

Addendum to Circular 244

TABLE 2, page 8, includes data from 36 companies instead of 35. Of the 40 companies which replied (p. 2) two reported no brine disposal wells and two reported brine disposal wells but did not give the rate of brine injection.

BRINE DISPOSAL IN ILLINOIS OIL FIELDS

Alfred H. Bell

ABSTRACT

This summary of brine disposal as of January 1, 1957, is the Illinois part of a report on brine disposal in oil fields of the United States, prepared by the Interstate Oil Compact Commission.

Illinois oil fields produce more than twice as much brine as oil and dispose of most of the brine by injecting it into wells that are either specially drilled for the purpose or converted from dry holes or abandoned producers. Only small quantities can be disposed of in any one place by evaporation from storage pits.

Illinois has about 370 oil fields of which about 90 use wells for subsurface brine disposal. In December 1956 about 210,000 bbls. of brine were injected daily into about 500 wells. About 70 percent of the total brine was injected into Mississippian formations. The rest was put into Devonian-Silurian (16 percent), Pennsylvanian (12 percent), and Ordovician and unclassified (2 percent).

The two major problems in brine disposal are corrosion of equipment and plugging of the disposal formation. Both are largely chemical problems.

INTRODUCTION

This report on brine disposal in Illinois was prepared as part of a report on brine disposal in the United States. The study was undertaken in 1955 by the Research Committee of the Interstate Oil Compact Commission. Preliminary reports on several states were submitted to the Research Committee at three previous meetings, in May 1956, December 1956, and June 1957.

At the June 1957 meeting the Research Committee adopted a comprehensive outline for the state reports and decided to ask each state to submit a revised report, if it wished to do so, giving the status of brine disposal at the beginning of 1957 and covering as many as possible of the items included in the outline.

The disposal of brine produced with crude oil in Illinois is a major problem and one that adds appreciably to the cost of producing oil. Because the climate is relatively humid, the disposal of brine by evaporation in any substantial quantity is not practical in Illinois, and accordingly much of the produced brine is disposed of by re-injection into subsurface formations through wells that are specially drilled or converted for this purpose. Because pollution of potable waters must be avoided, the formations selected for brine disposal are generally some hundreds of feet deeper than aquifers used for water supplies and are separated from them by relatively impervious formations.

Much produced brine is used in waterflooding operations to recover oil, and additional large quantities of brine are disposed of by injecting it into formations that do not carry oil in the area of injection. Formerly subsurface brine disposal into oil-bearing rocks often caused unexpected increases in oil production from adjacent wells. Thus what started as a purely disposal well may become an injection well for waterflooding. It is not always possible to distinguish between input wells for waterflooding and salt water disposal wells.

This discussion has been confined so far as possible to purely disposal operations but because of the overlap of brine disposal with injection for flooding, it is impossible to exclude some waterflooding operations. No attempt is made to consider the economic aspects of brine disposal.

This report is based on replies to questionnaires sent in July 1957 to about one hundred oil companies which, according to Survey records, had received permits for SWD (salt water disposal) wells, either original drillings or conversions, in the previous ten years. The questionnaires requested information on the following points:

- (1) Number of disposal wells operating in each pool on January 1, 1957.
- (2) Names, depths, and thickness of the formations into which brine is being injected.
- (3) Barrels of brine disposed of per day in December 1956, by wells or by pools, either measured or estimated. (If possible, separate the amounts by formations used for disposal; otherwise, give totals.)
- (4) Methods of construction and operation of disposal wells and any special problems you have encountered.

A total of 40 replies was received up to November 1, 1957, and 38 of them provided data on brine disposal.

BRINE DISPOSAL REGULATIONS

Regulations pertaining to oil and gas drilling in Illinois are administered by the Oil and Gas Division, Department of Mines and Minerals, Springfield. Rule IX is here quoted from the booklet entitled "An Act in Relation to Oil, Gas, and Other Surface and Underground Resources and Rules and Regulations," Revised Edition 1953, pages 60-61.

