State of Illinois
Adlai E. Stevenson, Governor
DEPARTMENT OF REGISTRATION AND EDUCATION
C. Hobart Engle, Director

Division of the

STATE GEOLOGICAL SURVEY

M. M. Leighton, Chief

Urbana

CIRCULAR NO. 176

SUMMARY OF WATER-FLOODING OPERATIONS IN ILLINOIS OIL POOLS TO 1951

By

Frederick Squires, and Members of the
Secondary Recovery Study Committee for Illinois,
Secondary Recovery Division, Interstate Oil Compact Commission

Reprint of the Report Published
by the Interstate Oil Compact Commission
1951

Printed by Authority of the State of Illinois

Urbana, Illinois
1951

PREFACE

The Interstate Oil Compact Commission, through its Secondary Recovery Division with Albert E. Sweeney, Jr., Director, and Paul Torrey, Chairman of the Secondary Recovery Advisory Committee, takes pleasure in presenting this "Summary of Water Flooding Operations in Illinois to 1951," the same being a second report on information regarding secondary recovery in the State of Illinois, the first report being designated "Summary Water Flooding Operations in Illinois, 1950" which was published and distributed by the Compact early in 1951. This publication represents the work of the Illinois Secondary Recovery Study Committee, with Frederick Squires as Chairman, acting in cooperation with the representatives of the Compact.

The first report has been in great demand, not only in the State of Illinois, but in most of the other oil and gas producing states, and we believe this report, in connection with the first report, will be of much greater interest and most helpful.

The Interstate Oil Compact Commission wishes to express its appreciation to all companies, organizations and individuals who have assisted in gathering data for this project. It is published in order that the public in general, and the oil industry in particular, may have factual information regarding secondary recovery operations in Illinois.

Earl Foster
Executive Secretary

FOREWORD

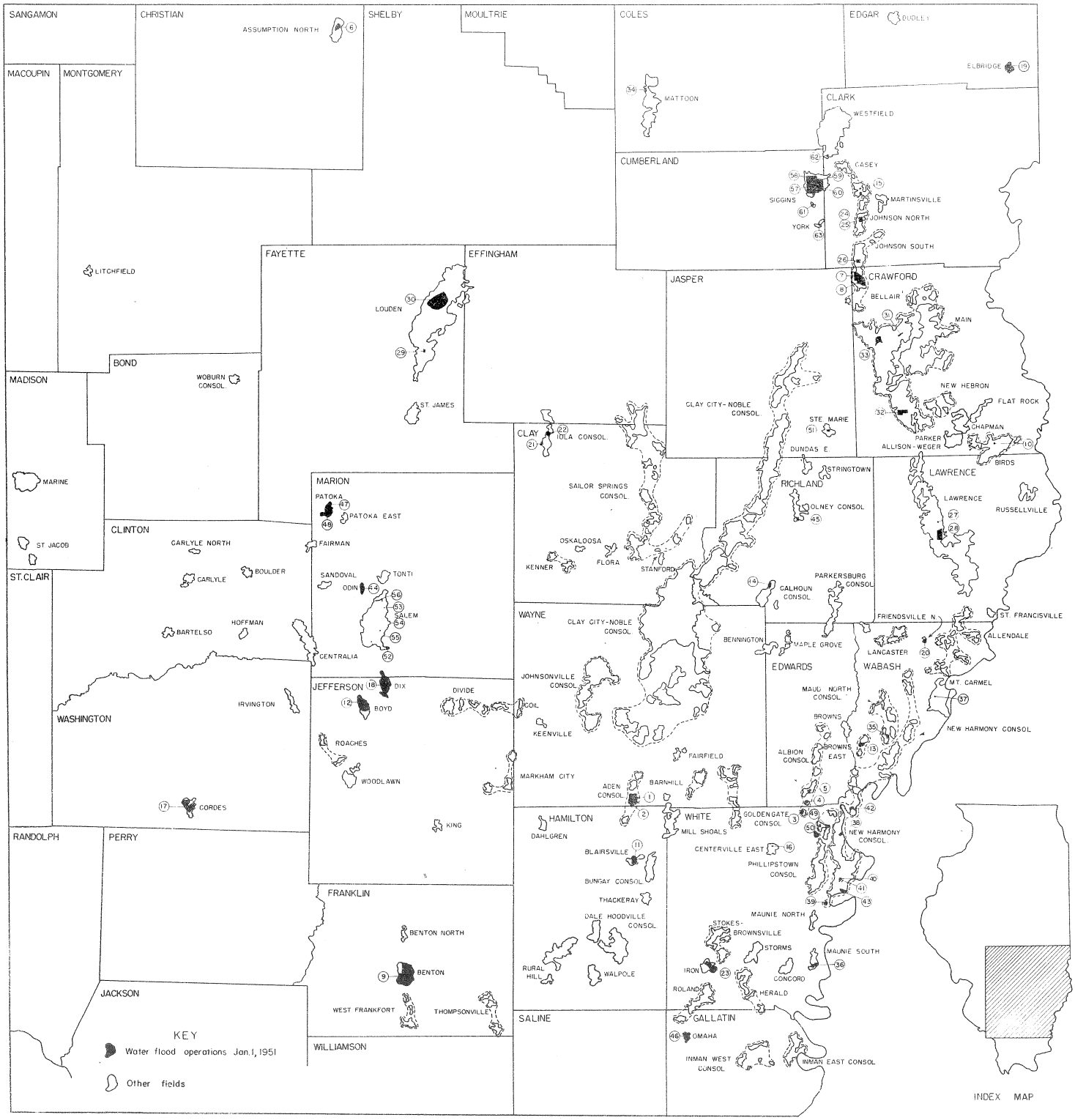
The State of Illinois takes pride in submitting its second report on secondary recovery operations to the Interstate Oil Compact Commission.

It is indeed encouraging to note that the studies and investigations conducted by the Illinois Secondary Recovery Study Committee have shown how oil recovery is being increased in substantial quantity in various fields. The data that are included in this report indicate impressively that there should be many other opportunities in Illinois where these successful results may be duplicated.

Recently Illinois has enacted an oil and gas conservation law which will facilitate the application of methods for the improvement of oil recovery to the fields of the State. The State is eager to promote this work in order that the maximum economic recovery may be obtained from every field. In order that these methods may be applied effectively, the State urges each operator to cooperate actively with the Secondary Recovery Study Committee in order that detailed information may be available to serve as a guide for future operations. It is believed confidently that the producers of oil in Illinois will profit from such cooperation just as the State and its people will be benefited by the employment of measures for the conservation of these valuable resources.

Adlai E. Stevenson
Governor of Illinois

FIGURE 1
INDEX MAP OF WATER-FLOOD OPERATIONS IN ILLINOIS



BY P. A. WITHERSPOON AND P. J. SHANOR

TABLE OF CONTENTS

Page

Preface i

Foreword ii

Introduction 1

Summary of Findings on Illinois Controlled Water Floods 2

Descriptions of Three Water Floods
- Salem Unit 15
- Benton Water Flood by C. V. Cameron 19
- South Johnson Water Flood by R. J. Cassin and Dale E. Parro 31

Water Supply by David H. Swann 41

Table 1. Data for Illinois Controlled Water Floods to January 1, 1951 6

Finis 43

LIST OF ILLUSTRATIONS

Figure

1. Index map of water-flood operations in Illinois iii
2. Structure map of the Illinois Basin 3
3. Generalized geologic column for Southern Illinois 4
4. Index map for counties, townships, and ranges 5
5. The Salem Unit, Devonian flood.
   A. Development map of Devonian lime B. Structure map on Devonian lime 16
6. The Salem Unit, McClosky flood 17
7. The Salem Unit, Benoist flood
   A. Development map of Benoist sand B. Structure map on Benoist sand 18
8. Structure map of Benton field, contours on Tar Springs formation 21
9. Cross sections of Benton field 22
10. Isopach map of Tar Springs sandstone showing effective pay thickness above 1,695 feet, subsea 23
11. Daily average oil production of entire Benton field 24
12. Water injection system layout 25
13. Produced fluid return system layout 26

LIST OF ILLUSTRATIONS

Figure — Page

14. Flow diagram of water-flood system 27

15. Average daily production and water injection for Benton flood unit 28

16. Details of flood performance over 13 months of operation 29

17. Formation fill-up map as of December 1, 1950 30

18. Index map of South Johnson flood 32

19. Structure on Upper Partlow sand, South Johnson flood 33

20. Permeability contours on Upper Partlow sand, South Johnson flood 34

21. Geologic column, South Johnson water-flood area 35

22. Flood performance graphs. Siggins-First and Second Siggins Sand, and Bellair-Bellair "500-foot" sand 36

23. Flood performance graphs, Albion, Aden, Friendsville North, and Patoka 37

24. Flood performance graphs of Grayville West, Browns East, Johnson South, Maunie South, New Harmony Consolidated 38

25. Flood performance graph of Patoka field (Benoist sand) 39

26. Map of Illinois Basin oil fields showing positions of surface streams relative to oil pools 40

27. Areas of possible fresh water-bearing sands and gravels and the known areas of Pennsylvanian sandstones that contain fresh water 42

SUMMARY OF WATER-FLOODING OPERATIONS IN ILLINOIS TO 1951

INTRODUCTION

Early in 1951, the Secondary Recovery Study Committee for Illinois, set up in 1949, was continued by Earl Foster, Executive Secretary, Interstate Oil Compact Commission, in order to bring up to 1951 the report entitled "Summary of Water-Flooding Operations in Illinois to 1950" already published and distributed. The report that follows is the result of the work done by this committee.

THE COMMITTEE

Frederick Squires, Chairman
Illinois State Geological Survey
Natural Resources Building
Urbana, Illinois

Hugh S. Barger
304 Locust Street
Evansville, Indiana

A. H. Bell
Illinois State Geological Survey
Natural Resources Building
Urbana, Illinois

C. V. Cameron
Shell Oil Company
Centralia, Illinois

W. S. Corwin
Tide Water Associated Oil Company
Keensburg, Illinois

R. E. Dunn
Magnolia Petroleum Company
P. O. Box 501
Salem, Illinois

Paul Phillippi
Forest Oil Corporation
Casey, Illinois

Mark Plummer
The Pure Oil Company
Olney, Illinois

R. J. Cassin, Secretary
Forest Oil Corporation
Casey, Illinois

L. C. Powell
The Ohio Oil Company
Terre Haute, Indiana

Paul J. Shanor
Illinois State Geological Survey
Natural Resources Building
Urbana, Illinois

Harry Swaneck
Gulf Refining Company
Centralia, Illinois

Ray Vincent
Sohio Petroleum Company
Box 352
Centralia, Illinois

E. C. Wells
Carter Oil Company
Mattoon, Illinois

Bob Wilson
Tide Water Associated Oil Company
Robinson, Illinois

M. R. Wilson
The Texas Company
Salem, Illinois

Paul A. Witherspoon
Illinois State Geological Survey
Natural Resources Building
Urbana, Illinois

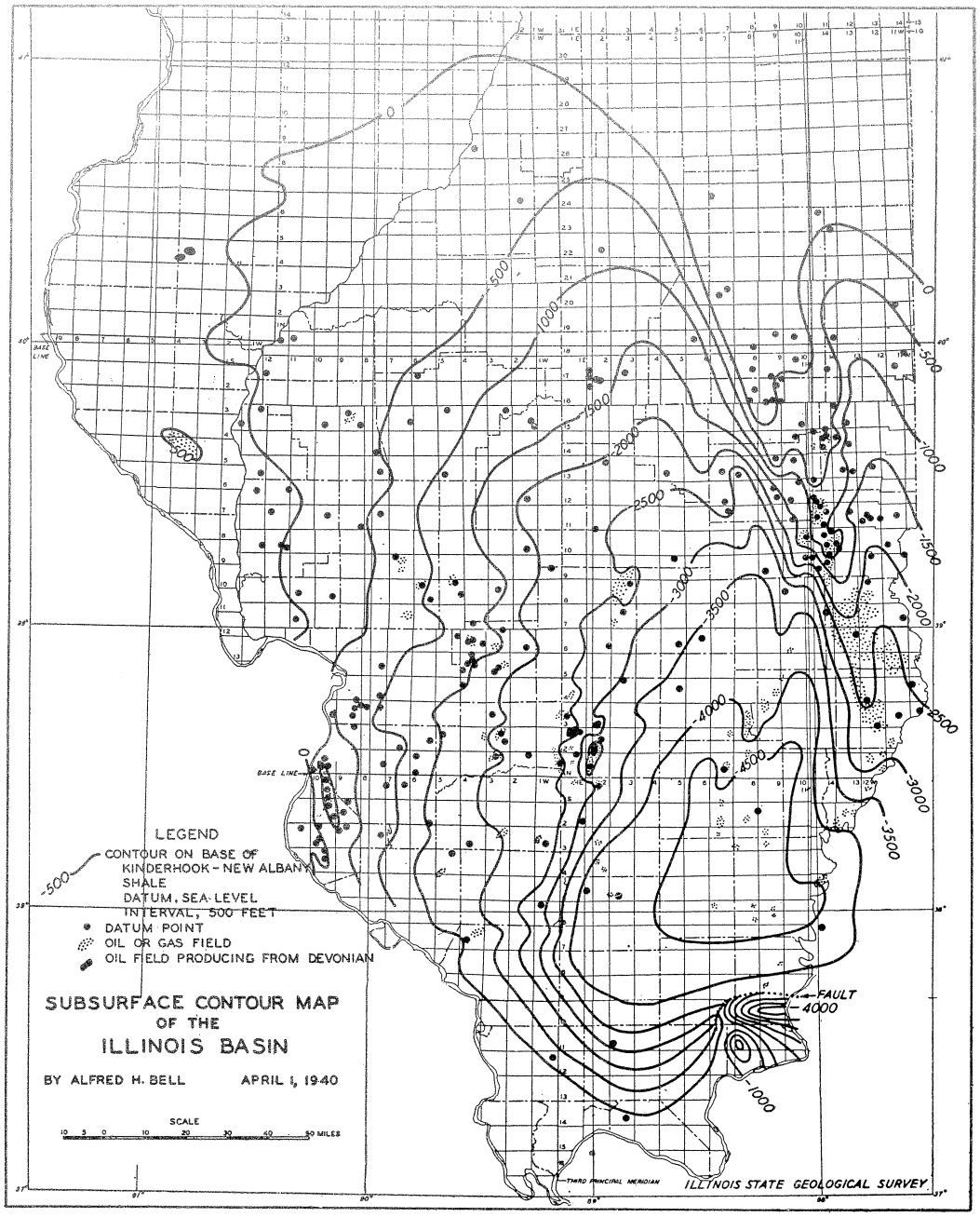
As a result of this study, it was found that the number of active controlled water-flood operations had more than doubled (from 31 to 63) since the preceding report (see map Fig. 1). Summary data for these 63 floods are given in Table 1, "Data for Illinois Controlled Water-Floods to January 1, 1951." Oil production and water input and output graphs for 12 floods are

included. Three floods have been selected for more detailed discussion herein, namely: (1) Salem Unit, (2) Benton, and (3) South Johnson. Descriptions of uncontrolled flooding operations have been omitted from this report because data for these were not available.

SUMMARY OF FINDINGS ON ILLINOIS CONTROLLED WATER FLOODS

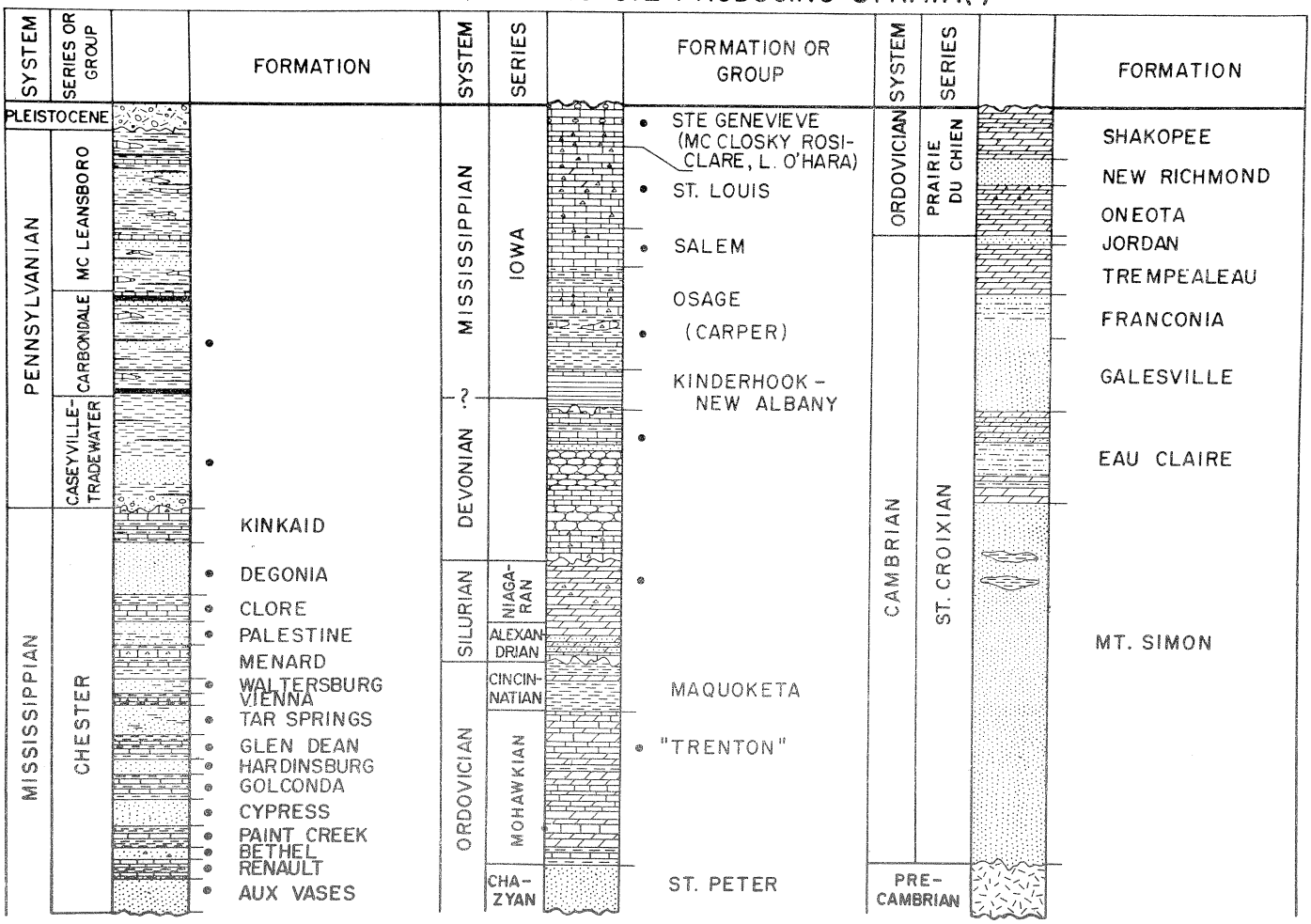
On January 1, 1951, Illinois had 63 active controlled floods (Table 1). These, together with the many McClosky dump floods, have produced more than 20,000,000 barrels of flood oil. This oil was obtained from sands having an average thickness of about 18 feet. Porosities averaged about 18 per cent and permeabilities approximately 176 millidarcys. The fluid saturations at the start of flooding averaged 45 per cent oil and 31 per cent water. The ratio of water input to oil produced was about 7 to 1 at the end of 1950.

