DOMESTIC SERVICE

Check the class of service desired; otherwise this message will be sent as a full rate telegram

| | | | |
|---|---|---|---|
| FULL RATE TELEGRAM | | SERIAL | |
| DAY LETTER | | NIGHT LETTER | |

# WESTERN UNION

1206

JOSEPH L. EGAN, PRESIDENT

INTERNATIONAL SERVICE

Check the class of service desired; otherwise this message will be sent at the full rate

| | | | |
|---|---|---|---|
| FULL RATE | | DEFERRED | |
| CODE | | NIGHT LETTER | |

| NO. WDS.-CL. OF SVC. | PD. OR COLL. | CASH NO. | CHARGE TO THE ACCOUNT OF | TIME FILED |
|---|---|---|---|---|
| | | | OIL CONSERVATION COMMISSION | |

*Send the following message, subject to the terms on back hereof, which are hereby agreed to*

SANTA FE, N. M. DECEMBER 21, 1948

MR. JOHN E. COCHRAN JR
COCHRAN AND SIEGENTHALER
ARTESIA, NEW MEXICO

ORDER APPROVED EXACTLY AS SUBMITTED. WILL AIRMAIL SIGNED COPY

DECEMBER 22.

R. R. SPURRIER

CLASS OF SERVICE

This is a full-rate Telegram or Cablegram unless its deferred character is indicated by a suitable symbol above or preceding the address.

# WESTERN UNION

1201

JOSEPH L. EGAN
PRESIDENT

| SYMBOLS |
| --- |
| DL = Day Letter |
| NL = Night Letter |
| LC = Deferred Cable |
| NLT = Cable Night Letter |
| Ship Radiogram |

The filing time shown in the date line on telegrams and day letters is STANDARD TIME at point of origin. Time of receipt is STANDARD TIME at point of destination

.DA137

D=DVA265 PD=ARTESIA NMEX 21 1046A=

=R R SPURRIER SECRETARY=

NEW MEXICO OIL CONSERVATION COMM SANTAFE NMEX=

:PLEASE ADVISE ME TELEGRAM COLLECT WHEN GRAYBURG OIL COMPANY WILL BE FURNISHED A COPY OF ORDER ENTERED IN CASE NO 164 MR HEARD IS QUITE ANXIOUS ABOUT THIS=

JOHN E COCHRAN JR=

:164=

THE COMPANY WILL APPRECIATE SUGGESTIONS FROM ITS PATRONS CONCERNING ITS SERVICE

LEA COUNTY OPERATORS COMMITTEE
DRAWER I
HOBBS, NEW MEXICO

October 23, 1948

File: GHC-2213-310.17

Re: Case No. 164 -
In the matter of the Application of the Grayburg Oil Company of New Mexico, and the Western Production Company, Inc. for an Order granting Permission to Unitize Certain Tracts within the Boundaries of the Grayburg Cooperative and Unit Area, in Township 17 South, Ranges 29 and 30 East, N.M.P.M., in the Grayburg-Jackson Pool of Eddy County, New Mexico for Proration and Allowable Purposes.

AIRMAIL

Mr. R. R. Spurrier
New Mexico Oil Conservation Commission
Santa Fe, New Mexico

Dear Sir:

At the hearing held on July 29, 1948, on the application of the Grayburg Oil Company and the Western Production Company, Inc. for an order granting permission to drill certain unorthodox wells and to allocate the allowable on a basic lease basis, Mr. J. O. Seth, representing the Lea County Operators Committee, stated that we did not have any objection to the granting of unorthodox locations, and requested that action of the Commission regarding an allocation of allowables be deferred.

The Grayburg Oil Company and the Western Production Company, Inc. have submitted a revised application to the Commission covering the allocation of allowables on the leases affected, which was forwarded to the Executive Committee of the Lea County Operators Committee with Mr. C. G. Staley's letter of September 27, 1948. The Executive Committee, after reviewing the revised application, have voted 6 to 1 that they have no objection to this application in its present form.

The revised application has been sent to all operators under date of October 15, 1948, and any operator wishing to do so may enter an objection to the proposed order of the Grayburg Oil Company and Western Production Company, Inc. at the hearing to be held on October 28.

Yours very truly,

G. H. Card, Chairman

GHC:gp
cc: J.O.Seth
John E. Cockran, Jr.

Charge to the account of OIL CONSERVATION COMMISSION $

| CLASS OF SERVICE DESIRED | | | |
|---|---|---|---|
| DOMESTIC | | CABLE | |
| TELEGRAM | | ORDINARY | |
| DAY LETTER | | URGENT RATE | |
| SERIAL | | DEFERRED | |
| OVERNIGHT TELEGRAM | | NIGHT LETTER | |
| SPECIAL SERVICE | | SHIP RADIOGRAM | |

Patrons should check class of service desired; otherwise the message will be transmitted as a telegram or ordinary cablegram.

# WESTERN UNION

1206-B

R. B. WHITE, PRESIDENT
NEWCOMB CARLTON, CHAIRMAN OF THE BOARD
J. C. WILLEVER, FIRST VICE-PRESIDENT

| CHECK |
|---|
| ACCOUNTING INFORMATION |
| TIME FILED |

*Send the following telegram, subject to the terms on back hereof, which are hereby agreed to*

16 November 1948

MR. JOHN COCHRAN
CARPER BLDG.,
ARTESIA, NEW MEXICO

ORDER NO. 791 COVERS CASE 164

OIL CONSERVATION COMMISSION

R. R. SPURRIER - DIRECTOR

U. S.

# UNITED STATES
# DEPARTMENT OF THE INTERIOR

Harold L. Ickes, Secretary

## GEOLOGICAL SURVEY

William E. Wrather, Director

ENGINEERING REPORT ON

GRAYBURG COOPERATIVE AND UNIT AREA

Eddy County, Mew Mexico

By

John A. Barnett and Merwin H. Soyster
(Conservation Branch - Oil & Gas Leasing Division)

121393

UNITED STATES
DEPARTMENT OF THE INTERIOR
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# ENGINEERING REPORT ON

# GRAYBURG COOPERATIVE AND UNIT AREA

Eddy County, New Mexico

by

John A. Barnett and Merwin H. Soyster
(Conservation Branch - Oil & Gas Leasing Division)

121393

Engineering Report on

# GRAYBURG COOPERATIVE AND UNIT AREA

Eddy County, New Mexico

- - -

By

John A. Barnett and Merwin H. Soyster

This report covers the area committed to the Grayburg Cooperative and Unit Agreement (I-Sec. 370) approved by the Assistant Secretary of the Interior on October 5, 1943, hereafter referred to as the "unit area", embracing 4,769.44 acres of public land in T. 17 S., Rs. 29 and 30 E., Eddy County, New Mexico. The area includes portions of the Anderson, Grayburg-Jackson, and Leonard oil fields as defined for proration purposes by the New Mexico Oil Conservation Commission. The unit area is covered by Federal oil and gas leases owned by the Grayburg Oil Company of New Mexico and the Western Production Company, Inc. The Grayburg Unit Association has been formed and designated to conduct and manage all operations in the unit area. As of December 31, 1943, there were forty-six producing oil wells within the unit area.

The report has been prepared for the purpose of assisting the Grayburg Unit Association in determining the proper locations of gas-injection wells and the best methods for future operation of the pressure-maintenance system that is being installed for the purpose of retarding the reservoir pressure decline and increasing the ultimate recovery of oil from the Grayburg Zone defined in the above-mentioned agreement as formations not more than 3300 feet below the surface. Data used in the report were obtained from records on file in the Geological Survey office at Roswell, New Mexico, and from the records of the Western Production Company and the Grayburg Oil Company. All data were carefully checked as to accuracy with engineers and fields representatives of both companies.

Maps, cross-sections and curves.

Included with this report are the following illustrations:

1. Well-record map, showing boundaries of the Cooperative and Unit Area, well locations, ownership and serial numbers of Federal oil and gas leases, and a type log of subsurface formations penetrated. In addition, the elevations, geologic correlation points, and other pertinent data are indicated for each well.

2. Structure map, contoured on top of the "Red Sand".

3. Production zone map. This map was prepared by correlation of all sample logs and electrical logs available. An index to the zones will be found in the type log included with the maps of the area.

4. Bottom-hole pressure map. The pressures, corrected to a datum of 800 feet above sea level, were taken during the period October 4, 1943, to January 8, 1944. For a few wells, current pressures were not available. For those wells the last available pressure tests were used (taken within the past year) and so indicated.

5. Production chart, indicating the annual oil production, cumulative oil production, and number of wells producing at the end of each year.

