1R - 160

REPORTS

DATE:

9/8/1987

Texaco USA
Producing Department
P O Box 3109
Midland TX 79702

September 8, 1987

Mr. Dave Boyer
New Mexico Oil Conservation Division
P. O. Box 2088
Land Office Building
Santa Fe, New Mexico 87504-2088

Dear Mr. Boyer:

As requested by Mr. M. A. Sirgo, I am sending you one copy each of the December, 1985 and the December, 1986 injection tracer surveys run on the New Mexico "BO" State Well No. 3 in the Moore Devonian Field, Lea County, New Mexico. Please advise if any additional information is needed.

Yours very truly,

Allan W. Dees

SEP 11 1987

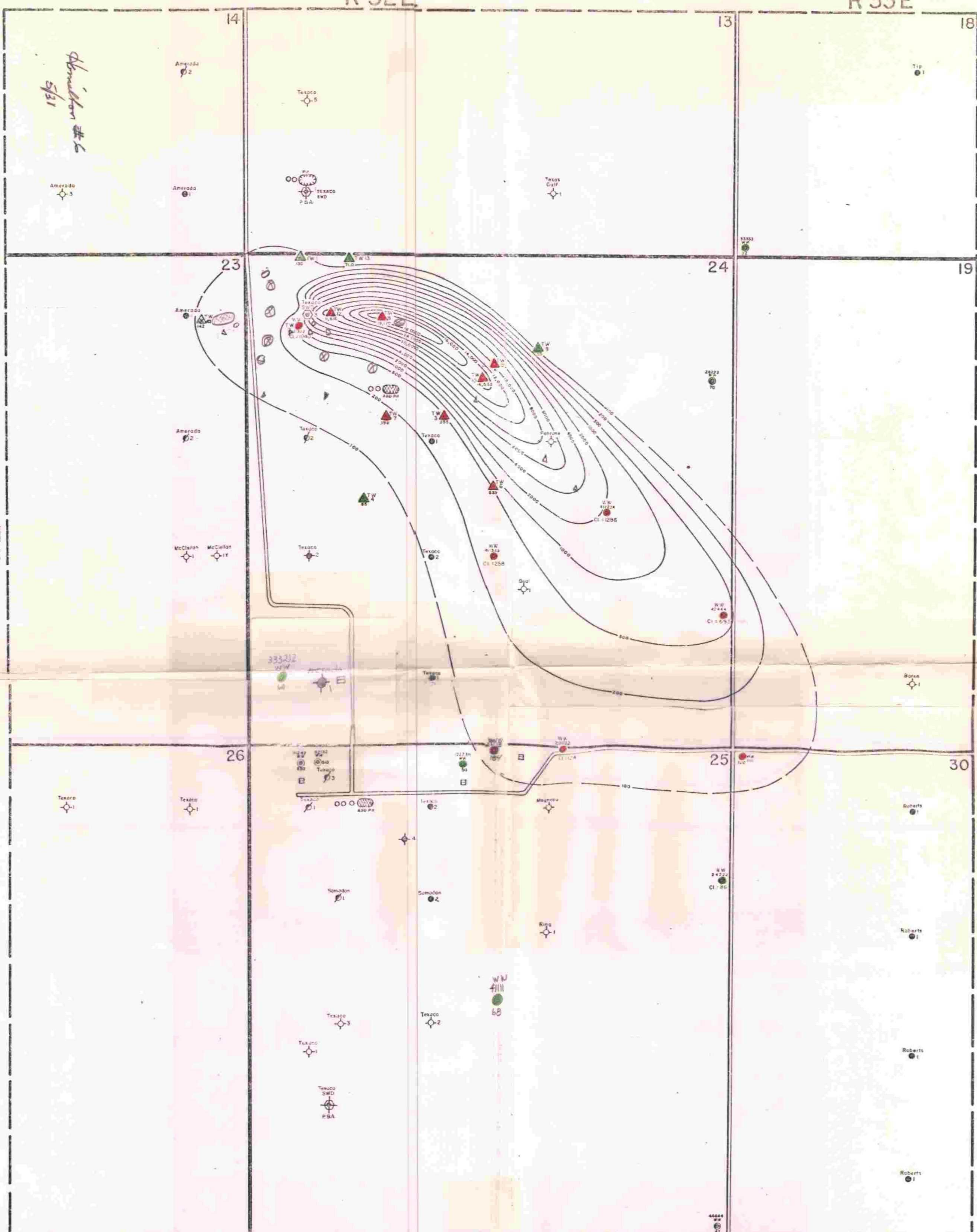
ALLAN W. DEES
Regulatory Compliance Manager

AWD:mg

Attachments

MAS

File
Chrono



PAUL HAMILTON WATER CONTAMINATION STUDY

MOORE DEVONIAN POOL

MAP SCALE: 1 Inch = 500 feet

LEGEND:
- WATER TEST WELL.
- WATER WELL.
- HOUSE.
- OIL WELL.
- TEMP. ABD. OIL WELL.
- P&A OIL WELL.
- SWD WELL.
- P&A SWD WELL.
- OPEN BATTERY PIT.
- ABD. (COVERED) BATT.