FIGURE 2
STRUCTURE MAP OF THE ILLINOIS BASIN



FROM "DEVELOPMENTS IN EASTERN INTERIOR BASIN 1939 AND FIRST QUARTER OF 1940"
BY ALFRED H. BELL
BULL. A.A.P.G. V24, NO. 6, JUNE 1940, P 963

FIGURE 3
GENERALIZED GEOLOGIC COLUMN FOR SOUTHERN ILLINOIS
SHOWING OIL PRODUCING STRATA(•)



ILLINOIS STATE GEOLOGICAL SURVEY

FIGURE 4

INDEX MAP FOR COUNTIES, TOWNSHIPS, AND RANGES

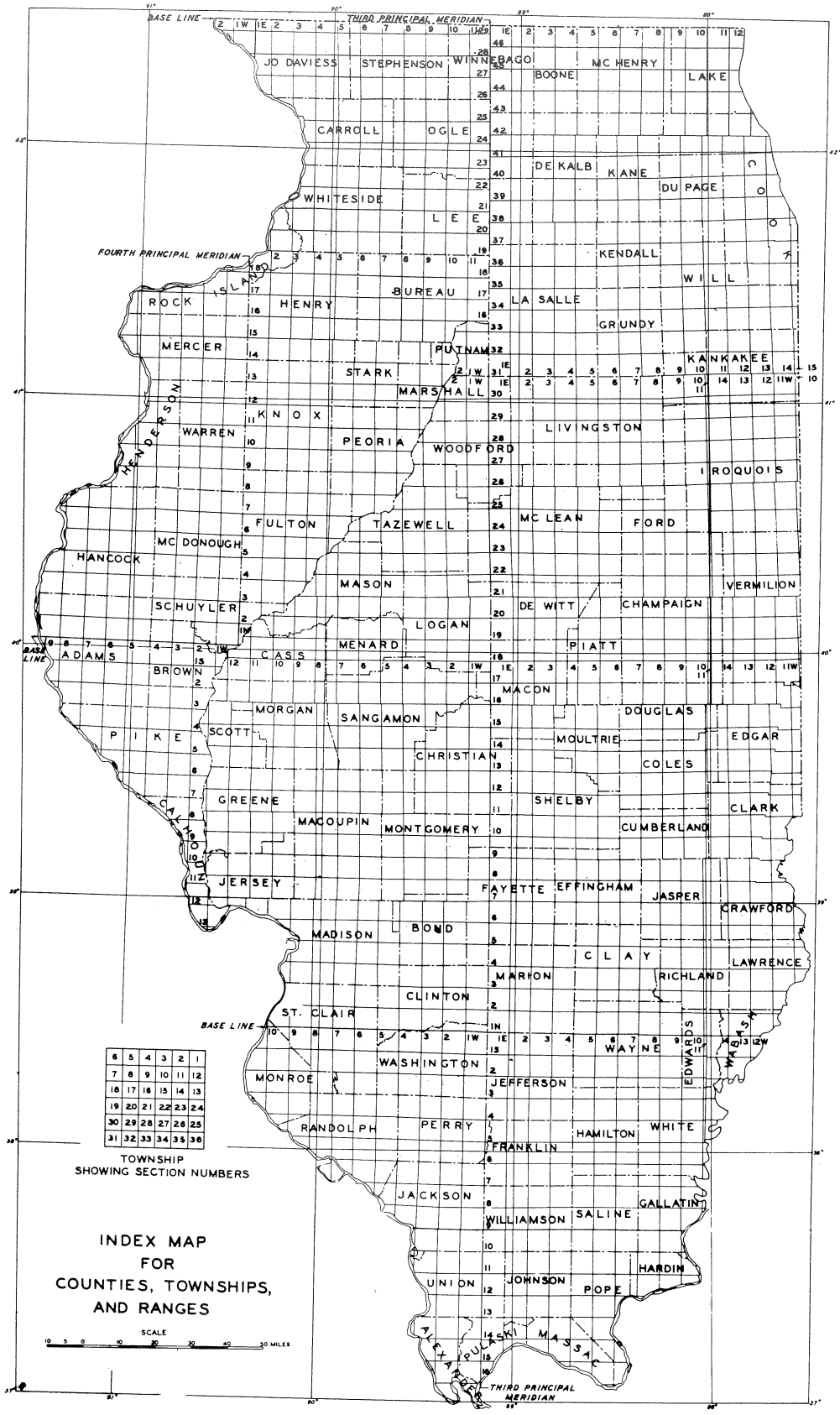


TABLE I
DATA FOR ILLINOIS CONTROLLED WATER FLOODS TO JANUARY 1, 1951 *

Line No.	Field	County	Project	Water-Flood Pay	Average Depth to Water-Flood Pay	Operator	Date of First Water Input
1	Aden Consolidated	Wayne	Aden	Aux Vases	3,200	Texas	Aug. 46
2	Aden Consolidated	Wayne	Aden	McClosky	3,350	Texas	Aug. 46
3	Albion Consolidated	Edwards, White	Biehl Unit #1	Upper Biehl	2,000	Yingling	Aug. 49
4	Albion Consolidated	Edwards, White	Biehl Unit #2	Biehl	1,950	Yingling	Dec. 50
5	Albion Consolidated	Edwards, White	So. Albion Bridgeport	Bridgeport	1,900	Superior	Aug. 46
6	Assumption North	Christian	Assumption Benoist	Benoist	2,750	Nat'l. Assoc.	Jun. 50
7	Bellair	Crawford	Forest - Bellair	Bellair "500"	550	Forest	Jul. 48
8	Bellair	Crawford	Fulton	Bellair "500"	560	Pure	Jul. 48
9	Benton	Franklin	Benton	Tar Springs	2,100	Shell	Nov. 49
10	Birds	Crawford	J. W. Lindsay	Robinson	960	Yingling	Aug. 50
11	Blairsville	Hamilton	Blairsville	Aux Vases	3,275	Texas	Jun. 48
12	Boyd	Jefferson	Boyd Repressure	Bethel	-	Superior	Jun. 45
13	Browns East	Wabash	Bellmont North	Cypress	2,600	Magnolia	Nov. 47
14	Calhoun Consolidated	Richland	Bohlander Lease	McClosky	3,150	Phillips	Jun. 50
15	Casey	Clark	Casey	Casey	450	Forest	Mar. 50
16	Centerville East	White	East Centerville	Tar Springs	2,530	Sun	Oct. 50
17	Cordes	Washington	Cordes	Benoist	1,230	Shell et al.	Aug. 50
18	Dix	Jefferson	Dix Pressure Maintenance	Benoist	-	Carter	Jan. 48
19	Elbridge	Edgar	Elbridge	Fredonia	-	Nat'l. Assoc.	-
20	Friendsville North	Wabash	Friendsville North	Biehl	1,500	Magnolia	Jul. 47
21	Iola Consolidated	Clay	Iola East	Aux Vases	2,350	Texas	Mar. 48
22	Iola Consolidated	Clay	Iola North	Weiler	-	Texas	Apr. 48
23	Iron	White	Iron Unit	Hardinsburg	2,500	Shell	Dec. 50
24	Johnson North	Clark	Clark County #1	Casey	-	Tidewater	Feb. 50
25	Johnson North	Clark	McMahon	Casey	450	McMahon	May 49
26	Johnson South	Clark	South Johnson	Upper Partlow	490	Forest	Mar. 49
27	Lawrence	Lawrence	Griggs Bridgeport #1	Kirkwood	1,350	Ohio	Jul. 47
28	Lawrence	Lawrence	Robins Bridgeport #2	Bridgeport	900	Ohio	Aug. 48
29	Louden	Fayette, Effingham	Louden Cypress	Cypress Press. Main	-	Carter	-
30	Louden	Fayette, Effingham	Louden Devonian	Devonian	-	Carter	Sept. 43
31	Main	Crawford	Ikemire-Henry	Robinson	935	Tidewater	Feb. 48
32	Main	Crawford	Hughes Robinson #3	Robinson	890	Ohio	Sept. 48
33	Main	Crawford	Wilkin Robinson #2	Robinson	950	Ohio	May 48
34	Mattoon	Coles	Mattoon Lease	Rosiclare	2,000	Phillips	Oct. 50
35	Maud North Consolidated	Wabash	West Maud	Benoist	2,750	Skiles	Oct. 50

*Information obtained by all members of the committee and arranged by R. J. Cassin.

As of January 1, 1951					1950				Cumulative Production and Input to January 1, 1951			
Acres Flooded	Total Acres Water-Flood Pay In Field	No. of Wells Producers	No. of Wells Input	Average Well Head Pressure	Water Flood Oil Production	Water Production	Water Input	Average Input Barrels Per Day Per Well Per Foot of Pay	Water Flood Oil Production	Water Production	Water Input	Line No.
30	800	10	6	1,210	55,014	17,394	426,094	19.5	83,996	52,299	921,594	1
30	2,300	10	6	-	-	-	-	-	-	-	-	2
172	-	10	2	600	96,000	-	400,000	32.0	115,507	-	502,318	3
68	1,000	6	1	-	-	-	-	-	-	-	-	4
378	-	14	3	200	-	-	180,000	8.3	-	-	601,100	5
270	400	27	13	-	-	-	-	-	-	-	-	6
200	1,000	51	56	285	96,634	-	2,291,860	2.9	125,415	-	5,007,028	7
443	1,000	125	131	265	148,389	1,007,810	4,277,541	4.0	201,463	1,149,145	8,214,252	8
1,900	2,200	120	84	320	None	230,928	9,663,381	8.5	None	239,601	10,478,994	9
29	4,500	15	9	-	None	None	191,266	5.0	None	None	191,266	10
100	730	16	2	600	16,696	15,212	243,288	21.4	20,459	28,754	487,741	11
1,800	1,800	58	3	-	-	-	472,855	22.6	-	-	3,714,733	12
174	480	11	3	-	85,960	8,100	117,210	9.7	252,613	9,018	352,519	13
60	-	11	2	-	None	7,306	46,376	6.4	None	7,300	46,376	14
55	1,540	11	13	250	17,400	35,000	452,475	11.6	17,400	35,000	452,475	15
-	380	5	1	10	None	None	2,372	5.3	None	None	2,372	16
640	1,100	70	35	160	9,937	101,011	586,966	8.2	9,937	101,011	586,966	17
-		-	-	-	-	-	-	-	-	-	-	18
-	360	-	-	-	-	-	-	-	-	-	-	19
40	120	3	2	918	21,400	22,907	57,879	11.2	91,789	37,715	159,951	20
40	1,300	3	1	810	1,721	8,006	68,984	27.0	4,444	22,510	131,204	21
70	430	6	1	675	6,463	52,868	65,761	-	16,794	-	201,932	22
390	430	21	19	-	-	-	-	-	-	-	-	23
40	900	5	12	-	8,039	35,500	390,750	-	8,039	35,500	390,750	24
200	900	-	-	-	-	-	-	-	-	-	-	25
160	1,700	15	36	250	89,243	-	2,204,652	3.5	150,828	-	3,279,315	26
35	16,200	-	-	-	-	-	-	-	-	-	-	27
328	5,050	-	-	-	-	-	1,656,782	-	-	-	2,021,568	28
-	-	-	-	-	-	-	-	-	-	-	-	29
-	-	-	-	-	-	-	-	-	-	-	-	30
54	34,320	13	16	350	66,000	66,560	296,500	5.5	111,000	92,000	639,000	31
325	34,320	-	-	-	-	-	805,242	-	-	-	1,024,165	32
242	34,320	-	-	-	-	-	1,591,489	-	-	-	2,306,383	33
10	3,700	5	1	-	None	2,941	2,941	3.9	None	2,941	2,941	34
110	-	4	7	-	-	-	-	-	-	-	57,620	35

TABLE I (Continued)

DATA FOR ILLINOIS CONTROLLED WATER FLOODS TO JANUARY 1, 1951

Line No.	Input Water			Number of Old Wells Used As		Are Wells		Flood Pay			At Start Of Water Flood Per Cent Of Pore Space Saturated 1/	
	Type	Source	Chemically Treated	Producers	Inputs	Cored	Shot	Net Thickness Feet	Average Porosity Per Cent	Average Permeability Millidarcys	Oil	Water
1	Brine	Penn. Sand	Yes	10	3	Yes	Yes	10.0	22.0	150	-	42.0
2	Brine	Penn. Sand	Yes	10	3	Yes	No	3.6	-	-	-	-
3	Brine	Penn. Sand	Yes	10	1	Yes	Yes	17.1	20.2	265	21.0	23.6
4	Brine	Penn. Sand	Yes	6	1	Yes	Yes	22.0	19.3	303	-	27.7
5	Brine	Produced	No	14	3	Yes	Yes	20.0	19.7	304	16.0	26.0
6	Brine	Penn. Sand	No	-	-	Yes	Yes	12.0	-	-	-	-
7	Fresh	Gravel Bed	No	9	0	Yes	Yes	38.0	17.1	148	35.5	42.7
8	Fresh	Gravel Bed	Yes	47	2	Yes	Yes	22.0	18.6	149	35.9	43.4
9	Fresh	Lake	Yes	119	83	Yes	Yes	37.0	19.0	65	50.6	25.0
10	Brine	1,300 Ft. Sand	Yes	9	0	Yes	Yes	31.0	19.1	135	27.9	37.9
11	Brine	Lower Weiler	No	12	2	Yes	Yes	15.5	19.0	92	-	-
12	Brine	Produced	No	58	0	Yes	Yes	19.0	17.5	175	17.5	28.0
13	Brine	Cypress	No	11	3	Yes	Yes	11.0	18.0	144	83.0	15.0
14	Brine	Cypress	No	11	2	Yes	No	10.0	11.2	68	50.0	20.0
15	Fresh	Gravel Bed	No	2	0	Yes	Yes	10.0	17.4	173	32.0	50.0
16	Fresh	Gravel Bed	Yes	5	1	No	Yes	6.0	-	-	-	-
17	Brine	Pottsville	Yes	70	35	Yes	Yes	14.0	20.0	250	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	Fresh	300 Ft. Penn. Sand	No	3	1	Yes	Yes	7.0	16.0	81	76.0	18.0
21	Brine	Produced	No	2	1	Yes	Yes	7.0	15.7	80	-	-
22	Brine	Produced	No	6	1	No	Yes	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	Fresh	Gravel Bed	No	4	1	Yes	Yes	17.0	20.0	425	41.0	40.0
25	-	-	-	-	-	-	-	-	-	-	-	-
26	Brine	Produced	Yes	9	0	Yes	Yes	48.0	16.6	319	33.6	55.0
27	-	-	-	-	-	-	-	-	-	-	-	-
28	Fresh	Gravel Bed	No	75	2	Yes	Yes	52.0	21.6	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
31	Brine	Penn. Sand	No	6	1	Yes	Yes	14.0	21.0	175	40.0	15.0
32	Fresh	Gravel Bed	No	72	2	Yes	Yes	25 to 45	20.1	-	-	-
33	Fresh	Gravel Bed	No	70	0	Yes	Yes	22.0	22.0	-	-	-
34	Brine	Produced	No	5	1	Yes	Yes	10.0	15.0	992	45.0	-
35	-	-	-	-	-	-	-	-	-	-	-	-

Oil Characteristics					
Viscosity Centipoises	API Gravity	Water-Flood Pattern	Input to Oil Well Distance	Remarks	Line No.
-	35.4	Perimeter	1,300	Wells are dual Aux Vases & McClosky completions - production not separated	1
-	35.4	Perimeter	1,300	Wells are dual Aux Vases & McClosky completions - production not separated	2
5.3 at 88° F.	38.0	Flank Inj.	-		3
6.0 at 84° F.	35.8	Flank Inj.	-		4
6.3 at 95° F.	32.5	Perimeter	660		5
-	38.0	Perimeter	-		6
16.0 at 77° F.	32.4	5-spot	310	Flowing Flood	7
18.7 at 77° F.	32.0	5-spot	310	Flowing Flood	8
3.5 at 86° F.	38.0	5-spot	660	Water-flood oil production considered that production in excess of normal decline extrapolated prior to conversion of producers to input wells #	9
17.0 at 80° F.	31.6	5-spot	300	Pilot Flood	10
4.3 at 99° F.	37.0	Perimeter	930		11
-	-	Flank	1,960	Several pays in field - separate production figures not available	12
4.6 at 92° F.	36.0	Line	1,500	Based on well cored with oil	13
-	36.0	5-spot	935		14
16.6 at 70° F.	31.9	5-spot	300		15
-	38.0	Spot	660	Pilot Flood	16
-	37.0	5-spot	660	Cooperative, Horton, McBride, Magnolia, Shell	17
-	-	-	-		18
-	-	Perimeter	-		19
7.5 at 86° F.	35.6	Approx. 5-spot	500	Based on well cored with oil	20
-	37.0	Spot	1,200	Pilot Flood	21
-	35.8	Spot	-	Pilot Flood	22
-	36.0	5-spot	660		23
-	32.0	5-spot	-	440 by 660 5-spot	24
-	-	-	-	Formerly operated by Pickens	25
14.7 at 77° F.	29.2	5-spot	310	Flowing Flood	26
-	-	-	-	Discontinued October, 1950	27
-	-	Irregular 5-spot	467	Net pay and porosity are 1949 figures	28
-	-	-	-		29
-	-	-	-		30
7.0 at 60° F.	35.0	5-spot	300	440 by 660 5-spot	31
-	-	5-spot	311 & 468	440 and 660 5-spots	32
-	-	5-spot	311 & 468	440 and 660 5-spots	33
-	36.8	Flank	660	Returning lease water only - pressure maintenance	34
-	-	-	-		35

#Actual production 1950, 470,813 barrels. Cumulative to 1951, 488,979 barrels.