RULE IX

Disposal of Salt Water or Other Liquids to Prevent Waste as Defined in the Act

"To prevent waste, no person shall dispose of salt water or other waste liquids except in the following manner. Any other method of disposal is hereby prohibited.

"(1) Mining Board Supervision

"When salt water or other waste liquid is not properly impounded or is being improperly disposed of, the Mining Board shall order such improper condition corrected when it is determined that the disposal method used pollutes fresh water supplies, creates a hazard, or is injurious to life, health or property.

"(2) Disposal in Underground Stratum

"Salt water or other waste liquids may be disposed of into an underground formation or strata after a permit to do so has been procured from the Mining Board or hereinbefore provided. The Mining Board shall have authority to designate and approve the stratum into which such liquids shall be disposed of, also the protective work necessary to confine such liquids to the intended stratum.

All such work shall be executed under the supervision of a Mining Board Representative and shall conform to the requirements imposed in granting the permit therefor.

"(3) Disposal in Earthen Pits

"Salt water or other waste liquids may also be disposed of by evaporation when impounded in excavated earthen pits, which may only be used for such purpose when the pit is underlaid by tight soil such as heavy clay or hardpan.

"Where the soil under the pit is porous and closely underlaid by a gravel or sand stratum, impounding of salt water or other waste liquids in such earthen pits is hereby prohibited. When such liquids are impounded in an earthen pit, it shall be so constructed and maintained as to prevent escape of such liquids therefrom.

"The Mining Board shall have authority to condemn any pit which does not properly impound such liquids and order the disposal of such liquids into an underground formation, as herein provided.

"The level of salt water or other waste liquids in earthen pits shall at no time be permitted to rise above the lowest point of the ground surface level. All pits shall have a continuous embankment surrounding them sufficiently above the level of the surface to prevent surface water from running into the pit. Such embankment shall not be used to impound salt water or other waste liquids.

"At no time shall salt water or other waste liquids impounded in earthen pits be allowed to escape over adjacent lands or into streams.

"(4) Pipes to be Kept in Repair

"A pipe conveying such liquids to any salt water disposal well or pit shall be kept in good repair and free from leaks, and no outlet valve will be permitted in such pipe between the place of origin and discharge."

ENFORCEMENT POLICIES AND PENALTIES FOR VIOLATIONS

The statute under which Rules and Regulations of the Department of Mines and Minerals for the Oil and Gas Division were approved and adopted November 7, 1951, became effective July 12, 1951. Enforcement policies are covered in Sec. 11 of the Act which is quoted below:

"Whenever it shall appear that any person is violating or threatening to violate any provision of this Act, or any Rule, Regulation or Order made hereunder, and unless the Mining Board, without litigation, can effectively prevent further violation or threat of violation, then the Mining Board through the Attorney General, who may call to his assistance the State's Attorney of the county in which suit is instituted, shall bring suit in the name of the people of the State of Illinois against such person in the circuit court of the county wherein is situated any part of the land which is the subject matter of such action, to restrain such person from continuing such violation or from carrying out the threat of violation. In such suit the Mining Board, in the name of the People of the State of Illinois, may obtain such injunctions, prohibitory and mandatory, including temporary restraining orders and temporary injunctions, as the facts may warrant."

Penalties for violations are set forth in Sec. 26(A). "Any person who violates any provision of this Act or who, after notice of any valid rule, regulation

