STATE OF ILLINOIS
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URBANA

CIRCULAR NO. 173

ILLINOIS WATER FLOODS—A SUMMARY

By

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PROGRESS REPORT: ILLINOIS WATER FLOODS

ILLINOIS had 31 active controlled floods on January 1, 1950 (see Table 1). These, together with the many McClosky dump floods, had produced about 15,400,000 bbl. of flood oil to January 1, 1950.

This oil was obtained from sands with an average thickness of about 20 ft. which took water at the rate of 10 bbl. per day per foot. Porosities averaged about 20 per cent and permeabilities approximately 150 md. The fluid saturations at the start of flooding averaged 64 per cent oil and 20 per cent water and the ratio of water input to flood oil produced was about 5 to 1 at the end of 1949.

The over-all recovery to January 1, 1950, from the 8,450 acres in the controlled floods was 1,213 bbl. per acre. As only a small part of the state's total oil-producing area of 376,000 acres has been affected by controlled water floods, there remains an extensive territory which has good prospects for oil recovery by water flooding.

This article summarizes the important work accomplished by the Secondary Recovery Study Committee for Illinois, of the Interstate Oil Compact Commission, and as recently published in the report, of the Interstate Oil Compact Commission and in Circular No. 165 of the Illinois State Geological Survey.

Membership of committee preparing report: chairman, Frederick Squires (Illinois State Geological Survey, Urbana); A. H. Bell (Illinois State Geological Survey, Urbana); H. R. Bolton (Ohio Oil Co., Terre Haute); C. V. Cameron (Shell Oil Co., Centralia); W. S. Corwin (Tide Water Associated Oil Co., Keensburg); R. E. Dunn (Magnolia Petroleum Co., Salem); R. W. Love (The Texas Co., Salem); R. J. Cassin, secretary (Illinois State Geological Survey, Urbana); Paul Phillippi (Forest Oil Corp., Casey); Mark Plummer (Pure Oil Co., Olney); L. C. Powell (Ohio Oil Co., Terre Haute); Harry Swaneck (Gulf Refining Co., Centralia); Ray Vincent (Sohio Petroleum Co., Centralia); E. C. Wells (Carter Oil Co., Mattoon); M. R. Wilson (The Texas Co., Salem).

Siggins Pool Water Floods

Water-flood history.—Systematic water flooding was first begun in Siggins field in 1942 when Forest Oil Corp. redrilled and flooded 40 acres of the first Siggins sand near the center of the field (Flood 2, Fig. 3).

Since 1942 the flooding has been expanded to 2,000 acres in both first and second Siggins sands. These floods are operated by Forest Oil Corp. and Pure Oil Co. Field daily average production increased from 100 bbl. or less per day in 1940 to 3,000 bbl. per day in October 1949, with a cumulative water-flood production to January 1, 1950, of 3,187,000 bbl.

Water-flood development.—With few exceptions the old wells were plugged and a new five-spot pattern drilled with input wells 440 ft. apart and input to oil well distances about 300 ft. Insofar as possible input wells are completed to have only net pay open to injection and are selectively

TABLE 1 — DATA FOR CONTROLLED

Line No.	Field	County	Project	Water-flood pay	Average depth to water-flood pay	Operator	Date of first water input	As of January 1, 1950: Acres flooded	Total acres water-flood pay in field	No. of wells: Producers	No. of wells: Input	Plant pressure
1	Aden Consolidated	Wayne	Aden	Aux Vases	3,200	Texas	August 1946	300	400	10	3	1,210
2	Aden Consolidated	Wayne	Aden	McClosky	3,350	Texas	August 1946	300	2,000	12	2	
3	Albion Consolidated	Edwards	Albion	Bridgeport	1,900	Superior	August 1946	192	250	30	3	....
4	Albion Consolidated	White	Biehl	Upper Biehl	1,900	Yingling	August 1949	172	....	10	2	966
5	Bellair	Crawford	Forest-Bellair	Bellair "500"	550	Forest	July 1948	200	....	24	56	285
6	Bellair	Crawford	Fulton	Bellair "500"	560	Pure	July 1948	443	....	124	131	250
7	Benton	Franklin	Benton	Tar Springs	2,100	Shell	November 1949	1,900	2,400	120	84	320
8	Blairsville	Hamilton	Blairsville	Aux Vases	3,275	Texas	June 1948	...	640	16	2	960
9	East Browns	Wabash	North Bellmont	Cypress	2,600	Magnolia	November 1947	174	174	12	3	1,543
10	North Friendsville	Wabash	North Friendsville	Biehl	1,500	Magnolia	July 1947	40	120	3	2	1,386
11	Iola Consolidated	Clay	East Iola	Aux Vases	2,350	Texas	March 1948	40		3	1	687
12	North Johnson	Clark	Pickens Flood	Casey	450	Pickens	May 1949	60	825	17	18	200
13	South Johnson	Clark	South Johnson	Upper Partlow	490	Forest	March 1949	160	1,710	13	24	250
14	Lawrence	Lawrence	Robins	Bridgeport	900	Ohio	August 1948	114	5,050	29	9	260
15	Lawrence	Lawrence	Griggs	Kirkwood	1,350	Ohio	July 1947	35	16,200	9	4	
16	Main	Crawford	Henry-Ikemire	Robinson	935	Tide Water	February 1948	45	34,320	10	12	130
17	Main	Crawford	Wilkin	Robinson	950	Ohio	May 1948	113	¶34,320	36	25	...
18	Main	Crawford	Hughes	Robinson	890	Ohio	September 1948	89		28	24	..
19	South Maunie	White	Tar Springs Unit	Tar Springs	2,200	Magnolia	August 1947	230	....	13	11	777
20	New Harmony-Keensburg	White	Greathouse	Bethel	2,750	Sun	January 1949	20	....	4	4	1,200
21	New Harmony-Keensburg	White	Ford "A"	McClosky	2,900	Sun	May 1948	40	....	1	1	15
22	New Harmony-Keensburg	White	Greathouse	McClosky	2,900	Sun	August 1947	60	....	2	2	1,100
23	New Harmony-Keensburg	White, Illinois Posey, Indiana	Waltersburg	Waltersburg	*2,220	Superior	August 1946	490	....	43	3	0
24	Odin	Marion	Odin	Cypress	1,750	Ashland	October 1949	196	210	20	1	20
25	Olney Consolidated	Richland	Olney	McClosky	3,060	Texas	November 1946	60	940	1	1	225
26	Patoka	Marion	Benoist Flood	Benoist	1,410	Sohio	September 1943	527	565	81	62	250
27	Patoka	Marion	Rosiclare	Rosiclare	1,550	Sohio	1948	469	469	12	14	
28	Phillipstown Consolidated	White	North Calvin	Biehl	1,800	Magnolia	September 1947	10	....	4	1	1,250
29	Siggins	Clark, Cumbl'd.	Forest	First Siggins	400	Forest	1942	1,300	3,190	247	314	200-280
30	Siggins	Clark, Cumbl'd.	Pure	First Siggins	404	Pure	December 1946	402	....	121	127	177
31	Siggins	Clark, Cumbl'd.	Pure	Second Siggins	464	Pure	December 1946	269	350			
								8,450	69,813	1,055	946	

*Actual core analyses. †Based on well cored in oil. ‡Corrected for invasion. §Estimated figures. ¶Represents same acreage as Line 16.