6. Production decline curve. This curve was constructed by plotting individual production declines of several representative wells that are believed to have been produced with practically unrestricted flow, and by interpolating a family decline curve therefrom. The normal future rate of production decline, using primary producing methods, was then obtained by projecting the curve on logarithmic cross-section paper.

7. Bottom-hole pressure decline curve. This curve was obtained by averaging the rates of pressure decline of all wells, plotted with reference to the time elapsed between the completion of each well and the recording of bottom-hole pressures. The future rate of pressure decline was then estimated by logarithmic projection.

8. Cross-section A-A', showing the geology and details of the producing formations along a line of wells from the west to the east side of the unit area.

9. Cross-section B-B' - a northwest-southeast down-dip section.

10. Cross-section C-C' - a northwest-southeast down-dip section.

History.

The first oil production in the unit area was obtained in 1929 by Grayburg Oil Company in its Burch No. 2-A well, located 1980 feet from the south line and 660 feet from the west line of sec. 19, T. 17 S., R. 30 E. This well was drilled to a total depth of 3142 feet and completed on June 27, 1929, for an initial production of 50 barrels of 36.3 API gravity oil per day. It was subsequently deepened to 3204 feet without encountering water or additional oil.

Owing to adverse business conditions, lack of knowledge as to the extent of the productive area, and other factors, drilling in this area was conducted sporadically up to August 1937. During that period only eight wells were completed, averaging one well per year. Between August 1, 1937, and September 1, 1941, a total of 12 wells were completed, an average of 3 wells per year. From September 1, 1941, to January 1, 1944, a total of 26 wells were completed for an average of slightly less than 12 wells per year.

The area has been developed with a well-spacing pattern of one well to each 40-acre subdivision. All recent drilling has been in the center of such subdivisions. Production has ranged from the unrestricted yield of earlier wells to a maximum daily allowable of less than 30 barrels per well, and more recently has been at a maximum daily well allowable of 48 barrels, which is the current top allowable for wells in other fields in southeastern New Mexico, as determined by the New Mexico Oil Conservation Commission.

Stratigraphy.

The surface of the unit area consists largely of small shifting sand hills, which preclude a determination of surface structure by examination of outcrops. The stratigraphy consequently has been determined by a study and correlation of samples of formations drilled, together with the correlation of electrical logs. Nomenclature, correlations and formation intervals used in this report are based on studies of southeast New Mexico and West Texas by Dickey1/, King2/ and others3/.

The surface sand is underlain by approximately 250 feet of sandstone and red shale which is undifferentiated but generally classified as belonging to the Dockum group of Triassic age. The lower portion of these beds, usually sandstone or sandy red shale, may be the Dewey Lake redbeds of Permian age. Below this horizon all formations penetrated thus far are of Permian age.

Unconformably below the Dewey Lake (?) redbeds occurs the Rustler formation, approximately 100 to 200 feet in thickness, composed mainly of anhydrite, with limestone present in some areas.

The Salado formation, commonly known as the "salt section", consists of 400 to 500 feet of salt, often potash-bearing, with occasional thin beds of anhydrite.

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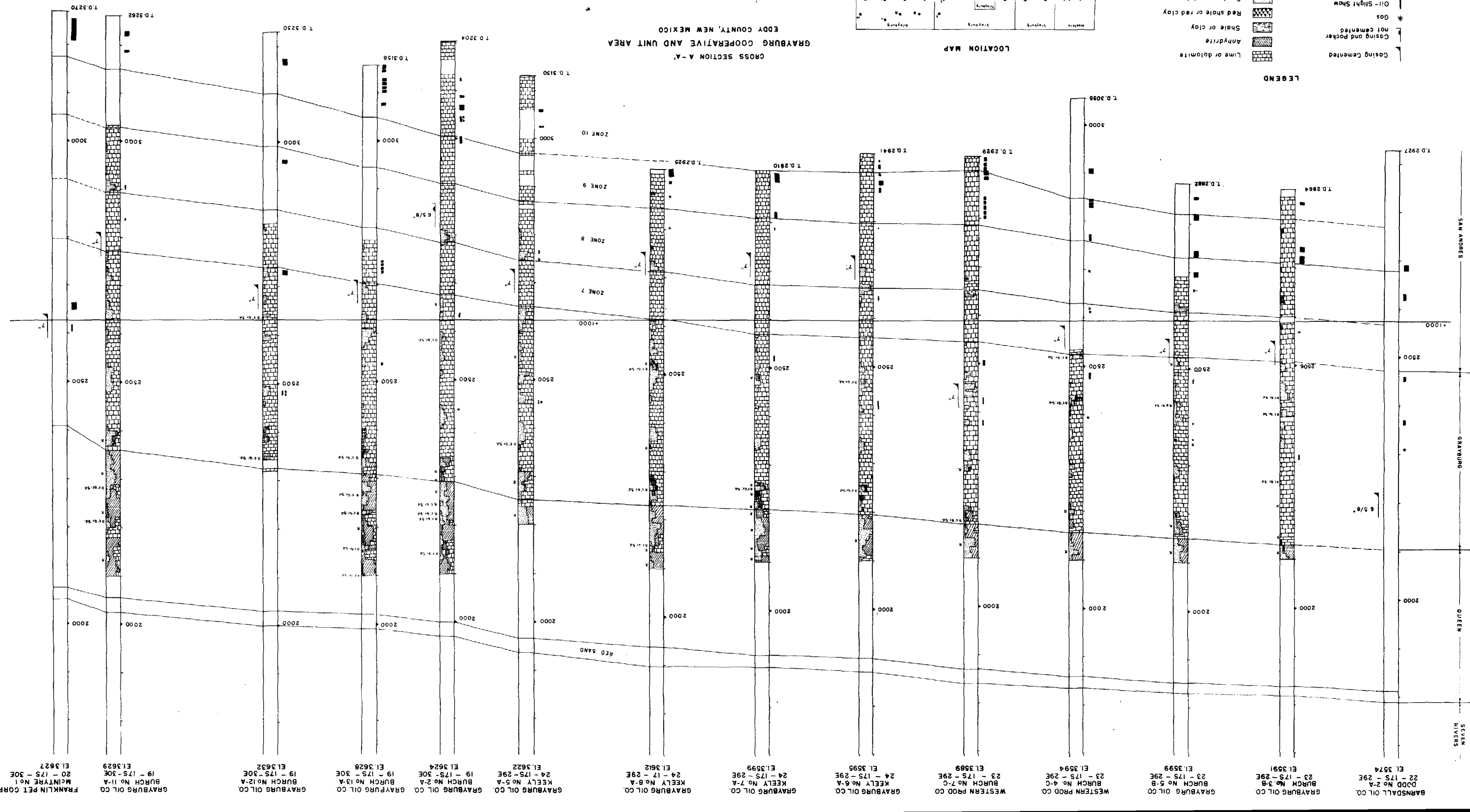
1/ Dickey, R. I., Geologic section from Fisher County through Andrews County, Texas, to Eddy County, New Mexico: Amer. Assoc. Petrol. Geol. Bull., Vol. 24, No. 1, pp. 37-51, January 1940.

2/ King, P. B., Permian of West Texas and southeastern New Mexico: Amer. Assoc. Petrol. Geol. Bull., Vol. 26, No. 4, April 1942.

3/ The Oil and Gas Resources of New Mexico, Second Edition: New Mexico School of Mines, State Bureau of Mines and Mineral Resources, Bull. 18, 1942.




CROSS SECTION A – A'
GRAYBURG COOPERATIVE AND UNIT AREA
EDDY COUNTY, NEW MEXICO

SCALE
0 600' 1200'
0 50' 100'

LOCATION MAP

LEGEND

- Casing Cemented
- Casing and Packer not Cemented
- Gas
- Oil - Slight Show
- Oil - Show
- Oil - Pay
- Lime or dolomite
- Anhydrite
- Shale or clay
- Red shale or red clay
- Sand or sandstone
- Red sand

GRAYBURG OIL CO.
KEELY No. 3-A
24 - 17S - 29E
El. 3611

GRAYBURG OIL CO.
BURCH No. 3-A
19 - 17S - 30E
El. 3628

GRAYBURG OIL CO.
BURCH No. 13-A
19 - 17S - 30E
El. 3628

WESTERN PROD. CO.
BURCH No. 3-C
19 - 17S - 30E
El. 3622

SEVEN RIVERS

QUEEN

GRAYBURG

SAN ANDRES

2000

2500

+1000

3000

R

RED SAND

R. & Gr. Sd.

65/8"

7"