TABLE I (Continued)
DATA FOR ILLINOIS CONTROLLED WATER FLOODS TO JANUARY 1, 1951

Line No.	Field	County	Project	Water-Flood Pay	Average Depth to Water-Flood Pay	Operator	Date of First Water Input
36	Maunie South	White	Tar Springs Unit	Tar Springs	2,200	Magnolia	Aug. 47
37	Mt. Carmel	Wabash	First Nat'l. Pet. Trst.	Biehl	1,350	1st Nat'l. Pet. Trst.	Jan. 50
38	New Harmony Cons.	White, Wabash, Edwards	Evans Lease	Aux Vases	2,800	Tidewater	Oct. 49
39	New Harmony Cons.	White, Wabash, Edwards	Ford "A" Lease	McClosky	2,900	Sun	May 48
40	New Harmony Cons.	White, Wabash, Edwards	Greathouse	Bethel	2,750	Sun	Jan. 49
41	New Harmony Cons.	White, Wabash, Edwards	Greathouse	McClosky	2,900	Sun	Aug. 47
42	New Harmony Cons.	White, Wabash, Edwards	Helm Lease	Waltersburg	2,150	Luboil	Dec. 50
43	New Harmony Cons.	White, Wabash, Edwards	Waltersburg	Waltersburg	2,220	Superior	Aug. 46
44	Odin	Marion	Odin	Cypress	1,700	Ashland	Oct. 49
45	Olney Consolidated	Richland	Olney	McClosky	3,060	Texas	Nov. 46
46	Omaha	Gallatin	Omaha Press. Maintenance	Palestine	-	Carter	Oct. 44
47	Patoka	Marion	Patoka Benoist	Benoist	1,410	Sohio	Sep. 43
48	Patoka	Marion	Patoka Rosiclare	Rosiclare	1,550	Sohio	- 48
49	Phillipstown Cons.	White, Edwards	Calvin North	Biehl	1,800	Magnolia	Sept. 47
50	Phillipstown Cons.	White, Edwards	North Calvin	Penn. Sand	-	British-American	Jun. 49
51	Ste. Marie	Jasper	Ste. Marie	McClosky	2,860	Lebow	Oct. 48
52	Salem	Marion	Rosiclare Sand Unit	Rosiclare	2,093	Texas	Apr. 50
53	Salem	Marion	Salem Unit	Benoist	1,800	Texas	Oct. 50
54	Salem	Marion	Salem Unit	Renault	1,800	Texas	Oct. 50
55	Salem	Marion	Salem Unit	Aux Vases	1,800	Texas	Oct. 50
56	Salem	Marion	Salem Unit	Devonian	3,400	Texas	Oct. 50
	(Salem Unit Totals) -		-	-	-	-	-
57	Siggins	Clark, Cumberland	Queen Lease	Siggins	450	Bell	-
58	Siggins	Clark, Cumberland	Siggins	First Siggins	400	Forest	- 42
59	Siggins	Clark, Cumberland	Union Group	First Siggins	400	Pure	Dec. 46
60	Siggins	Clark, Cumberland	Union Group	Second Siggins	465	Pure	Dec. 46
61	Siggins	Clark, Cumberland	Vevay Park	Lower Siggins	600	Partlow	-
62	Westfield	Clark, Coles	Parker	Penn. "Gas" Sand	270	Forest	Jun. 50
63	York	Cumberland	York	Penn. Sand	-	Partlow	-

1/ Based on several different methods of coring and core analysis.

Totals - Reported Data

Totals - Non-reported Data - Estimated

Totals Controlled Floods

Totals McClosky Dump Floods

Totals All Floods

Averages of Reported Data

As of January 1, 1951					1950				Cumulative Production and Input to January 1, 1951			
Acres Flooded	Total Acres Water-Flood Pay In Field	No. of Wells Producers	No. of Wells Input	Average Well Head Pressure	Water Flood Oil Production	Water Production	Water Input	Average Input Barrels Per Day Per Well Per Foot of Pay	Water Flood Oil Production	Water Production	Water Input	Line No.
280	410	15	14	660	144,620	447,980	640,410	8.0	687,683	517,178	1,796,755	36
-	600	-	1	-	-	-	-	-	-	-	-	37
40	5,000	3	1	-	-	-	-	-	-	-	-	38
40	3,900	1	1	50	5,428	-	12,538	4.9	8,024	-	37,432	39
130	5,000	10	6	1,325	9,945	66,816	310,500	6.1	10,426	70,731	541,032	40
60	3,900	1	1	1,450	3,663	56,167	108,206	59.0	17,765	76,690	367,544	41
-	100	3	3	200	0	0	8,000	7.0	0	0	8,000	42
490	600	-	-	-	-	-	-	-	-	-	-	43
196	290	22	10	255	44,286	None	255,103	4.7	44,286	None	268,980	44
65	2,100	1	1	660	12,037	84,803	246,271	67.5	37,697	108,723	591,147	45
-	-	-	-	-	-	-	-	-	-	-	-	46
527	920	72	66	-	254,000	3,493,000	4,124,167	6.3	5,659,226	12,188,000	19,676,091	47
476	476	11	14	-	317,000	108,000	590,411	12.9	512,000	487,000	954,464	48
10	800	8	1	1,370	16,247	11,603	43,493	10.8	56,247	20,909	123,183	49
-	800	-	6	-	-	-	-	-	-	-	-	50
240	720	2	1	-	3,702	40,911	337,940	92.0	19,010	72,280	696,344	51
100	-	6	3	185	5,005	1,620	125,617	11.6	5,005	1,620	125,617	52
-	-	-	2	-	-	-	-	-	-	-	-	53
-	-	-)		-	-	-	-	-	-	-	-	54
-	-	-)	2	-	-	-	-	-	-	-	-	55
-	-	-	8	-	-	-	-	-	-	-	-	56
-	8,000	-	12	-	717	-	461,849	-	717	-	461,849	
-	3,200	-	-	-	-	-	-	-	-	-	-	57
1,400	3,200	276	343	200	669,172	1,800,000	3,765,841	1.0	3,166,944	7,000,000	18,063,901	58
402	3,200	121	127	245	402,436	1,089,699	1,428,807	1.2	1,090,870	2,205,032	5,450,761	59
269	350	-	-	-	See Remarks				-	-	-	60
-	1,000	-	-	-	-	-	-	-	-	-	-	61
10	9,000	0	9	125	None	None	102,021	2.3	None	None	102,021	62
-	350	-	-	-	-	-	-	-	-	-	-	63
13,128	207,196	1,197	1,097	-	2,607,154	8,812,142	39,053,838		12,525,584	24,560,957	91,039,684	
1,000	10,000	-	-	-	500,000	2,000,000	5,000,000	-	1,300,000	3,000,000	8,000,000	
14,128	217,196				3,107,154	10,812,142	44,053,838		13,825,584	27,560,957	99,039,684	
					1,500,000	3,500,000	6,000,000		6,500,000	12,000,000	25,000,000	
					4,607,154	14,312,142	50,053,838		20,325,584	39,560,957	124,039,684	

TABLE I (Continued)

DATA FOR ILLINOIS CONTROLLED WATER FLOODS TO JANUARY 1, 1951

Line No.	Input Water: Type	Input Water: Source	Input Water: Chemically Treated	Number of Old Wells Used As: Producers	Number of Old Wells Used As: Inputs	Are Wells: Cored	Are Wells: Shot	Flood Pay: Net Thickness Feet	Flood Pay: Average Porosity Per Cent	Flood Pay: Average Permeability Millidarcys	At Start Of Water Flood Per Cent Of Pore Space Saturated 1/: Oil	At Start Of Water Flood Per Cent Of Pore Space Saturated 1/: Water
36	Brine	Tar Springs	No	15	14	Yes	Yes	15.7	18.5	529	73.0	17.0
37	-	-	-	-	-	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-
39	Fresh	Gravel Bed	No	1	1	Yes	Yes	7.0	-	-	-	-
40	Fresh	Gravel Bed	Yes	10	5	Yes	Yes	23.2	18.0	20	-	30.0
41	Fresh	Gravel Bed	Yes	1	1	Yes	No	5.0	-	-	-	-
42	Fresh	Gravel Bed	Yes	1	0	Yes	Yes	15.0	19.0	150	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-
44	Brine	Tar Springs	Yes	17	8	Yes	Yes	15.0	20.0	78	-	-
45	Brine	Produced	No	2	1	No	No	10.0	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	-	-
47	Brine	Tar Springs	Yes	32	10	Yes	Yes	27.0	19.0	110	53.0	20.0
48	Brine	Tar Springs	Yes	3	4	Yes	Yes	9.0	18.8	223	65.0	30.0
49	Brine	Penn. Sand	No	-	0	Yes	Yes	11.0	19.0	85	69.0	18.0
50	-	-	-	-	-	-	-	-	-	-	-	-
51	Brine	Cypress	No	2	1	No	No	10.0	-	-	-	-
52	Brine	Penn. Sand	No	6	3	Yes	Yes	14.0	11.5	43	56.3	31.0
53	Brine	Produced	No	-	-	Yes	Yes	28.0	17.9	150	47.6	17.4
54	Brine	Produced	No	-	-	Yes	Yes	7.0	16.5	18	43.8	23.7
55	Brine	Produced	No	-	-	Yes	Yes	26.0	16.3	28	44.7	24.1
56	Brine	Produced	No	-	-	Yes	No	19.0	16.8	300	43.9	17.7
	Brine	Produced	No	2,021	12	-	-	-	-	-	-	-
57	-	-	-	-	-	-	-	-	-	-	-	-
58	Brine	Fresh & Produced	Yes	184	0	Yes	Yes	32.0	17.5	56	36.7	46.7
59	Fresh	Gravel Beds	Yes	92	2	Yes	Yes	25.0	18.5	45	29.8	52.2
60	Fresh	Gravel Beds	Yes	-	-	Yes	Yes	6.0	18.3	66	26.7	52.5
61	-	-	-	-	-	-	-	-	-	-	-	-
62	Fresh	Gravel Beds	No	-	0	Yes	Yes	25.0	17.9	153	43.2	37.0
63	-	-	-	-	-	-	-	-	-	-	-	-
	Totals - Reported Data			3,042	211							
	Averages of Reported Data							18.5	18.0	176	45.3	31.2

Oil Characteristics					
Viscosity Centipoises	API Gravity	Water-Flood Pattern	Input to Oil Well Distance	Remarks	Line No.
4.6 at 89° F.	37.3	5-spot	660	Saturation corrected for invasion	36
-	-	-	-		37
-	-	-	-		38
-	38.0	Spot	940		39
-	38.0	5-spot	940		40
-	35.0	Spot	940		41
-	-	5-spot	400		42
-	-	-	-		43
8.3 at 69° F.	38.0	Perimeter	660		44
-	-	Perimeter	1,050		45
-	-	-	-		46
-	39.0	5-spot	460	Saturation corrected for invasion	47
4.1	40.0	Perimeter	-	Saturation corrected for invasion - 3 producing wells now temporarily abandoned	48
11.2 at 78° F.	32.2	Spot	550	Saturation corrected for invasion	49
-	-	-	-		50
-	-	Spot	1,200	Data from other operators unreported	51
-	36.5	Flank	935		52
-	-	-	-		53
-	-	-	-	Common injection into Renault and Aux Vases	54
-	-	-	-		55
-	-	-	-		56
-	37.0	Spot	-	Test Flood of each formation	
-	-	-	-		57
8.0 at 60° F.		5-spot	310		58
8.8 at 68° F.	36.6	5-spot	310	Production and input shown is that of both first and second Siggins sand	59
8.8 at 68° F.	36.0	5-spot	310		60
-	-	-	-		61
54.0 at 60° F.	28.1	5-spot	233	Producing wells not yet drilled	62
-	30.3	-	-		63
	35.5		700		

DESCRIPTIONS OF THREE WATER FLOODS

SALEM UNIT

Development drawings for this unitized project are shown to call attention to the great areal extent of territory and the large number of wells which will eventually be subjected to flooding.

The Salem Unit is by far the largest unitized field in Illinois and it represents a fine accomplishment in cooperation between a large number of operators and a really vast number of royalty owners.

Flooding before January 1, 1951, was confined to three horizons, the Devonian, the Aux Vases, and the Bethel. The McClosky is shown so as to cover the entire eventual floodable area of the field, even though water was not injected until after January 1, 1951.

The Devonian is operated with eight injection wells. 200,000 barrels of water per month from the Tar Springs and Pennsylvanian sands are being injected under gravity pressure.

There are two Benoist injection wells with an average monthly injection of 28,000 barrels into an average of 49 feet of pay at an average wellhead pressure of 159 pounds. The total water injected up to January 1, 1951, is 68,000 barrels.

The Aux Vases sand is being subjected to water injection through two wells at an average monthly rate of 33,000 barrels, into an average pay thickness of 86 feet under wellhead pressure of 28 pounds, for a total volume of injected water up to January 1, 1951, of 56,000 barrels.

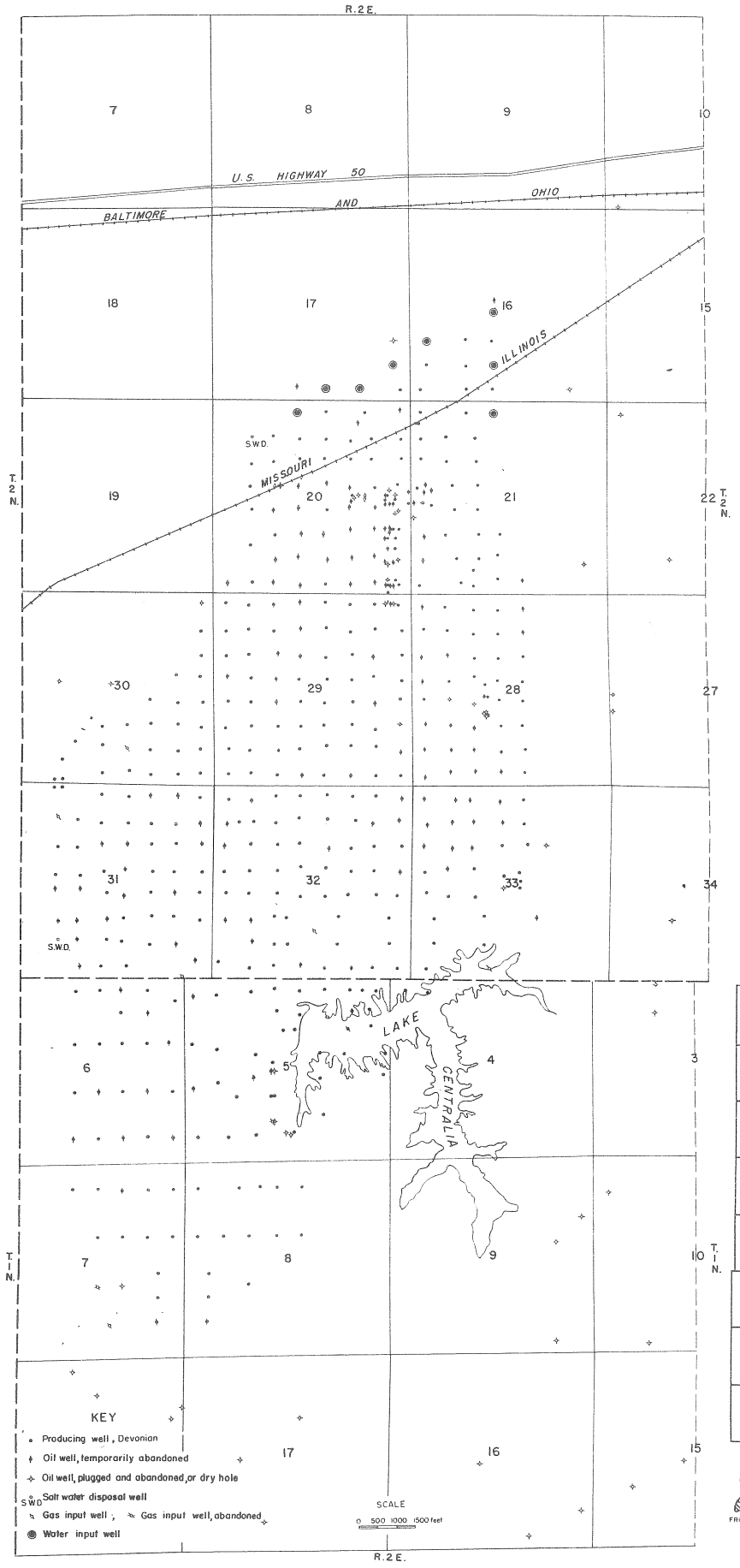
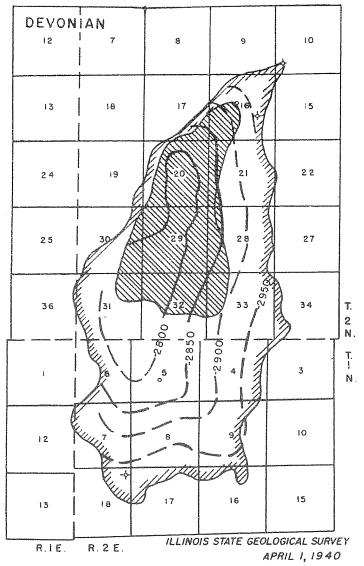


