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Waterflooding of Oilfields in Colorado

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 7959

Waterflooding of Oilfields in Colorado

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UNITED STATES DEPARTMENT OF THE INTERIOR
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WATERFLOODING OF OILFIELDS IN COLORADO

by

Paul Biggs[1] and Charles A. Koch[2]

ABSTRACT

This Bureau of Mines report contains information on 63 waterflood projects in Colorado. Water was injected in 10 formations located in 58 oilfields. Specific field data presented include location, discovery, development, water supply, fluid injection, oil and water production, oil reserves, and oil recoveries by primary and secondary methods.

An estimated 3.5 billion barrels of water has been injected to recover approximately 533 million barrels of oil, a ratio of 6.57 to 1. Most of the injection water is from alluvial deposits, although produced water is used in many fields. Injection water treatment is not a major problem. Appraisal of project success or failure in this report is based on technical, rather than economic, information.

INTRODUCTION

This publication contains individual reports on 58 Colorado oilfields (fig. 1) that encompass 63 waterflood projects. Major objectives of the study were to determine the amount and source of injection water and the additional oil recovered by waterflooding. Such data are not available elsewhere in published form.

In most waterflood operations, a formal agreement first is negotiated between the field operator and the royalty owners, then approved by the Colorado Oil and Gas Conservation Commission, and thereafter is identified as a unit agreement, or simply, "unit." Where no formal agreement is made, the operation normally is termed a "project," but a "unit" also can be, and often is, called a "project."

The Colorado Oil and Gas Conservation Commission will be referred to as the "State" in this report. A unit agreement approved by the U.S. Geological Survey will be referred to as a "Federal unit." The U.S. Geological Survey supervises oil and gas production from public owned lands and mineral rights.

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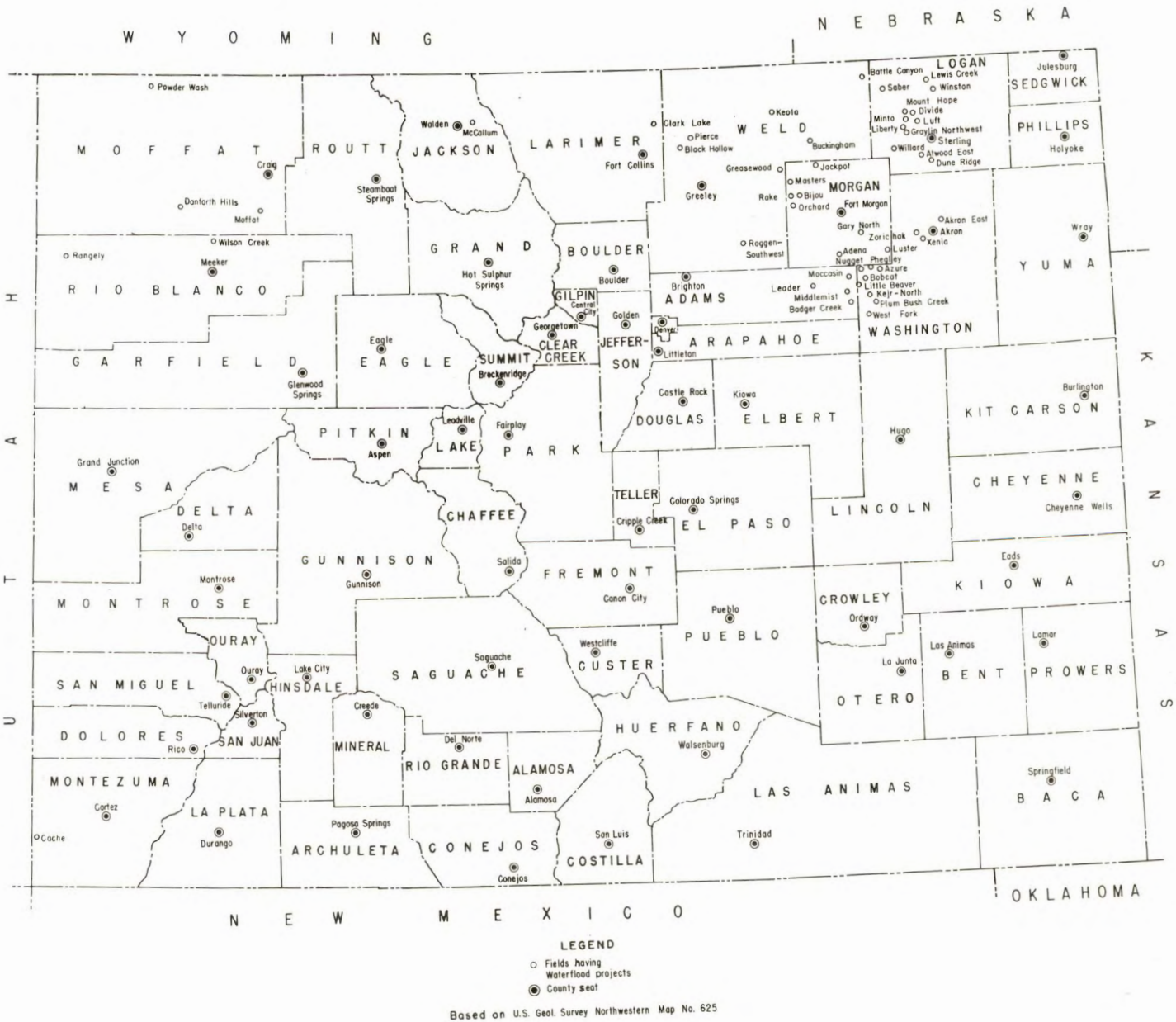
[1] Supervisory petroleum engineer.

[2] Petroleum engineer (now liaison officer--North Dakota).



Based on U.S. Geol. Survey Northwestern Map No. 625

FIGURE 1. - Colorado waterflood projects.

Eastern Colorado contains 54 waterflood projects in the Denver-Julesburg basin and one in North Park basin. The western slope contains eight projects in the following basins: Paradox, Piceance Creek, and Sand Wash. Although the western slope projects are limited in number, the area has the State's largest project at Rangely field.

The volumetric method was used to check estimates of original oil in place at each reservoir. Stock tank oil (surface) in place was estimated from the following formula:

$$\text{Stock tank oil in place} = \frac{7{,}758\ Ah\phi\ (1 - Sw)}{Bo}\ .$$

In the equation, 7,758 is the volume-barrels per acre-foot; A is the productive area in acres; h is the average reservoir thickness in feet; ϕ is the average porosity in the reservoir expressed as a fraction of the pore volume to bulk volume; Sw is the irreducible water saturation as a fraction of the pore volume; and Bo is the original formation volume factor in terms of reservoir barrels per stock tank barrels.

Oil reserves, production, and recovery estimates were obtained or developed from records of the Colorado Oil and Gas Conservation Commission. Formation names in this report are those used by industry and serve to identify the specific reservoir in a project. The well status in an oilfield is constantly changing; therefore, the status shown on the figures is for the posted date only. Appraisal of project success or failure is based on technical information.

WATER SUPPLY

Water supply for the projects is largely from shallow, alluvial, sand and gravel deposits, although produced water is important in some cases. Streams, lakes, deep wells, and city water supplies have not been used in Colorado as water sources for waterflooding. During 1972 and 1973, the Commission held hearings to obtain information on freshwater aquifers and oil formation waters in the State. Evaporation pits were essentially banned.

Underground disposal of produced water has been required in many areas. Thus, sometimes water disposal and waterflooding are difficult to separate.

In 1958 Vaughey and Vaughey constructed a water supply system to service projects in the Denver-Julesburg basin. The "water rights" were purchased, and Colorado water laws, observed. Water for the system is obtained from shallow alluvial deposits of sand and gravel of Pleistocene to Recent age in the Camp Creek valley about 15 miles east of Brush, Colo. The system consists of three water supply wells and 49 miles of pipeline ranging in size from a 12-3/4-inch trunkline to 4-1/2-inch delivery lines. At peak utilization the system supplied about 55,000 barrels daily to 13 projects (fig. 2), but now the daily demand is about 10,000 barrels.

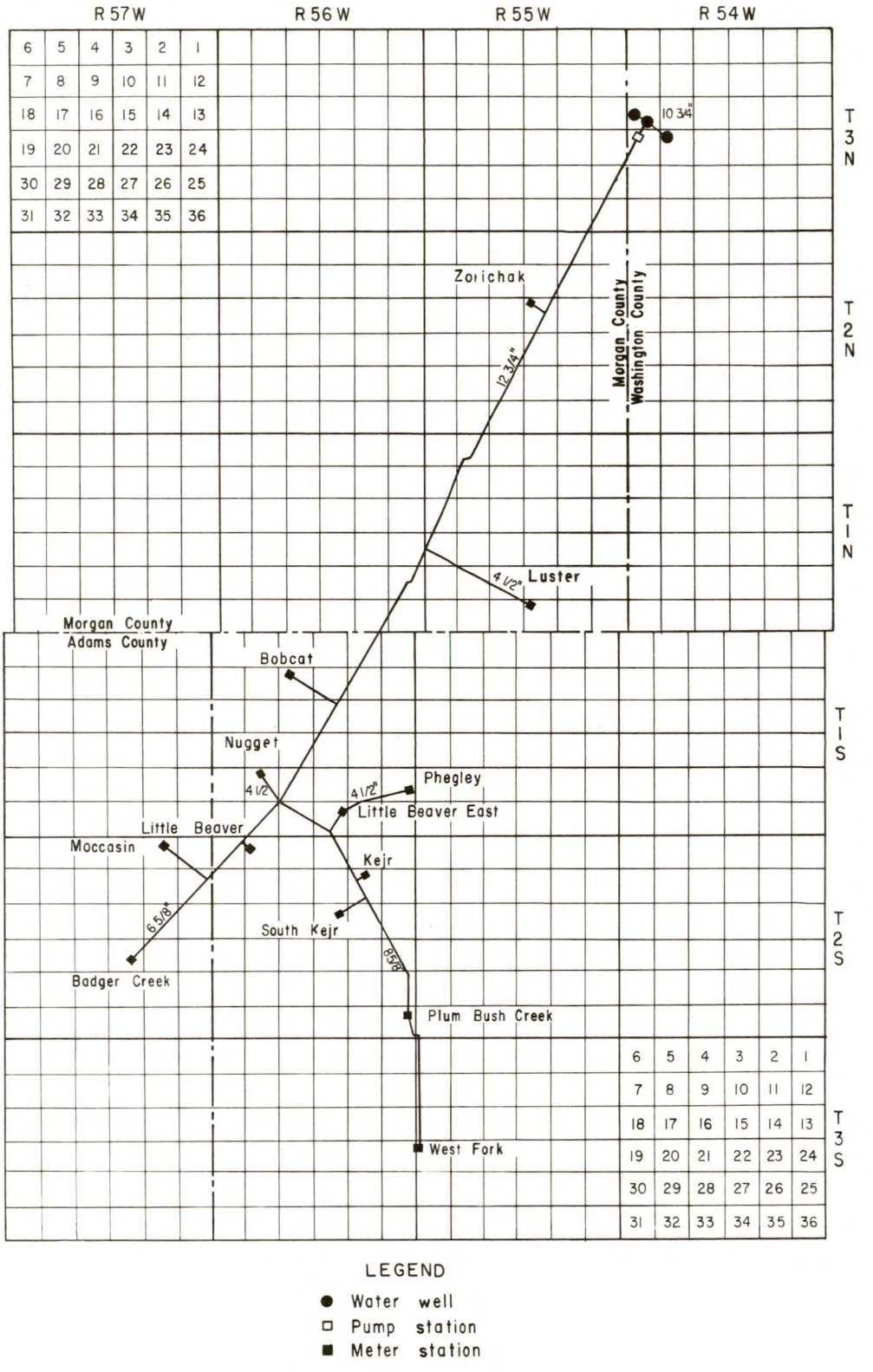


FIGURE 2. - Vaughey and Vaughey water supply system.

