42	
1130	R27	21	36	27	1980s	510e	Gulf Oil Corp., W.A. Ramsey (N.C.T.A.) #39	
1131	L31	21	36	31	1980n	1980e	Late Oil Co., Rector A #1	
1132	A33	21	36	33	1980s	1980e	Gulf Oil Corp., Arnett Ramsey NCT-D #12	
1133	R34	21	36	34	1980n	660w	Gulf Oil Corp., W.A. Ramsey NCT #38	
1134	C28	21	37	28	2085s	765e	Gulf Oil Corp., J.N. Carson (NCT) C#9	
1135	M31	21	37	31	1980n	660w	Gulf Oil Corp., N.T. Mattern (NCT) No. B-12	B#10 or B#12?, log unclear
1136	E06	22	29	6	660s	660e	William A. and Edward R. Hudson, Eddy Fed. #1	
1137	D33	22	29	33	1673s	29e	WIPP 32	
1138	D34	22	29	34	407s	1828e	WIPP 29	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1139	T01	22	30	1	990s	1980w	Troporo Oil and Gas Co., Cabana #1	
1140	M02	22	30	2	665s	2006e	Phillips Petroleum Co., James "A" #1	
1141	D11	22	30	11	1980n	1980e	Phillips Petroleum Co., James "E" #1	
1142	D13	22	30	13	1762s	2427w	WIPP 33	
1143	D15	22	30	15	1853s	2838e	WIPP 25	
1144	P24	22	30	24	312s	613w	P-14	Rev loc, elev from SAND79-0279
1145	O24	22	30	24	167n	195e	P-12	
1146	B27	22	30	27	660n	2003e	Richardson & Bass, Fed. Legg #1	
1147	D29	22	30	29	2232n	12e	WIPP 26	
1148	C06	22	31	6	1980n	660w	B. McKnight et al, Campana No. 1	
1149	Z08	22	31	8	698s	122e	Fenix & Scissons Inc., WIPP No. DOE-2	
1150	D09	22	31	9	712n	294w	WIPP 11	
1151	W09	22	31	9	202s	2000w	WIPP 34	
1152	I09	22	31	9	99s	2112e	WIPP 14	
1153	A11	22	31	11	935n	1979w	AEC 8	Ref elev typo revised
1154	P14	22	31	14	794s	103e	P-20	
1155	H15	22	31	15	1007n	134e	Fenix & Scisson, WIPP HYDRO H-5c	
1156	P15	22	31	15	852n	150e	P-21	
1157	B15	22	31	15	1980s	1980w	Clayton W. Williams Jr., Badger Unit Fed. No. 1	
1158	D17	22	31	17	2564s	1727w	Fenix & Scisson, WIPP #13	
1159	W17	22	31	17	175s	84e	Fenix & Scisson, Inc., WIPP No. 12	
1160	P17	22	31	17	202s	165e	P-5	
1161	P18	22	31	18	125n	116w	P-13	
1162	H18	22	31	18	281n	375w	Fenix and Scisson, Inc., WIPP H-6c	
1163	P20	22	31	20	103s	3122e	P-3	
1164	S20	22	31	20	4306s	50e	Fenix & Scisson, Inc., WIPP #18	
1165	W20	22	31	20	2547s	50e	Fenix & Scisson, Inc., WIPP #22	
1166	D20	22	31	20	1451s	10e	Fenix & Scisson, Inc., WIPP #21	
1167	I20	22	31	20	2986s	50e	Fenix & Scisson, Inc., WIPP #19	
1168	Q20	22	31	20	267s	177e	ERDA 9	
1169	P23	22	31	23	175n	177w	P-11	
1170	O23	22	31	23	1652s	2330w	P-19	
1171	W23	22	31	23	330s	330e	Texas Crude Oil Co., Wright-Fed. #1-23	
1172	O26	22	31	26	134s	797e	P-18	
1173	P26	22	31	26	2315n	339w	P-10	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1174	P28	22	31	28	146s	1487e	P-4	
1175	DOE1	22	31	28	182s	608e	DOE-1	
1176	O28	22	31	28	125n	172e	P-2	Rev loc from OFR78-592
1177	L29	22	31	29	623n	1083e	H-1	
1178	H29	22	31	29	372s	562w	Department of Energy, H-14	Elev from SAND89-0202; ?Cul
1179	R29	22	31	29	770n	3584e	ERDA, Hydrological H-2c	
1180	Y29	22	31	29	3200n	140e	Sandia National Laboratories, Hydrological No. 3	
1181	P29	22	31	29	327s	551w	P-1	
1182	P30	22	31	30	2767s	199w	P-6	
1183	P31	22	31	31	398s	184w	P-15	
1184	H33	22	31	33	1502s	105e	H-11	Rev for H11b3; SAND89-0200
1185	P33	22	31	33	1493s	143e	P-9	
1186	T13	22	32	13	660s	660e	Ray Smith Drilling Co., B&H Fed. 1	
1187	C14	22	32	14	660s	1980w	Carper Drilling Co., #2 Red Tank Unit	
1188	C17	22	32	17	1980s	1980e	Cleary Petroleum Corp., Fed. 1-17	
1189	T18	22	32	18	660s	660e	J.H. Trigg Co., Fed. Jennings 1-18	
1190	B19	22	32	19	660s	660e	Ralph Lowe, Bass Fed. #1	
1191	M20	22	32	20	1980n	1980e	R.J. Zonne, #1 Fed.	
1192	T22	22	32	22	1980n	660w	John M. Trigg Co., Fed. Red Tank Unit #1-22	
1193	A25	22	32	25	660n	1980w	Gulf Oil Co. -- U.S., Covington "A" Fed. #1	
1194	T36	22	32	36	660n	660e	Tidewater Oil Co., Richardson & Bass St. "AO" #1	
1195	H01	22	34	1	1980s	660e	Humble Oil and Refining Co., N.M. St. BS #1	
1196	N08	22	34	8	660s	1980e	Sunray Mid-Continent, New Mexico St. "AE" No. 1	Elev from Richey (1989); KB??
1197	H10	22	34	10	1980n	660e	Hudson & Hudson Personal, Allison Fed. No. 1	
1198	J01	22	35	1	660s	660w	British American Oil Prod. Co., Jalmat Deep #1	
1199	D03	22	35	3	660n	660w	Western Drilling Co., Donegan St. No. 1	
1200	A04	22	35	4	660s	660e	Ashmun & Hilliard No. 3 Ltd., Skelly St. #1-U	
1201	S05	22	35	5	660n	660e	Skelly Oil Co., St. "U" #1	
1202	H09	22	35	9	1980s	1980w	William A. & Edward R. Hudson, Humble St. #1	
1203	B11	22	35	11	660s	990w	British American Oil Prod. Co., Hall St. "F" #9	
1204	C20	22	35	20	1980n	660e	Carper Drilling Co., Carper Aztec No. 1	
1205	H22	22	35	22	1980s	1980e	Curtis Hankamer, Humble St. #1	
1206	A23	22	35	23	1980s	330e	Atlantic Refining Co., St. "AN" #1	
1207	G35	22	35	35	660s	660w	John M. Kelly, Gulf St. 1-A	
1208	L03	22	36	3	660n	660w	Gulf Oil Corp., Harry Leonard (NCT-D) No. 9	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1209	G03	22	36	3	1980n	1980w	Gulf Oil Corp., Harry Leonard NCT-D No. 10	
1210	J04	22	36	4	1980s	660e	Gulf Oil Corp., J.F. Janda NCT F#15	
1211	G09	22	36	9	1980s	660e	Sinclair Oil & Gas Co., St. 157 A #4	
1212	S09	22	36	9	660s	660e	Sinclair Oil & Gas Co., St. 157 A #3	
1213	W10	22	36	10	560s	660w	Western Natural Gas Co., Record #2	
1214	A17	22	36	17	1980n	1980w	Continental Oil Co., Arrowhead Deep Unit #1	
1215	C19	22	36	19	660n	330w	Cities Service Oil Co., Closson "B" #14	
1216	C23	22	36	23	660s	660w	Shell Oil, Christmas #A-2	Co. name uncertain
1217	A33	22	36	33	1980n	1830w	Atlantic Refining Co., J.L. Selby No. 2	
1218	M36	22	36	36	2310n	330w	The Ohio Oil Co., St. McDonald A/C 1-B #11	
1219	W15	22	37	15	1980s	660w	Amerada Petroleum Co., E.W. Walden No. 4	Rev loc NW1/4, SW1/4
1220	R16	22	37	16	2310s	1650e	E.P. Campbell, R.E. Cole #1	
1221	A36	22	37	36	1980s	1980e	Aztec Oil & Gas Co., St. BD 36 #1	
1222	W30	22	38	30	990s	330w	Western Oil Fields Inc., Gulf Drinkard #2	
1223	M02	23	28	2	1560s	330w	Neil H. Wills, Martin & Pardue #1	
1224	C11	23	28	11	2316s	2290w	Neil H. Wills, C.P. Pardue #1	
1225	P17	23	28	17	660n	2310e	Cities Service Co., Polk "A" #1	
1226	N12	23	29	12	1980s	1980w	Mesa Petroleum Co., Nash Unit #3	
1227	P13	23	29	13	2310s	330e	Mesa Petroleum, Nash Unit #5	
1228	M13	23	29	13	990n	330e	Mesa Petroleum Co., Nash Unit #4	
1229	U13	23	29	13	1980n	660e	Mesa Petroleum Co., Nash Unit #1	
1230	H14	23	30	14	2595n	2471w	Fenix & Scisson, Inc., WIPP H-7c	
1231	F16	23	30	16	1980s	1980e	Skelly Oil Co., Forty-Niner Rdige Unit #1	
1232	U18	23	30	18	1980n	330w	Mesa Petroleum Co., Nash Unit #6	
1233	S21?	23	30	21	1980n	1980e	Skelly Oil, Forty Niner Ridge Unit 2; ? DUP 1234	
1234	N21	23	30	21	1980n	1980e	Skelly Oil Co., Forty Niner Ridge Unit 2	
1235	S24	23	30	24	1980n	660w	Phillips Petroleum Co., Sandy Unit #1	
1236	Q34	23	30	34	200n	2327e	ERDA 10	Rev from BDR: SAND79-0271
1237	U34	23	30	34	2640n	2640w	Atomic Energy Commission, U.S.G.S. Test Hole #1	
1238	S02	23	31	2	660n	660e	Continental Oil Co., St. AA 2 No.1	
1239	O04	23	31	4	1351s	395w	P-17	Ref elev from OFR78-592
1240	P04	23	31	4	642n	96w	P-8	
1241	H05	23	31	5	447n	719w	Fenix & Scisson, WIPP No. H-4C	
1242	P05	23	31	5	513n	396w	P-7	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1243	C05	23	31	5	1990n	2017e	M.P. Grace Cabin Baby Fed. 1	Data from WTSD-TME-020
1244	O05	23	31	5	951s	1629w	P-16	
1245	B11	23	31	11	660s	660e	Max M. Wilson, Bauerdorf-Fed. #1	
1246	T14	23	31	14	1980s	1980w	Texas American Oil Corp., Todd Fed. "14" No. 1	
1247	H15	23	31	15	23n	92e	H-12	Rev from BDR; SAND90-0201
1248	A16	23	31	16	1980s	1980w	El Paso Natural Gas Co., Arco St. #1-16	
1249	P21	23	31	21	660s	660e	Patoil Corp., Muse Fed. #1	
1250	F23	23	31	23	1980s	1800e	Texas American Oil Corp., Todd Fed. 23 #3	
1251	T23	23	31	23	660s	1650e	Texas American Oil Corp., Todd "23" Fed. No. 1	
1252	T25	23	31	25	1980n	1970w	Skelly Oil Co., Todd 25 Fed. #1-Z	
1253	A26	23	31	26	1980n	1650e	Texas American Oil Corp., Todd Fed. #2	
1254	T26	23	31	26	1980n	1980e	Texas American Oil Corp., Todd Fed. "26" No. 1	
1255	B26	23	31	26	660n	1980e	Texas American Oil Corp., Todd Fed. #4	Rev elev from geophys log
1256	P27	23	31	27	1980s	660w	Patoil Corp., Wright-Fed. #1	
1257	M29	23	31	29	1980s	1980e	El Paso Natural Gas Co., Mobil-Fed. #1	
1258	L32	23	31	32	660n	660w	J.A. Leonard, Continental St. No. 1	
1259	W33	23	31	33	1980n	660w	Patoil Corp., Wright-Fed. #2	
1260	H36	23	31	36	660s	660w	Charles P. Miller, Pauley Harrison St. #1	sw1/4,sw1/4 converted
1261	K03	23	32	3	1980n	660e	O.B. Kiel, Jr., Fed. #1	
1262	M09	23	32	9	660s	1980e	McBee Oil Co., Continental Fed. #1-9	
1263	H11	23	32	11	1980n	1980e	Hill & Meeker & Ambass. Oil Corp., Matthews "11" #1	
1264	T15	23	32	15	1980n	1980e	John H. Trigg, Fed. Continental 1-15	
1265	F18	23	32	18	1980n	660e	Skelly Oil Co., Fed. Sand 18-1	
1266	K20	23	32	20	660s	1980e	Kirklin Drilling Co., Fed. Estill AF-1	Grnd elev from topo map
1267	H20	23	32	20	381s	1978e	Fenix & Scisson, Inc., WIPP No. H-10c	
1268	G21	23	32	21	660n	1980e	Curtis Hankamer, Gulf-Fed. "A-A" #1	
1269	H24	23	32	24	1650s	330e	H.L. Johnston, Sr., Conoco-Fields-Fed. #1	
1270	C24	23	32	24	660s	660e	Continental Oil Co., Fields Fed. No. 1	
1271	C25	23	32	25	990s	330w	Continental Oil Co., Fields No. 2	
1272	J25	23	32	25	990n	2310w	H.L. Johnston, Sr., Wehrli-Fed. #1	
1273	W26	23	32	26	330s	330e	John H. Trigg, Fed. "WL" #3-26	
1274	F26	23	32	26	1980s	330e	P.M. Drilling Co., Fed. James No. 4	
1275	P26	23	32	26	660s	1980w	P.M. Drilling Co., Fed. Field #1	Ref elev rev from log
1276	L26	23	32	26	330s	1650e	John H. Trigg Co., No. 4-26 Fed. WL	
1277	W28	23	32	28	660n	1980w	Max Wilson, Continental Fed. No. 1	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1278	H31	23	32	31	660s	660w	Curtis Hankamer, Hankamer No.1 Continental Fed.	
1279	C33	23	32	33	1980n	660e	Curtis Hankamer, Holder Fed. #1	
1280	P34	23	32	34	1980s	330e	The Pure Oil Co., Fed. "K" No. 1	
1281	Q35	23	32	35	1980s	1980e	PM Drilling Co., Fed. James No. 3	Ref elev rev from log
1282	A35	23	32	35	1650n	2310e	John H. Trigg, Fed. WL 1-35	
1283	T35	23	32	35	660n	660e	P.M. Drilling Co., Fed.-James No. 1	Ref elev rev from log
1284	M35	23	32	35	990n	2310w	P-M Drilling Co., Payne No. 2	
1285	J35	23	32	35	1650n	990e	John H. Trigg, Fed. "WL" No. 2-35	Ref elev rev from log
1286	F35	23	32	35	1980n	660w	P.M. Drilling Co., Payne Fed. No. 4	
1287	P35	23	32	35	2310n	2310w	P-M Drilling Co., Fed.-Payne No. 1	
1288	R35	23	32	35	660n	1980e	P.M. Drilling Co., Fed. James No. 2	
1289	D35	23	32	35	1980s	330w	P.M. Drilling Co., Fed. Payne No. 3	
1290	P36	23	32	36	330n	330w	Penroc Oil Corp., Triste St. #1	Ref elev rev from log
1291	B36	23	32	36	1980s	1980e	The Pure Oil Co., Brinninstool Deep Unit #1	
1292	G36	23	32	36	1980n	660w	David Fasken, Gulf St. #1	
1293	C04	23	33	4	660s	660e	Cabeen Exploration Corp., Continental Fed. #1-P	
1294	T06	23	33	6	330s	330e	William A. & Edward R. Hudson, Shell Fed. #1-6	
1295	H07	23	33	7	660s	660w	William A. & Edward R. Hudson, Fed. 7 Well #1	
1296	T17	23	33	17	660s	660w	P-M Oil Co., Texaco St. No. 1	
1297	S18	23	33	18	660s	660w	Helbing & Podpechan, #1 "A" Shell St.	
1298	T18	23	33	18	660n	1980e	Tenneco Oil Co., Skelly St. #1	
1299	M19	23	33	19	660s	1980w	Continental Oil Co., Marshall #3	
1300	B19	23	33	19	660s	660w	Continental Oil Co., I.J. Marshall 19-1	
1301	A19	23	33	19	1980s	625w	Continental Oil Co., Marshall #4	
1302	C19	23	33	19	1980s	1910w	Continental Oil Co., Marshall #19-2	
1303	A20	23	33	20	1980n	1980e	American Quasar, Brinninstool #1	
1304	C20	23	33	20	660s	660e	Continental Oil Co., Levick Fed. #1	
1305	K31	23	33	31	660n	660e	Kirklin Drilling Co., Lea St. #1	
1306	H32	23	33	32	660n	1980e	El Cinco Production Co., Ltd., Humble St. 1-32	
1307	B35	23	33	35	660s	660w	George L. Buckles Co., St. 1-35	
1308	B18	23	34	18	1980s	1980w	Continental Oil Co., Bell Lake #9	
1309	L19	23	34	19	1980n	1980w	Continental Oil Co., Bell Lake Unit #10	
1310	N22	23	34	22	1980n	1980e	Shell Oil Co., North Antelope Ridge Unit #1	
1311	S34	23	34	34	1980s	1650w	Shell Oil Co., Antelope Ridge Unit 34-1	
1312	E01	23	35	1	660n	660e	Kenwood Oil Co., Ehrman Fed. No. 1	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1313	M01	23	35	1	2310s	330w	Schermerhorn Oil Corp., Malco Fed. No. 1	
1314	G03	23	36	3	660n	660e	Albert Gackle, Sinclair St. #7	
1315	F17	23	36	17	1650n	990w	Continental Oil Co., Farney A-17 No. 3	
1316	S20	23	36	20	1980s	1980w	Sinclair Oil & Gas Co., Fed. 714 #4	
1317	H04	23	37	4	1980s	660w	Samedan Oil Corp., Hughes A-1 #6	
1318	K06	23	37	6	330n	330e	Ralph Lowe, King "B" #5	
1319	H09	23	37	9	1980s	1980w	Skelly Oil Co., Harrison B-10	
1320	T16	23	37	16	1980s	1980e	The Texas Co., #3 St. of New Mexico "BZ" NCT-8	
1321	O24	23	37	24	660s	660e	Earl M. Craig, Ohio St. #1	
1322	B31	23	37	31	1980s	660e	Texaco Inc., E.E. Blinberry A NCT 1-2	
1323	C05	24	29	5	1650s	660w	Chase Petroleum Co., Valley #1	
1324	E06	24	29	6	330s	2310e	El Capitan Oil Co., Fed. Reid No. 1	
1325	F07	24	29	7	2310s	2310e	Southern California Petrol. Corp., Fed. Reid #1	
1326	R07	24	29	7	2310n	2310e	Southern California Petrol. Corp., Fed. Reid #2	
1327	V07	24	29	7	990s	330w	Tennessee Production Comp., Valley Land Co. #2	
1328	T07	24	29	7	1650s	1650w	Tennessee Production Co., Valley Land #3	
1329	C09	24	29	9	770s	770e	Skelly Oil Co., Cedar Canyon #1	
1330	S09	24	29	9	660s	1980e	Skelly Oil Co., Cedar Canyon 9D #1	
1331	C10	24	29	10	2180n	1980w	Skelly Oil Co., Cedar Canyon #10-1	
1332	P27	24	29	27	660s	660w	Penzoil United Inc., Mobil-Fed. "27" #1	
1333	P04	24	30	4	660s	1980e	Perry R. Bass, Poker Lake Unit #54	
1334	P18	24	30	18	460n	660e	Perry R. Bass, Poker Lake Unit #45	
1335	H23	24	30	23	2062n	1466e	Fenix & Scisson, Inc., WIPP H No. 8-C	
1336	B25	24	30	25	660s	660w	Hill & Meeker, Bass Fed. #1-25	
1337	C29	24	30	29	660s	660e	Ford Chapman & Associates, Fed.-Nettles No. 1	
1338	T02	24	31	2	1980n	1980w	Skelly Oil Co., Todd "2" St. #1	
1339	J03	24	31	3	660s	660e	Max Wilson, Jennings Fed. No. 1	
1340	F03	24	31	3	660n	660w	Jack L. McClellan, Jennings Fed. No. 1	
1341	S04	24	31	4	660n	660e	Texaco, Inc., M.M. Stewart Fed. #1	
1342	H04	24	31	4	2482n	193w	Fenix & Scisson, Inc., WIPP No. H-9C	
1343	B04	24	31	4	1659n	2310w	Sundance Oil Co., Betty Fed. #1	
1344	E04	24	31	4	1980n	1980w	El Paso Natural Gas Co., Sundance Fed. #1	
1345	D06	24	31	6	1980n	1980w	American Quasar, Dunes Unit Fed. #1	
1346	Y07	24	31	7	660s	660e	Ambassador Oil Corp., Fed. "Y" #1	
1347	G11	24	31	11	660n	1980e	Gulf Oil Corp., Fed. Littlefield "CT" #1	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1348	E12	24	31	12	1980s	1980w	Coquina Oil Corp., El Paso Fed. No. 1	
1349	W17	24	31	17	660n	660e	W.J. Weaver, Continental Fed. #1	Ref elev calc from log
1350	R18	24	31	18	660s	660e	Charles B. Read, Ritchie Fed. #1	
1351	P20	24	31	20	660n	660e	Pauley Petroleum Inc., Jennings Fed. #1	
1352	F20	24	31	20	660s	1980w	David Fasken, Poker Lake #40	
1353	H21	24	31	21	660n	660e	Hill & Meeker, Carper Fed. #1-21	
1354	T24	24	31	24	660s	1980e	The Texas Co., T. Heflin-Fed. #1	
1355	M28	24	31	28	660s	660e	Pan American Petroleum Corp., Poker Lake Unit #36	
1356	M35	24	31	35	1980s	660w	Texaco, Inc., Cotton Draw Unit No. 67	
1357	U01	24	32	1	660s	1980e	Union Oil Co. of California, Union Fed. "1" #1	
1358	C01	24	32	1	1980s	660w	Cabeen Exploration Corp., Continental Fed. #1-L	
1359	M02	24	32	2	1990n	1990w	Calco, Marathon St. #1	
1360	O02	24	32	2	1980n	660e	P.M. Drilling Co., Ohio St. No. 1	
1361	H06	24	32	6	660n	1980e	Curtis Hankamer, Bondurant Fed. No. 1	
1362	G10	24	32	10	1980s	1980e	Gulf Oil Corp., Fed. Hanagan D #1	
1363	C11	24	32	11	660n	660e	Continental Oil Co., Wimberly #2	
1364	N11	24	32	11	660s	1980e	Curtis Hankamer, Hanagan Fed. No. 2	
1365	H11	24	32	11	1980s	660e	Gulf Oil Corp., Fed. Hanagan D #3	
1366	F11	24	32	11	1980s	1980e	Gulf Oil Corp., Fed. Hanagan D #2	
1367	G11	24	32	11	660s	660e	Curtis Hankamer, Gulf Hanagan #1	
1368	W11	24	32	11	1980n	1980e	Continental Oil Co., Wimberly #1	
1369	W12	24	32	12	660n	660e	Continental Oil Co., Wimberly 12 #1	Loc rev from geoph log
1370	C12	24	32	12	1980n	660e	Continental Oil Co., Wimberly "12" #2	
1371	H12	24	32	12	1980n	660w	Curtis Hankamer, Hanagan Fed. No. 3	Ref elev rev from log
1372	W13	24	32	13	660s	660e	WeSt.s Petroleum Corp. of Texas, Woolley #1	
1373	A13	24	32	13	660n	1980e	Continental Oil Co., Wimberly "A" #1	
1374	J14	24	32	14	660n	1980w	Tenneco Oil Co., #1 USA Jennings	
1375	T14	24	32	14	882s	882w	Tenneco Oil Co., USA Jennings N.M. 033503 No. 2	
1376	F14	24	32	14	1980s	1650w	Tenneco Oil Co., Jennings Fed. No. 4	
1377	U14	24	32	14	660n	1980e	Tenneco Oil Co., USA Jennings N.M. 033503 Well #3	
1378	F15	24	32	15	660s	720e	Gulf Oil Corp., Fed. Hanagan "B" #2	
1379	G15	24	32	15	1980s	660e	Gulf Oil Corp., Fed. Hanagan "B" #3	
1380	T15	24	32	15	660s	1980w	Tenneco Oil Co., Hicks-Fed. #1	
1381	H15	24	32	15	660s	1980e	Gulf Oil Corp., Fed. Hanagan "B" #1	
1382	B22	24	32	22	1980s	1980e	Charles B. Read, Bradley #1	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,si	fe,wl	Drillhole Name	Revisions
1383	R22	24	32	22	1980n	990e	Charles B. Read, Bradley #2	Ref elev rev from log
1384	G22	24	32	22	1980n	660w	Tenneco Oil Co., U.S. Smelting U.S.A. #2	
1385	S22	24	32	22	1980s	660e	Tenneco Oil Co., U.S. Smelting U.S.A. Well #3	
1386	U22	24	32	22	2310n	1650e	Tenneco Oil Co., U.S Smelting USA #4	
1387	T22	24	32	22	660n	1980e	Tennessee Gas Transmission Co., US Smelting USA #1	
1388	N22	24	32	22	990s	330e	Tenneco Oil Co., U.S. Smelting, USA No. 5	
1389	E23	24	32	23	1980n	660w	Curtis Hankamer, Ernest Fed. #1	
1390	B23	24	32	23	660n	660e	Charles B. Read, Bradley #3	
1391	W27	24	32	27	660n	1980e	Ralph E. Williamson, Wright Fed. No. 1	
1392	P30	24	32	30	1980n	1980e	Union Oil of California, Paduca Fed. #1	
1393	D33	24	32	33	660s	660e	Texaco Inc., Cotton Draw Unit Well #72	
1394	C34	24	32	34	1980s	1980w	Texaco, Inc., Cotton Draw Unit #69	
1395	R35	24	32	35	660s	660w	Sid W. Richardson, Inc., Fed. Delbasin #1	
1396	B01	24	33	1	660n	660e	Continental Oil Co., Bell Lake Unit #7	
1397	H06	24	33	6	1980s	660w	Hondo Drilling Co., Gulf N.W. #2	
1398	G06	24	33	6	660s	660w	Hondo Drilling Co., Gulf St. "NW" #1	
1399	I07	24	33	7	1980n	660w	Tom L. Ingram, St. "O" #2	
1400	O07	24	33	7	660n	660w	Tom L. Ingram, St. "O" #1	
1401	T07	24	33	7	330n	1750w	Tom L. Ingram, St. "P" #1	
1402	R07	24	33	7	660s	660e	George W. Riley Inc., St. #1-7	
1403	F07	24	33	7	2310n	2310w	David Fasken, Gulf St. #7-2	
1404	S08	24	33	8	660n	660w	Sunray Mid-Continent Oil Co., N.M. St. A.G. 1	
1405	B13	24	33	13	1980n	660e	Byard Bennett, Holland #1	
1406	T17	24	33	17	660s	660w	Tenneco Oil Co., St. Lowe #1	
1407	H17	24	33	17	660n	1980e	Robert B. Holt, Holly-St. #1	
1408	C20	24	33	20	660s	1980w	Continental Oil Co., St. "BB" 20 No. 1	
1409	J22	24	33	22	1980n	660w	F.R. Jackson, St. #1	
1410	T27	24	33	27	1980s	1980w	Tenneco Oil Co., Sunray St. #1	
1411	T29	24	33	29	660s	1980e	Tidewater Oil Co., St. "AP" #1	
1412	C30	24	33	30	330n	330w	Kirklin Drilling Co., Inc., Continental St. #1	
1413	G31	24	33	31	1980s	660e	Albert Gackle Operator, Continental St. #1	
1414	K36	24	33	36	660n	660e	Gulf Oil Corp. & Kirklin Drilling, #1 Lea St. "GX"	
1415	H01	24	34	1	1980n	1980e	Hanagan Petroleum Corp., #1 Gerdlag	
1416	D04	24	34	4	660n	1650e	Shell Oil Co., Fed. "BE" #1	
1417	C05	24	34	5	1650n	1650w	Continental Oil Co., Bell Lake Unit #14	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1418	B06	24	34	6	660n	3300e	Continental Oil Co., Bell Lake Unit No. 3	
1419	S09	24	34	9	660n	1980e	Shell Oil Co., Hall Fed. #1	
1420	W05	24	35	5	1980n	1980w	Gulf Oil Co. - U.S., Wilson Fed. Com. #1	
1421	A16	24	35	16	1650n	1980e	Texas International Pet. Corp., Aztec St. No. 1	
1422	F05	24	37	5	1966n	1980e	Texaco Inc., E.D. Fanning No. 7	
1423	H30	24	38	30	535n	2310w	Ralph Lowe, Hair #2	
1424	E28	25	28	28	1980n	1980w	Gulf Oil Corp., Eddy St. FD #1	
1425	B03	25	29	3	660n	660e	J. Glen Bennett, Superior Fed. #1-3	
1426	B08	25	29	8	980n	660w	J. Glen Bennett, Superior #1-8	
1427	W08	25	29	8	660s	660e	Neil H. Wills, Superior Fed. #1	
1428	M14	25	29	14	1980s	1980w	Mobil Oil Corp., Corral Draw Unit #1	
1429	B15	25	29	15	660s	660w	J. Glen Bennett, Superior Fed. 15 No.1	
1430	W22	25	29	22	1580s	1980w	Mobil Oil Corp., Corral Draw Unit #2	
1431	B26	25	29	26	660s	660e	J. Glen Bennett, No. 1-26 Superior Fed.	Ref elev rev from log
1432	B27	25	29	27	660s	660w	J. Glen Bennett, Superior Fed. 1-27	
1433	B29	25	29	29	660n	1880w	Bell Petroleum Co., Fed. #1	
1434	B30	25	29	30	660s	760e	Bell Petroleum Co., Cities Service Fed. #1	
1435	P03	25	30	3	1980s	990e	Bass Enterprises Prod. Co., Poker Lake Unit #47	
1436	P04	25	30	4	1980n	1980w	Pat Oil Corp., R & B Fed. #1	
1437	J04	25	30	4	660s	660w	J.M.C. Ritchie & Chambers & Kennedy, #1 Hopp Fed.	
1438	R08	25	30	8	1980n	660e	Fred Pool Drilling Co., Superior St. #1	Grnd el from topo; ref is +9ft
1439	K08	25	30	8	663s	667w	Ralph Lowe, Poker Lake St. #1	Ref el from log; topo differs
1440	L08	25	30	8	660s	660w	Ralph Lowe, Poker Lake St. #1; ? DUP 1439	Ref el rev from geoph log
1441	T08	25	30	8	660n	660w	Ralph Lowe, T&P St. #1	
1442	S08	25	30	8	1980s	1980w	Ralph Lowe, Superior St. #1	
1443	P08	25	30	8	1980s	660w	Ralph Lowe, Poker Lake St. #3	Ref el from topo; KB not given
1444	A10	25	30	10	660s	645w	Alamo Corp., Poker Lake Unit #5X-1A	
1445	P10	25	30	10	2030n	2180e	Bass Enterprises, Poker Lake #44	
1446	X17	25	30	17	610n	610w	Ralph Lowe, #1-X R&B Fed. "A"	
1447	A17	25	30	17	660s	660w	Alamo Corp., Poker Lake Unit #11A-7	
1448	J17	25	30	17	1980n	660w	J. Ray Stewart, Poker Lake #61	
1449	P17	25	30	17	330n	1650w	Jubilee Energy Corp., Poker Lake Unit 64	
1450	L17	25	30	17	1980s	330w	J. Ray Stewart, 66 Poker Lake Unit	
1451	B18	25	30	18	660n	1980e	Perry R. Bass, Jennings-Fed. No. 1	
1452	M18	25	30	18	660n	660e	Ralph Lowe, R&B Fed. #1	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1453	A18	25	30	18	660s	1980e	Alamo Corp., Poker Lake #12A-9	
1454	P19	25	30	19	330n	900e	Central St.s Oil Co., Poker Lake Unit No. 38	
1455	L19	25	30	19	660n	660e	J.R. Stewart, Poker-Lake Unit No. 65	
1456	C20	25	30	20	1980s	660w	Perry R. Bass, Continental-Fed. #2	
1457	F20	25	30	20	660n	660w	Perry R. Bass, Continental Fed. #1	
1458	A21	25	30	21	660n	660e	Alamo Corp., Poker Lake Unit #6-2A	
1459	P25	25	30	25	660s	660w	Bass Enterprises Prod. Co., Poker Lake Unit No. 56	
1460	D02	25	31	2	1980n	1980e	Texaco Inc., Cotton Draw Unit No. 65	
1461	A28	25	31	28	660n	660w	Alamo Corp., Poker Lake Unit 7-A-3	
1462	C32	25	31	32	660n	660w	J.A. Leonard, Continental St. No. 1	
1463	S35	25	31	35	660s	660w	Gold Metals & Santana Pet. Corp., #1 Del Basin Fed	
1464	C03	25	32	3	1650s	1980e	Texaco, Inc., Cotton Draw Unit No. 49	
1465	R09	25	32	9	330s	330e	Texaco Inc., E.F. Ray NCT-2 No. 1	Grnd el 3451 from topo map
1466	D09	25	32	9	1650s	330e	Texaco Inc., Cotton Draw Unit No. 52	
1467	T10	25	32	10	660n	660w	Tennessee Gas & Oil Co., Ray U.S.A. #1	
1468	C10	25	32	10	1980n	660w	Texaco Inc., Cotton Draw Unit No. 39	
1469	D10	25	32	10	660n	1980w	Texaco Inc., Cotton Draw Unit No. 40	
1470	Q10	25	32	10	2080n	760w	Texaco Inc., Cotton Draw Unit #66	
1471	Y10	25	32	10	660n	660w	Texaco Inc., Cotton Draw Unit No. 63; may dup 1467	
1472	M10	25	32	10	2145n	2310e	Texaco Inc., Cotton Draw Unit No. 60	
1473	R10	25	32	10	1980n	1980w	Texaco Inc., E.F. Ray Fed. "B" No. 2	Grnd el 3454 from topo, no KB
1474	V10	25	32	10	660s	1980e	Texaco Inc., E.F. Ray-Fed. "B" Well #1	Grnd el 3449 from topo map
1475	S10	25	32	10	660s	1980w	Texaco Inc., E.F. Ray Fed. No. 1	Grnd el 3445 from topo map
1476	F10	25	32	10	1980s	1980w	Texaco Inc., E.F. Ray-Fed. (NCT-1) No.2	Grnd el 3448 from topo map
1477	E10	25	32	10	1650s	660w	Tenneco Oil Co., Emily Flint Ray U.S.A. #41	
1478	C11	25	32	11	660s	1980e	WeSt.s Petroleum Corp. of Texas, Cont. Fed. #1	Loc rev from SW1/4, SE1/4
1479	P13	25	32	13	660s	1980w	Patoil Co., Union Fed. #1	
1480	F14	25	32	14	660s	660e	Joseph O'Neill Jr., Fed. "O" #1	
1481	O14	25	32	14	1980s	660e	Joseph O'Neill, Fed. "O" #2	
1482	H14	25	32	14	2310n	330w	Hill & Meeker, Ora Hall-Fed. 14 #1	
1483	U15	25	32	15	660s	660w	Tennessee Gas Transmission, #1 USA G.E. Jordan	
1484	F15	25	32	15	1980n	660w	Texaco Inc., G.E. Jordan Fed. (NCT-2) Well No.1	Grnd el 3441 from topo, +KB
1485	J15	25	32	15	1980s	1980w	Texaco Inc., G.E. Jordan Fed. (NCT-1)#2	Grnd el 3428 from topo, +KB
1486	R15	25	32	15	660n	1980w	Tennessee Gas & Oil Co., G.E. Jordan #3	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1487	E15	25	32	15	660n	1980e	Texaco Inc., G.E. Jordan Fed. (NCT-1) No. 8	Grnd el 3443 from topo, +KB
1488	G15	25	32	15	660n	660w	Texaco Inc., G.E. Jordan-Fed. (NCT-2) No. 2	Grnd el 3443 from topo, +KB
1489	N15	25	32	15	1980s	660w	Tennessee Gas & Oil Co., G.E. Jordan USA #4	
1490	T15	25	32	15	1980n	1980e	Texaco Inc., G.E Jordan Fed. (NCT-1) #6	
1491	M15	25	32	15	1980n	1980w	Tennessee Gas Transmission Co., G.E. Jordan USA #2	
1492	W15	25	32	15	2130s	2130e	Texaco Inc., Cotton Draw Unit No. 46	Grnd el 3431 from topo; +KB
1493	N16	25	32	16	660s	1980w	Tennessee Gas & Oil Co., St. Monsanto #4	
1494	B16	25	32	16	1980n	660e	Tennessee Gas Trans. Co., St. E.L. Bradley #1	
1495	P16	25	32	16	1650s	2310w	Tenneco Oil Co., St. Monsanto #6	
1496	M16	25	32	16	1980s	660e	Tennessee Gas Transmission Co., St. Monsanto #1	
1497	L16	25	32	16	1650s	1650e	Tenneco Oil Co., St. Monsanto #5	
1498	S16	25	32	16	1660s	990w	Tenneco Oil Co., Monsanto St. #8	
1499	F16	25	32	16	660n	660e	Tennessee Gas & Oil Co., St. Bradley #2	
1500	C16	25	32	16	330s	990w	Tenneco Oil Co., St. Monsanto #7	
1501	T16	25	32	16	2310n	2310w	Tenneco Oil Co., St. E.L. Bradley #3	
1502	Z16	25	32	16	1980n	1980e	Continental Oil Co., St. Z 16 #1	
1503	A16	25	32	16	660s	1980e	Tennessee Gas & Oil Co., St. Monsanto #3	
1504	E16	25	32	16	660s	660e	Tennessee Gas & Oil Co., Monsanto #2	
1505	X16	25	32	16	2080n	1650e	Shoreline Exploration Comp., Continental St. #1	Ref el rev from log
1506	D18	25	32	18	660n	1650w	Texaco Inc., Cotton Draw Unit #64	
1507	S18	25	32	18	660n	1980e	The Texas Co., Jack B. Shaw Fed. #1	
1508	C20	25	32	20	1650s	330e	Texaco Inc.(formerly PRBass), Cotton Draw Unit #42	
1509	D21	25	32	21	990s	990e	Texaco Inc., Cotton Draw Unit #57	Grnd el 3392 from topo, +KB
1510	M21	25	32	21	660s	660w	Panther City Investment Co., Perry Fed. #37	
1511	J21	25	32	21	1980s	660w	Panther City Investment Co., Perry Fed. #35	
1512	Y21	25	32	21	1980n	1980w	Panther City Investment, Inc., Perry Fed. No.6	Grnd el 3400 from log, no KB
1513	K21	25	32	21	660n	1980w	Panther City Invest. Inc., Perry Fed. No. 7	
1514	I21	25	32	21	2310s	990e	Panther City Investment Co., Perry Fed. #27	
1515	B21	25	32	21	1980s	1980e	Panther City Investment Co., Perry Fed. #28	
1516	E21	25	32	21	1980n	1980e	Tennessee Gas & Oil Co., #3 E.H. Perry-U.S.A.	
1517	N21	25	32	21	660s	1980w	Panther City Investment Co., Perry Fed. #38	
1518	V21	25	32	21	330s	330e	Perry R. Bass, Perry Fed. #43	
1519	C21	25	32	21	990s	2310e	Texaco Inc.(formerly Panther), Cotton Draw Unit 44	
1520	H21	25	32	21	1980n	660w	Tenneco Oil Co., E.H. Perry "USA" Well No. 36	
1521	P21	25	32	21	660n	660w	Tennessee Gas & Oil Co., E.H. Perry U.S.A. 2	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1522	R21	25	32	21	1980n	660e	Panther City Investment Co., Perry Fed. #2	
1523	T21	25	32	21	660n	1980e	Tennessee Gas Transmission Co., E.H. Perry USA #1	
1524	F21	25	32	21	660n	660e	Panther City Investment Co., Perry Fed. #1	
1525	G21	25	32	21	1980s	1980w	Panther City Investment Co., Perry Fed. #5	Ref elev rev from log
1526	J22	25	32	22	1980n	660w	Texaco Inc., G.E. Jordan Fed. #3	Grnd el 3409 from topo, +KB
1527	E22	25	32	22	660n	660w	Texaco Inc., G.E. Jordan Fed. No. 1	
1528	C22	25	32	22	2310s	330w	Texaco Inc., Cotton Draw Unit No. 48	
1529	T22	25	32	22	510n	1830w	Texaco Inc., G.E. Jordan Fed. NCT-1 #5	
1530	D22	25	32	22	1650n	1650w	Texaco, C.D. Unit No. 18	was T22 in T25S, R33E; misloc
1531	O23	25	32	23	660n	1980e	Joseph L. O'Neill, Fed. "P" #1	
1532	G25	25	32	25	660s	1980w	Texaco Inc., G.E. Jordan Fed. No. 4	
1533	C27	25	32	27	330n	330w	Texaco Inc., Cotton Draw Unit No. 61	
1534	U28	25	32	28	660n	1980w	Texaco Inc., Cotton Draw Unit No. 47	
1535	N28	25	32	28	660n	990e	Texaco Inc., Cotton Draw Unit No. 56	
1536	J28	25	32	28	2310s	1650w	Tenneco Oil Co., J.D. Sena U.S.A. No. 1	
1537	X28	25	32	28	660n	2310e	Texaco Inc., Cotton Draw Unit No. 51	
1538	W28	25	32	28	1980n	2310e	Texaco Inc., Cotton Draw Unit No. 54	
1539	C28	25	32	28	660n	660w	Texaco Inc., Cotton Draw Unit No. 45	
1540	Z28	25	32	28	1650n	990e	Texaco Inc., Cotton Draw Unit No. 59	
1541	V28	25	32	28	1980n	1980w	Texaco Inc., Cotton Draw Unit No. 50	
1542	D28	25	32	28	2310s	990w	Tenneco Oil Co., J.D. Sena Jr. U.S.A. No. 2	
1543	T29	25	32	29	1980n	330e	Texaco Inc., Cotton Draw Unit No. 58	
1544	C29	25	32	29	990s	330e	I.W. Lovelady, Conoco Fed. #1-29	
1545	S31	25	32	31	1980n	660w	Ray Smith, Ray Smith #1	
1546	C32	25	32	32	1980n	1980w	R.C. Graham, Conoco St. No. 1	
1547	W33	25	32	33	1980s	560e	WeSt.s Petroleum Corp. of Texas, Jennings #1	Ref el rev from log
1548	H33	25	32	33	660s	660w	Hill & Meeker, Hall-Fed. 1-33	
1549	M33	25	32	33	2310n	2310w	Hill & Meeker, Jennings-Fed. 1-33	DF 3354 log; grnd el 3346 topo
1550	J01	25	33	1	660n	660w	Perry R. Bass, Fed.-Muse #1	
1551	H05	25	33	5	660n	660e	Hill & Meeker, Bass Fed. #1	
1552	S08	25	33	8	1980s	660e	Santana Petroleum Corp., Annie Bass Fed. #1	
1553	H11	25	33	11	660n	660w	Curtis Hankamer, Muse Fed. #1	
1554	J18	25	33	18	660n	660w	Sam H. Jolliffe Jr., #1 Bass Fed.	
1555	H20	25	33	20	660n	1980e	Curtis Hankamer, Fed. Bass #1	
1556	B21	25	33	21	660n	660e	George L. Buckles Co., Fed. Marshall No. 1	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1557	A21	25	33	21	660s	660e	American Quasar Petroleum Co., Vaca Draw #1	
1558	M23	25	33	23	660s	660w	Hill & Meeker, Muse-Fed. 23 #1	
1559	F24	25	33	24	660s	660w	R.B. Farris, Perry Fed. 1	
1560	K25	25	33	25	1980s	660w	King Resources, Pan American Fed. No. 1	
1561	A25	25	33	25	660s	660e	Ashmun & Hilliard, Fed. No. 1-25	
1562	D27	25	33	27	660s	660e	Robert A. Dean, Harry Dickson #1	
1563	T28	25	33	28	660s	660e	Tidewater Oil Co., Annie R. Bass Fed. #1	
1564	C28	25	33	28	660n	660e	Curtis Hankamer, Conley Fed. #1	
1565	T29	25	33	29	1980n	660w	Tenneco Oil Co., W.H. Jennings Inc USA No. 1	
1566	T31	25	33	31	660s	660w	Tenn. Gas Transmission Co, Richardson & Bass USA#1	
1567	D32	25	33	32	330s	2310e	Pure Oil Co., Red Hills Unit #1	
1568	W32	25	33	32	1980s	660e	Neil H. Wills, Continental St. No. 1	
1569	W36	25	33	36	660s	660w	Max M. Wilson, Marathon-St. #1	
1570	A36	25	33	36	660n	660w	Ashmun Hilliard Oil Co., St. #1-36	
1571	F19	25	34	19	660n	1980w	Ashmun & Hilliard, Fed. 2-19	
1572	C27	25	34	27	1980n	660e	Tenneco Oil Co., Conoco Fed. #1	
1573	S02	25	37	2	2310s	1650e	Continental Oil Co., St. A-2 #2	log not recovered
1574	L03	25	37	3	330s	990w	George L. Buckles Co., Liberty Royalty No. 4	log not recovered
1575	J14	25	37	14	560n	330e	Johnson & French, Fed. "A" #1	log not recovered
1576	L14	25	37	14	1650s	1650e	Atlantic Refining Co., Langlie Fed. #2	
1577	W24	25	37	24	1980n	990w	Western Natural Gas, Wimberly #4	log not recovered
1578	H11	26	29	11	660s	660e	Curtis Hankamer, Hanson "A" #1	
1579	H12	26	29	12	458s	744w	Curtis Hankamer, Hansen Fed. #2	
1580	G13	26	29	13	660s	660w	Curtis Hankamer, Gulf Fed. #4-B	
1581	F13	26	29	13	660s	1980w	Curtis Hankamer, Gulf-Fed. No.1	
1582	C13	26	29	13	1980s	660w	Curtis Hankamer, Gulf Fed. 5-B	
1583	D13	26	29	13	1980s	1980w	S.P. Dillon, Gulf Fed. #1	
1584	G14	26	29	14	1980s	660e	Curtis Hankamer, Gulf Fed. Beady #3	
1585	F14	26	29	14	1980n	660e	Gulf Oil Corp., Fed. Boothe "E" #2	
1586	M22	26	29	22	2310s	330e	Challenger Energy Inc., Mobil "22" Fed. #2	
1587	F23	26	29	23	660s	660w	Gulf Oil Corp., Fed. Boothe E #1	
1588	G24	26	29	24	660n	660w	Curtis Hankamer, Gulf-Beaty No. 1	
1589	A27	26	29	27	2310n	330e	Worth Petroleum Co., Amoco Fed. #4	
1590	F34	26	29	34			Gulf Oil Corp., Fed. Littlefield "BO" #1	
1591	S02	26	30	2	660s	660w	Ford Chapman Associates, Sinclair St. No. 1-2	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1592	S03	26	30	3	660s	660w	Charles B. Read, Scott Fed. #1	
1593	K04	26	30	4	660n	660w	Aztec Oil Co., Fed. K.W. No. 1 [also Late Oil Co.]	Ref el 3179, 3180 from log
1594	B06	26	30	6	660s	660w	J. Glen Bennett, No. 1 Brunson Fed.	
1595	F06	26	30	6	660n	660w	T.W. Loffland, Brunson Fed. #2	
1596	M12	26	30	12	660s	660e	Montery Oil Co., Monteray Blaydes #1	
1597	F18	26	30	18	660s	660w	Curtis Hankamer, #1 AT Fed.	
1598	M18	26	30	18	330s	330w	Curtis Hankamer, McKenna Fed. #2	
1599	R28	26	30	28	1980s	660e	Penroc Oil Corp., Ross Draw Unit #6	
1600	B09	26	31	9	660s	660w	George L. Buckles, Buckles Fed. No. 1	
1601	F15	26	31	15	660s	660w	George L. Buckles Co., Fed. No. 1-15	
1602	P17	26	31	17	1980s	660e	Union Oil Co of Cal, Phantom Banks Unit Fed. 17 #1	
1603	P20	26	31	20	800s	1000w	Texas Pacific Oil Co., Phantom Draw Unit-Fed. #1	
1604	M20	26	31	20	660s	660w	Max Wilson, Hanson Fed. No. 1	
1605	C05	26	32	5	660n	1980w	Fred Pool Drilling Co., Conoco Bradley #1	
1606	B15	26	32	15	1980s	660e	Brown & Krug Co., Ben Fed. #1	Loc rev from NE1/4, SE1/4
1607	R19	26	32	19	660s	1980w	Continental Oil Co., Russell Fed. 19 No. 4	
1608	J25	26	32	25	990n	990w	Continental Oil Co., Wilder #23	
1609	G25	26	32	25	1980s	660e	Continental Oil Co., Wilder #13	
1610	F25	26	32	25	660s	660e	Continental Oil Co., Wilder #12	
1611	E25	26	32	25	1980n	660e	Continental Oil Co., Wilder #10	
1612	B25	26	32	25	1980s	1980e	Continental Oil Co., W.W. Wilder No. 7	
1613	I25	26	32	25	660n	1980w	Continental Oil Co., Wilder #15	Ref el rev from log
1614	H25	26	32	25	1980n	660w	Continental Oil Co., Wilder #14	
1615	A25	26	32	25	1980n	1980w	Continental Oil Co., Wilder #6	Grnd el 3122 from topo, +KB
1616	D25	26	32	25	660n	1980e	Continental Oil Co., W.W. Wilder Fed. #9	
1617	C25	26	32	25	1980n	1980e	Continental Oil Co., W.W. Wilder #8	
1618	K25	26	32	25	330s	330w	Continental Oil Co., Wilder 25 Fed. No. 1	
1619	L17	26	33	17	660s	660w	Gulf Oil Corp., Fed. Littlefield DP Optional #1	
1620	P30	26	33	30	1980s	660w	Continental Oil Co., Payne #3	
1621	Y03	26	34	3	660n	1980w	Gulf Oil Co., Gulf Yates Fed. #1	
1622	B19	26	34	19	1980s	1980e	Continental Oil Co., Bradley 19 #2	
1623	L20	26	34	20	660n	660e	Max Wilson, Leonard Fed. No. 1	
1624	S05	26	36	5	660s	660w	Cities Service Oil Co., Sand Hills Unit #9-A	
1625	J04	26	37	4	990s	990w	Jal Oil Co. Inc., Farnsworth #6	

ID No.	Hole ID	T.	R.	Location Data* Sec	fn,sl	fe,wl	Drillhole Name	Revisions
1626	L11	26	37	11	660s	660e	Stanolind Oil & Gas Co., U.S.A. Leonard Oil Co. #1	
1627	F07	26	38	7	1980s	660w	Forest Oil Corp., Fed. Lowe #1	
1628	S15	21	33	15	1980s	1980e	Getty Oil Co. Stock Unit #1	data entered from geophysical log
1629	S32	21	33	32	1980s	1980w	Amoco Production Co. St. "LT" #1	data entered from geophysical log
1630	H28	22	31	28	89n	175e	Department of Energy WIPP No. H-15	data from SAND89-0202
1631	R05	22	33	5	660s	330e	Dual Production Co. Richardson-Bass St. No. 1	data from geophysical log
1632	G15	22	33	15	1980s	1980e	Getty Oil Co. Getty Fed. "15" No. 1	data from geophysical log
1633	C20	22	33	20	1980n	660w	Davis and Collins Conoco Fed. #1	data from geophysical log
1634	E11	24	29	11	1980n	660e	Exxon Co., USA Exxon Pouche Fed. No. 1	data from geophysical log
1635	H04	24	33	4	1980n	1650w	Getty Oil Co. HNG St. 4-F #1	data from geophysical log
1636	G28	24	33	28	1980s	1680e	Getty Oil Co. Getty 28 St. No. 1	data from geophysical log
1637	S31	25	29	31	1980s	660e	Duncan Drilling Co. Slater "A" #1	data from geophysical log
1638	P05	25	31	5	660n	660w	Pauley Petroleum Poker Lake #46	data from geophysical log
1639	S32	22	33	32	660s	660w	Helbing & Podpechan Shell St. #1-B	data from geophysical log
1640	B14	26	29	14	660n	660w	Ford Chapman Booth Fed. #1	data from geophysical log
1641	Y20	22	31	20	1113s	1241e	H-16	data from SAND89-0203
1642	Z03	23	31	3	1466s	993w	H-17	data from SAND89-0204
1643	Z20	22	31	20	964n	446w	H-18	data from SAND89-0204

* All townships (T) are south and all ranges (R) east of the New Mexico Base Line. Distances from the section lines are in feet and are followed by a letter designation., This letter (n,s,e,w) and number designate the feet from the north, south, east, or west section line, respectively. Other tables of drillhole data are keyed to this location table by the identification number.