FIGURE 5
THE SALEM UNIT
DEVONIAN FLOOD

A. DEVELOPMENT MAP OF DEVONIAN LIME

B. STRUCTURE MAP ON DEVONIAN LIME



ILLINOIS STATE GEOLOGICAL SURVEY
APRIL 1, 1940

BOUNDARY OF PRODUCTION FROM MISSISSIPPIAN

AREA PROVED FOR DEVONIAN PRODUCTION

DEVONIAN WELL SHOWING OIL

DEVONIAN DRY HOLE

FROM "DEVELOPMENTS IN EASTERN INTERIOR BASIN" BY ALFRED H BELL
A.A.P.G. BULL. V 24, NO 6, JUNE 1940, P 967

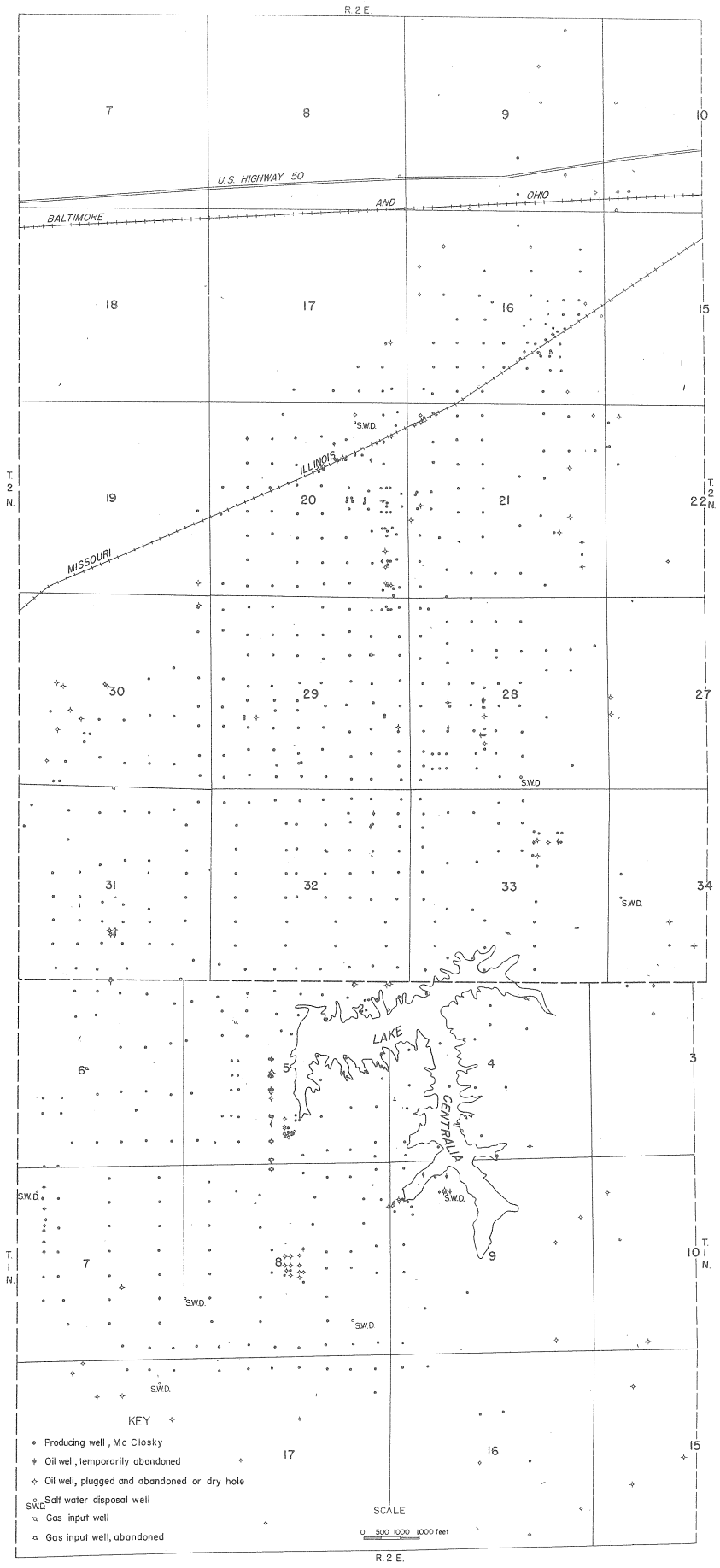


FIGURE 6
THE SALEM UNIT
McCLOSKY FLOOD

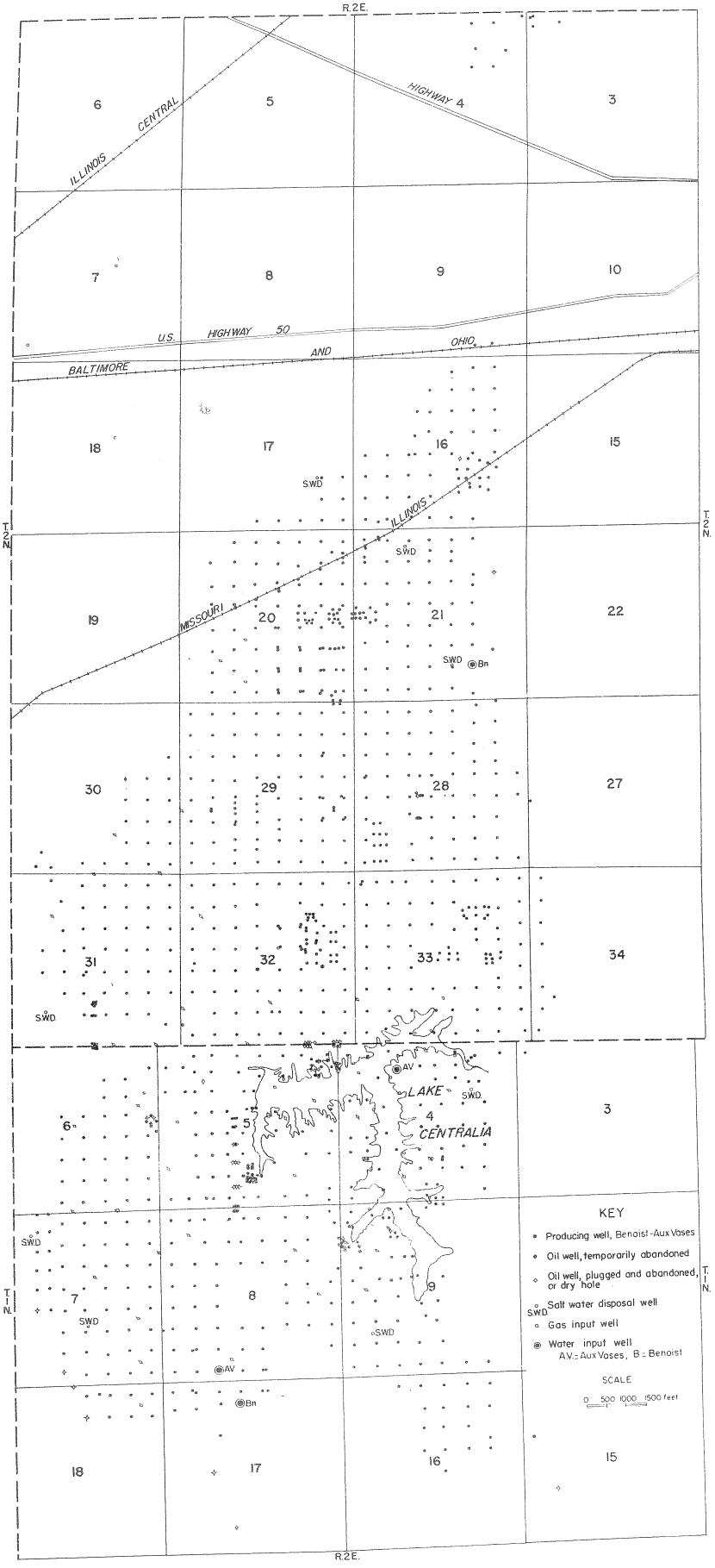
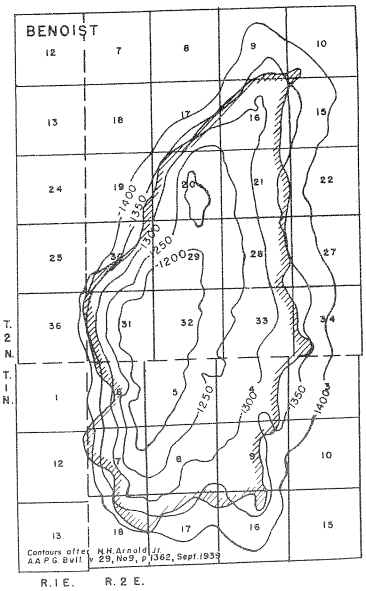


FIGURE 7
THE SALEM UNIT
BENOIST FLOOD

A. DEVELOPMENT MAP OF BENOIST SAND

B. STRUCTURE MAP ON BENOIST SAND



BOUNDARY OF PRODUCTION FROM MISSISSIPPIAN

FROM "DEVELOPMENTS IN EASTERN INTERIOR BASIN" BY ALFRED H. BELL A.A.P.G. BULL. V 24, NO 6, JUNE 1940, P 967

BENTON WATER FLOOD

by
C. V. Cameron*

Introduction and History

The Benton field, located in Franklin County, Illinois, covers about 2,200 productive acres centering around Section 25-6S-2E. A unitized water-flooding project covering about 90 per cent of the productive area has been in operation by Shell Oil Company since November 29, 1949.

The discovery well in the Benton field was completed during January, 1941, with production being obtained from the Tar Springs sandstone at a depth of about 2,100 feet. Ultimately, 242 Tar Springs producers were completed with most of the development occurring during the first year. In general the spacing density was one well to ten acres, but some irregularities resulted from drilling on small tracts, and in numerous cases it was necessary to deviate from the established pattern because of coal mining operations at the 600-foot level. The initial peak production during August, 1941, was about 33,000 barrels per day (Figure 11), and thereafter, the rate declined to about 1,600 barrels per day at the time water-flooding operations were commenced. The field cumulative production as of December 1, 1949, was 20,200,000 barrels of oil, and it is estimated that without flooding the field would have produced ultimately from 26 to 27 million barrels of oil.

General Geologic Conditions

The Benton field is an anticlinal structure approximately 1 1-4 miles wide and 2 3-4 miles long with a north-south axial trend. There is a maximum closure of approximately 70 feet (Figure 8) within the productive limits of the field. The producing reservoir which occurs in the upper part of the Tar Springs formation is limited to the east and west by low structural positions which carry the reservoir below the water level, whereas, the sand shales out to the north and south. The original oil-water contact was estimated at 1,695 feet, subsea. The net pay thickness above the original water level ranges from 0 to 60 feet for an average of about 35 feet (Figures 9 and 10) with the thicker pay sections coinciding with the more favorable structural positions.

Water-Flood History

During the first 13 months of flooding operations ending January 1, 1951, a total of 10,478,994 barrels of water were injected into 84 input wells. Oil production from 120 wells increased from a low of 730 barrels during December, 1949, to a rate of 3,250 barrels per day at the end of 1950.

Water-Flood Development

The Benton field is being flooded on a 20-acre 5-spot spacing pattern developed by converting alternate producers to water injection wells. In order to insure that the personnel and operations of the coal company would be safeguarded, each of the injection wells was equipped with a tubing packer set in the "shoe joint" of the casing and the annulus space between the casing and the tubing was filled with inhibited water (sodium chromate and water) under pressure. All wells converted to inputs were cleaned out, plugged back or deepened where necessary and the open hole calipered. No remedial work was performed on the producing wells except to modernize pumping equipment.

Water Source and Treatment

Source water for flooding is obtained from Lake Moses. The water is pumped from the

*Shell Oil Company, Centralia, Illinois

lake through a six-mile, eight-inch line to a storage reservoir located centrally within the Benton field. From this point the water is picked up and passes through a treating plant where it is processed by aeration, stabilization by the addition of lime and ferric chloride, filtration and chlorination. From the treating plant the water is distributed under pressure throughout the field by means of Goulds centrifugal pumps (Figures 12, 13, and 14). At the start of water-flooding operations the injection plant pressure was 250 pounds per square inch and was gradually increased to 545 pounds per square inch by the end of 1950.

Results Obtained

Prior to commencing water injection operations, that portion of the Benton field comprising the flood unit was producing at the rate of 1,400 barrels of oil and 550 barrels of water daily. Following the conversion of producers to injection wells, the production rate declined to 730 barrels of oil and 255 barrels of water per day. At the end of December, 1950, the daily production had increased to 3,250 barrels of oil and 1,670 barrels of water (Figures 15 and 16) with most of the increase occurring during the last six months. Total production during the 13-month period amounted to 488,979 barrels of oil and 239,601 barrels of water with the cumulative oil yield as of the end of the period being short of the estimated normal yield without flooding by about 52,000 barrels. The average daily water injection rate during the first 13 months of operation was 26,300 barrels for a cumulative total of 10,478,994 barrels. It is estimated that 36 per cent of the total pore space filled with gas at the time flooding was commenced was filled with water at the end of the first year's operations (Figure 17).