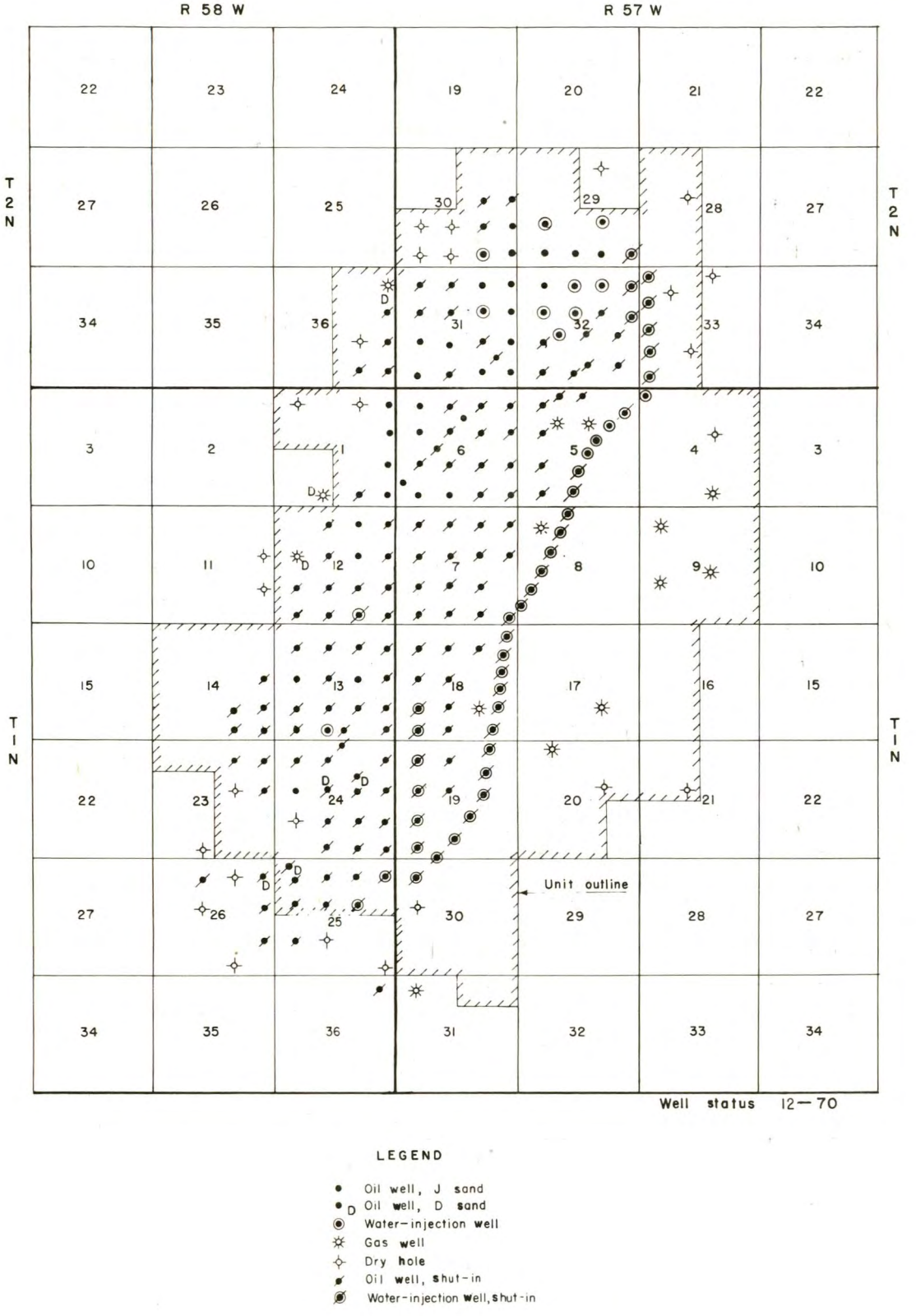


FIGURE 3. - Adena field.

WATERFLOOD PROJECTS

Each individual field report herein contains the location, discovery well and date, comments on field development, size of the reservoir, unit information, start of waterflooding, source of water, and status of operation and oil recovery during December 1972 and primary and secondary recovery to January 1973.

Three tables concerning the projects are presented. Table 1 gives pertinent information on reservoir data. Table 2 contains estimates of oil in place and primary and secondary recovery. Table 3 presents estimated primary and secondary oil production through December 1972.

Oil production by unit or project is given with each report. In a few instances oil production prior to 1960 had to be estimated or just was not available by operator.

Adena

The Adena field (fig. 3) is in Tps 1 and 2 N, Rs 57 and 58 W, Morgan County, about 14 miles south of Fort Morgan, Colo. In May 1953, Falcon Seaboard Drilling Co. completed the No. 1 Snodgrass in the NE¼NW¼ sec 20, T 1 N, R 57 W, as the discovery well in the gas cap in the southeast part of the field. Initial daily production was estimated at 8 million cubic feet of gas from the J sand at 5,542 to 5,562 feet. Field development began in November 1953, when Petroleum, Inc., drilled the D sand oil discovery, No. 1 Clar, NE¼NW¼ sec 24, T 1 N, R 58 W. The well had an hourly flow rate of 12 barrels of oil from the interval 5,650 to 5,658 feet. Later it was recompleted as a J sand oil well. Bill Tomberlin's J sand oil discovery well, No. 1 Cochran, SE¼NW¼ sec 12, T 1 N, R 58 W, was completed in December 1953. A 3-hour test had an hourly flow of 60 barrels of oil from the interval 5,665 to 5,683 feet. More than 170 oil wells were drilled in the field, principally in the J sand.

The Adena J sand field was about 7 miles long and 3.5 miles wide, the largest in the Denver-Julesburg basin. The reservoir dips to the west at about 50 feet per mile. Average reservoir depth was 5,650 feet. The stratigraphic trap originally contained 11,475 acres of oil zone and 4,650 acres of gas zone.

A unit agreement for development and operation of the J sand reservoir was approved by the Colorado Oil and Gas Commission on December 22, 1955. Pure Oil Co. was unit operator. Union Oil Co. of California purchased Pure Oil Co. in 1965. The unitized area contained 8,320 acres, and average thickness was 20.2 feet.

TABLE 1. - Reservoir data, Colorado waterflood projects[1]

Project and formation	Productive area, acres[2]	Average pay thickness, ft	Reservoir volume, acre-ft	Average porosity, pct	Average permeability, md	Oil gravity, ° API
Adena--J sand	8,320	20.2	168,064	19.7	356.0	43.4
Akron-East--D sand	510	10.0	5,100	21.0	190.0	34.0
Atwood-East--D sand	640	7.0	4,480	20.8	369.0	35.0
Aztec Wash--Tocito	40	5.0	200	16.0	18.0	28.0
Azure--D sand	400	7.0	2,800	18.0	50.0	37.0
Azure-East--D sand	280	4.0	1,120	15.8	141.0	37.0
Badger Creek--D sand	1,430	13.0	18,590	20.0	166.0	38.6
Badger Creek-West--D sand	240	4.0	960	20.0	166.0	38.0
Battle Canyon--J sand	960	10.0	9,600	14.0	35.0	36.0
Bijou--D sand	1,180	11.0	12,980	14.0	85.0	37.0
Bijou-West--D sand	1,320	10.0	13,200	14.0	85.0	37.4
Black Hollow--Lyons	1,300	30.0	39,000	12.0	88.0	36.0
Bobcat--D sand	1,240	23.0	28,520	20.7	217.0	39.0
Boxer--D sand	2,121	12.8	27,065	15.1	51.0	40.0
Boxer-North--D sand	350	15.0	5,245	15.7	48.0	40.0
Buckingham--D sand	480	12.0	5,760	13.0	12.2	38.0
Busy Bee--D sand	240	11.0	2,640	22.0	138.0	38.0
Cache--Ismay	880	32.0	28,160	9.0	22.5	45.0
Clarks Lake--Muddy	190	28.0	5,358	15.0	4.4	38.4
Danforth Hills--Morrison	240	16.0	3,840	20.0	102.0	35.0
Danforth Hills--Sundance	280	23.0	6,440	20.0	400.0	35.0
Divide--D sand	1,700	7.0	11,900	19.0	300.0	37.0
Dune Ridge--D sand	800	4.0	3,200	20.0	396.0	38.0
Gary-North--D sand	190	5.3	1,007	21.4	119.0	39.0
Graylin-Northwest--D sand	3,810	8.7	33,147	21.2	344.0	38.0
Graylin-Northwest--J sand	700	7.1	4,970	16.0	95.0	39.0
Greasewood--D sand	240	8.0	1,920	14.9	91.0	41.0
Jackpot--D sand	1,440	8.0	11,520	13.0	42.0	42.3
Kejr-North Unit--D sand	900	9.0	8,100	17.3	150.0	37.0
Keota--J sand	440	13.0	5,720	12.0	34.4	39.0
Leader--J sand	280	9.3	2,604	16.0	95.0	42.0
Lewis Creek--J sand	890	17.2	15,308	22.4	888.0	39.0
Liberty--J sand[3]	654	11.0	7,190	16.0	95.0	39.0
Little Beaver--D sand	1,900	14.0	26,600	20.0	300.0	40.0
Little Beaver-East--D sand	1,160	8.0	9,280	21.4	450.0	39.0
Luft--D sand	720	10.0	7,200	19.0	340.0	39.0
Luster--J sand	360	11.3	4,068	15.0	96.0	43.0
Masters--D sand	360	20.7	7,452	14.0	73.0	38.0
McCallum-North--Dakota-Lakota	940	30.0	28,200	15.0	150.0	47.6
Middlemist--J sand	760	14.0	10,640	18.0	73.0	42.0
Minto--J sand	250	15.4	3,850	24.8	1,150.0	40.0
Moccasin--J sand	380	10.0	3,800	18.3	188.0	43.0
Mount Hope--D sand	940	14.0	13,160	21.0	315.0	39.0
Nugget--D sand	730	13.5	9,855	19.4	147.0	39.0
Orchard-East--D sand	360	6.1	2,196	14.0	64.3	38.2
Orchard-West--D sand	200	6.1	1,220	12.7	59.4	38.2
Phegley--D sand	1,060	7.0	7,420	18.2	168.0	37.0
Pierce--Lyons	5,120	27.0	138,240	12.0	78.0	33.0
Plum Bush Creek--J sand	1,870	19.8	37,026	22.6	335.0	40.0
Powder Wash--Wasatch	200	23.0	4,600	20.4	40.0	45.0
Rake--D sand	380	7.0	2,660	15.1	119.0	39.0
Rangely--Weber	20,000	150.0	3,000,000	12.5	12.5	33.0
Roggen--SW (NW project)--D sand	200	9.6	1,920	16.0	176.0	45.0
Roggen--SW (SE project)--D sand	1,050	9.6	10,080	16.0	176.0	45.0
Saber--D sand	1,400	13.5	6,750	17.3	88.0	36.0
Swan (South Kejr)--D sand	660	8.8	5,808	17.4	282.0	37.0
Westfork--J sand	900	6.3	5,670	26.0	223.0	40.0
Willard--D sand	160	11.6	1,856	16.0	350.0	38.0
Wilson Creek--Morrison	3,000	71.0	213,000	19.4	11.0	50.0
Wilson Creek--Sundance	960	52.0	49,920	19.7	35.0	50.0
Winston--J sand	365	7.0	2,555	19.4	150.0	41.0
Xenia-West--J sand	560	10.0	5,600	23.0	175.0	41.0
Zorichak--D sand	520	10.0	5,200	25.0	195.0	40.0

[1] Data from Colorado Oil and Gas Conservation Commission records.
[2] Productive area of project or unit not necessarily entire field or reservoir.
[3] Oil portion of reservoir.