ZONE 7

ZONE 8

ZONE 9

ZONE 10

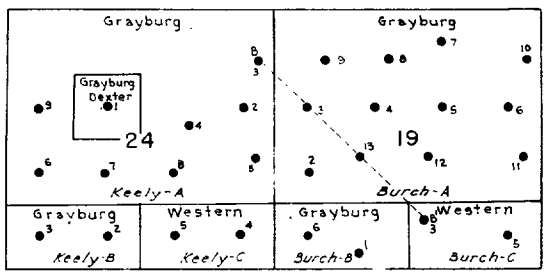
T. D. 3108

T. D. 3100

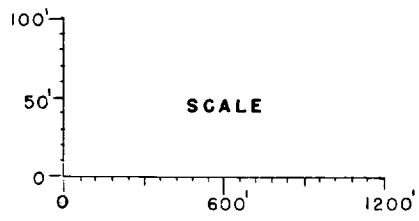
T. D. 3158

T. D. 3246

## LOCATION MAP




## CROSS SECTION B-B'
## GRAYBURG COOPERATIVE AND UNIT AREA
## EDDY COUNTY, NEW MEXICO



GRAYBURG OIL CO.
BURCH No. 8-B
23 - 17S - 29E
El. 3598

GRAYBURG OIL CO.
KEELY No. 6-A
23 - 17S - 29E
El. 3595

GRAYBURG OIL CO.
KEELY No. 2-B
24 - 17S - 29E
El. 3591

WESTERN PROD. CO.
KEELY No. 7-C
25 - 17S - 29E
El. 3603

SEVEN RIVERS

QUEEN

GRAYBURG

SAN ANDRES

R

RED SAND

2000

R. E' Gr. Sd.

2500

7"

+1000

ZONE 7

ZONE 8

ZONE 9

ZONE 10

T. D. 2904

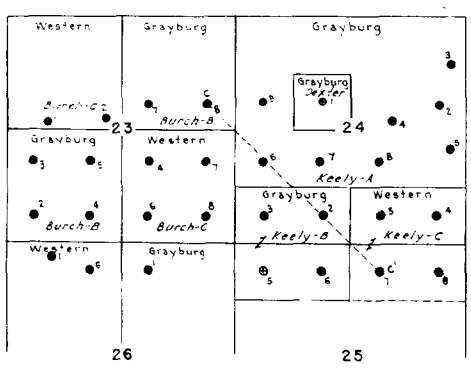
T. D. 2941

T. D. 2994

3000

T. D. 3104

LOCATION MAP




CROSS SECTION C - C'
GRAYBURG COOPERATIVE AND UNIT AREA
EDDY COUNTY, NEW MEXICO

SCALE
100'
50'
0
0
600'
1200'

Formations below the Salado are shown in detail on the cross-sections and type log. It will be noted that a system of numbers for the producing zones in the San Andres formation is shown. This is in conformity with a system originated in many other southeastern New Mexico fields by the Roswell office of the Oil and Gas Leasing Division, Conservation Branch, Geological Survey[4/], and now commonly used by many New Mexico operators, geologists, and engineers. As most of the oil found in the unitized area occurs in the San Andres formation, there are indicated on the cross-sections only the correlations of zones 7, 8, 9 and 10, which are the zones known to produce oil in the San Andres. Only four wells in the area produce oil from the Grayburg formation--two from zone 5 and two from zone 6. Below the eighth zone correlations are made almost entirely on the occurrence of oil pays rather than on stratigraphy or lithology. In zome areas, it is quite likely that oil pays in zones 9 and 10 may be inter-communicative. Particularly in the western portion of the unit area, zones 9 and 10 are closely related and somewhat difficult to correlate, and for production and engineering purposes might properly be considered as one zone.

Structure.

Subsurface contours on top of the "Red Sand" show the structure within the unit area to be an eastward plunging anticline, slightly asmetrical, with a steeper south flank, from which flank the greater portion of oil has been produced. The regional dip is approximately 50 feet to the mile in a southeastward direction, and the local dip of the southeastern flank of the anticline is approximately 200 feet per mile. There is no evidence of faulting. It is quite probable that, although structure has been a general factor influencing the accumulation of oil, the very irregular nature of the accumulations of oil is due to variations in permeability and cementation of the reservoir rock, and to minor structural flexures that serve as barriers or stratigraphic traps.

Reservoir Conditions.

As stated above, the major portion of the oil produced is from the San Andres formation. The amount of production from each well is dependent upon the porosity and permeability of the producing zones, which often vary greatly from well to well. No cores have been taken in the unit area, and it is not possible to state the range of porosities and permeabilities.

Productive zones, consisting of porous dolomite in the San Andres formation, are relatively thin. Several wells have thus far produced in excess of 150,000 barrels of oil, and some in excess of 350,000 barrels. On the other hand, some wells in the area will probably not yield 50,000 barrels ultimately. This is indicative of the wide range in porosity and permeability of the producing zones.

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4/ Barnett, John A., Maljamar Pool, The Oil and Gas Resources of New Mexico, New Mexico School of Mines, State Bureau of Mines and Mineral Resources, Bull. 18, pp. 243-244, 1942.

It is ordinarily necessary to shoot the formations above the San Andres, where found productive, in order to establish commercial production. It is likewise necessary to acidize under pressure the producing zones encountered in the San Andres formation, in most wells. A few wells have been drilled that require neither shooting nor acidizing.

Water.

Water in varying amounts is generally encountered at a short distance above the top of the salt, but no water is known to have been encountered below the salt. The production of water with the oil in the unit area has never been a problem. Lack of core data precludes the possibility of determining the amount of connate or interstitial water in the oil sands. Estimates based on neighboring fields where determinations have been made, indicate a probability of 15 to 30 percent connate water. There is no evidence of either a direct or an indirect water drive in the area.

Drilling and production methods.

All wells in the unit area have been drilled with cable-tool drilling equipment, usually portable machines. The average cost of drilling and completing a well for production is approximately $15,000.

The usual drilling program provides for a string of 10-3/4-inch or 8-5/8-inch casing set in the anhydrite immediately above the top of the Salado or "salt section" at depths ranging from 300 to 500 feet, and cemented with 50 sacks of cement, preceded by mud circulated to the surface. This serves as an "anchor string", and affords protection to the potash-bearing salt beds from infiltration of upper waters. It also affords protection against caving of the upper strata. A string of 7-inch or 5-3/16-inch casing is then set at a point approximately 100 feet above the first producing zone, and cemented with 100 sacks of cement, preceded by mud circulated to the surface.

Although wells are sometimes swabbed into production and completed naturally, it is usually necessary to stimulate production by acidizing the dolomite pay zones under pressure, in order to obtain production in commercial quantities. The oil is generally produced through 2-inch tubing, set about 20 or 30 feet above the pay zone.

All wells in the unit area are flowing except Grayburg Oil Company No. 9-A Burch, which is being pumped. The oil is usually produced intermittently through surface chokes on the tubing, in order to conserve gas. No bottom-hole chokes have been used, although it is contemplated that such practice may be resorted to in the future in order that the production may be attained without pumping equipment after bottom-hole pressures have been further reduced. Under present practices, approximately 215 pounds

per square inch is the minimum pressure at which the wells will continue to flow. It may be noted by reference to the bottom-hole pressure map accompanying this report that bottom-hole pressures in the unit area range from 230 to 1,018 pounds per square inch, depending upon the location and age of the wells.