** Names of drillholes have been shortened with some consistent abbreviations.

*** A few likely duplications in the original Holt and Powers (1988) data set are noted here.

APPENDIX A-2
TABLE OF DEPTHS TO SELECTED MARKER BEDS OF THE SALADO FORMATION

Table of Depths to Selected Marker Beds of the Salado Formation

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
				Depths (ft) to Marker Beds									
1001		3	278										
1002	3568	10											
1003	3510	0	316										
1004	3618	1	736										
1005	3466	10	624										
1006	3554	10	587										
1007	3510	9	557										
1008	3766	9	1017										
1009	3733	9	990										
1010	3651	7	840										
1011	3648	18											
1012	3624	10	790										
1013	3631	10	775										
1014	3551	10	785										
1015	3568	3	735										
1016	3566	3	810										
1017	3580	5	830										
1018	3571	0	840										
1019		3	828										
1020	3885	10	1394										
1021	3783	0	1350										
1022	3751	0	1274										
1023	3382	10	1300										
1024	4027	13	1828										
1025	4104	10	1988										
1026	3952	10	1880										
1027	3800	0	1663										
1028	3779	21	1546										
1029	4011	12	1677										
1030	4098	8	1843										
1031		12	2026										
1032	4023	11	2075										
1033	4000	13	2050										
1034	3957	17	1983										
1035	3920	14	1968										
1036	3961	14	1810										
1037	3962	11	1765										
1038	3968	13	1744										
1039	3958	14	1814										
1040	3991	12	1678										
1041	3980	0	1720										
1042	3948	13	2112										
1043	3789	0	2038										
1044	3822	11	2137										

			Depths (ft) to Marker Beds										
Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
1045	3816	0	2030										
1046	3783	0	1997										
1047	3698	0	1810										
1048	3750	13											
1049	3660	0	2168										
1050	3664	0	1653										
1051	3399	9	305										
1052		0	218										
1053		0	245										
1054	3402	10	388										
1055	3529	0	740										
1056	3577	21	978										
1057	3559	21	898										
1058	3526	8	746										
1059	3576	16	1172										
1060	3974	10	2150										
1061	3815	13	2080										
1062	3723	0	2045										
1063	3743	0	2052										
1064	3703	12	2080										
1065		0	1680										
1066	3759	11	1704										
1067	3744	11	2038										
1068	3702	0	1446										
1069	3580	0	1397										
1070		0	520										
1071	3325	18											
1072	3505	19	713	874	887	993	1006	1147	1153			1420	1433
1073	3523	16											
1074	3448	16	1170										
1075	3550	16	1495	1650	1660	1770	1794	1937	1943			2184	2200
1076	3510	15	1236	1376	1387	1487	1509	1650	1657			1876	1903
1077	3565	15	1524	1660	1670	1770	1793	1952	1962	2051	2053	2129	2148
1078	3586	7	1756	1907	1918	2022	2046	2230	2244			2408	2422
1079	3524	0	1470										
1080	3509	0	1450										
1081	3642	19	1887	2044	2057	2163	2186	2335	2344			2538	2554
1082	3677	21	2110										
1083	3708	7	1957	2104	2117	2222	2246	2382	2391	2542	2545	2594	2608
1084	3720	10	1949										
1085	3701	0	2315										
1086	3603	0	1218										
1087	3662	0	2330										
1088	3604	0	1671										
1089	3542	0	1635										
1090	3412	20	495										
1091	3471	18	500										

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
				Depths (ft) to Marker Beds									
1092	3472	13	550										
1093	3468	13	740										
1094	3487	17	1145										
1095	3432	18	680										
1096	3309	16	450										
1097	3458	18	655										
1098	3444	18	505										
1099	3177	0	421										
1100	3250	23	502										
1101	3218	22	485	492	508	612	618	785	798	970	975	1040	1063
1102	3347	0											
1103	3428	0	748										
1104	3540	0	811	970	984	1091	1114	1277	1287	1445	1454	1518	1538
1105	3748	14	1890										
1106	3792	18	1945	2104	2116	2216	2235	2390	2400	2555	2562	2610	2628
1107	3793	22	1988										
1108	3740	21	1950										
1109	3668	15	1765										
1110	3652	18	1580	1735	1748	1855	1879	2043	2051	2214	2219	2269	2287
1111	3800	17	1885										
1112	3862	10	2005										
1113	3861	22	1947										
1114	3834	21	1972	2139	2150	2258	2274	2440	2448	2608	2618	2660	2673
1115	3679	21	1455	1630	1645			1953	1963	2198	2202	2240	2258
1116	3798	13	1781	1958	1970	2092	2112	2282	2297	2470	2478	2544	2560
1117	3504	0											
1118	3662	8	982	1162	1178	1297	1318	1500	1508	1691	1700	1770	1787
1119	3780	23	1090	1272	1280	1394	1417	1584	1597	1763	1767	1835	1853
1120	3802	4	2180					2922	2930	3075	3088	3128	3150
1121	3564	0	1758										
1122	3638	17	2095										
1123	3603	11	2200	2359	2374	2483	2500						
1124		0											
1125		0											
1126	3594	5	1670										
1127	3550	0	1660										
1128	3593	10	1670										
1129	3568	0	1720										
1130	3545	10	1720										
1131	3635	0	1900										
1132	3581	0	1817										
1133	3580	3	1817										
1134		0	1377										
1135		0	1368										
1136	3304	12	495										
1137	3023	0	166										
1138	2977	0	130										
1139	3357	20	625										

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
			Depths (ft) to Marker Beds										
1140	3193	18	520	562	573	686	710	880	887	1056	1064	1130	1152
1141	3221	23	600			760	786	950	960	1130	1140	1205	1227
1142	3323	0	677										
1143	3214	1	565										
1144	3358	0	686	824	840	946	970	1133	1140	1315	1327	1393	1419
1145	3376	0	747	908	924	1034	1061	1226	1234	1405	1416	1484	1507
1146	3309	23	535										
1147	3152	0	306										
1148		0	708										
1149	3418	0	962										
1150	3439	13	964	1125	1139	1252	1273	1429	1434	1597	1606	1670	1688
1151	3433	0	973										
1152	3429	0	952										
1153	3541	9	990	1158	1170	1278	1302	1468	1475	1648	1658	1723	1743
1154	3553	0	1100	1276	1291	1405	1425	1602	1608	1784	1792	1862	1887
1155	3508	0	1041										
1156	3510	0	1040	1211	1225	1333	1359	1527	1533	1706	1715	1780	1805
1157	3496	21											
1158	3405	0	845	1031	1042	1161	1183	1359	1372	1543	1551	1622	1645
1159	3484	12	966										
1160	3472	0	946	1108	1120	1234	1260	1428	1434	1598	1610	1678	1702
1161	3345	0	720	884	898	1012	1039	1200	1211	1377	1384	1449	1474
1162	3349	0											
1163	3382	0	783	960	978	1088	1118	1287	1298	1473	1484	1556	1580
1164	3457	0	928										
1165	3426	0	885	1050	1063	1172	1196	1363	1378				
1166	3417	0	867										
1167	3433	0	894										
1168	3420	12	860	1040	1050	1165	1188	1365	1367	1549	1557	1630	1653
1169	3506	0	1058	1229	1244	1354	1378	1550	1556	1730	1740	1809	1832
1170	3546	0	1116	1296	1310	1422	1446	1620	1630	1808	1822	1892	1916
1171	3596	8	1190	1376	1387	1504	1526	1700	1717	1895	1910	1979	1998
1172	3479	0	1084	1258	1276	1400	1422	1601	1619	1789	1806	1866	1888
1173	3508	0	1084	1262	1276	1394	1416	1594	1602	1780	1797	1864	1886
1174	3441	0	928	1108	1124	1240	1268	1446	1456	1644	1660	1728	1752
1175	3473	8	977	1152	1163	1286	1310	1484	1490	1682	1695	1764	1785
1176	3478	0	1008	1188	1204	1312	1336	1506	1514	1694	1706	1774	1796
1177	3398	0	7										
1178	3346	0											
1179	3377	0											
1180	3395	6	826										
1181	3345	0	676	861	874	986	1011	1190	1193	1379	1391	1460	1483
1182	3354	0	656	840	857	965	989	1162	1166	1354	1363	1432	1460
1183	3310	0	542	729	743	860	883	1058	1062	1248	1261	1323	1352
1184	3413	0											
1185	3409	0	880	1062	1077	1200	1226	1400	1410	1591	1610	1668	1693
1186	3644	10	1275	1447	1461	1584	1604	1762	1777	1938	1954	2012	2030
1187	3731	11	1290	1470	1482	1607	1630	1823	1840	2033	2048	2118	2140

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
				Depths (ft) to Marker Beds									
1188	3701	20	1200										
1189	3696	15	1230	1409	1421	1540	1562	1735	1750	1920	1932	2008	2031
1190	3620	9	1245	1429	1440	1562	1583	1758	1768	1940	1957	2022	2041
1191	3640	19	1240										
1192	3687	12	1265	1448	1462	1587	1609	1786	1795	1973	1989	2046	2067
1193	3789	25	1462										
1194	3756	0	1608										
1195	3640	13	2160	2326	2337	2444	2463	2600	2609	2770	2786	2828	2839
1196	3537	0	2092										
1197	3573	0	2185										
1198	3611	18	2225	2353	2383	2487	2506	2638	2643	2794	2808	2842	2854
1199	3613	7	2285										
1200	3611	11	2300										
1201	3623	1											
1202	3581	13	2275										
1203	3610	0											
1204	3533	22	2470										
1205	3571	10	2292										
1206		0	2210										
1207		0	2275										
1208		13	1825										
1209	3571	0	1822										
1210	3587	0	1825										
1211	3552	0	1725										
1212	3540	0	1687										
1213	3560	0	1735										
1214	3582	18	1685	1795	1824	1918	1942	2067	2074	2232	2246	2282	2297
1215	3589	11	2008										
1216	3507	0	1805										
1217	3498	0	1683										
1218	3469	0	1684										
1219	3410	0	1385										
1220	3405	0	1360										
1221	3316	0	1408										
1222	3337	0	1350										
1223		10											
1224		0											
1225	3045	18											
1226	2996	19											
1227	3027	12	212										
1228	3014	12	195										
1229	3024	19	212										
1230	3163	0	283										
1231	3197	24	425										
1232	3028	12	217										
1233	3215	15											
1234	3215	15											
1235	3290	23	470	622	634	754	775	946	956	1141	1155	1211	1232

			Depths (ft) to Marker Beds										
Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
1236	3384	13	640										
1237		0	710										
1238	3453	10		1247	1260	1391	1414	1590	1603	1785	1804	1853	1871
1239	3340	0	713	890	904	1028	1052	1234	1240	1436	1452	1510	1532
1240	3336	0	715	894	906	1026	1052	1236	1240	1440	1454	1520	1540
1241	3335	0	626										
1242	3332	0	627	810	828	948	972	1154	1160	1354	1371	1430	1458
1243	3328	8	653										
1244	3323	0	642	822	836	965	990	1173	1180	1372	1388	1446	1468
1245	3492	10	1118	1292	1308	1432	1454	1635	1646	1834	1852	1903	1921
1246	3511	27	1100	1242	1252	1448	1468	1689	1702	1858	1875	1922	1934
1247	3426	0	976										
1248	3381	23	808	993	1005	1130	1149	1332	1348	1540	1557	1608	1629
1249	3374	9	797	979	992	1116	1126	1333	1357	1566	1582	1637	1655
1250	3452	22	1092										
1251	3461	11	1090										
1252	3506	21	1190										
1253	3454	10	1063	1247	1258	1395	1412	1602	1609	1832	1846	1902	1920
1254	3464	27	1070	1246	1260	1380	1400	1602	1610	1827	1843	1897	1916
1255	3459	12	1060										
1256	3402	12	837	1013	1028	1151	1172	1370	1381	1592	1610	1662	1671
1257	3374	22											
1258	3358	8	695	880	892	1038	1058	1235	1248	1458	1473	1528	1545
1259	3392	8	816	1021	1040	1192	1216	1408	1422	1645	1662	1718	1737
1260		7	1095										
1261	3727	12	1584	1752	1767	1883	1904	2072	2093	2250	2267	2308	2328
1262	3699	11	1545	1708	1724	1840	1860	2041	2050	2225	2240	2282	2300
1263	3723	5	1680	1852	1866	1988	2010	2190	2199	2376	2393	2439	2457
1264	3722	12	1640	1812	1828	1940	1957	2132	2140	2320	2335	2378	2395
1265	3622	21											
1266	3697	11	1512	1682	1697	1812	1830	2004	2017	2213	2228	2276	2292
1267	3699	14											1688
1268	3701	10	1517	1688	1702	1819	1840	2018	2026	2212	2230	2274	2290
1269	3720	10	1710	1888	1903	2025	2044	2214	2227	2417	2431	2477	2498
1270	3725	13	1727	1903	1919	2044	2064	2233	2243	2441	2456	2504	2520
1271	3700	13	1683	1863	1878	2002	2020	2194	2210	2405	2420	2470	2485
1272	3720	10	1695	1873	1888	2013	2032	2203	2217	2407	2420	2468	2485
1273	3698	12	1678	1861	1876	2003	2022	2201	2212	2412	2429	2478	2496
1274	3705	9	1680	1860	1873	1996	2010	2188	2200	2394	2410	2457	2474
1275	3659	11	1630	1814	1830	1950	1968	2147	2160	2360	2374	2424	2443
1276	3713	12	1667	1858	1870	1995	2014	2192	2202	2405	2423	2471	2490
1277	3687	0	1535	1714	1730	1850	1868	2048	2059	2257	2273	2321	2338
1278	3551	8	1206	1396	1411	1539	1556	1735	1748	1970	1988	2025	2048
1279	3666	8	1520										
1280	3629	9	1508	1700	1712	1840	1857	2031	2043	2248	2264	2316	2336
1281	3671	11	1623	1821	1837	1970	1990	2172	2180	2390	2407	2460	2478
1282	3694	12	1657	1854	1868	1993	2013	2190	2198	2404	2420	2472	2490
1283	3676	11	1675	1872	1884	2015	2029	2213	2227	2428	2443	2496	2512

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
					Depths (ft) to Marker Beds								
1284	3700	8	1635	1831	1844	1969	1980	2166	2177	2378	2393	2444	2465
1285	3692	12	1653	1846	1860	1995	2014	2194	2207	2414	2430	2482	2500
1286	3663	8	1567	1762	1775	1900	1918	2094	2103	2308	2323	2375	2396
1287	3689	11	1623	1818	1832	1960	1980	2157	2167	2369	2385	2437	2457
1288	3669	11	1655										
1289	3630	8	1505					2044	2054	2265	2280	2332	2350
1290	3695	8	1670	1858	1872	2005	2022	2202	2216	2418	2434	2486	2504
1291	3689	0	1680	1884	1898	2042	2062	2246	2257	2482	2498	2560	2576
1292	3664	11	1673	1864	1877	2010	2030	2210	2220	2430	2445	2500	2516
1293	3636	11	1657	1830	1848	1982	2008	2175	2184	2362	2378	2427	2449
1294	3704	10	1772	1947	1960	2099	2112	2287	2298	2478	2492	2535	2550
1295	3722	11	1757	1929	1945	2072	2096	2263	2274	2455	2470	2515	2534
1296	3715	12	1773	1947	1960	2093	2115	2284	2294	2484	2500	2548	2566
1297	3722	11	1710			2013	2030	2199	2210	2387	2401	2443	2458
1298	3726	9		1958	1975	2103	2117	2295	2304	2488	2504	2550	2565
1299	3711	13	1732	1903	1920	2046	2065	2240	2250	2445	2460	2509	2526
1300	3720	13	1735	1906	1923	2048	2066	2242	2250	2451	2465	2516	2535
1301	3713	13	1710	1875	1892			2204	2212	2400	2416	2464	2479
1302	3703	11	1720	1890	1905	2028	2047	2218	2227	2417	2432	2480	2498
1303	3713	25	1790										
1304	3701	12	1785	1953	1969	2098	2117	2296	2306	2502	2518	2570	2589
1305		11	1760	1940	1956	2085	2102	2280	2289	2493	2510	2560	2578
1306	3683	8	1770	1945	1960	2083	2100	2275	2286	2478	2494	2548	2567
1307	3659	0	1815	1998	2012	2130	2148	2323	2333	2528	2546	2598	2613
1308	3533	0	1469	1660	1675	1810	1830	2000	2012	2209	2224		
1309	3555	19	1605										
1310	3425	14	1275										
1311	3490	22	1400										
1312	3515	0	2030										
1313	3494	9	2020										
1314		0	1663										
1315	3468	0	1950										
1316	3459	0											
1317	3324	0	1337										
1318	3383	0	1493										
1319	3317	0	1287										
1320	3317	0	1228										
1321	3282	11	1620										
1322	3320	9	1435										
1323	2968	10											
1324	2984	0											
1325		6											
1326		0											
1327		4											
1328		6											
1329	2969	28											
1330	2941	11						454	460			665	690
1331	2997	18											

Borehole ID no.	Reference Elevation	KB (ft)	Depths (ft) to Marker Beds Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
1332	2924	11	696										
1333	3447	12	660										
1334	3179	11											
1335	3433	0											
1336	3429	12	840	848	858	928	946	1132	1141	1360	1378	1430	1454
1337	3266	5											
1338	3502	23	1250										
1339	3500	9	1010	1152	1167	1300	1320	1509	1517	1722	1736	1788	1805
1340	3432	2	835										
1341	3436	10	832	1017	1032	1155	1178	1368	1380	1582	1600	1645	1663
1342	3406	0	791										
1343	3414	10	812	997	1011	1132	1152	1340	1354	1562	1578	1630	1645
1344	3430	28	805	920	933	1062	1082	1260	1274	1485	1504	1556	1573
1345	3438	23	826										
1346	3535	11	960	960	976	1115	1135	1317	1325	1540	1560	1617	1634
1347	3528	13	1130	1299	1317	1450	1468	1644	1660	1860	1874	1923	1940
1348	3553	13	1098	1300	1312	1448	1466	1651	1667	1889	1905	1966	1986
1349	3553	4	1025										
1350	3514	10	915	944	956	1080	1100	1280	1284	1490	1510	1560	1578
1351	3530	11	965	968	981	1125	1145	1330	1342	1548	1565	1622	1641
1352	3490	12	895	918	924	1040	1062	1245	1252	1455	1472	1530	1549
1353	3535	11	923	993	1012	1140	1160	1340	1350	1562	1580	1629	1647
1354	3551	12	1017										
1355	3502	23											
1356	3508	25	1010										
1357	3620	10	1562	1748	1761	1888	1908	2084	2099	2301	2317	2368	2388
1358	3623	12											
1359	3632	11	1500										
1360	3631	11	1533	1727	1740	1870	1892	2074	2088	2296	2314	2369	2390
1361	3584	8	1246	1439	1453	1580	1600	1776	1783	2000	2017	2067	2088
1362	3628	10	1394	1599	1608	1752	1771	1959	1966	2182	2206	2263	2280
1363	3615	11											
1364		8											
1365	3637	14											
1366	3637	12											
1367	3637	11	1504	1688	1703	1855	1874	2069	2078	2293	2309	2360	2378
1368	3640	11	1502	1698	1708	1852	1867			2288	2304	2361	2376
1369	3590	10				1939	1958	2140	2152	2366	2382	2437	2458
1370	3600	10											
1371	3605	9	1495	1689	1700	1842	1863	2048	2063	2285	2300	2354	2373
1372	3586	0	1503										
1373	3599	9											
1374	3628	8	1445	1628	1640	1844	1966	2089	2104	2324	2340	2393	2410
1375	3588	10	1437	1631	1644	1800	1820	2016	2029	2267	2288	2305	2324
1376	3591	9	1456	1653	1665	1890	1915	2140	2149	2310	2327	2386	2402
1377	3624	10	1453	1638	1650	1850	1870	2066	2080	2295	2311	2363	2380
1378	3606	10	1438	1632	1646	1796	1822	2072	2090	2298	2313	2375	2405
1379	3591	10	1428	1612	1625	1778	1803	1996	2003	2230	2247	2299	2317

			Depths (ft) to Marker Beds										
Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
1380	3602	12	1340	1524	1539	1679	1700	1882	1897	2106	2122	2187	2208
1381	3622	10	1396	1571	1585	1730	1753	1940	1955	2174	2192	2252	2271
1382	3608	11	1368	1571	1583	1721	1741	1946	1957	2186	2206	2267	2287
1383	3605	10	1400	1598	1612	1757	1777	1980	1990	2216	2235	2296	2316
1384	3618	12	1312	1513	1528	1667	1688	1874	1887	2112	2130	2192	2212
1385	3607	11	1375	1590	1599	1745	1760	1968	1975	2201	2219	2280	2296
1386	3604	10	1383	1590	1602	1745	1764	1970	1975	2210	2227	2290	2308
1387	3602	11	1384	1579	1592	1735	1758	1958	1967	2192	2211	2275	2295
1388	3591	9	1362	1565	1579	1718	1738	1938	1946	2172	2190	2252	2272
1389	3609	8	1415	1627	1640	1786	1807	2009	2020	2243	2262	2320	2340
1390	3605	10	1412	1602	1618	1763	1783	1984	1992	2218	2234	2295	2316
1391	3589	11	1323	1535	1548	1676	1695	1883	1895	2113	2129	2185	2206
1392	3554	9	1070	1292	1304	1453	1479	1682	1696	1917	1932	1987	2007
1393	3510	10	1145	1345	1359	1485	1508	1707	1716	1937	1955	2010	2030
1394	3519	11	1190	1400	1412	1544	1565	1754	1762	1985	2004	2056	2075
1395	3524	12	1239	1455	1463	1598	1616	1806	1817	2036	2052	2108	2127
1396	3625	19	1806	1981	1995	2120	2140	2312	2324	2520	2539	2599	2613
1397	3606	8	1635	1829	1840	1969	1989	2172	2183	2393	2408	2460	2478
1398	3598	8	1612	1819	1830	1963	1982	2165	2175	2385	2403	2455	2473
1399	3603	10	1595	1797	1810	1948	1967	2152	2161	2371	2388	2442	2463
1400	3590	11	1635	1836	1850	1983	2003	2182	2192	2402	2418	2470	2486
1401	3636	10	1647	1846	1862	1996	2015	2195	2203	2416	2432	2483	2501
1402	3547	14	1620	1829	1835	1968	1987	2158	2168	2376	2392	2440	2457
1403	3578	11	1630	1835	1848	1982	2000	2175	2186	2393	2412	2462	2480
1404	3637	8	1700	1900	1911	2042	2063	2238	2248	2455	2472	2522	2540
1405	3598	11	1785	1988	2004	2135	2154	2342	2354	2562	2577	2633	2651
1406	3554	10	1540										
1407	3592	11	1676	1880	1890	2022	2042	2214	2222	2436	2454	2503	2522
1408	3540	11	1495	1709	1725	1859	1870	2110	2120	2285	2304	2359	2374
1409	3594	12	1735	2004	2024	2165	2190	2385	2396	2702	2723	2792	2820
1410	3502	11	1621	1851	1864	2006	2025	2216	2226	2449	2466	2525	2543
1411	3525	10	1492	1720	1734	1875	1896	2092	2100	2321	2339	2390	2408
1412	3556	10	1410	1620	1637	1773	1792	1982	1990	2203	2220	2270	2288
1413	3524	11	1392	1605	1620	1755	1775	1978	1986	2210	2229	2280	2300
1414		11	1695	1915	1926	2059	2077	2255	2265	2500	2521	2579	2595
1415	3447	10	1125										
1416	3567	19	1537	1735	1750	1885	1904	2089	2100	2308	2338	2400	2418
1417	3619	19	1690										
1418	3630	0	1760										
1419	3570	18	1660										
1420	3488	33	1085										
1421	3378	19	1186										
1422	3295	9											
1423	3156	0	1482										
1424	2997	19											
1425	2985	2	340										
1426	2921	2											
1427	2923	9		417	438	488	508	653	659			835	862

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
					Depths (ft) to Marker Beds								
1428	3118	17	945										
1429	3041	1	775										
1430	3078	16	905										
1431	3044	0	530										
1432	2990	2	414										
1433	2936	12								603	610	630	643
1434	2945	12	393										
1435	3333	9											
1436	3273	13	1096							1769	1781	1808	1823
1437	3283	12	1014										
1438	3222	9	760		772	796	809	955	962	1147	1162	1204	1225
1439	3210	11	1255										
1440	3200	11	915										
1441	3197	10	790										
1442	3210	10	1100										
1443	3192	0	880			1290	1300	1530	1542	1773	1784	1840	1859
1444	3282	2	1235										
1445	3317	14	1050	1061	1077	1212	1230	1404	1414	1626	1640	1688	1703
1446	3210	11	786	787	798	840	858	1014	1022	1225	1240	1283	1303
1447	3219	9	898	898	907	956	976	1139	1146	1307	1325	1360	1372
1448	3207	11		790	804	858	878	1045	1057	1249	1263	1307	1323
1449	3217	7											
1450	3209	11	829	829	840	890	912	1070	1080	1263	1279	1322	1333
1451	3186	10	1075	1076	1083	1140	1163	1404	1413	1558	1574	1592	1609
1452	3192	11	1205			1133	1157	1253	1266	1414	1438	1465	1477
1453	3207	11	1542										
1454	3209	12	1100										
1455	3203	10	942	942	951	1060	1070						
1456	3184	8	840	840	852	900	918	1108	1117	1191	1202	1210	1218
1457	3204	8	915	915	940	957	983	1187	1195	1393	1410	1455	1473
1458	3252	5	1373										
1459	3336	11											
1460	3476	21	1012			1090	1108	1300	1310	1530	1550	1604	1622
1461	3348	2	1123										
1462	3358	8	697	880	892	1037	1058	1235	1250	1448	1464	1528	1547
1463	3319	9	1622	1790	1806	1923	1935	2073	2079	2221	2230	2262	2274
1464	3486	11	1127	1320	1334	1468	1483	1680	1697	1923	1938	1996	2013
1465	3461	10	1160			1304	1327	1520	1535	1762	1780	1833	1850
1466	3461	9	1104	1177	1192	1323	1345	1540		1780	1802	1853	1870
1467	3460	11	1122	1191	1207	1334	1353	1548	1557	1780	1799	1852	1870
1468	3472	10	1130	1229	1245	1380	1397	1594	1609	1834	1850	1908	1923
1469	3478	10	1127	1270	1284	1418	1437	1630	1640	1875	1892	1948	1967
1470	3480	19	1140	1233	1250	1383	1402	1600	1613	1842	1860	1912	1930
1471	3477	9	1125										
1472	3464	9	1118	1240	1255	1390	1408	1595	1610	1840	1859		
1473	3454	0	1123	1210	1227	1368	1384	1580	1595	1821	1840	1893	1913
1474	3459	10	1140	1225	1240	1372	1392	1584	1600	1826	1842	1897	1916
1475	3455	10	1120	1203	1220	1360	1380	1573	1588	1808	1825	1879	1899

			Depths (ft) to Marker Beds											
Borehole ID no.	**Reference Elevation**	**KB (ft)**	**Top Sal**	**Top 103**	**Base 103**	**Top 109**	**Base 109**	**Top VT**	**Base VT**	**Top Un'n**	**Base Un'n**	**Top 123**	**Base 124**
1476	3458	10	1147	1228	1245	1377	1396	1586	1602	1818	1840	1894	1910
1477	3470	11	1140	1220	1237	1366	1385	1572	1590	1812	1830	1883	1903
1478	3410	10	1177										
1479	3468	10	1140	1333	1350	1488	1512	1694	1706	1923	1938	1991	2008
1480	3445	11	1103	1257	1274	1410	1437	1621	1637				
1481	3454	11	1132	1306	1328	1460	1481	1673	1687				
1482	3455	8	1133	1208	1222	1359	1382	1569	1583	1811	1829	1882	1901
1483	3427	10	1137	1137	1149	1262	1281	1466	1480	1688	1704	1753	1772
1484	3451	10	1158	1162	1176	1303	1320	1520	1530	1760	1778	1830	1850
1485	3438	10	1145	1145	1155	1278	1295	1487	1503	1721	1738	1790	1804
1486	3451	11	1144	1205	1222	1354	1374	1568	1581	1803	1820	1872	1895
1487	3453	10	1140	1200	1218	1352	1371			1810	1827	1880	1898
1488	3453	10	1158	1160	1171	1305	1327	1528	1542	1770	1789	1843	1860
1489	3441	11	1138	1138	1150	1273	1293	1488	1500	1722	1739	1792	1810
1490	3447	10	1137	1191	1208	1339	1362	1545	1556	1773	1792	1843	1862
1491	3443	10	1165	1164	1178	1307	1328	1520	1530	1754	1773	1824	1845
1492	3441	10	1150	1152	1162	1295	1312	1503	1520	1738	1753	1804	1826
1493	3421	9	1095		1106	1176	1202	1400	1412	1632	1651	1704	1725
1494	3444	9	1140	1140	1155	1284	1305	1500	1515	1741	1760	1810	1830
1495	3423	10	1098	1099	1112	1201	1222	1420	1432	1654	1670	1729	1747
1496	3439	9	1137	1137	1150	1270	1290	1479	1495	1710	1728	1780	1798
1497	3437	11	1120		1131	1224	1245	1434	1445	1665	1682	1732	1752
1498	3426	12	1077		1090	1183	1205	1410	1420	1650	1669	1728	1748
1499	3458	11	1157	1157	1178	1305	1329	1524	1545	1767	1784	1834	1853
1500	3411	10	1075		1085	1152	1174	1376	1385	1606	1624	1679	1700
1501	3434	11	1110		1125	1221	1243	1441	1457	1678	1698	1751	
1502	3444	13	1128	1127	1140	1258	1282	1485	1495	1720	1739	1792	1812
1503	3434	9	1115	1115	1125	1213	1233	1425	1438	1650	1668	1720	1738
1504	3433	9	1125		1136	1229	1250	1440	1451	1667	1682	1732	1750
1505	3443	8	1130	1130	1142	1265	1284	1482	1498	1721	1738	1792	1810
1506	3431	20	940	986	995	1083	1102	1310	1322	1547	1565	1616	1635
1507	3438	16	1015										
1508	3394	13	1086		1096	1159	1184	1380	1391	1618	1636		
1509	3403	11	1115		1128	1242	1262	1450	1462	1685	1700	1757	1775
1510	3398	19	1117	1115	1127	1188	1204	1395	1409	1630	1645	1700	1720
1511	3396	12	1100		1113	1170	1195	1395	1410	1643	1660	1720	1736
1512		0	1106			1195	1216	1422	1435	1666	1682	1740	1758
1513	3414	12	1097	1097	1110	1185	1203	1400	1413	1632	1647	1700	1718
1514	3406	11	1116		1130	1250	1270	1455	1470	1690	1706	1761	1780
1515	3413	13	1125			1233	1252	1449	1460	1682	1700	1754	1772
1516	3422	10	1125		1139	1234	1255	1450	1462	1691	1709	1762	1789
1517	3404	13	1148	1148	1160	1213	1234	1428	1440	1660	1676	1731	1750
1518	3382	13	1112		1124	1180	1198	1389	1405	1628	1643	1700	1717
1519	3400	11	1132		1145	1232	1253	1438	1452	1671	1686	1741	1758
1520	3404	11	1073	1076	1087	1155	1171	1370	1384	1610	1626	1683	1702
1521	3408	9	1062		1073	1142	1161	1351	1363	1583	1600	1655	1674
1522	3421	12	1109	1108	1122	1240	1262	1455	1469	1688	1706	1759	1777
1523	3428	9	1130		1145	1233	1254	1448	1462	1677	1693	1746	1764

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
			Depths (ft) to Marker Beds										
1524	3430	11	1128		1140	1255	1276	1465	1480	1695	1712	1764	1782
1525	3409	13	1117			1220	1240	1430	1449	1668	1687	1741	1758
1526	3419	10	1130		1141	1263	1288	1465	1480	1687	1702	1752	1772
1527	3419	9	1115	1120	1130	1242	1267	1456	1472	1689	1704	1755	1768
1528	3411	10	1117		1130	1249	1275	1458	1469	1683	1698	1750	1769
1529	3421	9	1142	1144	1155	1272	1296	1475	1490	1694	1710	1760	1778
1530	3414	10	1130	1130	1143	1270	1294	1476	1489	1696	1710	1759	1780
1531	3429	11	1085	1240	1256	1389	1412	1598	1610				
1532	3430	10	1155			1285	1310	1485	1496	1700	1718	1770	1782
1533	3391	11	1130	1132	1144	1266	1284	1470	1482	1700	1719	1770	1787
1534	3392	10	1170		1180	1240	1260	1448	1460	1675	1690	1744	1759
1535	3388	9	1118		1132	1220	1242	1430	1442	1668	1683	1740	1756
1536	3375	10			1268	1333	1356	1537	1552	1767	1782	1833	1850
1537	3398	10	1140			1248	1265	1444	1463	1677	1693	1750	1766
1538	3386	9	1178		1188	1247	1265	1450	1462	1678	1694	1750	1767
1539	3382	10	1175	1175	1188	1244	1266	1457	1470	1685	1701	1753	1772
1540	3386	10	1148	1150	1160	1242	1260	1440	1453	1668	1684	1740	1758
1541	3414	10	1230	1231	1240	1298	1318	1502	1514	1728	1742	1796	1812
1542	3370	11	1335	1336	1350	1390	1409	1596	1608	1850	1872	1922	1937
1543	3356	9	1310	1310	1322	1430	1452						
1544	3366	11	1485		1499	1634	1656						
1545	3311	2	1417										
1546	3307	10	1412	1446	1457	1584	1604	1768	1777	2009	2030	2074	2092
1547	3349	11	1297	1297	1308	1336	1351	1546	1555	1760	1775	1825	1837
1548	3332	9	1440		1449	1550	1573	1741	1752	1962	1975	2009	2027
1549		0	1405		1417	1507	1527	1700	1712	1932	1948	1996	2013
1550	3490	10	1673	1880	1897	2040	2058	2250	2258	2490	2507	2578	2597
1551	3478	11	1433	1668	1682	1816	1836	2032	2045	2260	2278	2333	2352
1552	3456	11	1428	1633	1646	1773	1792	1978	1993	2212	2229	2283	2302
1553	3424	11	1550	1752	1767	1910	1928	2112	2128	2360	2378	2444	2464
1554	3497	8	1312	1524	1538	1665	1689	1872	1883	2098	2116	2169	2188
1555	3431	10	1347	1565	1581	1716	1742	1932	1945	2164	2185	2245	2264
1556		0	1374									2268	2284
1557	3392	34	1335										
1558	3353	11	1410	1608	1625	1758	1778	1960	1976	2190	2206	2259	2280
1559	3358	9	1463	1670	1684	1822	1842	2030	2040	2280	2298	2355	2379
1560	3342	12	1435	1635	1650	1788	1807	1986	2000	2225	2242	2297	2317
1561	3332	11	1395	1596	1612	1744	1763	1950	1964	2198	2217	2271	2292
1562	3320	12	1387	1585	1607	1741	1762	1935	1946	2162	2178	2230	2249
1563	3353	10	1315	1510	1528	1658	1675	1848	1859	2072	2088	2140	2157
1564	3344	11	1339	1528	1545	1675	1695	1862	1873	2082	2099	2152	2170
1565	3422	9	1385	1564	1585	1726	1748	1944	1956	2177	2192	2245	2264
1566	3386	12	1096	1220	1237	1377	1400	1586	1604	1846	1862	1915	1934
1567	3332	0	1192	1374	1392	1535	1552	1734	1748	1977	1992	2042	2062
1568	3391	13	1224	1428	1443	1580	1599	1780	1792	2022	2038	2088	2108
1569	3325	7	1334	1542	1556	1697	1716	1902	1915	2152	2168	2222	2240
1570	3346	11	1432	1625	1642	1783	1801	1983	1998	2222	2240	2292	2310
1571	3346	12	1437	1639	1651	1792	1810	2005	2017	2256	2272	2332	2353

Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
			Depths (ft) to Marker Beds										
1572	3339	0	1265	1470	1486	1640	1666	1884	1901	2195	2216	2288	2313
1573	3163	10	1095										
1574	3143	1	1290										
1575	3123	0	1068										
1576	3115	10	1065										
1577	3087	0	973										
1578		0											
1579	3012	4											
1580	2965	10	375	430	447	472	491	652	662	855	872	932	950
1581	2975	11	600	634	645	753	770	923	933				
1582	2978	8											
1583	2993	8	790	810	831								
1584	2953	8	388	434	452	518	539	697	706	912	925	971	986
1585	2964	14	512	512	528	550	564			900	915	939	962
1586	2912	7	330	346	362	431	446			847	871	914	932
1587	2900	12	360	415	426	549	569	712	722	870	886	934	942
1588	2972	9											
1589	2875	9											
1590	2892	10	414	484	499	538	557	650	654	765	778	884	898
1591	3201	1	1545										
1592	3165	10	1632										
1593	3179	9						1580	1590			1677	1687
1594	3059	8	1162										
1595	3090	10											
1596	3210	10	1294	1294	1306	1356	1371	1540	1548	1742	1761	1783	1797
1597	3059	9											
1598		0	850	900	910	929	948	1050	1071				
1599	2982	10											
1600	3220	0	1300	1403	1416	1520	1538	1704	1714	1950	1972	1995	2008
1601		0	1267	1336	1345	1484	1500	1712	1723				
1602	3238	9	1202	1259	1271	1368	1382	1568	1579	1782	1796	1848	1868
1603	3225	32											
1604		0	1245	1270	1280	1348	1365	1550	1558	1720	1730	1754	1772
1605	3282	11	1685										
1606	3177	10	956	956	968	1094	1113	1298	1308	1525	1543	1591	1611
1607	3180	0	1595										
1608	3133	11	963	963	974	1090	1106	1346	1353	1523	1540	1587	1608
1609	3122	11	1020	1024	1035	1165	1183	1388	1400	1642	1660	1713	1735
1610	3113	11	1006	1010	1020	1157	1166	1382	1390	1632	1648	1708	1726
1611	3130	11	1034	1034	1047	1182	1200	1406	1419	1658	1675	1728	1749
1612	3122	11	987	993	1003	1114	1133	1342	1353	1589	1607	1660	1682
1613	3132	11	967	967	982	1097	1103	1298	1307	1522	1538	1583	1602
1614	3124	11	967	969	979	1084	1102	1292	1303	1527	1544	1596	1616
1615	3134	12	975	975	988	1093	1112	1302	1312	1528	1545	1588	1613
1616	3130	19	1005	1009	1018	1144	1163	1361	1371	1604	1622	1673	1696
1617	3131	9	994	994	1008	1126	1147	1347	1358	1585	1603	1652	1673
1618	3113	11	930	930	942	1033	1054	1243	1254	1484	1501	1554	1576
1619	3264	10	1095	1300	1314	1450	1472	1656	1665	1887	1903	1954	1976

			Depths (ft) to Marker Beds										
Borehole ID no.	Reference Elevation	KB (ft)	Top Sal	Top 103	Base 103	Top 109	Base 109	Top VT	Base VT	Top Un'n	Base Un'n	Top 123	Base 124
1620	3122	11	1055	1055	1066	1215	1233	1433	1443	1679	1697	1754	1775
1621	3414	10	1235	1458	1473	1637	1653	1865	1875	2155	2175	2253	2278
1622	3392	11	1115	1342	1356	1509	1532	1743	1756	2030	2048	2118	2142
1623	3332	0	1005			1402	1428	1671	1682	1990	2010	2088	2110
1624		9	1203										
1625		0	1265										
1626	3013	0	1163										
1627	3032	0	1194										
1628	3853	17	2331	2506	2516	2634	2646	2803	2815			3058	3069
1629	3741	26	1878	2076	2087	2212	2230	2398	2410	2600	2609	2674	2693
1630	3480	0											
1631	3659	9	1638	1840	1852	1985	2000	2180	2198	2383	2392	2454	2472
1632	3572	22	1467	1667	1680	1808	1816	1994	2007	2182	2196	2254	2269
1633	3645	11	1227	1412	1430	1557	1578	1742	1758	1937	1955	2010	2030
1634	3094	12	594										
1635	3612	24	1840	2030	2048	2178	2197	2374	2384	2587	2602	2658	2673
1636	3506	20	1550										
1637	2968	8	240										
1638	3456	11				858	874	1058	1068	1288	1308	1360	1377
1639	3726	12	1708	1885	1898	2030	2042	2220	2228	2403	2420	2463	2483
1640		2	1105										
1641	3410	0	842										
1642	3384	0											
1643	3413	0	821										

All drillholes within the Rustler data base were included, even if the Salado was uninterpretable. Drillhole locations, names, and other data are presented in tables of Rustler location data and can be cross-indexed with the identification number.