CHLORIDE MAP

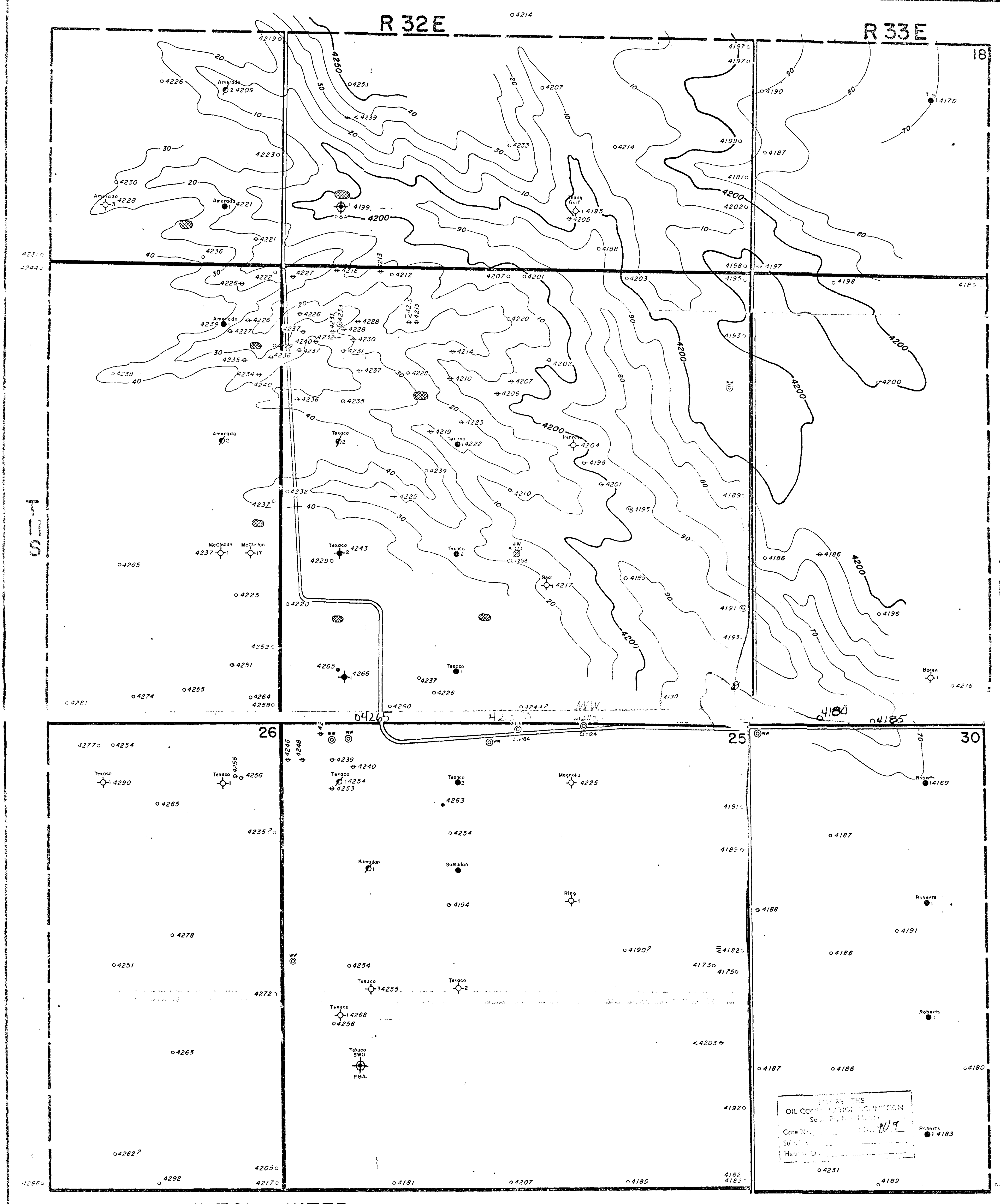
CONTOUR INTERVAL - 2000 PPM*

*Unless otherwise noted.

Hearing Date 5/31

NEW MEXICO OIL CONSERVATION COMMISSION
HOBBS, NEW MEXICO

JOHN W. RUNYAN – Geologist
January 5, 1978

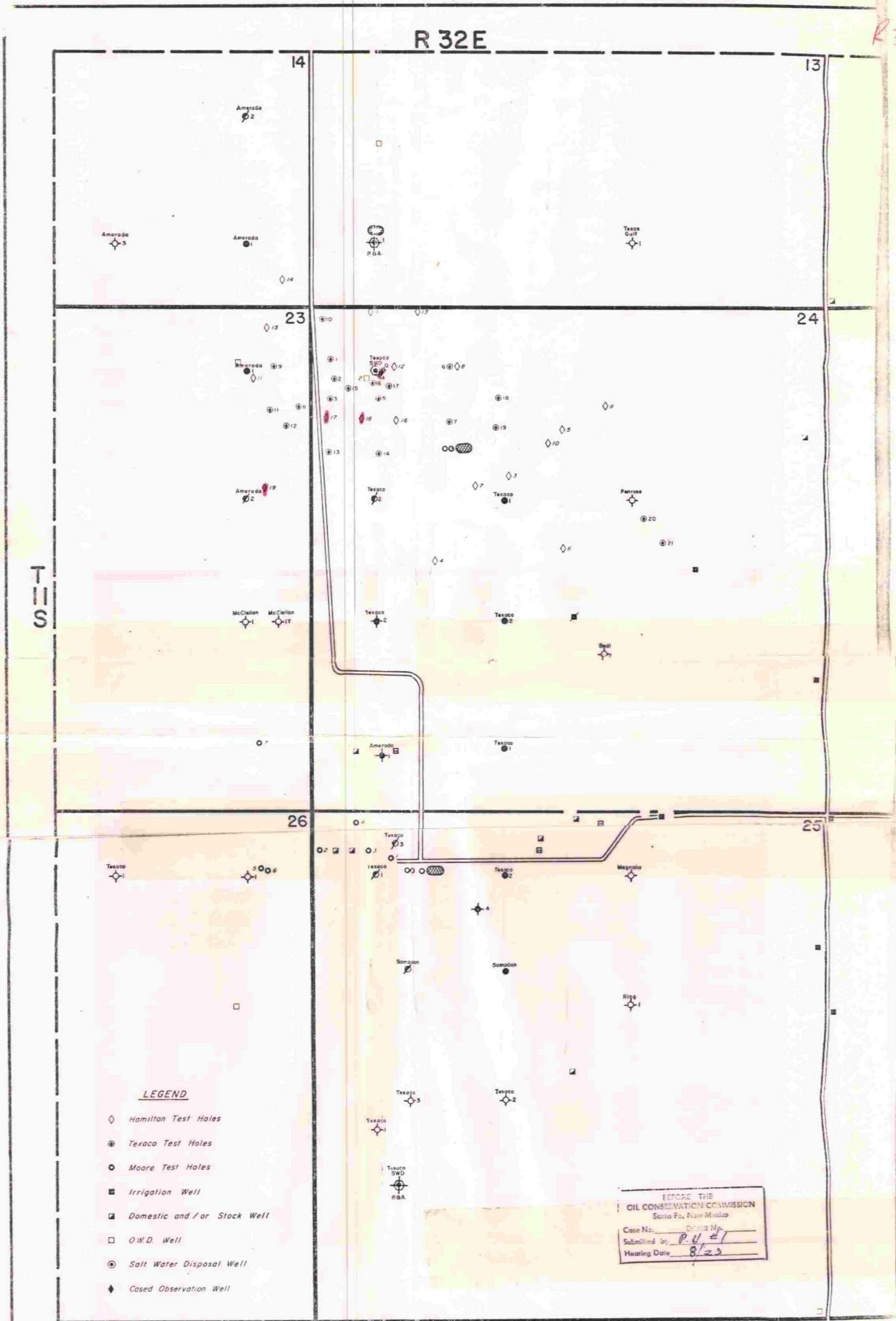


PAUL HAMILTON WATER CONTAMINATION STUDY

MOORE DEVONIAN POOL

ALTITUDE AND CONFIGURATION OF BASE OF POST-MESOZOIC SEDIMENTS IN VICINITY OF SECTION 24, TOWNSHIP 11 SOUTH, RANGE 32 EAST, N.M.P.M.