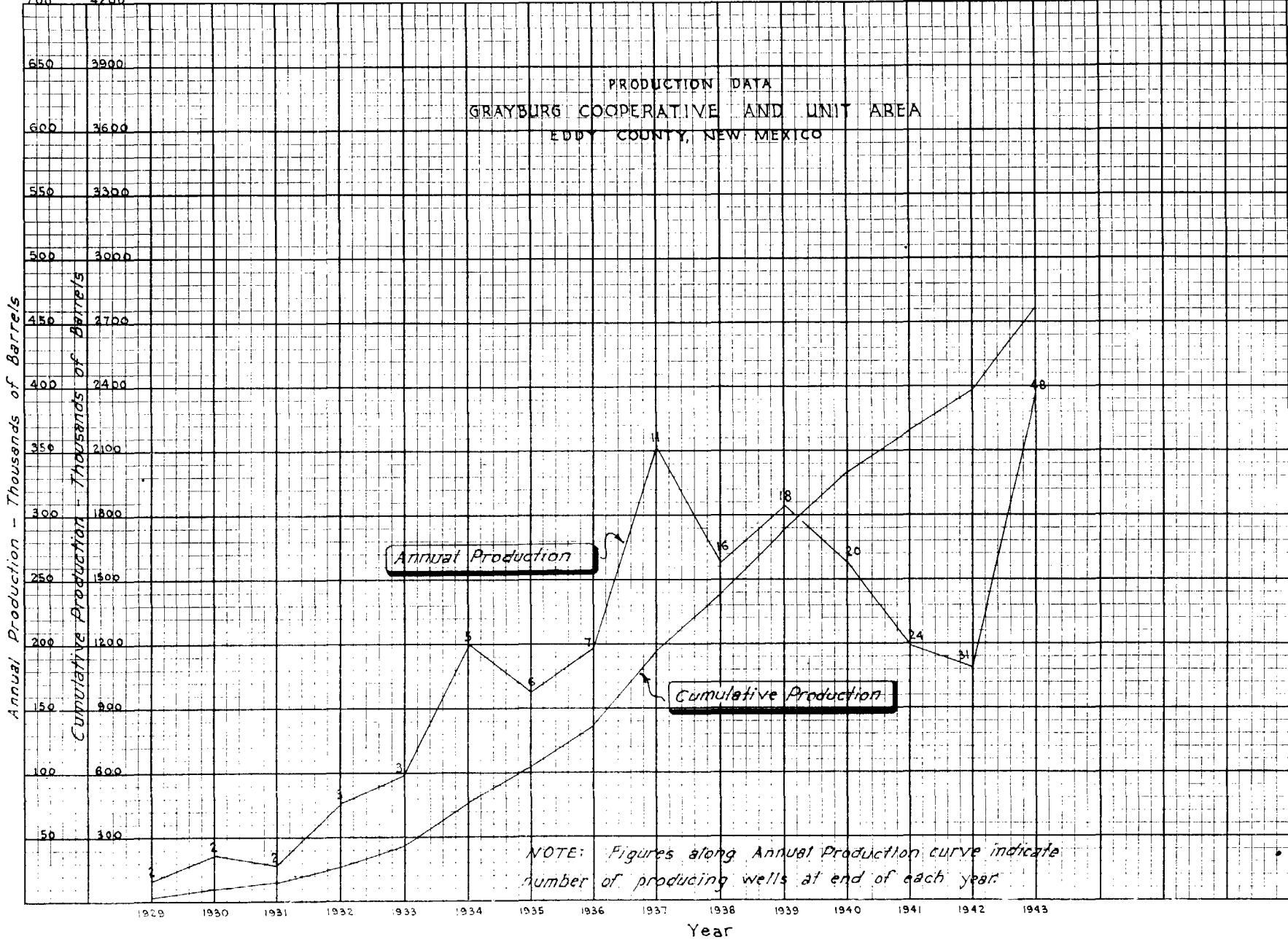
Production data.

To January 1, 1944, a total of 2,766,150 barrels of oil had been produced from 1,920 acres of proved oil land in the unit area, which represents an average recovery of approximately 1,440 barrels per acre. However, most of the wells in the area have been drilled in recent years, and one well that has been producing for almost 10 years has yielded more than 11,000 barrels per acre and still produces more than 40 barrels of oil per day.

The initial, cumulative, and present daily production data on each well in the unitized area are tabulated below:

OIL PRODUCTION DATA--GRAYBURG COOPERATIVE AND UNIT AREA

| Company | Lease | Well | Date of completion | Initial production Barrels, dly. | Cumulative production through 1943- Barrels | Average production December 1943- Barrels, daily |
|---|---|---|---|---|---|---|
| Grayburg | Burch | 2-A | 6-27-29 | 50 | 142,631 | 14.5 |
| " | " | 3-A | 5 -6-32 | 520 | 255,966 | 17.2 |
| " | " | 4-A | 1-15-34 | 425 | 373,386 | 35.1 |
| " | " | 5-A | 5 -5-34 | 525 | 453,996 | 46.2 |
| " | " | 6-A | 4-11-35 | 341 | 196,109 | 30.6 |
| " | " | 7-A | 8-30-36 | 440 | 139,879 | 31.2 |
| " | " | 8-A | 11 -4-37 | 20 | 18,391 | 3.3 |
| " | " | 9-A | 12-10-37 | 25 | 29,200 | 13.7 |
| " | " | 10-A | 2- 5-38 | 35 | 19,797 | 3.2 |
| " | " | 11-A | 4-11-38 | 105 | 65,186 | 14.2 |
| " | " | 12-A | 7-11-39 | 175 | 92,455 | 25.6 |
| " | " | 13-A | 12-20-39 | 206 | 60,681 | 18.7 |
| " | " | 14-A | 11-30-43 | 16 | 243 | 7.8 |
| " | " | 1-B | 8-27-41 | 32 | 23,032 | 25.1 |
| " | " | 2-B | 11- 9-41 | 80 | 24,698 | 26.4 |
| " | " | 3-B | 1 -9-42 | 150 | 23,406 | 26.0 |
| " | " | 4-B | 3 -7-42 | 70 | 19,990 | 26.2 |
| " | " | 5-B | 7 -2-42 | 125 | 17,637 | 26.1 |
| " | " | 6-B | 4-29-42 | 100 | 24,359 | 47.6R |
| " | " | 7-B | 9-14-42 | 206 | 18,380 | 37.1 |
| " | " | 8-B | 3-26-43 | 125 | 10,702 | 36.8 |
| " | Keely | 2-A | 11 -5-29 | 280 | 303,663 | 18.3 |
| " | " | 3-A | 7-29-37 | 155 | 73,728 | 18.3 |
| " | " | 4-A | 3-21-38 | 100 | 47,951 | 22.7 |
| " | " | 5-A | 6 -3-40 | 28 | 25,753 | 23.0 |
| " | " | 6-A | 9-29-43 | 200 | 4,795 | 53.3R |
| " | " | 7-A | 9-29-43 | 200 | 4,763 | 51.4R |


PRODUCTION DATA
GRAYBURG COOPERATIVE AND UNIT AREA
EDDY COUNTY, NEW MEXICO
Annual Production - Thousands of Barrels
Cumulative Production - Thousands of Barrels
650
600
550
500
450
400
350
300
250
200
150
100
50
3900
3600
3300
3000
2700
2400
2100
1800
1500
1200
900
600
300
Annual Production
Cumulative Production
2
2
2
3
3
5
6
7
14
16
18
20
24
31
48
NOTE: Figures along Annual Production curve indicate number of producing wells at end of each year.
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
Year

| | | | | | | |
|---|---|---|---|---|---|---|
| Grayburg | Keely | 8-A | 11-11-43 | 700 | 2,631 | 50.6R |
| " | " | 9-A | 12-11-43 | 100 | 839 | 52.4R |
| " | " | 1-B | 5 -5-43 | 250 | 10,528 | 41.3R |
| " | " | 2-B | 5-24-43 | 338 | 10,142 | 41.7R |
| " | " | 3-B | 9 -8-43 | 360 | 5,240 | 43.6R |
| Western | Burch | 1-C | 6 -3-38 | 50 | 33,937 | 11.8 |
| " | " | 2-C | 9-14-38 | 26 | 33,856 | 11.9 |
| " | " | 3-C | 9-21-41 | 30 | 18,965 | 15.9 |
| " | " | 4-C | 12- 9-42 | 32 | 8,430 | 17.0 |
| " | " | 5-C | 1-20-43 | 130 | 12,321 | 22.9 |
| " | " | 6-C | 2-14-43 | 125 | 11,654 | 33.3 |
| " | " | 7-C | 4-26-43 | 30 | 4,597 | 16.3 |
| " | " | 8-C | 5-10-43 | 50 | 3,933 | 15.3 |
| " | Keely | 1-C | 9-17-37 | 108 | 78,681 | 30.4 |
| " | " | 4-C | 11-12-42 | 215 | 17,510 | 39.5R |
| " | " | 5-C | 3-13-43 | 354 | 12,406 | 39.5R |
| " | " | 6-C | 2-27-43 | 262 | 14,106 | 45.7R |
| " | " | 7-C | 6-22-43 | 240 | 9,283 | 46.3R |
| " | " | 8-C | 8-12-43 | 300 | 6,314 | 46.1R |
| | | | Total | | 2,766,150 | |

Note: R after Average production for December 1943 indicates that well production was restricted by proration.

Oil analyses.

The following analyses were made by the U. S. Geological Survey at Casper, Wyoming, in accordance with the U. S. Bureau of Mines Hempel method. Although one sample of oil was taken from zone 9 and the other sample represents a mixture of oil from zones 9 and 10, the analyses are quite similar, indicating the probability that intercommunication does exist between some of the zones, at least in certain areas.