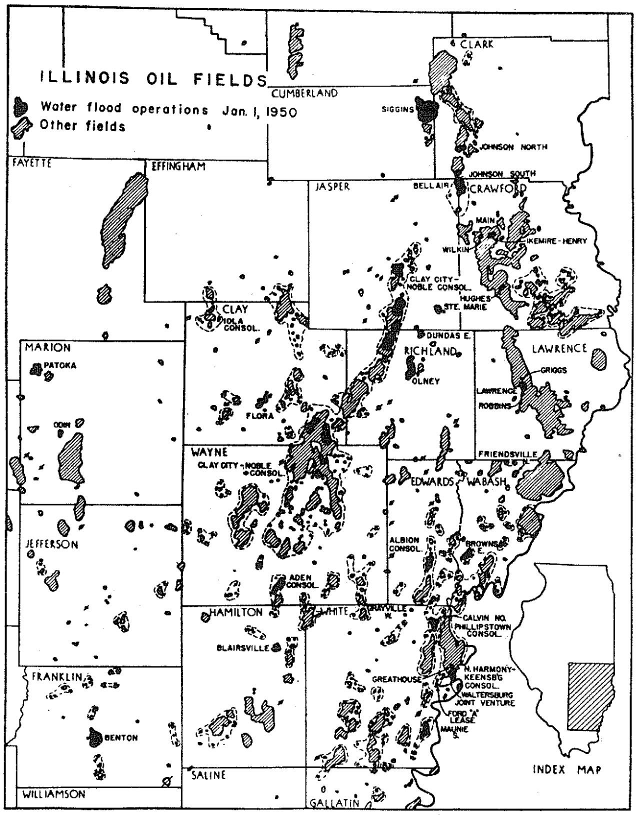

Fig. 1

shot to minimize the natural permeability differences.

Forest Oil Corp. input wells are completed by running a rag packer on 1½-in. tubing with a few sacks of cement to hold it. Only surface casing is used. The input wells of Pure Oil Co. are completed by inserting perforated tubing opposite the pay and gravel packing the annular space. The tubing is then cemented in place and the casing removed.

Well-head equipment on the input wells of both companies consists of a meter between two valves with an additional valve located off the injection line, making it possible to check pressures. Oil wells are conventionally completed pumping wells.

Water source and treatment.—By the first of January 1950, 18,344,000 bbl. of water had been injected into the first and second Siggins sands. This water was obtained from fresh-water wells and produced salt water.

The fresh water comes from a 100-ft.-deep glacial gravel in Hurricane Creek. Turbine pumps at the wells lift the water and push it 6 miles through 6-in. pipe to the field where it is used in Forest Oil Corp. floods 2, 3, and 6, and in Pure Oil Co.'s flood.

Producing wells furnish the brine. After separation from the oil the brine is aerated, chemically treated, and filtered. Brine is used in Forest floods 4, 5, and 7, and will be used in future Forest floods 8 and 9.

Booster pumps force the water at 200-128 lb. pressure through a series of cement-lined mains, laterals and individual lines to each of the injection wells. Sand face pressures are kept below the maximum safe pressure of 1 psi. per foot of depth. Daily average injection rates for 1949 average slightly in excess of 1 bbl. of water per foot of exposed sand.

Results obtained.—During the period 1942 through January 1, 1950, Siggins field has produced 3,187,000 bbl. of water-flood oil and, as of January 1, 1950, was producing in excess of 3,000 bbl. daily. Yields per acre are not yet representative of flood value because most properties are far from being flooded out. However, water-flood yields per acre to January 1, 1950, on some leases have been as high as 8,000 bbl.

Production curves of Forest floods (Fig. 4), with all floods shown as though they had been started at the same time, show a gradual decrease in production after the peak is