TABLE 2. - Original oil in place and recovery estimates, Colorado waterflood projects[1]

Project and formation	Initial oil in place, STB	Primary recovery estimate		Secondary recovery estimate[2]		Utimate recovery estimate	
		Oil in place, pct	STB	Oil in place, pct	STB	Oil in place, pct	STB
Adena--J sand	135,096,100	30	40,365,000	20	27,154,000	50	67,519,000
Akron-East--D sand	3,348,900	25	840,000	13	434,400	38	1,274,400
Atwood-East--D sand	2,833,600	33	944,600	14	400,000	37	1,344,600
Aztec Wash--Tocito	80,000	18	14,000	-	-	-	14,000
Azure--D sand	1,508,400	25	376,000	25	376,000	50	752,000
Azure-East--D sand	805,600	13	100,700	7	58,400	20	159,100
Badger Creek--D sand	12,350,000	13	1,562,900	11	1,330,900	24	2,893,800
Badger Creek-West--D sand	633,600	21	133,900	12	77,000	33	210,900
Battle Canyon--J sand	3,648,000	21	780,000	3	108,000	24	888,000
Bijou--D sand	7,410,000	19	1,400,000	2	170,100	21	1,570,100
Bijou-West--D sand	7,540,000	16	1,224,800	8	600,000	24	1,824,800
Black Hollow--Lyons	26,184,600	31	8,200,000	10	2,618,500	41	10,818,500
Bobcat--D sand	24,983,500	28	6,995,400	7	1,750,000	35	8,745,400
Boxer--D sand	8,537,000	19	1,625,500	10	820,000	29	2,445,500
Boxer-North--D sand	2,147,600	19	407,500	10	215,000	29	622,500
Buckingham--D sand	2,740,000	18	466,000	5	140,000	23	606,000
Busy Bee-D sand	2,254,600	12	271,000	10	225,000	-	496,000
Cache--Ismay	10,500,000	21	2,200,000	30	3,150,000	51	5,350,000
Clarks Lake--Muddy	3,000,000	29	876,900	13	380,000	42	1,256,900
Danforth Hills--Morrison	3,517,900	19	681,100	11	392,800	30	1,073,900
Danforth Hills--Sundance	5,110,000	30	1,515,100	3	150,000	33	1,665,100
Divide--D sand	7,973,000	25	2,035,100	21	1,633,500	46	3,668,600
Dune Ridge--D sand	3,308,800	37	1,235,200	14	448,900	51	1,684,100
Gary-North--D sand	853,100	28	240,000	16	140,000	44	380,000
Graylin-Northwest--D sand	27,298,400	32	8,841,300	13	3,677,400	46	12,518,700
Graylin-Northwest--J sand	3,275,000	22	720,000	21	687,500	43	1,407,500
Greasewood--D sand	1,235,000	20	247,000	4	50,500	24	297,500
Jackpot--D sand	5,514,600	23	1,264,000	21	1,142,000	44	2,406,000
Kejr-North Unit--D sand	5,921,100	20	1,167,000	20	1,200,000	40	2,367,000
Keota--J sand	3,270,000	34	1,105,000	18	600,000	52	1,705,000
Leader--J sand	1,704,000	9	148,200	2	50,000	12	198,200
Lewis Creek--J sand	17,542,900	26	4,500,000	14	2,500,000	40	7,000,000
Liberty--J sand	4,989,900	15	743,000	11	553,700	26	1,296,700
Little Beaver--D sand	36,548,400	26	9,400,000	22	8,149,600	48	17,549,600
Little Beaver-East--D sand	9,256,000	25	2,314,000	26	2,386,000	51	4,700,000
Luft--D sand	5,515,200	29	1,585,000	17	920,000	46	2,505,000
Luster--J sand	2,655,800	24	631,200	7	188,600	31	819,800
Masters--D sand	4,070,000	8	335,000	2	70,000	10	405,000
McCallum-North--Dakota-Lakota	17,950,000	22	3,863,900	3	566,000	25	4,429,900
Middlemist--J sand	7,706,900	28	2,195,900	16	1,250,000	44	3,445,900
Minto--J sand	3,987,000	36	1,436,000	16	639,000	52	2,075,000
Moccasin--J sand	2,900,000	21	600,000	12	350,000	33	950,000
Mount Hope--D sand	13,133,700	42	5,598,400	9	1,153,000	51	6,751,400
Nugget--D sand	8,403,100	20	1,680,600	10	840,300	30	2,520,900
Orchard-East--D sand	1,237,400	24	301,000	8	100,000	32	401,000
Orchard-West--D sand	766,000	17	130,000	7	50,000	24	180,000
Phegley--D sand	5,703,600	22	1,241,300	22	1,242,700	44	2,484,000
Pierce--Lyons	34,500,000	20	6,900,000	4	1,500,000	24	8,400,000
Plum Bush Creek--J sand	39,040,000	30	11,700,000	25	9,760,000	55	21,460,000
Powder Wash--Wasatch	3,130,000	25	798,800	10	313,000	35	1,111,800
Rake--D sand	1,506,000	29	432,000	5	71,000	34	503,000
Rangely--Weber	2,000,000,000	18	350,000,000	22	438,000,000	40	788,000,000
Roggen-SW (NW project)--D sand	1,465,000	15	212,900	3	50,000	18	262,900
Roggen-SW (SE project)--D sand	6,273,200	18	1,128,100	10	627,300	28	1,755,400
Saber--D sand	10,600,000	21	2,235,200	6	636,000	27	2,871,200
Swan (South Kejr)--D sand	4,566,700	21	959,000	25	1,138,600	38	2,097,600
Westfork--J sand	6,860,000	33	2,242,000	21	1,465,100	54	3,707,100
Willard--D sand	1,247,000	9	116,900	3	33,300	12	150,200
Wilson Creek--Morrison	160,000,000	26	41,500,000	4	6,500,000	30	48,000,000
Wilson Creek--Sundance	51,000,000	45	23,066,700	3	1,300,000	48	24,366,700
Winston--J sand	2,033,500	23	473,900	4	75,000	27	548,900
Xenia-West--J sand	4,995,200	20	999,200	19	950,000	39	1,949,200
Zorichak--D sand	5,325,000	11	578,000	6	300,000	17	878,000

[1] Obtained or calculated from records of the Colorado Oil and Gas Conservation Commission.
[2] Where known, oil recovery by "pressure maintenance" is shown in this column.

TABLE 3. - Primary and secondary oil production from Colorado waterfloods to January 1, 1973[1]

Project and formation	Primary oil, thousand bbl	Secondary oil, thousand bbl	Cumulative oil, thousand bbl
Adena--J sand	40,365	16,444	56,809
Akron-East--D sand	764	221	985
Atwood-East--D sand[2]	1,245	56	1,301
Aztec Wash--Tocito[3]	14	-	14
Azure--D sand[2]	366	139	505
Azure-East--D sand	82	-	82
Badger Creek--D sand	1,563	1,281	2,844
Badger Creek-West--D sand	181	30	211
Battle Canyon--J sand[4]	772	108	880
Bijou--D sand[4]	1,400	170	1,570
Bijou-West--D sand[5]	1,198	13	1,211
Black Hollow--Lyons	8,300	1,323	9,623
Bobcat--D sand	6,291	155	6,446
Boxer--D sand	1,538	15	1,553
Boxer-North--D sand	414	-	414
Buckingham--D sand[2]	389	-	389
Busy Bee--D sand[6]	250	-	250
Cache--Ismay	2,200	494	2,694
Clarks Lake--Muddy	664	212	876
Danforth Hills--Morrison	681	218	899
Danforth Hills--Sundance	1,515	109	1,624
Divide--D sand	2,032	1,638	3,670
Dune Ridge--D sand	1,235	419	1,654
Gary-North--D sand	240	52	292
Graylin-Northwest--D sand	8,172	2,703	10,875
Graylin-Northwest--J sand[2]	1,072	64	1,136
Greasewood--D sand[7]	248	14	262
Jackpot--D sand[8]	1,001	380	1,381
Kejr-North--D sand	1,168	1,022	2,190
Keota--J sand	908	20	928
Leader--J sand[9]	148	10	158
Lewis Creek--J sand	4,500	796	5,296
Liberty--J sand[4]	743	188	931
Little Beaver--D sand	9,400	3,264	12,664
Little Beaver-East--D sand	2,314	1,221	3,535
Luft--D sand[4]	1,554	930	2,484
Luster--J sand[2]	640	170	810
Masters--D sand[10]	335	19	354
McCallum-North--Dakota-Lakota	3,776	326	4,102
Middlemist--J sand	1,866	210	2,076
Minto--J sand	1,585	422	2,007
Moccasin--J sand	540	353	893
Mount Hope--D sand	5,384	1,122	6,506
Nugget--D sand	1,696	394	2,090
Orchard-East--D sand[8]	301	7	308
Orchard-West--D sand[8]	132	-	132
Phegley--D sand[11]	1,241	1,265	2,506
Pierce--Lyons	6,933	909	7,842
Plum Bush Creek--J sand	11,754	6,260	18,014
Powder Wash--Wasatch	110	38	148
Rake--D sand[2]	467	18	485
Rangely--Weber	358,675	101,852	460,527
Roggen-SW (NE project)--D sand[9]	213	28	241
Roggen-SW (SE project)--D sand[12]	496	56	552
Saber--D sand	2,090	186	2,276
Swan (South Kejr)--D sand[8]	843	874	1,717
Westfork--J sand	2,242	1,093	3,335
Willard--D sand[13]	117	33	150
Wilson Creek--Morrison	41,500	7,712	49,212
Wilson Creek--Sundance	21,425	1,892	23,317
Winston--J sand[4]	483	-	483
Xenia-West--J sand[14]	1,417	485	1,902
Zorichak--D sand[12]	608	40	648

[1] From records of the Colorado Oil and Gas Conservation Commission.
[2] Injection stopped in 1969.
[3] Injection stopped in 1964.
[4] Injection stopped in 1967.
[5] Injection stopped in December 1971.
[6] Injection stopped in July 1963.
[7] Injection stopped in July 1970.
[8] Injection stopped in 1968.
[9] Injection stopped in 1962.
[10] Injection stopped in 1963.
[11] Last injection in January 1972.
[12] Injection stopped in May 1970.
[13] Injection stopped in 1960.
[14] Injection stopped in 1965.

Early records of production and bottom hole pressures showed water encroachment from the west and northwest and probably expansion of the gas cap to the west. A bottom hole pressure maintenance by water injection was proposed that would--

1. Stop gas cap expansion by building a "water-bank" between the oil and gas zones.

2. Allow water to migrate or "flood" the oil zone from the up-dip side. Generally water is used to move oil up-dip, not down-dip as at Adena. Original water injection would be about 40,000 barrels a day, increasing to 75,000 barrels. As water reached the down-dip oil wells the water injection rate would be lowered.

On February 25, 1957, water injection began with 22 injection wells. The number of injection wells was increased to 32 wells by July 1957. Produced liquids were piped to a central plant and separated. The oil was sold through lease automatic custody transfer units. The produced water was treated for slime growth by chlorine injection, passed through sand filters, and reinjected in the J sand zone.

Additional injection water was purchased from the Comanche Ranch Co., which had six shallow (alluvium) water wells in secs 7, 17, and 18, T 2 N, R 57 W.

A propane injection program was started at the southern end of the field on July 27, 1961, in an attempt to flood this less permeable area and was followed by natural gas injection starting on November 28, 1962. Propane injection also continued intermittently until January 1963 when the cumulative injection was 270,633 barrels. Natural gas injection was continued until November 1965 and cumulatively totaled 251,945,000 cubic feet.

During December 1972, there were 30 producing oil wells and 6 active injection wells. Daily average production was 438 barrels of oil and 10,919 barrels of water. The daily average water injection was 1,563 barrels at injection pressure of 100 psig. The cumulative water injection to January 1, 1973, was 163,232,300 barrels.