APPENDIX A-3
TABLE OF DATA ON DEPTH TO RUSTLER UNITS

Table of Data on Depth to Rustler Units

ID No.	Reference Elevation	KB (ft)	49'r	Depth (ft) to top of units Mag	Tam	Cul	ulm	Sal	Revisions
1001		3	118					278	
1002	3568	10							
1003	3510	0	164					316	
1004	3618	1	504	565	582	660	675	736	
1005	3466	10	500			576	587	624	
1006	3554	10	358	411	434	508	525	587	
1007	3510	9	314	375	396	468	483	557	
1008	3766	9	794	841	856	927	942	1017	
1009	3733	9	757	808	824	902	913	990	
1010	3651	7	561	606	628	730	754	840	
1011	3648	18							
1012	3624	10	563	619	634	706	720	790	
1013	3631	10	578	632	650	721	736	775	
1014	3551	10	545	596	618	692	708	785	
1015	3568	3	500	555	576	648	663	735	
1016	3566	3	574	622	640	720	734	810	
1017	3580	5	590	638	660	732	748	830	
1018	3571	0	606	665	682	760	775	840	
1019		3	613	670	687	759	775	828	
1020	3885	10	1158	1207	1222	1302	1322	1394	
1021	3783	0	1103	1150	1168	1260	1275	1350	
1022	3751	0	1017	1044	1060	1157	1168	1274	
1023	3382	10	940	996	1019	1112	1137	1300	
1024	4027	13	1587	1634	1652	1743	1755	1828	
1025	4104	10	1753	1797	1815	1904	1915	1988	
1026	3952	10	1633	1682	1699	1796	1807	1880	
1027	3800	0	1407	1460	1479	1576	1588	1663	Rev loc ctr, NE1/4, SE1/4
1028	3779	21	1278	1330	1351	1447	1462	1546	
1029	4011	12	1483	1525	1540	1602	1615	1677	
1030	4098	8	1631	1675	1694	1774	1783	1843	
1031		12	1775	1824	1842	1932	1947	2026	
1032	4023	11	1820	1872	1892	1985	1999	2075	
1033	4000	13	1793	1852	1870	1960	1972	2050	
1034	3957	17	1714	1775	1793	1885	1905	1983	
1035	3920	14	1745	1794	1807	1885	1900	1968	
1036	3961	14	1600	1645	1658	1733	1750	1810	
1037	3962	11	1562	1604	1619	1690	1705	1765	
1038	3968	13	1535	1580	1595	1668	1683	1744	
1039	3958	14	1598	1643	1657	1737	1748	1814	
1040	3991	12	1512	1566	1582	1647	1653	1678	
1041	3980	0	1501	1547	1562	1640	1657	1720	
1042	3948	13	1853	1908	1926	2022	2036	2112	
1043	3789	0	1825	1870	1883	1945	1948	2038	
1044	3822	11	1909	1958	1969	2042	2050	2137	
1045	3816	0	1811	1855	1870	1940	1943	2030	
1046	3783	0	1783	1828	1840	1904	1908	1997	
1047	3698	0	1643	1685	1700			1810	
1048	3750	13							

ID No.	Reference Elevation	KB (ft)	49'r	Mag	Tam	Cul	ulm	Sal	Revisions
			Depth (ft) to top of units						
1049	3660	0	1965	2007	2017	2084	2090	2168	
1050	3664	0	1520	1560	1572			1653	
1051	3399	9						305	
1052		0				90	114	218	
1053		0				120	142	245	Rev loc NW1/4, NW1/4
1054	3402	10	183	223	245	290	310	388	
1055	3529	0	524	576	596	673	692	740	
1056	3577	21	682	745	764	853	873	978	
1057	3559	21	619	685	702	775	796	898	
1058	3526	8	497	565	586	666	683	746	
1059	3576	16	802	906	927	1045	1064	1172	
1060	3974	10	1855	1920	1940	2037	2063	2150	
1061	3815	13	1805	1867	1884	1979	2000	2080	
1062	3723	0	1761	1822	1840	1944	1963	2045	
1063	3743	0	1753	1818	1838	1950	1966	2052	
1064	3703	12	1779	1845	1863	1970	1995	2080	
1065		0	1480	1525	1538	1604	1614	1680	
1066	3759	11	1474	1517	1533	1650	1660	1704	
1067	3744	11	1777	1828	1841	1942	1955	2038	
1068	3702	0	1230	1280	1293	1363	1371	1446	Rev loc NE1/4, NW1/4
1069	3580	0	1220	1257	1272	1320	1325	1397	
1070		0				403		520	Log lacks loc data
1071	3325	18							
1072	3505	19	480	536	553	629	645	713	
1073	3523	16							
1074	3448	16	828	892	915	1052	1068	1170	
1075	3550	16	1121	1184	1207	1370	1387	1495	
1076	3510	15	883	949	972	1112	1128	1236	
1077	3565	15	1163	1248	1274	1404	1422	1524	
1078	3586	7	1372	1440	1464	1623	1648	1756	
1079	3524	0	1103	1172	1194	1343	1362	1470	
1080	3509	0	1076	1140	1165	1314	1335	1450	
1081	3642	19	1485	1560	1580	1752	1770	1887	
1082	3677	21	1743	1814	1830	1994	2009	2110	
1083	3708	7	1590	1654	1674	1832	1854	1957	
1084	3720	10	1567	1639	1660	1827	1847	1949	
1085	3701	0	1973	2048	2067	2208	2220	2315	
1086	3603	0	1005	1050	1062	1135	1143	1218	
1087	3662	0	1985	2058	2073	2210	2227	2330	
1088	3604	0	1465	1505	1516			1671	
1089	3542	0	1427	1470	1480	1551	1559	1635	
1090	3412	20	187					495	
1091	3471	18	200					500	
1092	3472	13	255				410	550	
1093	3468	13	445				608	740	
1094	3487	17	830	895	915	1012	1032	1145	
1095	3432	18	312	402	423	546	561	680	
1096	3309	16	146				291	450	

ID No.	Reference Elevation	KB (ft)	Depth (ft) to top of units 49'r	Mag	Tam	Cul	ulm	Sal	Revisions
1097	3458	18	345				490	655	
1098	3444	18	200					505	
1099	3177	0	152	175	193	292	318	421	
1100	3250	23	160					502	
1101	3218	22	130				356	485	
1102	3347	0	215	285	310	420	446	531	rev from geoph log
1103	3428	0	449	513	537	631	653	748	Ref El from SAND79-0284
1104	3540	0	538	598	623	713	739	811	
1105	3748	14	1505	1575	1598	1772	1785	1890	
1106	3792	18	1550	1622	1645	1820	1840	1945	
1107	3793	22	1568	1645	1665	1840	1862	1988	
1108	3740	21	1530			1838	1860	1950	
1109	3668	15	1345			1545	1570	1765	
1110	3652	18	1162	1236	1260	1444	1466	1580	
1111	3800	17	1450	1525	1550	1734	1760	1885	
1112	3862	10	1565	1642	1664	1837	1858	2005	Rev loc SE1/4, SE1/4
1113	3861	22	1515	1593	1617	1833	1858	1947	
1114	3834	21	1555	1630	1654	1840	1857	1972	
1115	3679	21	1056	1110	1130	1282	1303	1455	
1116	3798	13	1293	1360	1382	1610	1635	1781	
1117	3504	0							
1118	3662	8	670	732	758	872	896	982	
1119	3780	23	778	837	860	992	1008	1090	
1120	3802	4	1760	1838	1858	2032	2055	2180	
1121	3564	0	1455	1504	1526	1655	1668	1758	Surf El from log
1122	3638	17	1757	1825	1843	1983	1997	2095	
1123	3603	11	1825	1900	1917	2074	2092	2200	
1124		0	1804	1880	1896	2094	2105		
1125		0							
1126	3594	5	1425	1464	1475	1582	1590	1670	Rev loc SE1/4, SW1/4; log elev
1127	3550	0	1420			1572	1579	1660	
1128	3593	10	1426	1466	1478	1583	1589	1670	Rev loc SE1/4, SW1/4; ?DUP 1126
1129	3568	0	1476	1517	1527	1634	1640	1720	
1130	3545	10	1486	1517	1527	1630	1640	1720	
1131	3635	0	1580	1642	1661	1799	1807	1900	
1132	3581	0	1560	1600	1612	1735	1740	1817	
1133	3580	3	1555	1597	1614	1722	1732	1817	
1134		0	1167	1210	1219	1295	1305	1377	
1135		0	1150	1190	1200	1275	1283	1368	
1136	3304	12						495	
1137	3023	0	0	19	36	61	90	166	
1138	2977	0					43	130	
1139	3357	20	315	380	400	495	515	625	
1140	3193	18	170					520	
1141	3221	23	275					600	
1142	3323	0	401	449	468	550	578	677	
1143	3214	1	232	302	328	447	472	565	Rev loc, elev from SAND79-0279
1144	3358	0	387	452	477	576	595	686	

ID No.	Reference Elevation	KB (ft)	49'r	Mag	Tam	Cul	ulm	Sal	Revisions
1145	3376	0	462	519	544	636	656	747	
1146	3309	23	215					535	
1147	3152	0	12	79	99	187	208	306	
1148		0	395	454	479	572	591	708	
1149	3418	0	641	700	724	828	849	962	
1150	3439	13	676	740	764	857	881	964	
1151	3433	0	657	716	740	834	860	973	
1152	3429	0	639	707	729	817	836	952	Ref elev typo revised
1153	3541	9	668	727	750	848	873	990	
1154	3553	0	780	839	866	957	979	1100	
1155	3508	0	732	784	809	900	922	1041	
1156	3510	0	734	786	812	904	924	1040	
1157	3496	21							
1158	3405	0	517	564	583	704	725	845	
1159	3484	12	641	703	727	825	848	966	
1160	3472	0	623	685	710	808	827	946	
1161	3345	0	426	490	513	608	628	720	
1162	3349	0	427	492	515	612	632		
1163	3382	0	468	528	553	645	665	783	
1164	3457	0	614	674	698	791	810	928	
1165	3426	0	574	630	654	742	763	885	
1166	3417	0	559	617	641	732	752	867	
1167	3433	0	590	647	672	756	777	894	
1168	3420	12	550	608	632	716	739	860	
1169	3506	0	746	799	823	916	938	1058	
1170	3546	0	759	816	839	972	995	1116	
1171	3596	8	755	830	856	1018	1038	1190	
1172	3479	0	626	703	728	912	936	1084	
1173	3508	0	686	758	781	935	957	1084	
1174	3441	0	610	662	685	782	802	928	
1175	3473	8	668	722	745	829	851	977	rev from TME3159 BDR
1176	3478	0	690	748	774	864	884	1008	Rev loc from OFR78-592
1177	3398	0							
1178	3346	0	357	422	446	545	572		Elev from SAND89-0202; ?Cul
1179	3377	0	457	516	542	627	647		
1180	3395	6	509	565	590	680	700	826	
1181	3345	0	359	424	448	546	567	676	
1182	3354	0	358	418	442	540	560	656	
1183	3310	0	232	296	322	420	436	542	
1184	3413	0	566	623	649	740	766		Rev for H11b3; SAND89-0200
1185	3409	0	562	617	644	738	758	880	
1186	3644	10	860	920	942	1100	1125	1275	
1187	3731	11	950	1005	1025	1140	1165	1290	
1188	3701	20	885	940	960	1072	1103	1200	
1189	3696	15	900	955	980	1090	1110	1230	
1190	3620	9	760	835	860	1070	1090	1245	
1191	3640	19	835	895	920	1080	1110	1240	
1192	3687	12	870	935	960	1100	1125	1265	

ID No.	Reference Elevation	KB (ft)	49'r	Depth (ft) to top of units Mag	Tam	Cul	ulm	Sal	Revisions
1193	3789	25	1048	1115	1140	1285	1315	1462	
1194	3756	0	1145	1210	1230	1430	1460	1608	
1195	3640	13	1715	1785	1805	2000	2030	2160	
1196	3537	0	1600	1682	1700	1918	1942	2092	Elev from Richey (1989); KB??
1197	3573	0	1690	1778	1795	2005	2032	2185	
1198	3611	18	1822	1900	1915	2102	2112	2225	
1199	3613	7	1856	1936	1952	2148	2160	2285	
1200	3611	11	1860	1935	1955	2142	2175	2300	
1201	3623	1							
1202	3581	13	1810	1885	1905	2110	2142	2275	
1203	3610	0	1877	1960	1979	2180	2193		
1204	3533	22	1920	2005	2020	2290	2322	2470	
1205	3571	10	1815	1890	1910	2130	2165	2292	
1206		0	1755	1840	1855	2098	2108	2210	
1207		0	1770	1860	1877	2125	2142	2275	
1208		13	1560	1603	1611	1724	1735	1825	
1209	3571	0	1560	1603	1612	1722	1734	1822	
1210	3587	0	1567	1610	1620	1728	1739	1825	
1211	3552	0	1465	1508	1517	1632	1641	1725	
1212	3540	0	1424	1472	1480	1590	1600	1687	
1213	3560	0	1475	1517	1528	1637	1645	1735	
1214	3582	18	1360	1420	1430	1572	1588	1685	
1215	3589	11	1602	1678	1700	1875	1890	2008	
1216	3507	0	1535	1578	1588	1700	1715	1805	
1217	3498	0	1360	1415	1427	1562	1575	1683	
1218	3469	0	1422	1466	1474	1584	1594	1684	
1219	3410	0	1125	1170	1180	1295	1305	1385	Rev loc NW1/4, SW1/4
1220	3405	0	1130	1173	1182			1360	
1221	3316	0	1190					1408	
1222	3337	0	1123	1160	1170	1259	1268	1350	
1223		10							
1224		0							
1225	3045	18							
1226	2996	19							
1227	3027	12						212	
1228	3014	12						195	
1229	3024	19						212	
1230	3163	0	87	117	140	237	274	283	
1231	3197	24						425	
1232	3028	12						217	
1233	3215	15							?DUP 1234
1234	3215	15							
1235	3290	23	150	210	235	330	353	470	DWP reinterp log 9/20/94
1236	3384	13		378	397	489	517	640	Rev from BDR: SAND79-0271
1237		0	310					710	
1238	3453	10	623	700	722	891	917	1068	rev from geoph log
1239	3340	0	382	438	463	562	582	713	Ref elev from OFR78-592
1240	3336	0	391	450	477	565	587	715	

ID No.	Reference Elevation	KB (ft)	49'r	Mag	Tam	Cul	ulm	Sal	Revisions
			Depth (ft) to top of units						
1241	3335	0	315	377	403	493	515	626	
1242	3332	0	312	373	398	500	521	627	
1243	3328	8	363	375	414	469	487	653	Data from WTSD-TME-020
1244	3323	0	316	376	402	503	523	642	
1245	3492	10	742	809	833	968	992	1118	
1246	3511	27	794	850	876	968	990	1100	
1247	3426	0	621	678	703	825	849	976	Rev from BDR; SAND90-0201
1248	3381	23	476			657	682	808	
1249	3374	9	460	520	542	645	663	797	
1250	3452	22	763	817	841	942	968	1092	
1251	3461	11	775	830	850	945	978	1090	
1252	3506	21	865	922	940	1050	1072	1190	
1253	3454	10	750	810	830	927	950	1063	
1254	3464	27	758	814	835	922	955	1070	
1255	3459	12	750	806	825	920	945	1060	Rev elev from geophys log
1256	3402	12	497	560	585	680	705	837	
1257	3374	22							
1258	3358	8	360	430	450	570	587	695	
1259	3392	8	430	495	520	622	648	816	
1260		7	780	835	860	950	975	1095	sw1/4,sw1/4 converted
1261	3727	12	1155	1213	1235	1420	1445	1584	
1262	3699	11	1140	1195	1215	1383	1405	1545	
1263	3723	5	1195	1275	1294	1505	1529	1680	
1264	3722	12	1178	1243	1263	1473	1500	1640	
1265	3622	21	1025	1085	1110	1215	1245		
1266	3697	11	1210	1262	1285	1368	1392	1512	Grnd elev from topo map
1267	3699	14	1217	1270	1294	1376	1402		
1268	3701	10	1163	1215	1240	1377	1401	1517	
1269	3720	10	1225	1294	1315	1526	1557	1710	
1270	3725	13	1235	1308	1325	1532	1570	1727	
1271	3700	13	1208	1280	1300	1510	1532	1683	
1272	3720	10	1212	1282	1302	1520	1544	1695	
1273	3698	12	1225	1295	1315	1500	1525	1678	
1274	3705	9	1215	1288	1306	1512	1532	1680	
1275	3659	11	1222	1292	1312	1472	1493	1630	Ref elev rev from log
1276	3713	12	1225	1296	1312	1496	1520	1667	
1277	3687	0	1180	1236	1258	1385	1415	1535	
1278	3551	8	862	923	945	1050	1078	1206	
1279	3666	8	1200	1260	1285	1355	1386	1520	
1280	3629	9	1170	1230	1250	1365	1387	1508	
1281	3671	11	1187	1260	1278	1453	1472	1623	Ref elev rev from log
1282	3694	12	1206	1282	1298	1483	1506	1657	
1283	3676	11		1290	1308	1507	1527	1675	Ref elev rev from log
1284	3700	8	1215	1281	1302	1475	1495	1635	
1285	3692	12	1205	1275	1293	1475	1498	1653	Ref elev rev from log
1286	3663	8	1200	1263	1282	1425	1448	1567	
1287	3689	11	1193	1262	1280	1453	1475	1623	
1288	3669	11	1210	1282	1300	1490	1512	1655	

ID No.	Reference Elevation	KB (ft)	49'r	Mag	Tam	Cul	ulm	Sal	Revisions
			Depth (ft) to top of units						
1289	3630	8	1183	1233	1252	1355	1387	1505	
1290	3695	8	1207	1276	1295	1496	1526	1670	Ref elev rev from log
1291	3689	0	1210	1280	1296	1493	1517	1680	
1292	3664	11	1206	1278	1297	1495	1517	1673	
1293	3636	11	1160	1240	1260	1485	1507	1657	
1294	3704	10	1260	1340	1355	1600	1622	1772	
1295	3722	11	1270	1350	1367	1588	1612	1757	
1296	3715	12	1268	1350	1367	1590	1615	1773	
1297	3722	11	1230	1310	1328	1545	1568	1710	
1298	3726	9	1290	1370	1387	1610	1635		
1299	3711	13	1230	1310	1327	1550	1571	1732	
1300	3720	13	1233	1310	1330	1550	1573	1735	
1301	3713	13	1222	1296	1313	1530	1553	1710	
1302	3703	11	1225	1303	1320	1541	1568	1720	
1303	3713	25	1285	1364	1385	1610	1634	1790	
1304	3701	12	1280	1358	1376	1597	1620	1785	
1305		11	1252	1333	1349	1577	1600	1760	
1306	3683	8	1268	1343	1360	1582	1606	1770	
1307	3659	0	1310	1395	1415	1650	1672	1815	
1308	3533	0	988	1066	1084	1310	1330	1469	
1309	3555	19	1095	1182	1200	1425	1455	1605	
1310	3425	14	912	984	1006			1275	
1311	3490	22	944					1400	
1312	3515	0	1625	1708	1723	1888	1903	2030	
1313	3494	9	1655	1725	1740	1885	1900	2020	
1314		0	1393	1437	1446	1570	1577	1663	
1315	3468	0		1625	1635	1824	1837	1950	
1316	3459	0	1593	1672	1683				
1317	3324	0	1143	1176	1188	1244	1252	1337	
1318	3383	0	1262					1493	
1319	3317	0	1090	1130	1137	1192	1200	1287	
1320	3317	0	1047	1086	1097	1154	1165	1228	
1321	3282	11	1365	1410	1418	1522	1531	1620	
1322	3320	9	1168	1214	1219	1329	1340	1435	
1323	2968	10							
1324	2984	0							
1325		6							
1326		0							
1327		4							
1328		6							
1329	2969	28							
1330	2941	11							
1331	2997	18							
1332	2924	11	450					696	
1333	3447	12	370			470	493	660	
1334	3179	11							
1335	3433	0	400	467	492	589	614		
1336	3429	12	473	552	572	650	675	840	

ID No.	Reference Elevation	KB (ft)	49'r	Mag	Tam	Cul	ulm	Sal	Revisions
			Depth (ft) to top of units						
1337	3266	5							
1338	3502	23	853	912	935	1065	1095	1250	
1339	3500	9	676	750	762	852	880	1010	
1340	3432	2		578	600	696	725	835	
1341	3436	10	485	553	573	688	715	832	
1342	3406	0	465	535	565	665	687	791	
1343	3414	10	453	522	545	648	675	812	
1344	3430	28	455	528	548	658	680	805	
1345	3438	23	478	550	573	700	720	826	
1346	3535	11	600	670	692	790	810	960	
1347	3528	13	768	826	850	986	1010	1130	
1348	3553	13	762	819	843	936	959	1098	
1349	3553	4	665	730	755	850	873	1025	Ref elev calc from log
1350	3514	10	576	645	667	780	795	915	
1351	3530	11	605	670	690	800	820	965	
1352	3490	12	530	597	619	729	750	895	
1353	3535	11	693			792	813	923	
1354	3551	12	695	755	775	872	895	1017	
1355	3502	23	595						
1356	3508	25	628	702	722	828	855	1010	
1357	3620	10	1183	1252	1269	1410	1433	1562	
1358	3623	12							
1359	3632	11	1185	1239	1255	1348	1371	1500	
1360	3631	11	1172	1238	1255	1388	1408	1533	
1361	3584	8	888	947	965	1090	1116	1246	
1362	3628	10	1088	1138	1161	1248	1270	1394	
1363	3615	11							
1364		8							
1365	3637	14							
1366	3637	12							
1367	3637	11	1192	1247	1264	1352	1372	1504	
1368	3640	11	1157	1210	1227	1352	1378	1502	
1369	3606	11							Loc rev from geoph log
1370	3600	10	1204	1254	1270				
1371	3605	9	1130	1201	1220	1347	1370	1495	Ref elev rev from log
1372	3586	0	1187	1238	1260	1352	1371	1503	
1373	3599	9							
1374	3628	8	1132	1184	1204	1295	1315	1445	
1375	3588	10	1122	1182	1200	1283	1308	1437	
1376	3591	9	1130	1190	1210	1301	1323	1456	
1377	3624	10	1142	1199	1218	1309	1327	1453	
1378	3606	10	1122	1180	1198	1287	1306	1438	
1379	3591	10	1110	1158	1180	1275	1298	1428	
1380	3602	12	1025	1083	1102	1191	1208	1340	
1381	3622	10	1065	1126	1145	1239	1258	1396	
1382	3608	11	1052	1106	1122	1213	1235	1368	
1383	3605	10	1070	1132	1151	1243	1265	1400	Ref elev rev from log
1384	3618	12	998	1053	1072	1165	1188	1312	

ID No.	Reference Elevation	KB (ft)	Depth (ft) to top of units 49'r	Mag	Tam	Cul	ulm	Sal	Revisions
1385	3607	11	1060	1114	1132	1222	1243	1375	
1386	3604	10	1062	1120	1140	1226	1248	1383	
1387	3602	11	1066	1125	1140	1225	1246	1384	
1388	3591	9	1047	1100	1118	1201	1223	1362	
1389	3609	8	1093	1150	1170	1261	1284	1415	
1390	3605	10	1088	1148	1168	1253	1275	1412	
1391	3589	11	1008	1063	1082	1174	1197	1323	
1392	3554	19	746	806	829	928	953	1070	
1393	3510	10	830	890	910	1002	1025	1145	
1394	3519	11	881	940	960	1052	1075	1190	
1395	3524	12	906	962	980	1070	1090	1239	
1396	3625	19	1278	1367	1382	1600	1632	1806	
1397	3606	8	1187	1255	1272	1452	1475	1635	
1398	3598	8	1174	1246	1265	1445	1467	1612	
1399	3603	10	1204	1257	1276	1440	1465	1595	
1400	3590	11	1184	1257	1273	1452	1475	1635	
1401	3636	10	1203	1270	1290	1468	1490	1647	
1402	3547	14	1225	1295	1310	1462	1485	1620	
1403	3578	11	1194	1270	1287	1465	1486	1630	
1404	3637	8	1215	1291	1308	1520	1542	1700	
1405	3598	11	1245	1330	1347	1600	1613	1785	
1406	3554	10	1190	1250	1267	1385	1409	1540	
1407	3592	11	1205	1282	1297	1485	1503	1676	
1408	3540	11	1140	1212	1228	1335	1357	1495	
1409	3594	12	1220	1289	1309	1502	1527	1735	
1410	3502	11	1186	1259	1275	1458	1481	1621	
1411	3525	10	1146	1206	1224	1314	1332	1492	
1412	3556	10	1070	1120	1138	1240	1260	1410	
1413	3524	11	1063	1122	1141	1228	1250	1392	
1414		11	1163	1230	1243	1513	1535	1695	
1415	3447	10				995	1012	1125	
1416	3567	19	1045	1122	1139	1368	1392	1537	
1417	3619	19	1185	1263	1282	1517	1540	1690	
1418	3630	0	1245	1327	1345	1573	1598	1760	
1419	3570	18	1134	1215	1230	1455	1482	1660	
1420	3488	33	835	900	920	1005	1025	1085	
1421	3378	19	820	890	905	1040	1062	1186	
1422	3295	9	1155	1197	1210	1311	1320		
1423	3156	0	1202					1482	
1424	2997	19							
1425	2985	2				147	182	340	
1426	2921	2							
1427	2923	9							
1428	3118	17	670					945	
1429	3041	1						775	
1430	3078	16	680					905	
1431	3044	0	175					530	Ref elev rev from log
1432	2990	2	115					414	

ID No.	Reference Elevation	KB (ft)	Depth (ft) to top of units 49'r	Mag	Tam	Cul	ulm	Sal	Revisions
1433	2936	12							
1434	2945	12	260					393	
1435	3333	9					816	923	
1436	3273	13	848	915	937	1029	1041	1096	
1437	3283	12	888					1014	
1438	3222	9				560	597	760	Grnd el from topo; ref is +9ft
1439	3210	11	970			1078	1094	1255	Ref el from log; topo differs
1440	3200	11	745					915	Ref el rev from geoph log; ?DUP 1439
1441	3197	10	678					790	
1442	3210	10	970					1100	
1443	3192	0	699			820	848	880	Ref el from topo; KB not given
1444	3282	2	900					1235	
1445	3317	14	780	799	809	878	900	1050	
1446	3210	11	595					786	
1447	3219	9	640					898	
1448	3207	11	440	502	524	613	638		
1449	3217	7							
1450	3209	11	498	560	584	663	686	829	
1451	3186	10	725	782	797	886	908	1075	
1452	3192	11	1050					1205	
1453	3207	11	1053			1360	1375	1542	
1454	3209	12	880					1100	
1455	3203	10	756			820		942	
1456	3184	8	608					840	
1457	3204	8	675					915	
1458	3252	5	1178	1194	1208	1270	1283	1373	
1459	3336	11	1165			1243	1275		
1460	3476	21	715			842	870	1012	
1461	3348	2	820	890	915	1010	1032	1123	
1462	3358	8	360	427	450	560	588	697	
1463	3319	9	1325					1622	
1464	3486	11	803	863	882	978	1004	1127	
1465	3461	10	790	855	875	983	1006	1160	Grnd el 3451 from topo map
1466	3461	9	756	820	848	940	967	1104	
1467	3460	11	782	845	866	973	996	1122	
1468	3472	10	787	847	868	965	993	1130	
1469	3478	10	792	850	872	968	993	1127	
1470	3480	19	791	853	872	972	999	1140	
1471	3477	9	780	840	862	964	990	1125	
1472	3464	9	785	848	868	968	993	1118	
1473	3454	0	774	833	854	962	987	1123	Grnd el 3454 from topo, no KB
1474	3459	10	794	860	880	982	1007	1140	Grnd el 3449 from topo map
1475	3455	10	780	845	865	963	988	1120	Grnd el 3445 from topo map
1476	3458	10	793	858	878	980	1005	1147	Grnd el 3448 from topo map
1477	3470	11	793	850	872	972	993	1140	
1478	3410	10	837	899	923	1021	1044	1177	Loc rev from SW1/4, SE1/4
1479	3468	10	808	876	905	991	1013	1140	
1480	3445	11	762	825	848	949	972	1103	

ID No.	Reference Elevation	KB (ft)	49'r	Mag	Tam	Cul	ulm	Sal	Revisions
			Depth (ft) to top of units						
1481	3454	11	787	852	875	976	998	1132	
1482	3455	8	773	840	862	962	982	1133	
1483	3427	10	765	828	848	953	982	1137	
1484	3451	10	787	854	875	985	1003	1158	Grnd el 3441 from topo, +KB
1485	3438	10	782	843	863	968	992	1145	Grnd el 3428 from topo, +KB
1486	3451	11	780	843	865	963	993	1144	
1487	3453	10	780	845	867	966	990	1140	Grnd el 3443 from topo, +KB
1488	3453	10	792	858	878	983	1008	1158	Grnd el 3443 from topo, +KB
1489	3441	11	776	841	862	942	965	1138	
1490	3447	10	769	834	855	962	983	1137	
1491	3443	10	787	854	875	982	1003	1165	
1492	3441	10	780	846	867	973	995	1150	Grnd el 3431 from topo; +KB
1493	3421	9	695	758	779	902	927	1095	
1494	3444	9	763	827	850	960	983	1140	
1495	3423	10	743	805	823	915	938	1098	
1496	3439	9	769	833	856	955	980	1137	
1497	3437	11	745	810	832	942	960	1120	
1498	3426	12	715	778	800	898	922	1077	
1499	3458	11	766	828	852	962	984	1157	
1500	3411	10	697	765	786	895	918	1075	
1501	3434	11	742	813	835	940	961	1110	
1502	3444	13	760	822	844	952	972	1128	
1503	3434	9	727	795	816	936	960	1115	
1504	3433	9	772	833	852	953	976	1125	
1505	3443	8	768	836	855	961	983	1130	Ref el rev from log
1506	3431	20	607	668	692	803	822	940	
1507	3438	16	643	705	727	836	857	1015	
1508	3394	13	730	790	812	905	932	1086	
1509	3403	11	740	811	834	938	967	1115	Grnd el 3392 from topo, +KB
1510	3398	19	747	800	822	931	958	1117	
1511	3396	12	726	787	810	916	938	1100	
1512		0	726	792	813	927	953	1106	Grnd el 3400 from log, no KB
1513	3414	12	713	784	803	907	934	1097	
1514	3406	11	737	802	823	943	966	1116	
1515	3413	13	752	815	835	947	975	1125	
1516	3422	10	738	806	826	941	967	1125	
1517	3404	13	775	842	863	962	985	1148	
1518	3382	13	755	812	835	943	962	1112	
1519	3400	11	756	816	836	952	978	1132	
1520	3404	11	707	770	792	894	917	1073	
1521	3408	9	692	756	776	877	905	1062	
1522	3421	12	720	782	806	918	943	1109	
1523	3428	9	730	804	828	945	970	1130	
1524	3430	11	768	845	865	948	973	1128	
1525	3409	13	746	810	832	930	957	1117	Ref elev rev from log
1526	3419	10	748	812	835	942	966	1130	Grnd el 3409 from topo, +KB
1527	3419	9	738	800	825	933	959	1115	
1528	3411	10	747	810	832	935	960	1117	

ID No.	Reference Elevation	KB (ft)	49'r	Mag	Tam	Cul	ulm	Sal	Revisions
			Depth (ft) to top of units						
1529	3421	9	770	825	860	953	977	1142	
1530	3414	10	750	816	837	950	973	1130	
1531	3429	11	748	808	834	930	955	1085	
1532	3430	10	773	838	861	970	993	1155	
1533	3391	11	755	823	845	960	988	1130	
1534	3392	10	785	856	875	984	1008	1170	
1535	3388	9	738	802	822	930	953	1118	
1536	3375	10	900	958	977	1072	1097		
1537	3398	10	782	850	870	960	985	1140	
1538	3386	9	813	875	895	993	1018	1178	
1539	3382	10	818	875	895	993	1018	1175	
1540	3386	10	768	832	855	960	987	1148	
1541	3414	10	868	930	950	1040	1063	1230	
1542	3370	11	957	1023	1042	1140	1166	1335	
1543	3356	9	923	988	1012	1100	1132	1310	
1544	3366	11	1142	1202	1224	1315	1347	1485	
1545	3311	2	1072	1132	1150	1242	1270	1417	
1546	3307	10	1075	1130	1153	1238	1263	1412	
1547	3349	11	935	995	1020	1128	1155	1297	Ref el rev from log
1548	3332	9	1055	1116	1142	1250	1277	1440	
1549		0	1045	1112	1128	1225	1250	1405	DF 3354 log; grnd el 3346 from topo
1550	3490	10	1200	1255	1268	1506	1530	1673	
1551	3478	11	1106	1168	1186	1258	1292	1433	
1552	3456	11	1065	1120	1140	1259	1285	1428	
1553	3424	11	1138	1195	1213	1372	1395	1550	
1554	3497	8	985	1038	1057	1150	1180	1312	
1555	3431	10	1012	1077	1095	1183	1210	1347	
1556		0	1042	1098	1117	1207	1232	1374	
1557	3392	34	1006	1075	1092	1184	1209	1335	
1558	3353	11	1060	1114	1130	1227	1250	1410	
1559	3358	9	1045	1117	1136	1283	1310	1463	
1560	3342	12	1047	1105	1127	1258	1285	1435	
1561	3332	11	1045	1108	1125	1210	1237	1395	
1562	3320	12	1023	1082	1098	1213	1237	1387	
1563	3353	10	975	1038	1053	1143	1170	1315	
1564	3344	11	1002	1056	1074	1167	1188	1339	
1565	3422	9	995	1060	1083	1171	1196	1385	
1566	3386	12	742	800	824	927	951	1096	
1567	3332	0	875	927	945	1042	1067	1192	
1568	3391	13	900	956	971	1070	1096	1224	
1569	3325	7	965	1025	1045	1170	1197	1334	
1570	3346	11	1038	1102	1117	1250	1277	1432	
1571	3346	12	1023	1085	1104	1260	1287	1437	
1572	3339	0	852	905	925	1083	1119	1265	
1573	3163	10	917					1095	
1574	3143	1	1030					1290	
1575	3123	0	870	912	920	980	990	1068	
1576	3115	10	873	913	919	979	992	1065	

ID No.	Reference Elevation	KB (ft)	Depth (ft) to top of units 49'r	Mag	Tam	Cul	ulm	Sal	Revisions
1577	3087	0	790	830	838	906	915	973	
1578		0							
1579	3012	4							
1580	2965	10	200				263	375	
1581	2975	11	315			452	477	600	
1582	2978	8	700				858		
1583	2993	8	502	570	594	682	718	790	
1584	2953	8					238	388	
1585	2964	14						512	
1586	2912	7					190	330	
1587	2900	12					240	360	
1588	2972	9							
1589	2875	9							
1590	2892	10						414	
1591	3201	1	1260	1320	1347	1440	1462	1545	
1592	3165	10	1304	1375	1402	1502	1530	1632	
1593	3179	9	1046	1115	1133	1225	1257		Ref el 3179, 3180 from log
1594	3059	8	815			948	978	1162	
1595	3090	10							
1596	3210	10	950	1012	1037	1125	1165	1294	
1597	3059	9							
1598		9	455			688	711	850	
1599	2982	10							
1600	3220	0	1021	1080	1103	1209	1234	1300	topfnr revised 9/27/94
1601		0	1003	1044	1068	1147	1178	1267	
1602	3238	9	1000	1050	1062	1078	1103	1202	
1603	3225	32							
1604		0	920			1093	1115	1245	
1605	3282	11	1388	1445	1460	1542	1567	1685	
1606	3177	10	589	650	667	768	798	956	Loc rev from NE1/4, SE1/4
1607	3180	0	1280	1335	1350	1453	1467	1595	
1608	3133	11	583	643	662	770	794	963	
1609	3122	11	625	687	708	828	855	1020	
1610	3113	11	623	684	702	830	847	1006	
1611	3130	11	633	698	717	852	874	1034	
1612	3122	11	600	665	682	805	825	987	
1613	3132	11	587	653	672	792	813	967	Ref el rev from log
1614	3124	11	590	648	664	780	802	967	
1615	3134	12	593	656	676	798	816	975	Grnd el 3122 from topo, +KB
1616	3130	19	623	690	708	824	848	1005	
1617	3131	9	595	670	687	807	828	994	
1618	3113	11	540	600	620	745	765	930	
1619	3264	10	740	808	826	930	956	1095	
1620	3122	11	659	727	746	876	897	1055	
1621	3414	10	856	915	926	1052	1084	1235	
1622	3392	11	744	810	830	943	972	1115	
1623	3332	0	635	699	714	833	862	1005	
1624		9	1054	1102	1117	1152	1168	1203	

ID No.	Reference Elevation	KB (ft)	49'r	Depth (ft) to top of units Mag	Tam	Cul	ulm	Sal	Revisions
1625		0	983	1034	1045	1145	1156	1265	
1626	3013	0	932	972	981			1163	
1627	3032	0	970			1082	1102	1194	
1628	3853	17	1905	1983	2002	2202	2217	2331	
1629	3741	26	1422	1503	1523	1716	1737	1878	
1630	3480	0	692	748	773	859	885		
1631	3659	9	1164	1225	1248	1467	1490	1638	
1632	3572	22	1155	1210	1230	1340	1362	1467	
1633	3645	11	922	986	1008	1112	1137	1227	
1634	3094	12	266					594	
1635	3612	24	1322	1403	1422	1648	1673	1840	
1636	3506	20	1170	1226	1242	1392	1416	1550	
1637	2968	8						240	
1638	3456	11							
1639	3726	12	1212	1288	1308	1533	1558	1708	
1640		2	400	520	545	722	753	1105	
1641	3410	0	532	590	616	703	724	842	Data from BDR SAND89-0203
1642	3384	0	509	564	591	706	731		Data from BDR SAND89-0204
1643	3413	0	506	571	594	689	713	821	Data from BDR SAND89-0204

All drillholes within the Rustler data base were included, even if parts or all of the Rustler were uninterpretable. Drillhole location, names, and other data are presented in tables of Rustler location data and can be cross-indexed with the identification number.

APPENDIX A-4

TABLE OF DATA FOR DEPTHS TO DEWEY LAKE AND SANTA ROSA FORMATIONS

Table of Data for Depth to Dewey Lake and Santa Rosa Formations

Borehole ID no.	Reference Elevation	Rustler Fm	DEPTH (in feet) to Top of: Dewey Lake	Santa Rosa	"Chinle"
1072		480	130	0	0
1074	3448	828	520	355	
1075		1121	625	400	
1076	3510	883	450	230	
1077		1163	730	520	
1078		1372	905	690	
1079	3524	1103	635	415	100
1080	3509	1076	610	370	
1090	3412	187	90		
1091	3471	200	70		
1092	3472	255	40		
1093	3468	445	50		
1094	3487	830	620	510	10
1095		312	60		
1096	3309	146	30		
1099	3177	152	79		
1102	3347				
1103	3427	449	0		
1104	3540	538	72	17	
1105	3748	1505	1035	805	310
1106	3792	1550	1065	830	345
1107	3793	1568	1050	820	455
1108	3740	1530	1040	750	400
1109	3668	1345	840	565	
1110		1162	625	440	
1111	3800	1450	855	615	360
1112	3862	1565	985	825	
1113	3861	1515	1030	800	
1114	3834	1555	1055	790	
1115	3679	1056	580		
1118	3662	670	115		
1119		778	250		
1120	3802	1760	1275	1015	355
1137	3023				
1138	2977				
1141	3221	275	40		
1142	3323	401	44		
1143	3212	232	17		
1144	3358	387	42		
1145	3376	462	8		
1147	3152	12			
1148		395	20		
1149	3418	641	120		
1150	3439	676	174	42	
1151	3433	657	154	11	

Borehole ID no.	Reference Elevation	Rustler Fm	DEPTH (in feet) to Top of: Dewey Lake	Santa Rosa	"Chinle"
1152	3249	639	141	15	
1153	3541	668	177	35	
1154	3553	780	261	6	
1155	3508	732	224	8	
1156	3510	734	225	8	
1158	3405	517	80		
1159	3484	641	168	30	
1160	3472	623	146	12	
1161	3345	426	38		
1162	3349	427			
1163	3382	468	41		
1164	3457	614	140	8	
1165	3426	574	80		
1166	3417	559	73	40	
1167	3433	590	96	14	
1168	3420	550	63	54	
1169	3506	746	224	9	
1170	3546	759	232	8	
1172	3479	626	87	9	
1173	3508	686	151	8	
1174	3441	610	99	8	
1175	3473	668	133	46	
1176	3478	690	164	38	
1177	3398				
1178	3345	357	35		
1179	3377	457	32		
1180	3395	509			
1181	3345	359	40		
1182	3354	358	18		
1183	3310	232	32		
1184	3409	557	162	36	
1185	3409	562	66	11	
1186	3644	860	394		
1187	3731	950	450	90	
1188	3701	885	530		
1189	3696	900	395		
1190	3620	760	240	10	
1191	3640	835	330		
1192	3487	870	330	37	
1193	3789	1048	513		
1194	3756	1145	625		
1230	3163	87	57		
1237	3426	310	110		
1238		623	62		
1239	3339	382	46		
1240	3336	391	38		

Borehole ID no.	Reference Elevation	Rustler Fm	DEPTH (in feet) to Top of: Dewey Lake	Santa Rosa	"Chinle"
1241	3335	315			
1242	3332	312	45		
1244	3323	316	32		
1245		742	190		
1247	3425	621	70		
1248		476	64		
1249	3374	460	44		
1250		763	215	25	
1251	3461	775	210	135	
1252	3506	865	620		
1253	3454	750	190		
1254	3464	758	630		
1255	3458	750	120		
1256	3402	497	140		
1259		430	50		
1260		780	215		
1261	3727	1155	542	400	
1262	3699	1140	582	370	
1263	3723	1195	655	390	
1264	3722	1178	637	370	
1265	3622	1025	480	275	
1266	3696	1210	665	445	
1267	3699	1217	670	465	
1268	3701	1163	615	405	
1269	3720	1225	693	450	
1270	3725	1235	700	535	
1271	3700	1208	655	480	
1272	3720	1212	660	360	
1273	3698	1225	673	455	
1274	3705	1215	665	448	
1275	3658	1222	670	452	
1276	3713	1225	670	446	
1277	3687	1180	630	408	
1278	3551	862	330		
1279	3666	1200	640	420	
1280	3629	1170	630	445	
1281	3670	1187	635	408	
1282	3694	1206	640	420	
1283	3675		590	360	
1284	3700	1215	655	413	
1285	3691	1205	655	445	
1286	3663	1200	655	430	
1287	3689	1193	625	395	
1288	3669	1210	652	430	
1289	3630	1183	640	460	
1290	3694	1207	660	440	
1291	3689	1210	727		

Borehole ID no.	Reference Elevation	DEPTH (in feet) to Top of: Rustler Fm	Dewey Lake	Santa Rosa	"Chinle"
1292	3664	1206	650	420	
1293	3636	1160	637	365	
1294	3704	1260	790	496	
1295	3722	1270	740	504	
1296	3715	1268	730	506	
1297	3722	1230	700	475	
1298	3726	1290	745	525	
1299	3711	1230	695	455	
1300	3720	1233	695	470	
1301	3713	1222	690	440	
1302	3703	1225	690	445	
1303	3713	1285	700		
1304	3701	1280	705	500	
1305		1252	705	480	
1306	3686	1268	715	490	
1307	3659	1310	735	540	
1332	2924	450	20		
1333		370	205		
1335	3433	400	155	65	
1338	3502	853	290		
1341	3436	485	30		
1342	3406	465			
1343	3414	453	70		
1344	3430	455	70		
1345	3438	478	145		
1346	3535	600	155		
1347		768	210		
1348		762	250		
1349	3553	665	235		
1350	3514	576	120		
1351	3530	605	95		
1352	3490	530	165	85	
1353	3535	693	145		
1354	3551	695	165		
1355	3502	595	150		
1356	3508	628	270		
1357	3620	1183	635	455	
1359	3632	1185	615	435	
1360	3631	1172	555	380	
1361	3584	888	350	140	
1362	3628	1088	580	405	
1367	3637	1192	635	425	
1368	3640	1157	595	380	
1370	3600	1204	635	410	
1371		1130	590	350	
1372	3586	1187	605	390	
1374	3628	1132	520	375	
1375	3688	1122	510	305	

Borehole ID no.	Reference Elevation	Rustler Fm	DEPTH (in feet) to Top of: Dewey Lake	Santa Rosa	"Chinle"
1376	3591	1130	510	295	
1377	3624	1142	585	370	
1378	3606	1122	585	315	
1379	3591	1110	500	260	
1380	3602	1025	475	240	
1381	3622	1065	495	265	
1382	3608	1052	490	315	
1383	3604	1070	505	305	
1384	3618	998	450	225	
1385	3607	1060	485	300	
1386	3604	1062	490	305	
1387	3602	1066	495	280	
1388	3591	1047	475	270	
1389	3609	1093	520	340	
1390	3605	1088	505	295	
1391		1008	440		
1392		746	360		
1393	3510	830	295		
1394	3619	881	425	305	
1395		906	405		
1396	3625	1278	820	650	
1397	3606	1187	630	410	
1398	3598	1174	635	405	
1403	3578	1194	620	390	
1404	3637	1215	635	410	
1405	3598	1245	670	445	
1406	3554	1190	605	395	
1407	3592	1205	620	385	
1408	3540	1140	555	315	
1410	3502	1186	585	355	
1411	3525	1146	570	345	
1412	3556	1070	475	265	
1413	3524	1063	495	265	
1414		1163	665	340	
1436	3273	848	570		
1437	3283	888	485		
1440	3199	745	405		
1441	3197	678	350		
1443	3190	699	365		
1444	3282	900	400	200	
1445	3317	780	360	220	
1446	3210	595	360	195	
1447	3219	640	280		
1448		440	230		
1450		498	230		
1451	3186	725	470	380	
1452	3192	1050	705		
1453	3207	1053			

Borehole ID no.	Reference Elevation	Rustler Fm	DEPTH (in feet) to Top of: Dewey Lake	Santa Rosa	"Chinle"
1454	3209	880	330		
1455		756	300	190	
1456	3184	608	265		
1457	3204	675	375		
1458	3252	1178	595	305	
1459		1165			
1460	3476	715	345		
1461	3348	820	285		
1463	3319	1325	660	390	
1464	3486	803	280		
1465		790	250		
1466	3461	756	225		
1468	3472	787	260		
1471	3477	780	255		
1472	3464	785	255		
1473		774	240		
1474		794	250		
1477	3470	793	260		
1478	3410	837	300		
1479	3468	808	270		
1480	3445	762	210		
1481	3454	787	230		
1482	3455	773	215		
1486	3451	780	235		
1487		780	240		
1488		792	210		
1491	3443	787	240		
1492		780	225		
1495	3423	743	210		
1496	3439	769	220		
1499	3458	766	185		
1500	3411	697	215		
1501	3434	742	190		
1502	3444	760	215		
1503	3434	727	210		
1506	3431	607	190		
1507	3438	643	225		
1508	3394	730	220		
1509		740	145		
1512		726	215		
1513	3414	713	220		
1514	3406	737	170		
1515	3413	752	190		
1517	3404	775	195		
1522	3421	720	165		
1524	3430	768	210		
1526		748	160		
1527	3419	738	160		

Borehole ID no.	Reference Elevation	Rustler Fm	DEPTH (in feet) to Top of: Dewey Lake	Santa Rosa	"Chinle"
1528	3411	747	185		
1529	3421	770	200		
1530		770	140		
1531	3429	748	190		
1532	3430	773	175		
1533	3391	755	235		
1534	3392	785	215		
1535	3388	738	175		
1536	3375	900	225		
1537	3398	782	215		
1538	3386	813	255		
1539	3382	818	255		
1540	3386	768	205		
1541	3414	868	315		
1542	3370	957	385	125	
1543	3356	923	410	360	
1544	3366	1142	560		
1545	3311	1072	565	330	
1546	3307	1075	585	380	
1547	3348	935	350		
1548	3332	1055	700		
1549	3354	1045	450		
1550	3490	1200	580	320	
1551	3478	1106	525	270	
1552	3456	1065	460	255	
1553	3424	1138	530	270	
1554	3497	985	425	165	
1555	3431	1012	410	165	
1556		1042	430	200	
1557	3392	1006	385	180	
1558	3353	1060	465	230	
1559	3358	1045	445	205	
1560	3342	1047	455	255	
1561	3332	1045	410	200	
1562	3320	1023	520	225	
1563	3353	975	382	190	
1564	3344	1002	410	180	
1565	3422	995	390	200	
1566	3386	742	150		
1567	3332	875	285		
1568	3391	900	360	160	
1569	3325	965	360	165	
1570	3346	1038	445	220	
1580		200	20		
1581		315	130		
1582		700	220		
1591		1260	815	695	
1592		1304	845	755	

Borehole ID no.	Reference Elevation	Rustler Fm	DEPTH (in feet) to Top of: Dewey Lake	Santa Rosa	"Chinle"
1593		1048	530		
1594	3059	815	135		
1596		950	700	530	150
1598		605	455		
1600		1021	450	275	
1601		1003	605	445	
1602		1000			
1604		920	575	385	
1605	3282	1388	815	550	
1606	3177	589	50		
1607	3180	1280	860	685	
1608	3133	583	80		
1609	3122	625	85		
1611	3130	633	80		
1612	3122	600	95		
1613	3131	587	75		
1614	3124	590	95		
1615		593	85		
1616	3130	623	100		
1617	3131	595	80		
1618	3113	540	95		
1619	3264	740	125		
1620	3122	659	75		
1628		1905	1415	1160	190
1629		1422	895	670	
1630		693	170	90	
1631		1164	636		
1632		1155	560		
1633		922	460		
1634		266	55		
1635		1322	750	520	80
1636		1170	670		
1639		1212	670		
1640		400	245	150	
1641	3410	532	52		37
1642	3384	509	55		22
1643	3413	506	20		8

Drillhole locations, names, and other data are presented in tables of Rustler location data and can be cross-indexed with the identification number.