FIGURE 8

STRUCTURE MAP OF BENTON FIELD, CONTOURS ON TAR SPRINGS FORMATION

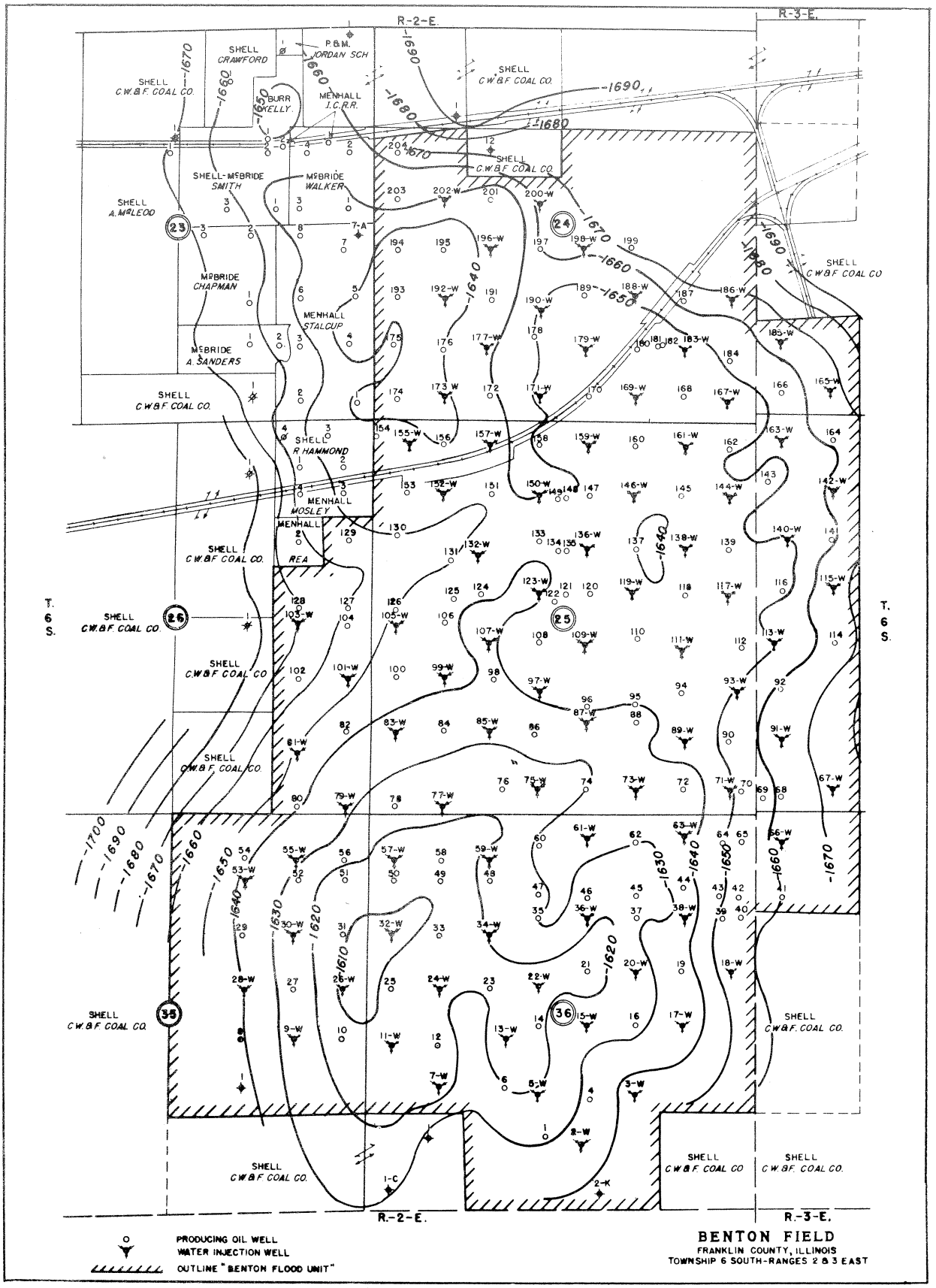


FIGURE 9
CROSS SECTIONS OF BENTON FIELD

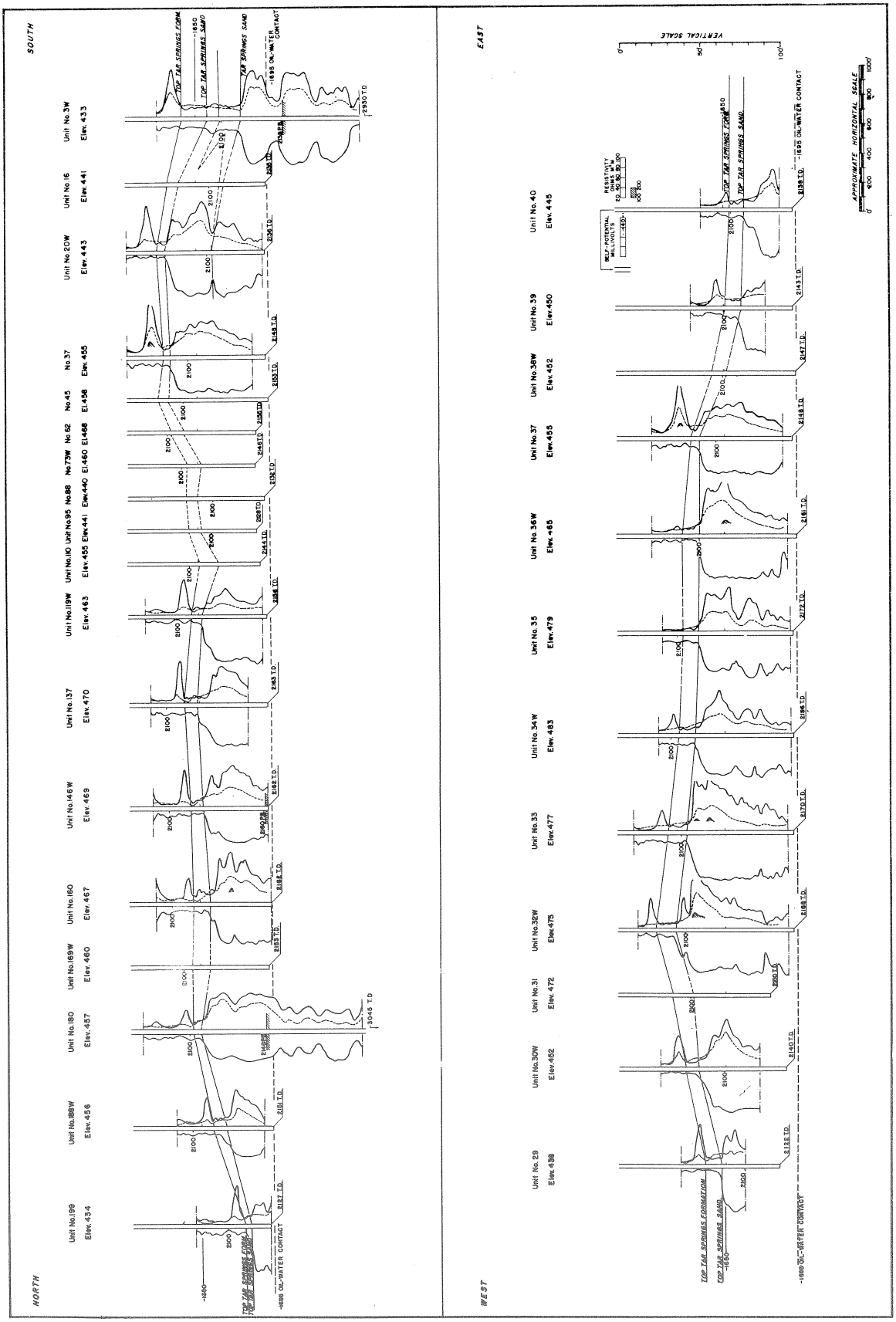


FIGURE 10

ISOPACH MAP OF TAR SPRINGS SANDSTONE SHOWING EFFECTIVE PAY THICKNESS ABOVE 1695', SUB SEA

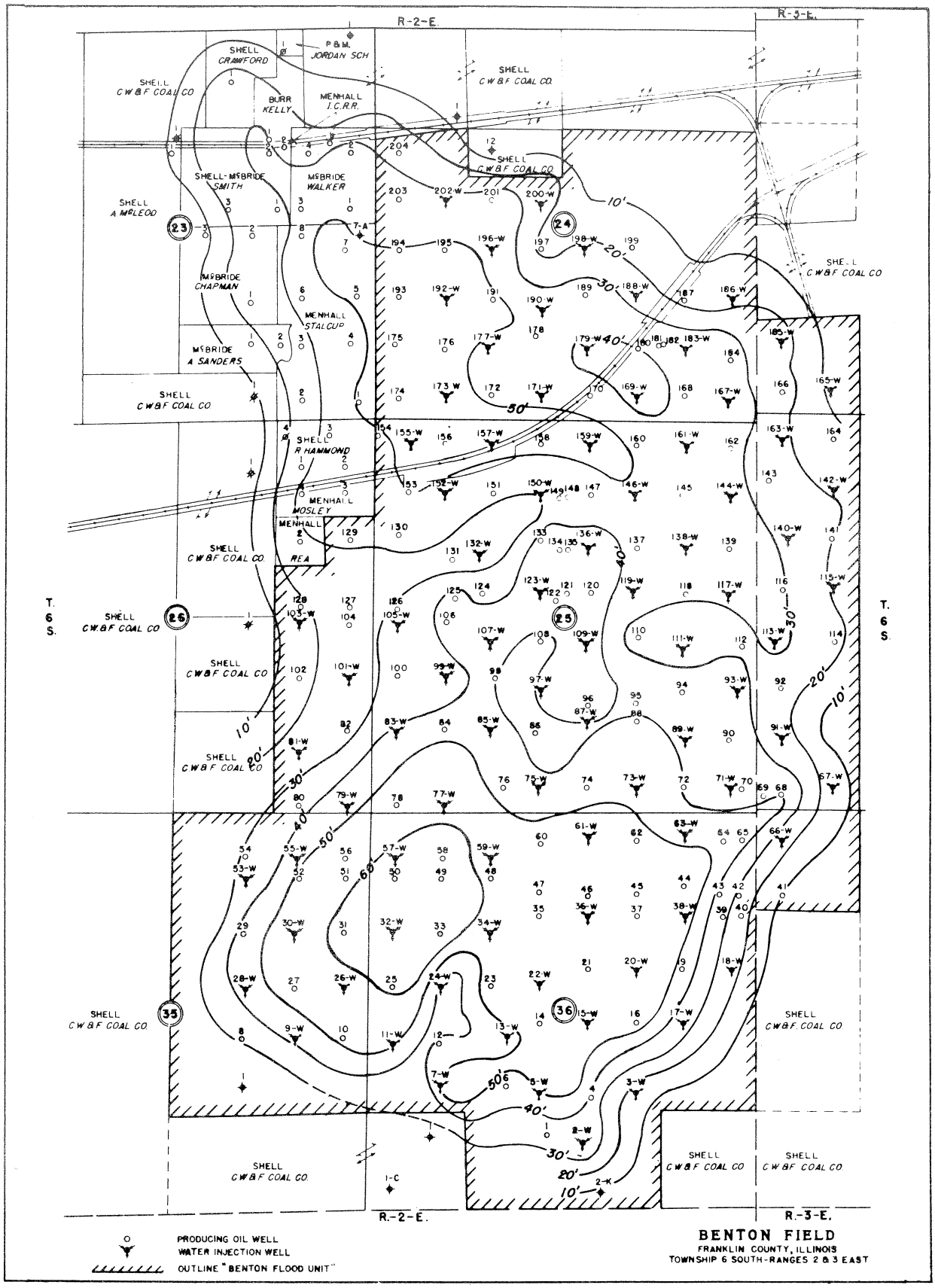


FIGURE 11

DAILY AVERAGE OIL PRODUCTION OF ENTIRE BENTON FIELD

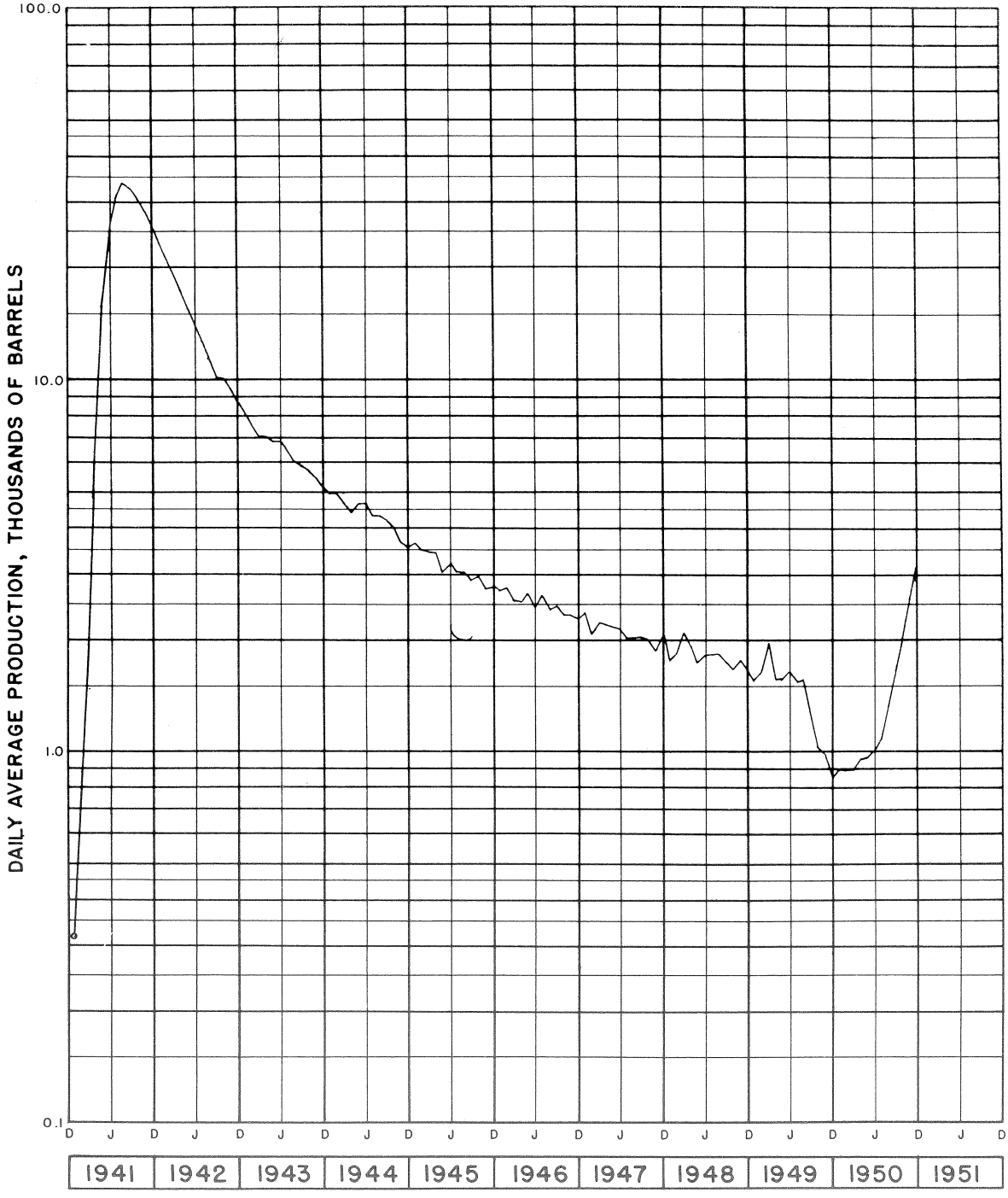


FIGURE 12
WATER INJECTION SYSTEM LAYOUT

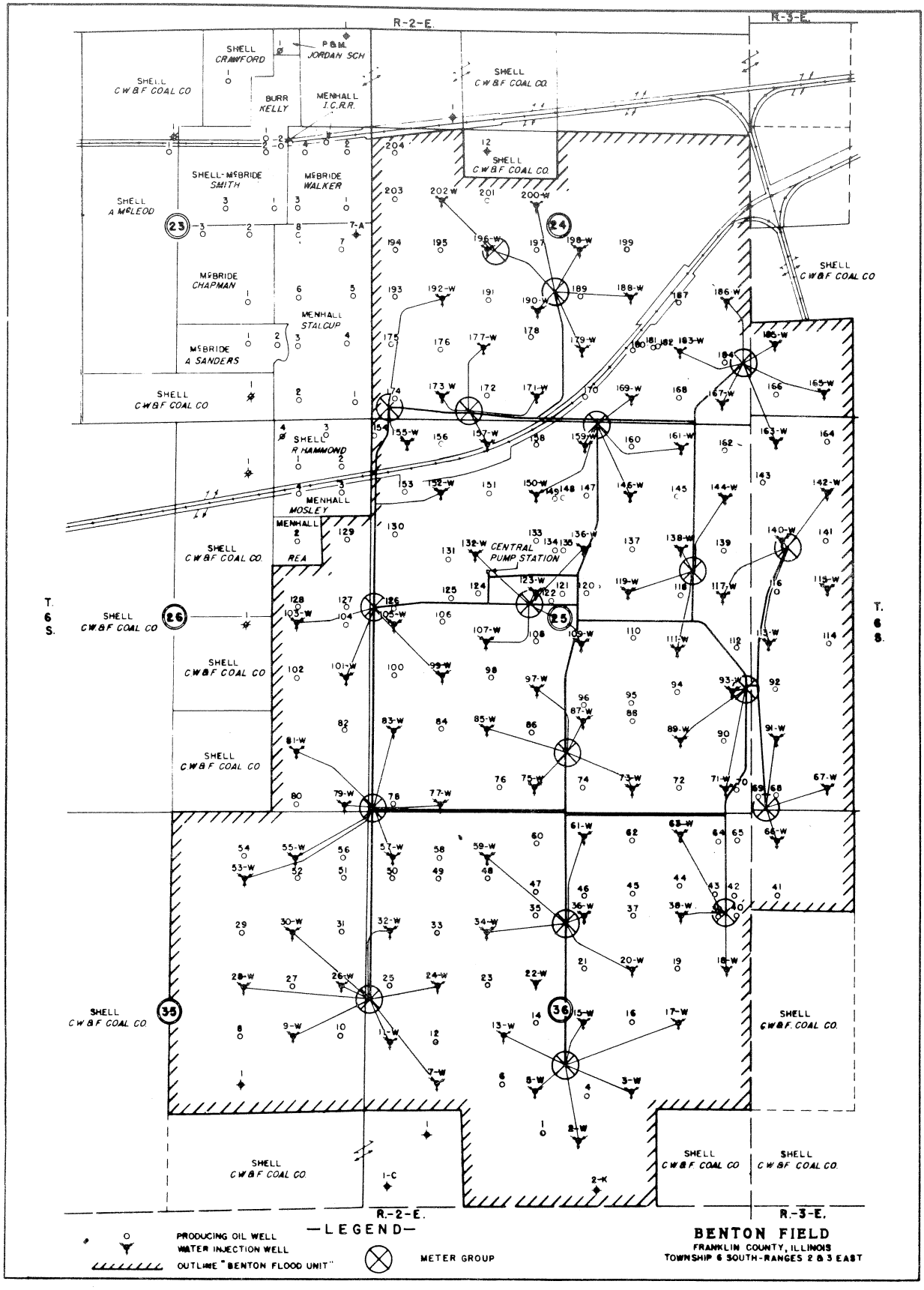


FIGURE 13

PRODUCED FLUID RETURN SYSTEM LAYOUT

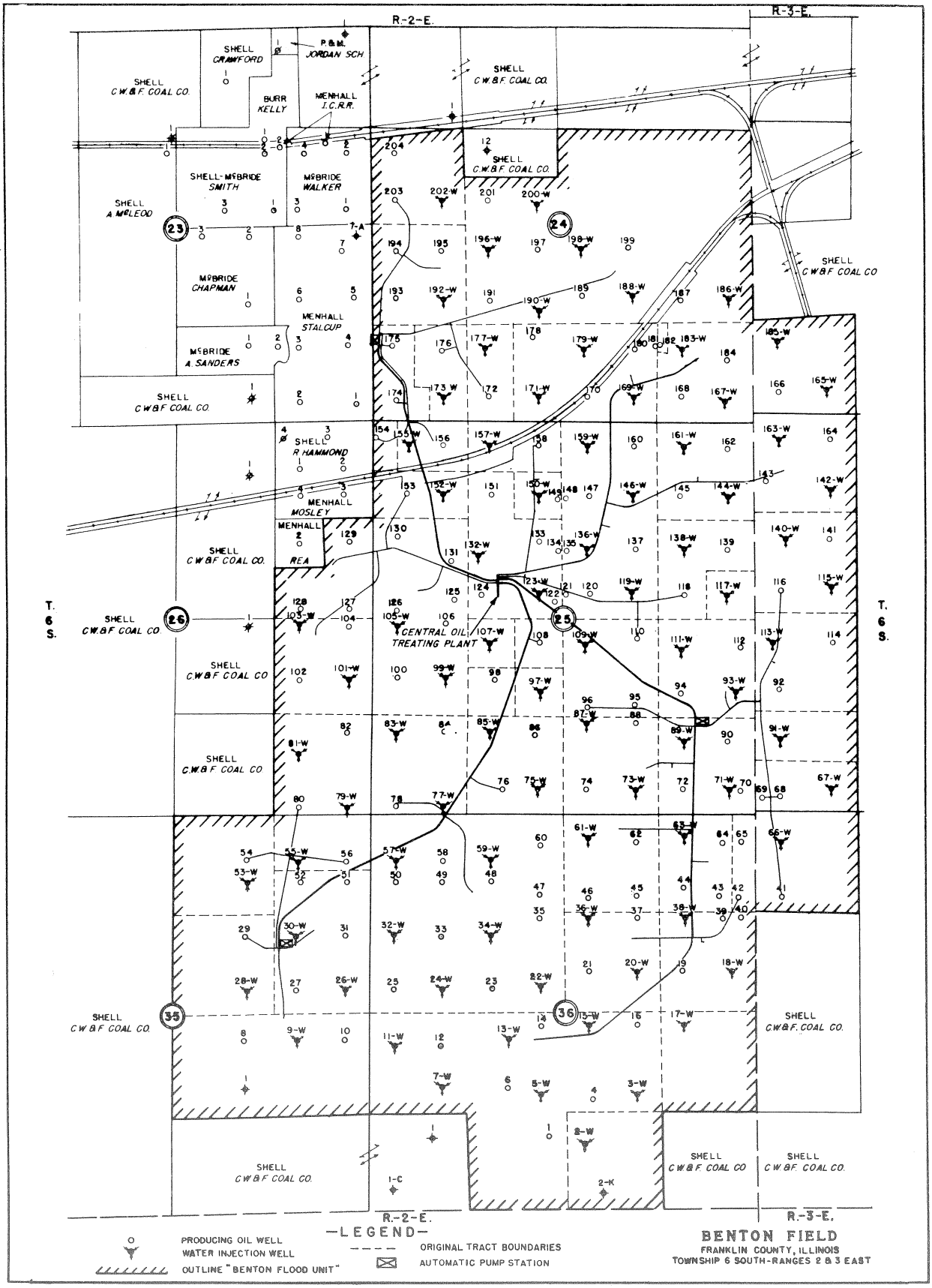


FIGURE 14

FLOW DIAGRAM OF WATER FLOOD SYSTEM

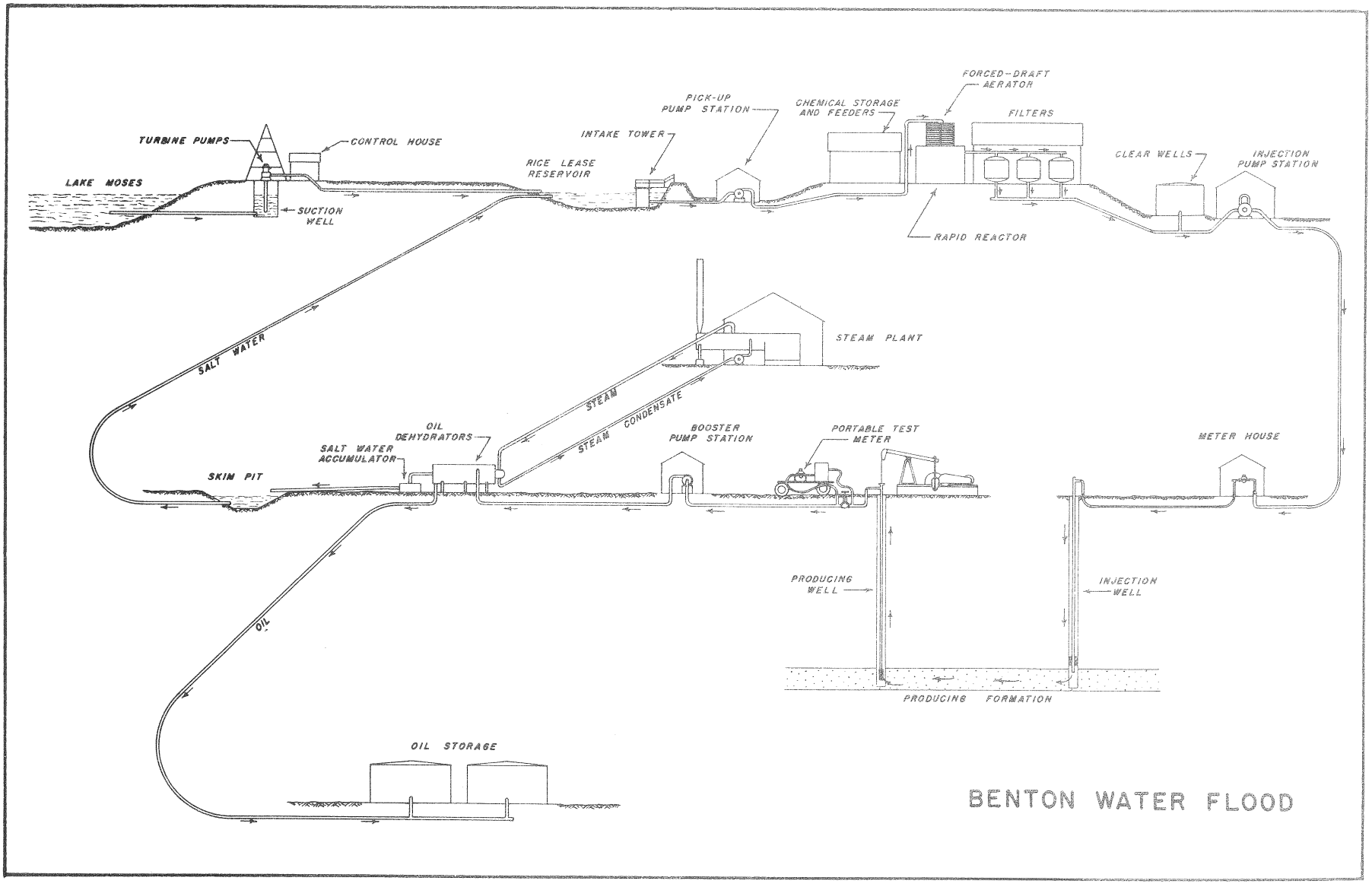


FIGURE 15

DAILY AVERAGE PRODUCTION AND WATER INJECTION FOR BENTON FLOOD UNIT

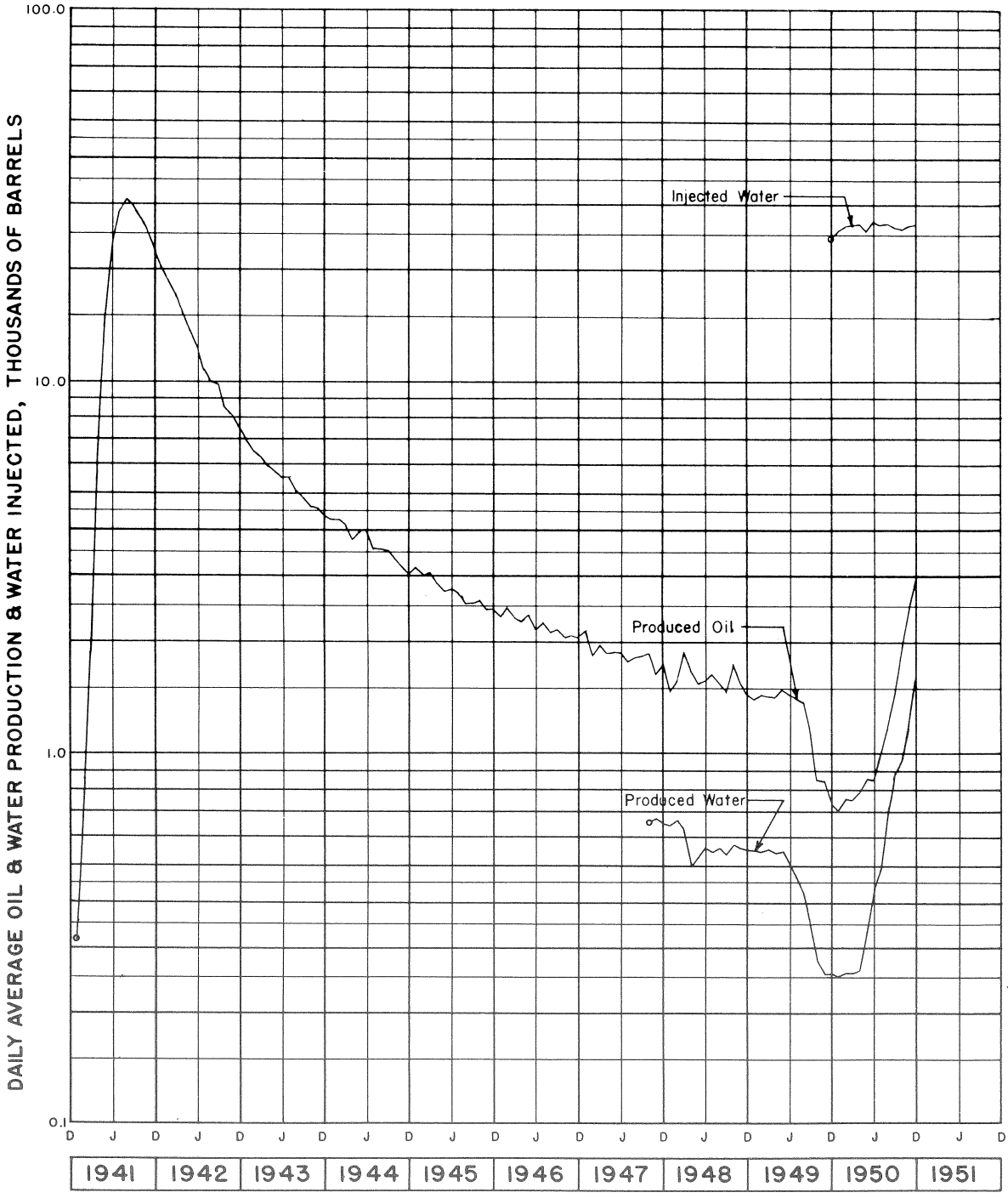


FIGURE 16

DETAILS OF FLOOD PERFORMANCE OVER 13 MONTHS OF OPERATION

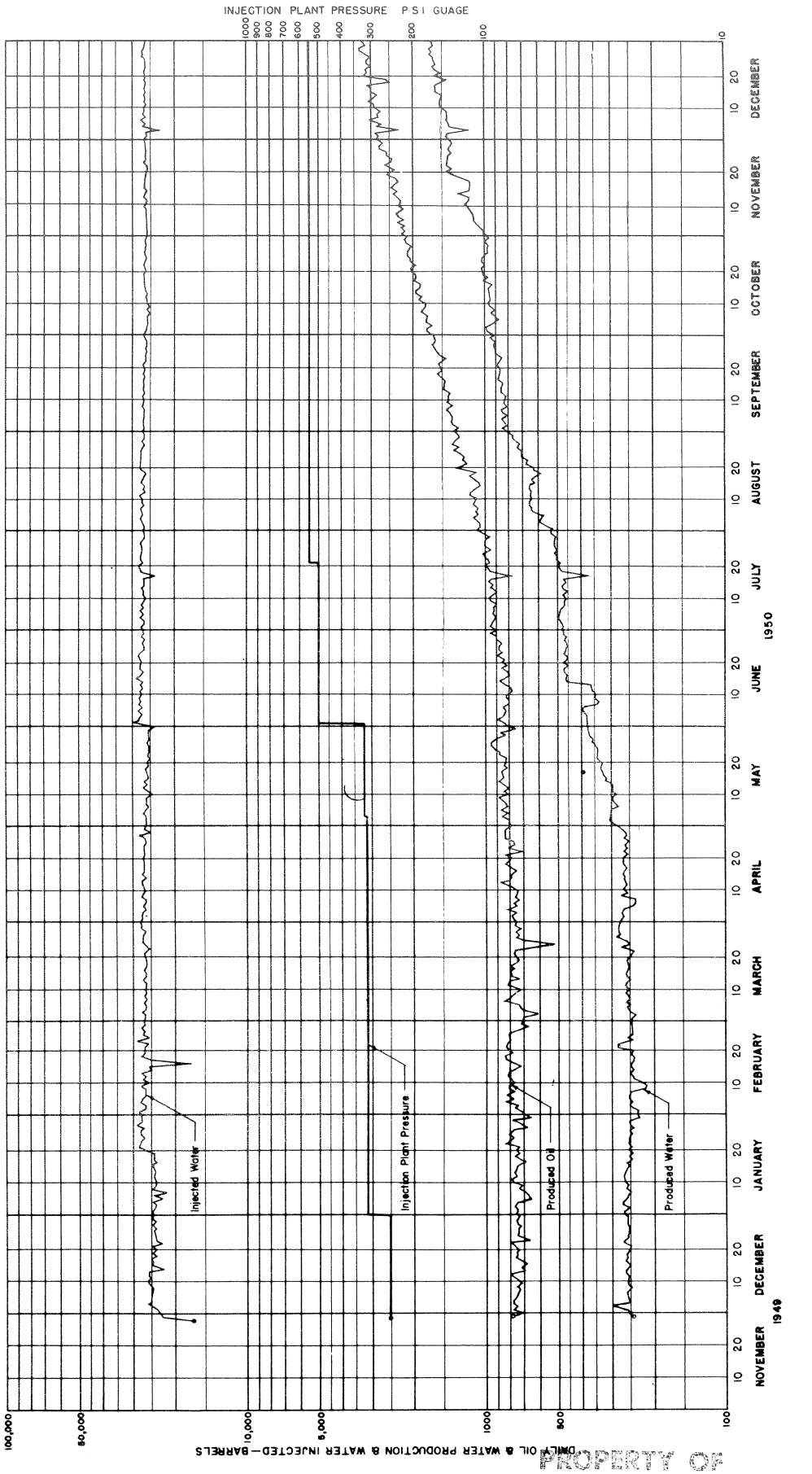
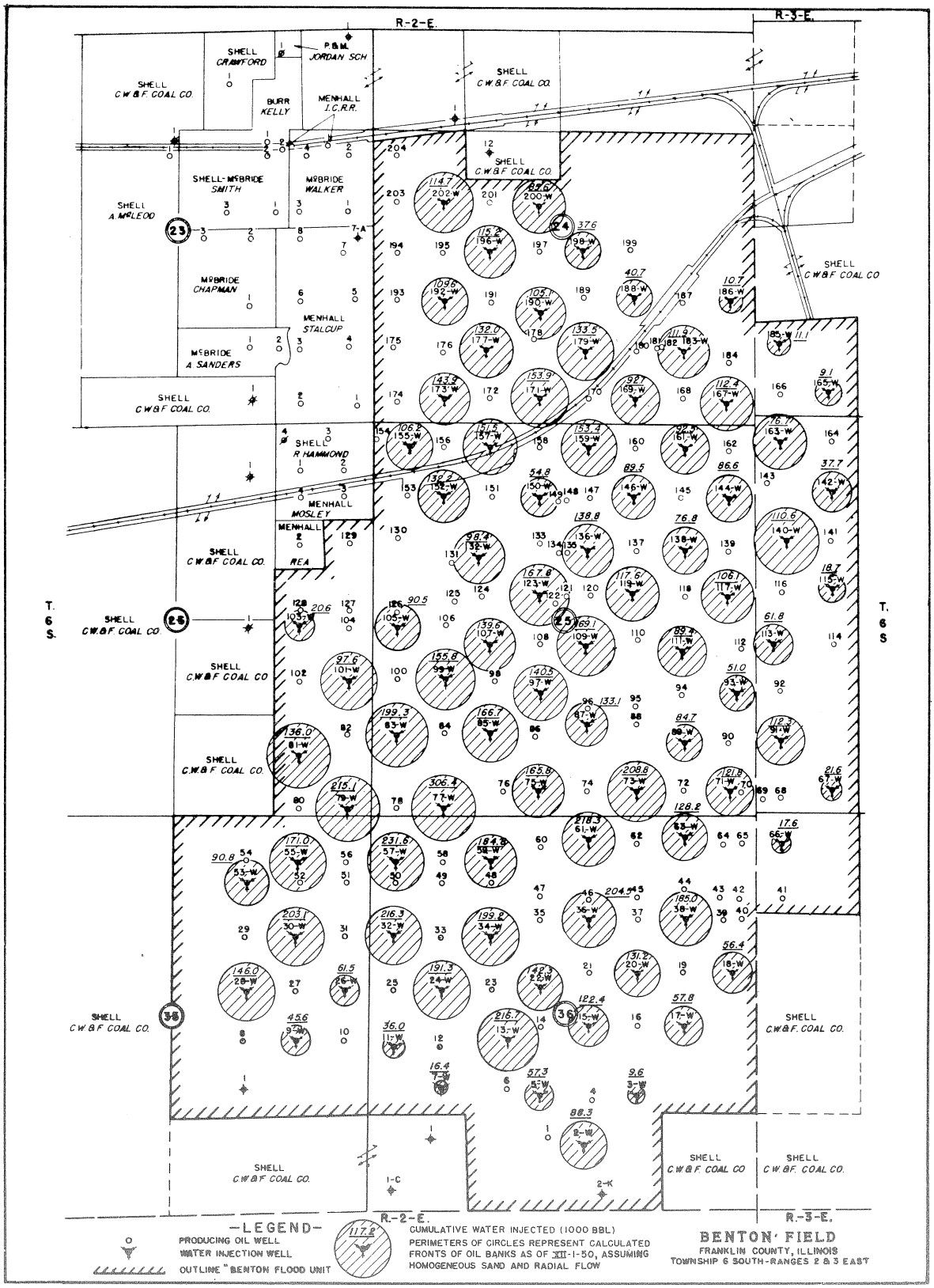


FIGURE 17

FORMATION FILL-UP MAP AS OF DECEMBER 1, 1950



SOUTH JOHNSON WATER FLOOD

by
Richard J. Cassin* and Dale E. Parro

Introduction and History

The South Johnson oil field is located in Township 8 N., Range 14 W., Clark County. The field was discovered in 1907 and was largely drilled up by the end of 1908. Many of the original wells are still pumping. Production is obtained from the Claypool, Casey, and Upper and Lower Partlow sands, all of Pennsylvanian age. Only the Upper Partlow has been water flooded to date, and the following discussion will be confined to this sand.

Water-Flood History