S. E. Galloway, Engineer, N.M.S.E.O., May 29, 1978



BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
Case No. ____ Exhibit No. ____
Submitted by P.H. #1
Hearing Date 8/23

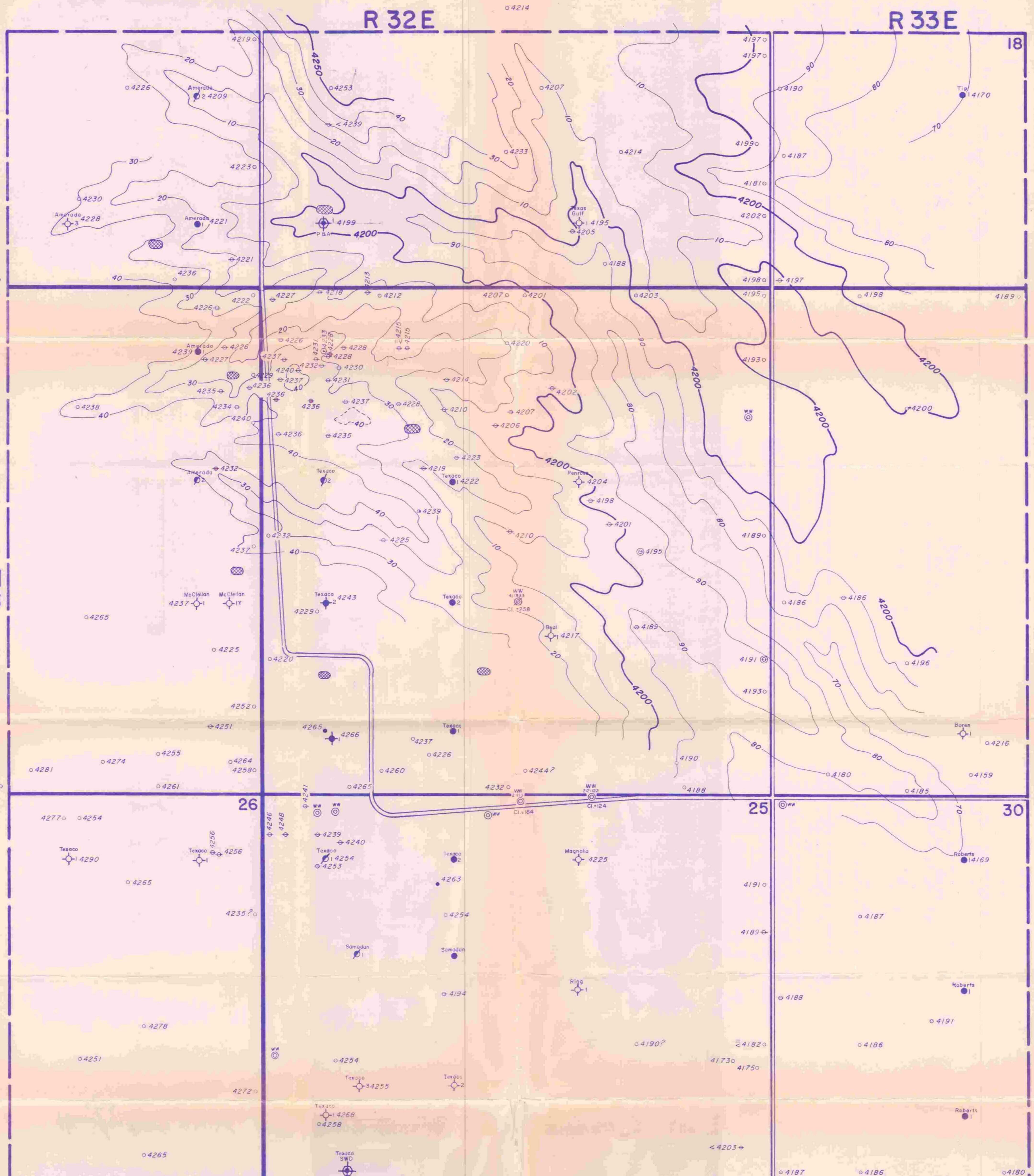
PAUL HAMILTON WATER CONTAMINATION STUDY

MOORE DEVONIAN POOL

Location of Test Holes and Wells
Section 24, Township 11 South, Range

MAP SCALE: 1 Inch = 500 feet

New Mexico State Engineer Office · April 1974



PAUL HAMILTON WATER CONTAMINATION STUDY

MOORE DEVONIAN POOL

ALTITUDE AND CONFIGURATION OF BASE OF POST-MESOZOIC SEDIMENTS IN VICINITY OF SECTION 24, TOWNSHIP 11 SOUTH, RANGE 32 EAST, N.M.P.M.