WATER FLOODS, JANUARY 1, 1950

Line No.	1949: Water flood oil production	1949: Water production	1949: Water input	Avg. input bbl. per day per ft. of pay	Cumulative production and input to January 1, 1950: Water flood oil production	Cumulative: Water production	Cumulative: Water input	Input water: Type	Input water: Source	Input water: Chemically treated	Flood pay: Net thickness (ft.)	Flood pay: Avg. porosity (%)	Flood pay: Avg. permeability (md.)	At start of water flood per cent of pore space saturated: Oil	At start of water flood per cent of pore space saturated: Water*	Oil characteristics: Viscosity centipoises	Oil characteristics: A.P.I. gravity	Water-flood pattern	Input to oil well distances
1											10	22.0	150	....	42.0				....
	28,332	10,620	230,264	18.0	28,952	34,605	542,801	Brine	Penn sand	Yes	3.6	....	...	....	....	7.6 at 100° F.	35.4	Perimeter	....
2																			
3	59,061	156,520	219,577	10.0	119,942	248,280	402,596	Brine Fresh	Produced Run off	Yes	20	19.7	304	22.0	29.0	6.3 at 95 at	32.5	Spot	...
4	20,188	3,173	111,227	22.0	20,188	3,173	111,227	Brine	Penn sand	No	17.1	20.2	265	.	23.6	5.1 at 88° F.	37.6	Flank inj.	...
5	29,181	§100,000	2,211,655	2.8	29,181	§90,000	2,719,268	Fresh	Gravel bed	No	38	17.1	148	35.5	42.7	16 at 77° F.	32.4	5-spot	300
6	53,700	141,335	2,894,101	2.8	53,700	141,335	3,936,711	Fresh	Gravel bed	Yes	22	18.6	149	35.9	43.4	18.7 at 77° F.	32.0	5-spot	300
7	None	8,400	815,600	8.2	None	8.400	815,600	Fresh	Lake	Yes	37	19.0	65	50.6	†26.4	3.5 at 86° F.	38.0	5-spot	660
8	3,722	9,273	208,582	18.0	3,722	13,542	252,611	Brine	Cypress sand	No	15.5	19.0	92	....	....	4.2 at 99° F.	37.6	Perimeter	..
9	90,877	918	139,241	11.5	166,653	918	235,319	Brine	Tar Springs sd.	No	11	18.0	144	83.0	†15.0	4.6 at 92° F.	36.0	Line	1,500
10	33,421	12,575	50,760	9.9	70,389	14,808	102,092	Fresh	Penn sand	No	7	16.0	81	76.0	†18.0	7.5 at 86° F	35.6	Near 5-spot	500
11	None	8,750	39.103	1.5	None	14,504	62,662	Brine	Produced	No	7	15.7	80				37.0	Spot	...
12	4,554	1,000	445,000	8.7	4,554	1,000	445,000	Fresh Brine	Gravel beds Produced	No	15	19.0	200	42.0	est.25.0	5 to 6 at 60° F.	31.0	5-spot (irreg.)	
13	61,585	§100,000	1,080,663	3.4	61,485	§100,000	1,080,663	Fresh Brine	Gravel beds Produced	Yes	48	16.6	319	33.6	55	14.7 at 77° F.	29.2	5-spot	300
14	32,987	22,917	295,109	1.7	44,037	22,917	364,786	Fresh	Gravel bed	No	52	21.6	...	...	....	.....	...	5-spot (irreg.)	400
15	5,116	15,722	63,745	1.9	9,627	31,460	307,690	Brine	Buchanan sd.	No	23	20.0	....	....	....	.....		5-spot	
16	41,250	21,000	237,200	3.9	45,000	25,440	342,500	Brine	Penn sand	No	14	21.5	175	40.0	‡15	7.0 at 60° F.	35.0	5-spot	300
17	29,979	40,128	601,383	3.0	34.400	44,429	714,894	Fresh	Gravel bed	No	22	22.0	...	...	..	..	....	5-spot	...
18	8.461	434	188.304	.6	9,070	434	218,923	Fresh	Penn sand	No	25-45	20.1	....	....	....	...	....	5-spot	....
19	280.054	140,263	533,150	8.5	528,086	167,917	1,148,565	Brine	Penn sand	No	15.7	18.5	529	73.0	‡17	4.6 at 89° F.	37.3	5-spot	660
20	543		230.588	7.0	543	§20.000	230.588	Fresh	Gravel bed	No	23	17.0	20	...	30	.....	38.0	5-spot	.....
21	2,596	None	14,610	5.7	2,596	None	24,894	Fresh	Gravel bed	No	7	....	....	....	....	.....	....	Spot	660
22	13.366	§[illegible]0 000	234.359	6.0	13,366	§10.000	259.338	Fresh	Gravel bed	No	5	....	....	....	....	.....	...	Spot	....
23	115,791	92,759	469,486	10.7	315,252	144,458	1,886,225	Brine	Produced	Yes	40	19.2	200	...	25	3.8 at 86° F.	36.8	Line	....
24	None	None	13,877	12.3	None	None	13,877	Brine	Tar Springs	No	15	20.0	78	28.0	33	8.3 at 70° F.	37.0	Perimeter	700
25	7,9[illegible]8	18,684	71,464	20.0	25,660	23,920	345,844	Brine	Produced	No	10	....	....	....	....	.....	....	Perimeter	....
26	§350 000	§2,800.000	§3,900.000		5,405,226	§9,000.000	15,593,206	Brine	Tar Springs	Yes	27	19.0	110	53.0	‡20.0	.....	39.0	5-spot	460
27	§120.000	§50,000	§200,000		195,378	§50,000	394,904	Brine	Tar Springs	Yes	9	18.8	223	65.0	‡30.0	.....	40.0	Perimeter	
28	9,254	7,134	43,343	10.8	24,936	9,306	86,690	Brine	Penn sand	No	11	19.0	85	69.0	‡18.0	11.2 at 78° F.	32.2	5-spot	550
29	682,574	§1,500,000	3,526,599	1.0	2,497,797	§4,000,000	14,321,908	Brine Fresh	Produced Gravel beds	Yes No	32	17.5	56	36.7	46.7	8 at 60° F.	36.6	5-spot	300
30											25	18.5	45	29.8	52.2		36.0	5-spot	300
	426,137	836,803	1,543,263	1.6	689,151	1,115,333	4,021,594	Fresh	Gravel beds	Yes						8.8 at 68° F.			
31																			
											6	18.3	66	26.7	52.5		....	....	....
	2,510,687	6,118,408	20,612,253	9.9 av.	10.398,891	15.336,179	50,982,976			Averages	20.1	18.9	156	‡63.7	‡19.8		35.6		