Sample No. 44-038, Grayburg Oil Co. No. 6-A Keely well, sec. 24, T. 17 S., R. 29 E. From lower portion zone 9 and zone 10.

| | |
|---|---|
| Specific Gravity.. .836 | A.P.I. Gravity 37.8 |
| Percent sulphur... .90 | Pour point.... Below 5° F. |
| Saybolt Univ. Viscosity at 70° F. 43 sec. | Color..... Green |
| Saybolt Univ. Viscosity at 100° F. 39 sec. | Base..... Intermediate |

DISTILLATION, BUREAU OF MINES, HEMPEL METHOD

Distillation at atmospheric pressure 632 mm. First Drop 75° F.

| Fraction No. | Cut at °F. | Per cent | Sum percent | °A.P.I. 60° F. | C.I. | S.U. Visc. 100° F. | Cloud Test °F. |
|---|---|---|---|---|---|---|---|
| 1 | 122 | 2.5 | 2.5 | 81.0 | -- | | |
| 2 | 167 | 4.4 | 6.9 | 74.2 | 18 | | |
| 3 | 212 | 7.2 | 14.1 | 65.9 | 22 | | |
| 4 | 257 | 8.5 | 22.6 | 57.2 | 29 | | |
| 5 | 302 | 7.0 | 29.6 | 51.3 | 32 | | |
| 6 | 347 | 4.5 | 34.1 | 47.8 | 32 | | |
| 7 | 392 | 4.3 | 38.4 | 44.9 | 32 | | |
| 8 | 437 | 5.3 | 43.7 | 42.6 | 32 | | |
| 9 | 482 | 5.4 | 49.1 | 39.4 | 34 | | |
| 10 | 527 | 6.0 | 55.1 | 36.2 | 36 | | |
| Distillation continued at 40 mm. | | | | | | | |
| 11 | 392 | -- | -- | -- | -- | | |
| 12 | 437 | 5.8 | 60.9 | 30.8 | 40 | 46 | 25 |
| 13 | 482 | 4.7 | 65.6 | 28.9 | 42 | 56 | 45 |
| 14 | 527 | 4.3 | 69.9 | 27.0 | 44 | 78 | 65 |
| 15 | 572 | 6.4 | 76.3 | 25.2 | 46 | 134 | 85 |
| Residuum | | 20.3 | 96.6 | 16.2 | | | |

Carbon residue of residuum 7.6% Carbon residue of crude 1.8%

APPROXIMATE SUMMARY

| | Percent | °A.P.I. 60° F. | Viscosity, secs. |
|---|---|---|---|
| Light gasoline | 14.1 | 70.9 | |
| Total gasoline and naphtha | 38.4 | 58.2 | |
| Kerosene distillate | 5.3 | 42.6 | |
| Gas oil | 16.4 | 35.6 | Below 50 |
| Nonviscous lubricating distillate | 9.8 | 30.0 - 26.3 | 50-100 |
| Medium lubricating distillate | 6.4 | 26.3 - 23.2 | 100-200 |
| Viscous lubricating distillate | --- | --- | Above 200 |
| Residuum | 20.3 | 16.2 | |
| Distillation loss | 3.4 | --- | |

Sample No. 44-039, Grayburg Oil Co. No. 8-B Burch well, sec. 23, T. 17 S., R. 29 E. From zone 9.

Specific gravity... .839
Percent sulphur.... .97
Saybolt Univ. Viscosity at 70° F. 42 sec.
Saybolt Univ. Viscosity at 100° F. 39 sec.
A.P.I. gravity... 37.2
Pour point..... Below 5° F.
Color..... Green
Base..... Intermediate

DISTILLATION, BUREAU OF MINES, HEMPEL METHOD

Distillation at atmospheric pressure 635 mm. First Drop 93° F.

| Fraction No. | Cut at °F. | Per cent | Sum percent | °A.P.I. 60° F. | C.I. | S.U. Visc. 100° F. | Cloud Test °F. |
|---|---|---|---|---|---|---|---|
| 1 | 122 | 1.1 | 1.1) | | | | |
| 2 | 167 | 3.8 | 4.9) | 71.2 | -- | | |
| 3 | 212 | 7.6 | 12.5 | 65.3 | 23 | | |
| 4 | 257 | 7.7 | 20.2 | 56.4 | 30 | | |
| 5 | 302 | 4.5 | 24.7 | 50.9 | 33 | | |
| 6 | 347 | 6.6 | 31.3 | 48.3 | 31 | | |
| 7 | 392 | 4.7 | 36.0 | 45.6 | 31 | | |
| 8 | 437 | 5.3 | 41.3 | 43.0 | 31 | | |
| 9 | 482 | 5.5 | 46.8 | 39.4 | 34 | | |
| 10 | 527 | 6.3 | 53.1 | 36.2 | 36 | | |
| Distillation continued at 40 mm. | | | | | | | |
| 11 | 392 | 0.1 | 53.2) | | | | |
| 12 | 437 | 6.0 | 59.2) | 31.0 | 40 | 48 | 25 |
| 13 | 482 | 5.0 | 64.2 | 28.9 | 42 | 56 | 45 |
| 14 | 527 | 4.1 | 68.3 | 26.8 | 44 | 78 | 65 |
| 15 | 572 | 6.2 | 74.5 | 25.2 | 46 | 124 | 85 |
| Residuum | | 21.8 | 96.3 | 16.1 | | | |

Carbon residue of residuum 7.6% Carbon residue of crude 1.9%

APPROXIMATE SUMMARY

| | Percent | °A.P.I. 60° F. | Viscosity, secs. |
|---|---|---|---|
| Light gasoline | 12.5 | 67.5 | |
| Total gasoline and naphtha | 36.0 | 56.4 | |
| Kerosene distillate | 5.3 | 43.0 | |
| Gas oil | 16.1 | 36.0 | Below 50 |
| Nonviscous lubricating distillate | 11.2 | 30.4 - 26.1 | 50-100 |
| Medium lubricating distillate | 5.8 | 26.1 - 24.3 | 100-200 |
| Viscous lubricating distillate | --- | --- | Above 200 |
| Residuum | 21.8 | 16.1 | |
| Distillation loss | 3.7 | --- | |

Gas-oil ratios

Gas-oil ratios in the unit area range from 500 to 4300 cubic feet of gas per barrel of oil. During January 1944 on test, the total gas volume

from the unit area averaged 1,354,000 cubic feet with an average production of 1,425 barrels of oil per day, and a gas-oil ratio for the unit of 947 cubic feet per barrel.

Bottom-hole pressures.

From the bottom-hole pressure map it may be noted that bottom-hole pressures in the unit area range from a low of 230 to a high of 1,018 pounds per square inch. The average bottom-hole pressure for the area has been computed as approximately 530 pounds per square inch during December 1943. For purposes of this report, low, intermediate, and high pressure areas have been designated and are indicated by appropriate hachures on the bottom-hole pressure map. The low pressure area includes all wells with bottom-hole pressures of less than 400 pounds and the high pressure area includes all wells with more than 700 pounds.

Pressure maintenance program.

The Grayburg Unit Association contemplates the initial injection of about one million cubic feet of available casing-head gas per day recovered from the producing oil wells in the unit area. For this purpose there have been installed three compressors with a total of 330 horse power and a capacity of 1,250,000 cubic feet of gas operating under 20-pound intake pressure and 800-pound discharge pressure. Initial injection pressures are not expected to exceed 700 pounds per square inch.

The determination of wells most suitable for gas injection is a matter of prime importance in the inception of any pressure maintenance program. With the volume of gas available and the number of producing wells in the unit area it was determined that five oil wells could reasonably be converted into input wells to give maximum recovery of oil for the amount of gas used. It will undoubtedly be necessary to use additional input wells as more oil wells are completed and more gas becomes available for injection within the unit area.

Criteria for determination of gas input wells include such factors as structure, bottom-hole pressures, gas-oil ratios, lithology, permeability, and other characteristics of the producing formation. Thorough study and detailed correlations were made of sample, electric, and drillers' logs, as well as all other available data obtained of the area, before the five proposed gas injection wells indicated on the bottom-hole pressure map were selected. The zones from which the wells are producing oil were considered, it being the object to centralize each injection well in a group of wells in the same zone or zones. As stated before, practically all the oil produced in the unit area is obtained from zones 9 and 10 and consideration was given to the injection of gas into those two zones only, so that the gas would not be dissipated into barren zones or upper zones of porosity or sands that could act in some instances as "thief sands" as indicated by Dowell Electric Pilot surveys. To insure this further, it is planned to inject gas through tubing with packers set in the injection wells immediately above zone 9.

Four of the five injection wells selected are located between low pressure areas that have been producing for some time, and high pressure areas recently drilled. It is anticipated that this will serve to retard the rate of decline in high pressure areas and at the same time build up or repressure the low pressure areas, thereby materially benefitting the recovery of oil in the entire unit area.

It is intended that the average field gas-oil ratio shall be maintained below 2,000 cubic feet per barrel, and that where ratios become excessive the oil production will be adjusted, remedial work done, or the offending wells shut in to conserve gas and maintain reservoir energy.

Estimate of future production.