With few exceptions, old wells have been plugged and new wells drilled in a five-spot pattern with 440 feet between like wells. Oil and water input wells have the same completion from the ground down. In both, 8-inch drive pipe is run through the glacial drift, 50 to 100 feet, and 7-inch casing set at about 180 feet. The well is then drilled through the sand and shot. A rag packer, run on 1 1-2 inch cement-lined pipe, is set at the top of the pay. Approximately 40 feet of cement is then placed on top of the packer. Each input well is equipped with a water-flow meter.

Water Source and Treatment

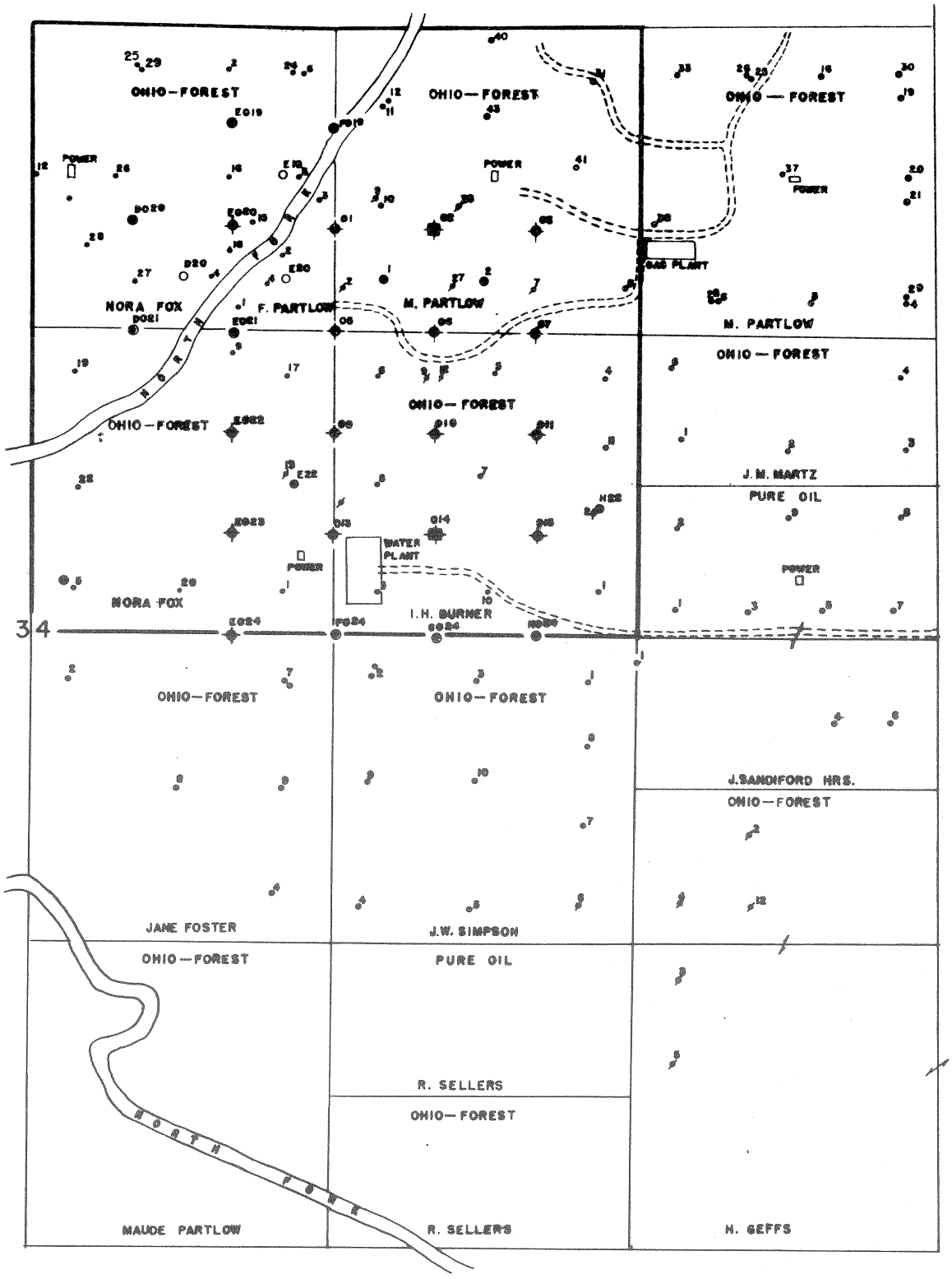
Shallow well, produced, and creek water are all used in the South Johnson flood. The well water, which is used in the original flood area, is produced from shallow river gravels. A closed system with filtration but without chemical treatment is maintained. Produced water from the nearby Bellair field and creek water from the North Fork are used in the remainder of the flood area. This water is pumped to high ground near the pressure plant, aerated, and settled in ponds. From the ponds the water flows by gravity to the chemical mixing tank, then to the settling tanks, through the filters, and into the clear tank. From the clear tank, horizontal duplex pumps distribute the water through cement-lined pipes to the individual water wells, at an average well-head pressure of 250 pounds per square inch. Daily input volume for the entire flood is 6,000 barrels, or 3.5 barrels per well per foot of sand.

Results Obtained

In slightly less than two years of operation, 150,800 barrels of water-flood oil have been produced from the 120 acres of the South Johnson water flood. Oil production has remained relatively constant throughout this period, although water production has increased to an approximate 90 per cent water cut. Water injected to January 1, 1951, was 3,300,000 barrels and water-flood oil production was 150,800 barrels. This ratio of 24 to 1 is high compared to those of the pumping floods.