MAP SCALE: 1 Inch = 500 feet

Date Revised: August 7, 1978

S.E. Galloway, Engineer, N.M.S.E.O., May 29, 1978

BR-71-D


New Mexico State Engineer's Office
40' Below Top Casing
UP
Each Division = 0.05'
Down
12:00 Midnight 8-7-78
12:00 Midnight 8-8-78
12:00 Midnight 8-9-78
12:00 Midnight 8-10-78
12:00 Midnight 8-11-78
12:00 Midnight 8-12-78
12:00 Midnight 8-13-78
12:00 Midnight 8-14-78
12:00 Midnight 8-15-78
12:00 Midnight 8-16-78
12:00 Midnight 8-17-78
12:00 Midnight 8-18-78
12:00 Midnight 8-19-78
12:00 Midnight 8-20-78
Each Division 0.89 Hrs.
Each Division 0.89 Hrs.
Each Division 0.89 Hrs.
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RECORDING CHARTS GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
No. A10
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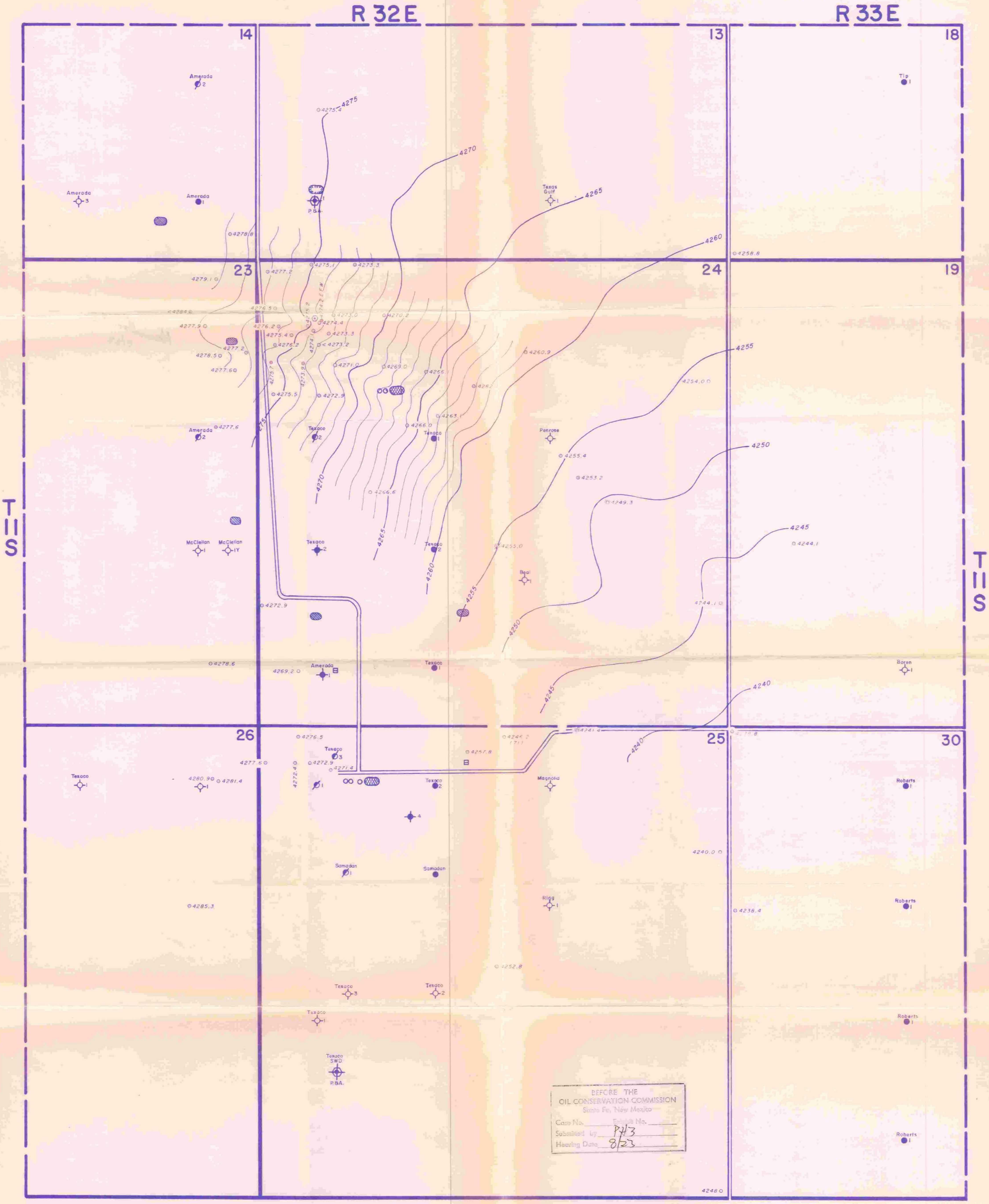

PAUL HAMILTON WATER CONTAMINATION STUDY

MOORE DEVONIAN POOL

ALTITUDE AND CONFIGURATION OF WATER TABLE IN VICINITY OF SECTION 24, TOWNSHIP 11 SOUTH, RANGE 32 EAST, N.M.P.M.

MAP SCALE: 1 inch = 500 feet

S.E. Galloway, Engineer, N.M.S.E.O., May 27, 1978

WT-49-D

ORIGINAL SURVEY | SURVEYED | PLOTTED | TEMPLATE | AREAS | AREAS CHECKED
NOTE BOOK
NO.

FINAL SURVEY | SURVEYED | PLOTTED | TEMPLATE | AREAS | AREAS CHECKED | BY | DATE
NOTE BOOK
NO.

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
Case No. Exhibit No. 4
Submitted by PH
Hearing Date 8/23

Theoretical rise of water table, in feet, resulting from discharge of water into homogeneous aquifer from a point source.

New Mexico State Engineer Office

Date Drawn: August 7, 1978

NM OIL CONSERVATION DEPT

WELL LOG # N.M. State B.O. #3

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NUMBER 43

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1R - 160

REPORTS

DATE:
1984

David G. Boyer

Hydrologic Report 7

New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

Selected papers on water quality and pollution in New Mexico

Proceedings of a Symposium on
Water Quality and Pollution in New Mexico
April 12, 1984, Socorro, NM

Compiled by William J. Stone
New Mexico Bureau of Mines and Mineral Resources

Sponsored by
Water Pollution Control Bureau, New Mexico Environmental Improvement Division
New Mexico Bureau of Mines and Mineral Resources
Geophysical Research Center, Research and Development Division,
New Mexico Institute of Mining and Technology

SOCORRO 1984

OIL-FIELD BRINE CONTAMINATION - A CASE STUDY, LEA CO., NM

Daniel B. Stephens, Associate Professor of Hydrology
Charles P. Spalding, Graduate Student
New Mexico Institute of Mining and Technology
Socorro, New Mexico 87801

ABSTRACT

Salt-water disposal practices in the Moore-Devonian oil field near Caprock, NM produced a plume of contamination approximately one mile long in the Ogallala aquifer near Caprock, NM. Maximum chloride concentrations are nearly 26,000 mg/l. The plume heads in the vicinity of an abandoned brine pit and an operating salt-water disposal well which injects brine underground at a depth of about 10,000 feet. There are also numerous pipelines, operating oil wells, and extensive areas scarred from brine spills. A court of law found that the abandoned pit and the injection well contributed to the contamination problem.

Ground-water monitoring near injection wells is not required by State regulation; however, such observation wells emplaced when injection begins and monitored routinely would provide data necessary to protect fresh water resources. In areas of multiple potential sources of seepage, ground-water monitoring may also protect owners and operators of disposal facilities from liability.

INTRODUCTION

The Ogallala aquifer is the sole source of potable ground water in much of southeastern New Mexico. The Ogallala is composed mostly of unconsolidated sand and gravel, and well yields are high. The availability of such an abundant supply of fresh ground water at shallow depths makes possible large-scale irrigated agriculture. In parts of eastern New Mexico this aquifer is underlain by oil reservoirs. Large quantities of brine are often produced along with oil.

The purpose of this article is to briefly describe a case of contamination of the Ogallala aquifer caused by brine seepage from oil-field activities, and to discuss existing legislation designed to protect aquifers from underground injection. It is not our intent to focus on one possible source of contamination or another, nor do we want any personal bias to be read into our description of the case study; instead we want to use this example to demonstrate that ground-water monitoring could be an effective addition to salt-water disposal practices and regulations. Thus, we have omitted discussion of technical details which, although important, do not pertain directly to the question of ground-water monitoring near salt-water disposal wells.