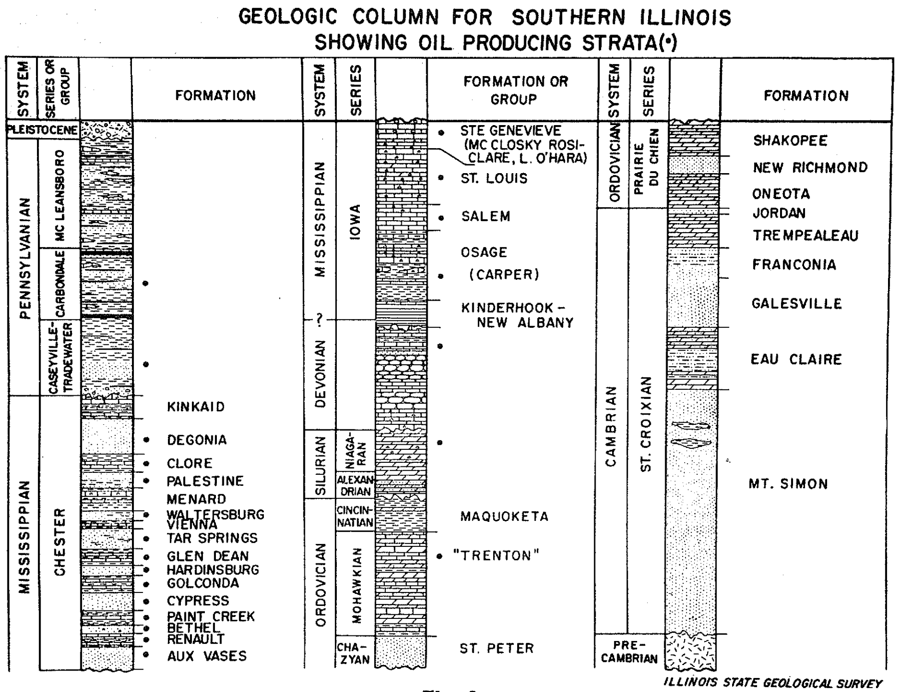

Fig. 2

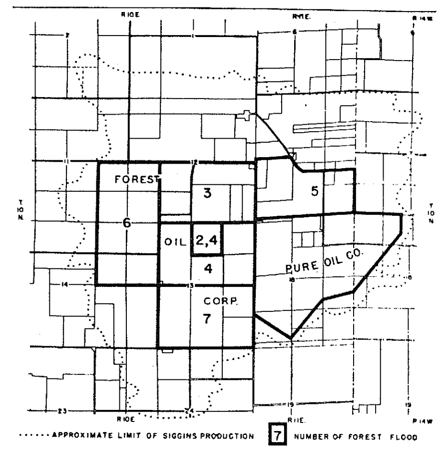

Fig. 3—Location of Siggins pool floods.

reached. The marked similarity in decline slope indicates a predictable future life for each flood if present injection and production methods are continued. From the decline rates it seems certain that Siggins floods will continue at a commercial level of production many years after peak production is reached.

Summary.—The Siggins water flood is one of the most successful in the state. At present it ranks third in cumulative water-flood production after the Patoka and basin McClosky floods which rank first and second.

The reservoir characteristics as shown in Table 1, Data for Illinois Controlled Water Floods, January 1, 1950, do not show superior conditions for flooding, but careful evaluation and efficient operating techniques employed are proving successful.

Bellair Water Flood

Introduction.—Bellair field has three pays, the 500 and 800-ft. Pennsylvanian sands, and the 900-ft. Mississippian sand. Only the 500-ft. Pennsylvanian sand is discussed here since it is the only one so far flooded. (See Fig. 5.)

Water-flood history.—The Bellair "500" flood is operated by Forest Oil Corp. and Pure Oil Co., covering 700 acres near the center of the field. Water was first injected in July 1948 and flood production first obtained about the middle of 1949. The daily average production for December 1949 was approximately 550 bbl. of oil.

Water-flood development.—With a few exceptions, old wells were plugged and new wells drilled in a five-spot pattern. Input wells are usually 400 to 440 ft. apart, with input to oil well distances about 300 ft.

Pure's producing wells are completed with casing cemented at the top of the producing zone and wells are flowed through the casing. Input wells are completed by running 1½-in. tubing perforated opposite the pay, filling the annular space to the top of the pay with gravel, and then adding about 5 ft. of sand topped with a few sacks of cement. Casing is then removed from the hole. Forest completes producing and input wells by running 1½-in. tubing with a rag packer cemented opposite the top of the injection interval. Only surface casing is left in the wells. Both companies shoot the sand to even the permeability profiles and equip each input well with a water-flow meter.

Water source and treatment.—Fresh water alone is used in the Bellair flood with approximately 6,656,000 bbl. injected into the sand to the first of January 1950. Water is obtained from gravel beds 100 ft. deep, ½ to ¾ miles southwest of Bellair field. Turbine pumps lift the water and push it through the 6-in. main lines.

Pure Oil uses two diesel engines close to the source wells to raise the pressure to 400 psi., a pressure sufficient to move the water 1½ miles to the filter plant, through the pressure filters, and into the wells at a pressure of about 225 psi.

Forest Oil uses the turbine pumps at the wells to lift and push the water to their booster pump and filter station about 1¼ miles away. Forest's well-head pressures are about 250 psi. Both companies use closed systems with pressure filtrations.

Iron precipitates on the filter elements have caused considerable difficulty. Recently Calgon and calcium hypochlorite treatment have been added by Pure. The 225-280 psi. well-head pressure plus the static head is close to the maximum safe flooding pressure of 1 psi. per foot of depth.

Results obtained.—Because the Bellair "500" flood is new, yields per acre, cumulative production, or other yardsticks of flood productivity are not yet significant. However, a few interesting points of flood behavior of the Bellair "500" are now known.

Production since the start of water flood to January 1, 1950, was 83,000 bbl. with daily production increasing from a few barrels in June to 550 bbl. in December 1949. Water was produced from the start of flood production and had increased to a 70 per cent water cut by January 1, 1950. The production from the wells of Pure which are flowed continuously and from those of Forest, which are flowed intermittently, is similar.

