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REPORTS

DATE:

10/30/1980

Report on the Paul Hamilton Water Contamination Observation Wells

Thomas A. Parkhill
Oil Conservation Division
October 30, 1980

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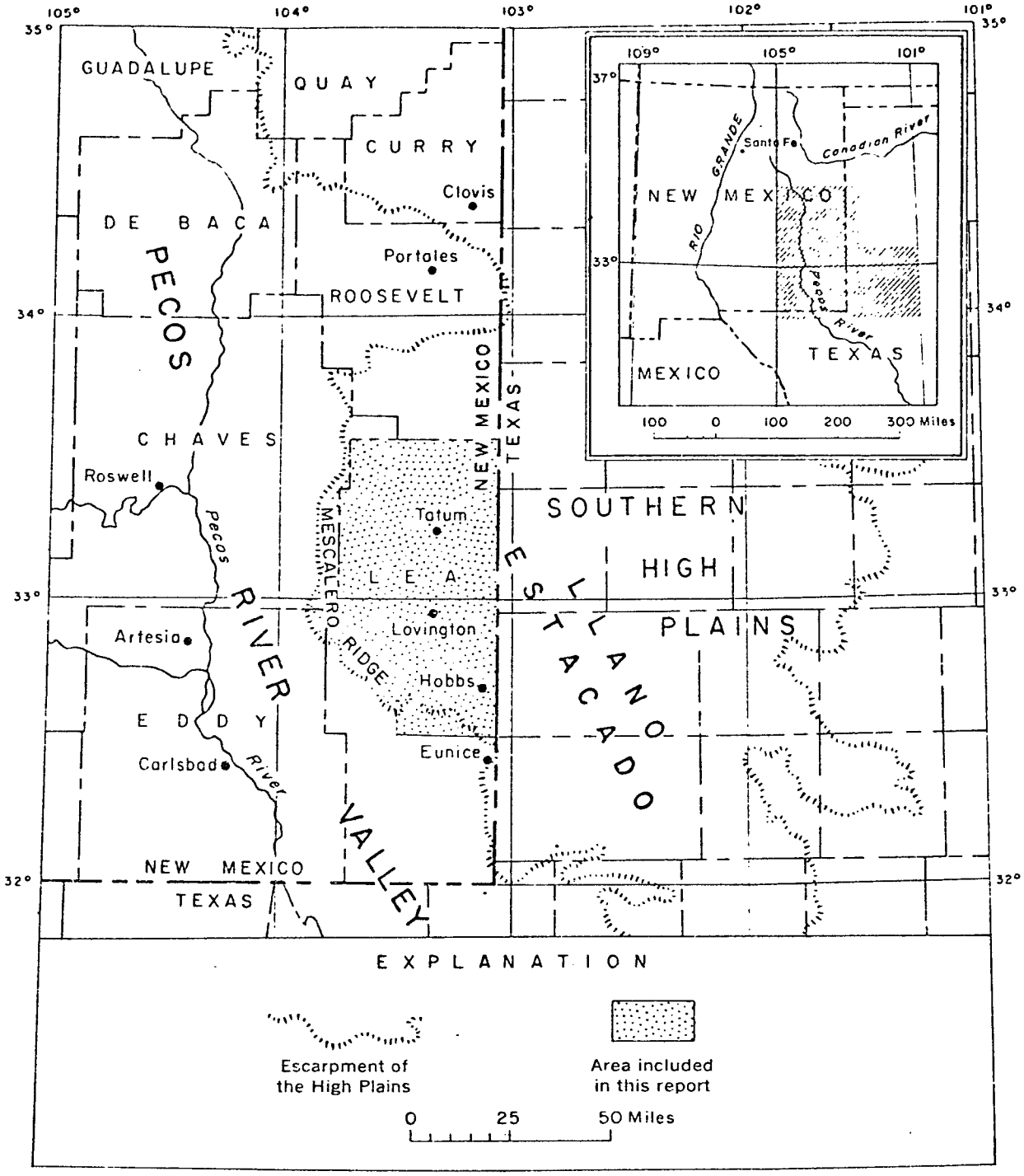
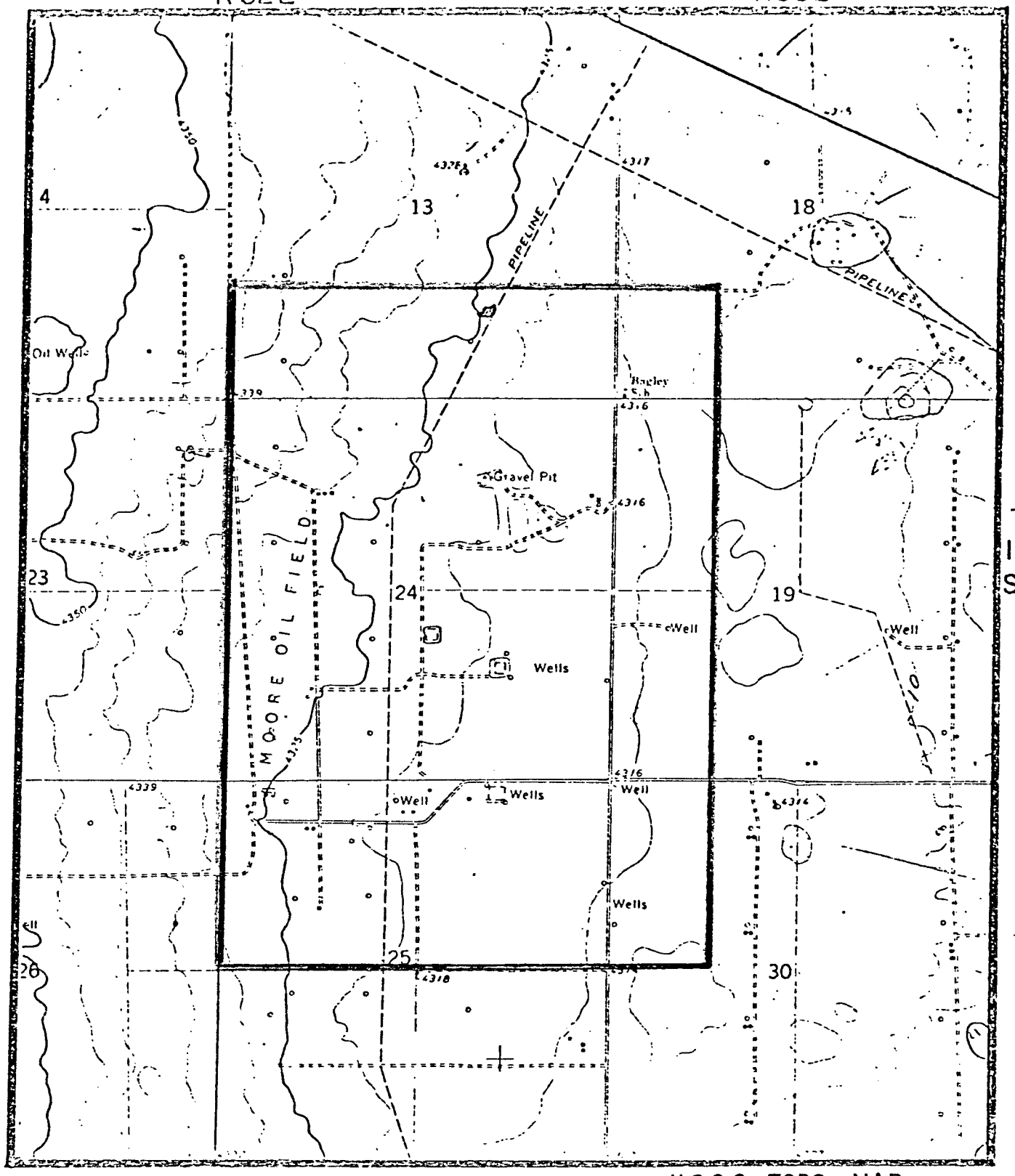