Annual and cumulative water injection and annual oil production for Adena field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1957-59	-	65,017	-
1960	23,241	88,258	7,408
1961	14,117	102,375	7,327
1962	10,083	112,458	4,153
1963	7,664	120,122	2,267
1964	6,711	126,833	1,339
1965	5,915	132,748	744
1966	5,174	137,922	528
1967	5,376	143,298	433
1968	5,237	148,535	362
1969	4,910	153,445	283
1970	4,322	157,767	212
1971	4,175	161,942	193
1972	1,292	163,234	179

Cumulative oil production to the start of injection was 14,872,000 barrels or 11 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 56,808,500 barrels or 42 percent of the original oil in place. Since the start of injection, 41,936,500 barrels of oil was produced, and 16,433,500 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 9.9 to 1. Available data indicate a technically successful project. Reports covering the propane and natural gas injection tests did not suggest success or failure of the effort.

Akron-East

The Akron-East field is in T 3 N, Rs 51 and 52 W, Washington County. Oil was discovered in January 1955 when Wytex Service Corp. and Jack G. Ladmer's No. 1 George Daniels well, SE¼SW¼ sec 25, was completed for an initial daily oil production of 80 barrels. The producing zone was the D sand at 4,540 to 4,554 feet. During 1955, 22 producing wells were drilled, and the remaining wells were drilled by early 1960. Range of initial daily production of the wells was from 12 to 246 barrels.

Areal extent of the reservoir is 510 acres, and average thickness is 10 feet. The producing mechanisms are a solution gas drive and a limited water drive.

A unit agreement for water injection was approved by the State on July 20, 1962, with Fred E. Wood as the operator. Later a State order on November 19, 1968, made the unit fieldwide.

On March 23, 1963, water injection began in three wells on the west side of the field. Water is obtained from depths of 50 to 75 feet in one well a

mile south of the field in NW¼ sec 1, T 2 N, R 52 W, and another well in SW¼ sec 24, T 3 N, R 52 W.

During December 1972, there were 7 producing oil wells and 17 water injection wells. Daily average production was 304 barrels of oil and 1,654 barrels of water. The daily average water injection was 1,902 barrels at injection pressures from 0 to 1,140 psig. The cumulative water injection to January 1, 1973, was 5,097,200 barrels.

Annual and cumulative water injection and annual oil production for East Akron field, D sand, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	46
1961	-	-	34
1962	-	-	28
1963	272	272	20
1964	500	772	27
1965	537	1,309	65
1966	492	1,801	57
1967	469	2,270	47
1968	456	2,726	70
1969	519	3,245	46
1970	474	3,719	27
1971	661	4,380	20
1972	717	5,097	15

Cumulative oil production at the start of injection was 642,700 barrels or 19.2 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 985,500 barrels or 29.4 percent of the original oil in place. Since the start of injection, 342,800 barrels of oil was produced, including 221,000 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 23 to 1. Available data indicate a technically successful project.

Atwood-East

The Atwood-East field is in Tps 6 and 7 N, Rs 52 and 53 W, Logan County. In January 1955, Strain Drilling Co. completed its No. 1 Kaepernik, SW¼NE¼ sec 25, T 7 N, R 53 W, with initial daily gas production of 6 million cubic feet from the D sand at 4,387 to 4,433 feet. Oil was discovered in February by Shell Oil Co. at the No. 1 Alex Fiebig, SW¼NW¼ sec 25. Initial daily production from the D sand at 4,423 to 4,429 feet was 53 barrels of oil and 94 barrels of water. Initial daily oil production of the wells ranged from 40 to 216 barrels.

The field has both oil and gas zones. The gas zone is on the east. Two separate oil zones are separated by a permeability barrier. Most of the wells in the main zone are in secs 24 and 25, T 7 N, R 53 W, extending in a line down the west side of the gas cap. Areal extent of the oil zone is 640 acres, and the average thickness is 7 feet. Oil is produced by both a solution gas expansion and gas cap expansion.

A unit agreement for the field was approved by the State on October 3, 1961. Excelsior Oil Corp. was the operator. The unit, in the northern portion of the field, contained initially 9 of the 19 field wells. By December 1968, it included five of nine remaining wells.

Water injection began on March 1, 1962, in six wells penetrating the gas-oil contact at the unit boundary. The injection wells are located here for two purposes: (1) To prevent migration of oil into the gas cap, and (2) to prevent migration across the unit boundary. Water was obtained from two water supply wells completed in the Fox Hills and Hygiene sections of the Pierre Shale at depths of 300 feet. The water supply wells and plant are in NW¼NW¼ sec 25. The water injection was stopped in May 1969 after a cumulative injection of 9,636,000 barrels.

Annual and cumulative water injection and annual oil production for Atwood-East field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	-
1961	-	-	71
1962	1,137	1,137	74
1963	1,939	3,076	113
1964	1,670	4,746	84
1965	1,428	6,174	69
1966	1,297	7,471	64
1967	1,198	8,669	47
1968	699	9,368	33
1969	269	9,637	20
1970	-	9,637	11
1971	-	9,637	8
1972	-	9,637	6

Cumulative oil production to the start of injection was 842,000 barrels or 29.7 percent of the original oil in place. On January 1, 1973, the cumulative production was 1,300,100 barrels or 45.8 percent of the original oil in place. Since the start of injection, 457,900 barrels of oil was produced, including 55,500 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 173.6 to 1. Available data indicate a technically successful project.

Aztec Wash

The Aztec Wash field was in secs 7 and 8, T 32 N, R 17 W, Montezuma County. The California Oil Co.'s well No. 9 Ute Mountain, NW¼SW¼ sec 8, was completed November 3, 1961. Initial daily pumping production was 2 barrels of oil from the Tocito sand from 899 to 904 feet. Ten or more wells were drilled in the field. Apparently the oil-saturated sand did not have enough reservoir pressure to move the oil into the well bore.

Graridge Corp.'s well No. 1 Philmo-Ute, SW¼SE¼ sec 16, was completed on November 9, 1961, for an initial daily pumping production of 18 barrels of oil. The Philmo-Ute well was called the Mancos Creek area, but oil production was reported as Aztec Wash field so some confusion exists regarding oil production. To add to the confusion, various geologists reported the same depth interval as (1) Tocito, (2) upper and lower Tocito, and (3) Gallup sand.

Commission order 167-1 dated May 22, 1962, approved a waterflood plan of Panther Oil and Gas Co. The approved Aztec Wash unit included the following lands:

Township 32 North, Range 17 West, N.M.P.M.

Section 5: S½SW¼
Section 6: All
Section 7: E½, NW¼, NE¼SW¼
Section 8: All
Section 17: E½, NW¼, NE¼SW¼
Section 18: NE¼NE¼
Section 20: E½E½, NW¼NE¼

Township 32 North, Range 18 West, N.M.P.M.

Section 1: NE¼NE¼SE¼

This is a rather large area of 2,840 acres for a unit with no recorded oil production. A 40-acre, five-spot flood was started September 23, 1962. Injection stopped during June 1964 after 255,000 barrels had been injected. Eight barrels of oil were reported in 1965, and 6 barrels, in 1966. The wells were abandoned in June 1966. The project was a failure.

Azure

The Azure field is in T 1 S, R 55 W, Washington County. In January 1957, Petroleum, Inc., completed the No. 1 Kral "A" NW¼SE¼ sec 15, T 1 S, R 55 W, for initial daily pumping production of 132 barrels of oil from the D sand at 4,863 to 4,870 feet. Development drilling occurred in two stages: Eight producing wells were drilled in secs 14, 15, and 23, during 1957 and 1958; later, the field was extended to the east when seven producing wells were drilled between 1965 and early 1970 in secs 13 and 24. Range of initial daily oil production of the wells was from 20 to 134 barrels.

Areal extent of the reservoir is 400 acres, and the average thickness is 7 feet. The producing mechanism was a fluid expansion drive.

The Kimbark Exploration Co.'s unit agreement for water injection was approved by the State on June 20, 1961. The unit included the S½ of sec 14 and the SE¼ of sec 15.

Water injection began on September 2, 1961, in two wells, one on the east side and the other on the west side of the unit. The injection pattern is considered a modified peripheral drive. Source of the water is a shallow alluvial sand well about 1 mile south of the field.

The wells were abandoned in 1970. Daily average water injection in August 1969, last month of injection, was 310 barrels at an injection pressure of 1,600 psi. The cumulative water injection to September 1, 1969, was 1,153,300 barrels.

Annual and cumulative water injection and annual oil production for Azure field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	36
1961	109	109	27
1962	230	339	71
1963	283	622	39
1964	201	823	22
1965	137	960	22
1966	93	1,053	20
1967	33	1,086	22
1968	38	1,124	17
1969	29	1,153	10
1970	-	1,153	3
1971	-	1,153	Plugged and abandoned
1972	-	1,153	-

Cumulative oil production at the start of injection was 291,900 barrels or 19.4 percent of the original oil in place. On January 1, 1973, the cumulative production was 504,900 barrels or 33.5 percent of the original oil in place. Since the start of injection, 213,000 barrels of oil was produced, and 139,000 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 8.3 to 1. Available data indicate a technically successful project.

Azure-East

The East Azure field is in secs 13 and 24, T 1 S, R 55 W, Washington County, about 1 mile east of the Azure field. The discovery well, Allison Drilling-Jim Stubbs' No. 1 Egbert, in NE¼SW¼ sec 13, was completed January 16, 1965. Initial daily pumping production was 125 barrels of oil from the D sand from perforations from 4,755 to 4,759 feet. Three oil wells were completed in East Azure field in 1965, two in 1969, and two in 1970. Dry holes were drilled in 1953, 1965, 1966, and 1969. Initial daily pumping oil production for the successful wells ranged from 22 to 134 barrels and averaged 88 barrels.

Areal extent of the reservoir is 280 acres, and the average thickness is 4 feet. The producing mechanism was reservoir fluid expansion in the small, thin-sand lens reservoir.

The unit and operating agreement for the East Azure D sand reservoir was approved by the State on April 21, 1970. Stratigraphic Oil Co. was the operator until 1972 when Bobcat Oil Co. took over.

Water injection started August 10, 1970. The injection water is from a well in the NW¼ sec 25, about 1.5 miles south of the field. The water well is 130 feet deep.

During December 1972, there were three oil wells and three injection wells in the East Azure unit. The daily production was 10 barrels of oil and 9 barrels of water, and the average daily water injection was 277 barrels at 295 psig. There was no water injection the first 8 months of 1972. Cumulative injection was 165,700 barrels of water to January 1, 1973.

Annual and cumulative water injection and annual oil production for East Azure field, D sand, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1965	-	-	22
1966	-	-	12
1967	-	-	8
1968	-	-	5
1969	-	-	11
1970	41	41	9
1971	85	126	9
1972	40	166	5

Oil production to start of injection was 62,800 barrels or 7.6 percent of the original oil in place. Since injection, 20,200 barrels of oil has been produced. No secondary oil is credited to the project to January 1, 1973.

Badger Creek

Badger Creek field (fig. 4) is in T 2 S, R 57 W, Adams County. Oil was discovered in May 1953, when Forest Oil Corp.'s No. 1 C. D. Causey, SW¼NW¼ sec 23, T 2 S, R 57 W, was completed pumping 213 barrels daily from the D sand at 5,245 to 5,275 feet. Development drilling resulted in 55 producing wells, 39 D sand wells, and 16 J sand wells. Drilling for both zones was on 20-acre spacing. Range of initial daily production for the two zones was 28 to 261 barrels for the D sand and 63 to 344 barrels for the J sand.

Areal extent of the D sand reservoir is 1,430 acres, and the average thickness is 13 feet. Regional dip in the field area is from 70 to 100 feet per mile to the west. Oil is produced by a solution gas drive and a partial water drive.