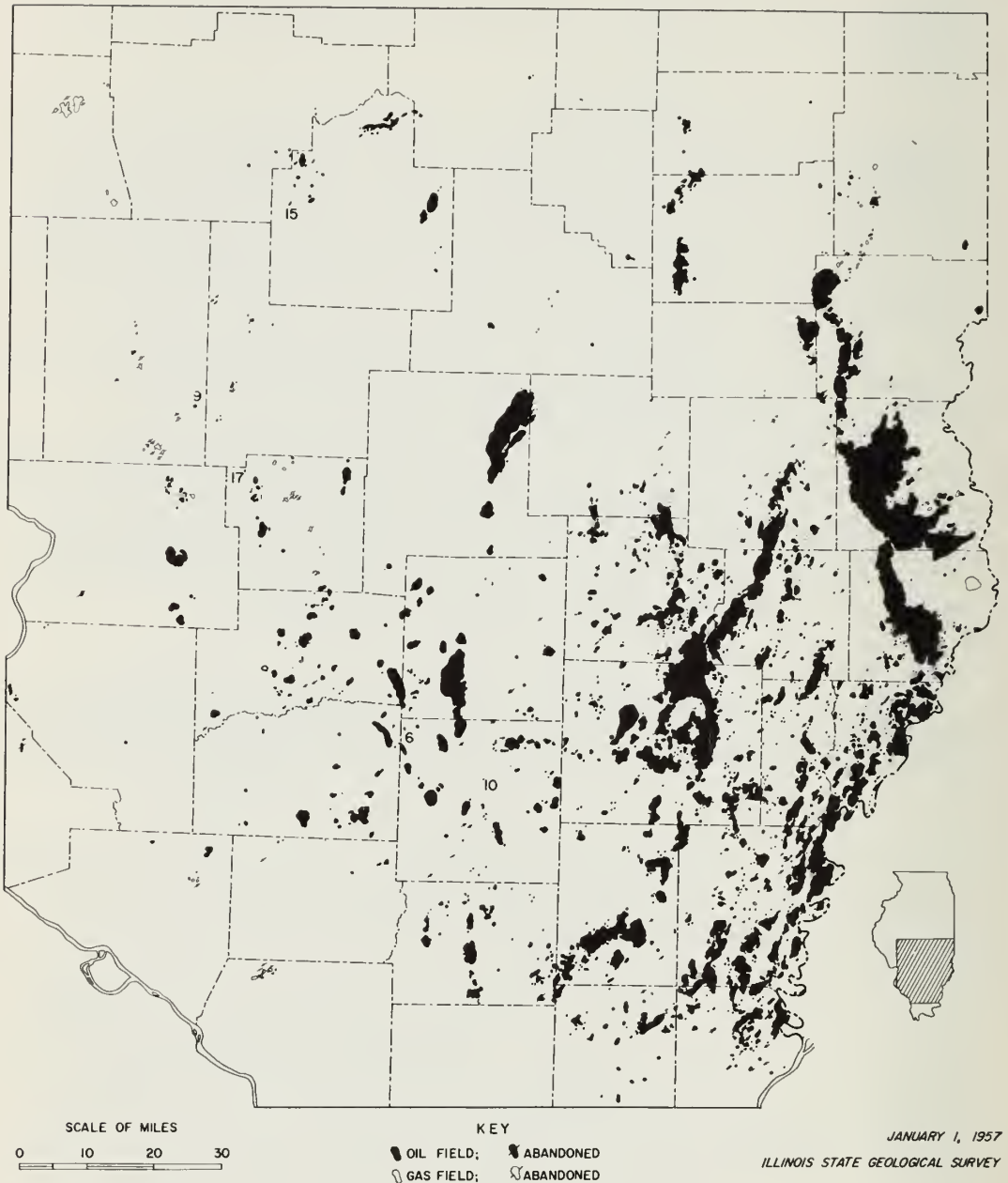


Fig. 1. - Oil and gas fields of Illinois except for a few that are outside of the area mapped. Illinois has about 370 oil fields, including abandoned fields. All but about 27 of them have been developed since 1937.