SITE DESCRIPTION

The study area is located in southeastern New Mexico, about 50 miles east of Roswell, just south of Caprock in northern Lea County. The topography is nearly flat, but slopes very gently eastward. Native vegetation consists mostly of sparse grasses. The mean annual precipitation is about 15 inches (38 cm) (Ash, 1963). The Ogallala Formation underlies the area and is about 100 feet (30 m) thick. The upper 20 feet (6.1 m) contains caliche which appears highly fractured in outcrops. The middle section of the Ogallala consists mostly of sand, and the lower 5 to 20 feet (1.5 to 6.1 m) contains sand with gravel in most parts of the study area. Ground water generally flows to the southeast, but the water table is influenced by irrigation pumping (Figure 1).

The Ogallala Formation was deposited during the Late Tertiary by ancestral streams from mountains to the west. The streams cut channels into underlying shale and claystone of the Triassic Chinle Formation, forming an unconformity with a very irregular surface. The very low permeability of the Chinle, also referred to as "the red beds," makes an excellent hydraulic barrier at the base of the Ogallala. The Chinle Formation is approximately 1600 feet (490 m) thick in this area (Sweeney et al., 1960). Underlying the Chinle is a thick sequence of Paleozoic sedimentary rocks, many of which bear hydrocarbons. Notable among these is a Devonian dolomite approximately 10,000 feet (3000 m) below land surface. Within the study area this oil-bearing formation is called the Moore Devonian Pool.

BRINE CONTAMINATION

In the 1950's, oil wells were drilled at approximately one-quarter mile (400 m) intervals in the Moore Devonian Pool. The proportion of saline water produced with the oil gradually increased with continued development. From about January 1953 to May 1958, approximately 752,000 barrels (119,500 m^3) of produced salt water were disposed into an unlined surface pit (Figure 1) in the northeast corner of section 23 (Runyan 1978a). The State banned the use of pits for saline water disposal in 1969, because of associated wide-spread problems of aquifer contamination. To handle the produced saline water in the Moore Devonian field, an oil well in the southwest part of section 15 (Figure 1) was converted to a salt-water disposal well. From 1966 to 1972 approximately 20 million barrels of salt water were collected from the Moore Devonian field and injected through this well, designated BO-4, back into the Devonian strata (Evelyn Downs, personal communication, N.M. Oil Conservation Div. [NMOCD], 1984). In 1972, it was discovered that the BO-4 injection well was so corroded that a repair of the well was not practical; the well was plugged and abandoned. The oil well one-

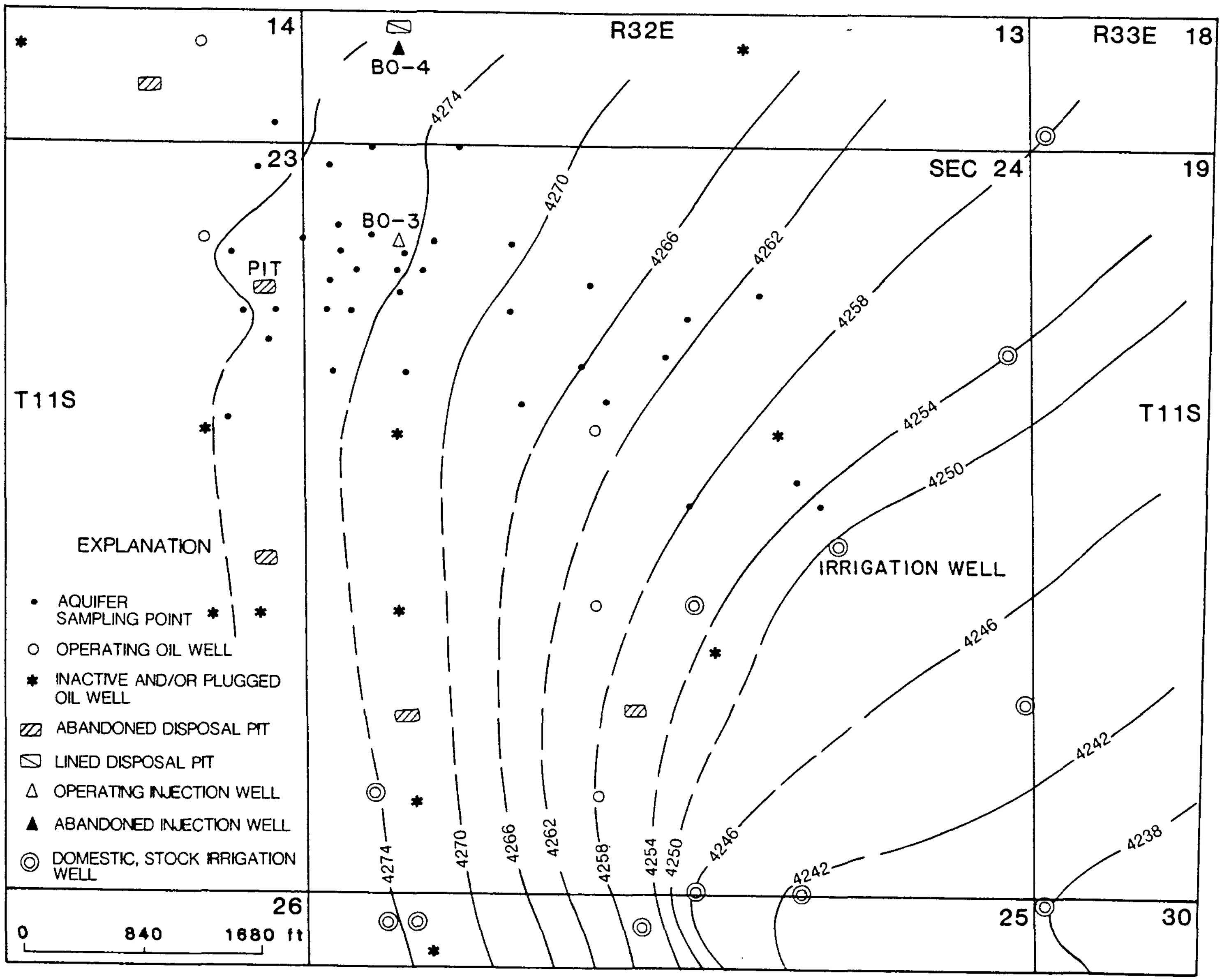

Figure 1. Water table contour map May 27, 1978 and well locations (modified from S.E. Galloway, NM State Engineers Office, Roswell)

quarter mile to the south, BO-3, in the northwestern corner of section 24, was then converted to a salt-water disposal well (Figure 1). Construction details of the converted oil well BO-3 are given in Figure 2; these are essentially the same as BO-4. From October 1972 through July 1977, approximately 20 million barrels of salt water were injected through BO-3 into the Devonian formation at a depth exceeding 10,500 feet (Evelyn Downs, personal communication, NMOCD, 1984).