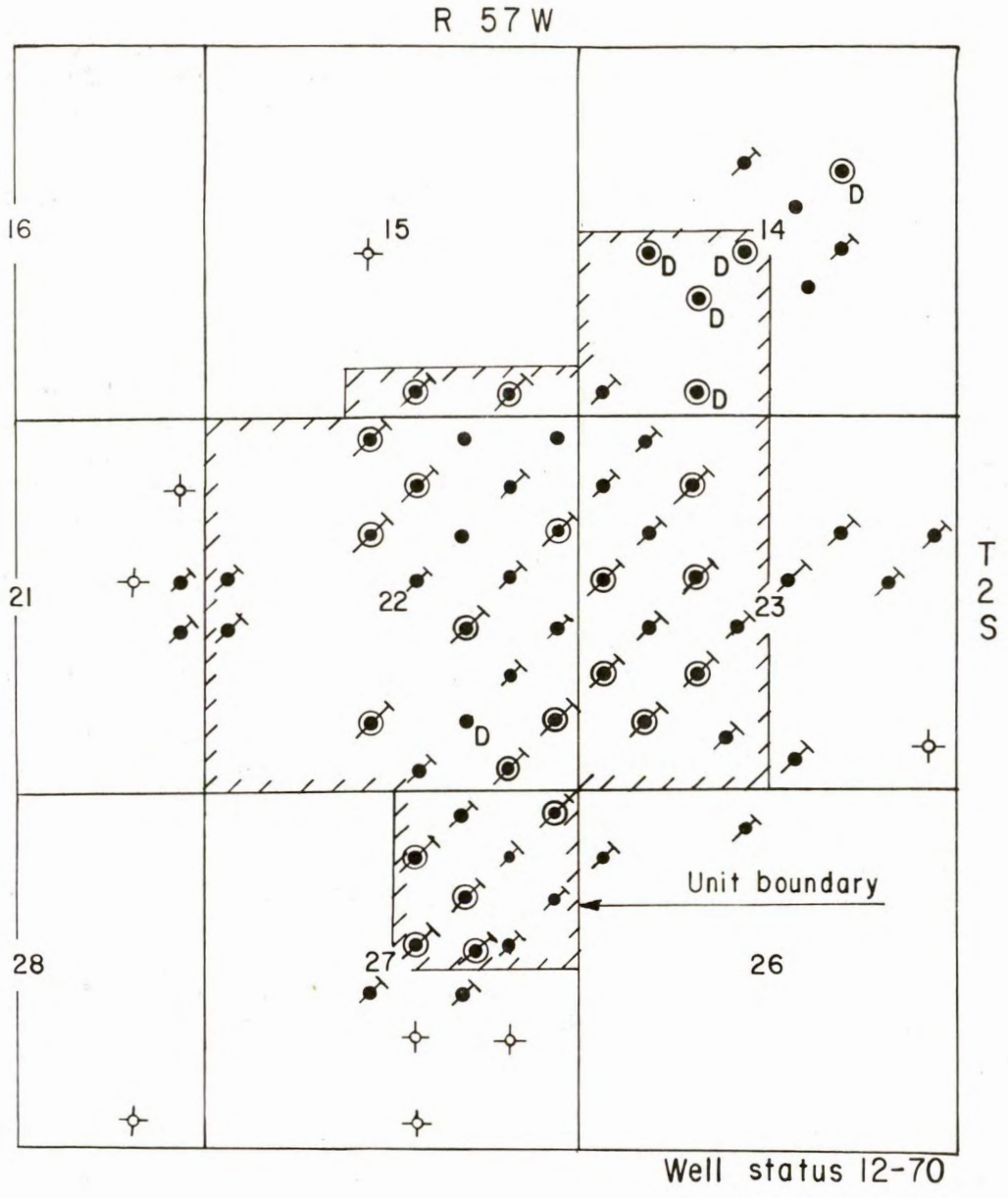
A cooperative agreement between Sinclair Oil and Gas Corp. (now Atlantic Richfield Co.) and Forest Oil Corp. for water injection of the D sand preceded the unit agreement. The unit agreement was approved by the State on July 21, 1959. Included in the unit area are sec 22, W½ sec 23, SW¼ sec 14, NE¼ sec 27, and 60 acres on the southern boundary of sec 15.

Water injection in two D sand wells was started on September 18, 1958. The injection pattern is a combination modified line drive and five-spot. Sources are produced D sand water and purchased water from the Vaughey and Vaughey water system.

During December 1972, there were three producing wells and four injection wells in the D sand unit. Daily average oil production for the month was 18 barrels of oil and 186 barrels of water. The daily average injection was 736 barrels at a pressure of 1,400 psi. The cumulative water injection to January 1, 1973, was 18,198,900 barrels.

Annual and cumulative water injection and annual oil production for Badger Creek, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953-59	-	2,159	1,548
1960	2,665	4,824	454
1961	2,815	7,639	415
1962	3,135	10,774	183
1963	2,511	13,285	100
1964	2,001	15,286	63
1965	972	16,258	32
1966	731	16,989	22
1967	297	17,286	8
1968	344	17,630	5
1969	148	17,778	4
1970	114	17,892	3
1971	91	17,983	3
1972	217	18,200	3



LEGEND

- Oil well, J sand
- Oil well, D sand
- Oil well, abandoned
- Water injection well
- Dry hole
- Water injection well, abandoned

FIGURE 4. - Badger Creek field.

Cumulative D sand unit oil production at the start of injection was 1,303,300 barrels or 10.5 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 2,844,300 barrels or 22.9 percent of the original oil in place. Since the start of injection, 1,541,000 barrels of oil has been produced, including 1,281,400 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 14.2 to 1. Available data indicate a technically successful project.

Badger Creek-West

The West Badger Creek field in secs 21 and 22, T 2 S, R 57 W, Adams County, was actually two small reservoirs or fields. The first West Badger Creek field was four oil wells and three dry holes in the E½E½ sec 21 and the W½W½ sec 22. The discovery well, Fallon Gas Co.'s well No. 1 Government, SE¼SE¼NE¼ sec 21, was completed August 5, 1953. Initial daily oil production was 344 barrels from the J sand interval of 5,384 to 5,398 feet. Three additional oil wells were drilled. All four oil wells were abandoned in 1960 after producing a total of 253,662 barrels.

The second (present) West Badger Creek field also has four oil wells, in sec 21. The discovery well was States Oil Co.'s well No. 1 Middlemist in the NE¼SW¼ sec 21, completed November 17, 1965. Initial daily production was 92 barrels of oil and 11 barrels of water from the J sand at 5,434 to 5,438 feet. Three more oil wells were completed in the field.

Areal extent of the reservoir is 240 acres, and the sand thickness averages 4 feet. The structure is a small "high" west of and down-dip from the larger Badger Creek field.

The unit agreement for waterflooding the West Badger Creek field by Le Clair Operating Co., Inc., was approved by the Commission on September 15, 1970.

Water injection started in two wells on November 28, 1970. The injection water is purchased from the Vaughey and Vaughey water system. In December 1972, the two oil wells were averaging 40 barrels of oil and 200 barrels of water daily. The two injection wells were receiving a total of 518 barrels of water a day. Oil production prior to injection was 161,000 barrels or 14.9 percent of the original stock tank oil in place. Oil produced to January 1, 1973, was 211,000 barrels. Of the 50,000 barrels produced since waterflooding, 30,000 barrels is credited to water injection. The project is too new to show success or failure.

Annual and cumulative water injection and annual oil production for West Badger Creek field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1965	-	-	6
1966	-	-	35
1967	-	-	43
1968	-	-	26
1969	-	-	31
1970	11	11	25
1971	179	190	19
1972	213	403	28

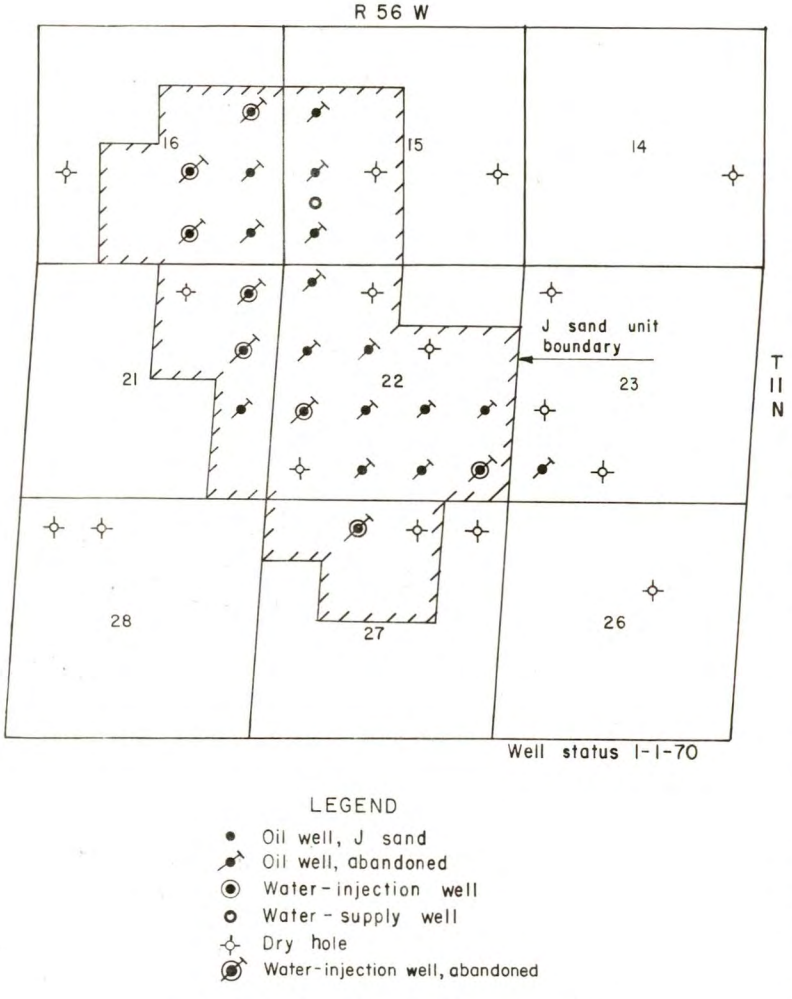


FIGURE 5. - Battle Canyon field.

Battle Canyon

Battle Canyon field (fig. 5) is in T 11 N, R 56 W, Weld County. In March 1953, Midwest Oil Corp. completed No. 1 D. P. Uhl, et al, NW¼NW¼ sec 22, T 11 N, R 56 W, for initial production of 5½ barrels of oil per hour from the J sand at 6,152 to 6,157 feet. Development drilling began in 1953, but most of the wells were drilled in 1954 and 1955. Twenty-two producing wells had initial daily production ranging from 32 to 348 barrels.

Areal extent of the J sand reservoir is 960 acres, and the average thickness is 10 feet.

Shell Oil Co.'s unit agreement was approved by the State on September 20, 1960. All but two wells, SW¼SW¼ sec 23, and NE¼NW¼ sec 27, were included in the original unit. Later, the well in sec 27 was added to the unit.

Water injection was started in seven wells on June 16, 1961. A peripheral injection pattern was used, and the wells were located along the west and south sides of the field. Water was obtained from a well in SW¼ sec 15, at a depth of 600 feet. The cumulative water injection was 2,946,500 barrels. The field was shut in during 1969, and the last injection was in December 1967.

Annual and cumulative water injection and annual oil production for Battle Canyon field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953-59	-	-	772
1960	-	-	21
1961	351	351	11
1962	540	891	23
1963	459	1,350	46
1964	472	1,822	29
1965	439	2,261	18
1966	294	2,555	11
1967	392	2,947	1
1968	-	2,947	Plugged and abandoned
1969	-	2,947	-
1970	-	2,947	-
1971	-	2,947	-
1972	-	2,947	-

Cumulative oil production at the start of injection was 424,000 barrels or 11.6 percent of the original oil in place. On August 1, 1969, the cumulative production was 888,000 barrels or 24.3 percent of the original oil in place. Since the start of injection, 464,000 barrels of oil was produced, including 108,000 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 27.3 to 1. Available data indicate a technically successful project.