APPENDIX B

RUSTLER FORMATION STRATIGRAPHIC DATA FROM RICHEY (1989)

APPENDIX B
RUSTLER FORMATION STRATIGRAPHIC DATA FROM RICHEY (1989)

Appendix B repeats Rustler Formation stratigraphic data available from Richey (1989) in a form comparable to Rustler information in Appendix A. Appendix B-1 reports the location and drillhole name as used by Richey. Drillhole formats differ from Appendix A, although boreholes common to each database (Appendix C) have names somewhat similar.

Richey assigned a unique numeric identifier for each drillhole and designated this number the FFG #. Those numbers range between 1 and 817, although not all consecutive numbers have been assigned (or have been deleted).

The depths to Rustler beds are reported by Richey in metric units, and we repeat the metric values (Appendix B-2). The original data would have been in English units, standard for geophysical logs in the United States. For use in our maps, we converted metric to English units.

We accept the data in Richey (1989) as substantially correct. A few typographical or other errors have been corrected and are noted. The tabular material has been carefully checked to try to avoid introducing new errors. Data from boreholes common to the Richey data set and the Holt and Powers data set were compared (Appendix C) to uncover any systematic errors.

APPENDIX B-1

DRILLHOLE NAME AND LOCATION DATA FROM RICHEY (1989)

Drillhole Name and Location Data from Richey (1989)

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
001	20	33	3	660s	660w	Fed. Trigg #1	
002	20	33	3	658n	660e	Fed. "Lea" #2-3	
004	20	33	7	660s	1980e	Brooks 7 Fed. #3	
005	20	33	10	330s	330e	Anderson Pritchard Fed. #1	
006	20	33	11	660s	660w	#1 Fed. 11	
007	20	33	14	2310n	990w	Fed. #4	
008	20	33	14	990s	2310w	Fed. C-1	
009	20	33	14	1980n	1650w	Fed. #3	
010	20	33	14	2310s	1980w	Fed. #1B	
011	20	33	14	660n	660w	Fed. #1A	
012	20	33	15	660n	660e	Fed. #1	
013	20	33	16	660n	1980e	St. Lea (886) #2	
014	20	33	18	1980n	660w	Welsh-St. #2	
015	20	33	19	2005n	1880w	Bass Fed. No. 1	
016	20	33	22	1980s	660e	"Wills" Fed. TA #1	
017	20	33	23	330n	1980e	Fed. Lindsey #1	
018	20	33	24	330s	330e	Dinnin #2	
019	20	33	26	660s	660w	Hudson Fed. #1	
020	20	33	30	1980n	1980w	#1 Bass Fed.	
021	20	33	30	660s	1300e	Bass Fed. #2	
022	20	33	31	660s	1980e	St. of New Mexico CM No. 1	
023	20	33	33	1980s	660w	#1 Aztec Fed.	
024	20	33	34	660s	1980e	Fed. "34" - #1	
025	20	33	35	660n	1980e	Shell Fed. #1	
026	20	33	35	660n	1980w	Shell Fed. #1	
027	20	33	35	1650n	990w	R.R. Morrison C & E Fed. #1	
028	19	35	5	1980n	1980w	Jackson #1	
029	19	35	12	1980s	1980w	W.M. Snyder #1	
030	19	35	15	330s	660e	Cabot St. #2	
031	19	35	17	1980s	1980e	Gulf Roberts #1	
032	19	35	19	990s	660w	Superior-Alves Trustee #1	
033	19	35	21	660s	1980e	McIntosh D #3	
034	19	35	24	1650n	660w	Texaco-Hamon St. A-1	
035	19	35	25	1980n	668e	Record No. 2	
036	19	35	29	2310n	990w	St. "PK" #1	
037	19	35	34	660n	660w	St. W.M.A. #1	
038	19	35	36	1980n	1980w	St. "PJ" #1	
039	20	32	10	330n	990w	Perry Fed. #1	
040	20	32	13	660s	1980w	Hanson St. #1	
041	20	32	15	1980s	1980w	Plata Deep Unit #1	
042	20	32	16	2310n	2310w	St. Little Eddy Unit #16	
043	20	32	21	1980s	660w	Big Eddy Unit #1-21	
044	20	32	23	1980s	1980w	Baetz "23" #1	
045	20	32	25	660s	660e	Audie Richards #1	

FFG No.	T.	R.	Sec.	Location Data: Distance from section line*		Drillhole Name**	Revision
046	20	32	36	1976n	660e	St. of New Mexico "CH" No. 1	
047	20	34	14	660s	1980e	Fed. Hanson B No. 1	
048	20	34	18	1980s	1980e	Fed. #1	
049	20	34	21	660s	660e	Muse No. 2	
050	20	34	26	330s	330w	Cruces No. 1	
051	20	34	27	330s	1650e	Fed. Keohone "A" No. 1	
052	20	34	27	330s	330e	Fletcher No. 2	
053	20	34	34	1650n	2310w	Lynch No. "A"-9	
054	20	34	34	660s	1980e	B.V. Lynch "A" No. 5	
055	20	34	34	1650s	660e	B.V. Lynch "A" No. 8	
056	20	34	34	1980n	1980e	Lynch "A" No. 11	
057	20	34	34	660n	1980w	B.V. Lynch "A" No. 10	
058	20	34	35	1650s	990w	Lynch A-7	
059	20	34	35	1650s	2310e	Neal No. 1	
060	20	34	35	990n	1650w	Fed. #4	
061	20	34	35	990n	990w	Fletcher No. 1	
062	20	35	3	670n	1980w	Linam 1	
063	20	35	5	1980s	330e	#8 Fed. Saunders	
064	20	35	6	660n	660e	Featherstone Fed. No. 1	
065	20	35	12	660n	660e	Leonard St. #1	
066	20	35	13	660n	660w	St. 13 #1	
067	20	35	17	1980s	660e	Hudson Fed. #1	
068	20	35	23	660n	660w	U.S.A. West Monument #1	
069	20	35	28	660s	660w	Phillips St. #1	
070	20	35	30			Sunray St. No. 1	
071	19	32	6	1980n	1980e	W.H. Peckham No. 1	
072	19	32	13	990s	990e	W.E. Bondurant #3	
073	19	32	13	2310n	330e	W.E. Bondurant #2	
074	19	32	13	2310s	330e	W.E. Bondurant #1	
075	19	32	15	1980n	660e	#8 Plains Unit	
076	19	32	16	660s	660w	Humble St. #1	
077	19	32	18	1980n	990e	Middleton Fed. "A" #1	
078	19	32	19	1980n	2310e	Southern Calif. Pet. Corp. No. 1	
079	19	32	21	1650s	990w	Atlantic No. 1	
080	19	32	33	660n	660w	Boellner Fed. No. 2	
081	19	32	25	330n	330e	Fed. Big Circle #1	
082	19	32	34	1980s	660e	Fed.-Boellner #1	
083	19	33	8	1980s	660w	USA Culbertson Irwin #1	
084	19	33	18	1980s	2035w	Fed. 18 No. 5	
085	19	33	18	2130n	689w	Fed. 18 No. 1	
086	19	33	18	2310s	330w	Fed. 18 No. 7	
087	19	33	21	660n	1980w	Bright Fed. No. 1	
088	19	33	22	1980s	495e	Miller-Fed. #1	
089	19	33	24	800s	330w	Donohue #1	
090	19	33	26	660s	1980w	Bates Fed. #1	
091	19	33	29	330s	1980e	Fed. No. 1	

FFG No.	Location Data T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
092	19	33	29	660n	660w	Fed. Carder #1	
093	19	33	30	660n	1980e	Signal Ross #1	
094	19	33	30	1980n	2004w	Signal Ross Fed. #2	
095	19	33	3	2082n	1980w	Buffalo Unit #1	
096	19	34	5	330n	660w	Fed. Littlefield "EA" #1	
097	19	34	7	1980n	1980e	Mescalero Unit #1	
098	19	34	12	660n	660w	U.S. Smelting St. #1	
099	19	34	13	2310s	330w	Atlantic Richfield #1	
100	19	34	15	330s	330w	Gulf Fed. #1	
101	19	34	25	1980s	660w	Superior Fed. #4	
102	19	34	28	990s	2310w	Fed. #1	
103	19	34	30	2310s	330w	Drlg. & Exploration Gillespie No. 1-"B"	
104	19	34	36	660s	330e	Pure St. #1	
105	21	30	25	1098s	969w	Wills-Crosby #1	
106	21	30	26	983n	1361w	Wills-Crosby #2	
107	21	30	26	660s	1980w	James "D" #1	
108	21	31	31	264n	471w	Wills #7	
109	21	31	32	300n	2540w	FC-63 (Kerr McGee)	
110	21	31	32	141s	141e	FC-68 (Kerr McGee)	
111	21	31	34	250n	2207e	FC-52 (Kerr McGee)	
112	21	31	34	100s	100w	FC-65 (Kerr McGee)	
113	21	31	34	141n	160w	FC-69 (Kerr McGee)	
114	22	30	1	990s	1980w	Cabana #1	rev'd 974s, 1976w w/log data
115	22	30	2	660s	2011e	James "A" #1	
116	22	30	3	693n	977e	Duval #96	
117	22	30	3	1320s	300e	USB&C #168	
118	22	30	4	50n	650e	Gypsy Oil Co. #3	
119	22	30	9	315s	291w	USPC #97A	
120	22	30	9	1320n	2600w	USB&C #163	
121	22	30	9	2406n	578w	IMC #322	
122	22	30	9	1485s	650w	IMC #343	
123	22	30	10	1883n	2574e	Duval #82	
124	22	30	11	1976n	1981e	James "E" #1	
125	22	30	11	1247s	1301w	D-121	
126	22	30	13	1574n	1566w	D-120	
127	22	30	14	136s	2178e	D-48	
128	22	30	21	109s	81e	Duval #33	
129	22	30	21	1320n	2640e	IMC #111	
130	22	30	21	1320s	1320w	IMC #112	
132	22	30	27	2664s	2625e	Duval #181	
133	22	30	27	38s	2643w	Duval #198	
134	22	30	27	500s	20w	Duval #200	
135	22	30	27	2370s	224e	Duval #231	
136	22	30	36	2463s	1124w	D-160	
137	22	30	36	660s	2006e	James Ranch #1	
138	22	31	6	1173s	1147w	U-134 (Miss. Chem. Corp.)	

FFG No.	T.	R.	Sec.	Location Data: Distance from section line*		Drillhole Name**	Revision
139	22	31	6	1978n	660w	Campana #1	
140	22	31	8	143s	249e	FC-92 (Kerr McGee)	
141	22	31	8	154s	37w	FC-82 (Kerr McGee)	
142	22	31	9	107n	91e	NF-1 (Kerr McGee)	
143	22	31	34	2022s	1978w	Fed. Cotton Baby #1	
144	23	29	1	2763s	2964e	Duval #29	
145	23	29	1	528s	528w	IMC I-184	
146	23	29	1	1320n	1320e	IMC I-263	
147	23	29	4	1255n	1374e	Arco #9	
148	23	29	12	2600n	700e	Shell Oil Co. #17 (Dogtown #)	
149	23	29	13	2100n	300e	Shell Oil Co. #21 (Dogtown #15)	
150	23	29	15	202n	2524e	Duval #8	
151	23	29	15	1160n	3276e	Duval #14	
152	23	29	17	660s	1980w	Teledyne "17" #1	
153	23	29	24	300n	300e	Shell Oil Co. #19 (Dogtown #13)	
154	23	29	25	200n	2500e	Shell Oil Co. #22 (Dogtown #16)	
155	23	29	27	660s	1980w	Laguna Grande #2	
156	23	29	28	1380s	990e	#1 Laguna Grande Unit	
157	23	29	35	1900s	100e	A-29	
158	23	29	36	1800s	1200e	A-31	
159	23	30	1	1834n	1978w	Hudson Fed. #1	
160	23	30	1	1973s	1648e	James Ranch Unit #3	
161	23	30	2	101s	1169w	Duval #1	
162	23	30	2	143n	112w	Duval D-31	
163	23	30	2	2655n	2655e	Duval D-179	
164	23	30	17	2505n	317w	Shell Oil Co. #6 (Dogtown #1)	
165	23	30	19	2244n	2096e	Duval #10	
166	23	30	24	1980n	660w	Sandy Unit #1	
167	23	30	26			USGS #22	
168	23	30	28	175s	232w	Duval #4	
169	23	30	29	261n	261e	Shell Oil Co. #7 (Dogtown #2)	
170	23	30	30	215n	2300w	Shell Oil Co. #20 (Dogtown #14)	
171	23	30	31	2640n	1750e	Arco #24	
172	23	30	32	1411n	2510e	Shell Oil Co. #23 (Dogtown #17)	
173	23	30	36	2150n	3090w	Leonard ?????? #1-S	
174	24	28	2	1980s	660w	Malaga "A" #1	
175	24	29	3	2030n	2310w	Weiner & McDonald Kerr #1	
176	24	29	4	1327s	1321e	Arco core test #13	
177	24	29	19	480n	330w	Bun #1	
178	24	29	27	660s	660w	Mobil Fed. "27" #1	
179	24	29	29	1980s	660w	Ellis Fed. 1-X	
180	24	30	2	200s	200w	Shell Oil Co. #16 (Dogtown #11)	
181	24	30	5	1147n	406e	Shell Oil Co. #11 (Dogtown #6)	
182	24	30	6	1990n	2185w	Arco #8	
183	24	30	9	2001n	2001e	Shell Oil Co. #8 (Dogtown #3)	
184	24	30	11	316s	390w	Shell Oil Co. #12 (Dogtown #)	

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
185	24	30	15	200n	200w	Shell Oil Co. #13 (Dogtown #)	
186	24	30	16	150n	2590e	Shell Oil Co. #24 (Dogtown #18)	
187	24	30	18	460n	660e	Poker Lake Unit #45	
188	24	30	20	100n	1320w	Southern Production Co. core test #6	
189	24	30	23	1606n	2294e	Shell Oil Co. #9 (Dogtown #4)	
190	24	30	23	660s	660w	Shugart Fed. 23 #1	
191	24	30	25	660s	660w	Bass Fed. #1-25	
192	24	30	27	336n	270e	Shell Oil Co. #10 (Dogtown #)	
193	24	30	29	660s	660e	Fed. Nettles (?) #1	
194	24	31	2	1980n	1980w	#1-2 Todd Fed.	rev'd 1945w to 1980w w/log data
195	24	31	3	660s	660e	Jennings Fed. #1	
196	24	31	4	660n	660e	Stewart Fed. #1	
197	24	31	4	1659n	2310w	Bestly (?) Fed. #1	
198	24	31	5	330n	330e	USGS potash core test #13	
199	24	31	6	1098n	2193e	Shell Oil Co. #15	
200	24	31	6	1980n	1980w	Dunes (?) Unit Fed. #1	
201	24	31	7	660s	660e	Fed. "Y" #1	
202	24	31	11	2531n	178e	Shell Oil Co. #4 (Fed. G-NM #4)	
203	24	31	11	660n	1980e	Fed. Littlefield "CT" #1	
204	24	31	13	1980s	1980e	1-13 Fed.	
205	24	31	17	660n	660e	Continental Fed. #1	rev'd 740e to 660e w/log data
206	24	31	18	660s	660e	Ritchie Fed. #1	
207	24	31	20	660n	660e	Jennings Fed. #1	
208	24	31	20	660s	1980w	Poker Lake #40	
209	24	31	21	660n	660e	Carper Fed. #1-21	
210	24	31	21	660s	660w	Poker Lake Unit #43	
211	24	31	28	660s	660e	Poker Lake #36	
212	24	31	24	660s	1980e	Heflin Fed. #1	
213	24	31	33	2310n	2313e	Ramley (?) #1	
214	24	31	35	1980s	660w	Cotton Draw Unit #67	
215	25	30	1	660n	660e	Poker Lake Unit #2	
216	25	30	4	1980n	1980w	R&B Fed. #1	
217	25	31	2	100n	1500w	Dog Town #2	
218	25	31	2	1980n	1980e	Cotton Draw Unit #65	FFG 602 eliminated as duplicate
219	25	31	10	1980n	1980e	Pauley & Harrison #2	
220	25	31	12	660n	660w	Pauley & Harrison #1	
221	25	31	15	780n	1230w	Pauley & Harrison PH-1	
222	25	31	28	660n	660w	Poker Lake Unit #7-A-3	
223	25	31	35	660s	660w	Del Basin #1	
224	21	32	1	330n	1380e	Sheperd #1	
225	21	32	1	3255n	1972e	ETZ Fed. #1	
226	21	32	1	660s	1980w	Fed. #1	
227	21	32	2	660s	1980e	#1 Hat Mesa "A"	
228	21	32	2	3300n	660w	Pubco Fed. #1	
229	21	32	3	660s	1980e	#1 TSS Fed. Comm.	
230	21	32	3	3300s	1980w	New Mexico Fed. "B" #1	

FFG No.	Location Data T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
231	21	32	4	1980n	1980e	New Mexico Fed. "A" #2	
232	21	32	4	3300s	1980w	New Mexico Fed. "D" #1	
233	21	32	4	1683n	1650w	New Mexico Fed. #1	
234	21	32	5	4650s	1980w	New Mexico Fed. "F" #1	
235	21	32	5	3300s	660e	New Mexico Fed. "E" #1	
236	21	32	6	3371n	2072w	Aid Fed. #1	
237	21	32	9	1980n	1980e	Halfway Fed. #1	
238	21	32	10	1980n	1980e	Government "H" Com. #1	
239	21	32	11	660s	660e	Fed. 1	
240	21	32	11	1980n	1980e	Hat Mesa #1	
241	21	32	12	1980s	660w	Fed. HM "12" #1	
242	21	32	21	660n	660w	Salt Lake South Unit #1	
243	21	32	26	1980n	660e	San Simon #1	
244	21	32	35	1980n	1980w	Chaney Fed. #1	
245	21	33	9	1980n	660e	South Lynch #1	
246	21	33	11	660n	640w	Mobil St. #2	
247	21	33	13	660s	1880e	New Mexico St. #1	
248	21	33	13	1980s	1980e	Berry St. #1	
249	21	33	15	1980s	1980e	Stock Unit #1	
250	21	33	18	660s	1980e	Eaves Unit #1	
251	21	33	24	660s	660e	St. SLA #1	
252	21	33	32	1980s	1980w	St. "LT" #1	
253	21	33	33	1980n	660e	#1 R.F. Legget	
254	21	33	34	1980n	660w	R.F. Legget "A" No. 1	
255	21	33	35	660n	660w	No. 1 Amarada St.	
256	21	34	2	1980s	1980e	"F" St. #1	
257	21	34	5	1980s	660w	Berry "5" St. Com. No. 1	
258	21	34	13	660n	660e	Shell St. No. 10	
259	21	34	16	660s	990e	Shell St. "A" No. 2	
260	21	34	24	2310n	1650w	St. "P" No. 5	
261	21	34	24	990s	2310e	St. #33	
262	21	34	31	660s	750w	Mascho Unit Well #1	
263	21	34	32	660s	1980e	Shamrock St. #1	
264	23	32	9	660s	1980e	Continental Fed. #1-9	
265	23	32	15	1980n	1980e	Fed. Continental 1-15	
266	23	32	24	660s	660e	Fields Fed. No. 1	
267	23	33	32	660n	1980e	Humble St. #1-32	
268	23	33	35	660s	660w	St. 1-35	
269	23	34	30	660s	3300e	Bell Lake Unit #2	
270	23	34	27	660s	1980w	Harris Fed. #1 (#1 Antelope Ridge Unit)	
271	23	34	26	660s	1980w	St. "FO" #1	
272	22	32	31	660n	1980e	Perry Fed. #1-31	
273	23	32	7	510n	660e	Fed. "WL" #5-7	
274	22	32	14	660s	1980w	#2 Red Tank Unit	
275	22	32	15	1980s	1980e	#1 Connally Fed.	
276	22	32	17	1980s	1980e	Fed. 1-17	

FFG No.	T.	R.	Sec.	Location Data: Distance from section line*		Drillhole Name**	Revision
277	22	32	18	660s	660e	Fed. Jennings #1-18	
278	22	32	19	660s	660e	Bass Fed. #1	
279	22	32	20	1980n	1980e	#1 Fed.	
280	22	32	22	1980n	660w	Fed. Red Tank Unit #1-22	
281	22	32	25	660n	1980w	Covington "A" Fed. #1	
282	22	32	36	330n	1980w	Shell et al Bootleg Ridge Unit #1	
283	22	33	1	660n	1980e	Cotter Fed. No. 1	
284	22	33	4	2310s	800w	Reed Fed. #1	
285	22	33	5	660s	330e	Richardson-Bass St. No. 1	
286	22	33	7	660s	660w	St. "K" #1	
287	22	33	7	1980s	1980e	S.S.T. St. #7-1	
288	22	33	9	660n	660w	Hudson Fed. No. 1	
289	22	33	15	1980s	1980e	Getty Fed. "15" No. 1	
290	22	33	20	1980n	660w	Conoco Fed. #1	
291	22	33	32	660s	660w	Shell St. #1-B	
292	22	33	33	660n	660e	Phillips St. #1"	
293	22	33	34	660s	1980e	#1 Humble St.	
294	22	34	1	1980s	660w	St. "AR" #1	
295	22	34	2	660s	1980w	New Mexico St. BU #1	
296	22	34	3	1650n	660w	#1 St. GRA	
297	22	34	4	2310n	2310w	#4 Fed. "GR"	
298	22	34	7	660s	660w	Bell Lake Unit #8	
299	22	34	8	660s	1980e	New Mexico St. "AE" No. 1	
300	22	34	22	330n	330e	Jacquie Ann #1	
301	22	34	26	1980s	660e	Merchant "B" #1	
302	22	35	1	660s	660w	Jalmat Deep #1	
303	22	35	3	660n	660w	Donegan St. No. 1	
304	22	35	9	1980s	1980w	Humble St. #1	
305	22	35	14	660n	1700w	Jalmat Water Supply #2	
306	22	35	16	1980n	1980e	North Rock Lake Unit #1	
307	22	35	17	660n	660e	Shell St. #1	
308	22	35	20	1980n	660e	Carper Aztec No. 1	
309	22	35	23	660s	1980w	St. Nix #1-23	
310	22	35	25	1980n	660w	Cone Jalmat Yates Pool Unit Tract 8 - #5	
311	22	35	28	1980s	660w	Rock Lake Unit #1	
312	22	35	35	660s	660w	Gulf St. 1-A	
313	22	32	6	1980n	660e	Fed. "CK" Com. #1	
314	22	32	13	660s	660e	B & H Fed. #1 (Texico-Weaver)	
315	23	32	3	1980n	660e	Fed. #1	rev'd 1969n to 1980n w/log data
316	23	32	11	1980n	1980e	Matthews "11" #1	
317	23	32	18	1980n	660e	Fed. Sand 18-1	
318	23	32	20	660s	1980e	Fed. Estill AF-1	
319	23	32	21	660n	1980w	Gulf-Fed. "A-A" #1	
320	23	32	25	990n	2310w	Wehrli-Fed. #1	
321	23	32	25	990s	330w	Fields No. 2	
322	23	32	26	330s	330e	Fed. "WL" #3-26	rev'd 660e to 330e w/log data

FFG No.	T.	R.	Sec.	Location Data: Distance from section line*		Drillhole Name**	Revision
323	23	32	26	660s	1980w	Fed. Field #1	
324	23	32	28	660n	1980w	Continental Fed. No. 1	
325	23	32	31	660s	660w	Hankamer No. 1 Continental Fed.	
326	23	32	33	1980n	660e	Holder Fed. #1	
327	23	32	34	1980s	330e	Fed. "K" No. 1	
328	23	32	35	1650n	2310e	Fed. W L #1-35	
329	23	32	36	1980n	660w	Gulf St. #1	
330	23	32	36	1980s	1980e	Brinninstool Deep Unit #1	
331	23	33	4	660s	660e	Continental Fed. #1-P	
332	23	33	6	330s	330e	Shell Fed. #1-6	
333	23	33	7	660s	660w	Fed. 7 Well #1	
334	23	33	17	660s	660w	Texaco St. No. 1	
335	23	33	18	660s	660w	#1 "A" Shell St.	
336	23	33	19	1980s	1910w	Marshall #19-2	
337	23	33	20	660s	660e	Levick Fed. #1	
338	23	33	31	660n	660e	Lea St. #1	
339	23	33	35	1980n	660e	8104 JVP Hat No. 1	
340	23	33	36	1980s	660e	Bell Lake Unit 1 #18	
341	23	34	1	660s	660w	Allan Hargrave #1 St.	
342	23	34	6	660s	1980e	Bell Lake Unit #6	
343	23	34	10	1560n	1830w	#1Y Fed. "AA"	
344	23	34	15	330s	330e	No. 1 Hall/ Hall-Fed. #1	
345	23	34	18	1980s	1980w	Bell Lake #9	
346	23	34	19	1980n	1980w	Bell Lake Unit #10	
347	23	34	22	1980n	1980e	North Antelope Ridge Unit #1	
348	23	34	23	660s	1980w	St. 23 Comm #1	
349	23	34	25	660s	1980w	St. R #1	
350	23	34	26	660n	1980w	St. "EO" #1	
351	23	34	31	330s	2970e	Bell Lake Unit-1-A St.	
352	23	34	31	660s	3300e	Bell Lake Unit #1	
353	23	34	32	1980s	1650w	Bell Lake Unit #17	
354	23	34	35	990n	1980w	St. AR #1	
355	20	27	1	2310n	2310w	Mary Jane No. 1	
356	20	27	13	1980n	1980w	Donahue No. 1	
357	20	28	5	1980s	660w	Wright Fed. No. 1	
358	20	28	15	1980n	660e	#1 Trigg Fed.	
359	20	28	26	2310s	330w	Connally #1	
360	20	28	30	1980n	660w	No. 1 Sun St.	
361	20	29	1	660n	1980e	Superior Fed. #2	
362	20	29	3	1980n	660e	Lambie Fed. #1	
363	20	29	4	660n	1980w	#1-X Fed.	
364	20	29	7	330s	330e	Yates Fed. #2	
365	20	29	9	1980n	660e	Lambie Fed. No. 1	
366	20	29	10	990n	990e	Jennings Fed. No. 1	
367	20	29	11	2310s	2310w	#1 McKee	
368	20	29	12	330s	990w	McKee Fed. No. 1	

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
369	20	29	13	1470n	1170w	Texaco Fed. No. 2	
370	20	29	13	660n	1980w	#1 Texaco Fed.	
371	20	29	13	660n	2310e	#1 Union	
372	20	29	14	2310s	2310e	Texaco No. 1	
373	20	29	16	660n	1980w	Fed. "X" #1-16	
374	20	29	17	660s	660e	#1 Yates Fed.	
375	20	29	18	660n	1980e	Yates Fed. #1	
376	20	29	25	330n	330w	Nicholas #1	
377	20	29	28	1650s	1650e	Pauline Trigg Fed. No. 1	
378	20	29	30	1980n	990e	Stebbins Fed. Deep #1	
379	20	29	31	330n	2310e	Yates Petroleum Corp. No. 1	
380	20	29	32	660s	660e	No. 1 Yates Fed.	
381	20	29	36	1980s	660w	#1 Zachary	
382	20	29	36	2080s	1880e	Golden Lane "36" Fed. #1	
383	20	30	1	660s	1980e	#1-1 Fed. "PA"	
384	20	30	5	1980n	1980w	Continental Fed. #1	
385	20	30	22	1980s	1980e	#1 Fed.	
386	22	28	2	1650n	1650w	Ford No. 2	
387	20	30	28	330s	1980w	Fed. No. 7	
388	20	30	28	1980n	1980w	USA Emperor Oil Co. #1	
389	20	30	31	1980n	760e	Lowe Fed. #1	
390	20	30	32	660n	330e	Eddy St. "BD" No. 1	
391	20	30	32	1980n	330e	Eddy St. "BD" No. 2	
392	20	30	33	1650n	990e	Gulf Fed. #1	
393	20	31	4	660s	660e	Big Eddy Unit 33	
394	20	31	6	660s	660e	#3 Big Eddy Unit	
395	20	31	7	1650s	660e	Big Eddy Unit #11	
396	20	31	30	330s	330e	Big Eddy Unit #1-30	
397	21	28	1	4620s	1980e	#1 Cowan	
398	21	28	2	3300s	660w	St. #1	
399	21	28	3	3630s	2310e	#1 Cowan	
400	21	28	5	1565n	1985w	BIg Eddy Unit #13	
401	21	28	7	660n	660w	#1 Richardson & Bass	
402	21	28	12	1980s	660e	Big Eddy Unit No. 36	
403	21	28	15	660s	660w	Big Eddy Unit #32	
404	21	28	20	1980s	1980e	Big Eddy Unit No. 60	
405	21	28	27	660s	660e	Fed. "GN" #1	
406	21	28	29	1180s	1980w	Big Eddy Unit #54	
407	21	28	29	1980n	1980e	Big Eddy No. 39	
408	21	28	30	1750s	1750e	#2 Nix & Yates Fed.	
409	21	28	30	1650n	1650w	#1 Nix-Yates Fed.	
410	21	28	31	535s	660w	Big Eddy Unit #31	
411	21	28	33	560s	660w	Richardson Bass Fed. No. 1	
412	21	28	35	990n	1650w	Big Eddy #59	
413	21	28	35	1980n	1980w	Big Eddy #47	
414	21	28	35	330s	2310w	Big Eddy Unit #62	

FFG No.	T.	R.	Sec.	Location Data: Distance from section line*		Drillhole Name**	Revision
415	21	28	35	1650s	330w	Big Eddy Unit #49	
416	21	28	35	1980n	2310e	Big Eddy Unit #56	
417	21	28	35	2310s	1650w	Big Eddy #58	
418	21	29	3	1980n	1980w	Big Eddy Unit #18	
419	21	29	4	4620s	1980w	Cowden Fed. #1	
420	21	29	4	838n	1650w	#1 Hudson Fed.	
421	21	29	5	630n	1980e	#1 Trigg Fed. "AA"	
422	21	29	5	1980n	660e	#1 Harris Bell	
423	21	29	5	2825n	2310w	#1 Harris Fed.	
424	21	29	6	3147n	660e	Harris "6" #1	
425	21	29	18	1980s	1980e	Big Eddy Unit #16	
426	21	29	19	660s	660e	Big Eddy Unit #55	
427	21	29	21	660s	660e	#1 Nix-Hall	
428	21	29	22	1980n	1980e	Big Eddy Unit No. 40	
429	21	29	34	660n	1980w	Big Eddy Unit No. 38	
430	21	30	16	1908n	751e	Big Eddy 45-Y	
432	21	30	35	1980s	660w	James "C" #1	
433	22	28	2	330n	2310w	Ford St. No. 1	
434	22	28	7	330s	794w	Old Indian Draw Unit #16	
435	22	28	7	330s	1650w	Old Indian Draw Unit #14	
436	22	28	7	2324n	2330e	Old Indian Draw Unit #33	
437	22	28	18	2310n	2150w	Old Indian Draw No. 7	
438	22	31	1	530s	330w	SCL Fed. #1	
439	22	28	18	2002s	1721w	Old Indian Draw No. 6	
440	22	28	18	660s	1980e	Old Indian Draw #2	
441	22	28	18	1980s	1980e	#1 Old Indian Draw Unit	
442	22	28	19	660n	1973w	Old Indian Draw Unit #17	
443	22	28	21	1980n	1980e	Pecos Irrigation #1	
444	22	28	22	1980n	1980w	Big Chief #1	
445	22	28	25	1980s	1980e	Big Eddy Unit #43	
446	22	28	27	1980n	1980w	Little Squaw #1	
447	22	28	29	660s	990w	C.R. Lopez "A" #1	
448	22	28	29	2210s	1980w	City of Carlsbad #1	
449	22	28	30	990s	330w	Nichols "HV" #1	
450	22	28	30	2310n	990e	Harroun #1	
451	22	28	31	900n	1650e	Eastland Brantley #1	
452	22	28	31	990n	330e	Gourley Fed. #3	
453	23	31	2	660n	660e	St. AA 2 #1	
454	23	31	6	1957n	1973e	James Ranch Unit #7	
455	23	31	11	660s	660e	Bauerdorf-Fed. #1	rev'd 330e to 660e w/log data
456	23	31	14	1980s	1980w	Todd Fed. "14" No. 1	
457	23	31	16	1980s	1980w	Arco St. #1-16	
458	23	31	21	660s	660e	Muse-Fed. #1	
459	23	31	25	1980n	1970w	#1-Z Todd "25" Fed.	
460	23	31	26	1980n	1650e	Todd "26" Fed. #2	
461	23	31	26	1980n	1980e	Todd Fed. "26" No. 1	

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
462	23	31	27	1980s	660w	Wright-Fed. #1	
463	23	31	32	660n	660w	Continental St. No. 1	
464	23	31	33	660n	1980e	Wright-Fed. #3	
465	23	31	33	1980n	660w	Wright-Fed. #2	
466	23	31	36	660s	660w	Pauley Harrison St. #1	
467	23	35	8	2310n	330w	Fed. SR #1-8	
468	23	35	9	1980s	1980e	Sand Well Unit #1	
469	23	35	12	1980n	1980w	#1 Fed. "F"	
470	23	35	14	660n	1983e	Ann Davis #1	
471	23	35	17	660n	660e	St. Henry #1-17	
472	23	35	28	660n	1980w	North Custer Mountain Unit #1	
473	23	35	36	660n	660w	St. "D" #1	
474	24	32	1	1980s	660w	Continental Fed. #1-L	
475	24	32	2	1980n	660e	Ohio St. No. 1	
476	24	32	6	660n	1980e	Bondurant Fed. No. 1	
477	24	32	10	1980s	1980e	Fed. Hanagan D #1	
478	24	32	11	1980s	1980e	Fed. Hanagan D #2	
479	24	32	11	1980n	1980w	Fed. Hanagan D-4	
480	24	32	12	1980n	660w	Hanagan Fed. No. 3	
481	24	32	13	660s	660e	Woolley #1	
482	24	32	14	660n	1980w	#1 USA Jennings	
483	24	32	15	660s	1980w	Hicks-Fed. #1	
484	24	32	22	1980n	990e	Bradley #2	
485	24	32	22	1980s	1980e	Bradley #1	
486	24	32	23	1980n	660w	Ernest Fed. #1	
487	24	32	23	1650n	330w	Exxon A Fed. No. 2	
488	24	32	24	330n	330w	Bon Durant Fed. No. 1	
489	24	32	25	1980n	1980w	Fed. "BM" #1	
490	24	32	29	1980n	660w	#1 Payne	
491	24	32	30	1980n	1980e	Paduca Fed. #1	
492	24	32	33	660s	660e	Cotton Draw Unit Well #72	
493	24	32	34	1980s	1980w	#69 Cotton Draw Unit	
494	24	32	34	660s	1980w	Cotton Draw Unit #74	
495	24	32	35	660s	660w	Fed. Del Basin #1	
496	24	33	1	1980n	1980e	#5 Bell Lake Unit	
497	24	33	7	660s	660e	St. #1-7	
498	24	33	8	660n	660w	New Mexico St. A.G. 1	
499	24	33	13	1980n	660e	Holland #1	
500	24	33	17	660n	1980e	Holly-St. #1	
501	24	33	20	660s	1980w	St. "BB" 20 No. 1	
502	24	33	22	1980n	660w	St. #1	
503	24	33	27	1980s	1980w	Sunray St. #1	
504	24	33	29	660s	1980e	St. "AP" #1	
505	24	33	30	330n	330w	Continental St. #1	
506	24	33	31	1980s	660e	Continental St. #1	
507	24	33	36	660n	660e	#1 Lea St. "GX"	

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
			Location Data				
508	24	34	2	1980s	1980w	St. "2" #2	
509	24	34	3	1980n	1980e	Antelope Ridge #6	
510	24	34	4	660n	1650e	Fed. "BE" #1	
511	24	34	6	660n	3300e	Bell Lake Unit No. 3	
512	24	34	10	1980n	1980e	Alexander #1	
513	24	34	11	660n	1980w	Madera Comm. #1	
514	24	34	13	660s	660w	Fed. Johnson #1	
515	24	34	17	1980s	1980e	Government M #1	
516	24	34	21	660n	1980e	Shell-Fed. "B" #1	
517	24	35	5	1980n	1980w	Wilson Fed. Com. #1	
518	24	35	8	1980s	1980e	Fed. "CR 8" #1	
519	24	35	9	1980s	1980w	Custer Mountain Unit Fed. #1	
520	24	35	10	660n	660w	Lea St. "GB" #2	
521	24	35	10	1980n	1650w	Cinta Roja "10" No. 1	
522	24	35	12	1980n	1980w	Fields #1	
523	24	35	13	1980s	660e	Peggy M. Baetz No. 1	
524	24	35	15	1980n	1980e	Lea St. "GB" #1	
525	24	35	13	660n	1980e	Luzon Fed. #1	
526	19	30	5	1980n	330w	#3 Perkins "AD"	
527	19	30	13	660s	1980e	C & I Fed. #1	
528	19	30	14	2310n	330e	#1 Southern California Petroleum	
529	19	30	16	2310n	990e	St. No. 1	
530	19	30	20	660s	1980w	#1 Kelly Fed.	
531	19	30	23	2310n	990e	Union Fed. #3	
532	19	30	24	1980s	330w	Fed. Holder #1	
533	19	30	24	1705s	1650w	Fed. "CR" No. 4	
534	19	30	24	1650s	2310e	C.R. Holder #5	
535	19	30	24	2310n	660w	Fed. Holder "CR" No. 3	
536	19	30	24	940s	1725w	Fed. Holder "CR" No. 6	
537	19	30	24	990s	330w	Fed. Holder "CR" No. 2	
538	19	30	24	990s	2310e	Fed. Holder "CR" #7	
539	19	30	25	1980n	1650e	Lebow Fed. No. 7	
540	19	30	25	660n	660e	Lebow Fed. No. 5	
541	19	30	25	990s	660e	Lebow Fed. No. 10	
542	19	30	25	660s	660w	Lebow Fed. No. 12	
543	19	30	28	990s	330w	Yates Fed. "A" No. 1	
544	19	30	29	990s	990e	Lane #1	
545	19	30	30	660s	1980e	Fed. Yates #1	
546	19	30	31	660s	660w	Fed. "B" #1	
547	19	30	32	330n	2310w	Lowe St. #1	
548	19	30	36	1650s	1650e	Aikman Stanolind St. #1	
549	25	29	3	660n	660e	Superior Fed. #1-3	
550	25	29	8	660s	660e	Superior Fed. #1	
552	25	29	15	660s	660w	Superior Fed. 15 No. 1	
556	25	29	27	660s	660w	Superior Fed. #1-27	
559	25	29	31	1980s	660e	#1 Slater	

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
				Location Data			
561	26	31	1	660s	1980e	#1 Ruth Ross "O"	
562	26	31	9	660s	660w	Buckles Fed. No. 1	
563	26	31	11	1980s	660e	Baverdorf #1	
564	26	31	15	660s	660w	Fed. No. 1-15	
565	26	31	17	1980s	660e	Phantom Banks Unit Fed. 17 #1	top Rustler 302.5, not 332.5
566	26	31	20	660s	660w	Hanson Fed. No. 1	
568	26	31	25	330s	330w	Hanson #1	
569	26	31	25	1650s	330w	Hanson #3	
570	26	31	34	330n	330e	Hanson #2	
572	25	30	4	660s	660w	#1 Hopp Fed.	
575	25	30	7	660n	660w	Carper Hanson Superior St. No. 1	
577	25	30	8	1980s	660w	Poker Lake St. #3	
580	25	30	8	1980n	660e	Superior St. #1	
582	25	30	9	660s	660w	Richardson & Bass Fed. #1	
583	25	30	10	660s	645w	Poker Lake Unit #5X-1A	
584	25	30	10	2030n	2180e	Poker Lake #44	
585	25	30	12	1980n	1980w	Shugart Fed. No. 1	
586	25	30	14	1980n	660w	Poker Lake Unit #10A-6	
589	25	30	17	660s	660w	Poker Lake Unit #11A-7	
593	25	30	20	1980s	660w	Continental Fed. #2	
594	25	30	21	660n	660w	Poker Lake #6-2A	
595	25	30	21	1980s	660e	Poker Lake Unit #4	
596	25	30	22	1980s	660w	#3 Poker Lake Unit	
599	25	30	30	660s	660w	#1-30 Superior Fed.	
600	25	30	35	1980n	660e	Marshall Fed. #1	
601	25	30	35	660s	660w	Richardson & Bass Fed. No. 1	
602	25	31	2	1980n	1980e		Data dropped; Same as FFG218
606	25	31	35	660n	1980e	Big Sinks Fed. Unit #1	
607	25	35	5	660s	660w	Fed. Mounsey "B" #1	
608	25	35	6	460n	660w	Mounsey Fed. #1	
609	25	35	7	660n	660w	Mounsey "A" Fed. #1	
610	25	35	18	660s	660w	McCormick #1	
611	25	35	20	1980n	660w	Fed. Mounsey "C" #1	
612	25	35	22	660s	660w	Elliott Fed. #1	
613	25	35	26	660s	660e	Harper Fed. #1	
614	26	29	1	660s	1980e	Continental Fed. #1	
615	26	29	2	660n	660e	St. #1	
617	26	29	6	660s	660w	Ashland Fed. #1	
618	26	29	11	660s	660e	Hanson "A" #1	
620	26	29	13	1980s	1980w	Gulf Fed. #1	
621	26	29	13	1980s	660w	Gulf Fed. "B" #5	
624	26	29	14	660n	660w	Booth Fed. #1	
627	26	29	19	300n	2096e	Baker Fed. No. 1	
628	26	29	22	1980s	1980w	Ashland Fed. #1	
629	26	29	23	660s	660w	Fed. Boothe E #1	
630	26	29	24	660n	1980e	Gulf-Fed.-Beatty #2	

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
631	26	29	24	660n	660w	Gulf-Beatty No. 1	
637	26	29	34	949n	1660e	Fed. Littlefield "BO" #1	?= #1590 (F34) in Appendix A
638	26	30	2	660s	660w	Sinclair St. No. 1-2	
639	26	30	3	660s	660w	Scott Fed. #1	
640	26	30	4	660n	660w	Fed. K.W. No. 1	
642	26	30	6	660s	660w	No. 1 Brunson Fed.	
643	26	30	12	660s	660e	Monteray Blaydes #1	
644	26	30	16	660s	660e	St. #1	
645	26	30	18	660s	660w	#1 AT Fed.	
647	26	30	20	2310n	330w	U.S.A. #1	
648	26	30	24	1980n	1980w	#1-24 Strat Test	
652	19	31	2	330n	2310e	St. No. 2	
653	19	31	3	2310s	1980e	Hanson Fed. No. 2	
654	19	31	4	660n	990e	Carper Fed. No. 1-A	
655	19	31	4	760n	1980w	South Shugart Deep Fed. Unit #1	
656	19	31	4	1650n	2310e	Carper Welch #2	
657	19	31	5	330n	330w	Pan American Fed. #1	
658	19	31	5	2310n	2310e	Pan American Fed. #1-X	
659	19	31	6	990s	330e	Hodges Fed. #1	
660	19	31	6	330n	330w	Featherstone Fed. No. 1-B	
661	19	31	9	1980s	1980e	Continental Fed. No. 1	
662	19	31	11	660s	1980w	General Energy Corp. Fed. #1	
663	19	31	11	1980n	1980w	Gulf Oil Corp. #1 Holder "CT" Fed.	
664	19	31	13	1980s	2310w	H.J. "13" Fed. Comm. #1	
665	19	31	15	1980n	660w	Robert A. Dean & Jack McCellan #1 Fed. #15	
666	19	31	16	660s	1980w	Gulf St. #1	
667	19	31	17	660n	660e	Ross-Fed. #1	
668	19	31	18	660s	660w	Holt Fed. #1	
669	19	31	19	1980s	1980e	Tidewater "FE" #2	
670	19	31	20	990s	2310w	Sun Fed. #1	
671	19	31	20	660n	1980w	English Fed. #2	
672	19	31	20	330s	1980e	English Fed. #1	
673	19	31	20	1980s	990w	Sun-Fed. #2	
674	19	31	21	330s	330w	Tenneco #2-21	
675	19	31	23	1980n	660e	Jones Fed. #1	
676	19	31	23	1980n	1980w	Jones Fed. No. 2	
677	19	31	28	330n	330w	Tenneco-Fed. #1	
678	19	31	29	2310s	2310w	Barbera Fed. #1	
679	19	31	29	660n	1980e	CEM Oil Co. Fed. #1	
680	19	31	30	1980n	330w	Southern Fed. No. 6	
681	19	31	30	990s	330w	Southern Fed. No. 7	
682	19	31	30	1980n	667e	#2-Y Southern Union	
683	19	31	31	330n	330w	Brook & Adams Fed. No. 1	
684	19	31	32	330n	660e	Machris St. #1	
685	22	29	6	660s	660e	#1 Eddy Fed.	
689	25	32	3	1650s	1980e	Cotton Draw Unit No. 49	

FFG No.	Location Data T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
690	25	32	9	1650s	330e	Cotton Draw Unit No. 52	
691	25	32	10	2145n	2310e	Cotton Draw Unit No. 60	
692	25	32	11	660s	1980e	Continental Fed. #1	
693	25	32	14	2310n	330w	Ora Hall Fed. 14 #1	
694	25	32	15	660s	1980w	G.E. Jordan Fed. No. 4	
695	25	32	15	660n	1980w	G.L. Jordan #3	
696	25	32	15	455n	1980w	Cotton Draw Unit No. 75	
697	25	32	16	1980n	1980e	St. Z 16 #1	
698	25	32	18	660n	1650w	Cotton Draw Unit #64	
699	25	32	20	1650s	330e	Cotton Draw Unit #42	
700	25	32	20	330s	330e	Perry Fed. #43	
701	25	32	21	990s	990e	Cotton Draw Unit #57	
702	25	32	22	2310s	330w	Cotton Draw Unit No. 48	
703	25	32	23	660n	1980e	Fed. "P" #1	
704	25	32	27	330n	330w	Cotton Draw Unit No. 61	
705	25	32	28	2310s	990w	J.D. Sena Jr.	
706	25	32	28	2310s	1650w	J.D. Sena U.S.A. No. 1	
707	25	32	29	1980n	330e	Cotton Draw Unit No. 58	
708	25	32	29	330n	330e	Cotton Draw Unit No. 55	
709	25	32	31	1980n	660w	Ray Smith #1	
710	25	32	32	1980n	1980w	Conoco St. No. 1	
711	25	32	33	660s	660w	Hall-Fed. "33" #1	
712	25	32	33	1980s	560e	Jennings #1	
713	25	32	33	660s	1980e	Jennings #3	
714	25	32	34	660n	660w	Fed. Sunshine Royalty #1	
715	25	32	34	660n	660e	Sunshine Royalties #1	
716	25	33	1	660n	660w	Fed.-Muse #1	
717	25	33	5	660n	660e	Bass Fed. #1	
718	25	33	8	1980s	660e	Annie Bass Fed. #1	
719	25	33	11	660n	660w	Muse Fed. #1	
720	25	33	13	980s	660e	Fed. "BK" #1	
721	25	33	15	1980n	1980e	Ochoa Fed. No. 1	
722	25	33	18	660n	660w	#1 Bass Fed.	tops Tamarisk, Mag wrong
723	25	33	19	1980s	660w	Fed. #1-19	
724	25	33	20	660n	1980e	Fed. Bass #1	
725	25	33	21	660n	660e	Fed. Marshall No. 1	
726	25	33	23	660s	660w	Muse-Fed. 23 #1	
727	25	33	24	660s	660w	Perry Fed. #1	
728	25	33	25	660s	660e	Fed. No. 1-25	
729	25	33	27	660s	660e	Harry Dickson #1	
730	25	33	28	660s	660e	Annie R. Bass Fed. #1	
731	25	33	28	660n	660e	Conley Fed. #1	
732	25	33	29	1980n	660w	W.H. Jennings Inc. U.S.A. No. 1	
733	25	33	31	660s	660w	Richardson & Bass USA #1	
734	25	33	32	1980s	660e	Continental St. No. 1	
735	25	33	36	660n	660w	St. #1-36	

FFG No.	T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
736	25	34	2	660s	1980w	Southeast Bell Unit #1	
737	25	34	5	660n	660w	Bass Fed. #1	
738	25	34	8	660s	660e	Fed.-Muse #1	
739	25	34	10	660s	660w	Mildred Smith #1	
740	25	34	14	990s	1980e	Mildred Smith #1	
741	25	34	19	660s	1980e	No. 1-19 Fed.	
742	25	34	21	1980s	1980w	Ethel Nolen Fed. #1	
743	25	34	27	1980n	660e	Conoco Fed. #1	
744	25	34	31	660n	660e	Continental Fed. No. 1	
745	25	34	35	1980s	1980e	Olson Fed. No. 1	
746	25	34	36	660n	1980w	New Mexico St. #1	
747	26	32	1	1980s	660e	8105 JV-P Mesa #1	
748	26	32	1	660s	660w	Richardson-Fed. #1	
749	26	32	4	1980n	2310w	Sun Fed. "4" #1	
750	26	32	5	330s	2310e	Sun Fed. No. 1	
751	26	32	5	660n	1980w	Conoco Bradley #1	
753	26	32	7	990n	660e	N.C. Higgins Fed. #2	
754	26	32	7	660s	1980w	Continental Fed. #1	
755	26	32	8	1980s	660w	#1 N.C. Higgins Fed.	
756	26	32	15	1980s	660e	Ben Fed. #1	
757	26	32	16	1980s	1980w	Ohio St. No. 1	
759	26	32	18	1980n	660e	Thompson Fed. 18 No. 5	
760	26	32	18	1650s	1980w	#4-18 Thompson Fed.	
761	26	32	21	660s	660e	Fed. Payne No. 1	
762	26	32	24	330s	1650e	Fed.-Littlefield DR #1	
763	26	32	25	990n	990w	Wilder #23	
764	26	32	25	660s	1980w	Wilder 25-2	
765	26	32	26	1980n	1980e	Wilder #25	
766	26	32	30	660s	1980e	Russell Fed. 30 #1	
767	26	32	31	760n	2002w	Russell #1	
768	26	32	35	490s	330e	E. Payne 35 Fed. #1	
769	26	32	35	660n	660w	Bradley 35 #2	
770	26	33	1	660n	660e	Continental Fed. #1	
771	26	33	2	660n	1980w	Texaco St. "2" #1	
772	26	33	4	660s	660e	G.W. Miller Fed. NCT-1 No. 1	
773	26	33	6	1750s	1750e	Jones Fed. #1	
774	26	33	8	660s	660e	Miller-Fed. #1	
775	26	33	10	1980s	1980w	Goedeke Fed. No. 1	
776	26	33	10	2310n	2310w	Malcom R. Madera No. B-1	
777	26	33	13	660s	660e	Bradley 13 #1	
778	26	33	15	660n	1710e	Conoco Fed. #2	
779	26	33	15	660n	1980w	Fed. No. 1	
780	26	33	17	660s	660w	Fed. Littlefield DP Optional #1	
781	26	33	19	660s	660w	Fed. Littlefield "DO" #1	
782	26	33	21	1980s	660w	Continental Fed. #1	
783	26	33	22	660n	660w	Madera Fed. #1	

FFG No.	Location Data T.	R.	Sec.	Distance from section line*		Drillhole Name**	Revision
784	26	33	23	660s	1980w	Humble Madera #1	
785	26	33	25	660n	1980w	Elliott Fed. #1	
786	26	33	26	660s	1980e	Fed. Hall #1	
787	26	33	27	1980s	660w	Dixon 27 #1	
788	26	33	29	1880n	660e	Gulf Fed. Littlefield #1	
789	26	33	30	1980s	660w	Payne #3	
790	26	33	31	660n	660w	Payne #7	
791	26	34	2	330s	330e	Lea St. "JV" #1	
792	26	34	3	660n	1980w	Gulf Yates Fed. #1	
793	26	34	4	660s	660w	Yates Fed. #1-4	
794	26	34	6	1980s	660w	Fed. K #1	
795	26	34	9	660s	660e	Yates Fed. No. 1	
796	26	34	18	660n	660e	Continental-Fed. #1	
797	26	34	18	1980s	1996w	Pogo No. 1 Fed. 18	
798	26	34	19	660n	660w	Bradley 19 #1	
799	26	34	20	660n	660e	Leonard Fed. No. 1	
800	26	34	22	660n	1980e	Fed. "CH" #1	
801	26	34	26	660n	660e	Kirklin Drilling Hondo Fed. #1	
802	26	34	33	660s	660e	Elliott-Fed. #1	
803	26	35	1	1650s	660w	#1 Sinclair Fed. "A"	
804	26	35	2	660s	1980w	Talco Unit #2	
805	26	35	6	1980s	1980e	Perro Grande Unit #1	
806	26	35	10	330n	660w	Sinclair et al "A" #1	
807	26	35	10	300n	300e	Sinclair Fed. "B" #1	
808	26	35	11	660s	660w	De Mooy Fed. No. 1	
809	26	35	11	330n	330e	Sinclair et al Fed. "B" #1	
810	26	35	11	1980n	660e	Talco Unit #1	
811	26	35	13	660n	660e	Fed. #1	
812	26	35	21	1980n	1980w	New Mexico Fed. "P" #1	
813	26	35	22	1980s	1980w	Byers Fed. No. 1	
814	26	35	25	1980n	1980w	Sinclair et al "C" #1	
815	26	35	27	660n	660e	Fed. Boothe "BD" #1	
817	26	32	3	660n	660w	Fed. Boothe "BD" #1	

* The distances for the borehole locations are measured in feet from north, south, west, or east for the section (square mile) as noted by n, s, w, or e.