FIGURE 1.—INDEX MAP SHOWING THE LOCATION OF THE NORTHERN LEA COUNTY AREA AND ITS RELATION TO THE HIGH PLAINS AND THE PECOS RIVER VALLEY

Modified from Ash, 1963



PAUL HAMILTON WATER
CONTAMINATION STUDY

U.S.G.S TOPO. MAP
Soldier Hill - 7½'

Figure 2

= Area of study.

INTRODUCTION

Three observation wells were drilled during September 9, 1980 through September 12, 1980 to supplement data collected during previous studies of the area by John Runyan, Oil Conservation Division, Hobbs office. All of the holes were drilled in Section 24, Township 11 South, Range 32 East, northern Lea County, New Mexico.

Water quality data obtained from this study will be used by Paul Hamilton in his future litigation against Texaco over alleged ground water contamination caused by a leaking salt water disposal well.

PHYSIOGRAPHY

The topography of this area is dominated by the Llano Estacado, which is the southern extension of the high plains in southeastern New Mexico (Figure 1). It is a plateau which stands about 100 to 300 feet above the surrounding area. In general, the Llano Estacado surface is smooth and slopes toward the southeast at 10 to 20 feet per mile.

The most characteristic features of the Llano Estacado are undrained depressions or playas ranging from a few feet to 50 feet or more and from a few hundred feet to a mile or more in diameter. Most of the depressions form temporary ponds or lakes only during the summer rainy season. Some of the larger depressions contain perennial lakes of "alkali" or "saline water."

The Llano Estacado's stream drainage is poorly developed. Stream dissection is very shallow with almost no development of tributaries. The long shallow valleys follow the slope of the land surface at widely spaced intervals.

GEOLOGY

The surface geology of the study area is dominated by sediments of Quaternary, Tertiary and Triassic age which relate directly to useable ground water. The subsurface geology of the area includes rocks which range from Precambrian to Permian in age. They are not significant to useable ground water, but they are the source of the highly mineralized water produced with oil. Rocks of these ages will not be described here.

Table 1. Stratigraphic Units in and around T11S, R32E

	Geologic Age	Geologic Unit	Thickness (ft.)	General Character	Water-Bearing Properties
Cenozoic Quaternary	Recent and Pleistocene	Alluvium	0-30 ±	Sand and gravel; may include redeposited material from Ogallala formation and Cretaceous and Triassic rocks	Above the zone of saturation, hence does not yield water to wells. Aids recharge to underlying formations by permitting rapid infiltration of rain water.
		Ogallala formation	0-350 ±	Irregularly bedded sand, grit, and local gravel conglomerate cemented by lime or caliche, and local beds of sand, clay and limestone; may include some redeposited material from Cretaceous and Triassic rocks.	Major water-bearing formation of the area. Well yields varied widely throughout area.
Mesozoic Triassic		Dockum group, undivided	1400-2100 ±	Maroon, red, and gray irregularly bedded sandstone, bright- and dark-red shale and sandy shale and purplish limestone pebble beds.	The rocks of Triassic age contain some water but they are not considered productive aquifer.
Paleozoic Ordovician through Permian			11,000-14,000 ±	Thick deposits ranging from evaporites, limestone, dolomites, shale and sandstones.	No presently useable water supply available from these rocks. Source of highly mineralized oil-field waters.
Precambrian				Granite and volcanic rocks	Not hydrologically significant.

Modified from Ash, 1963

Triassic age rocks of the Dockum group unconformably overlie rocks of Permian age and range in thickness from 1,400 to 2,100 feet in northern Lea County. The Dockum group can be divided into the Santa Rosa sandstone and the Chinle formation, but the distinction is not made in this area because of lithologic similarities and poor exposures. The group's lower section has a maximum thickness of 600 feet and consists mostly of a reddish sandstone but also includes minor amounts of variegated shale and limestone. The upper part of the group can have a thickness up to 1,200 feet. This section is predominately a reddish shale but does contain minor amounts of variegated shale, sandstone, conglomerate and limestone. The Dockum group is exposed in SW/4 of Section 3, Township 11 South, Range 31 East.

Tertiary age rocks of the Ogallala formation have been deposited directly on the Triassic Dockum group erosion surface. In northern Lea County, the Ogallala ranges in thickness from 0 to about 350 feet, with an average of 200 feet.

The Ogallala formation consists of clay, silt, fine to coarse grained sand, gravel and caliche. The lithology changes rapidly within short distances, both horizontally and vertically, and individual beds or lenses are not continuous over wide areas.

Most of the Ogallala is unconsolidated, except for near the top and locally within the formation where the sediments have been cemented, chiefly with calcium carbonate, to form beds of caliche. The degree of cementation of caliche varies greatly from partially cemented to well cemented. No sharp break exists between the caliche caprock and the underlying sediments because the amount of cementation decreases gradually with depth. A bed of caliche on top of a formation will form a prominent topographic high because of its resistance to erosion.

Pleistocene and Recent age sediments composed of sand, soil and alluvium unconformably overlie the Ogallala formation on the Llano Estacado. The thickness of sediments ranges from 0 to about 30 feet. The sediments are off-white to light brown in color.

GROUND WATER RESOURCES

All useable ground water in this study area comes from two (2) principal geologic units, the Dockum group and Ogallala formation. No potable water is found below the Permian-Triassic unconformity.

The Ogallala formation of Tertiary age and the alluvium, soil, and sand of Pleistocene and Recent ages form a single hydrologic unit and in this report their hydrologic characteristics will be discussed together.

The water wells of the Tertiary deposits are generally of a better chemical quality than that from Triassic age deposits. The younger rocks are more permeable, therefore producing wells with better yields.