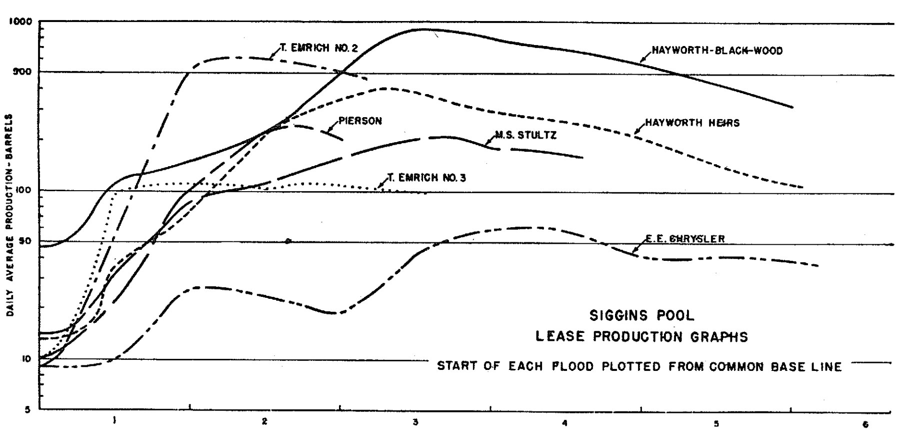

Fig. 4

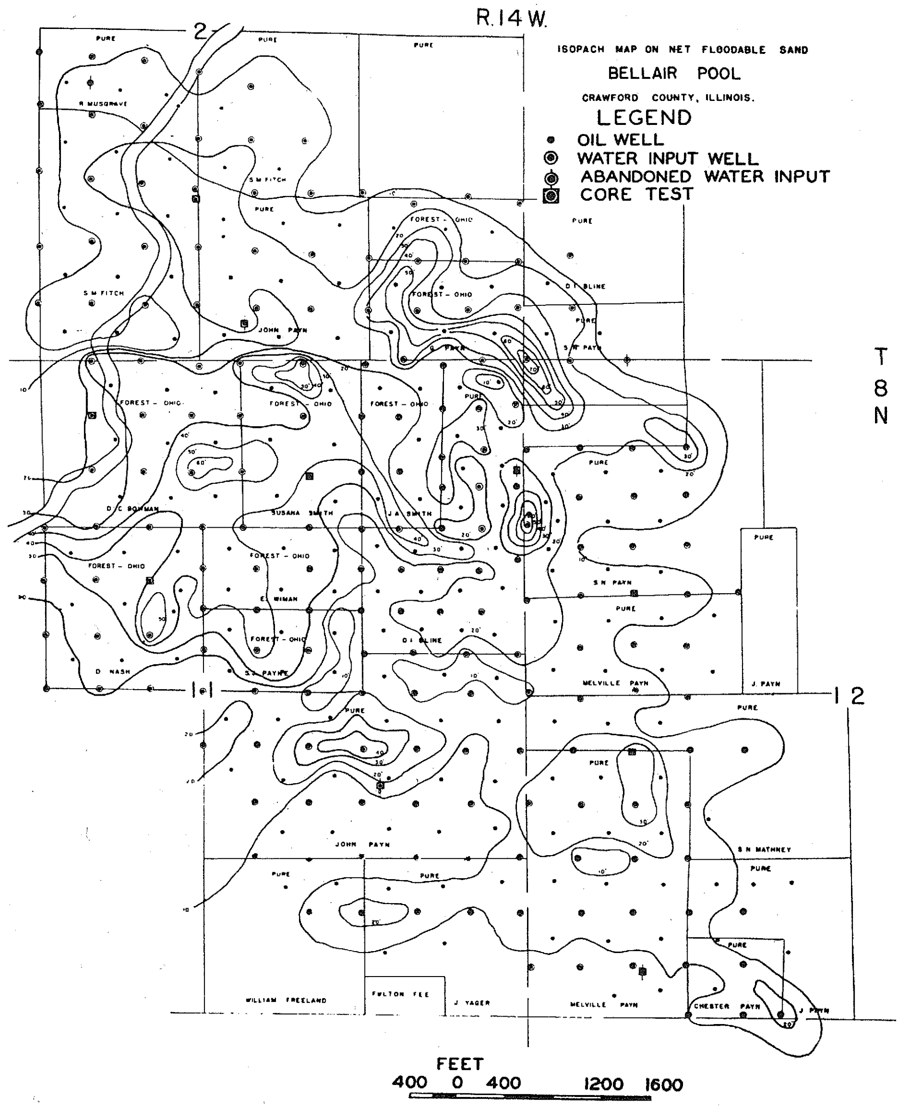

Fig. 5

Ikemire-Henry Lease Flood in Main Pool, Crawford County

Introduction and history.—Oil was discovered in this area in 1906. The Ikemire-Henry lease was developed in 1907 and 1908. Wells had average initial productions of 80 bbl. of oil per day. In 1911 daily production was down to 3 bbl. of oil per well per day. In attempts to increase production, vacuum was used in 1919 and air injection in 1932. These methods recovered 800-1,000 bbl. per acre over a 14-year period. The present Ikemire-Henry water flood was started in 1946.

General geologic conditions.—The Ikemire-Henry flood pay is a small Robinson sand lens ½ by 1 mile, trending northeast-southwest (Fig. 6). Sand thickness ranges from about 35 ft. at the center to zero at the lens edge. The main Robinson sand body underlies the lens and in most places is separated from it by a considerable thickness of shale, but at some places by only a thin shaly sand. The top of the lens is about 940 ft. below the surface.

Water - flood history.—Tide Water Associated Oil Co. first injected water into the Ikemire-Henry lens in February 1948, and flood production was first obtained in August 1948, when production of the 45-acre flood area increased from a few barrels to 35 bbl. per day. By the end of December 1949, the daily average production was 140 bbl. of oil and cumulative water-flood production was 45,000 bbl.