* Some consistent abbreviations have been used to shorten names.

The location data for this table was taken from Table 2 of Richey (1989). The FFG number is used to cross-refer to other data tables based on the work of Richey.

APPENDIX B-2
TABLE OF RUSTLER FORMATION DATA FROM RICHEY (1989)

Table of Rustler Formation Data From Richey (1989)

		Depths (meters) to Top of Units						
FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
001	1083.0	396.8					507.5	
002	1090.3	404.2	422.8	429.8	465.5	472.2	511.5	
004	1068.3	329.2	350.5	357.5	401.7	408.4	440.4	
005	1089.7	395.9	414.8	421.8	461.2	467.6	507.8	
006	1091.5	402.6	421.5	430.1	474.9	483.4		
007	1093.9	415.7	438.0	444.1	491.9	500.2	534.9	
008	1099.1	424.3			499.9	506.9	540.1	
009	1094.8	416.7	437.4	444.7	490.7	498.3	519.7	
010	1096.4	418.5			493.2	500.8	536.4	
011	1092.7	408.1	428.5	435.6	482.8	489.2	522.4	
012	1092.1	405.1	424.3	432.5	478.2	485.9	520.0	
013	1080.2	383.4	405.4	412.4	434.0	445.9	497.7	
014	1068.6	326.7	347.5	355.1	400.8	409.7	445.6	
015	1082.0	342.6	363.6	370.3				
016	1099.7	432.8	454.8	462.1	511.8	520.3	554.7	
017	1100.9	431.3	452.6	460.2	506.0	513.6	545.6	
018	1116.5	444.1	464.2	470.6	517.9	525.8	558.1	
019	1111.0	444.7	466.3	473.4	522.4	530.7	562.1	
020	1091.5	350.8	373.1	379.2	429.5	436.2	469.1	
021	1096.4	361.5	385.3	392.6			481.9	
022	1106.7	384.6	412.0	419.6			495.2	
023	1109.8	431.3	455.7	462.4	513.6	522.1	556.3	
024	1124.6	462.6	485.8	492.5	545.5	552.8	585.4	
025	1117.6	443.5	465.4	471.5	519.1	525.8	557.2	
026	1116.0	445.2	466.5	472.6	523.5	530.5	563.4	
027	1117.4	453.2	474.3	481.0	531.9	538.9	571.8	
028	1183.9	554.1	571.2	576.4	605.3	611.4	634.3	
029	1145.4	529.4	546.2	551.4	581.9	587.3	607.5	
030	1154.3	537.7	556.0	561.4	591.3	597.1	621.5	
031	1168.3	558.7	578.2	584.3	613.9	620.9	645.9	
032	1158.5	546.6	566.4	572.5	609.1	612.4	639.5	
033	1143.6	536.4	555.3	560.8	594.4	601.4	624.8	
034	1139.3	538.0	556.9	561.4	590.7	596.8	621.5	
035	1121.1	530.8	548.5	554.6	587.2	590.2	616.2	
036	1147.6	545.0	565.4	570.9	606.2	612.0	637.3	
037	1129.3	536.4	557.5	562.4	595.3	600.5	626.4	
038	1118.3	538.9	558.7	564.2	594.7	600.8	626.4	
039	1046.1	247.5	267.3	274.0	314.2	320.6	351.7	
040	1077.2	336.5	356.3	363.6	421.8	431.9	452.3	
041	1065.3	264.3	284.7	291.7	331.6	338.9	373.4	
042	1069.5	264.0	284.1	291.7	328.9	339.5	374.3	
043	1067.1	257.1	279.0	285.1	331.4	338.4	370.1	
044	1080.5	318.2	339.5	346.9	391.4	399.6	434.9	
045	1091.8	344.4	367.3	374.9		432.2	466.3	
046	1094.2	340.2					464.2	
047	1112.8	479.4	498.9	505.3	551.7	556.8	586.7	

FFG No.	Reference Elevation	Depths (meters) to Top of Units Forty niner	Mag- enta	Tama- risk	Cul- ebra	ulm	Salado salt	Revisions
048	1106.1	452.9	475.2	482.8	525.8	532.8	578.5	
049	1119.2	477.3	498.3	504.4	551.7	559.6	592.5	
050	1132.5	484.5	504.9	511.0	550.0	557.6	595.1	
051	1131.1	482.2	503.8	509.0	557.2	564.8	600.2	
052	1132.0	480.4	501.7	507.8	536.8	542.2	566.3	
053	1137.5	494.7	514.2	522.1	574.5	581.9	627.0	
054	1150.2	508.3	529.6	536.9	587.5	593.6	631.4	
055	1145.1	503.5	524.0	532.5	579.4	587.3	623.9	
056	1136.6	492.3	514.8	521.2	572.1	579.7	615.7	
057	1134.8	489.2	509.6	517.2	570.0	576.7	610.2	
058	1147.7	506.7	524.1	532.6	578.4	586.9	621.0	
059	1156.1	512.7	532.5	538.6	586.4	591.3	626.4	
060	1138.4	492.9	511.1	520.3	569.1	575.2	605.6	
061	1137.5	491.6	511.5	517.6	566.9	572.4	605.0	
062	1122.6	548.3	569.4	575.5	608.7	615.4	643.4	
063	1118.1	583.4	604.4	609.6	647.4	652.3	679.7	
064	1127.2	567.5	588.6	595.3	629.7	638.3	666.0	
065	1110.7	567.8	590.1	595.3	638.9	646.2	661.1	
066	1113.7	616.9	639.8	644.3	679.4	684.6	712.0	
067	1127.5	590.4	611.1	616.3	657.5	663.5	691.6	
068	1125.0	628.5	643.1	649.2	694.9	701.0	728.5	
069	1130.2	605.9	627.8	633.9	682.7	688.8	722.3	
070	1130.8	577.0	598.6	604.7	646.2	651.7	688.8	
071	1115.3	304.2	324.6	331.0	360.3	367.0	415.1	
072	1105.2	365.5	384.1	390.2	424.0	431.0	459.4	
073	1107.4	389.6	407.9	416.8	448.1	455.2	484.1	
074	1107.0	383.3	403.7	408.6	440.6	446.7	476.3	
075	1108.3	335.0	352.3	359.1	390.4	396.2	424.9	
076	1097.3	260.9	279.2	286.8	319.7	325.8	355.4	
077	1095.8						323.7	
078	1087.2	212.8	232.0	240.2	272.5	279.5	310.3	
079	1091.2	243.2	261.5	267.6	304.2	310.3	340.8	
080	1082.3	254.8	274.0	281.9	316.7	324.0	354.8	
081	1097.0	350.2	369.1	376.1	413.9	422.1	452.6	
082	1084.8	305.7	325.5	331.6	373.7	379.5	411.8	
083	1115.6	422.6	440.9	447.0	477.5	483.6	511.0	
084	1107.6	386.5	405.4	413.0	446.2	452.9	481.6	
085	1108.9	394.7	413.3	421.5	453.5	459.9	488.0	
086	1107.3	384.7	401.7	410.0	442.3	449.9	477.0	
087	1107.3	409.3	427.3	435.9	470.6	477.3	506.0	
088	1108.9	414.5	434.3	441.7	482.8	486.2	513.6	
089	1108.6	432.8	452.6	459.0	494.7	502.0	531.9	
090	1094.5	394.7					494.1	
091	1091.2	371.2	390.8	398.4	438.9	447.4	477.0	
092	1097.6	362.7	381.0	391.1	426.7	435.3	463.9	
093	1097.9	360.6	379.8	387.7	424.3	429.8	460.2	
094	1095.1	354.5	374.9	381.9	420.9	428.5	458.1	
095	1138.7	432.2	449.9	457.2	487.1	493.5	520.0	
096	1174.4	484.9	503.2	509.3	538.9	545.0	569.4	
097	1149.4	478.2	497.7	504.4	534.6	541.0	568.8	

FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
098	1208.2	562.7	582.8	588.3	620.3	626.4	652.3	
099	1205.8	564.2	584.9	590.4	623.3	631.2	655.6	
100	1153.1	528.2	549.2	555.0	588.3	594.4	622.7	
101	1142.7	549.6	567.8	573.3	609.0	615.4	642.5	
102	1127.2	513.3	533.7	539.8	578.2	584.3	614.8	
103	1108.6	434.0	453.2	456.6	499.3	506.9		
104	1127.5	555.0	576.4	582.5	619.4	625.4	653.2	
105	995.2	68.3	85.6	93.9	127.7	133.8	182.3	
106	981.5	26.8	41.8	49.7	78.9	86.9	140.8	
107	987.6	42.4	64.6	70.7	99.7	108.8	151.5	
108	1015.9	82.3	97.5	103.6	137.2	146.3	179.8	
109	1039.1	121.9	140.2	146.3	176.8	182.9	207.3	
110	1045.5	158.5	179.8	185.9	213.4	221.0	246.9	
111	1062.2	165.5	190.5	195.1	225.6	231.6	256.0	
112	1056.1	176.8	195.1	201.2	231.6	239.3	271.3	
113	1054.9	161.5	179.8	185.9	216.4	224.0	252.7	
114	1014.7	90.5	109.1	116.4	144.2	151.5	185.9	
115	970.5	56.7	75.0	81.1	113.1	122.2	167.0	
116	972.0	42.7	61.0	67.1	100.6	106.7	176.8	
117	966.2	30.5	54.9	64.0	97.5	109.7	155.4	
118	968.7						124.1	
119	950.1	12.2			79.2	85.3	121.9	
120	956.5	12.2	33.5	42.7	82.3	91.4	137.2	
121	958.6	12.2	30.5	36.6	76.2	85.3	128.0	
122	954.0	9.1	27.4	33.5	77.7	85.3	140.2	
123	961.6	33.5	61.0	67.1	94.5	100.6	146.3	
124	977.2	76.8	111.9	119.5	139.3	146.3	191.7	
125	976.2	64.0	85.3	93.0	125.0	134.1		
126	1014.2	109.7	128.0	134.1	161.5	167.6	201.2	
127	1019.2	109.7	128.0	134.1	158.5	167.6	195.1	
128	994.3	46.3	67.7	76.8	107.3	116.7	141.7	
129	961.9	38.1	62.5	68.6	103.6	109.7	146.3	
130	979.9	25.9	50.3	59.4	82.3	91.4	125.0	
132	1002.2	45.7	67.1	73.2	103.6	111.3	149.4	
133	993.0	33.5	54.9	61.0	91.4	97.5	155.4	
134	988.2	24.4	44.2	52.7	83.8	91.4	126.5	
135	1002.5	65.2	85.0	91.7	121.6	127.4	158.5	
136	1007.5	73.2	88.4	96.0	125.0	131.1	163.1	
137	1007.4	60.6	79.5	88.1	114.6	122.8	154.2	
138	1023.9	126.5	143.3	149.4	179.8	189.0	225.6	
139	1023.5	115.8	133.8	141.1	167.9	175.6	213.4	
140	1042.6	193.5	213.4	219.5	249.9	257.6	292.6	
141	1030.4	157.3	176.2	184.7	210.3	217.9	247.5	
142	1042.8	193.5	213.4	221.0	246.9	254.5	285.0	
143	1052.7	196.9	213.4	221.0	248.7	255.4		
144	905.0	1.5			10.7	21.3	79.9	
145	905.3	0.0			12.2	18.3	74.7	
146	912.9	0.0			6.1	15.2	86.9	
147	908.3	10.4	10.4	14.6	25.6	32.9	92.0	
148	907.7	0.0			7.6	12.8	75.6	

FFG No.	Reference Elevation	Depths (meters) to Top of Units Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
149	916.5	4.3			5.8	13.4	74.4	
150	903.7	1.5					79.2	
151	901.6	10.7			12.2	21.3	79.2	
152	905.3	12.2					68.6	
153	917.1	0.0				15.2	88.4	
154	933.3	8.2					95.7	
155	918.1	4.0	4.0	12.5	16.8	24.1	87.2	
156	908.3	1.8			1.8	12.8	70.7	
157	926.0	10.7	10.7	18.9	21.9	27.4		
158	941.8	4.6	4.6	10.7	13.7	23.8	85.0	
159	1001.3	45.1	64.6	72.5	102.7	109.7	141.7	
160	1002.5	52.4	72.8	78.3	107.3	116.4	146.9	
161	987.9	30.5	51.8	57.9	86.9	93.0	131.1	
162	988.8	32.9	55.5	63.4	96.9	104.2	131.1	
163	988.8	33.5	54.9	61.0	91.4	100.6	132.6	
164	955.9	0.0			18.3	27.4	101.2	
165	935.7	0.0			22.9	33.5	96.9	
166	993.0	38.7	57.0	64.6	93.0	101.2	134.7	
167	1019.6	82.9	97.5	105.2	132.6	141.7	182.9	
168	1001.0	33.5	56.4	67.1	94.5	102.1	157.9	
169	986.0	5.8	28.7	36.9	66.8	76.8	124.7	
170	934.8	1.2	11.9	18.0	31.1	41.8	95.7	
171	956.8	25.3	25.3	32.6	34.7	47.5	108.8	
172	986.0	48.8	48.8	53.0	70.7	79.9	134.1	
173	1022.6	87.8	108.5	116.1	145.7	154.8	191.1	
174	908.6	2.1						
175	937.0	116.4					175.3	
176	927.5	59.4					135.0	
177	913.2	24.1			24.1	33.2	100.6	
178	888.2	170.1			170.1	176.8	349.0	
179	896.4	9.8			9.8	21.3	79.6	
180	1062.2	118.3	141.7	147.2	179.2	187.5	237.1	
181	1016.5	65.2	65.2	69.8	86.0	93.6	147.5	
182	986.0	129.5	138.4	143.6	173.4	181.7	228.9	
183	1020.5	81.4			116.1	127.1	183.2	
184	1047.9	120.1	120.1	123.1	156.7	164.3	196.3	
185	1022.6	88.1	88.1	92.7	123.1	130.8	182.6	
186	1013.5	149.7	149.7	155.8	185.6	194.2	247.2	
187	965.6						275.5	
188	979.0	104.9	104.9	110.0	133.2	141.4	197.8	
189	1046.1	123.4	143.9	151.8	178.3	186.5	241.1	
190	1037.8	136.2	155.4	163.1	194.2	202.7	244.4	
191	1041.5	140.2	163.4	171.0	196.0	202.1	261.5	
192	1031.4	196.9	216.1	224.9	256.9	267.0	323.4	
193	994.0	247.8			247.8	262.1	324.6	
194	1075.4	235.7	253.3	259.8	286.9	294.8	336.6	
195	1059.2	203.9	225.2	230.4	255.7	266.4	305.7	
196	1042.4	144.8	165.5	172.5	205.4	214.9	249.9	
197	1034.5	135.0	156.4	163.7	193.5	203.3	244.4	
198	1031.4	133.2	153.9	160.0	190.5	199.6	247.5	

FFG No.	Reference Elevation	Forty niner	Mag- enta	Tama- risk	Cul- ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
199	1038.8	150.0	171.3	178.9	211.8	220.1	258.2	
200	1040.9	138.4	160.0	167.9	202.7	212.8	255.7	
201	1074.1	179.5	200.9	208.5	235.9	244.1	295.4	
202	1075.6	241.4	259.1	267.3	301.8	312.4	352.0	
203	1071.4	230.1	248.4	255.7	295.4	303.9	343.8	
204	1096.4	231.6	249.9	258.5	282.9	291.1	329.2	
205	1082.0	201.4	221.5	228.8	256.9	265.4	313.5	
206	1067.7	171.9	193.2	200.3	230.7	239.6	288.3	
207	1072.6	180.4	200.3	207.6	239.0	246.6	296.9	
208	1060.1	157.3	178.0	185.9	217.0	225.6	279.8	
209	1074.1	200.9	200.9	207.9	235.9	244.4	286.8	
210	1066.2	180.4	200.3	207.3	238.7	247.5	300.2	
211	1060.4	174.3					283.5	
212	1078.4	207.9	225.6	233.2	260.9	269.4	310.0	
213	1051.6	148.1	177.1	183.2	213.7	222.8	256.3	
214	1061.6	183.8	206.7	213.4	243.2	253.0	303.9	
215	1041.8	189.3	210.6	218.2	248.7	256.9	307.2	
216	993.6	256.6	276.8	283.2	304.8	310.9	473.0	
217	1057.7	184.1	206.3	214.0	242.9	252.1	301.4	
218	1053.1	189.6	209.1	217.3	249.6	258.8	309.1	dup FFG 602; deleted 602
219	1036.3	125.9	146.6	156.4	187.5	196.0	253.0	
220	1051.0	191.1	214.3	218.8	252.4	261.5	308.8	
221	1027.8	213.4	231.6	240.8	271.3	283.5	342.9	
222	1019.9	249.3	270.1	278.3	306.6	314.9	415.4	
223	1008.9						491.0	
224	1133.6	456.6	477.9	485.5	535.8	543.5	575.5	
225	1138.3	454.6	475.9	482.0	534.8	540.3	572.0	
226	1150.3	467.1	489.3	496.3	548.5	555.5	588.4	
227	1149.4	471.2					598.9	
228	1133.6	459.9	481.9	490.4	545.3	552.9	584.3	
229	1146.0	444.4	466.6	474.0	531.3	538.9	573.9	
230	1134.5	445.9	469.4	476.4	533.4	539.5	576.1	
231	1120.1	416.1	438.3	445.9	500.2	506.3	541.9	
232	1124.1	406.3	428.5	435.9	492.6	498.3	538.0	
233	1114.7	405.4	428.9	435.9	490.7	496.8	532.8	
234	1112.8	367.0	390.1	397.8	452.6	459.3	496.5	
235	1117.1	394.7	418.5	425.8	481.6	488.6	521.2	
236	1101.2	332.8	354.8	362.7	418.5	424.0	459.3	
237	1137.8	402.5	425.7	433.0	491.6	503.4	537.0	
238	1152.8	436.2	461.8	467.3	524.3	531.3	568.5	
239	1177.1	474.0	498.0	503.8	556.6	563.6	606.6	
240	1162.2	467.0	491.0	497.7	552.3	559.6	593.4	
241	1165.3	476.4	499.0	506.3	560.2	567.2	602.6	
242	1115.0	315.2	331.9	338.3	382.8	390.8	433.7	
243	1153.7	389.9	410.6	418.2	485.3	494.4	538.6	
244	1120.0	321.6	339.2	346.9	398.7	404.8	430.7	
245	1170.7	573.6	597.7	603.8	659.9	667.2	700.1	
246	1161.9	560.2	583.4	588.9	645.9	653.8	688.8	
247	1145.4	556.3	581.6	587.4	644.1	651.7	685.3	
248	1150.0	555.3	578.8	584.0	643.4	651.7	685.5	

		Depths (meters) to Top of Units						
FFG No.	**Reference Elevation**	**Forty niner**	**Mag-enta**	**Tama-risk**	**Cul-ebra**	**ulm**	**Salado salt**	**Revisions**
249	1169.2	575.5	599.5	605.0	663.9	670.9	705.0	
250	1159.8	485.7	508.3	515.3	572.3	579.3	614.3	
251	1139.0	570.3	594.1	600.5	661.7	669.0	706.8	
252	1134.1	425.5	450.2	456.3	514.5	521.5	566.6	
253	1108.6	448.1	469.4	476.1	541.9	547.1	586.7	
254	1111.6	460.6	481.6	487.7	549.6	556.9	593.8	
255	1122.6	512.7	534.9	542.5	608.1	616.3	655.3	
256	1136.0	578.2	600.8	606.2	658.1	665.1	697.1	
257	1137.2	536.8	557.8	563.6	613.9	620.0	653.2	
258	1120.4	505.4	525.5	532.8	574.2	584.0	622.7	
259	1139.6	554.7	578.5	586.1	636.4	644.7	682.8	
260	1111.0	489.2	507.2	513.6	554.7	562.1	595.9	
261	1106.1	495.9	513.3	519.7	563.9	568.8	603.5	
262	1109.5				623.9	632.5	669.0	
263	1115.6	562.2	589.0	594.5	659.1	667.1	708.8	
264	1121.1	343.5	360.6	367.9	417.3	424.9	467.6	
265	1130.8	355.4	374.9	381.0	444.7	453.5	496.2	
266	1131.4	372.5	394.7	400.5	466.0	474.6	521.8	
267	1120.4	384.0	406.9	412.1	479.1	487.7	537.7	
268	1115.9	399.9	425.2	431.3	502.3	509.6	552.6	
269	1105.8	376.6	403.4	408.9	478.1	488.2	537.5	
270	1057.0	265.2	282.5	287.7	326.7	335.9	367.6	
271	1049.4	215.5	234.4	240.5	275.5	281.6	316.1	
272	1073.5	226.9	251.0	257.1	321.7	329.6	376.3	
273	1079.2	262.3	281.8	289.1	326.0	333.9	377.5	
274	1137.2	286.2	303.0	310.0	344.1	351.4	389.8	
275	1135.7	277.1	295.4	301.4	335.0	341.1	368.5	
276	1125.9	264.3	280.7	288.3	323.1	330.1	359.7	
277	1123.2	269.7	286.5	294.1	327.7	334.1	369.7	
278	1098.2	229.8	252.4	259.7	321.6	332.8	375.8	
279	1107.9	247.8	267.0	274.6	331.0	340.2	372.2	
280	1120.3	261.7	283.0	289.4	331.5	340.3	382.1	
281	1147.3	311.5	333.1	339.9	384.7	392.9	438.0	
282	1146.4	349.3					485.5	
283	1090.9	506.3	527.0	532.8	594.7	601.7	640.4	
284	1117.1	386.8	405.1	411.2	469.1	475.8	520.9	
285	1112.5	352.3	371.2	377.6	442.9	452.0	496.5	
286	1101.5	264.0	281.3	287.4	327.7	335.5	372.8	
287	1094.6	282.6	301.5	308.5	356.4	361.3	401.5	
288	1110.4	344.7	365.5	371.6	441.7	447.8	493.5	
289	1081.9	345.6	362.0	368.1	401.3	408.0	442.8	
290	1103.4	277.7	296.9	303.9	332.5	342.6	370.0	
291	1132.0	365.8	389.5	395.3	463.3	471.2	516.9	
292	1090.6	316.4	332.2	338.3	365.8	372.8	403.9	
293	1085.1	319.1	334.4	340.5	367.0	374.6	412.7	
294	1095.5	500.2	522.7	528.5	591.0	598.0	637.3	
295	1087.5	504.7	527.3	532.8	598.0	607.5	648.6	
296	1106.4	513.9					661.7	
297	1104.9	537.4	565.7	572.4	635.8	649.5	684.6	
298	1070.0	500.8	517.6	523.3	541.9	549.6	580.0	

FFG No.	Reference Elevation	Forty niner	Mag- enta	Tama- risk	Cul- ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
299	1078.4	484.0	509.3	514.2	580.6	588.6	637.0	
300	1062.2	518.5	541.6	546.8	581.6	589.2	645.3	
301	1046.4	531.6	555.3	560.8	610.5	616.0	687.0	
302	1092.7	550.2	574.2	578.5	649.2	655.9	672.4	
303	1099.3	563.4	588.1	594.2	650.3	657.3	694.5	
304	1088.1	547.7	570.6	575.2	642.2	649.2	688.8	
305	1093.9	559.3	584.6	590.7	650.7	659.3	694.3	
306	1075.9	583.7	606.6	610.8	662.9	670.6	714.5	
307	1078.7	560.8	585.2	590.7	646.5	654.4	694.9	
308	1075.9	584.6	610.2	615.4	699.8	708.1	752.9	
309	1093.6	558.4	585.5	590.4	659.0	665.7	705.0	
310	1087.5	523.3	548.3	552.9	612.3	618.4	657.5	
311	1085.4	586.7	598.9	604.4	656.8	665.1	698.0	
312	1076.9	539.5	566.3	572.4	647.1	652.9	692.8	
313	1106.1	171.8	191.0	198.0	235.8	244.1	273.9	
314	1121.1	258.8	278.0	285.0	332.2	339.5	386.2	
315	1131.1	348.2	366.8	372.6	429.6	436.9	480.2	
316	1133.2	361.8	385.3	391.1	454.8	463.0	509.0	
317	1097.6	305.4	320.6	324.9	365.2	372.5	404.5	
318	1123.5	365.5	381.3	388.9	413.3	420.9	457.5	
319	1120.7	351.4	369.1	374.9	416.1	424.3	458.7	
320	1129.6	367.3	388.3	394.1	460.2	467.6	513.6	
321	1124.7	364.2	386.8	392.6	456.3	463.0	511.8	
322	1124.7	369.6	391.5	397.3	454.9	462.5	507.9	
323	1120.4	369.3	390.9	397.0	445.2	452.5	493.6	
324	1122.0	360.3	376.7	384.0	422.5	429.8	468.8	
325	1079.9	260.3	279.5	286.5	317.6	326.7	366.4	
326	1117.7	363.3	381.6	388.6	411.2	419.7	460.2	
327	1102.2	353.9	373.1	378.6	412.4	420.3	456.9	
328	1121.4	364.4	386.9	392.7	447.6	456.7	500.9	
329	1120.4	364.8	386.5	392.0	451.4	459.0	507.2	
330	1115.6	360.7	382.4	387.6	446.1	454.6	504.0	
331	1103.7	350.2	375.2	381.0	450.8	456.9	501.1	
332	1124.7	380.7	405.4	410.9	485.2	491.9	537.7	
333	1130.5	384.2	407.7	413.2	479.9	487.5	531.7	
334	1125.9	382.8	407.8	413.3	481.0	488.9	536.8	
335	1129.6	372.5	395.9	404.8	466.3	474.6	521.8	
336	1124.1	369.7	393.5	399.0	466.0	473.7	520.9	
337	1124.4	385.9	410.6	416.4	482.5	490.1	539.8	
338	1123.5	378.7	402.8	408.3	476.6	484.5	533.9	
339	1107.9	396.8	423.1	427.6	496.2	503.8	554.1	
340	1107.0	385.6	413.0	418.2	489.2	497.7	547.1	
341	1025.0	523.3					623.3	
342	1056.1	308.5	329.2	335.9	373.4	379.8	404.5	
343	1032.1	732.1						
344	1040.6	327.2	347.9	355.5	381.5	389.7	418.0	
345	1073.2	297.7	321.1	326.6	394.6	401.9	444.6	
346	1076.9	328.1	354.6	360.1			482.0	
347	1039.7	273.7	295.0	303.0	340.2	346.9	384.4	
348	1035.7	244.8	262.4	267.6	297.2	302.7	349.6	

FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
349	1034.8	270.6	292.6	296.8	320.3	325.5	356.0	
350	1041.5	232.6	252.4	258.5	296.3	301.8	329.2	
351	1102.8	370.6	397.2	401.7	473.4	481.6	531.3	
352	1103.1	371.6	397.5	403.6	473.7	481.3	530.0	
353	1095.8	344.1	369.1	374.6	444.7	451.7	497.4	
354	1051.0	233.2	250.2	255.7	289.0	295.0	328.6	
355	1027.2	32.3						
356	1008.9	45.1					120.4	
357	1011.9	54.3						
358	988.6	25.1						
359	985.4	41.1					144.8	
360	1008.9							
361	1012.5	1.5	25.6	29.9	57.3	64.0	106.7	
362	1010.7	54.3			91.4	99.7	169.2	
363	1009.5	36.6			62.5	71.6	128.0	
364	993.6	50.9			75.3	83.8		
365	1003.4	60.0						
366	1010.4	50.0	69.8	76.5	98.8	106.4	146.6	
367	1006.4	30.5	51.8	57.9	74.7	83.8	129.5	
368	1012.5	-0.3						
369	1012.1							
370	1012.9	0.0			44.2	50.3	93.6	
371	1012.9	0.0	15.2	18.3	47.2	54.3	93.0	
372	1006.4				57.3	64.9		
373	998.1	53.1			89.1	96.1		
374	995.2	48.8	54.3	65.5	86.9	93.0	140.2	
375	994.3	76.2						
376	1010.4	25.6			62.8	70.7	114.0	
377	996.7	118.0					225.2	
378	986.6	72.2						
379	986.0	89.0						
380	989.4	80.6					210.8	
381	1021.4	0.0			106.7	112.8	146.3	
382	1034.8	60.7						
383	1046.1	90.8	107.3	114.9	137.8	143.9	178.9	
384	976.0		30.2	38.1	54.9	63.7		
385	990.6	68.6			74.7	83.8	134.1	
386	961.9	58.2					153.3	
387	1019.9	53.3	79.6	85.3	108.8	118.3	157.9	
388	1019.6	60.4	82.9	90.2	118.9	125.9		
389	1008.0	31.4			83.2	90.5		
390	1022.6	48.2	68.6	77.1	103.0	109.1	159.1	
391	1025.3	51.8	73.8	80.8	106.1	112.2	157.0	
392	1019.6	51.8	71.0	77.7	109.1	115.2	156.4	
393	1061.6	226.0	245.5	251.0	276.0	280.6	308.9	
394	1050.3	124.4	141.7	147.2	167.9	173.1	203.6	
395	1059.2	140.8	157.6	163.4	184.7	191.7	217.0	
396	1090.0	188.4	205.7	212.8	236.2	242.9	302.7	
397	1036.9	254.8	285.0	290.2	338.3	358.1		
398	1011.6	185.9	206.0	213.1	239.9	244.4		

FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
399	1001.6	163.1			216.4	221.0		
400	980.5	74.1						
401	972.3	97.5			132.6	138.7		
402	1023.1	20.6	43.7	51.1	76.0	86.4		
403	995.2	32.2	53.8	59.9	80.6	91.9	148.3	
404	976.6	50.9	75.0	79.2	103.3	109.4		
405	970.2	62.2					144.5	
406	968.4	0.0						
407	969.9	11.6	29.9	37.5	61.9	71.0		
408	965.0	51.8	51.8	56.4	57.9	64.0	137.2	
409	970.5				27.4	38.1		
410	950.7	94.0					223.6	
411	957.7	70.4			70.4	83.8	168.6	
412	970.2	14.9					125.3	
413	968.7	53.6			53.6	62.5	133.5	
414	965.8	47.7					157.4	
415	964.4	32.6					114.9	
416	971.1	40.8					130.8	
417	966.7	46.6					128.6	
418	1033.9	50.6			103.6	110.9		
419	1052.5	55.5	75.9	83.5	109.7	115.8		
420	1045.1	52.4	71.6	80.8	108.2	117.3		
421	1047.0	63.4	86.9	92.0	123.7	133.2	167.6	
422	1054.3	77.7	96.0	108.2	131.1	138.7		
423	1057.0	196.9					299.3	
424	1057.7	247.8						
425	1003.7	40.2					158.2	
426	996.1	34.1			69.2	76.8	139.6	
427	1042.7	94.5					166.1	
428	1048.5	110.9					205.7	
429	1044.2	63.1					160.6	
430	1007.7	44.5					198.4	
432	978.4	46.6	54.3	60.4	93.9	101.5	141.1	Surf el, top Rust wrong?
433	968.0	47.5			70.4	75.6	151.2	
434	944.6	41.1					118.2	
435	943.7	0.0					94.5	
436	943.4	42.2					120.3	
437	937.9	27.9					118.7	
438	1082.2	189.6	207.6	215.5	246.6	252.4	284.7	
439	941.2	23.8						
440	938.5	51.5					120.1	
441	938.8	32.3					120.7	
442	937.0							
443	934.2						113.7	
444	943.4	32.8					118.2	
445	960.7	40.5			40.5	49.1	133.5	
446	937.0	19.8					107.6	
447	922.3	25.0					98.8	
448	924.2	6.4					108.8	
449	931.8						112.5	

FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
450	925.7						106.4	
451	929.3	9.1					106.7	
452	934.2						126.8	
453	1049.5	187.3			267.2	276.6	323.0	
454	1011.8	87.2					184.7	
455	1061.3	223.7	243.8	250.9	291.1	299.9	337.4	
456	1063.4	234.4	250.9	258.2	286.8	293.5	332.5	
457	1023.5	138.4	155.4	162.2	192.3	200.9	239.0	
458	1025.8	137.6	153.2	163.5	192.5	200.7	240.3	
459	1070.5	253.9	271.0	278.6	309.1	318.2	353.3	
460	1049.7	225.6					321.0	
461	1047.6	222.2					317.9	
462	1032.1	148.0	166.3	174.6	203.5	211.4	250.8	
463	1021.1	107.6	128.0	134.7	166.7	177.4	209.7	
464	1035.4	135.0	155.4	163.1	192.0	201.8	247.8	
465	1031.4	128.6	148.4	156.1	186.5	196.3	247.5	
466	1070.5	235.6					331.6	
467	1025.7	519.5	537.5	542.4	594.8	602.7	645.4	
468	1064.7	571.2	599.2	604.7	687.0	691.6	742.5	
469	1046.4	612.3					688.5	
470	1067.1	557.5	582.2	587.0	659.0	664.5	707.1	
471	1036.6	510.8	536.1	541.6	610.5	616.0	664.2	
472	1032.4	468.2	494.1	499.6	530.7	536.8	593.1	
473	1060.7	569.1	592.5	597.1	670.3	677.0	721.2	
474	1100.6	349.9	371.2	377.3	423.1	428.9	465.7	
475	1103.7	354.0	374.8	379.9	417.4	426.0	465.9	
476	1090.1	268.3	285.1	292.7	329.9	338.4	378.7	
477	1102.8	328.3	342.0	351.1	376.1	384.0	423.1	
478	1104.8	349.2	365.1	371.2	402.2	410.8	449.5	
479	1106.4	353.9	370.0	376.4	399.6	407.5	445.3	
480	1096.1	341.7	363.6	369.7	408.1	414.8	454.5	
481	1090.9	359.1	375.2	381.9	409.3	416.4	455.7	
482	1103.4	342.0	359.1	364.8	391.7	399.6	438.0	
483	1094.2	309.1	326.4	332.8	353.0	361.5	403.3	
484	1095.6	323.4	342.0	347.5	369.7	374.9	423.4	
485	1096.5	317.1	333.9	339.7	366.2	373.5	413.7	
486	1097.6	331.3	348.1	354.2	381.6	389.2	428.9	
487	1097.0	333.1	350.5	356.6	381.6	390.1	427.6	
488	1088.6	340.6	357.4	362.0	390.3	396.1	439.7	
489	1086.6	322.0	338.2	344.3	369.3	377.8	423.5	
490	1072.6	217.0	233.8	239.9	265.8	271.3	306.9	
491	1077.5	221.6	241.1	247.2	277.7	284.4	324.9	
492	1067.4	249.9	268.8	274.9	301.8	310.3	346.9	
493	1069.2	265.6	283.9	289.4	316.8	326.0	359.5	
494	1069.5	258.2	277.4	283.5	315.5	322.5	356.3	
495	1072.3	272.9	289.3	295.1	322.5	329.2	375.9	
496	1108.3	392.9	419.7	424.0	492.3	504.1	552.9	
497	1090.6	369.1	389.5	395.0	440.7	448.4	488.9	
498	1104.9	367.9	390.8	396.5	459.3	467.3	515.7	
499	1091.5	376.1	402.0	406.9	479.1	488.3	541.6	

		Depths (meters) to Top of Units						
FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
500	1091.5	365.5	386.8	392.9	448.1	456.3	508.7	
501	1075.6	344.1	365.5	371.6	402.6	410.0	450.2	
502	1092.4	367.6	389.5	395.0	454.2	461.5	525.2	
503	1064.1	358.7	380.1	384.7	440.1	447.8	490.4	
504	1070.5	346.9	364.5	370.6	396.2	402.9	451.7	
505	1077.8	323.1	338.3	343.5	375.5	381.6	427.3	
506	1069.8	320.6	338.9	344.4	369.7	379.2	420.3	
507	1051.9	339.1	359.5	363.5	444.9	452.5	502.8	
508	1051.9	288.6	307.8	313.3	363.0	371.2	423.1	
509	1066.5	298.7	321.3	327.4	398.4	404.2	450.2	
510	1080.5	313.2	335.7	341.8	410.4	421.7	465.3	
511	1102.8	374.6	400.5	406.3	473.7	483.4	532.2	
512	1073.5	325.2	352.7	358.7	429.8	438.9	496.8	
513	1061.0	298.0	320.3	326.1	394.0	401.7	455.0	
514	1060.1	305.4	328.9	334.1	414.2	423.1	482.8	
515	1082.3	359.7	384.4	389.5	465.1	471.5	526.1	
516	1075.0	359.1	383.7	389.5	462.4	473.4	529.1	
517	1053.1	243.8	264.3	269.4	297.8	302.4	320.6	
518	1036.3	238.4	258.2	264.3	294.1	300.5	316.1	
519	1033.9	268.2	290.2	293.8	329.8	337.4	374.0	
520	1030.8	377.8	395.4	399.1	439.9	445.4	488.1	
521	1028.7	355.4	373.7	378.3	395.6	400.5	424.0	
522	1055.2	523.5	550.9	555.5	621.0	627.7	672.8	
523	1041.8	500.5	524.9	532.5	592.5	598.6	652.9	
524	1024.1	331.0	349.0	353.3	408.1	416.7	462.4	
525	1047.0	503.7	533.3	538.5	603.1	610.4	658.6	
526	1033.9	60.4			83.2	90.8	122.8	
527	1031.7	72.8	93.0	98.1	137.5	143.6	160.6	
528	1023.5	71.9	89.3	97.5	127.4	132.0	159.4	
529	1022.3	36.3						
530	1016.5	16.2			50.6	58.8	86.3	
531	998.2	78.9			103.3	109.4	143.0	
532	990.3	74.7		83.2	110.6	117.3	151.8	
533	994.3	65.5					138.7	
534	1021.1	74.7			128.3	137.8		
535	995.9	56.2	76.0	83.1	113.8	120.2	145.5	
536	996.1	67.7			103.6	111.6	142.6	
537	985.4	80.8			105.5	112.8	144.8	
538	1017.1	73.2						
539	1019.6	86.0					182.6	
540	1028.1	79.6					178.9	
541	1047.0	103.3					189.9	
542	1011.9	104.9					204.5	
543	997.9	27.0			65.7	71.2		
544	999.7	19.7					101.3	
545	1013.8	12.8						
546	1013.5	30.2	33.2	37.8	59.1	66.8		
547	1000.0	27.4					118.9	
548	1047.3	116.7	133.2	139.6	164.0	170.1		
549	909.8	37.5				55.8	110.0	

FFG No.	Reference Elevation	Forty niner	Mag- enta	Tama- risk	Cul- ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
550	889.1	35.4					99.1	
552	922.9	190.2			190.2	200.9		
556	908.9	60.4			60.4	75.6		
559	902.3	0.0			102.7	108.8	171.3	
561	1002.2							
562	981.5	310.9	329.2	336.2	359.7	367.0		
563	969.9	387.4	405.1	412.4	432.5	441.7		
564	969.3	306.3					411.5	
565	984.2	302.5	317.3	321.3	337.4	341.1	389.2	Rustler 302.5, not 332.5
566	971.3	277.4	292.0	317.0	336.8	342.9	393.2	
568	957.1	322.5			325.2	331.3		
569	952.2	263.0	281.6	289.0	319.4	328.0		
570	945.8	387.7				415.1		
572	995.2	252.4			252.4		320.0	
575	966.2	333.1						
577	972.9	203.1						
580	979.6	164.9					244.1	
582	981.8	271.6					356.9	
583	998.2	275.2					377.3	
584	1006.8	233.6	239.1	242.5	264.1	270.2	315.9	
585	1025.0	294.1			338.3	346.6	381.6	
586	1020.2	376.7					465.7	
589	975.4	192.5					280.3	
593	968.0	181.9					261.4	
594	989.7	253.0						
595	999.1	328.6						
596	1004.9	352.1						
599	942.4	247.7					298.9	
600	1003.4	274.3	275.8	281.3	303.3	310.9		
601	983.9	338.3	360.9	368.2	403.9	411.2		
602								Data dropped; Same as FFG218
606	1012.9	289.9	309.4	317.0	339.2	345.3	409.7	
607	1001.3	258.2	278.0	282.9	320.0	329.5	377.0	
608	1018.6	264.0	286.8	292.0	355.4	363.9	424.9	
609	1025.3	267.0	286.5	292.6	368.8	378.6	439.2	
610	1023.2	276.5	300.8	310.0	374.0	383.1	434.9	
611	1009.2	277.4	301.8	306.0	365.2	373.7	429.8	
612	977.1	243.7	261.4	264.4	298.0	307.4	352.2	
613	945.9	217.4	232.4	240.0	268.0	277.2	324.1	
614	919.0	242.3						
615	926.9	200.3					281.0	
617	881.2	18.3						
618	897.0	195.1			210.3	217.9		
620	909.9	150.1	171.4	178.7				
621	905.9	210.9						
624	907.1					71.2		
627	870.5					69.5		
628	881.5	13.3						
629	881.8	51.2					128.6	
630	912.6	56.7						

FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
631	903.1	44.7						
637	878.4							Location in question
638	975.4	383.7	402.3	408.1	438.6	445.3		
639	961.5	395.2	417.7	424.1	453.4	463.1		
640	966.2	317.1	335.4	343.1	368.4	379.6	446.7	
642	929.9			246.0			358.7	
643	975.4	286.5	305.7	313.0	333.1	338.3	399.3	
644	936.7	213.2	230.3	235.5	259.5	266.2		
645	929.6	165.7						
647	931.5	158.5						
648	960.7	402.3	419.4	424.6	447.4	460.2		
652	1106.4	227.7	246.6	252.7	283.5	290.5	320.0	
653	1096.1	216.1	236.2	242.0	273.4	280.4	307.5	
654	1098.5	199.0	218.5	223.7	252.7	259.4	286.2	
655	1093.0	195.7	214.9	219.8	245.7	252.7	280.1	
656	1091.8	197.5	214.9	221.0	246.6	253.3	282.9	
657	1083.3	177.1	193.5	199.6	220.4	227.1	253.3	
658	1088.1	189.9	206.3	213.7	238.7	245.4	271.9	
659	1072.6	170.7	186.5	192.9	215.8	224.0	251.5	
660	1071.1	151.9	169.6	174.2	197.7	204.7	226.0	
661	1082.0					215.8	243.2	
662	1085.7	191.1	209.4	214.9	242.3	248.4	275.5	
663	1093.9	209.4					294.1	
664	1084.5	196.3	216.1	222.5	248.1	253.6	289.6	
665	1075.3	157.0					237.4	
666	1063.1	125.0	142.6	148.7	173.1	179.2	203.0	
667	1059.2	135.9	153.6	159.7	183.5	189.9	213.4	
668	1043.3	95.6			117.2	123.9	138.2	
669	1036.3	102.1			123.4	130.5	145.7	
670	1049.1	103.0	122.2	129.8	151.8	160.0	173.1	
671	1044.9	127.2			144.9	153.7	171.4	
672	1058.0	114.3	132.3	138.1	160.9	168.2	189.9	
673	1037.2	122.5			143.0	149.7	166.7	
674	1064.7	127.7	143.0	149.7	171.3	179.2	204.5	
675	1078.4	182.4	200.7	206.8	226.9	234.2	259.2	
676	1084.5	179.5	192.6	200.3	222.2	229.8	252.7	
677	1064.4	132.0	146.6	153.9	174.7	181.1	207.3	
678	1062.8	127.1					197.8	
679	1060.7	125.9	143.6	150.3	169.5	176.8	199.6	
680	1043.6	86.3					162.5	
681	1041.2	93.9					168.6	
682	1059.2	92.4					168.6	
683	1032.7	140.5						
684	1061.9	152.7					231.3	
685	1003.5	85.4			85.4	92.4	177.8	
689	1059.2	242.0	259.7	265.5	294.7	302.4	341.1	
690	1052.2	227.4	247.2	253.3	283.5	291.4	334.1	
691	1052.5	236.2	256.3	262.1	291.7	299.6	341.1	
692	1057.7	251.5	271.3	277.4	307.8	316.1		
693	1050.6	232.9	253.6	259.7	290.2	296.9	338.0	

FFG No.	Reference Elevation	Forty niner	Magenta	Tamarisk	Culebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
694	1042.4	232.3	253.0	259.1	292.0	299.3	362.1	
695	1048.5	234.4	253.6	259.7	292.0	299.3	345.9	
696	1050.6	234.7	253.6	260.0	292.3	299.0	347.5	
697	1045.8	227.7	246.6	252.1	285.6	291.7	345.9	
698	1039.7	178.3	198.1	204.2	237.7	244.4	304.8	
699	1029.6	218.5	236.8	242.9	274.0	280.1	338.6	
700	1027.1	225.7	244.6	250.1	277.8	282.7	344.9	
701	1032.1	221.5	243.5	250.2	282.5	291.3	345.6	
702	1036.6	224.9	243.8	249.9	281.0	289.6	342.9	
703	1047.0	229.8	248.1	255.4	285.3	293.2	330.1	
704	1032.7	226.5	247.2	253.3	287.1	295.4	346.3	
705	1023.8	288.3	308.2	314.2	344.1	352.0	413.0	
706	1025.7	270.7	289.6	295.0	323.4	331.3	388.6	
707	1019.3	278.3	299.0	305.1	332.5	342.3	402.6	
708	1026.6	235.0	253.3	259.4	289.9	297.8	356.9	
709	1008.6	327.1	344.1	349.9	375.8	382.8		
710	1007.4	324.9	342.0	348.1	375.8	382.2	428.2	
711	1012.9	318.5	337.7	344.7	378.3	386.8	442.3	
712	1018.0	282.4	299.2	307.1	339.7	348.5		
713	1011.3	338.8	355.5	363.2	390.6	397.6		
714	1024.1	233.8	253.9	262.2	292.6	299.0		
715	1025.3	225.6	242.3	250.5	283.5	290.2		
716	1060.6	362.7	379.8	384.0	455.7	463.3	507.5	
717	1056.1	333.6	352.8	358.0	383.9	390.9	434.2	
718	1044.9	321.4	338.2	344.0	380.2	388.8	432.1	
719	1040.4	343.7	361.0	366.2	414.4	421.7	469.2	
720	1019.9	320.3	340.8	348.4	394.1	405.4	449.3	
721	1026.9	328.9	347.8	353.3	380.7	387.4	432.5	
722	1063.4	297.8	345.0	350.5	348.1	357.2	396.8	Top Tamarisk, Magenta wrong
723	1054.3	246.1	262.6	269.0	291.5	299.2	341.8	
724	1044.2	305.3	325.1	330.6	357.7	366.2	410.4	
725	1029.6	317.3	334.7	339.9	376.7	383.1	419.1	
726	1018.6	319.7	335.9	341.1	370.0	377.6	429.5	
727	1020.8	317.9	340.8	345.9	381.6	390.1	445.3	
728	1012.2	315.8	334.4	338.9	365.5	374.0	421.8	
729	1014.4	307.8	325.5	330.7	365.5	373.4	418.5	
730	1018.9	294.1	313.3	317.6	345.3	353.6	396.2	
731	1022.3	301.6	319.3	324.5	351.9	359.5	404.6	
732	1040.3	300.8	319.7	327.1	353.9	362.1		
733	1028.4	221.9	240.8	247.2	278.6	286.5	330.1	
734	1029.0	270.4	287.1	292.0	321.6	329.8	374.9	
735	1016.5	312.4	331.9	337.4	377.6	386.2	432.5	
736	1025.6	266.9	286.5	293.2	349.2	357.8	410.2	
737	1040.5	337.9	357.7	361.7	420.2	428.7	481.2	
738	1018.3	304.5	321.3	325.8	356.3	363.9	408.1	
739	1015.1	261.2	280.7	285.3	320.3	331.3	386.5	
740	1015.6	260.9	278.9	285.0	353.0	362.4	406.6	
741	1014.7	293.5	311.8	317.0	356.0	363.6	412.4	
742	1023.8	249.3	270.1	275.2	323.1	333.1	377.3	
743	1013.2	256.0	272.8	278.0	327.1	338.0	382.5	

FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
744	1012.5	272.8	289.6	294.7	335.3	341.7	382.5	
745	1006.4	276.1	297.5	300.5	348.7	356.0	408.1	
746	1007.5	287.7	308.4	314.5	362.0	370.3	425.7	
747	1016.2	234.1	253.0	259.1	290.2	297.2		
748	999.7	207.9	224.6	231.6	259.7	267.9	315.5	
749	1000.7	362.1	380.4	386.5	412.7	419.1	474.0	
750	996.4	298.7	315.8	323.7	351.1	359.7		
751	997.0	419.7	436.8	441.7	466.6	475.2	510.2	
753	991.5	329.1	354.1	359.5	389.4	397.3		
754	983.6	272.2	292.3	299.0	327.4	335.9	382.8	
755	980.8	342.6	357.2	364.8	375.5	383.1	552.3	
756	965.3	176.8	195.1	201.2	222.8	230.7	294.7	
757	966.8	173.7	192.6	197.2	226.2	234.7	292.6	
759	975.4						384.7	
760	983.0	386.0	402.5	408.0	433.9	443.0	480.2	
761	953.4	178.9					282.2	
762	956.5	192.5	214.1	219.9	252.8	261.4	317.8	
763	951.6	174.0	192.3	198.7	239.3	246.9	297.5	
764	945.8	167.0	185.6	191.7	222.2	229.5		
765	946.4	164.1	182.7	191.9	226.6	232.7	290.6	
766	950.7	252.1	270.7	277.4	306.6	315.8	363.3	
767	959.2	277.1	294.4	299.9	329.5	337.7	377.6	
768	941.5	153.6	172.2	178.6	216.1	223.7	278.0	
769	943.4	143.6	162.8	168.9	208.8	214.6	271.0	
770	1011.6	282.3	297.0	301.8	331.7	340.6	386.6	
771	1011.6	292.3	310.6	316.7	356.9	365.5	411.2	
772	1014.7	274.6	294.1	299.3	332.5	341.1	386.5	
773	1007.7	234.6	253.2	259.3	290.1	298.6	343.7	
774	1003.4	237.3	257.1	263.5	302.2	309.8	354.0	
775	1016.5	280.1	300.2	306.6	338.6	345.6	399.0	
776	1015.0	276.5	295.4	301.4	338.9	348.1	393.5	
777	1022.6	239.9	258.2	263.7	294.1	303.9	345.9	
778	1009.5	280.8	299.7	306.1	336.9	345.7	389.3	
779	1002.8	272.5	291.4	298.4	328.9	338.0	383.7	
780	991.8	222.4	243.1	248.9	280.3	288.2	331.8	
781	958.9	206.3	227.7	233.2	267.3	277.4	334.1	
782	990.3	234.1	253.9	261.5	290.8	299.6	344.7	
783	1002.8	266.7	286.2	292.0	323.1	330.7	373.7	
784	1005.5	256.3	274.6	279.5	321.0	326.4	363.0	
785	1019.3	244.1	266.7	274.3	304.8	313.3	356.6	
786	1014.7	253.6	271.9	278.0	310.6	320.0	358.4	
787	995.2	242.9	261.5	268.2	301.1	309.1	350.8	
788	976.3	219.8	239.9	245.4	277.7	285.9	325.2	
789	950.4	197.8	218.2	224.0	263.0	270.1	322.8	
790	943.1	185.6	204.5	210.0	246.6	255.7	312.7	
791	1005.2	292.5	316.8	322.0	366.8	376.3	422.0	
792	1008.3	257.6	276.1	279.5	317.0	326.4	373.4	
793	1016.5	235.9	254.2	259.4	324.0	333.1	353.3	
794	1014.4	240.8	256.3	262.1	290.5	298.7	344.4	
795	1011.3	232.0	251.2	254.8	293.8	302.1	346.3	

FFG No.	Reference Elevation	Forty niner	Mag-enta	Tama-risk	Cul-ebra	ulm	Salado salt	Revisions
		Depths (meters) to Top of Units						
796	1027.2	213.4	231.6	237.7	271.0	279.2	322.5	
797	1027.8	228.6	246.3	252.4	284.1	293.5	334.7	
798	1027.8	231.0	250.2	256.6	289.5	298.1	337.7	
799	1015.3	194.2	213.4	217.9	256.0	262.7	306.3	
800	987.7	239.3	257.3	261.2	294.4	301.8	349.9	
801	979.0	289.4	307.1	311.7	354.3	363.5	408.3	
802	1001.3	249.3	267.0	271.0	309.7	318.8	366.1	
803	929.0	204.8	224.9	228.6	266.7	276.8	322.5	
804	953.4	241.2	261.7	265.0	301.6	311.4	356.5	
805	999.6	310.2	335.0	338.9	382.2	390.8	445.6	
806	963.2	314.2	331.9	335.6	366.1	374.0	417.3	
807	944.3	260.0	280.1	285.6	317.9	326.7	371.9	
808	935.7	266.1					378.0	
809	929.0	210.0	230.7	235.0	271.0	280.4	325.8	
810	928.7	222.8	242.9	246.9	287.1	293.5	339.2	
811	909.9	377.2	391.8	396.4	432.0	441.2	488.4	
812	961.0	302.4	334.1	337.1	409.7	423.4	475.2	
813	939.7	287.4	312.4	317.0	375.8	386.2	443.5	
814	905.3	206.5	225.4	229.4	265.0	274.2	316.8	
815	932.0	275.7	301.6	304.6	350.4	359.5	415.0	
817	1009.8	327.7	351.4	359.7	399.3	406.9		

This table was created by reproducing Table 2 of Richey (1989) with a few additional notations where obvious typographical errors or duplications occurred.
Locations and other data for each borehole can be found in a supplemental table in this appendix.
Cross-referencing is through the FFG number assigned to the drillhole by Richey.

APPENDIX C

COMPARISON OF DATA SETS FROM RICHEY (1989) AND HOLT AND POWERS (1988 AND SUPPLEMENT)

APPENDIX C

COMPARISON OF DATA SETS FROM RICHEY (1989) AND HOLT AND POWERS (1988 AND SUPPLEMENT)

To examine systematic differences, if any, between the controlled data set presented in Holt and Powers (1988), and supplemented here, and the data set in Richey (1989), we identified drillholes common to each set (Appendix C-1). The thickness of each Rustler unit or equivalent was computed in English units. For each data set, basic thickness statistics were computed (Appendix C-2). The difference in thickness between data sets for each unit was calculated for each drillhole, and basic statistic were again computed (Appendix C-2).

Given the methods of interpreting geophysical logs (see Holt and Powers, 1988, for a review), differences of 1 or 2 feet are not generally significant, especially for a single drillhole. The Forty-niner, Magenta, Tamarisk, and Culebra fall within this range, while the unnamed lower member differs considerably.

We note that the Richey data indicate an average of about 2 ft more Tamarisk and about 2 ft less Culebra when compared to our data. There is a systematic difference in how we place the Culebra–Tamarisk contact (Holt and Powers, 1988) that fits very well with the statistical analysis here.

Our thickness of unnamed lower member is not comparable to data in the Richey reference. Richey clearly designates this final measurement as depth to Salado salt. We attempted to determine the depth to the stratigraphic contact between the Rustler and the Salado. *These are two very different concepts leading to very different depth data.* Salt has been dissolved from the upper Salado in many drillholes, leading to significant differences. It is also possible that the top of salt may have been interpreted within the Rustler for some drillholes. The relatively small average difference reflects the fact that top of Salado salt coincides with Rustler–Salado contact in drillholes at and east of the Waste Isolation Pilot Plant. If top of salt was interpreted within the Rustler in some drillholes, these values would tend to average out differences when Salado salt was dissolved.

Our data were prepared under IT Corporation quality assurance procedures. The fact that these data sets correspond closely for equivalent units demonstrates that the technical approach was very similar for the Richey data set, although we do not have a reported procedure for their work.

APPENDIX C-1

TABLE OF IDENTICAL DRILLHOLES IN RICHEY (1989) AND HOLT AND POWERS (1988) SUPPLEMENTED BY DRILLHOLES RECENTLY INTERPRETED BY POWERS

Table of Identical Boreholes in Richey (1989 and Holt and Powers (1988) Supplemented by Boreholes Recently Interpreted by Powers

ID No.	FFG No.	T.	R.	Sec.	Distance (in ft) from section lines	
1054	526	19	30	5	1980n	330w
1060	98	19	34	12	660n	660w
1071	389	20	30	31	1980n	760e
1072	395	20	31	7	1650s	660e
1074	39	20	32	10	330n	990w
1075	40	20	32	13	660s	1980w
1076	41	20	32	15	1980s	1980w
1090	418	21	29	3	1980n	1980w
1091	419	21	29	4	4620s	1980w
1092	422	21	29	5	1980n	660e
1094	424	21	29	6	3147n	660e
1096	425	21	29	18	1980s	1980e
1097	428	21	29	22	1980n	1980e
1098	429	21	29	34	660n	1980w
1100	107	21	30	26	660s	1980w
1101	432	21	30	35	1980s	660w
1105	225	21	32	1	3255n	1972e
1106	226	21	32	1	660s	1980w
1107	227	21	32	2	660s	1980e
1108	228	21	32	2	3300n	660w
1109	233	21	32	4	1683n	1650w
1111	238	21	32	10	1980n	1980e
1112	239	21	32	11	660s	660e
1114	240	21	32	11	1980n	1980e
1115	242	21	32	21	660n	660w
1116	243	21	32	26	1980n	660e
1136	685	22	29	6	660s	660e
1139	114	22	30	1	990s	1980w
1186	314	22	32	13	660s	660e
1187	274	22	32	14	660s	1980w
1188	276	22	32	17	1980s	1980e
1189	277	22	32	18	660s	660e
1190	278	22	32	19	660s	660e
1191	279	22	32	20	1980n	1980e
1192	280	22	32	22	1980n	660w
1193	281	22	32	25	660n	1980w
1196	299	22	34	8	660s	1980e
1198	302	22	35	1	660s	660w
1199	303	22	35	3	660n	660w
1202	304	22	35	9	1980s	1980w
1204	308	22	35	20	1980n	660e
1207	312	22	35	35	660s	660w
1235	166	23	30	24	1980n	660w
1238	453	23	31	2	660n	660e
1245	455	23	31	11	660s	660e
1246	456	23	31	14	1980s	1980w

ID No.	FFG No.	T.	R.	Sec.	Distance (in ft) from section lines	
1248	457	23	31	16	1980s	1980w
1249	458	23	31	21	660s	660e
1252	459	23	31	25	1980n	1970w
1253	460	23	31	26	1980n	1650e
1254	461	23	31	26	1980n	1980e
1256	462	23	31	27	1980s	660w
1258	463	23	31	32	660n	660w
1259	465	23	31	33	1980n	660w
1260	466	23	31	36	660s	660w
1261	315	23	32	3	1980n	660e
1262	264	23	32	9	660s	1980e
1263	316	23	32	11	1980n	1980e
1264	265	23	32	15	1980n	1980e
1265	317	23	32	18	1980n	660e
1266	318	23	32	20	660s	1980e
1270	266	23	32	24	660s	660e
1271	321	23	32	25	990s	330w
1272	320	23	32	25	990n	2310w
1273	322	23	32	26	330s	330e
1275	323	23	32	26	660s	1980w
1277	324	23	32	28	660n	1980w
1278	325	23	32	31	660s	660w
1279	326	23	32	33	1980n	660e
1280	327	23	32	34	1980s	330e
1282	328	23	32	35	1650n	2310e
1291	330	23	32	36	1980s	1980e
1292	329	23	32	36	1980n	660w
1293	331	23	33	4	660s	660e
1294	332	23	33	6	330s	330e
1295	333	23	33	7	660s	660w
1296	334	23	33	17	660s	660w
1297	335	23	33	18	660s	660w
1302	336	23	33	19	1980s	1910w
1304	337	23	33	20	660s	660e
1305	338	23	33	31	660n	660e
1306	267	23	33	32	660n	1980e
1307	268	23	33	35	660s	660w
1308	345	23	34	18	1980s	1980w
1309	346	23	34	19	1980n	1980w
1310	347	23	34	22	1980n	1980e
1332	178	24	29	27	660s	660w
1334	187	24	30	18	460n	660e
1336	191	24	30	25	660s	660w
1337	193	24	30	29	660s	660e
1338	194	24	31	2	1980n	1980w
1339	195	24	31	3	660s	660e
1341	196	24	31	4	660n	660e
1343	197	24	31	4	1659n	2310w
1345	200	24	31	6	1980n	1980w
1346	201	24	31	7	660s	660e
1347	203	24	31	11	660n	1980e

ID No.	FFG No.	T.	R.	Sec.	Distance (in ft) from section lines	
1349	205	24	31	17	660n	660e
1350	206	24	31	18	660s	660e
1351	207	24	31	20	660n	660e
1352	208	24	31	20	660s	1980w
1353	209	24	31	21	660n	660e
1354	212	24	31	24	660s	1980e
1355	211	24	31	28	660s	660e
1356	214	24	31	35	1980s	660w
1358	474	24	32	1	1980s	660w
1360	475	24	32	2	1980n	660e
1361	476	24	32	6	660n	1980e
1362	477	24	32	10	1980s	1980e
1366	478	24	32	11	1980s	1980e
1371	480	24	32	12	1980n	660w
1372	481	24	32	13	660s	660e
1374	482	24	32	14	660n	1980w
1380	483	24	32	15	660s	1980w
1382	485	24	32	22	1980s	1980e
1383	484	24	32	22	1980n	990e
1389	486	24	32	23	1980n	660w
1392	491	24	32	30	1980n	1980e
1393	492	24	32	33	660s	660e
1394	493	24	32	34	1980s	1980w
1395	495	24	32	35	660s	660w
1402	497	24	33	7	660s	660e
1404	498	24	33	8	660n	660w
1405	499	24	33	13	1980n	660e
1407	500	24	33	17	660n	1980e
1408	501	24	33	20	660s	1980w
1409	502	24	33	22	1980n	660w
1410	503	24	33	27	1980s	1980w
1411	504	24	33	29	660s	1980e
1412	505	24	33	30	330n	330w
1413	506	24	33	31	1980s	660e
1414	507	24	33	36	660n	660e
1416	510	24	34	4	660n	1650e
1418	511	24	34	6	660n	3300e
1420	517	24	35	5	1980n	1980w
1425	549	25	29	3	660n	660e
1427	550	25	29	8	660s	660e
1429	552	25	29	15	660s	660w
1432	556	25	29	27	660s	660w
1436	216	25	30	4	1980n	1980w
1437	572	25	30	4	660s	660w
1438	580	25	30	8	1980n	660e
1443	577	25	30	8	1980s	660w
1444	583	25	30	10	660s	645w
1445	584	25	30	10	2030n	2180e
1447	589	25	30	17	660s	660w
1456	593	25	30	20	1980s	660w

ID No.	FFG No.	T.	R.	Sec.	Distance (in ft) from section lines	
1460	218	25	31	2	1980n	1980e
1460	602	25	31	2	1980n	1980e
1461	222	25	31	28	660n	660w
1463	223	25	31	35	660s	660w
1464	689	25	32	3	1650s	1980e
1466	690	25	32	9	1650s	330e
1472	691	25	32	10	2145n	2310e
1478	692	25	32	11	660s	1980e
1482	693	25	32	14	2310n	330w
1486	695	25	32	15	660n	1980w
1502	697	25	32	16	1980n	1980e
1506	698	25	32	18	660n	1650w
1508	699	25	32	20	1650s	330e
1509	701	25	32	21	990s	990e
1528	702	25	32	22	2310s	330w
1531	703	25	32	23	660n	1980e
1533	704	25	32	27	330n	330w
1536	706	25	32	28	2310s	1650w
1542	705	25	32	28	2310s	990w
1543	707	25	32	29	1980n	330e
1545	709	25	32	31	1980n	660w
1546	710	25	32	32	1980n	1980w
1547	712	25	32	33	1980s	560e
1548	711	25	32	33	660s	660w
1550	716	25	33	1	660n	660w
1551	717	25	33	5	660n	660e
1552	718	25	33	8	1980s	660e
1553	719	25	33	11	660n	660w
1554	722	25	33	18	660n	660w
1555	724	25	33	20	660n	1980e
1556	725	25	33	21	660n	660e
1558	726	25	33	23	660s	660w
1559	727	25	33	24	660s	660w
1561	728	25	33	25	660s	660e
1562	729	25	33	27	660s	660e
1563	730	25	33	28	660s	660e
1564	731	25	33	28	660n	660e
1565	732	25	33	29	1980n	660w
1566	733	25	33	31	660s	660w
1568	734	25	33	32	1980s	660e
1570	735	25	33	36	660n	660w
1572	743	25	34	27	1980n	660e
1578	618	26	29	11	660s	660e
1582	621	26	29	13	1980s	660w
1583	620	26	29	13	1980s	1980w
1587	629	26	29	23	660s	660w
1588	631	26	29	24	660n	660w
1591	638	26	30	2	660s	660w
1592	639	26	30	3	660s	660w
1593	640	26	30	4	660n	660w

ID No.	FFG No.	T.	R.	Sec.	Distance (in ft) from section lines	
1594	642	26	30	6	660s	660w
1596	643	26	30	12	660s	660e
1597	645	26	30	18	660s	660w
1600	562	26	31	9	660s	660w
1601	564	26	31	15	660s	660w
1602	565	26	31	17	1980s	660e
1604	566	26	31	20	660s	660w
1605	751	26	32	5	660n	1980w
1606	756	26	32	15	1980s	660e
1608	763	26	32	25	990n	990w
1619	780	26	33	17	660s	660w
1620	789	26	33	30	1980s	660w
1621	792	26	34	3	660n	1980w
1623	799	26	34	20	660n	660e
1628	249	21	33	15	1980s	1980e
1629	252	21	33	32	1980s	1980w
1631	285	22	33	5	660s	330e
1632	289	22	33	15	1980s	1980e
1633	290	22	33	20	1980n	660w
1637	559	25	29	31	1980s	660e
1639	291	22	33	32	660s	660w
1640	624	26	29	14	660n	660w

The basic data for this report were prepared using Rbase 3.1, a commercial product of Microrim, Inc.

Tables of data from Richey (1989) and the Holt and Powers (1988) set, supplemented by recent data from Powers, were compared to find exact matches between the five columns including township, range, section, and distance from north, south, east, or west lines.

APPENDIX C-2
STATISTICAL COMPARISON OF RUSTLER DATA SETS

APPENDIX C-2
STATISTICAL COMPARISON OF RUSTLER DATA SETS

APPENDIX C-2
STATISTICAL COMPARISON OF DRILLHOLES COMMON TO RUSTLER DATA SETS

There were 219 drillholes in these two sets of data for which the drillhole locations are identical. Locations were matched exactly for township, range, section, distance from north or south line, and distance from east or west line. There may be other identical drillholes not identified because of minor differences in reported locations from source to source.

All data reported in tables for this appendix are based on English units of length. Data from Richey (1989), as presented in Appendix B-2, have been converted from metric to English units with a conversion factor of 3.28 feet/meter.

The thickness of each Rustler member was calculated for each data set by subtracting the depth to the top of the unit from the depth to the base of the unit, yielding a positive number for thickness. The two data sets were compared by subtracting the thickness value of the unit for any drillhole in the Richey data set from the equivalent thickness value in the Holt and Powers data set. If the Richey data set produces a larger value, this number will be negative.

Because the upper four members of the Rustler are easily interpreted, the differences between the two data sets tend to average near zero (bottom table). There is a slightly different interpretive criterion for the Tamarisk–Culebra contact that should produce a thicker Tamarisk and thinner Culebra in our data compared to Richey. The average thickness differences are consistent with this approach. Our concepts of a stratigraphic base of Rustler differs from "top of salt" in the Richey data, and the larger statistical measures are a consequence.

All data and statistical calculations were produced using Rbase 3.1™, a commercial product of Microrim, Inc. Standard statistical functions were unmodified. Simple variable functions were created to produce tabular data of thickness for each unit in each data set.

The number of values (sample size) for each unit varies because geophysical logs are not always interpretable for each unit in each drillhole. In addition, FFG 722 in the Richey data was eliminated from some calculations because of obvious mistakes in the depth to some units.

Rustler Data Prepared for This Report (Appendix A-3) for Drillholes in Common[a] With Richey (1989)

Unit / Number of Values[a]		Average Thickness[b]	Minimum Thickness[b]	Maximum Thickness[b]	Standard Deviation	Variance
Forty-niner	178	66	19	120	10	112
Magenta	178	20	10	28	3	11
Tamarisk	177	135	16	270	53	2,845
Culebra	188	24	10	40	4	23
Unnamed lower member	190	136	32	352	29	891

Differences Between Common Drillholes in Data Set in Appendix A-3 and Richey (1989) Data Set (Appendix B-2)

Unit / Number of Values[a]		Average Thickness Difference[c]	Minimum Thickness Difference[c]	Maximum Thickness Difference[c]	Standard Deviation	Variance
Forty-niner[d]	168	0	-9	10	2	6
Magenta[d]	169	0	-12	11	3	9
Tamarisk[d]	165	2	-45	41	10	103
Culebra	174	-2	-18	23	5	28
Unnamed lower member	166	-8[e]	-476	77	44	1,955

[a]There were 219 common drillholes identified (Appendix C-1) based on exact match of location data. Basic statistics were computed using Rbase 3.1, a commercial product of Microrim, Inc., without modifying statistical functions. Databases and data tables were established by Powers using Rbase 3.1.
[b]Thickness data are in feet. Richey data were converted from metric units by using a factor of 3.28 feet/meter. Standard Rbase functions were used to convert the data.
[c]The thickness differences (in feet) were computed by subtracting the value in the Richey data from our data. A negative number indicates that the Richey thickness is greater than our thickness.
[d]Drillhole FFG 722 was eliminated from these calculations because of major internal inconsistencies in depth data for the upper three Rustler members.
[e]The numbers in the Richey data set are not always equivalent to the unnamed lower member, and the difference in average value clearly shows that differing concepts were used in the different data sets.

Appendix H

Letter Transmitting Oil Company Responses re Brine Occurrences

Matthew Silva
(Environmental Evaluation Group)

Dennis

ENVIRONMENTAL EVALUATION GROUP

AN EQUAL OPPORTUNITY / AFFIRMATIVE ACTION EMPLOYER

7007 WYOMING BOULEVARD, N.E.
SUITE F-2
ALBUQUERQUE, NEW MEXICO 87109
(505) 828-1003
FAX (505) 828-1062

March 20, 1996

Mr. Peter Swift
Sandia National Laboratories
Organization 6707, MS 1341
P.O. Box 5800
Albuquerque, NM 87185-1341

Dear Mr. Swift:

Per your telephone request this afternoon, please find enclosed the information I have collected on brine encounters during drilling in the WIPP Area. These include letters and/or data from Unocal, Mobil, Texaco, Yates, Phillips, and Strata. In addition to the responses from the oil companies, I have also included from our records the expert witness report of John Pickens which states "It is my opinion that the waterflow encountered at the Bates #2 well, while larger than the other reported waterflows from the Salado, is most likely of natural origin considering how common naturally occurring waterflows are in the region." Please note that one oil company, Pogo, politely declined to provide waterflow information and a number of oil companies did not respond to my request. These would include Bass Enterprises, Enron, Mitchell Energy, Conoco, Santa Fe Energy and others. Your organization may wish to request the information from them. If so, kindly forward copies to EEG as you receive them. Also, last week I faxed to Wendell Weart, at his request, oil field incident reports which include at least one brine inflow incident, the Collins and Ware well. He should be able to provide you with that record.

Sincerely,

Matthew Silva
Chemical Engineer

MS:js
Enclosures

cc: Wendell Weart, SNL
L. Shephard, SNL

WPCV 1

Unocal Oil & Gas Division
Unocal Corporation
1004 North Big Spring Street. Suite 300
P.O. Box 671
Midland, Texas 79702
Telephone (915) 684-8231

UNOCAL 76

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DEC 16 1992
ENVIRONMENTAL EVALUATION GROUP

November 25, 1992

Southwestern Region

Mr. Matthew Silva
Environmental Evaluation Group
7007 Wyoming Blvd., N.E.
Albuquerque, New Mexico 87109

Dear Mr. Silva:

I am responding to the request for information regarding brine water flows in the Castille Formation in your letter dated November 18, 1992. Our files do not indicate the presence of water flows in the following wells.

Halfway Fed #1	S9-T21S-R32E
Union Oil #1 Halfway Fed	S9-T21S-R32E
Barclay Fed #1	S1-T23S-R31E
Barclay 11 Fed #1	S11-T23S-R31E
Barclay State #1	S2-T23S-R31E
Medano State Comm #1	S36-T22S-R31E

These are the only wells that I currently have access and are relevant to your indicated study area.

If you find that Union Oil Company of California, dba UNOCAL, operates other wells in an area of interest, please feel free to contact myself at 915-682-9731. If we can be of further assistance, please advise.

Sincerely,

Patrick A. Ryan

Patrick A. Ryan
Advanced Drilling Engineer
Union Oil Company of California
dba UNOCAL

Mobil Exploration & Producing U.S. Inc.

P.O. BOX 633
MIDLAND, TEXAS 79702-0633

M. R. White

Producing Manager
Midland South

February 23, 1993

New Mexico Institute of Mining & Technology
Environmental Evaluation Group
7007 Wyoming Blvd, N.E., Suite F-2
Albequerque, New Mexico 87109

Attn: Matthew Silva

BRINE RESERVOIRS IN WIPP AREA

Dear Mr. Silva:

In response to your letter of January 4, 1993, requesting information on brine production during drilling, the following is furnished.

Review of our well files for the drilling of three (3) wells in the Township 23S and Range 32E of the Delaware Basin indicate no brine reservoir encounters. The wells Mobil Exploration and Producing US Inc. as agent for Mobil Producing TX & NM Inc. has permitted and drilled in the area of interest are listed below:

Well Name/Number	API #	Drill Date	Current Status
Tristi Draw Federal #1	30-025-26844	01-80	P & A 05-16-89
Tristi Draw Federal #2	30-025-27708	03-82	P & A 06-26-89
Tristi Draw Gulf Federal #1	30-025-27655	02-82	Sold to Gulf: 02-28-85

If we can be of further assistance, please feel free to contact me at 915-688-2013.

Sincerely,

M R White

M. R. White
Producing Manager
Midland South Asset Team

kp

WPCU 14-1

Texaco Exploration and Production Inc
Midland Producing Division
500 N Loraine
Midland TX 79701
P O Box 3109
Midland TX 79702

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DEC 14 1992
ENVIRONMENTAL EVALUATION GROUP

December 09, 1992

Mr. Matthew Silva
Environmental Evaluation Group
7007 Wyoming Boulevard, N.E.
Suite F-2
Albuquerque, New Mexico 87109

Dear Mr. Silva:

In reference to your letter dated November 12, 1992, attached is the information you requested. Some of our Getty Oil records were sketchy and could not get the information you needed. The Texaco wells we had drilling records on are included in the attachment. If you have any questions contact Ms. S.D. Harmon at (915) 688-4608.

Sincerely,

John A. Schell

John A. Schell
Drilling Manager

SDH\wp

File
Chrono

Attachment

CASTILE BRINE RESERVOIR INTERACTIONS IN WIPP AREA

WELLNAME: BILBREY "5" FEDERAL #1
OPERATOR: GETTY OIL
LOCATION: SEC. 5, T-22-S, R-32-E
SPUD DATE: 11/26/81
TD: 14,915'
BRINE FLOW: 2965'-3066', WATER FLOW 10#/GAL. NO RECORD OF VOLUMES.

WELLNAME: BILBREY "29" FEDERAL COM #1
OPERATOR: GETTY OIL
LOCATION: SEC. 29, T-21-S, R-32-E
SPUD DATE: 04/07/82
TD: 14,720'
BRINE FLOW: NO RECORDS

WELLNAME: BILBREY "32" STATE COM #1
OPERATOR: TEXACO
LOCATION: SEC. 32, T-21-S, R-32-E
SPUD DATE: 05/23/90
TD: 14,915'
BRINE FLOW: NO WATER FLOW

WELLNAME: BILBREY "33" FEDERAL #1
OPERATOR: TEXACO
LOCATION: SEC. 33, T-21-S, R-32-E
SPUD DATE: 03/05/90
TD: 14,900'
BRINE FLOW: NO WATER FLOW

WELLNAME: BILBREY FEDERAL COM #1
OPERATOR: GETTY OIL
LOCATION: SEC. 4, T-22-S, R-32-E
SPUD DATE: 08/02/81
TD: 15,105'
BRINE FLOW: NO RECORDS

WELLNAME: FORTY-NINER RIDGE UNIT #3
OPERATOR: TEXACO
LOCATION: SEC. 16, T-23-S, R-30-E
SPUD DATE: 12/31/87
TD: 6400'
BRINE FLOW: NO WATER FLOW

WELLNAME: GETTY "24" FEDERAL #5WD
OPERATOR: TEXACO
LOCATION: SEC. 24, T-22-S, R-31-E
SPUD DATE: 10/07/91
TD: 5200'
BRINE FLOW: NO WATER FLOW

WELLNAME: GETTY "24" FEDERAL #2
OPERATOR: TEXACO
LOCATION: SEC. 24, T-22-S, R-31-E
SPUD DATE: 02/24/90
TD: 8000'
BRINE FLOW: NO WATER FLOW

WELLNAME: GETTY "24" FEDERAL #3
OPERATOR: TEXACO
LOCATION: SEC, 24, T-22-S, R-31-E
SPUD DATE: 03/15/90
TD: 8410'
BRINE FLOW: NO WATER FLOW

WELLNAME: GETTY "24" FEDERAL #4
OPERATOR: TEXACO
LOCATION: SEC. 24, T-22-S, R-31-E
SPUD DATE: 01/15/91
TD: 8400'
BRINE FLOW: NO WATER FLOW

WELLNAME: NEFF "13" FEDERAL #2
OPERATOR: TEXACO
LOCATION: SEC. 13, T-22-S, R-31-E
SPUD DATE: 09/07/89
TD: 8450'
BRINE FLOW: NO WATER FLOW

WELLNAME: NEFF "13" FEDERAL #3
OPERATOR: TEXACO
LOCATION: SEC. 13, T-22-S, R-31-E
SPUD DATE: 10/02/89
TD: 8450'
BRINE FLOW: NO WATER FLOW

WELLNAME: NEFF "13" FEDERAL #4
OPERATOR: TEXACO
LOCATION: SEC. 13, T-22-S, R-31-E
SPUD DATE: 12/27/90
TD: 8450'
BRINE FLOW: NO WATER FLOW

WELLNAME: NEFF "13" FEDERAL #5
OPERATOR: TEXACO
LOCATION: SEC. 13, T-22-S, R-31-E
SPUD DATE: 02/04/91
TD: 8398'
BRINE FLOW: 3340', 480 BBLS/HR. SLOWED TO 150 BBLS/HR IN 12 HRS. NO TOTAL VOLUME RECORDED.

1980 fn, fwl
Y 507 ~~280~~ 264
X 685 ~~250~~ 216

WELLNAME: NEFF "13" FEDERAL #6
OPERATOR: TEXACO
LOCATION: SEC. 13, T-22-S, R-31-E
SPUD DATE: 10/19/91
TD: 8400'
BRINE FLOW: NO WATER FLOW

WELLNAME: NEFF "13" FEDERAL #7
OPERATOR: TEXACO
LOCATION: SEC. 13, T-22-S, R-31-E
SPUD DATE: 04/10/92
TD: 8386'
BRINE FLOW: NO WATER FLOW

WELLNAME: NEFF "13" FEDERAL #8
OPERATOR: TEXACO
LOCATION: SEC. 13, T-22-S, R-31-E
SPUD DATE: 04/12/92
TD: 8378'
BRINE FLOW: NO WATER FLOW

WELLNAME: NORTH BILBREY "7" FEDERAL #1
OPERATOR: GETTY OIL
LOCATION: SEC. 7, T-21-S, R-32-E
SPUD DATE: 03/31/81
TD: 14,320'
BRINE FLOW: NO RECORDS

WELLNAME: NORTH BILBREY "18" FEDERAL #1
OPERATOR: GETTY OIL
LOCATION: SEC. 18, T-21-S, R-32-E
SPUD DATE: 04/22/81
TD: 14,523'
BRINE FLOW: NO RECORDS

MARTIN YATES, III
1912 - 1985
FRANK W. YATES
1936 - 1986

YATES PETROLEUM CORPORATION

105 SOUTH FOURTH STREET
ARTESIA, NEW MEXICO 88210
TELEPHONE (505) 748-1471

S. P. YATES
CHAIRMAN OF THE BOARD
JOHN A. YATES
PRESIDENT
PEYTON YATES
EXECUTIVE VICE PRESIDENT
RANDY G. PATTERSON
SECRETARY
DENNIS G. KINSEY
TREASURER

October 19, 1992

Environmental Evaluation Group
7007 Wyoming Boulevard, N.E.
Suite F-2
Albuquerque, NM 87109

RECEIVED
OCT 23 1992
ENVIRONMENTAL EVALUATION GROUP

Attention: Matthew Silva

Dear Mr. Silva,

Yates Petroleum Corporation has drilled 56 wells in the review area that you outlined in your letter. Our drilling reports indicate that only five encountered water flows. Attached is a list detailing these 5 wells. All water flows were stopped and isolated by cementing of the casing strings. If you have any questions, feel free to give me a call at (505)748-1471.

Sincerely,

Chuck Morgan

Chuck Morgan

Enclosure

CM/sj

YATES PETROLEUM CORPORATION
LIVINGSTON RIDGE REPORTED WATER FLOWS

Kiwi AKX State #1 P 16-22S-32E 330'FS & 330'FE	Flow on connections, 3360'-water flow, 3757'-no flow, 3791'-on wireline survey-26 bbls/hr
Lost Tank AIS State #1 I 36-21S-31E 1980'FS & 660'FE	Water flow @ 2970', 150 gpm, SICP 25#, no flow after 3 hrs X 687 761 Y 521 757
Lost Tank AIS State #4 K 36-21S-31E 1980'FS & 1980'FW	Water flow @ 3280', SIDPP 475 psi, SICP 500 psi, 60-80 gpm X 685 122 Y 521 752
Martha AIK Federal #3 O 11-22S-31E 660'FS & 1650'FE	Well flowing @ 3311', displace hole with 11# mud; well flowing @ 3577', casing 40 psi
Martha AIK Federal #4 J 11-22S-31E 1980'FS & 1650'FE	Well flowing @ 3745', SICP 0, 10 gpm; shut well in @ 3950', SICP 110 psi, 9 gpm; well flowing @ 4302', SICP 110 psi, 10 gpm

WPCV 14-1

PHILLIPS PETROLEUM COMPANY

4001 PENBROOK

ODESSA, TEXAS 79762

FACSIMILE COVER SHEET

DATE: 4/1/93

TO: Matthew Silva

LOCATION: EEG

FROM: Alan Sewell

LOCATION: Odessa

NUMBER OF PAGES TRANSMITTED (INCLUDING THIS COVER SHEET)

3

PLEASE CALL (915) 368-1431, IF TRANSMISSION PROBLEM

COMMENTS: Please give me a call if you have any questions.

prod/mbuja/facs

Phillips Petroleum Company

WIPP Area Brine Flow Review

Well Name	Location	Spud Date	TD ft	Depth of Brine Flow ft	Initial Est. Flow Rate BPH	Est. Total Prod. Vol. BBL	Remarks
	T-21-S, R-30-E						
Peak View #1	Sec 35, 660 FSL, 330 FEL	05/05/1991	7540				None Reported
	T-22-S, R-30-E						
James A #2	Sec 2, 1652 FSL, 1980 FEL	12/20/1986	8000				None Reported
James E #2	Sec 11, 535 FNL, 2080 FWL	06/02/1987	7480				None Reported
James A #3	Sec 2, 1980 FSL, 1980 FWL	06/20/1987	7490				None Reported
James A #4	Sec 2, 1980 FNL, 1980 FEL	07/09/1987	7461				None Reported
James A #5	Sec 2, 660 FSL, 1800 FEL	08/21/1988	6258				None Reported
James A #6	Sec 2, 1980 FSL, 660 FEL	12/17/1988	7600				None Reported
James A #7	Sec 2, 500 FSL, 660 FEL	12/11/1989	7537				None Reported
James E #3	Sec 11, 500 FNL, 1800 FEL	01/08/1990	7498				None Reported
James A #8	Sec 2, 1650 FNL, 660 FEL	04/16/1990	7500				None Reported
James A #9	Sec 2, 660 FNL, 500 FEL	05/31/1990	7629				Flowed 1/2" stream while logging at @ TD. Incr MW from 8.6 to 9.1 ppg.
James A #10	Sec 2, 660 FSL, 2310 FWL	05/08/1990	7466				None Reported
James E #4	Sec 11, 760 FNL, 330 FEL	06/19/1990	7620				None Reported
James E #5	Sec 11, 1810 FNL, 330 FEL	09/30/1990	7625				None Reported
Livingston Ridge Fed #1	Sec 1, 660 FSL, 700 FWL	10/15/1990	7655				None Reported
Livingston Ridge Fed #6	Sec 1, 1980 FSL, 1980 FWL	10/14/1991	7635				None Reported
Livingston Ridge Fed #4	Sec 1, 430 FNL, 860 FWL	04/15/1991	7675				None Reported
Livingston Ridge Fed #2	Sec 1, 2240 FSL, 1200 FWL	12/11/1990	7758				None Reported
Livingston Ridge Fed #3	Sec 1, 1450 FNL, 660 FWL	11/20/1990	7718				None Reported
James A #11	Sec 2, 660 FNL, 1980 FEL	11/04/1990	7495				None Reported
James E #12	Sec 12, 660 FNL, 1980 FWL	09/14/1991	7750				None Reported
James E #13	Sec 12, 1980 FNL, 660 FWL	11/03/1991	7640				None Reported
James E #14	Sec 12, 1980 FNL, 1980 FWL	11/22/1991	7551				None Reported
James E #11	Sec 12, 660 FNL, 660 FWL	08/20/1991	7680				None Reported
James A #W12	Sec 2, 1250 FSL, 1150 FEL	09/29/1991	7510				None Reported
James E #6	Sec 11, 1980 FSL, 1980 FEL	12/13/1991	7560				None Reported

Phillips Petroleum Company

WPP Area Brine Flow Review

Well Name	Location	Spud Date	TD ft	Depth of Brine Flow ft	Initial Est. Flow Rate BPH	Est. Total Prod. Vol. BBL	Remarks
	T-22-S, R-31-E						
Molly State #1	Sec 1, 660 FNL, 1980 FWL	09/25/1991	8420	3080	35	630	H_2S 70 ppm at shaker. SIDPP 73 psi. No flow while circulating.
Molly State #2	Sec 1, 1980 FNL, 1980 FWL	09/26/1991	8425				None Reported
Molly State #3	Sec 1, 660 FNL, 660 FWL	10/20/1991	8593	3023	300	4000	H_2S 200 ppm (ambient air). SIDPP 60 psi. Decr to < 10 gpm in 64 hrs.
Molly State #4	Sec 1, 1980 FNL, 535 FWL	10/16/1991	8409				None Reported
	T-21S, R-32-E						
Luke Fed #2	Sec 31, 660 FNL, 560 FWL	11/06/1991	8585				None Reported
Luke Fed #1	Sec 31, 1980 FNL, 660 FWL	11/12/1991	8364	3057	540	19000	H_2S 99 ppm at flowline. SIDPP 50 psi. Decr & stab at 3 BPM after 25 hrs.
Bilbrey 34 Fed Com #1	Sec 34, 660 FSL, 1980 FWL	12/05/1991	14985				None Reported

Lost circulation [illegible]

MS 1 X 685~~200~~ 129
Y 519~~700~~ 124

MS 3 X 683~~400~~ 812
Y 519~~700~~ 116

SIDPP
SHUT IN DRILL PIPE PRESSURE

POGO PRODUCING COMPANY

RECEIVED
JUN 16 1993
ENVIRONMENTAL EVALUATION GROUP

June 14, 1993

Environmental Evaluation Group
7007 Wyoming Boulevard, N.E.
Suite F-2
Albuquerque, New Mexico 87109
Attention: Matthew Silva

Re: Neff Prospect NM-503
Eddy County, New Mexico
WIPP Site
Request for Brine Flow Information

Gentlemen:

Reference is made to your November 12, 1992 letter to Pogo requesting information on water flows encountered while drilling oil and/or gas wells in nine townships in the WIPP Site Area.

Regrettably, please be advised that Pogo does not wish to provide such information.

If you have any questions, please contact the undersigned.

Very truly yours,

POGO PRODUCING COMPANY

Terry Gant
Senior Landman

TG:lf/c:Wipp

cc: Richard L. Wright

500 WEST ILLINOIS, SUITE 600 • POST OFFICE BOX 10340 • MIDLAND, TEXAS 79702-7340 • 915/682-6822 • FAX 915/682-8139

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ENVIRONMENTAL EVALUATION GROUP

STRATA PRODUCTION COMPANY

LECHUZA FEDERAL #4	GRACE RIG #405 Page (1)
Section 15-22S-32E	Elevation = 3703'
Lea County, New Mexico	KB = 3719'
660'FSL & 1650'FWL	Red Tank Prospect

12/30/92: Spud 17 1/2" hole at 2:00 PM on 12/29/92. Drlg at 600', formation Redbed, ftg made 600'. Ran Totco at 200' 1 deg. Mud wt 8.7, Vis 31, PH 7.5. Bit wt 55, RPM 100, Bit #1, Serial #500754, Type S33, Jets (3) 16, Depth in 0', 14 1/4 hrs, ftg 600'. Pump type DC700, SPM 62, Liner 5 1/2", Press 1400#, DC# 18, 8", 75,000#. Water loads (14) fresh. MI & RU 9 1/2 hrs, Rot 14 1/4 hrs, Totco 1/4 hr. DC $23,700. CC $23,700.