The success of a pressure maintenance project is measured by the amount of oil recovered after gas injection as compared with a reasonable estimate of the amount of oil that would have been recovered without the return of gas to the producing formations.

Two decline curves have been prepared, that should aid in evaluating this increased production at a later date, namely, a bottom-hole pressure decline curve and a production decline curve. All data and varying conditions were considered in arriving at the information plotted on these curves, and it is believed that they represent average conditions for the unit area. After injection of gas, it is quite probable that both curves will assume new rates of decline. The intervals between the new curves and those that we would normally expect under primary producing methods will represent the benefits derived from the secondary recovery project.

The following tabulation has been prepared from the production decline curve, and provides in readily usable form an estimate of normally expected future production, based on primary recovery methods, for wells of different potentials. However, in using this tabulation, it is necessary that the "Present daily production" be construed as the settled average daily capacity of a well over a period of several weeks rather than the flush potential as determined by a short test.

ESTIMATED FUTURE PRODUCTION CHART FOR INDIVIDUAL WELLS
Based on primary recovery methods and
economic limit of three barrels of oil daily.

| Present daily production (Bbl.) | Estimated Future life (Yr.-Mo.) | Estimated future production (Bbl.) |
|---|---|---|
| 150 | 17 - 10 | 186,643 |
| 125 | 17 - 4 | 162,553 |
| 100 | 16 - 10 | 141,018 |
| 90 | 16 - 6 | 130,068 |
| 80 | 16 - 1 | 116,414 |
| 70 | 15 - 8 | 105,491 |
| 60 | 15 - 1 | 91,226 |

| | | |
|---|---|---|
| 50 | 14 - 4 | 76,535 |
| 45 | 13 - 10 | 67,714 |
| 40 | 13 - 4 | 60,231 |
| 35 | 12 - 11 | 54,300 |
| 30 | 12 - 4 | 47,700 |
| 25 | 11 - 8 | 41,008 |
| 20 | 10 - 10 | 34,043 |
| 15 | 9 - 4 | 24,645 |
| 10 | 7 - 2 | 14,988 |
| 5 | 3 - 0 | 4,270 |

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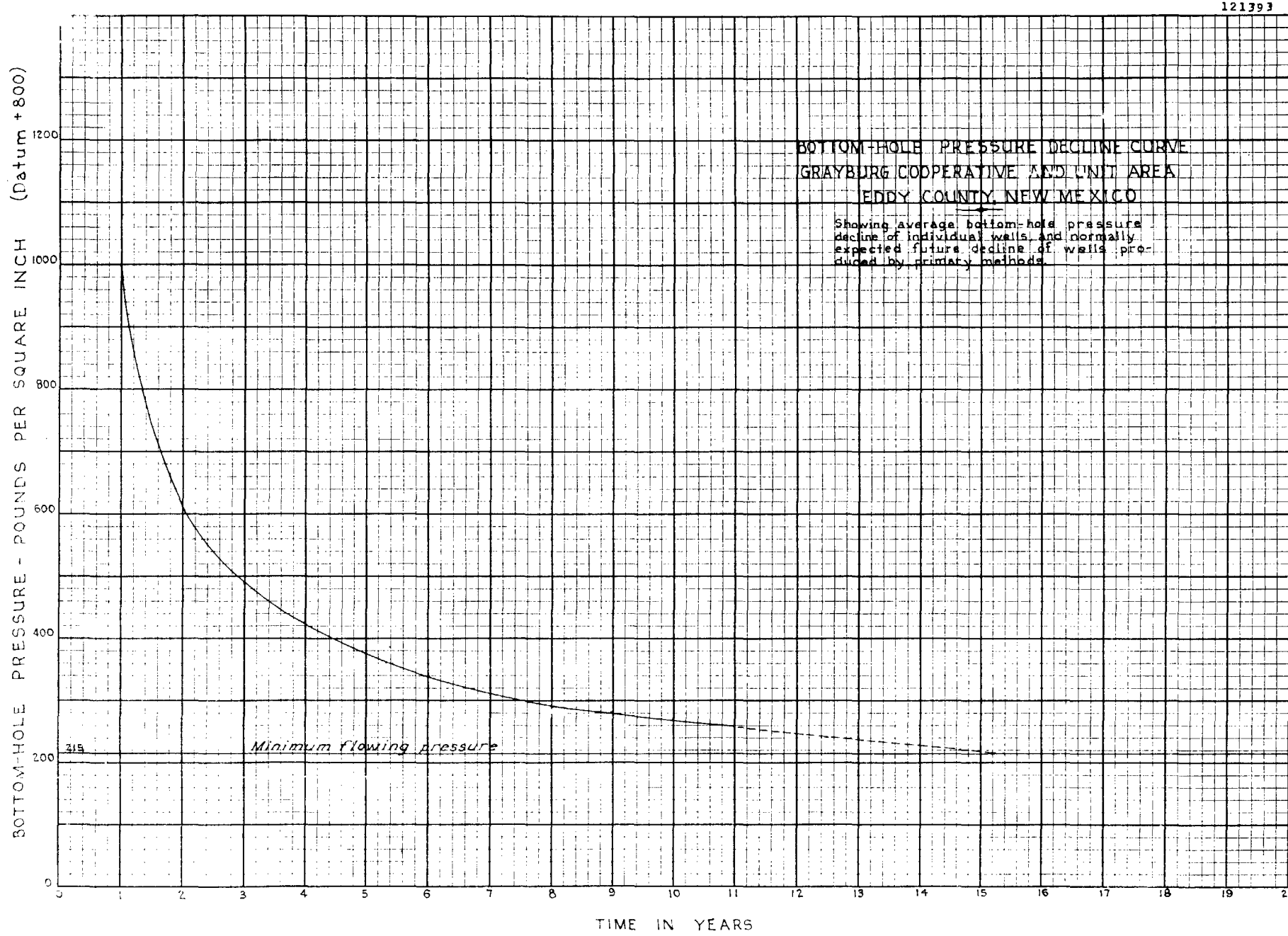
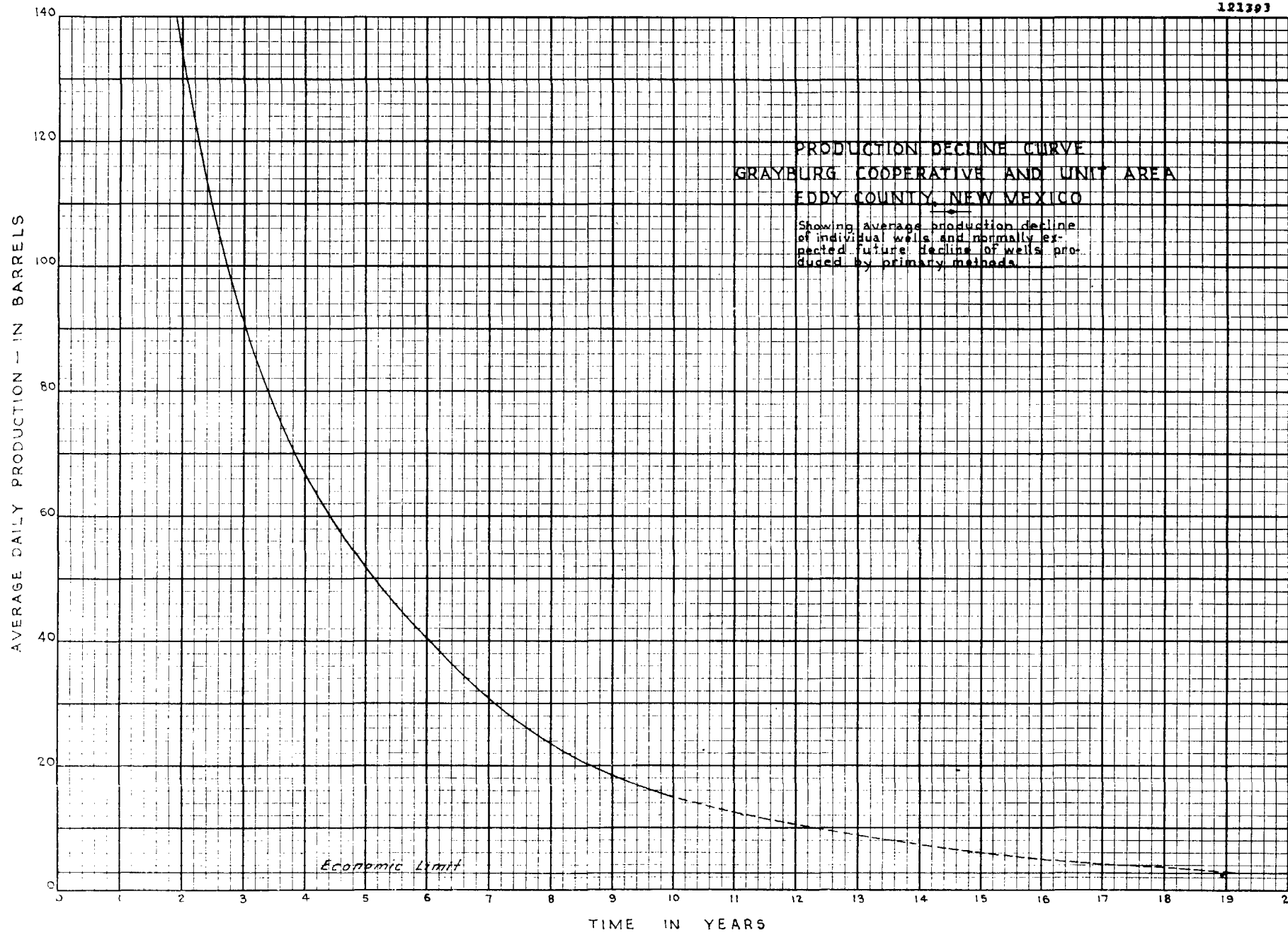
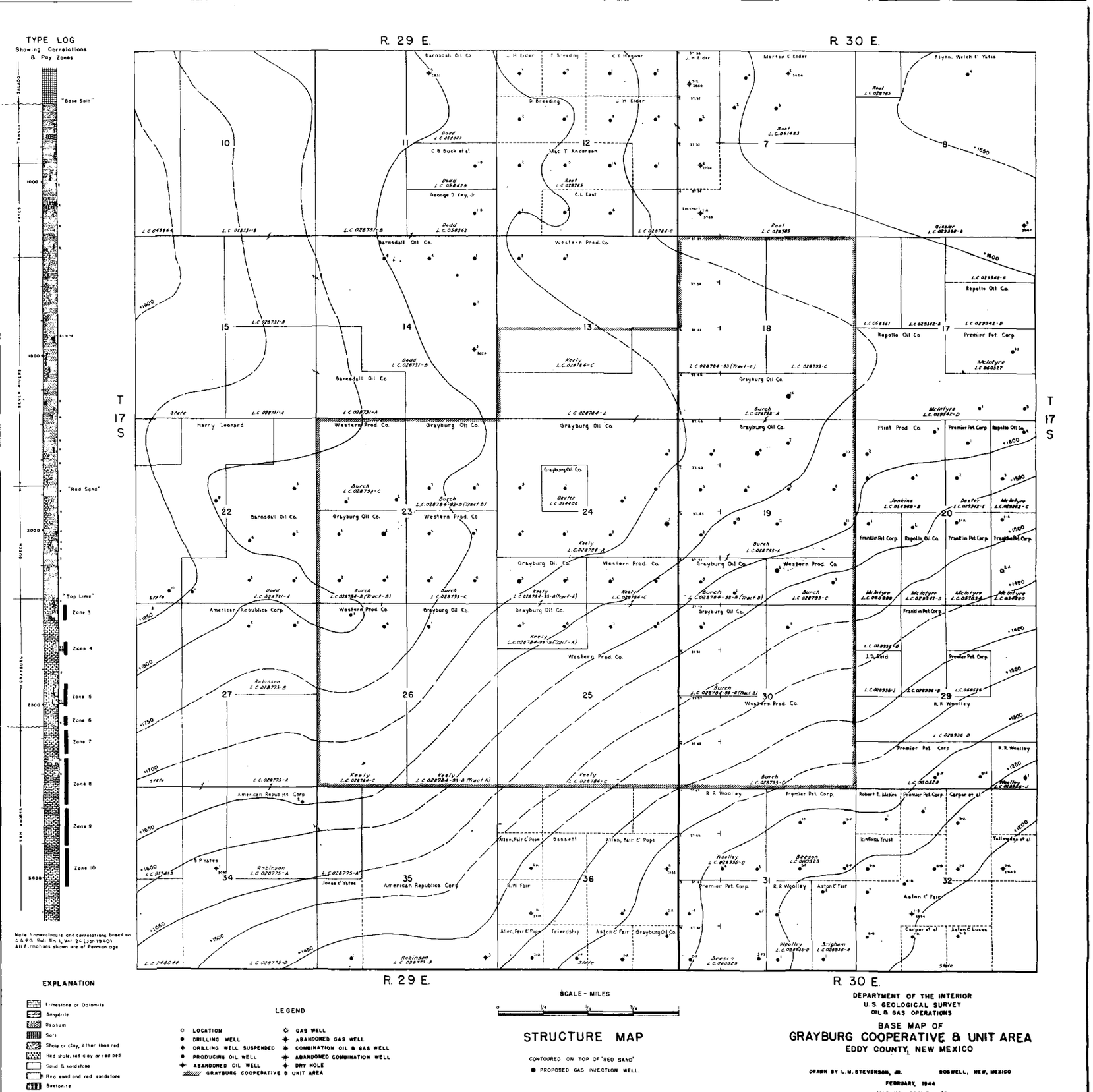