An irrigation well, completed in 1973, approximately 3900 feet (1190 m) southeast of BO-3 injection well began producing water from the Ogallala with a chloride concentration exceeding 1200 mg/l in July 1977. Crops irrigated from this well were severly damaged and the bank soon foreclosed on the farm property. There was no evidence of crop damage prior to 1977, and it is assumed that ground water quality at this well was near background, which is less than 100 mg/l chloride.

Test drilling and sampling from 1977-1978 (Runyan, 1978a,b) showed that there was a plume of saline water which appeared to originate in the northwest corner of section 24 and the northeast corner of section 23 (Figure 3). The highest concentrations of chloride occurred around the BO-3 injection well and southeast of the abandoned brine disposal pit; in places these concentrations were more than 100 times the recommended drinking water standards. The hydraulic gradients indicated in Figure 1 suggest that the probable source of contamination was either the old pit or the BO-3 injection well. Average ground-water flow velocity is on the order of at least a few hundred feet per year, on the basis of hydraulic conductivity and effective porosity data obtained from an aquifer pumping test near BO-3 (Water Resource Associates, Phoenix, written communication, 1982), irrigation well performance data (NM State Engineer Office, Roswell, NM, open file records), and hydrogeologic reports (Ash, 1963; Haven, 1966; Nicholson and Clebsch, 1961). Assuming a simple solute-transfer model, saline water from the pit which may have entered the Ogallala shortly after 1958, should have travelled well beyond the irrigation well in question by 1977.

A ground-water monitor well completed in 1978, near the base of the Ogallala, 60 feet southeast of BO-3,was sampled and analyzed. Figure 4 shows that in this well, sampled over a two year period, ground water had a chloride concentration which was generally similar to the injection water, except for the obvious peak. Moreover, the chloride concentration in this observation well was relatively unchanged over nearly a three to five year period when compared with data in Figure 3. Unless there was a subsurface barrier inhibiting saline ground-water movement, or a continuous source of saline water introduced to the aquifer, fresh ground water should have displaced much of the contamination from the vicinity of BO-3.

On the other hand, there is also evidence which suggests

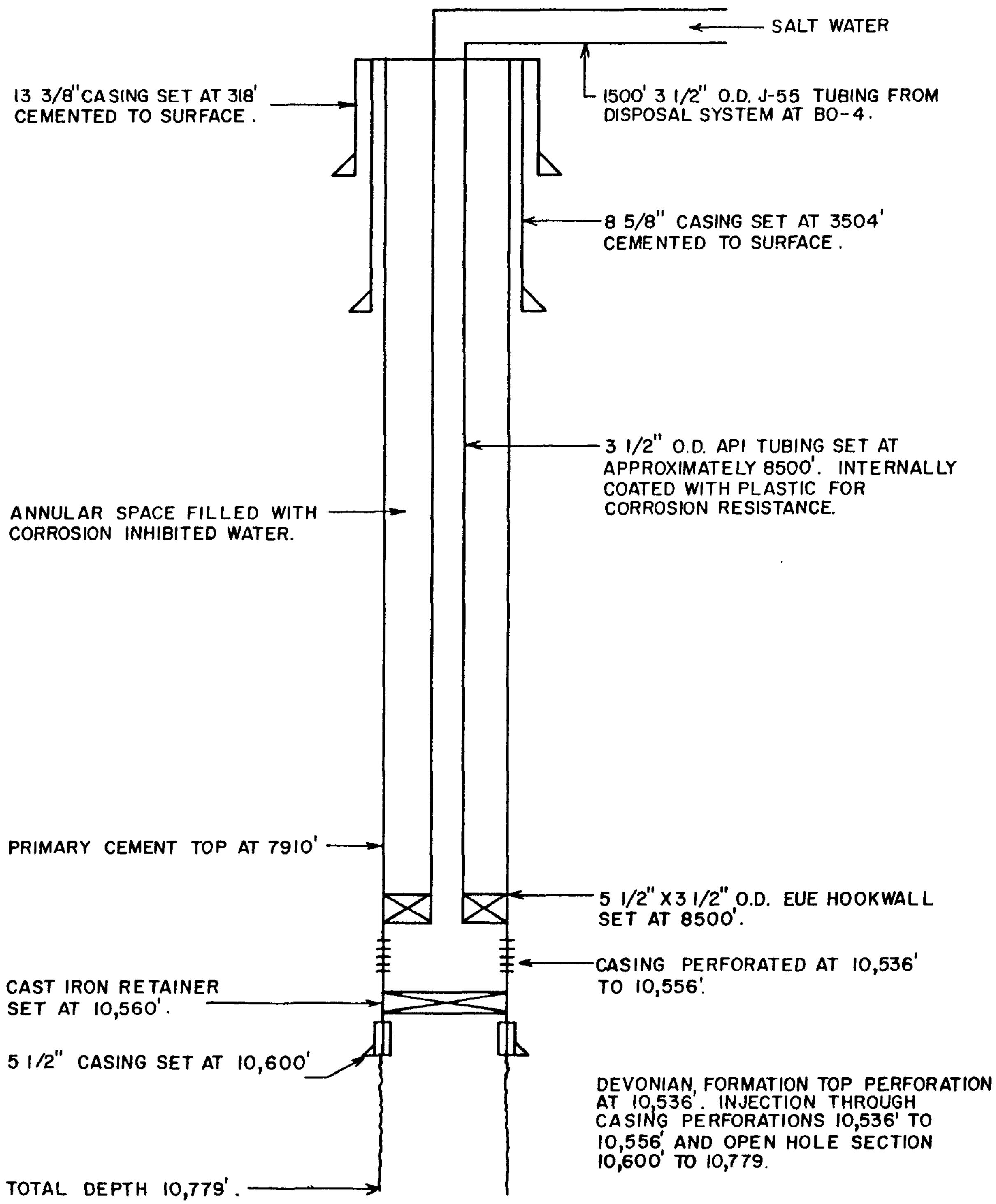

Figure 2. Injection well construction (Modified from Texico, Inc. SWD Well proposal)