The amount of water pumped (well yield) in gallons per minute varies widely throughout the area. Well yields differ greatly within relatively short distances and this may be due to formation differences or differences in well construction.

In this area the ground water flows from the Northwest to the Southeast (Runyan, May 25, 1978). The Water Resources Division estimated lateral water movement of 0.8 feet per day x time x distance that contamination had moved (Runyan, May 25, 1978). Unfortunately this figure for water velocity was not confirmed by a tracer study.

HISTORY OF GROUND WATER CONTAMINATION

In August, 1977, Paul Hamilton advised the Oil Conservation Division about an apparent problem at two (2) of his water wells.

Tests were run shortly thereafter on fifteen (15) Moore-Devonian Pool wells to determine if any casing leaks existed. No leaks were discovered.

During November and December of 1977, thirteen (13) test wells were drilled. After a report was written, Texaco decided to drill twenty-one (21) additional test wells. This work was done during the time interval between February and May of 1978. A revised report was completed on this area using the newly obtained information.

Water samples were taken and they were run for chlorides concentrations. This information was used to develop the chloride concentration maps found in John Runyan reports about this area.

PRESENTATION OF DATA

Data assimulation of information obtained from three (3) recently drilled observation holes and the thirty-four (34) holes drilled under John Runyan's supervision would be almost impossible to do. It could even produce misleading conclusions about the nature and severity of the problem.

Water chemistry analysis programs were handled in completely different manners and had different standards of quality control. Putting the two (2) sets of data together could create significant differences which may not exist.

Lithological logs compiled by this author cannot be correlated to the previous project's drillers' logs. Unfortunately, there is no way to resolve this problem because the rock samples were not preserved from previous drilling projects.

With these facts in mind, only information obtained from this study will be presented in this report.

WATER QUALITY OF OBSERVATION WELLS

All water samples from the three (3) observation wells had chemical analyses to determine the amount of Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Bicarbonate (HCO_3), Carbonate (CO_3), Sulfate (SO_4), Chlorite (Cl) and Total Dissolved Solids (TDS). These values have been expressed in milligram per liter (mg/l) or parts per million (ppm). The chemical analyses were done by Albuquerque Analytical, Inc. of Albuquerque, New Mexico.

Two (2) of the three (3) observation wells contained contaminated water. HO-1 was the most highly contaminated with a Total Dissolved Solids (T.D.S.) of 21,288.0 ppm and a Chloride content of 10,220.0 ppm. This well was drilled just southeast of Texaco's Salt Water Disposal (SWD) well. HO-2 was drilled north of Texaco's SWD well and was less contaminated with a T.D.S. of 4648.0 ppm and Chloride content of 2385.0 ppm. HO-3 was drilled west of the Texaco SWD well and was not contaminated. It had a T.D.S. of 556.0 ppm and a Chloride content of 90.2 ppm. See appendix of chemical analysis for other elements.

A water sample was collected from Texaco's SWD well in Section 24, Township 11 South, Range 32 East. The brine water has a T.D.S. of 45,872.0 ppm and a Chloride content of 25,200.0 ppm. The Appendix-chemical analysis has further information on this water.

The chemical properties of the water were plotted on a trilinear diagram (figure 3) to display results of water-chemistry study of this area.

It does appear that there is a strong chemical relationship between Texaco's SWD well and HO-1 and HO-2. (See figure 3.) On the basis of dominant ion classification, it is clear that these wells contain Sodium cation type water and a Chloride anion type water. The brine water appears to have been diluted due to dispersion and mixing with the fresh water of the Ogallala formation.

Hole HO-3 (see figure 3) is fresh water. It would have to be classified as a Sodium cation type water and a no dominant anion type water. This water probably represents a good example of water which is uncontaminated by any brine water.

PROPERTIES

Area of circle indicates concentration in parts per million, thus:

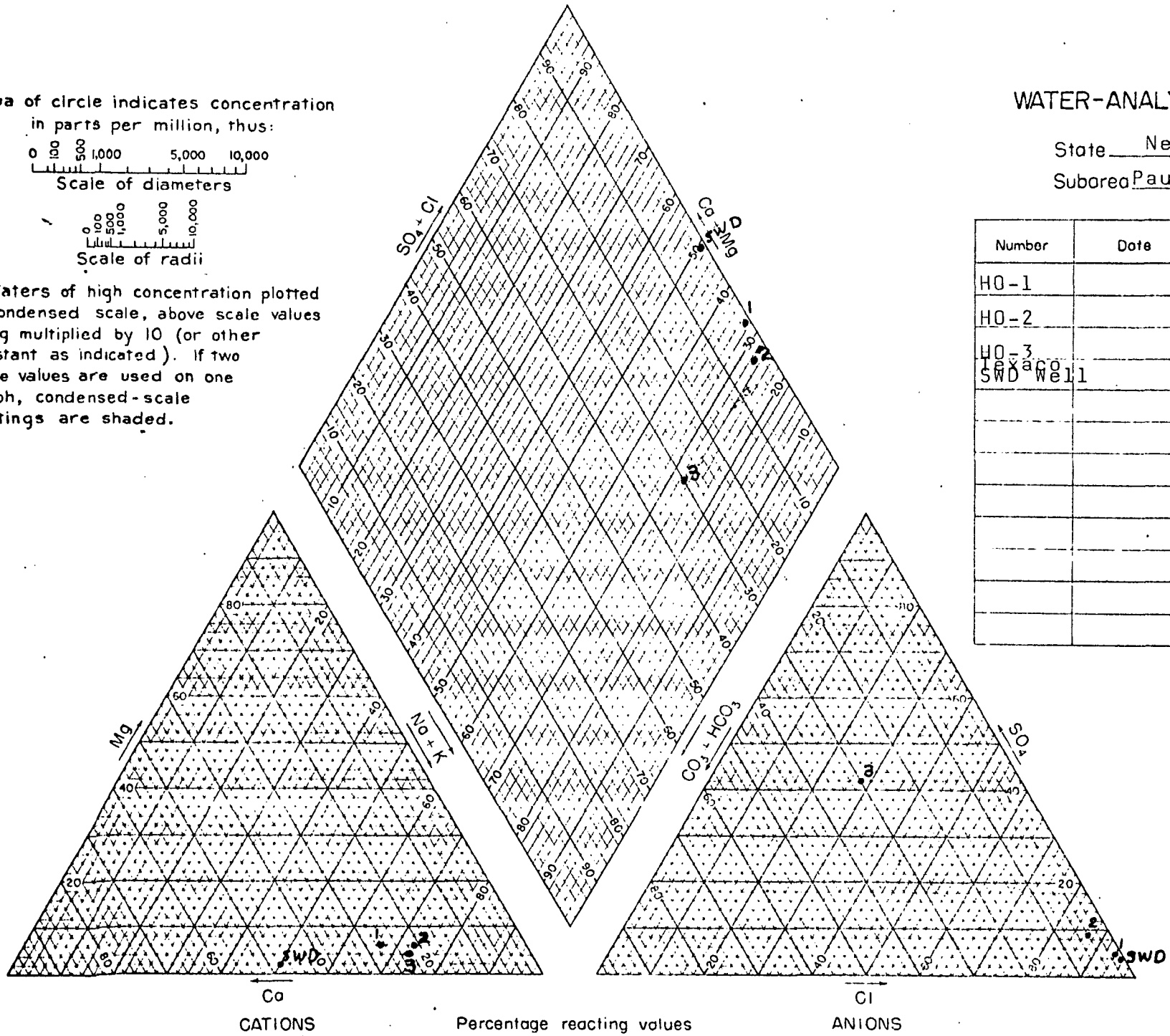
0 100 500 1,000 5,000 10,000

Scale of diameters

0 100 500 1,000 5,000 10,000

Scale of radii

Waters of high concentration plotted at condensed scale, above scale values being multiplied by 10 (or other constant as indicated). If two scale values are used on one graph, condensed-scale plottings are shaded.



WATER-ANALYSIS DIAGRAM

State New Mexico

Subarea Paul Hamilton Area

Number	Date	Parts per million	Depth or perforations
HO-1			
HO-2			
HO-3 Texaco SWD Well			

Plotted by _____

Checked by _____

Date _____

Figure 3.

LITHOLOGY OF THE OBSERVATION HOLES

The holes were drilled through the Tertiary age Ogallala formation. The top twenty (20) to twenty-five (25) feet of the hole consisted of a hard yellowish-white caliche. A well cemented, very fine sand, seventy-five (75) to eighty (80) feet thick, brown, orange or flesh color, lies directly below the caliche cap. The gravels of the lower Ogallala formation were found at 100 feet in all three (3) observation wells. Its thickness ranged from five (5) to ten (10) feet and was composed of a black, white, orange and red color, with a size range from 1/4 to 1/2 inch.

The Triassic Red Beds were penetrated from 105 to 110 feet in this area. It is composed of a brick red or maroon clay with a few thin light green, shaley sand beds. Only the top ten (10) to thirty-five (35) feet of this unit was penetrated during the project.

The total depth of the observation holes ranged from 120 to 140 feet. See sample logs in appendix for more detailed information about the lithology of the observation holes.

WATER LEVEL MEASUREMENTS

The State Engineers Office measured the water level of the wells when the hole locations were surveyed in. The water level in the observation wells from ground level were: HO-1 62.00 feet, HO-2 62.40 feet, and HO-3 60.25 feet.

RECOMMENDATIONS

The observation wells should have water samples taken and a complete chemical analysis run on them once every month. It should be noted that the most representative sample is obtained from the mechanical pumping of the well. The O.C.D. should attempt to obtain water samples by this means in the near future.

A tracer should be used to determine what the actual ground water velocity is in this area.

Further work might include stratigraphic drilling to get an accurate picture of the subsurface geology. This would also present an opportunity to obtain water samples for a complete chemical analysis for the following: Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Bicarbonate (HCO_3), Carbonate (CO_3), Sulfate (SO_4), Chlorite (Cl) and Total Dissolved Solids (T.D.S.). This work was not done during earlier studies.

REFERENCES

Ash, S. R., (1963), Ground-Water Conditions in northern Lea County, New Mexico: U.S. Geol. Survey Hydrol. Inv. Atlas 62, 2 sheets, 5 figs.

Cronin, J. G., (1969), Ground Water in the Ogallala Formation in the southern High Plains of Texas and New Mexico: U.S. Geol. Survey Hydrol. Inv. Atlas 330, 4 p., 4 sheets.

Fetter, C. W., (1980), Applied Hydrogeology: Columbus, Ohio, Charles E. Merrill Publishing Co., 488 p.

Mourant, W. A., (1971), Saturated thickness of post-Mesozic deposits in the central and northern parts of Lea County, New Mexico, January 1962: N. Mex. State Eng. Maps LC 4 and LN 4, 2 sheets.

Nicholson, A., and Clebsch, A., (1961), Geology and Ground-Water conditions in southern Lea County, New Mexico: N. Mex. Bur. of Mines Ground-Water Report 6, 123 p.

Runyan, J. W., (1978), Paul Hamilton water contamination study, Moore Devonian Pool (Caprock, Lea County): N. Mex. Oil Cons. Commission open-file rept., 6 p.

Runyan, J. W., (1978), Paul Hamilton water contamination study, Moore Devonian Pool (Caprock, Lea County), Report II: N. Mex. Oil Cons. Commission open-file rept., 10 p.

Todd, D. K., (1959), Ground-Water Hydrology: New York, J. Wiley and Sons, 336 p.

Appendix A

OBSERVATION WELL FIELD NOTES

OBSERVATION WELL FIELD NOTES

HO-2

September 9, 1980 0 to 120 feet T.D.
Hole completed with 3 inch plastic PVC pipe

7.0 x 142.0 = 994.0 ppm Cl	15 min.	jetting of well
9.1 x 142.0 = 1292.2 ppm CL	30 min.	jetting of well
10.6 x 142.0 = 1505.2 ppm Cl	45 min.	jetting of well
14.2 x 142.0 = 2006.4 ppm Cl	60 min.	jetting of well
3.3 x 710.0 = 2343.0 ppm Cl	90 min.	jetting of well
3.9 x 710.0 = 2769.0 ppm Cl	105 min.	jetting of well

Note: Waters Chloride content would not stabilize.

HO-3

September 9, 1980 0. to 120 feet T.D.
Hole completed with 3 inch plastic PVC pipe

1.5 x 142.0 = 213.0 ppm Cl	15 min.	jetting of well
0.8 x 142.0 = 113.6 ppm Cl	30 min.	jetting of well

HO-1

September 12, 1980 0 to 140 feet T.D.
Hole completed with 3 inch plastic PVC pipe

7.9 x 710.0 = 5,609.0 ppm Cl	15 min.	jetting of well
12.0 x 710.0 = 8,520.0 ppm Cl	30 min.	jetting of well
13.5 x 710.0 = 9,585.0 ppm Cl	45 min.	jetting of well
14.5 x 710.0 = 10,295.0 ppm Cl	60 min.	jetting of well

Note: Very low yield aquifer because of small amount of gravel present in hole.

Appendix B

WATER ANALYSES

[505] 266-9106
[505] 294-6310 Nights

Albuquerque Analytical, Inc.