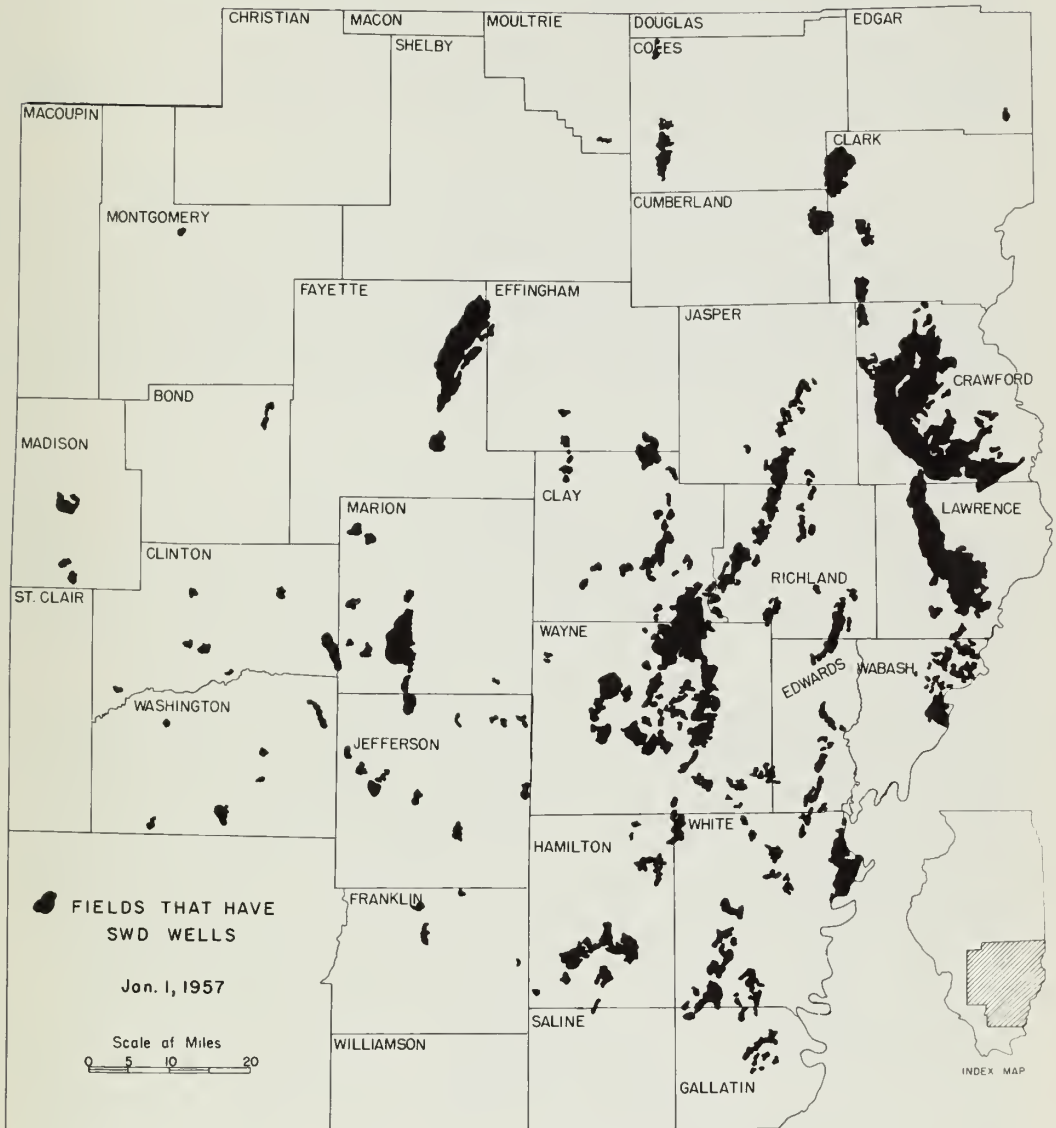


Fig. 2. - Illinois oil fields that have salt water disposal wells. The wide distribution of subsurface brine disposal is illustrated by comparison of the two maps. The 90 or so fields shown above have 86 percent of the total oil field area and 88 percent of the total oil production. If any fields have been inadvertently omitted from this survey of brine disposal, these two percentages should be correspondingly increased.

or order of the Mining Board made hereunder, violates, repeats or continues the violation thereof, shall be subject to a fine of not to exceed \$50 a day for each and every act of violation. (b) Any person wilfully aiding or abetting any other person in the violation of any provision of this Act, or any Rule, Regulation and Order made hereunder, shall be subject to the same penalties as are prescribed herein for the violation by such other person."