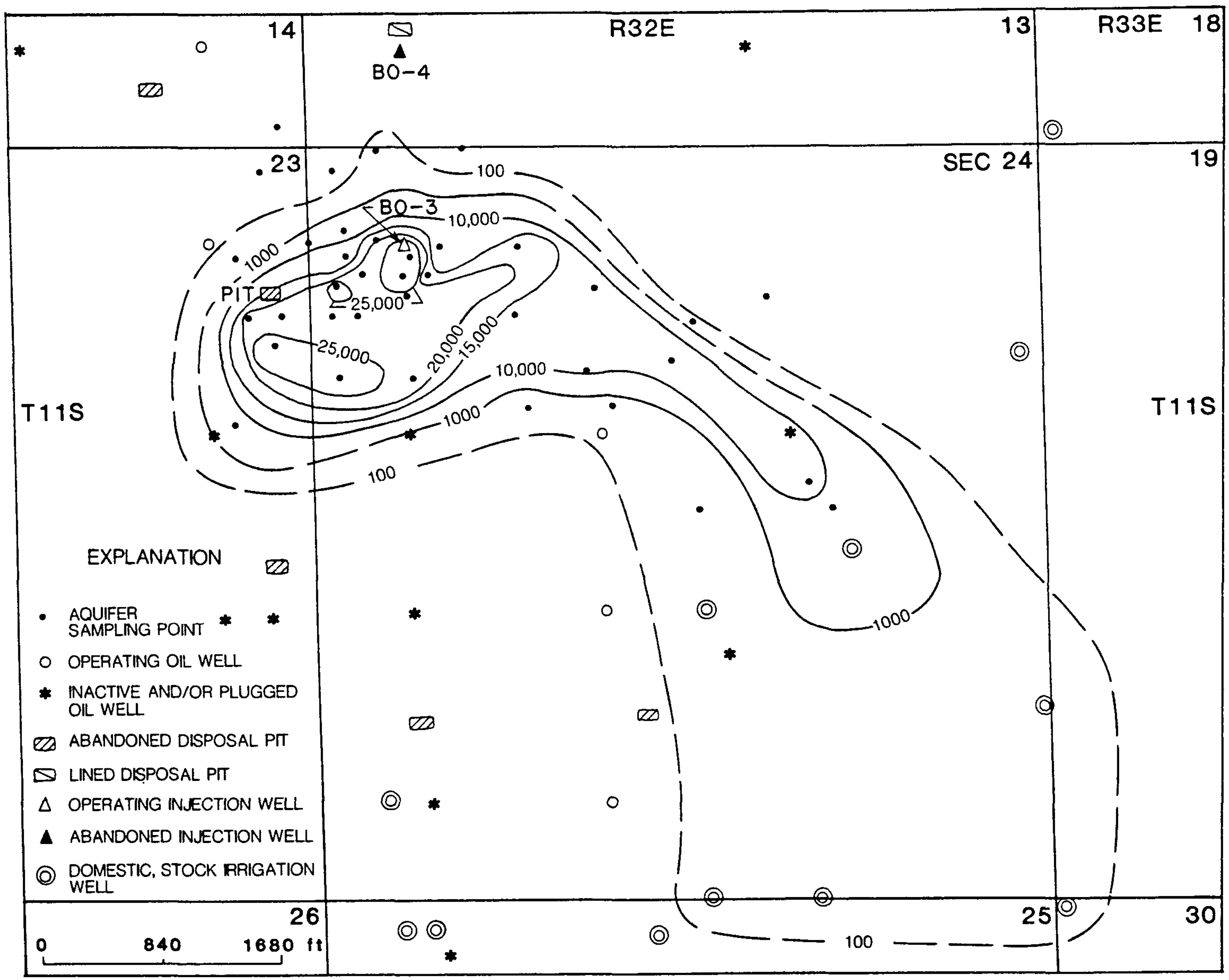

Figure 3. Chloride concentration contour map May 25, 1978 (modified from J. Runyan, NM Oil Conservation Division)