Bijou

Bijou field is in Tps 4 and 5 N, Rs 59 and 60 W, Morgan County, about 15 miles northwest of Fort Morgan, Colo. In January 1958, Williamson and Kissinger completed their No. 1 Bijou Irrigation District "A," NE¼SW¼ sec 8, T 4 N, R 59 W, for an initial daily production of 13,500,000 cubic feet of gas from the D sand at 6,072 to 6,088 feet. The first oil well, the No. 1 State, SW¼NW¼ sec 5, T 4 N, R 59 W, was completed by Thames and Turnbull on May 2, 1958. Development drilling occurred from 1958 through 1960. The range of initial daily oil production was from 10 to 960 barrels.

Areal extent of the reservoir is 1,180 acres, and the average thickness is 11 feet. The D sand contains the D-1 and D-2 zones in the field. Gas caps

were found on the southeast side of both zones. Initially the oil was produced by a solution gas drive and gas cap expansion.

Gulf Oil Corp.'s unit agreement was approved by the State on September 12, 1961. All the field wells were included in the expanded unit on December 28, 1962.

Water injection was started on November 22, 1963, in seven wells. A 100-foot-deep water well on the bank of the South Platte River, in the SW¼SW¼SW¼ sec 31, T 5 N, R 59 W, produced 5,000 barrels of water per day on test. Injection was stopped in October 1967 after a cumulative water injection of 6,245,900 barrels.

Annual and cumulative water injection and annual oil production for Bijou field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958-59	-	-	709
1960	-	-	385
1961	-	-	158
1962	-	-	101
1963	188	188	72
1964	1,654	1,842	59
1965	1,322	3,164	53
1966	2,208	5,372	21
1967	874	6,246	12
1968	-	6,246	½
1969	-	6,246	Plugged and abandoned

Cumulative oil production at the start of injection was 1,398,000 barrels or 18.9 percent of the original oil in place. On January 1, 1973, the cumulative production was 1,570,000 barrels or 21.2 percent of the original oil in place. Since the start of injection, 172,100 barrels of oil was produced, including 170,100 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 36.7 to 1. The project was shut in during 1969-72. Water injection resulted in recovery of only 2.1 percent of the original oil in place. The project was not a technical success.

Bijou-West

The Bijou-West field is in T 4 N, R 60 W, Morgan County. Oil was discovered in January 1958, when Williamson-Kissinger's No. 1 Matthews, SE¼NW¼ sec 12, T 4 N, R 60 W, was completed flowing 930 barrels daily from the D sand at 6,182 to 6,188 and 6,192 to 6,196 feet. Most of the field wells were

drilled during 1958 and 1959, resulting in 20 producing wells. Initial range of daily oil production from the wells was 24 to 1,008 barrels.

Areal extent of the reservoir is 1,320 acres, and the average thickness is 10 feet. Initial reservoir-producing mechanism was solution gas expansion.

Gulf Oil Corp.'s unit agreement for water injection was approved by the State on June 18, 1968.

Water injection began on December 13, 1968, in two wells at the north end of the field. Source of the water was the Bijou unit water supply well.

Water injection stopped in November 1971, after 3,941,000 barrels had been injected.

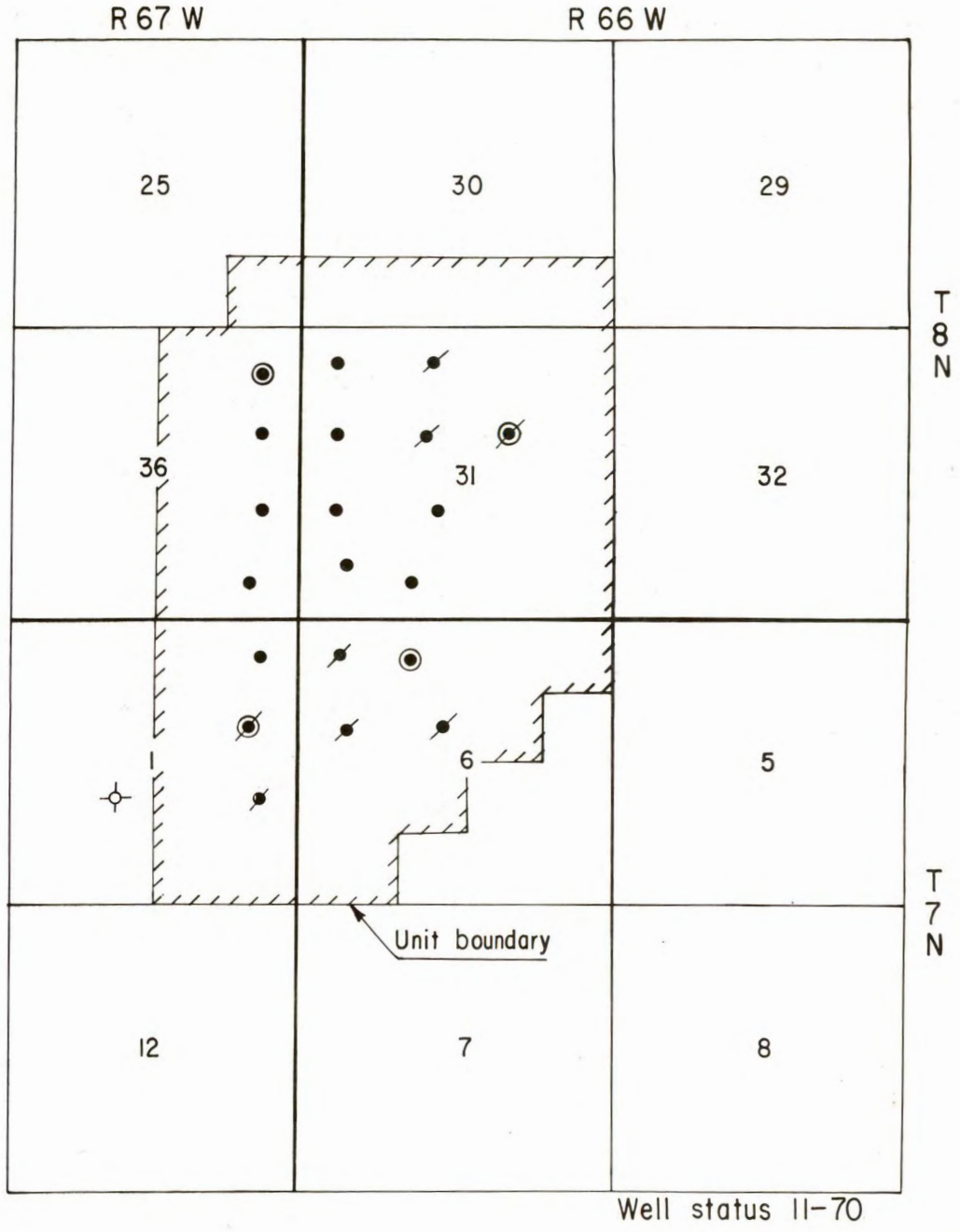
Annual and cumulative water injection and annual oil production for Bijou-West field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958	-	-	440
1959	-	-	187
1960	-	-	171
1961	-	-	120
1962	-	-	59
1963	-	-	64
1964	-	-	45
1965	-	-	34
1966	-	-	27
1967	-	-	22
1968	39	39	15
1969	1,342	1,381	11
1970	1,857	3,238	8
1971	703	3,941	5
1972	-	3,941	1

Cumulative oil production to start of injection was 1,186,400 barrels or 15.7 percent of the original stock tank oil in place. Total oil production to abandonment in 1972 was 1,210,900 barrels. The project was a failure because only 12,700 barrels of oil was recovered by the waterflood.

Black Hollow

The Black Hollow field (fig. 6) is in Tps 7 and 8, Rs 66 and 67 W, Weld County, about 14 miles east of Fort Collins, Colo. In August 1953, the California Co. completed No. 1 Baiamonta, NE¼NW¼ sec 6, T 7 N, R 66 W, in the southern portion of the field for an initial daily oil production of 304 barrels from the Lyons sand at 8,918 to 8,940 feet. Most of the development



LEGEND

- Oil well, Lyons
- Oil well, shut-in
- Water injection well
- Dry hole
- Water injection well, shut-in

FIGURE 6. - Black Hollow field.

wells were drilled in 1954-55 and the field contained 20 producing wells. Range of initial daily oil production for the wells was from 23 to 440 barrels.

Areal extent of the reservoir is 1,300 acres, and the average thickness is 30 feet. The reservoir is an anticlinal trap roughly oriented north-south. The oil-water contact is on the west side. Oil is produced by a combined limited water drive and fluid expansion.

The Chevron Oil Co.'s unit agreement was approved by the State on July 3, 1958. Initially there were 17 producing wells and 2 injection wells in the unit.

Water injection was started on August 16, 1958, in two wells along the east side of the field. Both purchased surface water and produced water are used. Produced water is the primary source because the amount of produced water, plus the natural water encroachment, should equal the fluid withdrawals.

In December 1972, there were six producing wells and two injection wells. Daily average production for the month was 280 barrels of oil and 2,284 barrels of water. The daily average water injection was 3,050 barrels at pressures of 696 psig. On January 1, 1973, the cumulative water injection was 12,233,300 barrels.

Annual and cumulative water injection and annual oil production for Black Hollow field are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953	-	-	70
1954	-	-	500
1955	-	-	789
1956	-	-	658
1957	-	-	675
1958	145	145	547
1959	122	267	527
1960	118	385	465
1961	225	610	484
1962	280	890	514
1963	500	1,390	549
1964	657	2,047	588
1965	1,416	3,463	758
1966	1,567	5,030	731
1967	1,347	6,377	501
1968	1,098	7,475	367
1969	1,291	8,766	292
1970	1,192	9,958	274
1971	1,111	11,069	204
1972	1,164	12,233	133

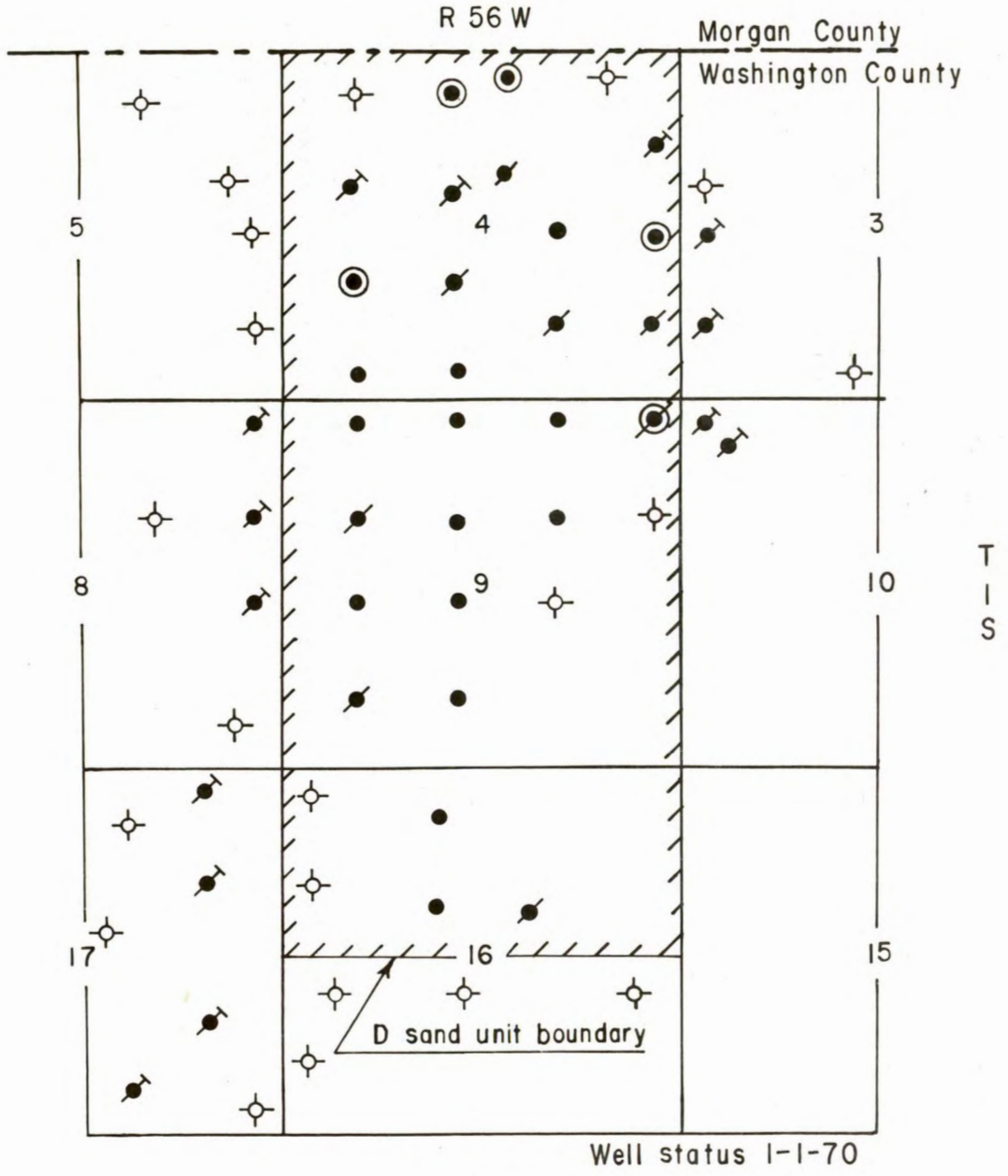


FIGURE 7. - Bobcat field.