4115 Silver S.E.
Albuquerque, N.M. 87108

No. 12686

Rec'd. September 19, 1980

WATER ANALYSIS

Owner Oil Conservation Address P.O. Box 2088 Santa Fe, NM 87501

Appearance and Data HO-1 Chemist J.M. Grover, M.S.

	mg/l	meq/l
Aluminum		
Ammonium		
Arsenic		
Barium		
Cadmium		
Calcium	1976.0	
Chromium ($CrO_3^=$)		
Cobalt		
Copper		
Gold		
Iron		
Lead		
Lithium		
Magnesium	269.7	
Manganese		
Mercury I		
Nickel		
Potassium	29.0	
Silver		
Sodium	5714.0	
Uranium (U_3O_8)		
Zinc		

	mg/l	meq/l
Beryllium ($BeO_3^=$)		
Bicarbonate	208.0	
Boron (BO_2^-)		
Bromide		
Carbonate	<0.1	
Chloride	10220.0	
Cyanide		
Fluoride		
Hydroxide		
Iodide		
Molybdenum ($MoO_4^=$)		
Nitrate		
Nitrite		
Phosphate (Tot.)		
Phosphate (Meta)		
Phosphate (Ortho)		
Selenium ($SeO_4^=$)		
Sulfate	700.0	
Sulfite		
Tellurium ($TeO_3^=$)		
Vanadium		

Acidity		ppm
Alkalinity		ppm
BOD		ppm
Chlorine		ppm
COD		ppm
Color		PCU
Conductance		μho/cm
Dissolved O_2		ppm
Hardness		ppm
H_2S		ppm
Hydrazine		ppm
Odor		T.O.
pH		
Phenols		ppm
Silica		ppm
Solids (Tot.)		ppm
Solids (Tot. Diss.)	21,288.0	ppm
Solids (Tot. Susp.)		ppm
Solids ( )		ppm
Surfactant		ppm
Turbidity		JTU
Volatile Acids		ppm

Albuquerque Analytical, Inc.

[505] 266-9106
[505] 294-6310 Nights

4115 Silver S.E.
Albuquerque, N.M. 87108

No. 12686

Rec'd. September 19, 1980

WATER ANALYSIS

Owner Oil Conservation Address P.O. Box 2088 Santa Fe, NM 87501

Appearance and Data HO-2 Chemist J.M. Grover, M.S.

	mg/l	meq/l		mg/l	meq/l		
Aluminum			Beryllium (BeO_3^-)			Acidity	ppm
Ammonium			Bicarbonate	190.0		Alkalinity	ppm
Arsenic			Boron (BO_2^-)			BOD	ppm
Barium			Bromide			Chlorine	ppm
Cadmium			Carbonate	<0.1		COD	ppm
Calcium	340.0		Chloride	2385.0		Color	PCU
Chromium (CrO_3^-)			Cyanide			Conductance	μmho/cm
Cobalt			Fluoride			Dissolved O_2	ppm
Copper			Hydroxide			Hardness	ppm
Gold			Iodide			H_2S	ppm
Iron			Molybdenum (MoO_4^-)			Hydrazine	ppm
Lead			Nitrate			Odor	T.O.
Lithium			Nitrite			pH	
Magnesium	60.25		Phosphate (Tot.)			Phenols	ppm
Manganese			Phosphate (Meta)			Silica	ppm
Mercury T			Phosphate (Ortho)			Solids (Tot.)	ppm
Nickel			Selenium (SeO_4^-)			Solids (Tot. Diss.)	4648.0 ppm
Potassium	6.4		Sulfate	345.0		Solids (Tot. Susp.)	ppm
Silver			Sulfite			Solids ( )	ppm
Sodium	1347.5		Tellurium (TeO_3^-)			Surfactant	ppm
Uranium (U_3O_8)			Vanadium			Turbidity	JTU
Zinc						Volatile Acids	ppm

[505] 266-9106
[505] 294-6310 Nights

Albuquerque Analytical, Inc.

4115 Silver S.E.
Albuquerque, N.M. 87108

No. 12686

Rec'd. September 19, 1980

WATER ANALYSIS

Owner Oil Conservation Address P.O. Box 2088 Santa Fe, NM 87501

Appearance and Data HO-3 Chemist J.M. Grover, M.S.

	mg/l	meq/l		mg/l	meq/l		
Aluminum			Beryllium (BeO_3^-)			Acidity	ppm
Ammonium			Bicarbonate	168.0		Alkalinity	ppm
Arsenic			Boron (BO_2^-)			BOD	ppm
Barium			Bromide			Chlorine	ppm
Cadmium			Carbonate	<0.1		COD	ppm
Calcium	44.4		Chloride	90.2		Color	PCU
Chromium (CrO_3^-)			Cyanide			Conductance	μmho/cm
Cobalt			Fluoride			Dissolved O_2	ppm
Copper			Hydroxide			Hardness	ppm
Gold			Iodide			H_2S	ppm
Iron			Molybdenum (MoO_4^-)			Hydrazine	ppm
Lead			Nitrate			Odor	T.O.
Lithium			Nitrite			pH	
Magnesium	6.5		Phosphate (Tot.)			Phenols	ppm
Manganese			Phosphate (Meta)			Silica	ppm
Mercury T			Phosphate (Ortho)			Solids (Tot.)	ppm
Nickel			Selenium (SeO_4^-)			Solids (Tot. Diss.)	556.0 ppm
Potassium	2.1		Sulfate	187.5		Solids (Tot. Susp.)	ppm
Silver			Sulfite			Solids ( )	ppm
Sodium	170.0		Tellurium (TeO_3^-)			Surfactant	ppm
Uranium (U_3O_8)			Vanadium			Turbidity	JTU
Zinc						Volatile Acids	ppm

Albuquerque Analytical, Inc.

[505] 266-9106
[505] 294-6310 Nights

4115 Silver S.E.
Albuquerque, N.M. 87108

No. 12686

Rec'd. September 19, 1980

WATER ANALYSIS

Owner Oil Conservation Address P.O. Box 2088 Santa Fe, NM 87501

Appearance and Data TEXACO SW Dwell Sec 24-T11S R32E Chemist J.M. Grover, M.S.