Water-flood development.—A somewhat irregular five-spot pattern is

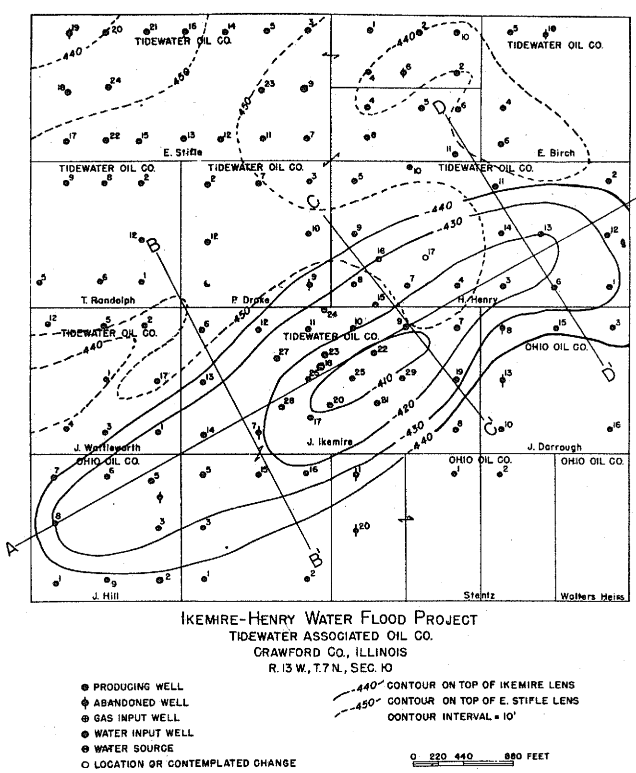

Fig. 6

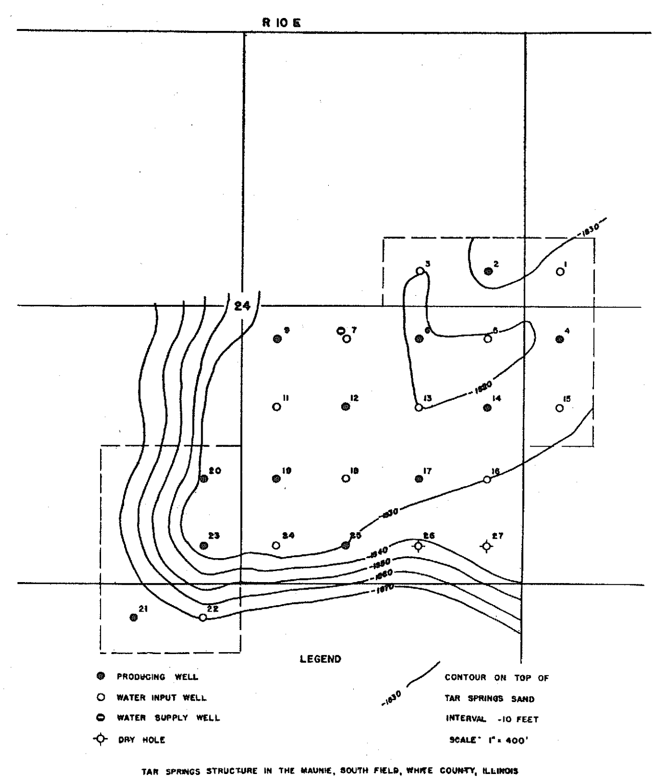

Fig. 7

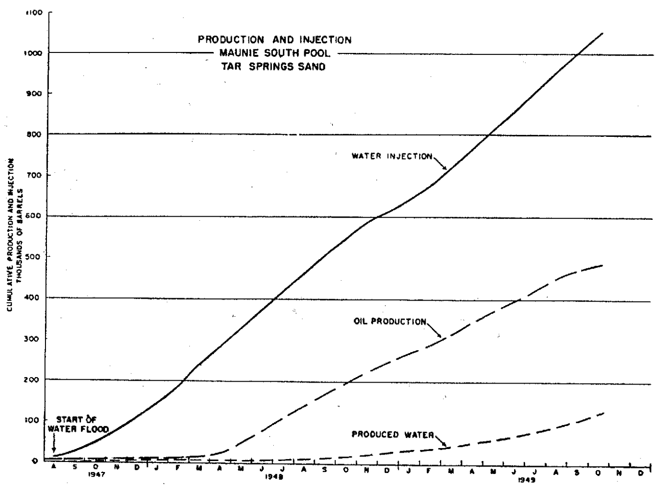

Fig. 8

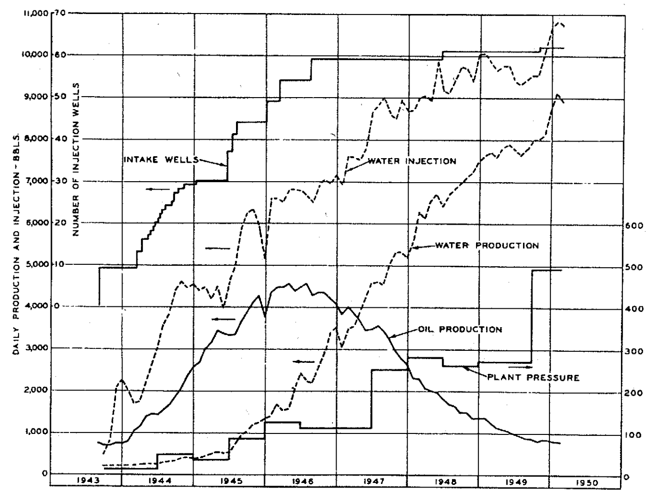

Fig. 10—Patoka Benoist water flood.

used in the Ikemire-Henry lease flood (Fig. 6). Input to input well distances are generally 440 ft.; oil well to input well distances are about 300 ft. Variation in spacing results from the use of a few original wells in the five-spot pattern.

Wells are drilled with cable tools and shot to equalize permeability profiles. Producing wells are completed with 5½-in. casing and pumped through 2⅜-in. tubing. Input wells are completed with 4½-in. casing cemented through the drained upper part of the sand. Individual meters are used on input wells.

Water source and treatment.—One old oil well deepened to a basal Pennsylvanian sand at 1,200 ft. has furnished the entire 342,500 bbl. of water injected into the Ikemire-Henry lens to January 1, 1950. A conventional oil-well pump is used to lift the water and distribute it to the nine injection wells.

Iron precipitates have caused a reduction of intake rates at times, but acid treatment has been an aid in remedying this condition. The daily injection rate as of January 1, 1950, was approximately 670 bbl. of water at 130 psi., or 4 bbl. per foot of sand per day.

Results obtained.—By the end of December 1949, the 45-acre flooded area of the Ikemire-Henry lease had produced 45,000 bbl. of flood oil and the rate of production was increasing each month. The per cent water cut has increased, from 38 per cent in September 1948 to 51 per cent in December 1949.

South Maunie Water Flood

Introduction and history.—Since the discovery of South Maunie field in 1941, 10 pays have been found in the Pennsylvanian and Mississippian systems. Only the water-flooded sand, the Tar Springs of the upper Mississippian, is discussed here.

Initial production from Tar Springs wells ranged from 10 to 500 bbl. of oil per day. Primary production from the Tar Springs is not accurately known because production from the many pays was not separated, but it is estimated at 486,000 bbl.

General geologic conditions. — South Maunie Tar Springs reservoir is on a northeast-southwest elongated rise with little closure, 25 ft., and of varying sand thickness, 10-30 ft. It is about 20 miles southeast of the deepest part of the Illinois basin. The structurally highest Tar Springs in the South Maunie field is 1,820 ft. below sea level (Fig. 7).

Water-flood history.—Water was first injected into the Tar Springs sand August 11, 1947, and by January 1, 1950, 1,148,565 bbl. of water had been injected into the 230 acres of water-flooded sand.

Immediately prior to water flooding, Tar Springs oil production from the flood acreage was about 40 bbl. per day; in July 1948, it was 1,040 bbl. per day. The cumulative water-flood production to January 1, 1950, was 528,086 bbl.

Water-flood development.—A five-spot pattern was made by converting alternate wells of a regular 10-acre spacing to water-input wells (Fig. 7). This arrangement puts input wells 930 ft. apart and input to oil wells 660 ft. apart. Water is injected through tubing with upside-down hookwall packers. Water lines and tubing are plastic lined and each input well is equipped with a meter Producers are conventional pumping wells.

Water source and treatment.—Water is obtained from a Pennsylvanian sand by one well located in 24-6s-10e. In September 1948 this water source was augmented by returning produced water to the sand. Water injection is maintained in a closed system without treatment although occasional acid treatments have been used to clean tight wells. A Reda pump is used in the source well and two horizontal triplex plunger pumps furnish the line pressure. Initially input wells took water under vacuum or with very little pressure. In December 1949 plant pressures of approximately 800 psi. were used and a daily injection rate was maintained of close to 1,550 bbl., or about 8.5 bbl. per day per foot of sand.