Cumulative production at the start of injection was 3,052,000 barrels or 11.7 percent of the original oil in place. On January 1, 1973, the cumulative production was 9,623,000 barrels or 36.9 percent of the original oil in place. Since the start of injection, 6,571,000 barrels of oil has been produced, of which 1,323,000 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 9.2 to 1. Available data indicate a successful project.

Bobcat

The Bobcat field (fig. 7) is in T 1 S, R 56 W, Washington County. In February 1954, Continental Oil Co. completed No. 1 Selby well, NE¼SW¼ sec 9, for an initial daily oil production of 645 barrels flowing from the D sand at 5,131 to 5,166 feet. Most of the development drilling occurred during 1954, but a supplemental drilling program in 1962 resulted in five producing wells at the southern end of the field. The field contained 35 producing wells with a range of initial daily oil production from 4 to 903 barrels.

Areal extent of the D sand reservoir is 1,240 acres, and the average thickness is 23 feet. Initial reservoir-producing mechanism was a solution gas drive.

Continental Oil Co.'s unit agreement was approved by the State on July 18, 1967.

Water injection was started on April 12, 1968, in four wells at the northeast end of the field. Water supply is partly from Vaughey and Vaughey pipeline system and partly produced water.

During December 1972, there were five producing and five injection wells. Daily average oil production for the month was 75 barrels of oil and 886 barrels of water. The daily average injection was 885 barrels at pressures from 0 to 1,100 psig. Cumulative injection to January 1, 1973, was 8,621,000 barrels.

Annual and cumulative water injection and annual oil production for Bobcat field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1954	-	-	456
1955	-	-	1,094
1956	-	-	830
1957	-	-	600
1958	-	-	610
1959	-	-	415
1960	-	-	364
1961	-	-	400
1962	-	-	451
1963	-	-	317
1964	-	-	266
1965	-	-	167
1966	-	-	119
1967	-	-	87
1968	2,124	2,124	74
1969	3,034	5,158	84
1970	2,135	7,293	52
1971	962	8,255	35
1972	366	8,621	26

Cumulative oil production at the start of injection was 6,191,500 barrels or 24.8 percent of the original oil in place. On December 31, 1972, the cumulative production was 6,446,700 barrels or 25.8 percent of the original oil in place. Since the start of injection, 255,200 barrels of oil has been produced, including 155,400 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 55.5 to 1. The high injection ratio indicates some channeling of injected water. Even so, the project is a technical success.

Boxer

The Boxer field, secs 20, 28, 29, and 32, T 2 N, R 58 W, and sec 5, T 1 N, R 58 W, Morgan County, was discovered in April 1965. The discovery well, Champlin Petroleum Co.'s No. 1 Rigli, SE¼NW¼ sec 32, had an initial production of 68 barrels of oil per day from the D sand interval of 5,821 to 5,824 feet. The field was developed in 3 years. Continued drilling yielded 27 oil wells, 3 gas wells, and 5 dry holes. Reported initial daily oil production of the wells ranged from 11 to 492 barrels and averaged 151 barrels. Producing mechanism was solution gas drive and small gas cap.

The productive area contained 2,121 acres, and the pay zone averaged 12.8 feet in thickness. The Boxer waterflood unit was approved April 20, 1971. Water injection commenced February 18, 1972. Water produced in the Adena field is used for injection. Oil production prior to waterflooding was 1,487,300 barrels. In December 1972, the 14 oil wells averaged daily 237 barrels of oil and 255 barrels of water. Water injection at the same time averaged 8,901 barrels in 17 wells.

Annual and cumulative water injection and annual oil production for Boxer field are listed (D sand unit):

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1965	-	-	34
1966	-	-	218
1967	-	-	555
1968	-	-	332
1969	-	-	165
1970	-	-	112
1971	-	-	74
1972	2,787	2,787	74

The Boxer waterflood reacted very fast. It is much too soon to determine success or failure. The project should last 4 or 5 years or through 1976 or 1977.

Boxer-North

The North Boxer unit is in sec 21, T 2 N, R 58 W, Morgan County. The operator could not reach agreement to unitize, hence the Boxer unit and the North Boxer unit. The North Boxer unit is an extension of the Boxer field. The first drilling in sec 21 was a dry hole completed in December 1964, and the first oil well was completed March 17, 1967. A total of nine oil wells and three dry holes has been drilled in sec 21. Daily oil production ranged from 108 to 480 barrels and averaged 248 barrels. Initial daily water production averaged 34 barrels.

The productive area contains about 350 acres, and the pay zone averages 15 feet in thickness. The North Boxer D sand unit was approved May 16, 1972. Water injection started June 29, 1972, using two injection wells. Oil production prior to water injection was 410,000 barrels.

Annual and cumulative water injection and annual oil production for North Boxer field are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1967	-	-	194
1968	-	-	69
1969	-	-	28
1970	-	-	16
1971	-	-	11
1972	129	129	7

During December 1972, the three oil wells averaged 17 barrels of oil and 32 barrels of water daily. Water injection daily average was 617 barrels, using two wells. The project is too new to evaluate success or failure.

Buckingham

The Buckingham field is in T 8 N, R 59 W, Weld County. In October 1950, Shell Oil Co. completed the No. 1 Hulda A. Hanson, NE¼NE¼ sec 22, for an initial daily oil production of 32 barrels from the D sand at 6,715 to 6,726 feet. Three producing wells were drilled during 1950 and 1951, and three additional producing wells were drilled during 1955 and 1956. The six producing wells had a range of initial daily oil production of 32 to 311 barrels.

Areal extent of the reservoir is 480 acres, and the average thickness is 12 feet. Initial producing mechanism was a solution gas drive.

Vaughey and Vaughey's unit agreement was approved by the State on November 15, 1966.

Water injection began on March 5, 1967, in one well on the west side of the field. Source of the water was a shallow well in SW¼NE¼ sec 33. Injection was stopped on April 5, 1969, after a cumulative injection of 663,400 barrels.

Annual and cumulative water injection and annual oil production for Buckingham field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	19
1961	-	-	15
1962	-	-	12
1963	-	-	10
1964	-	-	8
1965	-	-	7
1966	-	-	6
1967	220	220	5
1968	333	553	1
1969	111	664	1
1970	-	664	Plugged and abandoned

No secondary oil was produced, and the project is considered a technical failure.

Busy Bee

The Busy Bee field, in secs 8, 9, and 10, T 3 S, R 60 W, Adams County, was discovered in August 1955. Cortez Drilling Co.'s well No. 2 Flader in the SE¼SE¼NE¼ sec 9 had an initial pumping production of 100 barrels of oil in 12 hours. Fifteen additional holes were drilled in the area. Of these, five produced some oil from the D sand. The average depth to top of the D sand was 6,398 feet. The structure is a small ridge or nose plunging a little south of east.

The reservoir contained 240 acres with an average sand thickness of 11 feet. Oil was produced initially by solution gas expansion.

Sundance Oil Co.'s unit plan for waterflooding Busy Bee was approved October 18, 1960. Water injection started on January 11, 1961. Injection water was from a well in the field. Injection stopped July 25, 1963, after 309,739 barrels had been injected.

The following oil production does not show any change due to the water injection. Starting in March 1961, the injection pressure increased from 960 psig to 4,500 psig in July 1962. This could indicate some kind of formation plugging. The project was a failure.

Annual and cumulative water injection and annual oil production for Busy Bee field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1955	-	-	10
1956	-	-	20
1957	-	-	12
1958	-	-	18
1959	-	-	53
1960	129	129	33
1961	138	267	21
1962	42	309	12
1963	-	309	9
1964	-	309	9
1965	-	309	7

Cache

The Cache field (fig. 8) is in Tps 34 and 35 N, R 20 W, Montezuma County, about 25 miles southwest of Cortez, Colo. In October 1964, Pan American Petroleum Corp. (now Amoco Production Co.) completed No. 1 Veach, NW¼NW¼ sec 2, T 34 N, R 20 W, for an initial flowing daily oil production of 1,434 barrels from the Ismay Limestone at 5,428 to 5,578 feet. Most of the development

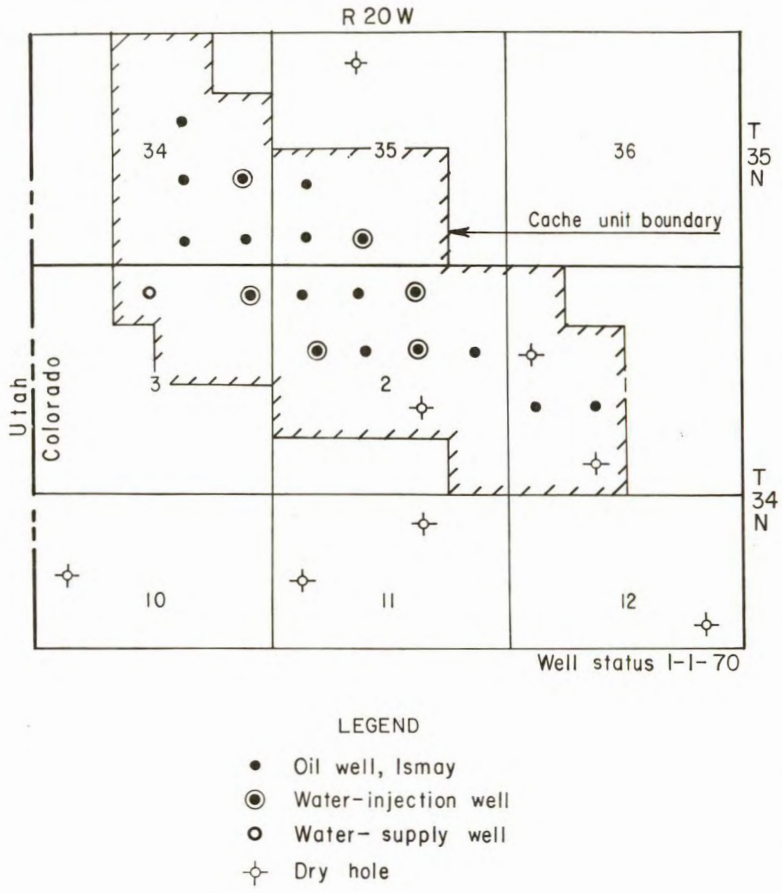


FIGURE 8. - Cache field.

drilling occurred during 1965. The field contained 18 producing wells with initial daily ranges of oil production from 8 to 3,185 barrels.