*Forest Oil Corporation, Casey, Illinois

FIGURE 18
INDEX MAP SOUTH JOHNSON FLOOD



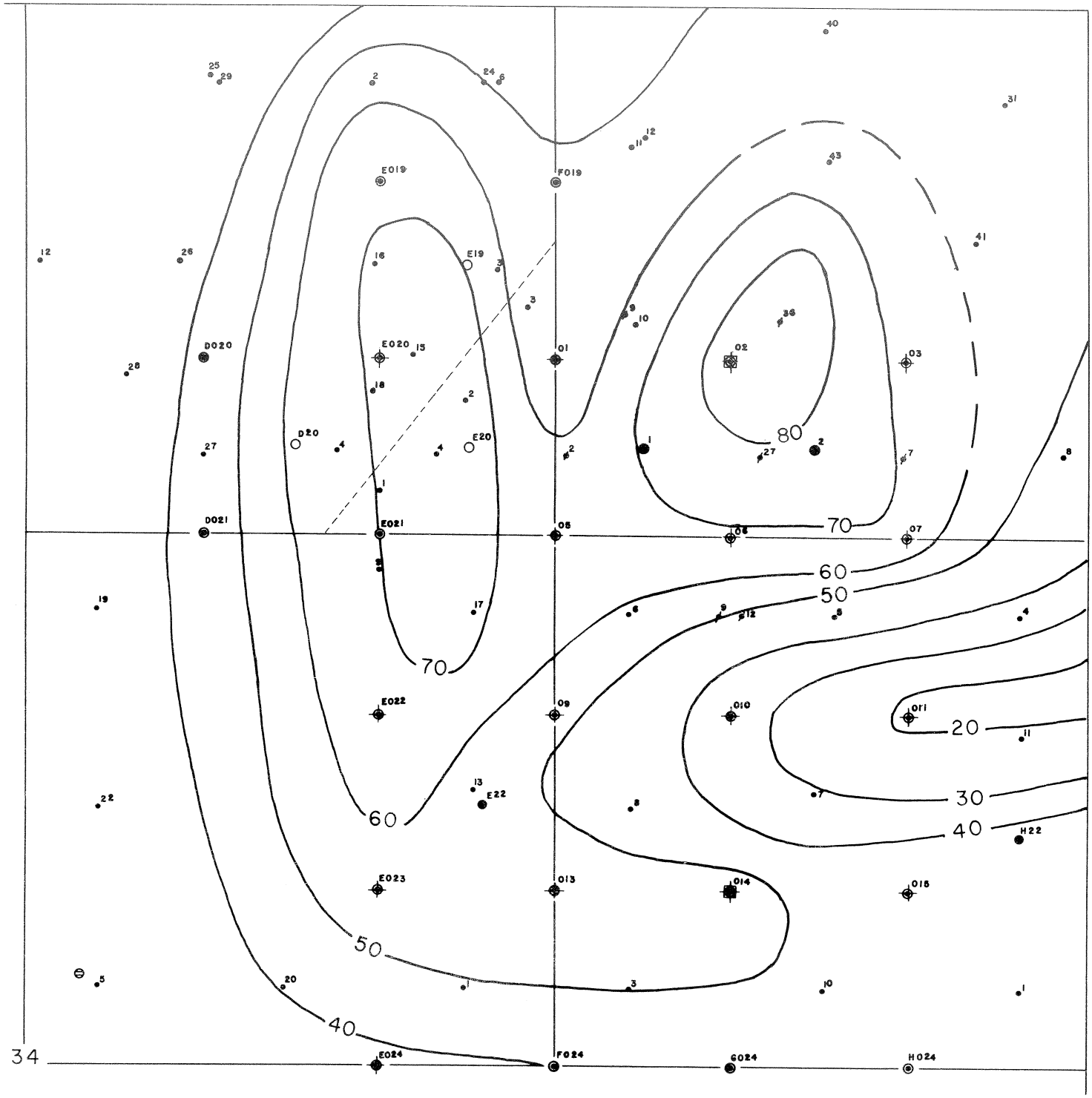
LEGEND

- OLD WELL
- ABANDONED WELL
- LOCATION FLOOD PRODUCER
- COMPLETION FLOOD PRODUCER
- LOCATION INTAKE WELL
- COMPLETION INTAKE WELL
- CORE WELL
- WATER SUPPLY WELL FOR FLOOD
- AREA BEING FLOODED

SCALE 1" 400'

FIGURE 19

STRUCTURE ON UPPER PARTLOW SAND, SOUTH JOHNSON FLOOD



LEGEND

- OLD PRODUCER
- ABANDONED WELL
- LOCATION FLOOD PRODUCER
- COMPLETED FLOOD PRODUCER
- LOCATION INTAKE WELL
- COMPLETION INTAKE WELL
- CORE WELL
- WATER SUPPLY WELL FOR FLOOD

CONTOUR INTERVAL 10'

DATUM PLANE —— SEA LEVEL

SCALE 1"= 800'

FIGURE 20

PERMEABILITY CONTOURS ON UPPER PARTLOW SAND, SOUTH JOHNSON FLOOD

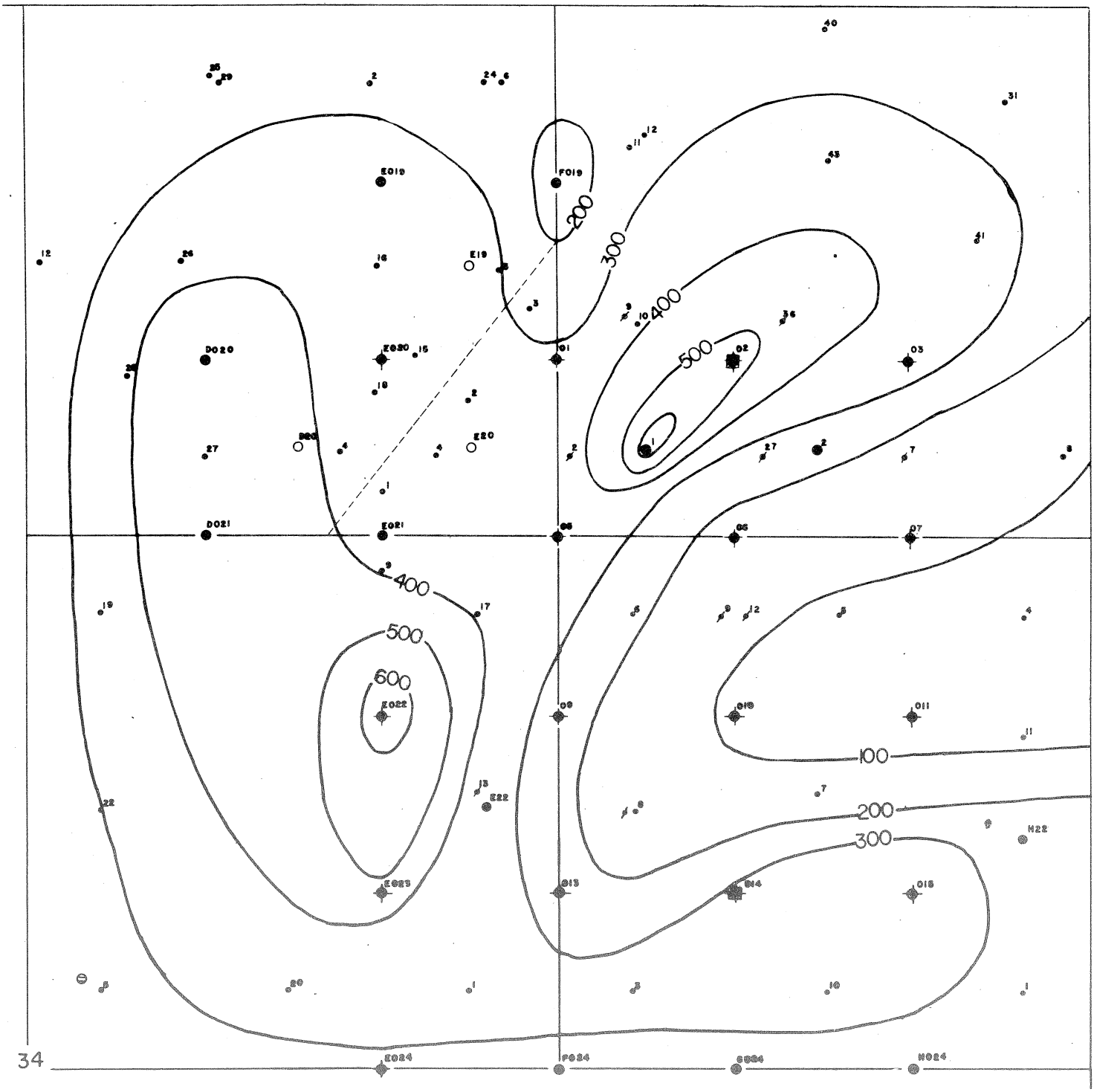


FIGURE 21
GEOLOGIC COLUMN
SOUTH JOHNSON WATER FLOOD AREA

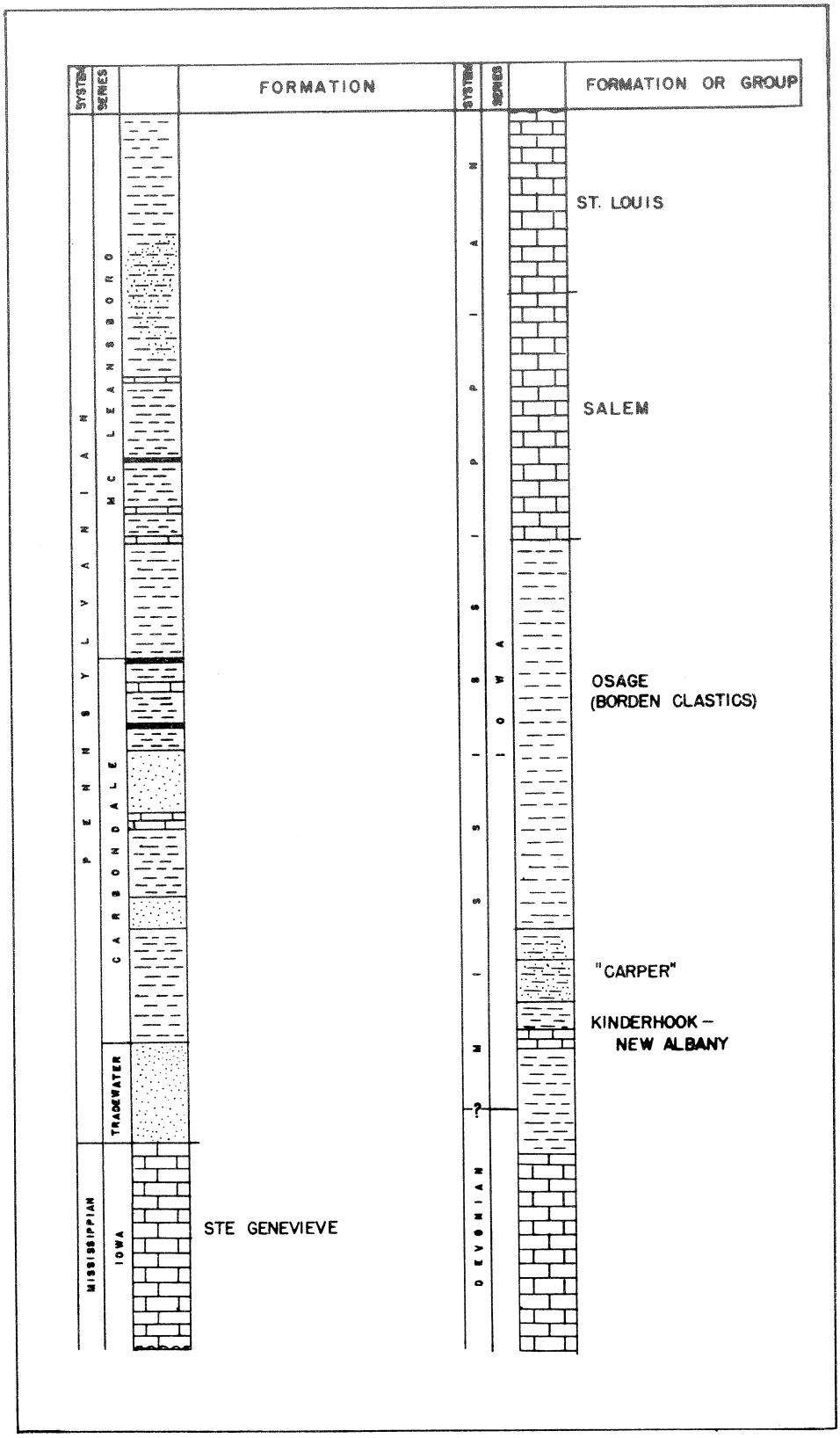
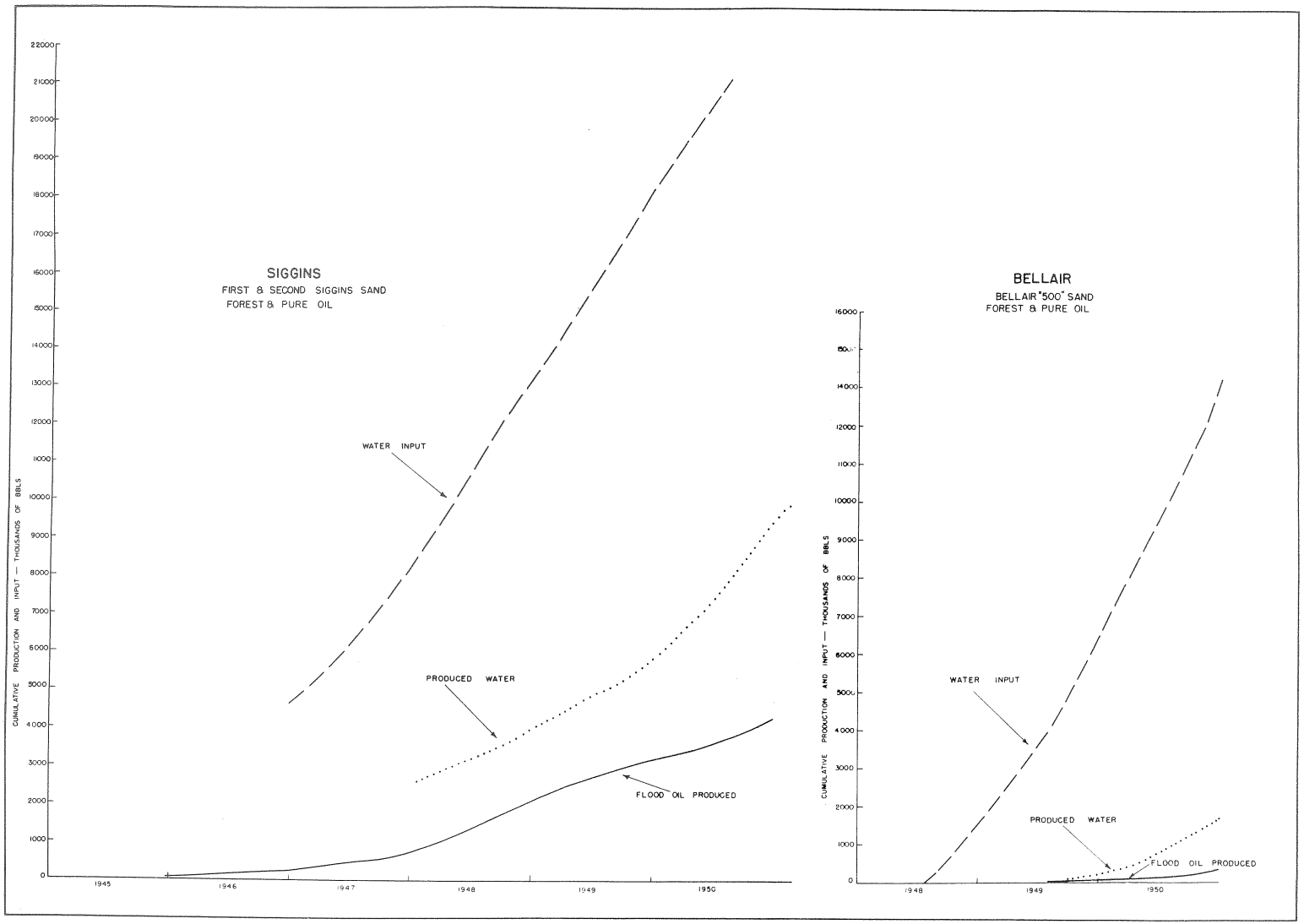