Results obtained.—By the end of December 1949, 528,086 bbl. of flood oil had been produced from the 230-acre flooded area. This is approxi-

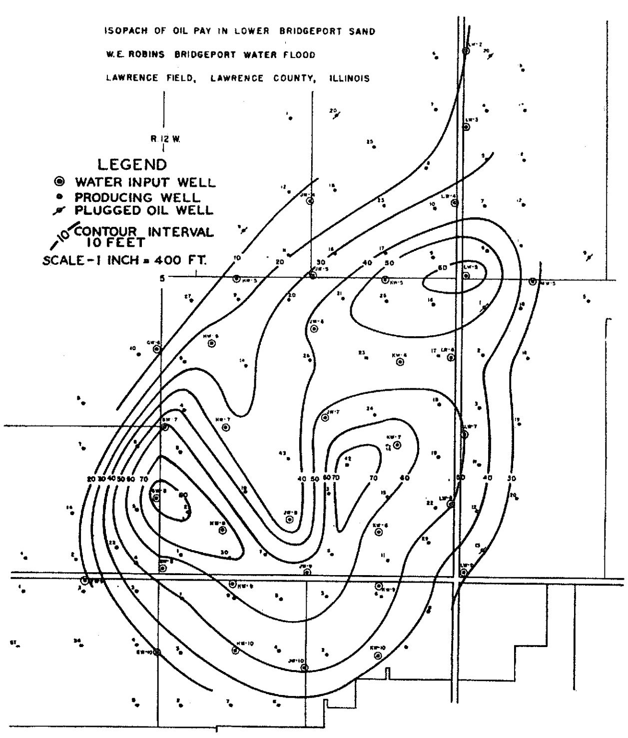

Fig. 9

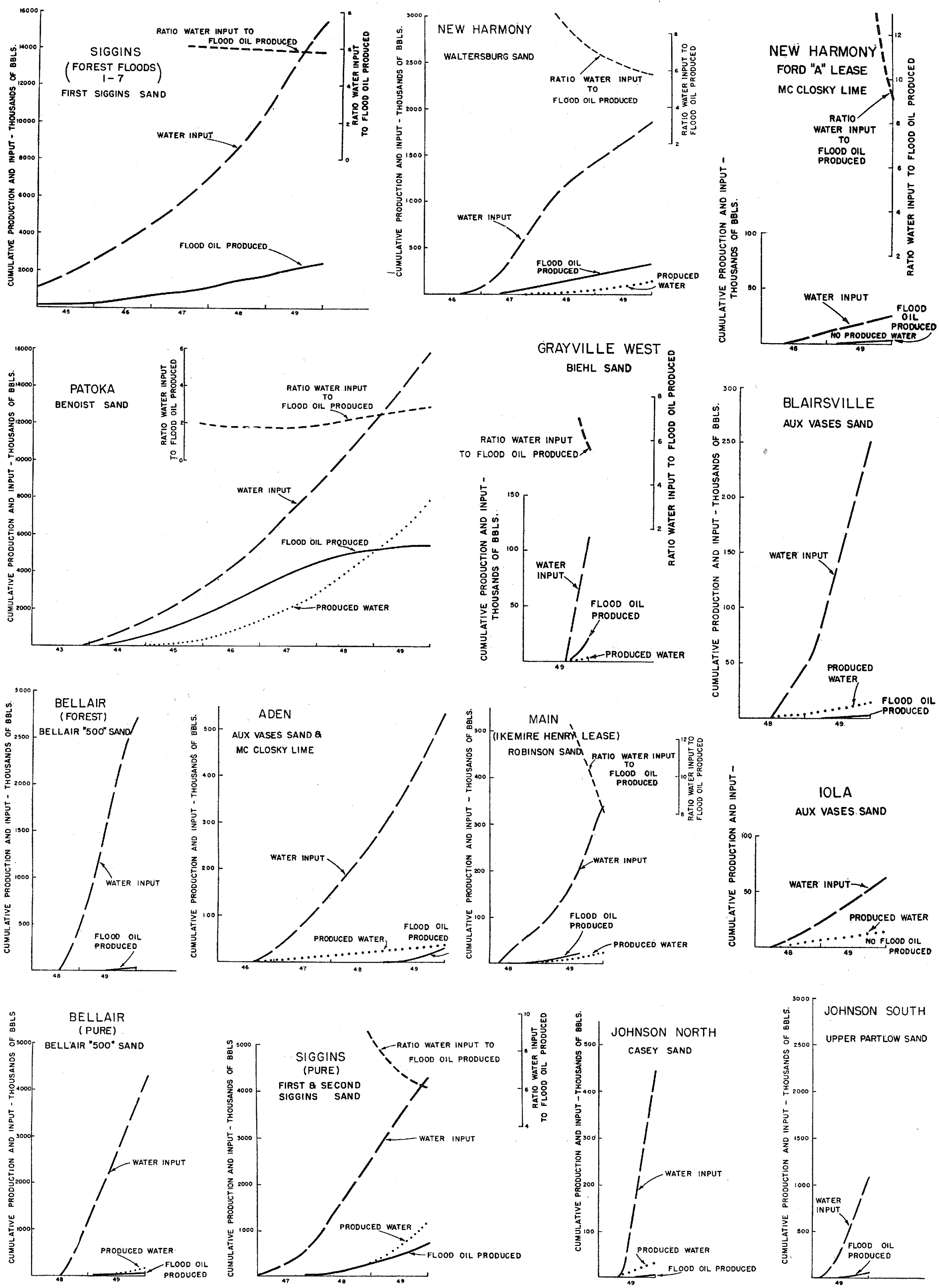

Fig. 11—Graphs of water input and oil produced by water flooding.

mately 2,300 bbl. per acre, or 144 bbl. per acre-foot. Daily average production has remained high with cumulative production showing a constant rate of increase.

Summary.—The Tar Springs flood in South Maunie field was the first 10-acre spacing sand flood in Illinois and the first in Illinois to convert producing wells to input wells. Its success has greatly influenced water-flood procedures in the state, because of the great saving in cost of the operation in comparison with the drilling of new wells for input wells and of closer spacing of wells. The secondary recovery to January 1, 1950, of 528,086 bbl. is greater than the primary production of 486,000 bbl. The success of the South Maunie flood is of particular importance to the new fields of Illinois where there is much pay sand of similar physical characteristics.

W. E. Robins Bridgeport Water Flood

Introduction and history.—The W. E. Robins Bridgeport water flood is being operated by Ohio Oil Co. in Lawrence field, Lawrence County, Illinois. The flooded zone is the lower Bridgeport sand. The part of the flood now active covers the whole of the Robins lease which occupies the SE¼ 5-3n-12w.