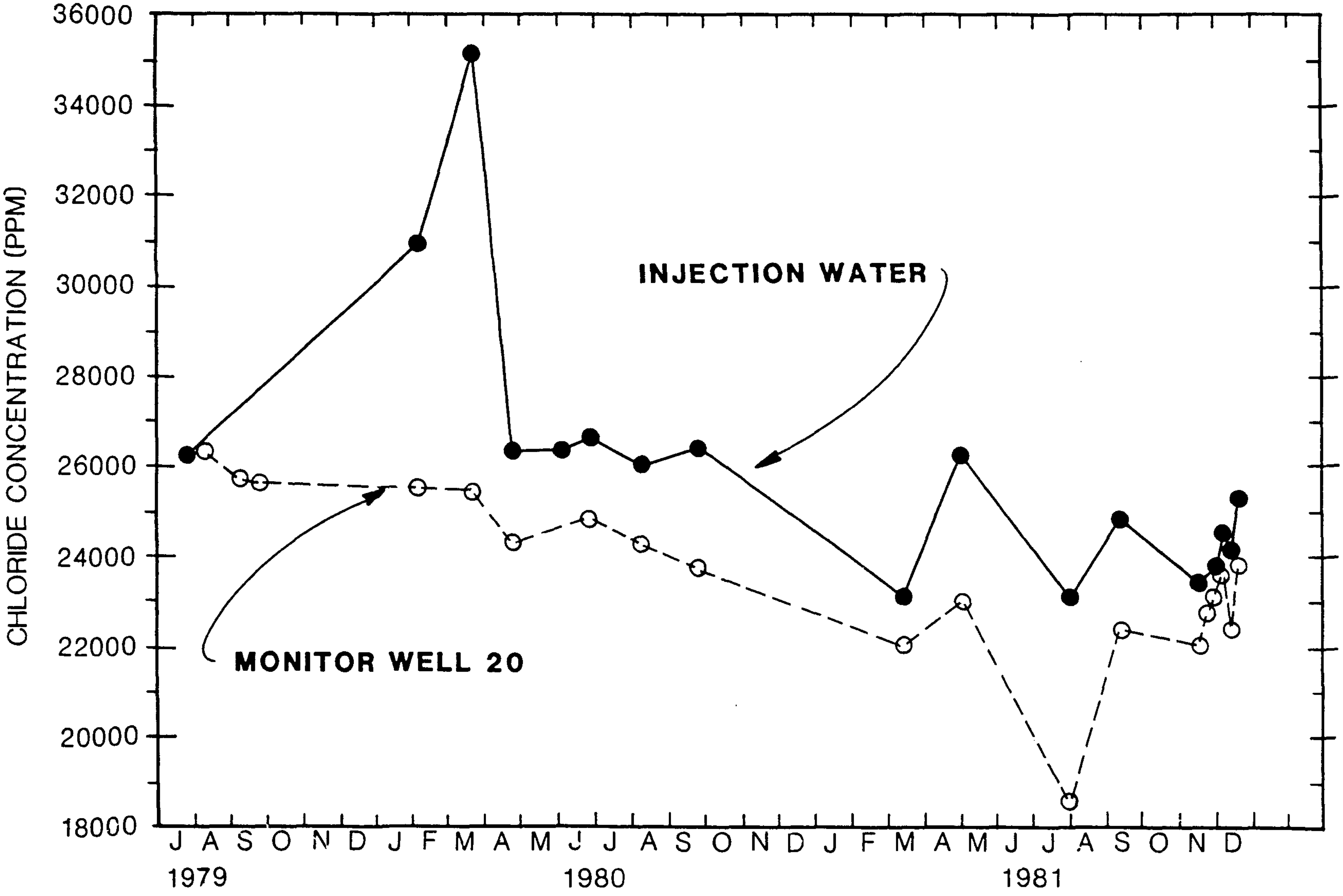

Figure 4. Chloride concentration of injected water and ground water in the Ogallala aquifer. (Analyses by New Mexico Oil Conservation Division)

that BO-3 may not have been leaking. Figure 2 shows that BO-3 was designed to insulate injection fluid from the Ogallala with four steel casings, two of which were cemented to the surface; furthermore, the saline water is being injected nearly two miles below the bottom of the Ogallala. Mechanical integrity tests, which consist of applying and/or monitoring pressure on the casing or injection tubing annuli, were ordered by the N.M. Oil Conservation Division to detect leakage. Radioactive tracer surveys were also conducted. Mr. Richard L. Stamets (OCD, written communication, 1984) indicates that on the basis of "the numerous hearings conducted on this matter before the Oil Conservation Division, the expert witnesses appearing, the expert testimony presented, and the findings of the Commission,... there was no definitive evidence that the salt-water disposal well in question was the source of the contamination."

In 1982, a jury found that both the pit and the injection well contributed to ground-water contamination which reached the irrigation well, on the basis of the above described, and many other, technical issues (Hamilton v. Texaco, US District Court, Santa Fe).

DISCUSSION

In 1981, the OCD assumed responsibility for enforcing the federal Underground Injection Control (UIC) Program which was set forth under the Safe Drinking Water Act (PL 93-523, as amended). According to these regulations, monitoring for Class II injection wells is only required in the injection well unless otherwise stipulated in the permit by the NMOCD. Monitoring essentially consists of a mechanical integrity test at least once every five years; however, since 1978 New Mexico has performed bradenhead tests to check mechanical integrity annually on all salt-water disposal wells in southeast New Mexico (R. L. Stamets, NMOCD, written communication, 1984). According to regulations, the injection well also needs to have facilities available to make measurements of injection and annulus pressure, and monthly injected fluid volume. Other tests may also be required, as ordered by the Director of NMOCD. In reference to the case study of underground injection of saline oil-field water in northern Lea County, no ground-water monitoring in the Ogallala aquifer was required, according to existing regulations. The following discussion will illustrate some of the arguments in favor of ground-water monitoring for the protection of injection well operators and potable ground-water users.

In a typical oil field there are numerous potential sources of saline seepage to shallow aquifers besides injection wells and pits. According to the Petroleum Engineer journal (July, 1967, p. 35) "oil field pollution occurs from ... overflowing waste pits, leakage from broken lines, improperly plugged wells, improperly cased and cemented wells, salt water production from an exploratory core hole, and many other surface and subsurface forms". Many of these potential sources of contamination may be owned and operated by different companies. On the basis of this case study, it might be prudent for the owner of a newly completed salt-water disposal well to install monitor wells to establish baseline conditions before injection begins, as well as a ground-water monitoring-well network surrounding the injection well in order to detect encroaching salt water from other sources. That is, if it is true that the injection well did not ever leak and that all saline water is attributed to the pit, then a few shallow ground water monitor wells drilled prior to converting BO-3 would have shown that the aquifer was already contaminated; this conclusive finding probably would have prevented the costly litigation just described.

Ground-water monitoring of underground injection beneath highly vulnerable and valuable aquifers such as the Ogallala, is crucial to protecting the agricultural economy of the area described in this report. In this case study, 160 acres of farm land was rendered unirrigable, owing to the brine contamination. (However, the present landowner, Mr. Jess Tolton [Caprock NM, personal communication, 1984], reported that he has used an irrigation well located south of the affected irrigation well, apparently just beyond the plume, for small-scale irrigation.) If one assumes, on the basis of hydrologic evidence, that the injection well actually had a leak when the mechanical integrity tests were performed, then the mechanical integrity tests alone may not be a sufficiently reliable means of protecting aquifers. Part of the problem in interpreting mechanical integrity tests may be in detecting leaks which are quite small. A continous, slow rate of leakage comprising only a few percent of the total injection rate could have accounted for contamination near BO-3, for example. Without ground-water monitor wells, extensive aquifer contamination is possible during the five-year period between mechanical integrity tests. At rates of ground-water flow on the order of a few hundred feet per year, typical of high permeability aquifers, the number of contaminated agricultural and domestic wells would soon be appreciable. Annual testing of Class II wells in New Mexico which began in 1978, is a step toward minimizing impacts to ground water, and annual mechanical integrity tests on all injection wells (including Class I and III) completed near fresh-water sources should be encouraged. Depending upon the magnitude of the leak and the time when the leak first develops, even annual mechanical integrity tests may not be adequate to avoid extensive brine contamination. It is reported that annual testing in New Mexico reveals about two percent failures (U.S. EPA, 1983, p. 5).

Injection well BO-3 continues to operate as the salt-water disposal well for the Moore Devonian Pool. There has been no effort to date to clean-up the contamination described in this case study, owing in part to litigation which was pending in 1982. More importantly perhaps, the cost of restoring the Ogallala would be quite substantial, inasmuch as the volume of aquifer contamination is on the order of 50 million cubic feet. Valuable irrigated farm land is located east and southeast of the case study area, in the direction of the contaminant plume described in Figure 3. A few shallow ground-water monitor wells at strategic locations near injection wells, drilled at a cost of approximately $15 per foot of depth, would be a relativiely inexpensive means of monitoring injection wells and protecting ground-water resources.

ACKNOWLEDGEMENTS

The authors would like to thank the reviewers of drafts of this paper for their comments, in particular Mr. R. L. Stamets and staff of the N. M. Oil Conservation Division. The cooperation of Mr. John Gannon of Texaco Inc., Mr. Paul Hamilton, Mr. Jim Wright and Mr. Sherman "Pinky" Galloway of the State Engineer's Office is also acknowledged.

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