EXTENT OF BRINE PRODUCTION AND DISPOSAL

As most Illinois oil wells produce brine, the problem of its proper disposal is an ever present one in the oil-producing area. In many pools where only small quantities of brine are produced it is impounded in evaporation pits. Pits are used almost always in connection with brine disposal operations whether there is subsurface disposal or not. Many companies reported that they use storage pits or corrosive-resistant tanks into which brine is piped from producing wells. From these storage pits or tanks brine is pumped or siphoned into the injection wells.

The present report does not include any detailed survey of brine disposal in evaporation pits.

Out of a total of some 370 oil pools in Illinois (fig. 1; Bell et al., in press) only about 90 have brine disposal wells (fig. 2 and table 3). However, these 90 oil pools include nearly all of the larger pools in the State and they are widely distributed throughout the oil producing region. They had 86 percent of the total oil producing area and 88 percent of the daily average production in December 1956.

Brine produced with oil from oil wells and used in waterflooding is estimated to total 106,179,000 barrels in 1956 (Pryor et al., 1957) or an average of approximately 290,000 barrels per day for the whole year. Brine injected into disposal wells in December 1956 was at a daily average rate of approximately 209,740 barrels. Assuming that the daily average of brine injected for waterflooding was the same in December 1956 as it was for the whole year, the total brine produced and injected both for waterflooding and for disposal amounted to a daily average of 499,740 barrels in December 1956. As the daily average oil production in that month was about 225,000 barrels, brine was produced in a ratio of 2.2 barrels to 1 barrel of oil. This does not take account of brine disposed of in evaporation pits for which no quantitative measure is available.

The continued expansion of waterflooding operations in Illinois will demand more and more water and it seems likely that the use of produced brine for waterflooding will increase. This should result in a decreasing need for purely disposal operations. For this reason and because some subsurface disposal operations may have been omitted in this survey the actual water-oil ratio is probably somewhat greater than 2.2 to 1.

The succession of rock strata in southern Illinois down to the St. Peter sandstone of Ordovician age is summarized in table 1. This table indicates which formations produce oil and gas and which ones are used for brine disposal. It is noteworthy that nearly all of the oil or gas producing formations are in use for brine disposal.

Table 1. - Geologic Column for Southern Illinois Showing Oil or Gas Producing Formations and Formations used for Salt Water Disposal

System or series	Oil or gas	SWD	Group or formation, and lithology ls - limestone, ss - sandstone, sh - shale
Pleistocene			Glacial drift and loess
Tertiary-Cretaceous			Chert gravel, sand and clay
Pennsylvanian	o		McLeansboro group - sh., ls., thin ls. and coal
	o	x	Carbondale group - sh., ls., ss., coal Tradewater group - ss., sh., and thin coal Caseyville group - ss., sh., and thin coal
Chester Series	o	x	Kinkaid - ls., sh.
	o	x	Degonia - ss.
	o	x	Clore - ls., sh., ss.
	o	x	Palestine - ss.
	o	x	Menard - ls., sh.
	o	x	Waltersburg - ss.
	o	x	Vienna - ls., sh.
	o	x	Tar Springs - ss.
	o	x	Glen Dean - ls., sh.
	o	x	Hardinsburg - ss.
	o	x	Golconda - ls., sh.
	o	x	Cypress - ss.
	o	x	Paint Creek - ls., sh., ss.
Valmeyer Series	o	x	Bethel - ss.
	o	x	Renault - ls., sh., ss.
	o	x	Aux Vases - ss.
	o	x	Ste. Genevieve
	o	x	St. Louis - ls.
	o	x	Salem - ls.
	o		Warsaw - ls.
Kinderhook Series	o		Keokuk - ls.
	o		Burlington - ls.
	o		Fern Glen - ls.
	o		Osage group
Mississippian and Devonian			Sh., ls., ss.
Devonian	o	x	Chattanooga - New Albany sh.
Silurian	o	x	Limestone
Ordovician	o		Dolomite
	o		Maquoketa - sh.
	o		Kimmswick - ls.
	o		Plattin - ls.
Pre-St. Peter	o		Joachim - ls.
	o		St. Peter - ss.
Pre-St. Peter			Unidentified