FIGURE 22

FLOOD PERFORMANCE GRAPHS - SIGGINS - FIRST AND SECOND SIGGINS SAND, AND BELLAIR - BELLAIR "500 foot" SAND

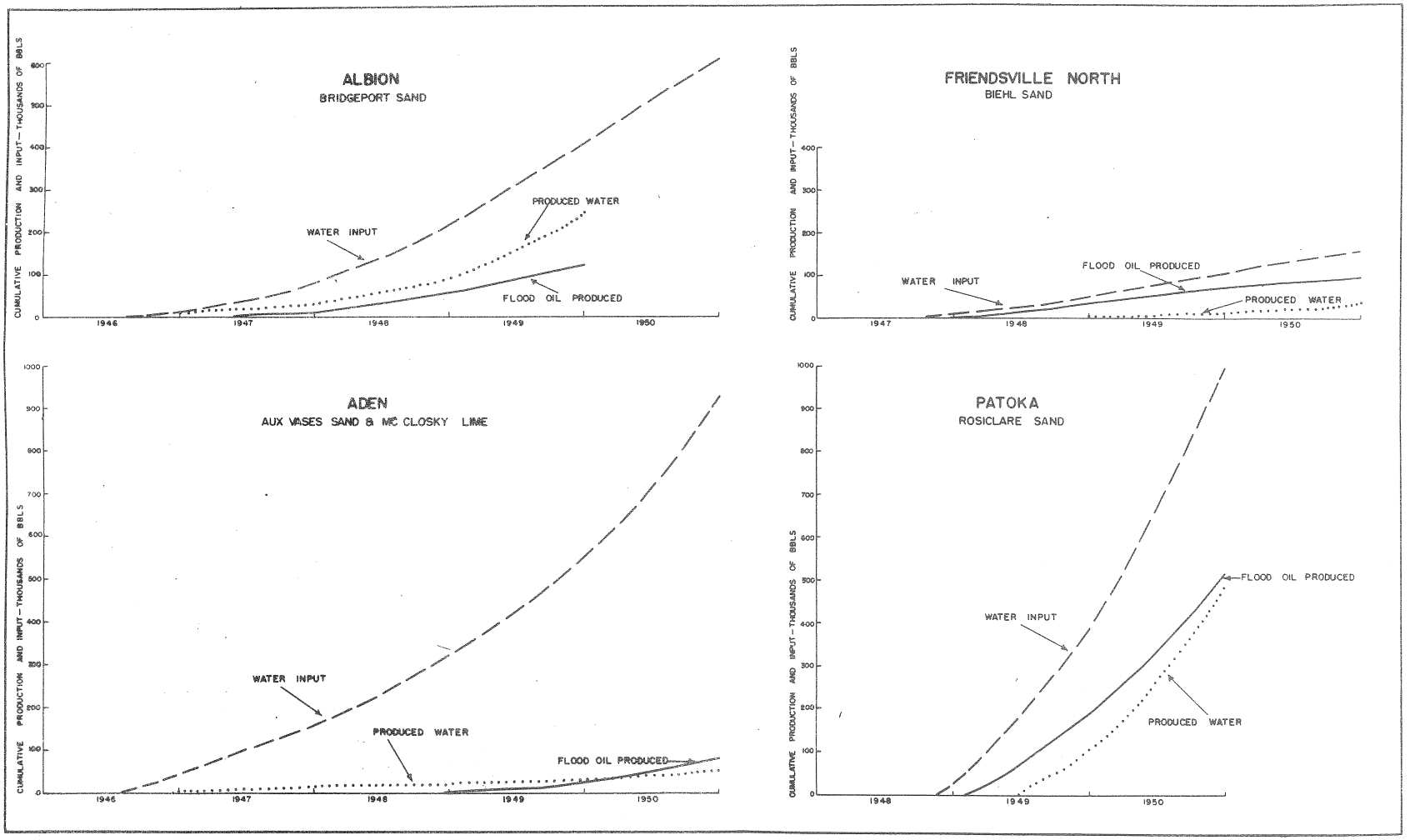


BY R. J. CASSIN

FIGURE 23

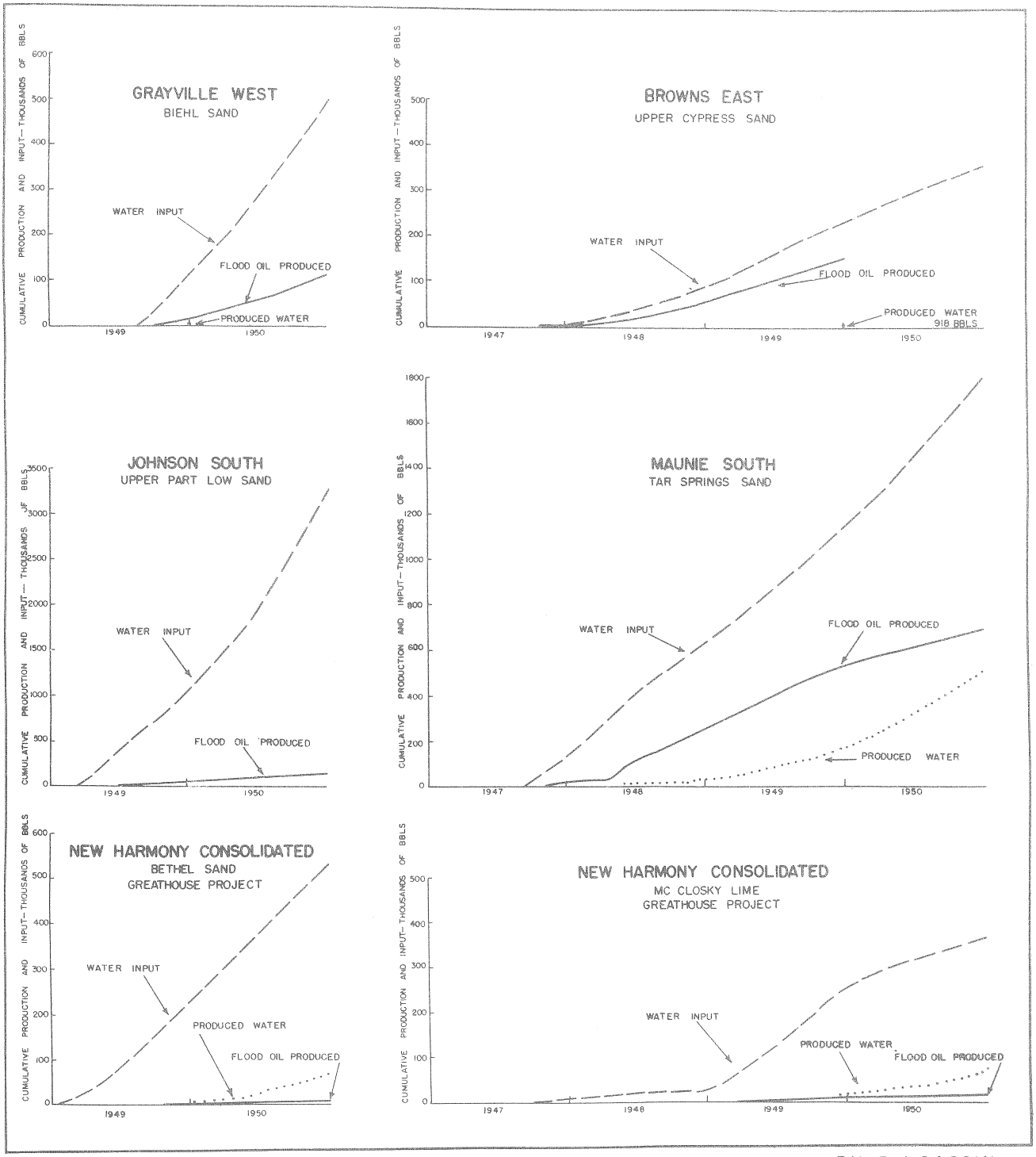
FLOOD PERFORMANCE GRAPHS

ALBION, ADEN, FRIENDSVILLE NORTH, AND PATOKA



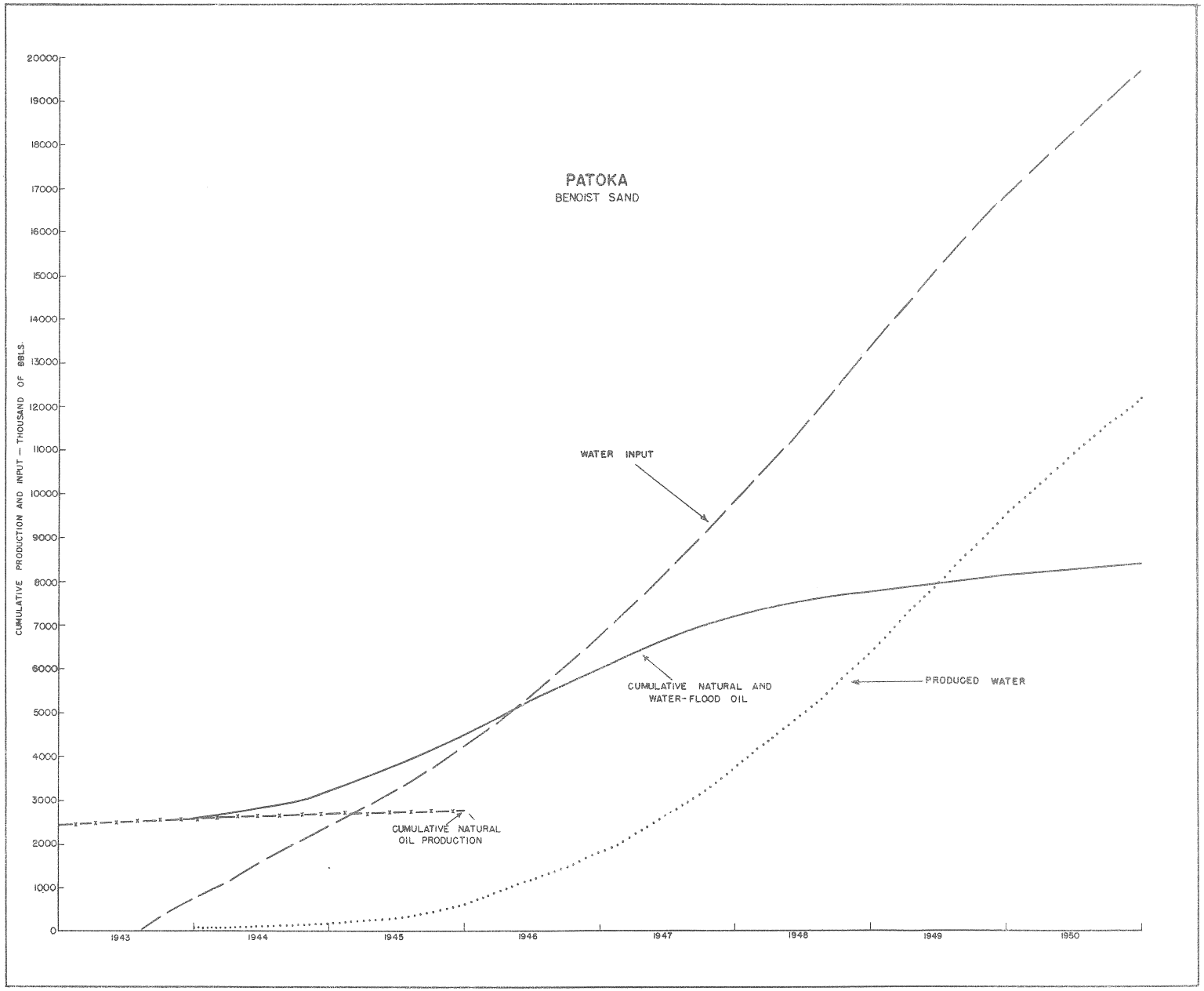
BY R.J. CASSIN

FIGURE 24
FLOOD PERFORMANCE GRAPHS
GRAYVILLE WEST, BROWNS EAST, JOHNSON SOUTH, MAUNIE SOUTH, NEW HARMONY CONSOLIDATED



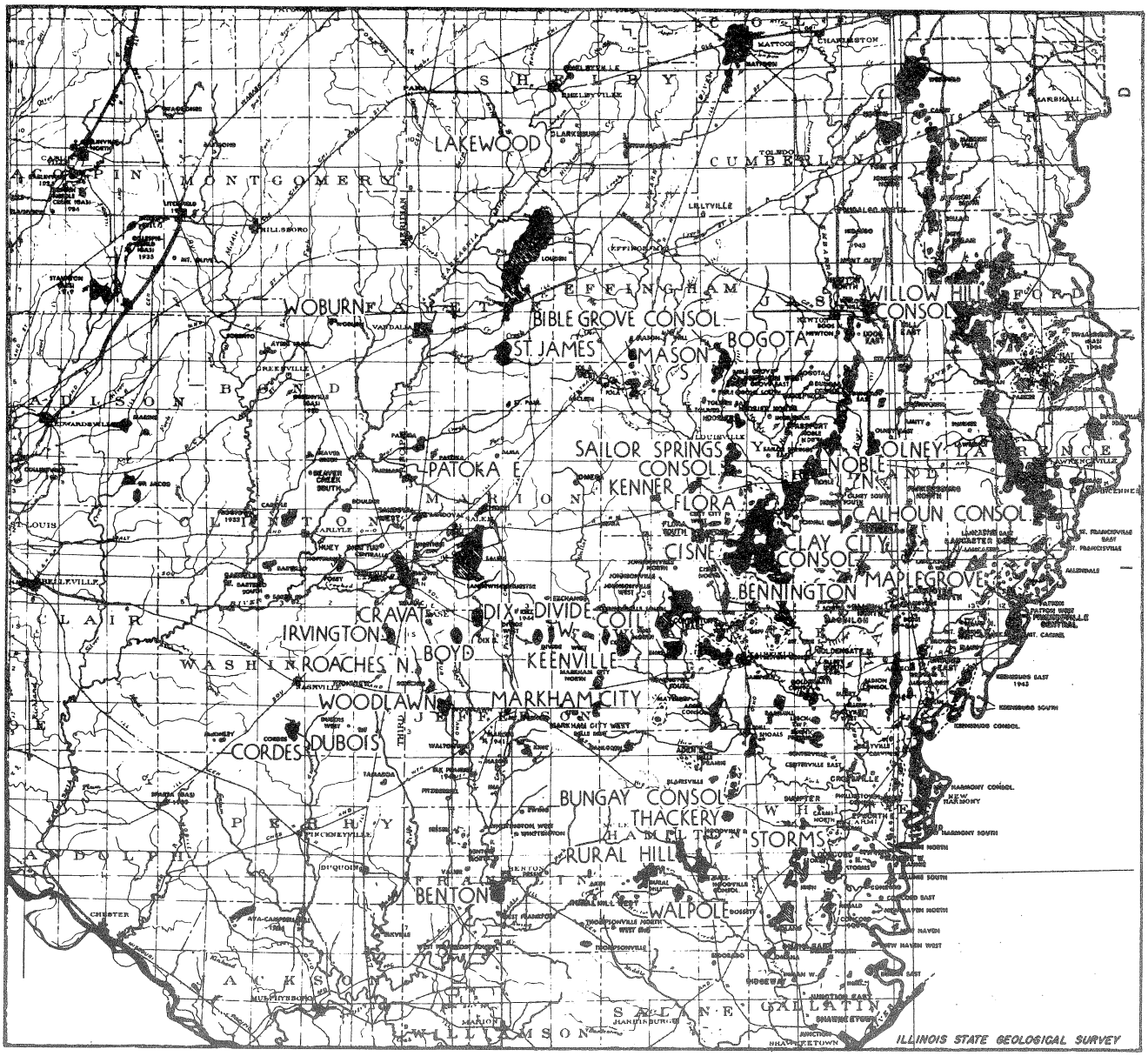
BY R.J.CASSIN

FIGURE 25
FLOOD PERFORMANCE
GRAPH OF PATOKA FIELD (BENOIST SAND)



BY R. J. CASSIN

FIGURE 26
MAP OF THE ILLINOIS BASIN OIL FIELDS,
SHOWING POSITIONS OF SURFACE STREAMS RELATIVE TO OIL POOLS



WATER SUPPLY

by
David H. Swann*

In addition to the fresh water supplies shown in Figs. 26 and 27, brines are available in the following areas.

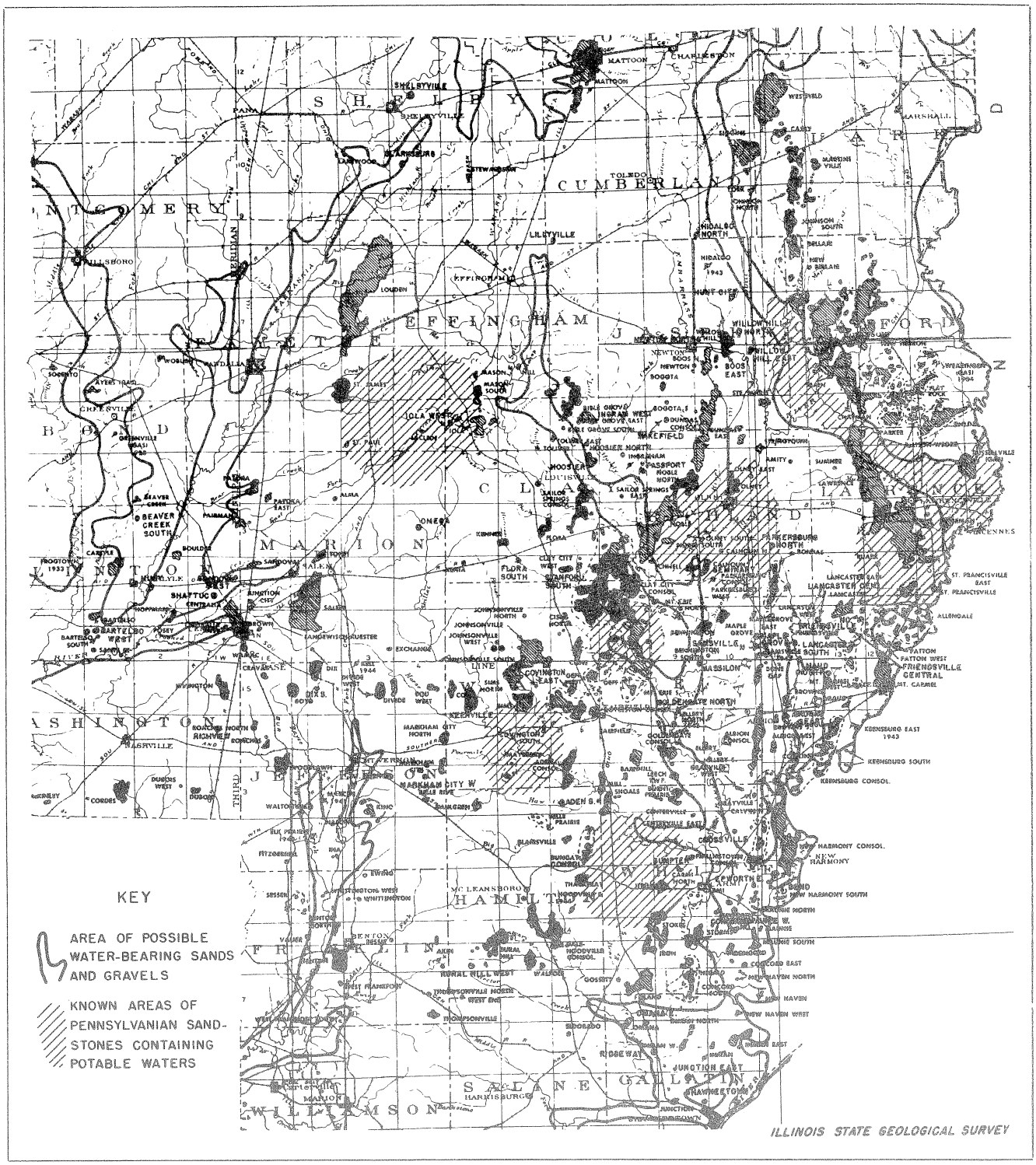
There are few, if any, spots in the oil fields of southern Illinois where brine deposits can be economically developed in quantity sufficient for the water-flooding of projects of the size of Salem or even Benton. On the other hand, brine sufficient for small projects is available in most parts of the oil region. In the area of the old Southeastern Illinois field, there is little brine above the principal oil zones. At the northern end of the Southeastern field the Salem limestone, several hundred feet below the major oil zones, is the shallowest brine reservoir, but farther south, basal Pennsylvanian and, in a few townships, Cypress sandstones provide brine in the same range of depths as the major oil zones.

In the central part of the basin the Salem is too deep for economical use, but the basal Pennsylvanian, the Tar Springs, and the Cypress provide brine in many spots at the approximate level of or above the local oil zone. Toward the western margin of the basin the Degonia and Aux Vases sandstones, in addition, should be capable of yielding brine in quantity, though neither has yet been used as a source for flood water.

*Geologist, Illinois Geological Survey, Urbana, Illinois

FIGURE 27

AREAS OF POSSIBLE FRESH WATER-BEARING SANDS AND GRAVELS AND THE KNOWN AREAS OF PENNSYLVANIAN SANDSTONE THAT CONTAIN FRESH WATER



Finis