-17-

	mg/l	meq/l
Aluminum		
Ammonium		
Arsenic		
Barium		
Cadmium		
Calcium	16040.0	
Chromium ($CrO_3^=$)		
Cobalt		
Copper		
Gold		
Iron		
Lead		
Lithium		
Magnesium	312.75	
Manganese		
Mercury T		
Nickel		
Potassium	105.0	
Silver		
Sodium	18750.0	
Uranium (U_3O_8)		
Zinc		

	mg/l	meq/l
Beryllium ($BeO_3^=$)		
Bicarbonate	516.0	
Boron (BO_2^-)		
Bromide		
Carbonate	<0.1	
Chloride	25200.0	
Cyanide		
Fluoride		
Hydroxide		
Iodide		
Molybdenum ($MoO_4^=$)		
Nitrate		
Nitrite		
Phosphate (Tot.)		
Phosphate (Meta)		
Phosphate (Ortho)		
Selenium ($SeO_4^=$)		
Sulfate	1575.0	
Sulfite		
Tellurium ($TeO_3^=$)		
Vanadium		

Acidity		ppm
Alkalinity		ppm
BOD		ppm
Chlorine		ppm
COD		ppm
Color		PCU
Conductance		µmho/cm
Dissolved O_2		ppm
Hardness		ppm
H_2S		ppm
Hydrazine		ppm
Odor		T.O.
pH		
Phenols		ppm
Silica		ppm
Solids (Tot.)		ppm
Solids (Tot. Diss.)	45,872.0	ppm
Solids (Tot. Susp.)		ppm
Solids ( )		ppm
Surfactant		ppm
Turbidity		JTU
Volatile Acids		ppm

Appendix C

LITHOLOGY LOGS

SAMPLE LOG

Hole HO-1 Logged by Thomas A. Parkhill Date Sept. 12, 1980 page 1 of 1

Driller John Scarborough TD 140 ft. Date 9-12-80

Probe None TD Date

Est Mud Wt. Water Hole Size 4 ¾ in. Log Types Collar Elev. 4335.8 ft.

Location 610 FNL 750 FWL Sec. 24 T 11S R 32E

Area Caprock County Lea State N. Mex. Collar Coor. N E

Remarks

Depth	Log	Description
		Caliche - yellowish-white, tr. of vf. qtz. grains, hard
		Sand - orangish-brown, vf. qtz. grains, ang. to subrd., well cemented, tr. of clay matrix
50		Sand - light orange, vf. qtz. grains, ang. to subrd., well cemented, tr. of clay matrix
100		Gravel - black, white, ⅛ to ½ in., subang. to subrd., tr. of clay - mostly sand 100 to 105 ft.
		Clay - brick red, tr. of vf. qtz. grains
		Shaley Sand - light green, vf. to f. qtz. grains, clay matrix ang. to subrd.
		Clay - brick red, tr. of vf. qtz. grains and mica
		Shaley Sand - light green, vf. to f. qtz. grains, ang. to subrd., clay matrix
150		T.D. - 140 ft.
200		

SAMPLE LOG

Hole HO-2 Logged by Thomas A. Parkhill Date Sept. 9, 1980 page 1 of 1

Driller John Scarborough TD 120 ft. Date 9-9-80

Probe None TD Date

Est Mud Wt. Water Hole Size 4¾ in. Log Types Collar Elev. 4337.3 ft

Location 800 FNL 650 FWL Sec. 24 T 11S R 32E

Area Caprock County Lea State N. Mex. Collar Coor. N E

Remarks

Depth	Log	Description
		Caliche - whitish-yellow, tr. of vf. qtz. grains, hard
		Sand - flesh, vf. to f. qtz. grains, ang. to subrd., mod. clay matrix
50		
		Sand - brown, vf. qtz. grains, ang. to subrd., mod. clay matrix
100		
		Gravel - black, white, orange, ⅛ to ½ in., subang. to subrd., 100 to 110 ft.
		Clay - maroon, mod. silt, tr. of mica
		T.D. - 120 ft.
150		
200		

SAMPLE LOG

Hole HO-3 Logged by Thomas A. Parkhill Date Sept. 9, 1980 page 1 of 1

Driller John Scarborough TD 120 ft. Date 9-9-80

Probe None TD Date

Est Mud Wt. Water Hole Size 4¾ in. Log Types Collar Elev. 4337.4 ft.

Location 600 FNL 40 FEL Sec. 24 T 11S R 32E

Area Caprock County Lea State N. Mex. Collar Coor. N E

Remarks

Depth	Log	Description
		Caliche - whitish-pink, tr. of vf. qtz. grains, hard
		Sand - flesh, vf. qtz. grains, ang. to subrd., well cemented, mod. clay matrix
50		
100		Gravel - black, white, red, ¼ to ½ in., subang. to subrd., no matrix 100 to 105 ft.
		Clay - brick red, tr. of vf. qtz. grains
		T.D. - 120 ft.
150		
200		

Hole No HO-3
page 1 of 1

Appendix D

DRILLER'S LOGS

SCARBOROUGH DRILLING
TEST HOLES — WATER WELLS
122 N. 24th St. - Ph. 806-872-3285 or 3125
LAMESA, TEXAS 79331

Ho-2

WELL LOG

From	To	FORMATION
0	2	Top Soil
2	30	Caliche
30	45	Sand & clay Mixed
45	105	Sand & Gravel
105	120	Red Bed
		Drilled 5" Well
		Run 3" PVC Pipe
		Set 2" Jet Pipe
		Jetted Well
		Pull 2" Jet Pipe
		# @4.00 480.00

Date 10-9-80 Driller Scarborough

SCARBOROUGH DRILLING
TEST HOLES — WATER WELLS
122 N. 24th St. - Ph. 806-872-3285 or 3125
LAMESA, TEXAS 79331

Ho-1

WELL LOG

From	To	FORMATION
0	2	Top Soil
2	30	Caliche
20	40	Sandy clay & sand mixed
40	105	Sand
105	140	Red Bed
		Run 3" PVC Pipe
		Run 2" Jet Pipe
		Jetted Well Pull Jet Pipe
		@4.00 #560.00

Date 5-12-80 Driller Scarborough

SCARBOROUGH DRILLING
TEST HOLES — WATER WELLS
122 N. 24th St. - Ph. 806-872-3285 or 3125
LAMESA, TEXAS 79331

Ho-3

WELL LOG

From	To	FORMATION
0	2	top soil
2	30	Caliche
30	40	Sand & clay mixed
40	110	Sand & Gravel
110	120	Red Bed
		Drilled 5" Hole Run 3" PVC Pipe Set 2" Jet Pipe Jetted Well Pull 2" Jet Pipe
		@400 480.00

Date 10-9-80 Driller Scarborough

Appendix E

STATE ENGINEER'S WELL SCHEDULE

FE-1 State of New Mexico
State Engineer

WELL SCHEDULE

Source of data: Obser ☒ Owner ☐ Other _____

Date 9/18 19 80 Record by O'Hare

LOCATION: County Lea Map 95.2.3

OWNER O.C.C. Observation well # HO-1

DRILLER Scarborough Completed 9/17 19 80

TOPO SITUATION _____ SE Elev 4335.8

DEPTH 140 ft ☒ Rept ☐ Meas Use OBS

CASING 3 in to _____ ft Log Driller

PUMP: Type None Make _____

Ser.no./model _____ Size of dischg _____ in.