12/31/92: Drlg cmt at 610', formation Redbed, ftg made 10'. Ran Totco at 610' 3/4 deg. Mud wt 10, Vis 10, PH 10. Bit wt 15 to 20, RPM 60+. Bit #1, Serial #500754, Type S33, Jets (3) 16, Depth out 610', Depth in -0-, 14 3/4 hrs, ftg 610'. Bit #2, Serial #KV739A, Type F27, Jets (3) 12, Depth in 610'. Pump type DC 700, SPM 62, Liner 5 1/2", Press 1200#. DC #18, 8", 548.84', 75,000#. Water loads (2) brine and (7) fresh. WO Halliburton. Ran 15 jts 13 3/8" 48# H40 csg. Cmtd at 610' w/300 sx Hal Lite w/1/4# Flocele per sx. Tail in w/200 sx Class "C" w/2% CaCL. Circ 114 sx to pit. PD at 1:00 PM on 12/31/92. Tagged cmt at 565'. Drld 45' cmt. Rot 1 hr, Trip 3 hrs, Totco 1/4 hr, Circ 2 1/4 hrs, Run csg 2 1/2 hrs, Cmt csg 1 hr, WOC 3 hrs, Cut off wellhead and NU 11 hrs. DC $2,623. CC $26,323.

01/01/93: Drlg at 2115', formation Salt and Anhydrite, ftg made 1505'. Ran Totco at 1084' 1 1/4 deg and 1585' 1 deg. Mud wt 10, Vis 29, PH 9, CL 103,000. Bit wt 60, RPM 60+, Bit #2, 20 hrs, ftg 1505'. Water loads -0-. Rot 22 1/2 hrs, Totco 1/2 hr, Repair rotating head 1 hr. DC $17,300. CC $43,623.

01/02/93: Drlg at 3150', formation Salt and Anhydrite, ftg made 1035'. Ran Totco at 2085' 1 deg, 2308' 1 1/2 deg, 2600' 1 3/4 deg and 2900' 2 1/4 deg. Mud wt 10, Vis 29, PH 10, CL 103,000. Bit wt 20 to 60, RPM 90, Bit #2, 41 1/4 hrs, ftg 2540'. Pump type DB550, SPM 62, Liner 5 1/2", Press 1500#. Water loads (2) brine. Centrifical pump broke down. Hooked up pump #2 to reserve and changed swab. Rot 21 1/4 hrs, Totco 1 1/4 hr, Change swab 1 1/4 hr, Hook up #2 pump 1/4 hr. DC $12,487. CC $56,110.

01/03/93: Drlg 35'/hr at 3530', formation Salt and Anhydrite, ftg made 380'. Ran Totco at 3120' 2 1/4 deg and 3310' 1 deg. Mud wt 10.1, Vis 29, PH 9, CL 103,000. Bit wt 20 to 50, Bit #2, 57 3/4 hrs, ftg 2920'. Pump Type DC 700, SPM 62, Liner 5 1/2", Press 1400#. Water loads -0-. Drld into water flow w/600 PPM H2S. SD. WO H2S equipment. Rot 16 1/2 hrs, Totco 1 hr, WO H2S equipment 6 1/2 hrs. DC $12,860. CC $68,970.

154
X 706 ~~250~~
Y 504 ~~850~~ 787

01/04/93: Drlg at 4210', formation Salt and Anhydrite, ftg made 680'. Ran Totco at 3500' 1 1/4 deg, 3685' 1 3/4 deg, 3884' 2 deg and 4065' 1 1/2 deg. Mud wt 10.1, Vis 29, PH 8 to 11. Bit wt 15 to 50, RPM 90, Bit #2, 79 1/4 hrs, ftg 3600'. Lost circ at 3830' and 3840'. Pumped 30 sx paper and 20 sx Maxiseal. Regained circ. Flowing back 800 bbls/hr. Rot 21 1/2 hrs, Totco 2 hrs, Mix LCM 1/2 hr. DC $18,117. DC $87,087.

Mr. Silva,
The Lechuza #4 was the only well drilled by Strata to encounter significant water flow. Strata encountered a 600 barrel per hour flow at 3800 feet. It took a day to get the hydrostatic column in balance with the flow. We did see 600 ppm H_2S and successfully handled it by shutting the well in and waiting on equipment. We now have H_2S equipment on all wells in this area. I hope this data is of use [illegible]

FIRST JUDICIAL DISTRICT

COUNTY OF SANTA FE

STATE OF NEW MEXICO

94 DEC 5 AM 8:53

DOYLE HARTMAN and MARGARET HARTMAN d/b/a
DOYLE HARTMAN, OIL OPERATOR,

Plaintiffs,

vs. NO. SF 93-2387(C)

TEXACO INC. a Delaware Corporation, and
TEXACO EXPLORATION AND PRODUCTION INC.
a Delaware Corporation.

Defendants.

MOTION TO EXCLUDE TRIAL TESTIMONY
OF JOHN F. PICKENS

Plaintiffs ("Hartman") respectfully request that the Court preclude Texaco from offering at trial testimony of one of its designated expert witnesses, John F. Pickens, on the issue of whether Hartman's saltwater blowout was caused by natural water. As grounds for this Motion, Hartman states as follows:

1. The Pre-Trial Order was entered in this case November 23, 1994. Texaco advances two affirmative defenses in the case, Hartman's negligence in drilling the Bates #2 well, and Hartman's failure to mitigate damages. Texaco expressly and affirmatively deleted the affirmative defenses of "Act of God" and "Unavoidable Accident" in the Pre-Trial Order.

2. Dr. Pickens was retained in this case in order to provide opinions for Texaco that the cause for Hartman's saltwater blowout was natural Salado water. See Expert Witness Report By John F. Pickens, copy attached hereto as Exhibit "A" ("It is my

opinion that the waterflow encountered at the Bates #2 well, while larger than the other reported waterflows from the Salado, is most likely of natural origin considering how common naturally occurring waterflows in the Salado are in the region.")

3. Any contention by Texaco that the waterflow encountered by Hartman at the Bates #2 well was of natural origin goes beyond a mere denial of the claims in this case. Such a contention requires affirmative proof by Texaco as to the source of the water. Any such proof would be in the nature of an affirmative defense. Beyale v. Arizona Public Service Company, 105 N.M. 112, 729 P.2d 1366 (Ct. App. 1986) (an affirmative defense refers to a state of facts provable by defendant that will bar plaintiff's recovery once a right to recover is established); McCasland v. Prather, 92 N.M. 192, 585 P.2d 336 (Ct.App. 1978) (burden is on the defendant to raise any matter constituting avoidance or affirmative defense to plaintiff's complaint).

4. Proof that the water encountered by Hartman at the Bates #2 well was natural in origin does not relate to either of the affirmative defenses which Texaco has decided to advance at trial.

5. Texaco's natural source theory falls precisely within the parameters of an Act of God affirmative defense. SCRA 1986 13-1618 provides as follows:

> The defendant contends that the accident and the claimed damages resulted from an Act of God. An Act of God is an unusual, extraordinary, sudden and unexpected manifestation of the forces of nature for which no human is responsible.
>
> The defendant is not liable if you

000754

find that an Act of God was the sole proximate cause, and would have caused the accident and claimed damages regardless of whether the defendant was negligent. Defendant is liable, on the other hand, if you find that the accident and damages could have been avoided by defendant in the exercise of ordinary care under the circumstances of the act of nature.

6. Where Texaco has affirmatively deleted any affirmative defense which might encompass a natural waterflow theory, Texaco is precluded from pursuing that theory at trial. Ortega, Snead, Dixon & Hanna v. Gennitti, 93 N.M. 135, 597 P.2d 745 (1979) (a pre-trial order made and entered without objection, and to which no motion to modify has been made, controls the subsequent course of this action).

WHEREFORE, on the basis of the foregoing points and authorities, Hartman respectfully requests that the Court preclude Texaco from offering trial testimony of John F. Pickens on the issue of natural occurring Salado water as the cause of the salt water blowout at the Bates #2 lease.

Respectfully submitted,

GALLEGOS LAW FIRM, P.C.

By [signature]

J.E. GALLEGOS
MICHAEL J. CONDON
141 East Palace Avenue
Santa Fe, New Mexico 87501
(505) 983-6686

Attorneys for Plaintiffs

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of Plaintiffs' Motion to Exclude Trial Testimony of John F. Pickens was hand delivered this 9th day of December, 1994, to the following parties:

Eric Lanphere
Hinkle, Cox, Eaton, Coffield & Hensley
c/o Eldorado Hotel
W. San Francisco Street
Santa Fe, New Mexico 87501

Michael J. Condon

000756

NO. SF 93-2387(C)

DOYLE HARTMAN and MARGARET HARTMAN d/b/a DOYLE HARTMAN, OIL OPERATOR, Plaintiffs,	§	IN THE FIRST JUDICIAL DISTRICT, COUNTY OF SANTA FE, STATE OF NEW MEXICO
vs.	§	
TEXACO INC. a Delaware Corporation, and TEXACO EXPLORATION AND PRODUCTION INC., a Delaware Corporation, Defendants.	§	

EXPERT WITNESS REPORT BY JOHN F. PICKENS

Opinions

Opinions in this report may be supplemented or subject to change based on additional information obtained prior to trial.

1. U.S. Department of Energy (1983) documents 13 naturally occurring brine reservoirs that have been encountered during the drilling of 60 boreholes in the vicinity of the Waste Isolation Pilot Plant (WIPP) site in southeastern New Mexico. The location of these boreholes are shown on Exhibit A. These brine reservoirs are encountered in anhydrite units that are located between overlying and underlying halite (salt) units. The brine reservoirs have high permeabilities, high pressures (Exhibits B and C), and high brine fluid outflow rates to ground surface (Exhibits B and D). The high permeabilities are associated with naturally occurring fracture zones in the anhydrites. These fractures were formed over geologic time scales of millions of years in response to deformation and breaking of the more brittle anhydrites as the more plastic halite creeped or deformed. The high pressures are characteristic of deep anhydrite/halite formations. The high outflow rates occur because of the combination of the high permeabilities and high pressures. These brine reservoirs are typically of limited areal extent. Thus,

Exhibit "A" 000052

Pickens
Exhibit No. 96

boreholes located short distances apart may or may not encounter the same reservoir (see Exhibit A).

Multiple layers of halite and anhydrite exist in the Salado at the Bates No. 2 well location. The high flow rates encountered at the Bates No. 2 well indicate that high permeabilities occur at the well similar to those encountered at the natural brine reservoirs that have been identified in the vicinity of the WIPP site. It is my opinion that the pressures and flow rates observed at the Bates No. 2 well are consistent with the expected conditions for a naturally occurring brine reservoir in an anhydrite unit.

2. Texaco has installed a number of wells within their waterflood area over time. Several fluid outflows have been encountered in the Salado during drilling these wells. All of these fluid outflows have been very minor in comparison to the fluid outflow rate observed at the Bates No. 2 well. It is not physically possible to have higher fluid outflow rates in the Salado at the Bates No. 2 well located at about 2 miles distance from the Texaco field than in the Salado at the Texaco field itself. It is my opinion that the high outflow rates at the Bates No. 2 well cannot be the result of Texaco operations located at 2 miles distance but rather are the result of the well penetrating a naturally occurring high pressure, high outflow rate reservoir.

3. The similarity of the pressure gradient at the Bates No. 2 well to the pressure gradient in the Salado at the WIPP underground facility and for brine reservoirs in the vicinity of the WIPP site provides direct evidence that the pressures observed at the Bates No. 2 well are natural. The basis of this statement is as follows.

The maximum downhole pressure for the Bates No. 2 well can be calculated to be 1,838 psi at a depth of 2,275 feet corresponding to depth of water inflow. This calculation is based on the measured annulus pressure of 655 psi after the well was shut in from 11:00 a.m. to 4:10 p.m. on January 16, 1994 (Reference: Handwritten driller's notes listed as Exhibit 21 of Hartman deposition) and saturated brine fluid with a brine pressure gradient of 0.52 psi/ft depth in the annular water column in the borehole. This

000258

calculation yields a maximum pressure because it utilizes a maximum borehole fluid density. The pressure gradient for the Bates No. 2 well can be calculated as 1,838 psi ÷ 2,275 feet or 0.81 psi/ft.

An evaluation of whether this pressure gradient is the result of natural or man-made causes can be determined by comparison of the Bates No. 2 pressure gradient with the pressure gradient calculated from measurements at the underground facility at the WIPP site. An estimated natural pressure of 1,820 psi (12.55 MPa) was determined from testing in a borehole in the WIPP facility at a depth of 2,163 feet (659.3 m) below ground surface (Sandia National Laboratories, 1993). This pressure and depth is very similar to conditions for the Bates No. 2 well and yields a pressure gradient of 0.84 psi/ft which is even higher than for the Bates No. 2 well. Assuming a pressure gradient for a vertical column of brine of 0.52 psi/ft depth, the equivalent shut-in pressure at ground surface at the WIPP site location is 695 psi. Thus, the pressure and the pressure gradient for the Bates No. 2 well are consistent with those measured for natural occurring conditions at the WIPP underground facility. In addition, pressure gradients calculated for two of the naturally occurring brine reservoirs where pressure data are available are almost as large as the pressure gradient for the Bates No. 2 well (Exhibits B and C). It is my opinion that the pressure and pressure gradient in the Salado at the Bates No. 2 well are consistent with those expected under natural conditions.

4. Naturally occurring water flows are common in the Salado. Water or gas flow pockets have been hit on a routine basis during drilling in portions of the Salado in the vicinity of the WIPP site with the largest pocket reported containing an estimated 100,000 gallons of brine (Sandia National Laboratories, 1977). High pressures are expected to occur naturally and are well documented in studies of the Salado at the WIPP site. Brine outflow to surface is a direct indication that localized naturally-occurring high permeability exists around the borehole. Without this naturally occurring high permeability zone, brine would not flow freely to the borehole and then to ground surface.

It is my opinion that the water flow encountered at the Bates No. 2 well, while larger than the other reported water flows from the Salado, is most likely of natural origin considering how common naturally occurring water flows in the Salado are in the region.

References

Doyle Hartman deposition taken on August 25, 1994.

Driller's Handwritten Notes for Bates No. 2 well from January 16-17, 1991. Attached as Exhibit 21 to Doyle Hartman deposition taken on August 25, 1994.

Sandia National Laboratories, 1977. Site Selection and Evaluation Studies of the Waste Isolation Pilot Plant (WIPP), Los Medaños, Eddy County, NM. Report SAND77-0946. Albuquerque, NM.

Sandia National Laboratories, 1993. Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretative Report. Report SAND92-0533. Albuquerque, NM.

Texaco well files.

U.S. Department of Energy, 1983. Brine Reservoirs in the Castile Formation, Waste Isolation Pilot Plant (WIPP) Project, Southeastern New Mexico. Report TME-3153. Albuquerque, NM.

Van Kirk Report concerning Salt Water Blow-Out January 1991 on the "Bates Lease", dated September 16, 1994.

List of Exhibits

The exhibits that will be used in conjunction with my opinions are listed below and are attached.

Exhibit A	Location Map Showing Boreholes that have Encountered Naturally Occurring Brine Reservoirs in the Vicinity of the WIPP Site in South-Eastern New Mexico
Exhibit B	Flow Rates and Pressure Gradients from Naturally Occurring Brine Reservoirs in Halite/Anhydrite Formations
Exhibit C	Comparison of Pressure Gradients in Halite/Anhydrite Formations

Exhibit D	Flow Rates from Naturally Occurring Brine Reservoirs in Halite/Anhydrite Formations
Exhibit E	Schematic of Brine Reservoir Development

Other Attachments

Attachment 1	Resume

Qualifications

I am a hydrogeologist with a Ph.D. in Earth Sciences and Bachelors and Masters Degrees in Civil Engineering from the University of Waterloo. I am the Vice President of the Hydrogeology Division of INTERA Inc., based in Austin, Texas. I am a member of the American Geophysical Union and the Association of Ground-Water Scientists and Engineers. For the past 20 years, I have actively conducted research and investigated site-specific applications of ground-water flow and contaminant transport in hydrogeologic systems. I have managed a multiyear contract with a Swiss agency to provide field hydrogeologic consulting services, coordinate and supervise hydraulic testing and geochemical sampling of deep boreholes in sedimentary and crystalline formations, and perform and supervise interpretations of the hydraulic tests to determine formation pressures and permeabilities. Since 1985, I have managed a large multidisciplinary hydrogeologic project involving site characterization and ground-water flow and contaminant transport modeling for the U.S. Department of Energy's Waste Isolation Pilot Plant (WIPP) site in southeastern New Mexico for the deep disposal and isolation of defense wastes, and have made a series of presentations on these site characterization and modeling activities to Sandia National Laboratories and the National Academy of Sciences WIPP Review Panel and at scientific conferences. Some of the activities I have conducted or supervised with respect to the WIPP site include: hydraulic-test interpretations to determine pressures and permeabilities in the various geologic units, detailed data-base development and evaluation for regional ground-water modeling, evaluating the important contaminant-transport mechanisms and assessing parameter sensitivity/importance for off-site transport, implementation and interpretation of hydraulic tests in boreholes drilled into the halite and anhydrite units of the Salado Formation surrounding the WIPP underground facility, interpretation of hydraulic tests performed in a borehole penetrating a high-pressure, high outflow rate reservoir in a naturally-fractured anhydrite unit in the Castile formation, and multi-phase flow simulations to evaluate gas generation and migration from the WIPP underground facility. I have provided expert testimony on ground-water flow and transport modeling of deepwell liquid injection in sedimentary formations. I have published numerous articles regarding geology and hydrogeology in journals or in conference proceedings. A copy of my resume is attached as Attachment 1.

Compensation

The compensation to be paid to INTERA for this study is $140/hour for myself and $80/hour to $90/hour for other staff consultants. The compensation to be paid for my expert testimony for deposition and trial has a standard multiplicative factor of 1.75 on the base rate. INTERA will also be reimbursed for direct costs such as any travel in the performance of this study.

Other Expert Witness Cases

I have testified as an expert by deposition and at trial for one other case during the preceding four years. This case, *Rose M. Chance, et al. vs BP Chemicals Inc.*, was heard in the Court of Common Pleas, Cuyahoga County, Ohio. I testified on behalf of BP Chemicals Inc. with regards to the underground location of the plume generated by their deepwell liquid injection activities in Lima, Ohio. My oral deposition for this case was taken on September 28, 1993 and I testified at trial during the week of November 14, 1993.

Respectfully Submitted,

J. Pickens

Dr. John F. Pickens
September 22, 1994

APPENDIX I

Comparison of Brine Intercept/No-Intercept Sample Semi-Variogram Calculations

Table I-A: Results from UNCERT's VARIO Module

Table I-B: Results from GSLIB's GAM2V Module

Table I-C: Results from VARIOWIN

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

BRSM5: Isotropic				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	575	0.0312	32
750	2250	1560	0.07	1242
2250	3750	2990	0.0715	1944
3750	5250	4440	0.0699	2204
5250	6750	5980	0.0748	2448
6750	8250	7530	0.0839	2490
8250	9750	9040	0.0737	2620
9750	11200	10500	0.0782	2622
11200	12800	12000	0.0743	2544
12800	14200	13500	0.0777	2472
14200	15800	15000	0.072	2444
15800	17200	16500	0.0756	2686
17200	18800	18000	0.0721	2914
18800	20200	19500	0.0726	3308
20200	21800	21000	0.0749	3230
21800	23200	22500	0.0805	3416
23200	24800	24000	0.0748	3344
24800	26200	25500	0.0758	3362
26200	27800	27000	0.0655	3388
27800	29200	28500	0.0651	3700
29200	30800	30000	0.0688	4054
30800	32200	31500	0.0863	4286
32200	33800	33000	0.0894	4126
33800	35200	34500	0.0787	4102
35200	36800	36000	0.0843	3854
36800	38200	37500	0.0762	3280
38200	39800	39000	0.0797	2860
39800	41200	40500	0.0766	2482
41200	42800	42000	0.0858	2284
42800	44200	43500	0.087	2160
44200	45800	45000	0.0864	2038
45800	47200	46500	0.0868	1648
47200	48800	48000	0.086	1698
48800	50200	49500	0.0688	1556
50200	51800	51000	0.0471	1592
51800	53200	52500	0.0477	1782
53200	54800	54000	0.0369	1950
54800	56200	55500	0.0368	1738
56200	57800	57000	0.0448	1630
57800	59200	58500	0.035	1516
59200	60800	60000	0.0299	1472
60800	62200	61500	0.0453	1632
62200	63800	63000	0.0438	1528
63800	65200	64500	0.0319	1224
65200	66800	66000	0.0525	990
66800	68200	67500	0.0484	910
68200	69800	69000	0.0573	908

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

69800	71200	70400	0.0593	910
71200	72800	72000	0.0592	692
72800	74200	73500	0.0671	656
74200	75800	75000	0.0915	612
75800	77200	76500	0.0816	588
77200	78800	78000	0.0874	572
78800	80200	79500	0.0934	482
80200	81800	80900	0.0991	434
81800	83200	82500	0.0628	398
83200	84800	84000	0.067	358
84800	86200	85500	0.0641	390
86200	87800	87000	0.0707	410
87800	89200	88500	0.0689	392
89200	90800	90000	0.0575	400
90800	92200	91500	0.0632	364
92200	93800	93000	0.0469	320
93800	95200	94400	0.081	284
95200	96800	95900	0.0634	284
96800	98200	97400	0.0734	286
98200	99800	99000	0.0511	274
99800	101000	100000	0.05	220
101000	103000	102000	0.075	240
103000	104000	104000	0.0799	288
104000	106000	105000	0.0522	364
106000	107000	106000	0.0633	316
107000	109000	108000	0.0308	292
109000	110000	109000	0.0448	268
110000	112000	111000	0.041	268
112000	113000	112000	0.0567	282
113000	115000	114000	0.0431	232
115000	116000	116000	0.0654	214
116000	118000	117000	0.0353	170
118000	119000	118000	0.0326	184
119000	121000	120000	0.0529	170
121000	122000	121000	0.0556	144
122000	124000	123000	0.12	100
124000	125000	124000	0.0476	84
125000	127000	126000	0.0417	72
127000	128000	128000	0.104	48
128000	130000	129000	0.0682	44
130000	131000	131000	0.0312	32
131000	133000	132000	0.0588	34
133000	134000	133000	0.0588	34
134000	136000	135000	0.167	18
136000	137000	136000	0.143	14
137000	139000	138000	0.167	6
139000	140000	139000	0.25	4
140000	142000	141000	0	2
BRSM5: Azimuth = 0 deg				

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	565	0.167	3
750	2250	1380	0.0608	148
2250	3750	2910	0.0637	204
3750	5250	4380	0.0657	236
5250	6750	5950	0.0757	350
6750	8250	7560	0.0687	284
8250	9750	9130	0.0805	261
9750	11200	10600	0.0931	274
11200	12800	12000	0.0728	268
12800	14200	13400	0.0907	248
14200	15800	14800	0.0655	275
15800	17200	16400	0.0757	317
17200	18800	18000	0.0666	323
18800	20200	19500	0.0703	313
20200	21800	21100	0.0734	293
21800	23200	22600	0.0762	282
23200	24800	24000	0.064	258
24800	26200	25400	0.0672	268
26200	27800	26900	0.0581	241
27800	29200	28400	0.06	250
29200	30800	30000	0.0764	229
30800	32200	31500	0.0687	182
32200	33800	33000	0.0588	153
33800	35200	34500	0.0815	135
35200	36800	35900	0.072	118
36800	38200	37300	0.0813	80
38200	39800	38900	0.143	63
39800	41200	40400	0.0882	68
41200	42800	42000	0.0513	39
42800	44200	43700	0.118	34
44200	45800	45100	0.0625	16
45800	47200	46500	0	10
47200	48800	47900	0.1	10
BRSM5: Azimuth = 20 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	669	0	1
750	2250	1580	0.0362	69
2250	3750	2960	0.0642	179
3750	5250	4460	0.0726	248
5250	6750	5980	0.0745	282
6750	8250	7510	0.0865	289
8250	9750	9080	0.0736	292
9750	11200	10500	0.0899	267
11200	12800	12000	0.0846	254
12800	14200	13500	0.084	238
14200	15800	15000	0.0687	211
15800	17200	16500	0.0817	202
17200	18800	18000	0.0619	218

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

18800	20200	19500	0.0742	229
20200	21800	21000	0.0682	220
21800	23200	22500	0.0777	206
23200	24800	24000	0.0632	190
24800	26200	25500	0.0736	163
26200	27800	26900	0.0397	126
27800	29200	28400	0.0265	132
29200	30800	30000	0.0364	110
30800	32200	31500	0.0913	104
32200	33800	33000	0.0526	95
33800	35200	34600	0.0345	87
35200	36800	36000	0.0402	87
36800	38200	37400	0.0676	74
38200	39800	39000	0.0643	70
39800	41200	40400	0.0476	84
41200	42800	42000	0.121	62
42800	44200	43500	0.138	69
44200	45800	45000	0.148	44
45800	47200	46400	0.125	32
47200	48800	47900	0.093	43
48800	50200	49400	0.158	19
50200	51800	50700	0	8
51800	53200	52300	0	7
53200	54800	53800	0	3
BRSM5: Azimuth = 45 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	480	0	2
750	2250	1760	0.0775	129
2250	3750	3150	0.0705	149
3750	5250	4570	0.0657	198
5250	6750	6080	0.0757	185
6750	8250	7580	0.0769	169
8250	9750	9080	0.0686	153
9750	11200	10500	0.0864	162
11200	12800	12000	0.0653	176
12800	14200	13500	0.058	138
14200	15800	15000	0.0449	167
15800	17200	16500	0.0572	166
17200	18800	18000	0.0594	160
18800	20200	19500	0.0632	174
20200	21800	21000	0.0669	172
21800	23200	22500	0.0495	182
23200	24800	24000	0.0604	207
24800	26200	25500	0.0625	192
26200	27800	27000	0.0378	172
27800	29200	28500	0.0505	198
29200	30800	30000	0.0414	169
30800	32200	31500	0.0582	189
32200	33800	33000	0.0466	204

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

33800	35200	34500	0.0502	219
35200	36800	36000	0.062	250
36800	38200	37500	0.0422	225
38200	39800	39000	0.0718	209
39800	41200	40500	0.0812	191
41200	42800	42000	0.108	190
42800	44200	43500	0.123	163
44200	45800	45000	0.0909	165
45800	47200	46500	0.108	111
47200	48800	47900	0.112	103
48800	50200	49500	0.0688	80
50200	51800	51000	0.0592	76
51800	53200	52400	0.0887	62
53200	54800	54000	0.0439	57
54800	56200	55600	0.0341	44
56200	57800	57100	0.0465	43
57800	59200	58600	0.0233	43
59200	60800	60000	0.0536	28
60800	62200	61500	0.0278	36
62200	63800	63000	0.0192	26
63800	65200	64400	0	23
65200	66800	66000	0.0833	12
66800	68200	67600	0.0714	7
68200	69800	69300	0	3
71200	72800	71900	0	1
72800	74200	73500	0	1
75800	77200	76400	0	1
77200	78800	78500	0	1
BRSM5: Azimuth = 70 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	590	0	2
750	2250	1470	0.05	70
2250	3750	2940	0.078	141
3750	5250	4450	0.0822	146
5250	6750	5920	0.0522	115
6750	8250	7530	0.0906	160
8250	9750	9020	0.0727	172
9750	11200	10500	0.06	150
11200	12800	12000	0.0669	157
12800	14200	13500	0.0544	147
14200	15800	15000	0.0707	198
15800	17200	16500	0.0538	195
17200	18800	18000	0.0723	242
18800	20200	19500	0.0751	313
20200	21800	21000	0.0646	271
21800	23200	22600	0.0603	307
23200	24800	24000	0.0544	285
24800	26200	25500	0.0689	305
26200	27800	27000	0.054	324

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

27800	29200	28500	0.066	356
29200	30800	30000	0.0691	369
30800	32200	31500	0.0854	404
32200	33800	33000	0.0778	392
33800	35200	34500	0.0903	382
35200	36800	36000	0.081	352
36800	38200	37500	0.0685	336
38200	39800	39000	0.0641	281
39800	41200	40500	0.052	250
41200	42800	42000	0.0541	222
42800	44200	43500	0.0544	193
44200	45800	45000	0.0485	196
45800	47200	46500	0.0479	188
47200	48800	48100	0.0488	205
48800	50200	49500	0.0556	243
50200	51800	51000	0.0432	266
51800	53200	52500	0.0474	232
53200	54800	54000	0.0381	210
54800	56200	55500	0.0373	201
56200	57800	57000	0.0258	194
57800	59200	58500	0.0398	176
59200	60800	59900	0.0385	156
60800	62200	61500	0.0631	111
62200	63800	62900	0.101	79
63800	65200	64600	0.0714	56
65200	66800	66000	0.0317	63
66800	68200	67500	0.0333	60
68200	69800	69000	0.0446	56
69800	71200	70400	0.049	51
71200	72800	71900	0.0732	41
72800	74200	73500	0.0185	27
74200	75800	74900	0.111	18
75800	77200	76400	0.0417	12
77200	78800	78100	0.0882	17
78800	80200	79400	0.0417	12
80200	81800	81000	0.0667	15
81800	83200	82600	0.0588	17
83200	84800	84000	0.0972	36
84800	86200	85600	0.0714	35
86200	87800	87000	0.0595	42
87800	89200	88400	0.134	41
89200	90800	89900	0.0769	26
90800	92200	91400	0.125	28
92200	93800	93000	0.0429	35
93800	95200	94500	0.167	21
95200	96800	95800	0.0833	18
96800	98200	97500	0.0667	15
98200	99800	99000	0.0333	15
99800	101000	101000	0.15	10

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

101000	103000	102000	0.0455	11
103000	104000	103000	0	9
104000	106000	105000	0	9
106000	107000	107000	0	10
107000	109000	108000	0.05	10
109000	110000	109000	0	6
110000	112000	111000	0	13
112000	113000	113000	0	6
113000	115000	114000	0	5
115000	116000	116000	0	3
116000	118000	117000	0	5
118000	119000	118000	0	3
119000	121000	121000	0	1
122000	124000	123000	0	2
BRSM5: Azimuth = 90 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	502	0	5
750	2250	1400	0.0748	127
2250	3750	2870	0.0782	147
3750	5250	4470	0.0721	111
5250	6750	5980	0.0576	165
6750	8250	7570	0.11	178
8250	9750	9080	0.0669	172
9750	11200	10600	0.0656	183
11200	12800	12000	0.0533	150
12800	14200	13400	0.0595	168
14200	15800	15000	0.0607	206
15800	17200	16500	0.0588	255
17200	18800	18000	0.0807	316
18800	20200	19500	0.0809	377
20200	21800	21100	0.071	352
21800	23200	22500	0.0725	338
23200	24800	24000	0.0812	308
24800	26200	25500	0.066	341
26200	27800	27000	0.0652	422
27800	29200	28500	0.0586	469
29200	30800	30000	0.0651	584
30800	32200	31500	0.0869	633
32200	33800	33000	0.0962	608
33800	35200	34500	0.0788	641
35200	36800	36000	0.0807	607
36800	38200	37400	0.0798	545
38200	39800	39000	0.0645	442
39800	41200	40500	0.0659	364
41200	42800	42000	0.0733	300
42800	44200	43600	0.0828	296
44200	45800	45000	0.115	243
45800	47200	46500	0.113	200
47200	48800	48000	0.0782	211

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

48800	50200	49500	0.0537	205
50200	51800	51000	0.0237	232
51800	53200	52500	0.0338	340
53200	54800	54000	0.0275	400
54800	56200	55500	0.0279	340
56200	57800	57000	0.0443	271
57800	59200	58500	0.0356	225
59200	60800	60000	0.0409	171
60800	62200	61400	0.0703	192
62200	63800	62900	0.0583	163
63800	65200	64500	0.0294	119
65200	66800	66000	0.0375	120
66800	68200	67500	0.0223	112
68200	69800	69000	0.0472	106
69800	71200	70400	0.0233	129
71200	72800	71900	0.0575	113
72800	74200	73400	0.0966	119
74200	75800	74900	0.17	97
75800	77200	76500	0.117	90
77200	78800	78000	0.121	99
78800	80200	79400	0.0948	58
80200	81800	81000	0.0862	58
81800	83200	82500	0.0294	51
83200	84800	84000	0.111	45
84800	86200	85400	0.0703	64
86200	87800	87100	0.0959	73
87800	89200	88600	0.0522	67
89200	90800	90000	0.0526	76
90800	92200	91500	0.0738	61
92200	93800	92900	0.0543	46
93800	95200	94400	0.115	39
95200	96800	95900	0.113	40
96800	98200	97500	0.157	35
98200	99800	99100	0.0735	34
99800	101000	100000	0.0256	39
101000	103000	102000	0.0952	21
103000	104000	104000	0.188	24
104000	106000	105000	0.107	28
106000	107000	106000	0.1	40
107000	109000	108000	0.00909	55
109000	110000	109000	0.05	50
110000	112000	111000	0.0857	35
112000	113000	112000	0.0909	22
113000	115000	114000	0.0625	16
115000	116000	116000	0.138	29
116000	118000	117000	0.0185	27
118000	119000	118000	0.0395	38
119000	121000	120000	0.0526	19
121000	122000	122000	0	14

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

122000	124000	123000	0.15	10
124000	125000	124000	0.0625	16
125000	127000	126000	0.0417	12
127000	128000	128000	0	5
128000	130000	129000	0	7
130000	131000	131000	0	3
131000	133000	132000	0	6
133000	134000	133000	0	4
134000	136000	135000	0.333	3
136000	137000	137000	0.5	2
BRSM5: Azimuth = 110 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	733	0	2
750	2250	1460	0.102	59
2250	3750	2910	0.0696	115
3750	5250	4440	0.0599	142
5250	6750	5980	0.0625	144
6750	8250	7490	0.0942	191
8250	9750	9070	0.0644	225
9750	11200	10500	0.0588	221
11200	12800	12000	0.061	205
12800	14200	13500	0.0753	186
14200	15800	15000	0.0803	193
15800	17200	16500	0.0858	233
17200	18800	18000	0.0739	284
18800	20200	19500	0.0697	373
20200	21800	21000	0.0806	397
21800	23200	22500	0.0966	440
23200	24800	24000	0.0893	431
24800	26200	25500	0.0937	411
26200	27800	27000	0.0982	448
27800	29200	28500	0.0725	524
29200	30800	30000	0.0687	648
30800	32200	31500	0.101	695
32200	33800	33000	0.0951	652
33800	35200	34500	0.0645	667
35200	36800	36000	0.0842	594
36800	38200	37500	0.0778	527
38200	39800	39000	0.0713	449
39800	41200	40500	0.071	352
41200	42800	42000	0.0682	308
42800	44200	43500	0.0681	301
44200	45800	45000	0.0825	285
45800	47200	46500	0.0911	225
47200	48800	48000	0.115	205
48800	50200	49500	0.11	155
50200	51800	51000	0.0575	174
51800	53200	52500	0.0476	189
53200	54800	54000	0.0381	236

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

54800	56200	55500	0.0405	222
56200	57800	57000	0.0536	224
57800	59200	58500	0.0285	228
59200	60800	60000	0.0196	280
60800	62200	61500	0.0343	379
62200	63800	63000	0.0345	406
63800	65200	64400	0.0297	320
65200	66800	65900	0.0721	215
66800	68200	67500	0.0802	187
68200	69800	69000	0.0777	206
69800	71200	70400	0.107	168
71200	72800	72000	0.0798	94
72800	74200	73500	0.0408	98
74200	75800	75000	0.027	111
75800	77200	76500	0.0463	108
77200	78800	78000	0.0471	85
78800	80200	79500	0.06	100
80200	81800	80900	0.0652	92
81800	83200	82500	0.0345	58
83200	84800	84000	0.0244	41
84800	86200	85500	0.05	40
86200	87800	87000	0.0488	41
87800	89200	88500	0.0128	39
89200	90800	89900	0.0303	33
90800	92200	91400	0.0303	33
92200	93800	93000	0.04	25
93800	95200	94500	0.02	25
95200	96800	96000	0.075	20
96800	98200	97500	0.0345	29
98200	99800	98900	0.0172	29
99800	101000	100000	0.0294	17
101000	103000	102000	0.0385	26
103000	104000	104000	0.0303	33
104000	106000	105000	0.0455	33
106000	107000	106000	0.147	17
107000	109000	108000	0.1	10
109000	110000	110000	0.0357	14
110000	112000	111000	0.0833	18
112000	113000	113000	0.208	12
113000	115000	114000	0	6
115000	116000	115000	0	8
116000	118000	117000	0	4
118000	119000	118000	0	10
119000	121000	120000	0.0385	13
121000	122000	121000	0	7
122000	124000	123000	0	5
124000	125000	125000	0	4
125000	127000	126000	0	8
127000	128000	128000	0	1

128000	130000	129000	0	1
131000	133000	132000	0	1
133000	134000	133000	0	1
134000	136000	135000	0	1
136000	137000	136000	0	1
137000	139000	138000	0	2
139000	140000	140000	0	1
140000	142000	141000	0	1
BRSM5: Azimuth = 135 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	468	0	1
750	2250	1720	0.082	122
2250	3750	3110	0.0776	116
3750	5250	4550	0.0579	164
5250	6750	6110	0.0762	164
6750	8250	7550	0.0888	197
8250	9750	9060	0.083	229
9750	11200	10500	0.0657	251
11200	12800	12000	0.0574	235
12800	14200	13500	0.0801	206
14200	15800	15000	0.0963	187
15800	17200	16600	0.0778	212
17200	18800	18000	0.0884	215
18800	20200	19500	0.0745	255
20200	21800	21000	0.1	285
21800	23200	22500	0.125	332
23200	24800	24000	0.104	317
24800	26200	25500	0.107	338
26200	27800	27000	0.0895	313
27800	29200	28500	0.0841	315
29200	30800	30100	0.084	405
30800	32200	31500	0.0947	470
32200	33800	33000	0.119	519
33800	35200	34500	0.114	444
35200	36800	36000	0.125	409
36800	38200	37500	0.0971	314
38200	39800	38900	0.143	251
39800	41200	40500	0.136	202
41200	42800	42000	0.142	194
42800	44200	43500	0.113	181
44200	45800	45000	0.0895	162
45800	47200	46400	0.0661	121
47200	48800	48000	0.0439	114
48800	50200	49500	0.051	98
50200	51800	51000	0.0844	77
51800	53200	52400	0.0592	76
53200	54800	54000	0.0663	83
54800	56200	55500	0.0758	66
56200	57800	57000	0.0851	47

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

57800	59200	58300	0.0854	41
59200	60800	59900	0.0909	22
60800	62200	61400	0.0682	22
62200	63800	62900	0	12
63800	65200	64200	0.125	8
65200	66800	65800	0.143	7
66800	68200	67300	0.0833	6
68200	69800	68900	0	3
69800	71200	70600	0	5
71200	72800	71700	0	3
72800	74200	73400	0	3
74200	75800	75000	0	4
BRSM5: Azimuth = 160 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	739	0	1
750	2250	1520	0.0259	58
2250	3750	2960	0.0671	164
3750	5250	4420	0.0851	188
5250	6750	5940	0.0714	224
6750	8250	7490	0.0826	230
8250	9750	9070	0.0792	240
9750	11200	10600	0.0959	245
11200	12800	12000	0.0977	266
12800	14200	13500	0.0981	265
14200	15800	14900	0.0742	236
15800	17200	16400	0.0636	236
17200	18800	18000	0.0617	227
18800	20200	19600	0.0656	244
20200	21800	21000	0.0683	205
21800	23200	22500	0.0611	229
23200	24800	24000	0.0681	235
24800	26200	25500	0.0508	266
26200	27800	27000	0.0488	256
27800	29200	28500	0.0667	255
29200	30800	30000	0.0612	245
30800	32200	31500	0.047	202
32200	33800	33000	0.0625	176
33800	35200	34500	0.0724	152
35200	36800	36000	0.0541	157
36800	38200	37500	0.063	127
38200	39800	39000	0.0577	104
39800	41200	40500	0.0915	82
41200	42800	41900	0.0493	71
42800	44200	43500	0.0116	43
44200	45800	44900	0.0233	43
45800	47200	46400	0.06	25
47200	48800	48100	0.0862	29
48800	50200	49400	0	20
50200	51800	50900	0.0625	8

TABLE I-A SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

51800	53200	52500	0	9
53200	54800	53500	0	1

TABLE I-B SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM GSLIB'S GAM2V MODULE

Isotropic (Omnidirectional)						
				Non-Ergodic	Gen. Rel.	
Lag	Avg. Space	# Pairs	Semivariogram	Covariance	Semi-Variogram	Semi-Rodogram
1	0.0	708	0.0000	0.0705	0.0	0.0000
2	574.7	32	0.0313	-0.0010	64.0	0.0313
3	1556.0	1244	0.0699	0.0047	21.2	0.0699
4	2986.4	1944	0.0715	0.0053	20.3	0.0715
5	4440.2	2204	0.0699	0.0089	18.8	0.0699
6	5979.8	2448	0.0748	0.0006	22.2	0.0748
7	7526.3	2490	0.0839	-0.0004	19.8	0.0839
8	9043.4	2620	0.0737	0.0036	20.7	0.0737
9	10540.1	2622	0.0782	0.0028	19.8	0.0782
10	11996.8	2544	0.0743	0.0050	19.7	0.0743
11	13493.0	2472	0.0777	0.0007	21.1	0.0777
12	14957.5	2444	0.0720	0.0024	21.9	0.0720
13	16491.2	2686	0.0756	0.0012	21.5	0.0756
14	18004.0	2914	0.0721	-0.0023	25.3	0.0721
15	19520.7	3308	0.0726	-0.0027	25.4	0.0726
16	21028.3	3230	0.0749	-0.0035	25.0	0.0749
17	22511.0	3416	0.0805	-0.0036	22.8	0.0805
18	23977.9	3344	0.0748	0.0005	22.3	0.0748
19	25477.0	3362	0.0759	-0.0007	22.7	0.0759
20	26984.9	3388	0.0655	-0.0007	27.0	0.0655
21	28504.1	3700	0.0651	-0.0024	28.8	0.0651
22	30032.4	4054	0.0688	-0.0039	28.2	0.0688
23	31512.0	4286	0.0863	-0.0063	22.4	0.0863
24	33010.5	4126	0.0894	-0.0056	21.0	0.0894
25	34481.7	4102	0.0787	-0.0021	22.5	0.0787
26	35972.3	3854	0.0843	-0.0024	20.8	0.0843
27	37459.3	3280	0.0762	0.0009	21.5	0.0762
28	38972.0	2860	0.0797	0.0012	20.2	0.0797
29	40500.2	2482	0.0766	-0.0004	22.2	0.0766
30	42012.0	2284	0.0858	-0.0016	19.9	0.0858
31	43522.8	2160	0.0870	-0.0045	21.1	0.0870
32	44980.7	2038	0.0864	-0.0010	19.5	0.0864

TABLE I-B SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM GSLIB'S GAM2V MODULE

Anisotropic: Azimuth = 160 deg.						
				Non-Ergodic	Gen. Rel.	
Lag	Avg. Space	# Pairs	Semivariogram	Covariance	Semi-Variogram	Semi-Rodogram
1	0.0	354	0.0000	0.0705	0.0	0.0000
2	739.3	1	0.0000	0.0000	0.0	0.0000
3	1520.0	58	0.0259	-0.0006	77.3	0.0259
4	2958.1	164	0.0671	0.0063	21.3	0.0671
5	4423.0	188	0.0851	0.0015	18.6	0.0851
6	5940.0	224	0.0714	-0.0051	28.0	0.0714
7	7492.4	230	0.0826	0.0005	19.8	0.0826
8	9072.9	240	0.0792	-0.0022	22.8	0.0792
9	10577.8	245	0.0959	0.0015	16.4	0.0959
10	12046.8	266	0.0977	0.0064	14.4	0.0977
11	13498.8	265	0.0981	-0.0046	18.9	0.0981
12	14911.2	236	0.0742	0.0059	19.7	0.0742
13	16431.0	236	0.0636	0.0091	21.9	0.0636
14	17969.4	227	0.0617	0.0045	24.8	0.0617
15	19552.1	244	0.0656	-0.0026	30.5	0.0656
16	21041.7	205	0.0683	0.0001	25.5	0.0683
17	22506.5	229	0.0611	-0.0028	32.7	0.0611
18	24005.7	235	0.0681	-0.0032	29.4	0.0681
19	25460.1	266	0.0508	-0.0020	39.4	0.0508
20	26959.1	256	0.0488	-0.0015	41.0	0.0488
21	28496.8	255	0.0667	-0.0007	26.8	0.0667
22	29986.2	245	0.0612	-0.0038	32.7	0.0612
23	31474.5	202	0.0470	-0.0021	42.5	0.0470
24	32984.7	176	0.0625	-0.0036	32.0	0.0625
25	34481.2	152	0.0724	-0.0052	27.6	0.0724
26	35974.3	157	0.0541	0.0028	29.6	0.0541
27	37488.8	127	0.0630	-0.0039	31.8	0.0630
28	38950.1	104	0.0577	-0.0032	34.7	0.0577
29	40452.3	82	0.0915	-0.0054	21.9	0.0915
30	41898.0	71	0.0493	0.0000	40.6	0.0493
31	43481.5	43	0.0116	0.0000	172.0	0.0116
32	44924.6	43	0.0233	0.0000	86.0	0.0233

TABLE I-C SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM VARIOWIN

Variable : Brinehit						
ANISOTROPIC		Direction : 110*				
		Angular Tolerance : 15		Maximum BW : 10000		
Data Variance.: 7.04539e-02			Code for missing values : -9999			
Lag	NPairs	Mean |h|	Semivariogram	N.E. Cov.	N.E. Corr.	Semimadogram
1	58	1519.96	2.5862E-02	-5.9453E-04	-2.5031E-02	2.5862E-02
2	164	2958.05	6.7073E-02	6.2463E-03	8.7975E-02	6.7073E-02
3	188	4422.96	8.5106E-02	1.4996E-03	1.7347E-02	8.5106E-02
4	224	5939.99	7.1429E-02	-5.0821E-03	-7.6774E-02	7.1429E-02
5	230	7492.42	8.2609E-02	5.2930E-04	6.4464E-03	8.2609E-02
6	240	9072.90	7.9167E-02	-2.1528E-03	-2.9554E-02	7.9167E-02
7	245	10577.80	9.5918E-02	1.4827E-03	1.6035E-02	9.5918E-02
8	266	12046.80	9.7744E-02	6.3599E-03	6.4598E-02	9.7744E-02
9	265	13498.80	9.8113E-02	-4.5568E-03	-5.5661E-02	9.8113E-02
10	236	14911.10	7.4153E-02	5.9250E-03	7.8799E-02	7.4153E-02
11	236	16431.00	6.3559E-02	9.0671E-03	1.6280E-01	6.3559E-02
12	227	17969.40	6.1674E-02	4.5411E-03	7.4799E-02	6.1674E-02
13	244	19552.10	6.5574E-02	-2.6203E-03	-5.4834E-02	6.5574E-02
14	205	21041.70	6.8293E-02	1.1898E-04	1.8615E-03	6.8293E-02
15	229	22506.50	6.1135E-02	-2.8032E-03	-5.6422E-02	6.1135E-02
16	235	24005.70	6.8085E-02	-3.1689E-03	-6.0456E-02	6.8085E-02
17	266	25460.10	5.0752E-02	-1.9786E-03	-4.6876E-02	5.0752E-02
18	256	26959.10	4.8828E-02	-1.5259E-03	-4.1087E-02	4.8828E-02
19	255	28496.80	6.6667E-02	-6.7666E-04	-1.0739E-02	6.6667E-02
20	245	29986.20	6.1225E-02	-3.7484E-03	-6.5217E-02	6.1225E-02
21	202	31474.50	4.7030E-02	-2.0586E-03	-4.7615E-02	4.7030E-02
22	176	32984.70	6.2500E-02	-3.6157E-03	-6.4150E-02	6.2500E-02
23	152	34481.20	7.2368E-02	-5.1939E-03	-7.7693E-02	7.2368E-02
24	157	35974.30	5.4140E-02	2.7993E-03	4.9870E-02	5.4140E-02
25	127	37488.80	6.2992E-02	-3.9060E-03	-6.6702E-02	6.2992E-02
26	104	38950.10	5.7692E-02	-3.2360E-03	-6.0371E-02	5.7692E-02
27	82	40452.30	9.1463E-02	-5.3540E-03	-8.0684E-02	9.1463E-02
28	71	41898.00	4.9296E-02	0.0000E+00	-9.9990E+03	4.9296E-02
29	43	43481.50	1.1628E-02	0.0000E+00	-9.9990E+03	1.1628E-02
30	43	44924.60	2.3256E-02	0.0000E+00	-9.9990E+03	2.3256E-02
* Variowin measures direction clockwise from X axis which differs from both UNCERT and						
GSLIB. An UNCERT azimuth of 160 deg. equals a VARIOWIN angle of 110 deg.						