Table 2. - Brine Disposal in Illinois by Formations, Jan. 1, 1957

Based on information furnished by 35 companies

System Series Formation	Brine Disposal (barrels per day) av. for Dec. 1956	No. SWD Wells	Percent Average		
Pennsylvanian	24,953	69	11.9	11.9	
Mississippian					
Chester					
Degonia	94	1	}	34.9	
Palestine	437	2			0.2
Waltersburg	1,531	3			0.7
Tar Springs	21,588	58			10.3
Glen Dean	2,350	1			1.1
Hardinsburg	7,603	14			3.6
Cypress	26,195	45			12.6
Paint Creek	240	1			0.1
Benoist	856	8			0.4
Aux Vases	12,245	70			5.9
Valmeyer					
Ste. Genevieve (Ohara, Rosiclare, McClosky)	54,028	170	26.0	}	
St. Louis	600	1	0.3		
Salem	18,946	15	9.0		
Devonian	32,846	17	15.6	}	
Silurian	1,731	3	0.8		
Ordovician					
Trenton	10	1			
Miscellaneous					
"Stray" and unclassified	<u>3,060</u>	<u>23</u>	<u>1.5</u>	<u>1.5</u>	
Total	209,740	502	100.0	100.0	

Table 2 gives the amounts of brine disposal in barrels per day in December 1956 by geologic systems, series, and formations. The Mississippian rocks were taking a total of 70 percent of the brine of which about half was into Chester series and half into Valmeyer series. Smaller amounts were being put into Devonian-Silurian, Pennsylvanian, and Ordovician rocks.

The Devonian had the highest average intake per well, about 1728 barrels per day in December 1956. The Pennsylvanian, Chester, and Valmeyer had 360 barrels, 368 barrels, and 376 barrels respectively.

TECHNICAL PROBLEMS OF DISPOSAL

Since most of the brine disposal wells in Illinois are converted oil wells, disposal techniques are controlled in large measure by the completion methods used when the well was originally drilled. Normal procedure under these circumstances consists of injecting water either into the formation that previously produced oil or into some suitable zone through perforations in the casing.

Where wells are drilled specifically for brine disposal, the casing string - often cement-lined - is cemented solidly from bottom to top. The casing is then perforated opposite the disposal zone.

Injection may be either through tubing set on a packer above the disposal formation or directly into the formation from the casing string. Although a considerable number of the wells take the brine by gravity flow most of them require pumps operating at surface pressures that range from a few pounds to 400 or 500 pounds per square inch. One was reported to be 900 pounds.

Both closed and open systems are in use. In open systems the brine is commonly stored in a pond or corrosion-resistant tank until a sufficient quantity for injection has accumulated.

The chief troubles encountered in brine disposal are corrosion of equipment and plugging of the disposal formation. Chemical treatment, especially acidizing, is commonly used to combat plugging of the formation.

ACKNOWLEDGMENTS

The cooperation of the forty oil companies who replied to the letters requesting data on brine disposal operations in Illinois is gratefully acknowledged. Two of the companies reported no brine disposal wells in operation. Lester L. Whiting of the Survey staff helped in preparing the section on technical problems of brine disposal.