BOTTOM-HOLE PRESSURE DECLINE CURVE
GRAYBURG COOPERATIVE ACD UNIT AREA
EDDY COUNTY, NEW MEXICO
Showing average bottom-hole pressure decline of individual wells, and normally expected future decline of wells produced by primary methods.
BOTTOM-HOLE PRESSURE - POUNDS PER SQUARE INCH (Datum +800)
0
200
400
600
800
1000
1200
315
Minimum flowing pressure
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
TIME IN YEARS

121393


PRODUCTION DECLINE CURVE
GRAYBURG COOPERATIVE AND UNIT AREA
EDDY COUNTY, NEW MEXICO
Showing average production decline of individual wells and normally expected future decline of wells produced by primary methods.
AVERAGE DAILY PRODUCTION — IN BARRELS
140
120
100
80
60
40
20
0
Economic Limit
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
TIME IN YEARS




EXPLANATION

- Limestone or Dolomite
- Anhydrite
- Gypsum
- Salt
- Shale or clay, other than red
- Red shale, red clay or red bed
- Sand & sandstone
- Red sand and red sandstone
- Bentonite

LEGEND

- LOCATION
- DRILLING WELL
- DRILLING WELL SUSPENDED
- PRODUCING OIL WELL
- ABANDONED OIL WELL
- GAS WELL
- ABANDONED GAS WELL
- COMBINATION OIL & GAS WELL
- ABANDONED COMBINATION WELL
- DRY HOLE
- GRAYBURG COOPERATIVE & UNIT AREA

SCALE - MILES

0 1/4 1/2 3/4

# STRUCTURE MAP

CONTOURED ON TOP OF "RED SAND"

● PROPOSED GAS INJECTION WELL.