TABLE I-C SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM VARIOWIN

ISOTROPIC						
Direction : 0		Angular Tolerance : 90			Maximum BW : NA	
Lag	NPairs	Mean |h|	Semivariogram	N.E. Cov.	N.E. Corr.	Semimadogram
0	32	574.72	3.1250E-02	-9.7656E-04	-3.2258E-02	3.1250E-02
1	1244	1556.01	6.9936E-02	4.6623E-03	6.2498E-02	6.9936E-02
2	1944	2986.36	7.1502E-02	5.3152E-03	6.9193E-02	7.1502E-02
3	2204	4440.21	6.9873E-02	8.9023E-03	1.1301E-01	6.9873E-02
4	2448	5979.77	7.4755E-02	6.1124E-04	8.1103E-03	7.4755E-02
5	2490	7526.26	8.3936E-02	-4.2596E-04	-5.1007E-03	8.3936E-02
6	2620	9043.41	7.3664E-02	3.5719E-03	4.6247E-02	7.3664E-02
7	2622	10540.10	7.8185E-02	2.7822E-03	3.4362E-02	7.8185E-02
8	2544	11996.70	7.4293E-02	5.0320E-03	6.3436E-02	7.4293E-02
9	2472	13492.90	7.7670E-02	7.3575E-04	9.3839E-03	7.7670E-02
10	2444	14957.40	7.2013E-02	2.4383E-03	3.2750E-02	7.2013E-02
11	2686	16491.20	7.5577E-02	1.1736E-03	1.5291E-02	7.5577E-02
12	2914	18004.00	7.2066E-02	-2.2682E-03	-3.2497E-02	7.2066E-02
13	3308	19520.70	7.2551E-02	-2.6885E-03	-3.8483E-02	7.2551E-02
14	3230	21028.30	7.4923E-02	-3.5139E-03	-4.9208E-02	7.4923E-02
15	3416	22511.00	8.0504E-02	-3.5459E-03	-4.6076E-02	8.0504E-02
16	3344	23977.90	7.4761E-02	4.6323E-04	6.1580E-03	7.4761E-02
17	3362	25477.00	7.5848E-02	-7.4184E-04	-9.8772E-03	7.5848E-02
18	3388	26984.90	6.5525E-02	-7.1995E-04	-1.1109E-02	6.5525E-02
19	3700	28504.10	6.5135E-02	-2.3668E-03	-3.7706E-02	6.5135E-02
20	4054	30032.40	6.8821E-02	-3.8864E-03	-5.9851E-02	6.8821E-02
21	4286	31512.00	8.6328E-02	-6.2962E-03	-7.8672E-02	8.6328E-02
22	4126	33010.50	8.9433E-02	-5.6185E-03	-6.7035E-02	8.9433E-02
23	4102	34481.70	7.8742E-02	-2.1163E-03	-2.7618E-02	7.8742E-02
24	3854	35972.30	8.4328E-02	-2.3982E-03	-2.9271E-02	8.4328E-02
25	3280	37459.30	7.6220E-02	8.4622E-04	1.0981E-02	7.6220E-02
26	2860	38972.00	7.9720E-02	1.2035E-03	1.4872E-02	7.9720E-02
27	2482	40500.20	7.6551E-02	-4.4219E-04	-5.8099E-03	7.6551E-02
28	2284	42012.00	8.5814E-02	-1.6102E-03	-1.9123E-02	8.5814E-02
29	2160	43522.80	8.7037E-02	-4.5302E-03	-5.4907E-02	8.7037E-02
30	2038	44980.70	8.6359E-02	-1.0247E-03	-1.2008E-02	8.6359E-02
* Variowin measures direction clockwise from X axis which differs from both UNCERT and						
GSLIB. An UNCERT azimuth of 160 deg. equals a VARIOWIN angle of 110 deg.						

APPENDIX J

Cowden Isopach Sample Semi-Variogram Calculations

Table J-A: Results from UNCERT's VARIO Module

TABLE J-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM
CALCULATIONS FROM UNCERT'S VARIO MODULE

Experimental Semivariogram Solution from VARIO				
icowr3: Isotropic				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	488	1.81E+03	42
750	2.25E+03	1.55E+03	4.35E+03	1194
2.25E+03	3.75E+03	2.99E+03	8.35E+03	1874
3.75E+03	5.25E+03	4.45E+03	1.33E+04	2060
5.25E+03	6.75E+03	5.98E+03	1.69E+04	2290
6.75E+03	8.25E+03	7.53E+03	2.31E+04	2428
8.25E+03	9.75E+03	9.04E+03	2.54E+04	2628
9.75E+03	1.12E+04	1.05E+04	2.55E+04	2612
1.12E+04	1.28E+04	1.20E+04	2.69E+04	2492
1.28E+04	1.42E+04	1.35E+04	2.78E+04	2454
1.42E+04	1.58E+04	1.50E+04	2.83E+04	2506
1.58E+04	1.72E+04	1.65E+04	2.89E+04	2770
1.72E+04	1.88E+04	1.80E+04	2.91E+04	2976
1.88E+04	2.02E+04	1.95E+04	3.17E+04	3422
2.02E+04	2.18E+04	2.10E+04	3.53E+04	3390
2.18E+04	2.32E+04	2.25E+04	3.56E+04	3488
2.32E+04	2.48E+04	2.40E+04	3.65E+04	3536
2.48E+04	2.62E+04	2.55E+04	3.65E+04	3484
2.62E+04	2.78E+04	2.70E+04	3.29E+04	3658
2.78E+04	2.92E+04	2.85E+04	3.25E+04	3982
2.92E+04	3.08E+04	3.00E+04	3.13E+04	4098
3.08E+04	3.22E+04	3.15E+04	3.14E+04	4338
3.22E+04	3.38E+04	3.30E+04	3.25E+04	4090
3.38E+04	3.52E+04	3.45E+04	3.29E+04	4030
3.52E+04	3.68E+04	3.60E+04	3.29E+04	3804
3.68E+04	3.82E+04	3.75E+04	3.80E+04	3404
3.82E+04	3.98E+04	3.90E+04	3.69E+04	3180
3.98E+04	4.12E+04	4.05E+04	4.02E+04	2940
4.12E+04	4.28E+04	4.20E+04	3.81E+04	2712
4.28E+04	4.42E+04	4.35E+04	4.26E+04	2638
4.42E+04	4.58E+04	4.50E+04	4.90E+04	2434
4.58E+04	4.72E+04	4.65E+04	5.33E+04	2146
4.72E+04	4.88E+04	4.80E+04	5.54E+04	2096
4.88E+04	5.02E+04	4.95E+04	5.30E+04	2000
5.02E+04	5.18E+04	5.10E+04	5.84E+04	1996
5.18E+04	5.32E+04	5.25E+04	5.64E+04	2090
5.32E+04	5.48E+04	5.40E+04	5.08E+04	2174
5.48E+04	5.62E+04	5.55E+04	4.66E+04	1914
5.62E+04	5.78E+04	5.70E+04	3.70E+04	1698
5.78E+04	5.92E+04	5.85E+04	3.44E+04	1516
5.92E+04	6.08E+04	6.00E+04	2.92E+04	1512
6.08E+04	6.22E+04	6.15E+04	2.70E+04	1710
6.22E+04	6.38E+04	6.30E+04	2.48E+04	1594
6.38E+04	6.52E+04	6.45E+04	2.51E+04	1164
6.52E+04	6.68E+04	6.60E+04	3.25E+04	872
6.68E+04	6.82E+04	6.75E+04	3.39E+04	736

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM
CALCULATIONS FROM UNCERT'S VARIO MODULE

6.82E+04	6.98E+04	6.90E+04	3.13E+04	762
6.98E+04	7.12E+04	7.05E+04	3.18E+04	850
7.12E+04	7.28E+04	7.19E+04	3.19E+04	672
7.28E+04	7.42E+04	7.35E+04	3.34E+04	586
7.42E+04	7.58E+04	7.50E+04	4.14E+04	488
7.58E+04	7.72E+04	7.65E+04	3.71E+04	528
7.72E+04	7.88E+04	7.80E+04	3.38E+04	418
7.88E+04	8.02E+04	7.95E+04	3.28E+04	378
8.02E+04	8.18E+04	8.09E+04	2.83E+04	322
8.18E+04	8.32E+04	8.24E+04	2.75E+04	276
8.32E+04	8.48E+04	8.39E+04	4.04E+04	224
8.48E+04	8.62E+04	8.56E+04	2.70E+04	226
8.62E+04	8.78E+04	8.71E+04	4.45E+04	216
8.78E+04	8.92E+04	8.85E+04	4.01E+04	188
8.92E+04	9.08E+04	9.00E+04	4.61E+04	134
9.08E+04	9.22E+04	9.14E+04	3.70E+04	136
9.22E+04	9.38E+04	9.30E+04	6.91E+04	106
9.38E+04	9.52E+04	9.44E+04	6.33E+04	84
9.52E+04	9.68E+04	9.59E+04	7.83E+04	76
9.68E+04	9.82E+04	9.75E+04	5.59E+04	54
9.82E+04	9.98E+04	9.90E+04	4.51E+04	68
9.98E+04	1.01E+05	1.00E+05	4.85E+04	46
1.01E+05	1.03E+05	1.02E+05	4.45E+04	20
1.03E+05	1.04E+05	1.04E+05	4.59E+04	28
1.04E+05	1.06E+05	1.05E+05	2.11E+04	42
1.06E+05	1.07E+05	1.06E+05	4.48E+04	68
1.07E+05	1.09E+05	1.08E+05	3.13E+04	56
1.09E+05	1.10E+05	1.09E+05	1.20E+04	26
1.10E+05	1.12E+05	1.11E+05	3.68E+04	20
1.12E+05	1.13E+05	1.13E+05	1.59E+04	26
1.13E+05	1.15E+05	1.14E+05	3.17E+04	48
1.15E+05	1.16E+05	1.15E+05	1.67E+04	36
1.16E+05	1.18E+05	1.17E+05	2.22E+04	26
1.18E+05	1.19E+05	1.18E+05	2.07E+04	14
1.19E+05	1.21E+05	1.20E+05	1.07E+04	14
1.21E+05	1.22E+05	1.22E+05	2.15E+04	18
1.22E+05	1.24E+05	1.23E+05	3.52E+04	16
1.24E+05	1.25E+05	1.24E+05	1.27E+04	10
1.25E+05	1.27E+05	1.26E+05	3.19E+04	12
1.27E+05	1.28E+05	1.28E+05	2.96E+03	2
1.28E+05	1.30E+05	1.29E+05	1.61E+04	14
1.30E+05	1.31E+05	1.31E+05	3.84E+04	8
1.31E+05	1.33E+05	1.32E+05	2.10E+04	8
1.33E+05	1.34E+05	1.34E+05	8.53E+03	8
1.36E+05	1.37E+05	1.36E+05	5.44E+03	6
1.39E+05	1.40E+05	1.40E+05	4.75E+04	4
1.40E+05	1.42E+05	1.41E+05	1.71E+04	4
1.42E+05	1.43E+05	1.42E+05	7.81E+03	2
1.43E+05	1.45E+05	1.44E+05	9.47E+03	4

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM
CALCULATIONS FROM UNCERT'S VARIO MODULE

1.46E+05	1.48E+05	1.47E+05	1.04E+05	2
icowr3: Az = 0 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	593	4.77E+03	4
750	2.25E+03	1.36E+03	4.54E+03	142
2.25E+03	3.75E+03	2.91E+03	9.54E+03	200
3.75E+03	5.25E+03	4.41E+03	1.79E+04	223
5.25E+03	6.75E+03	5.95E+03	1.70E+04	333
6.75E+03	8.25E+03	7.57E+03	2.13E+04	271
8.25E+03	9.75E+03	9.12E+03	2.27E+04	252
9.75E+03	1.12E+04	1.06E+04	2.45E+04	261
1.12E+04	1.28E+04	1.20E+04	2.96E+04	252
1.28E+04	1.42E+04	1.34E+04	2.98E+04	249
1.42E+04	1.58E+04	1.48E+04	3.45E+04	295
1.58E+04	1.72E+04	1.64E+04	3.84E+04	315
1.72E+04	1.88E+04	1.80E+04	3.30E+04	312
1.88E+04	2.02E+04	1.96E+04	3.79E+04	322
2.02E+04	2.18E+04	2.11E+04	3.90E+04	301
2.18E+04	2.32E+04	2.26E+04	4.08E+04	260
2.32E+04	2.48E+04	2.40E+04	4.36E+04	267
2.48E+04	2.62E+04	2.55E+04	4.12E+04	265
2.62E+04	2.78E+04	2.69E+04	3.63E+04	256
2.78E+04	2.92E+04	2.85E+04	3.55E+04	246
2.92E+04	3.08E+04	3.00E+04	4.55E+04	204
3.08E+04	3.22E+04	3.16E+04	4.99E+04	181
3.22E+04	3.38E+04	3.30E+04	5.01E+04	137
3.38E+04	3.52E+04	3.45E+04	5.21E+04	118
3.52E+04	3.68E+04	3.59E+04	4.67E+04	106
3.68E+04	3.82E+04	3.74E+04	6.34E+04	71
3.82E+04	3.98E+04	3.89E+04	7.37E+04	74
3.98E+04	4.12E+04	4.05E+04	6.66E+04	75
4.12E+04	4.28E+04	4.22E+04	6.00E+04	41
4.28E+04	4.42E+04	4.37E+04	5.61E+04	41
4.42E+04	4.58E+04	4.50E+04	5.71E+04	35
4.58E+04	4.72E+04	4.64E+04	4.93E+04	32
4.72E+04	4.88E+04	4.78E+04	6.38E+04	27
4.88E+04	5.02E+04	4.94E+04	3.86E+04	21
5.02E+04	5.18E+04	5.10E+04	5.96E+04	13
5.18E+04	5.32E+04	5.27E+04	4.48E+04	4
5.32E+04	5.48E+04	5.36E+04	1.39E+04	3
5.48E+04	5.62E+04	5.53E+04	3.38E+04	5
5.78E+04	5.92E+04	5.80E+04	2.63E+03	2
6.22E+04	6.38E+04	6.37E+04	4.29E+04	1
icowr3: Az = 20 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	699	3.60E+03	2
750	2.25E+03	1.54E+03	3.76E+03	69
2.25E+03	3.75E+03	2.96E+03	1.04E+04	171
3.75E+03	5.25E+03	4.45E+03	1.75E+04	236

5.25E+03	6.75E+03	5.98E+03	1.85E+04	260
6.75E+03	8.25E+03	7.50E+03	2.21E+04	275
8.25E+03	9.75E+03	9.08E+03	2.73E+04	280
9.75E+03	1.12E+04	1.06E+04	2.69E+04	243
1.12E+04	1.28E+04	1.20E+04	2.65E+04	252
1.28E+04	1.42E+04	1.35E+04	3.20E+04	243
1.42E+04	1.58E+04	1.49E+04	3.29E+04	230
1.58E+04	1.72E+04	1.65E+04	3.36E+04	227
1.72E+04	1.88E+04	1.80E+04	3.57E+04	216
1.88E+04	2.02E+04	1.95E+04	3.73E+04	231
2.02E+04	2.18E+04	2.10E+04	4.04E+04	238
2.18E+04	2.32E+04	2.25E+04	4.67E+04	218
2.32E+04	2.48E+04	2.40E+04	5.00E+04	214
2.48E+04	2.62E+04	2.55E+04	5.91E+04	173
2.62E+04	2.78E+04	2.69E+04	5.44E+04	147
2.78E+04	2.92E+04	2.84E+04	5.41E+04	149
2.92E+04	3.08E+04	3.00E+04	5.32E+04	126
3.08E+04	3.22E+04	3.15E+04	4.82E+04	125
3.22E+04	3.38E+04	3.30E+04	4.40E+04	124
3.38E+04	3.52E+04	3.45E+04	4.79E+04	129
3.52E+04	3.68E+04	3.60E+04	5.05E+04	125
3.68E+04	3.82E+04	3.75E+04	5.14E+04	134
3.82E+04	3.98E+04	3.90E+04	5.86E+04	131
3.98E+04	4.12E+04	4.05E+04	6.79E+04	129
4.12E+04	4.28E+04	4.20E+04	6.69E+04	118
4.28E+04	4.42E+04	4.35E+04	8.26E+04	127
4.42E+04	4.58E+04	4.50E+04	9.36E+04	100
4.58E+04	4.72E+04	4.65E+04	1.17E+05	92
4.72E+04	4.88E+04	4.79E+04	1.12E+05	69
4.88E+04	5.02E+04	4.95E+04	1.15E+05	45
5.02E+04	5.18E+04	5.09E+04	8.84E+04	44
5.18E+04	5.32E+04	5.24E+04	5.90E+04	28
5.32E+04	5.48E+04	5.39E+04	2.99E+04	21
5.48E+04	5.62E+04	5.57E+04	1.90E+04	15
5.62E+04	5.78E+04	5.68E+04	6.42E+03	12
5.78E+04	5.92E+04	5.86E+04	3.48E+03	3
5.92E+04	6.08E+04	6.01E+04	7.57E+04	1
6.38E+04	6.52E+04	6.42E+04	3.41E+04	1
icowr3: Az = 45 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	494	2	1
750	2.25E+03	1.78E+03	6.24E+03	123
2.25E+03	3.75E+03	3.14E+03	9.45E+03	141
3.75E+03	5.25E+03	4.58E+03	1.47E+04	185
5.25E+03	6.75E+03	6.08E+03	1.33E+04	171
6.75E+03	8.25E+03	7.56E+03	1.99E+04	150
8.25E+03	9.75E+03	9.10E+03	2.53E+04	148
9.75E+03	1.12E+04	1.05E+04	2.45E+04	151
1.12E+04	1.28E+04	1.20E+04	2.81E+04	169

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM
CALCULATIONS FROM UNCERT'S VARIO MODULE

1.28E+04	1.42E+04	1.35E+04	2.93E+04	128
1.42E+04	1.58E+04	1.50E+04	2.59E+04	143
1.58E+04	1.72E+04	1.65E+04	2.55E+04	156
1.72E+04	1.88E+04	1.80E+04	3.25E+04	164
1.88E+04	2.02E+04	1.95E+04	3.45E+04	189
2.02E+04	2.18E+04	2.10E+04	4.58E+04	210
2.18E+04	2.32E+04	2.25E+04	4.30E+04	215
2.32E+04	2.48E+04	2.40E+04	4.66E+04	244
2.48E+04	2.62E+04	2.55E+04	5.54E+04	222
2.62E+04	2.78E+04	2.70E+04	4.58E+04	202
2.78E+04	2.92E+04	2.85E+04	5.47E+04	236
2.92E+04	3.08E+04	3.00E+04	4.54E+04	205
3.08E+04	3.22E+04	3.15E+04	4.43E+04	206
3.22E+04	3.38E+04	3.31E+04	4.36E+04	203
3.38E+04	3.52E+04	3.45E+04	4.02E+04	238
3.52E+04	3.68E+04	3.60E+04	4.14E+04	245
3.68E+04	3.82E+04	3.75E+04	4.82E+04	237
3.82E+04	3.98E+04	3.90E+04	4.50E+04	238
3.98E+04	4.12E+04	4.05E+04	5.21E+04	214
4.12E+04	4.28E+04	4.20E+04	6.09E+04	207
4.28E+04	4.42E+04	4.35E+04	7.15E+04	180
4.42E+04	4.58E+04	4.50E+04	9.88E+04	195
4.58E+04	4.72E+04	4.65E+04	1.07E+05	165
4.72E+04	4.88E+04	4.79E+04	1.18E+05	142
4.88E+04	5.02E+04	4.94E+04	1.15E+05	120
5.02E+04	5.18E+04	5.10E+04	1.16E+05	99
5.18E+04	5.32E+04	5.25E+04	1.06E+05	72
5.32E+04	5.48E+04	5.39E+04	1.04E+05	75
5.48E+04	5.62E+04	5.55E+04	8.88E+04	55
5.62E+04	5.78E+04	5.70E+04	5.96E+04	56
5.78E+04	5.92E+04	5.86E+04	5.06E+04	58
5.92E+04	6.08E+04	6.00E+04	3.27E+04	37
6.08E+04	6.22E+04	6.15E+04	2.67E+04	45
6.22E+04	6.38E+04	6.29E+04	2.73E+04	32
6.38E+04	6.52E+04	6.45E+04	5.61E+04	25
6.52E+04	6.68E+04	6.61E+04	1.35E+05	19
6.68E+04	6.82E+04	6.75E+04	1.26E+05	9
6.82E+04	6.98E+04	6.88E+04	1.46E+05	6
6.98E+04	7.12E+04	7.08E+04	1.86E+05	7
7.12E+04	7.28E+04	7.22E+04	9.41E+04	4
7.28E+04	7.42E+04	7.34E+04	7.04E+04	3
7.42E+04	7.58E+04	7.52E+04	6.23E+04	4
7.58E+04	7.72E+04	7.65E+04	1.17E+05	2
7.72E+04	7.88E+04	7.77E+04	2.21E+04	4
7.88E+04	8.02E+04	7.96E+04	1.53E+04	1
8.18E+04	8.32E+04	8.20E+04	5.88E+04	1
8.48E+04	8.62E+04	8.49E+04	1.62E+03	1
icowr3: Az = 70 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

0	750	437	119	4
750	2.25E+03	1.46E+03	1.88E+03	59
2.25E+03	3.75E+03	2.95E+03	4.68E+03	127
3.75E+03	5.25E+03	4.48E+03	1.05E+04	139
5.25E+03	6.75E+03	5.96E+03	2.33E+04	116
6.75E+03	8.25E+03	7.52E+03	2.31E+04	167
8.25E+03	9.75E+03	9.05E+03	2.39E+04	184
9.75E+03	1.12E+04	1.05E+04	2.70E+04	154
1.12E+04	1.28E+04	1.20E+04	2.86E+04	155
1.28E+04	1.42E+04	1.35E+04	2.91E+04	149
1.42E+04	1.58E+04	1.50E+04	2.80E+04	179
1.58E+04	1.72E+04	1.65E+04	3.07E+04	188
1.72E+04	1.88E+04	1.80E+04	3.47E+04	242
1.88E+04	2.02E+04	1.95E+04	4.10E+04	324
2.02E+04	2.18E+04	2.10E+04	5.65E+04	285
2.18E+04	2.32E+04	2.25E+04	5.11E+04	313
2.32E+04	2.48E+04	2.40E+04	5.83E+04	310
2.48E+04	2.62E+04	2.55E+04	5.22E+04	329
2.62E+04	2.78E+04	2.70E+04	3.70E+04	337
2.78E+04	2.92E+04	2.85E+04	3.41E+04	374
2.92E+04	3.08E+04	3.00E+04	3.00E+04	383
3.08E+04	3.22E+04	3.15E+04	3.05E+04	381
3.22E+04	3.38E+04	3.30E+04	3.81E+04	371
3.38E+04	3.52E+04	3.45E+04	4.47E+04	359
3.52E+04	3.68E+04	3.60E+04	5.39E+04	316
3.68E+04	3.82E+04	3.75E+04	5.54E+04	329
3.82E+04	3.98E+04	3.90E+04	4.99E+04	287
3.98E+04	4.12E+04	4.05E+04	4.62E+04	263
4.12E+04	4.28E+04	4.20E+04	3.77E+04	263
4.28E+04	4.42E+04	4.35E+04	4.06E+04	240
4.42E+04	4.58E+04	4.50E+04	4.01E+04	224
4.58E+04	4.72E+04	4.65E+04	4.37E+04	228
4.72E+04	4.88E+04	4.80E+04	4.78E+04	248
4.88E+04	5.02E+04	4.95E+04	5.17E+04	296
5.02E+04	5.18E+04	5.10E+04	5.35E+04	330
5.18E+04	5.32E+04	5.25E+04	6.11E+04	294
5.32E+04	5.48E+04	5.40E+04	6.13E+04	218
5.48E+04	5.62E+04	5.55E+04	5.94E+04	203
5.62E+04	5.78E+04	5.70E+04	4.06E+04	176
5.78E+04	5.92E+04	5.85E+04	3.37E+04	167
5.92E+04	6.08E+04	5.99E+04	3.89E+04	154
6.08E+04	6.22E+04	6.15E+04	4.95E+04	119
6.22E+04	6.38E+04	6.30E+04	5.88E+04	82
6.38E+04	6.52E+04	6.45E+04	8.54E+04	43
6.52E+04	6.68E+04	6.61E+04	7.70E+04	47
6.68E+04	6.82E+04	6.75E+04	6.75E+04	47
6.82E+04	6.98E+04	6.90E+04	6.59E+04	40
6.98E+04	7.12E+04	7.05E+04	5.98E+04	38
7.12E+04	7.28E+04	7.19E+04	6.81E+04	32

7.28E+04	7.42E+04	7.35E+04	4.83E+04	38
7.42E+04	7.58E+04	7.50E+04	6.09E+04	43
7.58E+04	7.72E+04	7.64E+04	4.19E+04	34
7.72E+04	7.88E+04	7.79E+04	3.77E+04	23
7.88E+04	8.02E+04	7.94E+04	4.33E+04	24
8.02E+04	8.18E+04	8.10E+04	4.27E+04	15
8.18E+04	8.32E+04	8.23E+04	5.46E+04	16
8.32E+04	8.48E+04	8.36E+04	4.85E+04	4
8.48E+04	8.62E+04	8.56E+04	2.73E+04	4
8.62E+04	8.78E+04	8.69E+04	7.81E+04	7
8.78E+04	8.92E+04	8.81E+04	1.65E+05	2
8.92E+04	9.08E+04	9.03E+04	8.42E+04	3
9.08E+04	9.22E+04	9.12E+04	1.82E+05	2
9.22E+04	9.38E+04	9.29E+04	1.26E+05	2
9.38E+04	9.52E+04	9.41E+04	8.55E+04	4
9.52E+04	9.68E+04	9.57E+04	1.15E+05	1
9.68E+04	9.82E+04	9.79E+04	2.44E+04	1
9.82E+04	9.98E+04	9.92E+04	2.33E+03	2
1.06E+05	1.07E+05	1.06E+05	7.88E+04	2
icowr3: Az = 90 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	368	984	11
750	2.25E+03	1.41E+03	3.26E+03	124
2.25E+03	3.75E+03	2.88E+03	6.46E+03	132
3.75E+03	5.25E+03	4.45E+03	1.05E+04	99
5.25E+03	6.75E+03	5.97E+03	2.67E+04	150
6.75E+03	8.25E+03	7.56E+03	3.84E+04	192
8.25E+03	9.75E+03	9.09E+03	2.94E+04	183
9.75E+03	1.12E+04	1.05E+04	2.82E+04	186
1.12E+04	1.28E+04	1.20E+04	2.64E+04	151
1.28E+04	1.42E+04	1.34E+04	2.04E+04	146
1.42E+04	1.58E+04	1.50E+04	2.34E+04	207
1.58E+04	1.72E+04	1.65E+04	2.79E+04	248
1.72E+04	1.88E+04	1.80E+04	2.75E+04	304
1.88E+04	2.02E+04	1.95E+04	2.73E+04	361
2.02E+04	2.18E+04	2.11E+04	3.40E+04	340
2.18E+04	2.32E+04	2.25E+04	3.86E+04	324
2.32E+04	2.48E+04	2.40E+04	3.64E+04	298
2.48E+04	2.62E+04	2.55E+04	3.09E+04	357
2.62E+04	2.78E+04	2.70E+04	2.30E+04	445
2.78E+04	2.92E+04	2.85E+04	1.84E+04	503
2.92E+04	3.08E+04	3.00E+04	1.97E+04	549
3.08E+04	3.22E+04	3.15E+04	2.15E+04	610
3.22E+04	3.38E+04	3.30E+04	2.87E+04	562
3.38E+04	3.52E+04	3.45E+04	3.33E+04	575
3.52E+04	3.68E+04	3.60E+04	3.55E+04	570
3.68E+04	3.82E+04	3.74E+04	4.40E+04	522
3.82E+04	3.98E+04	3.90E+04	4.15E+04	410
3.98E+04	4.12E+04	4.05E+04	4.85E+04	375

4.12E+04	4.28E+04	4.21E+04	3.60E+04	319
4.28E+04	4.42E+04	4.36E+04	4.10E+04	305
4.42E+04	4.58E+04	4.50E+04	3.86E+04	270
4.58E+04	4.72E+04	4.64E+04	4.31E+04	244
4.72E+04	4.88E+04	4.80E+04	4.98E+04	224
4.88E+04	5.02E+04	4.95E+04	5.22E+04	201
5.02E+04	5.18E+04	5.10E+04	6.34E+04	234
5.18E+04	5.32E+04	5.26E+04	6.36E+04	327
5.32E+04	5.48E+04	5.40E+04	5.62E+04	386
5.48E+04	5.62E+04	5.55E+04	5.05E+04	331
5.62E+04	5.78E+04	5.70E+04	4.09E+04	264
5.78E+04	5.92E+04	5.85E+04	3.80E+04	193
5.92E+04	6.08E+04	6.00E+04	3.16E+04	176
6.08E+04	6.22E+04	6.15E+04	3.11E+04	193
6.22E+04	6.38E+04	6.29E+04	2.74E+04	168
6.38E+04	6.52E+04	6.45E+04	1.97E+04	115
6.52E+04	6.68E+04	6.60E+04	2.88E+04	89
6.68E+04	6.82E+04	6.76E+04	4.53E+04	61
6.82E+04	6.98E+04	6.90E+04	4.04E+04	80
6.98E+04	7.12E+04	7.04E+04	3.99E+04	104
7.12E+04	7.28E+04	7.19E+04	4.26E+04	96
7.28E+04	7.42E+04	7.35E+04	3.87E+04	84
7.42E+04	7.58E+04	7.51E+04	4.14E+04	60
7.58E+04	7.72E+04	7.65E+04	2.94E+04	71
7.72E+04	7.88E+04	7.79E+04	2.68E+04	52
7.88E+04	8.02E+04	7.94E+04	4.19E+04	50
8.02E+04	8.18E+04	8.08E+04	3.47E+04	32
8.18E+04	8.32E+04	8.24E+04	2.96E+04	35
8.32E+04	8.48E+04	8.40E+04	6.48E+04	39
8.48E+04	8.62E+04	8.56E+04	3.16E+04	39
8.62E+04	8.78E+04	8.72E+04	6.91E+04	37
8.78E+04	8.92E+04	8.86E+04	4.43E+04	31
8.92E+04	9.08E+04	9.00E+04	5.20E+04	21
9.08E+04	9.22E+04	9.13E+04	4.73E+04	13
9.38E+04	9.52E+04	9.46E+04	5.96E+03	4
9.52E+04	9.68E+04	9.58E+04	2.48E+04	10
9.68E+04	9.82E+04	9.77E+04	3.03E+04	4
9.82E+04	9.98E+04	9.91E+04	5.24E+04	12
9.98E+04	1.01E+05	1.00E+05	3.26E+04	6
1.03E+05	1.04E+05	1.04E+05	1.86E+04	5
1.04E+05	1.06E+05	1.05E+05	3.57E+04	4
1.06E+05	1.07E+05	1.06E+05	4.64E+04	9
1.07E+05	1.09E+05	1.08E+05	3.29E+04	11
1.09E+05	1.10E+05	1.09E+05	9.81E+03	2
1.10E+05	1.12E+05	1.10E+05	1.05E+04	1
1.12E+05	1.13E+05	1.12E+05	3.67E+04	1
1.13E+05	1.15E+05	1.14E+05	4.04E+04	6
1.15E+05	1.16E+05	1.15E+05	1.10E+04	2
1.16E+05	1.18E+05	1.17E+05	4.11E+04	5

1.18E+05	1.19E+05	1.18E+05	0.5	1
1.21E+05	1.22E+05	1.22E+05	2.41E+04	2
1.22E+05	1.24E+05	1.23E+05	6.44E+04	3
1.24E+05	1.25E+05	1.25E+05	7.56E+03	1
1.25E+05	1.27E+05	1.26E+05	4.95E+04	3
1.28E+05	1.30E+05	1.29E+05	1.35E+04	2
1.30E+05	1.31E+05	1.31E+05	7.23E+04	2
1.31E+05	1.33E+05	1.32E+05	4.99E+04	1
1.40E+05	1.42E+05	1.40E+05	3.41E+04	1
1.42E+05	1.43E+05	1.42E+05	7.81E+03	1
icowr3: Az = 110 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	733	242	1
750	2.25E+03	1.46E+03	1.26E+03	59
2.25E+03	3.75E+03	2.92E+03	5.36E+03	116
3.75E+03	5.25E+03	4.46E+03	7.97E+03	123
5.25E+03	6.75E+03	5.97E+03	1.94E+04	133
6.75E+03	8.25E+03	7.52E+03	3.49E+04	201
8.25E+03	9.75E+03	9.08E+03	3.19E+04	232
9.75E+03	1.12E+04	1.05E+04	2.90E+04	236
1.12E+04	1.28E+04	1.20E+04	1.86E+04	187
1.28E+04	1.42E+04	1.35E+04	1.31E+04	181
1.42E+04	1.58E+04	1.50E+04	1.56E+04	201
1.58E+04	1.72E+04	1.65E+04	1.58E+04	237
1.72E+04	1.88E+04	1.80E+04	1.75E+04	276
1.88E+04	2.02E+04	1.95E+04	1.75E+04	370
2.02E+04	2.18E+04	2.10E+04	1.84E+04	387
2.18E+04	2.32E+04	2.25E+04	1.86E+04	429
2.32E+04	2.48E+04	2.40E+04	1.55E+04	420
2.48E+04	2.62E+04	2.55E+04	1.50E+04	392
2.62E+04	2.78E+04	2.70E+04	1.95E+04	463
2.78E+04	2.92E+04	2.85E+04	2.18E+04	550
2.92E+04	3.08E+04	3.00E+04	2.37E+04	652
3.08E+04	3.22E+04	3.15E+04	2.40E+04	698
3.22E+04	3.38E+04	3.30E+04	2.19E+04	653
3.38E+04	3.52E+04	3.45E+04	1.78E+04	613
3.52E+04	3.68E+04	3.60E+04	1.17E+04	542
3.68E+04	3.82E+04	3.75E+04	1.70E+04	491
3.82E+04	3.98E+04	3.89E+04	1.83E+04	428
3.98E+04	4.12E+04	4.05E+04	2.27E+04	363
4.12E+04	4.28E+04	4.20E+04	1.70E+04	298
4.28E+04	4.42E+04	4.35E+04	2.07E+04	305
4.42E+04	4.58E+04	4.50E+04	1.39E+04	277
4.58E+04	4.72E+04	4.65E+04	1.35E+04	226
4.72E+04	4.88E+04	4.80E+04	1.61E+04	214
4.88E+04	5.02E+04	4.94E+04	1.61E+04	181
5.02E+04	5.18E+04	5.10E+04	2.37E+04	162
5.18E+04	5.32E+04	5.25E+04	2.63E+04	190
5.32E+04	5.48E+04	5.40E+04	2.86E+04	258

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM
CALCULATIONS FROM UNCERT'S VARIO MODULE

5.48E+04	5.62E+04	5.55E+04	2.23E+04	247
5.62E+04	5.78E+04	5.70E+04	2.47E+04	232
5.78E+04	5.92E+04	5.85E+04	2.82E+04	219
5.92E+04	6.08E+04	6.00E+04	1.98E+04	255
6.08E+04	6.22E+04	6.15E+04	1.76E+04	365
6.22E+04	6.38E+04	6.30E+04	1.50E+04	361
6.38E+04	6.52E+04	6.45E+04	1.49E+04	263
6.52E+04	6.68E+04	6.60E+04	1.40E+04	170
6.68E+04	6.82E+04	6.75E+04	1.76E+04	156
6.82E+04	6.98E+04	6.90E+04	1.50E+04	158
6.98E+04	7.12E+04	7.05E+04	1.70E+04	156
7.12E+04	7.28E+04	7.20E+04	9.31E+03	107
7.28E+04	7.42E+04	7.34E+04	1.68E+04	89
7.42E+04	7.58E+04	7.50E+04	1.83E+04	71
7.58E+04	7.72E+04	7.65E+04	2.02E+04	79
7.72E+04	7.88E+04	7.80E+04	2.49E+04	66
7.88E+04	8.02E+04	7.95E+04	1.33E+04	69
8.02E+04	8.18E+04	8.09E+04	1.63E+04	60
8.18E+04	8.32E+04	8.24E+04	1.02E+04	38
8.32E+04	8.48E+04	8.40E+04	2.57E+04	32
8.48E+04	8.62E+04	8.55E+04	2.14E+04	38
8.62E+04	8.78E+04	8.71E+04	2.11E+04	33
8.78E+04	8.92E+04	8.84E+04	3.20E+04	34
8.92E+04	9.08E+04	9.01E+04	3.94E+04	26
9.08E+04	9.22E+04	9.15E+04	3.33E+04	35
9.22E+04	9.38E+04	9.30E+04	4.41E+04	36
9.38E+04	9.52E+04	9.45E+04	5.52E+04	24
9.52E+04	9.68E+04	9.59E+04	1.12E+05	15
9.68E+04	9.82E+04	9.76E+04	6.24E+04	10
9.82E+04	9.98E+04	9.90E+04	8.31E+04	7
9.98E+04	1.01E+05	1.01E+05	1.01E+05	8
1.01E+05	1.03E+05	1.02E+05	7.91E+04	5
1.03E+05	1.04E+05	1.04E+05	7.73E+04	4
1.04E+05	1.06E+05	1.05E+05	2.42E+04	2
1.06E+05	1.07E+05	1.06E+05	420	1
1.07E+05	1.09E+05	1.08E+05	6.19E+04	2
1.09E+05	1.10E+05	1.09E+05	2.83E+04	1
1.10E+05	1.12E+05	1.11E+05	5.50E+04	5
1.12E+05	1.13E+05	1.12E+05	3.92E+04	2
1.13E+05	1.15E+05	1.14E+05	1.68E+05	1
1.15E+05	1.16E+05	1.15E+05	5.61E+04	1
1.18E+05	1.19E+05	1.18E+05	3.80E+04	3
1.19E+05	1.21E+05	1.20E+05	1.80E+04	1
1.21E+05	1.22E+05	1.21E+05	5.41E+04	1
1.22E+05	1.24E+05	1.22E+05	3.92E+04	1
1.24E+05	1.25E+05	1.24E+05	3.92E+04	1
1.25E+05	1.27E+05	1.26E+05	4.18E+04	1
1.28E+05	1.30E+05	1.29E+05	3.75E+04	1
1.33E+05	1.34E+05	1.33E+05	2.74E+04	1

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM
CALCULATIONS FROM UNCERT'S VARIO MODULE

icowr3: Az = 135 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	468	264	1
750	2.25E+03	1.73E+03	4.67E+03	118
2.25E+03	3.75E+03	3.12E+03	5.94E+03	114
3.75E+03	5.25E+03	4.55E+03	9.78E+03	155
5.25E+03	6.75E+03	6.11E+03	7.93E+03	144
6.75E+03	8.25E+03	7.56E+03	1.44E+04	186
8.25E+03	9.75E+03	9.05E+03	2.59E+04	239
9.75E+03	1.12E+04	1.05E+04	3.25E+04	270
1.12E+04	1.28E+04	1.20E+04	2.98E+04	239
1.28E+04	1.42E+04	1.35E+04	3.03E+04	216
1.42E+04	1.58E+04	1.50E+04	2.81E+04	201
1.58E+04	1.72E+04	1.65E+04	2.05E+04	238
1.72E+04	1.88E+04	1.80E+04	2.08E+04	255
1.88E+04	2.02E+04	1.95E+04	2.19E+04	280
2.02E+04	2.18E+04	2.10E+04	2.26E+04	306
2.18E+04	2.32E+04	2.25E+04	2.72E+04	350
2.32E+04	2.48E+04	2.40E+04	2.87E+04	341
2.48E+04	2.62E+04	2.55E+04	3.10E+04	346
2.62E+04	2.78E+04	2.70E+04	3.34E+04	326
2.78E+04	2.92E+04	2.85E+04	3.62E+04	355
2.92E+04	3.08E+04	3.00E+04	3.10E+04	417
3.08E+04	3.22E+04	3.15E+04	3.44E+04	478
3.22E+04	3.38E+04	3.30E+04	3.10E+04	512
3.38E+04	3.52E+04	3.45E+04	2.94E+04	445
3.52E+04	3.68E+04	3.60E+04	2.94E+04	418
3.68E+04	3.82E+04	3.75E+04	3.14E+04	319
3.82E+04	3.98E+04	3.89E+04	2.93E+04	305
3.98E+04	4.12E+04	4.05E+04	2.62E+04	267
4.12E+04	4.28E+04	4.20E+04	2.93E+04	225
4.28E+04	4.42E+04	4.35E+04	3.29E+04	215
4.42E+04	4.58E+04	4.50E+04	4.28E+04	173
4.58E+04	4.72E+04	4.65E+04	2.31E+04	122
4.72E+04	4.88E+04	4.80E+04	2.49E+04	132
4.88E+04	5.02E+04	4.95E+04	2.13E+04	113
5.02E+04	5.18E+04	5.10E+04	3.34E+04	94
5.18E+04	5.32E+04	5.25E+04	3.97E+04	106
5.32E+04	5.48E+04	5.40E+04	3.11E+04	85
5.48E+04	5.62E+04	5.55E+04	4.03E+04	79
5.62E+04	5.78E+04	5.69E+04	3.22E+04	56
5.78E+04	5.92E+04	5.84E+04	3.37E+04	54
5.92E+04	6.08E+04	6.00E+04	4.27E+04	32
6.08E+04	6.22E+04	6.14E+04	2.31E+04	24
6.22E+04	6.38E+04	6.28E+04	3.23E+04	21
6.38E+04	6.52E+04	6.44E+04	1.76E+04	19
6.52E+04	6.68E+04	6.60E+04	3.66E+04	24
6.68E+04	6.82E+04	6.74E+04	2.26E+04	8
6.82E+04	6.98E+04	6.95E+04	1.86E+04	6

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM
CALCULATIONS FROM UNCERT'S VARIO MODULE

6.98E+04	7.12E+04	7.05E+04	2.08E+04	5
7.12E+04	7.28E+04	7.17E+04	7.73E+03	4
7.28E+04	7.42E+04	7.39E+04	1.23E+04	2
7.42E+04	7.58E+04	7.47E+04	6.79E+03	2
7.58E+04	7.72E+04	7.70E+04	7.20E+03	1
7.72E+04	7.88E+04	7.77E+04	6.96E+03	1
8.18E+04	8.32E+04	8.28E+04	2.14E+04	1
8.32E+04	8.48E+04	8.34E+04	6.73E+03	1
8.62E+04	8.78E+04	8.69E+04	2.24E+04	2
9.08E+04	9.22E+04	9.15E+04	1.03E+04	2
9.22E+04	9.38E+04	9.30E+04	1.50E+04	1
9.38E+04	9.52E+04	9.39E+04	2.31E+03	1
9.68E+04	9.82E+04	9.75E+04	1.25E+04	1
icowr3: Az = 160 deg				
MIN. LAG	MAX. LAG	AVG SPACE	GAMMA H	# PAIRS
0	750	739	420	1
750	2.25E+03	1.50E+03	2.66E+03	54
2.25E+03	3.75E+03	2.95E+03	9.60E+03	161
3.75E+03	5.25E+03	4.42E+03	1.48E+04	184
5.25E+03	6.75E+03	5.92E+03	1.46E+04	216
6.75E+03	8.25E+03	7.50E+03	1.69E+04	221
8.25E+03	9.75E+03	9.05E+03	1.59E+04	235
9.75E+03	1.12E+04	1.06E+04	2.03E+04	242
1.12E+04	1.28E+04	1.20E+04	2.61E+04	254
1.28E+04	1.42E+04	1.35E+04	3.13E+04	272
1.42E+04	1.58E+04	1.49E+04	3.50E+04	262
1.58E+04	1.72E+04	1.64E+04	3.99E+04	242
1.72E+04	1.88E+04	1.80E+04	3.59E+04	229
1.88E+04	2.02E+04	1.95E+04	3.80E+04	250
2.02E+04	2.18E+04	2.10E+04	3.60E+04	224
2.18E+04	2.32E+04	2.25E+04	3.41E+04	236
2.32E+04	2.48E+04	2.40E+04	3.09E+04	255
2.48E+04	2.62E+04	2.55E+04	3.11E+04	258
2.62E+04	2.78E+04	2.70E+04	3.43E+04	281
2.78E+04	2.92E+04	2.85E+04	3.38E+04	268
2.92E+04	3.08E+04	3.00E+04	3.67E+04	255
3.08E+04	3.22E+04	3.15E+04	4.02E+04	237
3.22E+04	3.38E+04	3.30E+04	3.84E+04	194
3.38E+04	3.52E+04	3.45E+04	3.89E+04	194
3.52E+04	3.68E+04	3.60E+04	3.31E+04	203
3.68E+04	3.82E+04	3.75E+04	3.56E+04	177
3.82E+04	3.98E+04	3.90E+04	3.47E+04	195
3.98E+04	4.12E+04	4.05E+04	4.01E+04	164
4.12E+04	4.28E+04	4.20E+04	3.90E+04	146
4.28E+04	4.42E+04	4.35E+04	4.17E+04	110
4.42E+04	4.58E+04	4.49E+04	4.98E+04	86
4.58E+04	4.72E+04	4.65E+04	7.31E+04	67
4.72E+04	4.88E+04	4.80E+04	6.04E+04	57
4.88E+04	5.02E+04	4.95E+04	4.74E+04	50

TABLE II-A

COWDEN ISOPACH SAMPLE SEMI-VARIOGRAM CALCULATIONS FROM UNCERT'S VARIO MODULE

5.02E+04	5.18E+04	5.10E+04	6.67E+04	40
5.18E+04	5.32E+04	5.24E+04	4.42E+04	27
5.32E+04	5.48E+04	5.42E+04	3.64E+04	15
5.48E+04	5.62E+04	5.53E+04	3.55E+04	16
5.62E+04	5.78E+04	5.72E+04	2.30E+04	9
5.78E+04	5.92E+04	5.87E+04	1.29E+04	3
5.92E+04	6.08E+04	5.95E+04	2.53E+04	1
6.08E+04	6.22E+04	6.18E+04	213	2
6.38E+04	6.52E+04	6.46E+04	2.31E+04	9
6.52E+04	6.68E+04	6.61E+04	1.20E+04	2
6.68E+04	6.82E+04	6.74E+04	1.84E+04	2
6.82E+04	6.98E+04	6.84E+04	7.32E+03	1