PRIME MOVER: Make _____ HP _____

Ser.no. _____ Power/Fuel _____

PUMP DRIVE: ☐ Gear Head ☐ Belt Head ☐ Pump Jack

Make _____ Ser.no _____ ☐ VHS

WATER LEVEL: 63.60 ft (rept) (meas) 9/18 19 80 (above) (below) TC

_____

_____ which is 1.60 ft (above) (below) LS

PERMANENT RP is _____

_____

_____

_____

which is _____ ft (above) (below) described MP and _____ ft (above) (below) LS

REMARKS Hole is located 68' NE of Hamilton

APPRAISAL Tag

Well No. ___ on Photo _____ DPN _____

File No L- _____ Loc. No. 11.32.24 112333

Remarks cont. TH #20 and is 96' ENE of the Texaco State BO #3 SWD well. Casing is perforated from 85' to 105'.

SKETCH:

INITIAL WATER-LEVEL MEASUREMENT	DEPTH TO WATER			
	Below MP			Below LS
	1st	2nd	3rd	
Date Sept 18, 1980	80.00			63.60
Hour ____ AM PM Obs KO	16.40			1.60
Not POA (X) POA ( )	63.60			62.00

W L meas after pump shut off ____ min. Pumping W L ( )

Remarks ____

FE-1 State of New Mexico
State Engineer

WELL SCHEDULE

Source of data: Obser ☒ Owner ☐ Other _____

Date 9/18 19 80 Record by O'Hare

LOCATION: County Lea Map 95.2.3

OWNER O.C.C. observation well # HO-2

DRILLER Scarborough Completed 9/9 19 80

TOPO SITUATION _____ SEO Elev 4337.3

DEPTH 120 ft ☒ Rept ☐ Meas Use OBS

CASING PVC 3 in to 120 ft Log Drillers

PUMP: Type None Make _____

Ser.no./model _____ Size of dischg _____ in.

PRIME MOVER: Make _____ HP _____

Ser.no. _____ Power/Fuel _____

PUMP DRIVE: ☐ Gear Head ☐ Belt Head ☐ Pump Jack

Make _____ Ser.no _____ ☐ VHS

WATER LEVEL: 64.08 ft (rept) (meas) 9/18 19 80 (above) (below) TC

_____

_____ which is 1.60 ft (above) below LS

PERMANENT RP is _____

_____

_____

_____

which is _____ ft above below described MP and _____ ft above below LS

REMARKS Well is located 267' north and 8' west

Acoustic: Tog

Well No. ___ on Photo _____ DPN _____

File No L- _____ Loc. No. 11.32.24 1114324

Remarks cont. 31 the Wheat State BO 3 SWD well. Casing is perforated from 85' to 105'.

SKETCH:

N

INITIAL WATER-LEVEL MEASUREMENT	DEPTH TO WATER			
	Below MP			Below LS
	1st	2nd	3rd	
Date Sept 18, 19 80	80.00			64.08
Hour ____ AM PM Obs KO	15.92			1.60
Not POA (X) POA ( )	64.08			62.48

W L meas after pump shut off ____ min. Pumping W L ( )

Remarks ____

ER
Below LS
63.60
1.60
62.00

ng W L ( )

FE-1 State of New Mexico
State Engineer

WELL SCHEDULE

Source of data: Obser ☒ Owner ☐ Other _____

Date 9/18 1980 Record by O'Hare

LOCATION: County Lea Map 45.2.3

OWNER O.C.C. observation well # HO-3

DRILLER Scarborough Completed 9/9 1980

TOPO SITUATION _____ SEO Elev 4337.4

DEPTH 120 ft ☒ Rept ☐ Meas Use OBS

CASING PVC 3½ in to _____ ft Log Driller

PUMP: Type None Make _____

Ser.no./model _____ Size of dischg _____ in.

PRIME MOVER: Make _____ HP _____

Ser.no. _____ Power/Fuel _____

PUMP DRIVE: ☐ Gear Head ☐ Belt Head ☐ Pump Jack

Make _____ Ser.no _____ ☐ VHS

WATER LEVEL: 61.85 ft (rept) (meas) 9/18 1980 (above) (below) TC

_____

_____ which is 1.60 ft (above) (below) LS

PERMANENT RP is _____

_____

_____

_____

which is _____ ft (above) (below) described MP and _____ ft (above) (below) LS

REMARKS HO-3 is located 39' west of the west
T09

Well No. HO-3 on Photo L-4-44-15 DPN _____

File No L- Loc. No. 11.32.24.111333

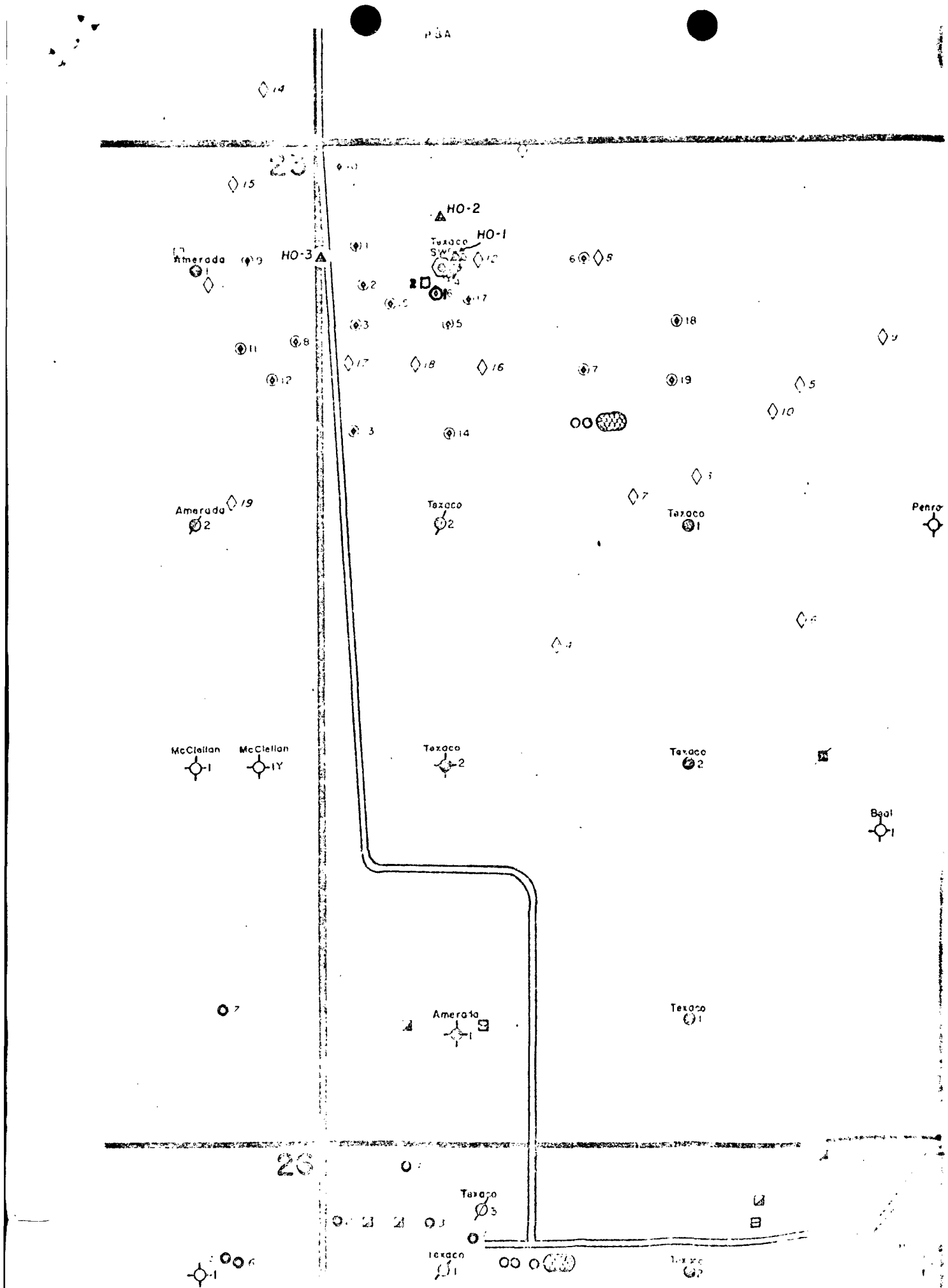
Remarks cont. Edge of road and in 40' east of section line and is 83' NNE of Cattle guard Casing is perforated from 90' to 110'.