ILLINOIS STATE GEOLOGICAL SURVEY

Table 3. - Brine Disposal by Pools in Illinois

Pool: County	Barrels per day Average, Dec. 1956	Number of SWD wells
Aden South: Hamilton	33	1
Akin: Franklin	170	1
Albion Cons.: Edwards, White	1,686	2
Allendale: Wabash, Lawrence	335	1
Barnhill: Wayne	128	2
Bartelso: Clinton	1,143	8
Bartelso East: Clinton	429	2
Beaucoup: Washington	125	1
Beaucoup South: Washington	10	1
Benton North: Franklin	440	1
Blairsville West: Hamilton	64	1
Bogota: Jasper	6	1
Bone Gap Cons.: Edwards	475	3
Boulder: Clinton	7,942	2
Bungay: Hamilton	171	3
Calhoun Cons.: Richland, Wayne	1,560	7
Centerville East: White	94	1
Centralia: Clinton, Marion	18,482	9
Clay City Cons.: Jasper, Richland, Clay, Wayne	84,065	211
Clay City West: Clay	260	1
Coil West: Jefferson	148	1
Cooks Mills Cons.: Coles	50	1
Cordes: Washington	656	2
Dale Cons.: Hamilton, Saline, Franklin	5,715	23
Divide East: Jefferson	389	1
Dundas East: Richland, Jasper	170	1
Elbridge: Edgar	2,830	6
Ellery Cons.: Edwards, Wayne	90	1
Ewing: Franklin	85	1
Exchange East: Marion	105	1
Friendsville Central: Wabash	520	1
Frogtown North: Clinton	3,362	3
Gays: Moultrie	65	1
Germantown East: Clinton	1,200	1
Golden Gate Cons.: Wayne, White	176	3
Herald Cons.: White, Gallatin	382	4
Inman West Cons.: Gallatin	157	1
Iola Cons.: Clay, Effingham	1,103	5
Irrington: Washington	4,619	8

Table 3. - Continued

Pool: County	Barrels per day Average, Dec. 1956	Number of SWD wells
Johnsonville Cons.: Wayne	638	5
Junction City: Marion	3,000	2
Kenner: Clay	899	1
Kenner North: Clay	70	1
King: Jefferson	183	3
Lawrence: Lawrence, Crawford	804	2
Long Branch: Saline, Hamilton	125	1
Louden: Fayette	7,929	12
McKinley: Washington	600	1
Main: Crawford	8,200	11
Marine: Madison	3,355	9
Markham City: Jefferson	44	1
Mason North: Effingham	157	1
Mattoon: Coles	403	2
Mill Shoals: White, Hamilton, Wayne	727	3
Mt. Carmel: Wabash	145	1
New Harmony Cons.: White	1,078	4
New Memphis: Clinton	557	1
Okawville: Washington	50	1
Olney Cons.: Richland	552	1
Parkersburg Cons.: Richland, Edwards	633	4
Patoka: Marion	5,295	1
Patoka East: Marion	94	2
Phillipstown Cons.: White, Edwards	273	5
Raccoon Lake: Marion	4,474	1
Raymond East: Montgomery	11	1
Reservoir: Jefferson	22	1
Rinard North: Wayne	50	1
Roaches: Jefferson	140	1
Roaches North: Jefferson	649	1
Roland Cons.: White, Gallatin	6,206	9
Ruark: Lawrence	1,448	2
Ritter: Richland	150	1
Sailor Springs Cons.: Clay, Effingham	5,619	16
St. James: Fayette	1,905	3
Salem Cons.: Marion, Jefferson	70	2
Sumpter: White	100	1
Sumpter East: White	85	1
Tonti: Marion	1,032	1
Trumbull: White	429	2
St. Jacob: Madison	910	2

Table 3. - Continued

Pool: County	Barrels per day Average, Dec. 1956	Number of SWD wells
Trumbull: White	429	2
Walpole: Hamilton	276	1
Whittington West: Franklin	75	1
Williams Consol.: Jefferson	1,000	1
Woburn Consol.: Bond	2,506	2
Woodlawn: Jefferson	2,184	7
Zenith South: Wayne	460	1
Miscellaneous pools	4,261	33

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- Pryor, W. A., Maxey, G. B., and Parizek, R. R., 1957, Sources of Groundwater for Waterflooding in Illinois: Illinois Geol. Survey Bull. 80, p. 66.

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