DEPARTMENT OF THE INTERIOR
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OIL & GAS OPERATIONS

BASE MAP OF

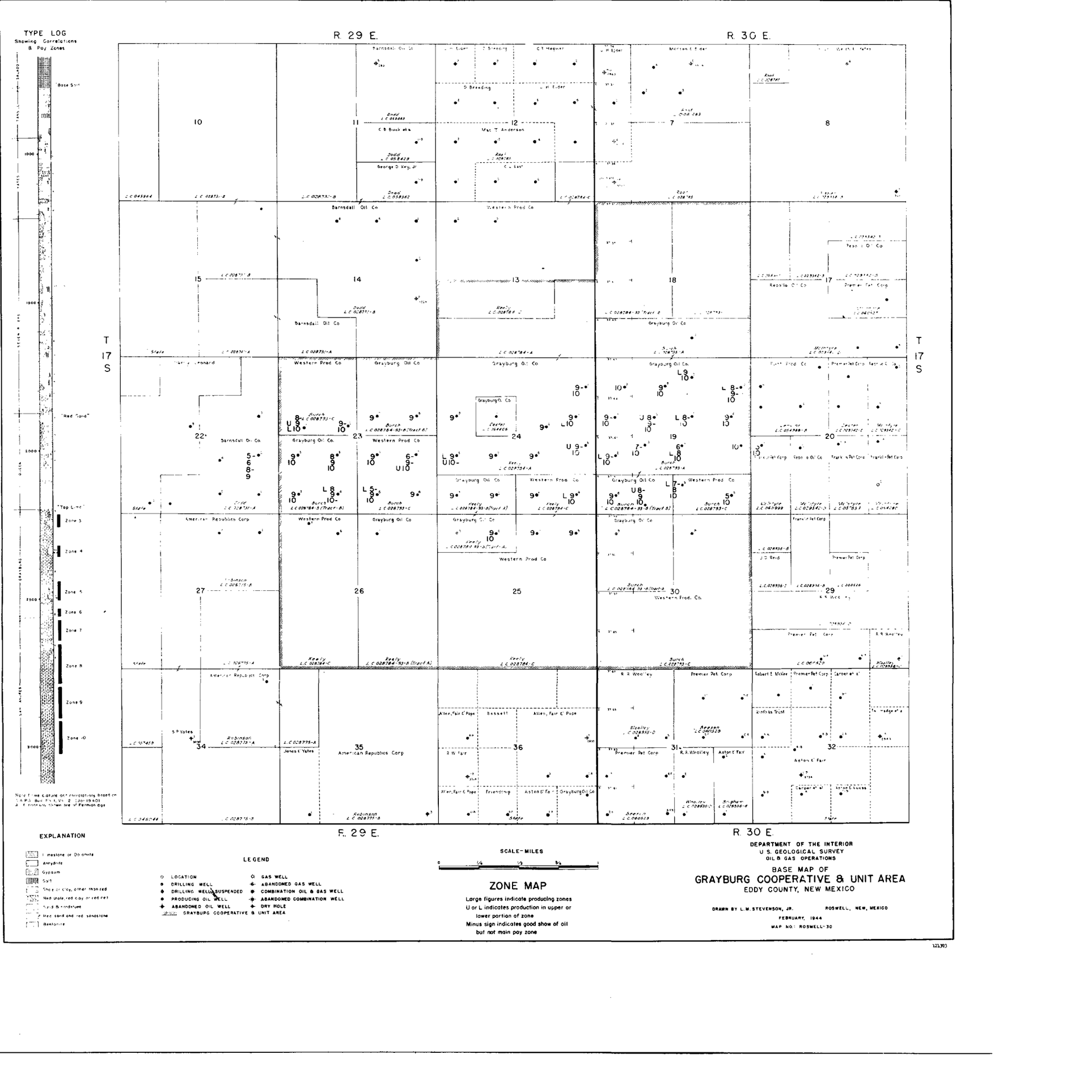
# GRAYBURG COOPERATIVE & UNIT AREA

EDDY COUNTY, NEW MEXICO

DRAWN BY L. M. STEVENSON, JR. ROSWELL, NEW MEXICO

FEBRUARY, 1944

MAP NO.: ROSWELL-50




EXPLANATION

- Limestone or Dolomite
- Anhydrite
- Gyspum
- Salt
- Shale or Clay, other than red
- Red shale, red clay or red rock
- Sand & sandstone
- Red sand and red sandstone
- Bentonite

LEGEND

- LOCATION
- DRILLING WELL
- DRILLING WELL SUSPENDED
- PRODUCING OIL WELL
- ABANDONED OIL WELL
- GRAYBURG COOPERATIVE & UNIT AREA
- GAS WELL
- ABANDONED GAS WELL
- COMBINATION OIL & GAS WELL
- ABANDONED COMBINATION WELL
- DRY HOLE

SCALE - MILES

0 1/4 1/2 3/4 1

## ZONE MAP

Large figures indicate producing zones
U or L indicates production in upper or lower portion of zone
Minus sign indicates good show of oil but not main pay zone

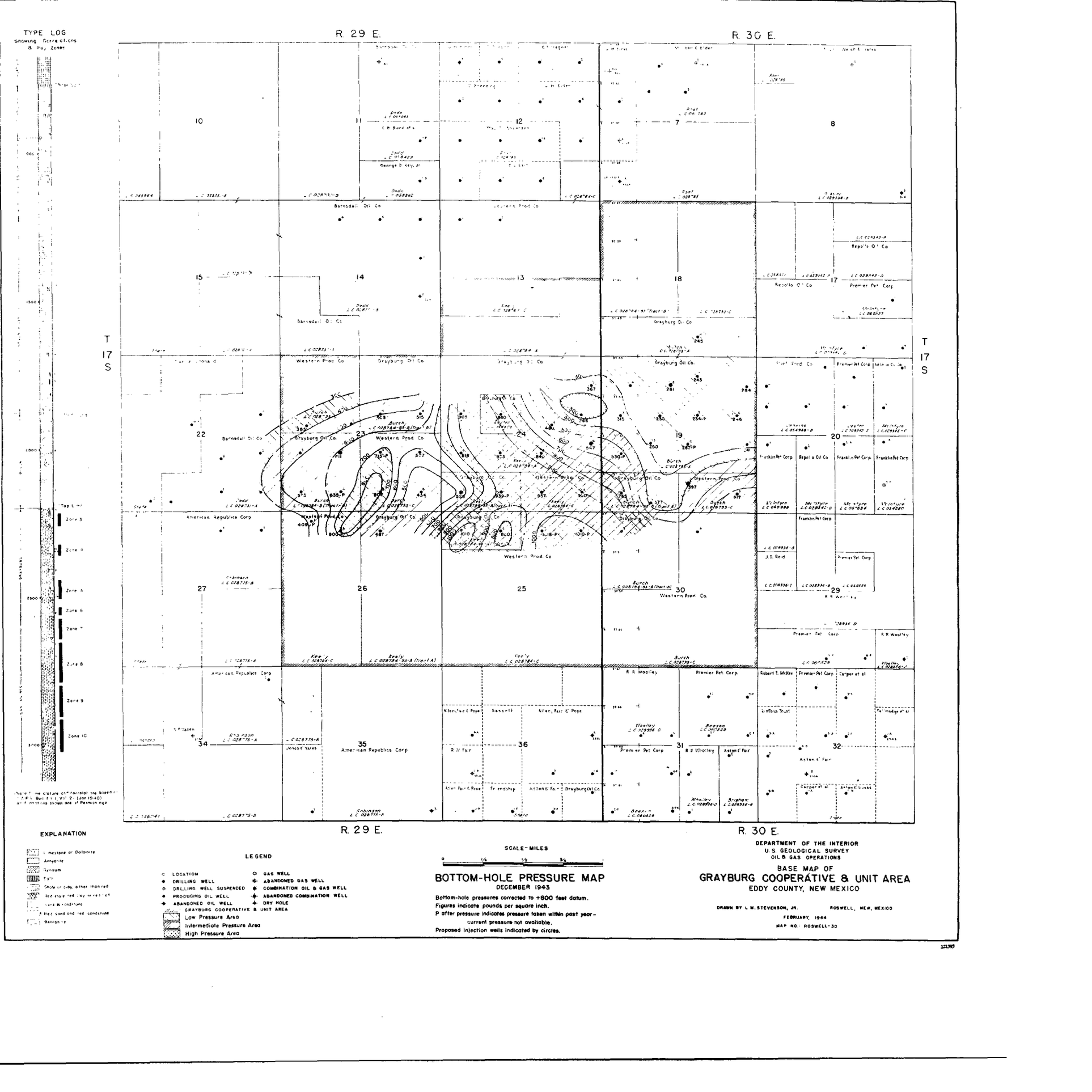
DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY
OIL & GAS OPERATIONS

# BASE MAP OF GRAYBURG COOPERATIVE & UNIT AREA

EDDY COUNTY, NEW MEXICO

DRAWN BY L. M. STEVENSON, JR. ROSWELL, NEW MEXICO
FEBRUARY, 1944
MAP NO.: ROSWELL-30

121393


TYPE LOG
Showing Correlations & Pay Zones
R. 29 E.
R. 30 E.
T 17 S
T 17 S
Top Lime
Zone 3
Zone 4
Zone 5
Zone 6
Zone 7
Zone 8
Zone 9
Zone 10
1500
2000
2500
3000
EXPLANATION
Limestone or Dolomite
Anhydrite
Gypsum
Salt
Shale or clay, other than red
Red shale, red clay or red bed
Sand & sandstone
Red sand and red sandstone
Wellsite
LEGEND
LOCATION
DRILLING WELL
DRILLING WELL SUSPENDED
PRODUCING OIL WELL
ABANDONED OIL WELL
GRAYBURG COOPERATIVE & UNIT AREA
Low Pressure Area
Intermediate Pressure Area
High Pressure Area
GAS WELL
ABANDONED GAS WELL
COMBINATION OIL & GAS WELL
ABANDONED COMBINATION WELL
DRY HOLE
SCALE - MILES
0
1/4
1/2
3/4
BOTTOM-HOLE PRESSURE MAP
DECEMBER 1943
Bottom-hole pressures corrected to +800 feet datum.
Figures indicate pounds per square inch.
P after pressure indicates pressure taken within past year - current pressure not available.
Proposed injection wells indicated by circles.
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
OIL & GAS OPERATIONS
BASE MAP OF
GRAYBURG COOPERATIVE & UNIT AREA
EDDY COUNTY, NEW MEXICO
DRAWN BY L. M. STEVENSON, JR. ROSWELL, NEW MEXICO
FEBRUARY, 1944
MAP NO.: ROSWELL-30