The first Bridgeport producer in this area was completed in 1906. The Robins lease was developed between 1909 and 1913. The initial production of the wells averaged 80 bbl. of oil per day, but production dropped off rapidly to a few barrels of oil per day.

Repressuring by air and gas was used from 1944 to 1948 in an attempt to increase production. Production which had been 450 bbl. per week for the lease was increased to a maximum of 900 bbl. per week as a result of the operation. The present flood on the Robins lease was started in 1948.

General geologic conditions.—This water-flood pay is located on the eastern flank of the LaSalle anticline just downdip from the crest. The sand thickness ranges from a few feet to slightly over 100 ft. in the center of the lease. On the west side of the lease the sand body is largely replaced by shale. The top of the lower Bridgeport sand is about 900 ft. below the surface.

Water-flood history.—Ohio Oil Co. first injected water in the lower Bridgeport sand on the Robins lease in August 1948 and a definite increase in production was noticed by April 1949. A total of 1,306,585 bbl. of water had been injected into the 29 intake wells of the flood by July 31, 1950. An estimated 35,000 bbl. of water-flood oil have been produced from the start of the flood to July 31, 1950.

Water-flood development.—An irregular five-spot pattern is used in the Robins flood. The distance between wells is quite variable as a result of including the original wells in the five-spot pattern.

The intake wells are drilled with a rotary rig and completed with 4½-in. casing set with cement through a depleted zone in the upper part of the sand. The wells are cleaned with a wall-scratcher prior to water injection. Water is injected through the 4½-in. casing. Each injection well is equipped with an individual meter. The producers on the lease are pumped, some from a central power unit and others from individual units powered by electric motors.

Water source and treatment.—During the early part of the flood, water was supplied from a well in the Buchanan sand, and injected into the reservoir through a closed system without treatment. Since October 1949, a fresh-water well in alluvial gravels along the Embarras River 6 miles north of the lease has supplied the water for the flood. The water is pumped through a pressure filter en route to the intake wells. The water system is closed. No chemical treatment is used. Water is supplied to the well-heads at pressures up to 325 psi., but most of the intake wells receive water at little or no pressure. Reduction of intake rates due to plugging of the sand face has been corrected by the use of scratchers. Intake rates range from 0.5 bbl. per foot of sand per day to 10 bbl. per foot per day with an average of 5 bbl. per foot per day.

Results obtained.—Because the W. E. Robins Bridgeport flood is new, the ultimate productivity of the flood is difficult to estimate. Since the start of the flood in 1948, 95,000 bbl. of oil have been produced from the Robins. Daily production has almost tripled since the start of the flood although fillup has not been attained in all segments of the flood pattern. Fluids produced averaged about 30 per cent water during the month of July 1950.

Patoka Water Flood*

Water - flood history.—Patoka was discovered in February 1937, and was developed by 132 wells on 700 acres. A history of water flooding in the Benoist sand of Patoka field is shown graphically in Fig. 10. This flood was begun in 1943 and the first increase in production was realized early in 1944. A slight increase over immediate preflood production of about 700 bbl. daily still exists. Peak production by primary recovery was slightly over 2,000 bbl. daily.

Water-flood development.—By August 1946, 59 intakes and 39 new producing wells were completed. Forty off-pattern wells in the original drilling were abandoned, and three were plugged back and recompleted in the Tar Springs as brine supply wells. The water-flooding pattern is in general a 10-acre five-spot with somewhat wider spacing at the extreme north and shorter and less regular spacing in the south near the town of Patoka. The final water-flood development included the drilling of 62 intake wells and 40 oil wells, which combined with the wells retained from the original development gives a total of 80 producers on 566 acres. All wells were completed with cemented-in casing. Flooding water is being introduced into the casing in input wells and the oil wells pumped through tubing in the usual way.

*The complete history of Patoka field both primary and flood production, was given by Hugh S. Barger in his article in the May 25, 1950, issue of The Oil and Gas Journal. A summary description is included here because the operation was skillfully designed and operated and the results in oil production were spectacular.

Water source and treatment.—The flooding water is obtained from three wells completed in the Tar Springs sand, one of which is capable of producing 15,000 bbl. per day. The supply and produced water is aerated, settled, chemically treated, and then filtered. Water in sufficient volume at first entered the sand with a vacuum on the casing. The line pressures were advanced as increasing resistance was encountered until it now operates at 500 psi.

Results obtained.—The entire water injected as of March 1950 was 16,300,000 bbl. and the cumulative oil produced was 5,451,000 bbl. This ratio of 2.9 is unusually good.

Conclusions from a Comparison of the Six Described Floods

The six floods described have some notable similarities. Probably the most important of these is that much was known concerning the physical characteristics of the reservoir rocks and fluids before the floods were started. Other similarities are that all of the floods are pattern floods and that flood development covers an extensive area. Some of the more important dissimilarities are different operating techniques, different geologic ages of flood pays, and the great difference in the term of primary production.

The data given above for the six floods will be useful in considering the flooding possibilities of other areas where some information on reservoir characteristics is available. In addition the behavior of these six floods should furnish a sound basis on which to check computations on fillup time, water requirements, oil production, and life of flood production once a flood project is started.

General conclusions.—Although all of the 31 controlled floods tabulated in this report were started since 1942, 5 out of the 7 Chester (upper Mississippian) sand zones and the 2 most important lower Mississippian producing zones now have water floods in operation. These Mississippian floods plus the 15 floods in the many Pennsylvanian sands give Illinois a nearly complete check on the general floodability of its many producing zones.

The Pennsylvanian sand floods are numerically in the lead because of their shallow depth and because they are closer to primary depletion than the more recently drilled producing formations. McClosky floods are next in numerical order primarily because their high permeability makes flooding on the primary well spacing feasible and because McClosky producing areas have generally been favored by abundant water supplies in the shallower formations. The remaining zones undergoing water flooding in Illinois have from one to three floods each. Of these zones, two have been outstandingly successful, the Tar Springs in South Maunie, and the Benoist in the Patoka field. The three floods in the high water content Aux Vases sand have not yet settled the question of the floodability of the Aux Vases sand, but the progress of these floods has improved the prospects for the eventual successful flooding of this horizon.

There does not appear to be any "best" formation for flooding in Illinois. All formations seem capable of possessing the necessary characteristics for successsful flooding in one or more places within the state.

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