SKETCH:

INITIAL WATER-LEVEL MEASUREMENT	DEPTH TO WATER			
	Below MP			Below LS
	1st	2nd	3rd	
Date Sept 18, 1980	80.00			61.85
Hour ____ AM PM Obs KC	18.15			1.60
Not POA (X) POA ( )	61.85			60.25

W L meas after pump shut off ____ min. Pumping W L ( )

Remarks ____

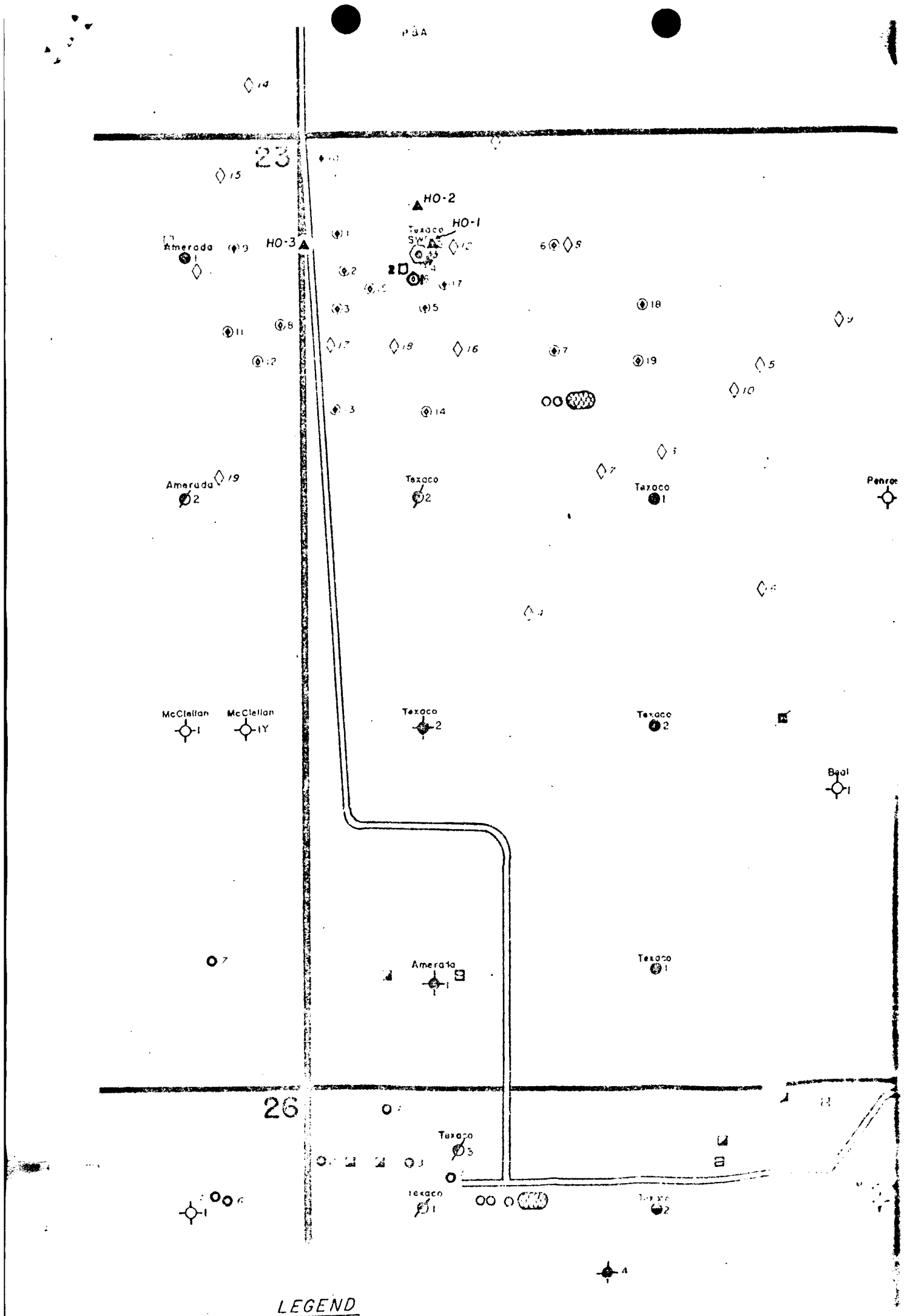


LEGEND

- ◊ Hamilton Test Holes
- ⊛ Texaco Test Holes
- ◘ Moore Test Holes
- ▣ Irrigation Well
- ◪ Domestic and / or Stock Well
- □ O.W.D. Well
- ◉ Salt Water Disposal Well
- ◈ Cased Observation Well
- ▲ O.C.C. Observation Well

PAUL HAMILTON WATER CONTAMINATION STUDY

MOORE DEVONIAN POOL



LEGEND

- ◊ Hamilton Test Holes
- ◉ Texaco Test Holes
- ◉ Moore Test Holes
- ■ Irrigation Well
- ◪ Domestic and / or Stock Well
- □ O.W.D. Well
- ◉ Salt Water Disposal Well
- ♦ Cased Observation Well
- ▲ O.C.C. Observation Well

PAUL HAMILTON WATER CONTAMINATION STUDY

MOORE DEVONIAN POOL