Areal extent of the reservoir is 880 acres, and the average thickness is 32 feet. There are up to seven producing zones in the Ismay Limestone. The fifth and seventh zones (numbered from the top down) are the best and contain more than half the oil reserves. Initial producing mechanism was primarily a solution gas drive, and the lower zones had limited water drives.

Pan American Petroleum Corp.'s unit agreement was approved by the State on September 19, 1967.

Water injection in four wells was started on March 12, 1968. Initially, the injection was to be concentrated in the fifth and seventh zones. Sources of the water are produced water and water from a well in the NE¼NW¼ sec 3, T 34 N, R 20 W, completed in the Salt Wash zone of the Morrison Formation at 800 to 1,000 feet.

During December 1972, there were 11 producing and 6 injection wells. Daily average production for the month was 330 barrels of oil and 584 barrels of water. The average daily injection was 2,037 barrels at 2,600 psig. Cumulative injection to January 1, 1973, was 4,601,100 barrels.

Annual and cumulative water injection and annual oil production for Cache field unit are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1964	-	-	197
1965	-	-	1,229
1966	-	-	1,840
1967	-	-	2,118
1968	806	806	2,267
1969	898	1,704	2,384
1970	1,007	2,711	2,481
1971	991	3,702	2,576
1972	899	4,601	2,694

Cumulative oil production at the start of injection was 2,147,200 barrels or 20.4 percent of the original oil in place. On January 1, 1973, the cumulative production was 2,694,200 barrels, or 25.6 percent of the original oil in place. Since the start of injection, 547,000 barrels of oil has been produced, including 494,200 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 9.3 to 1. Available data indicate a technically successful project.

Clarks Lake

The Clarks Lake field is in sec 15, T 9 N, R 68 W, Larimer County. Oil was discovered in April 1944, when Amerada Petroleum Corp.'s No. 1 Galvin, SE¼SW¼ sec 15, was completed pumping 61 barrels of oil and 3 barrels of water daily from the Muddy sand at 5,939 to 6,000 feet. The field was developed on 20-acre spacing during 1944. A total of five producing wells was drilled and had an initial daily range of production from 61 to 186 barrels.

Areal extent of the reservoir is 190 acres, and the average thickness is 28 feet. Initial reservoir-producing mechanism was a water drive.

Amerada Petroleum Corp.'s unit agreement was approved by the State on February 16, 1965.

Water injection was started August 5, 1965, in one well at the north end of the field. The water supply well, located south of the injection well, was completed between 1,300 and 1,800 feet.

During December 1972, there were two producing wells and two shut-in injection wells in the unit. Daily average oil production was 66 barrels of oil and 100 barrels of water. The cumulative water injection to December 31, 1972, was 1,350,600 barrels.

Annual and cumulative water injection and annual oil production for Clarks Lake field are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958	-	-	20
1959	-	-	19
1960	-	-	18
1961	-	-	16
1962	-	-	15
1963	-	-	14
1964	-	-	16
1965	143	143	19
1966	289	432	25
1967	212	644	43
1968	184	828	48
1969	193	1,021	41
1970	173	1,194	34
1971	144	1,338	35
1972	12	1,350	31

Cumulative oil production at the start of injection was 610,200 barrels or 20.3 percent of the original oil in place. On December 21, 1972, the cumulative production was 875,800 barrels or 29.1 percent of the original oil in place. Since the start of injection, 265,600 barrels of oil had been produced, including 211,800 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 6.4 to 1. Available data indicate a technically successful project.

Danforth Hills

The Danforth Hills field is in T 5 N, R 95 W, Moffat County, about 45 miles southwest of Craig, Colo. In August 1954, Texaco, Inc., completed No. 1 Govt.-Treleaven, SW¼SW¼ sec 32, for an initial daily production of 320 barrels of oil from the Morrison Formation at 6,625 to 6,647 and 6,652 to 6,658 feet. Three other producing formations were found in the field by Texaco, Inc. Oil was discovered in October 1959, in the Sundance Formation when the No. 4 Govt.-Treleaven, NE¼NE¼ sec 31, was completed pumping 624 barrels daily from two intervals between 6,430 and 6,714 feet. In November 1960, oil was found in the Weber Formation when the No. 7 Govt.-Treleaven, NW¼NE¼ sec 31, was completed pumping 445 barrels daily from the intervals 8,123 to 8,132 and 8,172 to 8,182 feet. The last discovery was in October 1967 when the No. 2 Govt.-Treleaven, SW¼NW¼ sec 32 (formerly a Sundance producer), was recompleted pumping 697 barrels daily from the Dakota Formation at 6,108 to 6,128 feet. The Weber zone was not produced during 1966-70, and the Dakota zone was not produced 1971-72.

Morrison Project

Areal extent of the reservoir is 240 acres, and the average thickness is 16 feet. The oil is located in a structural trap on the Danforth Hills

anticline. Initial reservoir-producing mechanism was a combination solution gas expansion and a limited water drive.

Water injection was started in the Govt.-Treleaven No. 3 well on March 16, 1962, by Texaco, Inc., the project operator. Only 200 barrels of water daily could be injected. Injection was stopped and the Govt.-Treleaven No. 1 well was used as an injection well. Produced water from the Morrison, Sundance, and Weber Formations is the water source.

During December 1972, the unit was shut in. Cumulative water injection to January 1, 1973, was 226,400 barrels.

Annual and cumulative water injection and annual oil production for Danforth Hills, Morrison Formation, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1959	-	-	34
1960	-	-	138
1961	-	-	104
1962	10	10	62
1963	-	10	33
1964	-	10	55
1965	-	10	77
1966	-	10	52
1967	87	97	55
1968	63	160	38
1969	67	227	39
1970	-	227	38
1971	-	227	25
1972	-	227	15

Cumulative oil production at the start of injection was 422,900 barrels or 12 percent of the original oil in place. On January 1, 1973, the cumulative production was 899,300 barrels or 25.5 percent of the original oil in place. Since the start of injection, 476,400 barrels of oil had been produced, including 218,200 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 1 to 1. Available data indicate a technically successful project.

Sundance Project

Areal extent of the reservoir is 280 acres, and the average thickness is 23 feet. Original reservoir-producing mechanisms were solution gas drive and a limited water drive.

A water injection project was started on June 13, 1963, by Texaco, Inc., the project operator. The water injection well had been a Morrison injection

well but was deepened 20 feet and used as a Sundance injection well. Water also is being injected into Govt.-Treleaven No. 7 well. Produced water is used for injection.

During December 1972, the unit was shut in. Cumulative water injection to January 1, 1973, was 7,436,800 barrels.

Annual and cumulative water injection and annual oil production for Danforth Hills, Sundance Formation, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1959	-	-	224
1960	-	-	390
1961	-	-	261
1962	-	-	131
1963	536	536	95
1964	1,099	1,635	73
1965	1,045	2,680	46
1966	917	[1]3,338	27
1967	726	4,064	24
1968	888	4,952	11
1969	948	5,900	23
1970	536	6,436	13
1971	687	7,123	8
1972	314	7,437	-

[1]Adjusted cumulative in Colorado Oil and Gas Statistics 1966.

Cumulative oil production at the start of injection was 1,347,700 barrels or 26.4 percent of the original oil in place. On January 1, 1973, the cumulative production was 1,624,400 barrels or 31.8 percent of the original oil in place. Since the start of injection, 276,700 barrels of oil was produced, of which 109,300 barrels was attributed to water injection. The ratio of water injected to secondary oil produced is 68 to 1. Available data indicate some secondary oil was recovered, but the project appears to be technically unsuccessful.

Divide

The Divide field is in Tps 8 to 9 N, R 53 W, Logan County, about 7 miles northwest of Sterling, Colo. In May 1954, McDermott and Barnhart completed the No. 1 M. Armstrong, SW¼NE¼ sec 34, T 9 N, R 53 W, as the discovery well for the Minto-West field. On January 26, 1960, the field was added to the Divide field. Initial daily production was 199 barrels of oil from the J sand at 4,893.5 to 4,896.5 feet. Oil was discovered in the D sand 1 month later at the No. 1 Monroe, NE¼NW¼ sec 10, T 8 N, R 53 W, by Miracle and Fifer Drilling Co. Initial daily production was 150 barrels of oil from the interval 4,815

to 4,820 feet. Most of the field development occurred during 1954 and 1955, and by 1957, drilling was completed. Of the 42 producing wells, most were D sand wells that had a range of daily production from 25 to 726 barrels.

Areal extent of the D sand reservoir is 1,700 acres, and the average thickness is 7 feet. Initial reservoir-producing mechanism was a solution gas drive.

Shell Oil Co.'s unit agreement for water injection in the D sand was approved by the State on November 16, 1959. The initial unit had 18 producing wells and 11 injection wells.

Water injection was started in 16 wells on a peripheral pattern on November 25, 1960. Two water wells completed between 200 and 600 feet in sec 3 and produced water are the sources of the water.

During December 1972, there were seven producing wells and nine injection wells in the unit. Daily average production for the month was 52 barrels of oil and 3,200 barrels of water. The daily average water injection was 3,200 barrels at pressures from 200 to 250 psig. Cumulative water injection to January 1, 1973, was 18,936,500 barrels.

Annual and cumulative water injection and annual oil production for Divide field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	200	200	55
1961	1,711	1,911	60
1962	2,148	4,059	146
1963	1,931	5,990	145
1964	1,760	7,750	210
1965	2,065	9,815	319
1966	1,163	10,978	171
1967	1,362	12,340	121
1968	1,274	13,614	81
1969	1,678	15,292	57
1970	1,192	16,484	47
1971	1,219	17,703	38
1972	1,232	18,935	28

Cumulative oil production at the start of injection was 1,075,000 barrels or 13.5 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 3,669,900 barrels or 46.1 percent of the original oil in place. Since the start of injection, 2,594,900 barrels of oil had been produced, including 1,637,800 barrels attributed to water injection. The ratio of cumulative injection to cumulative secondary oil production is 11.6 to 1. Available data indicate a technically successful project.

Dune Ridge

The Dune Ridge field is in Tps 6 and 7 N, R 52 W, Logan County, about 8 miles south of Sterling, Colo. Oil was discovered in the D sand on June 21, 1954, at the No. 1-A State, NW¼SE¼ sec 32, T 7 N, by Shell Oil Co. The well was completed flowing 249 barrels of oil daily from the interval 4,457 to 4,465 feet. Most of the development drilling occurred during 1954, but additional producing wells were drilled in 1957 and 1959. The range of initial daily production of the wells was from 25 to 476 barrels.

Areal extent of the reservoir is 800 acres, and the average thickness is 4 feet. Initial reservoir-producing mechanisms were a gas cap expansion and a solution gas expansion.

Shell Oil Co.'s unit agreement was approved by the State on December 10, 1957. On October 20, 1959, the unit boundary was expanded.

During mid-1955 the producing gas-oil ratio rose abruptly, and reservoir pressure declined. In an effort to stabilize the reservoir pressure, a gas cycling operation began on July 19, 1955, and was discontinued on February 4, 1959, after 1,167,813,000 cubic feet of gas had been injected.

Water injection was started on February 1, 1958, in six wells on a peripheral pattern. One injection well was located at the gas-oil contact to prevent migration of the oil into the gas cap. Two water supply wells, one in the SE¼NW¼ sec 29 and the other in the NW¼SE¼ sec 32, were drilled to a water zone at the depth of 560 feet.

During December 1972, there were seven producing wells and four injection wells. Daily average production was 8 barrels of oil and no water. The daily average water injection was 365 barrels. The cumulative water injection to January 1, 1973, was 8,205,400 barrels.

Annual and cumulative water injection and annual oil production for Dune Ridge, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1954	-	-	158
1955	-	-	227
1956	-	-	186
1957	-	-	159
1958	650	650	122
1959	717	1,367	242
1960	870	2,237	249
1961	901	3,138	96
1962	766	3,904	49
1963	543	4,447	31
1964	648	5,095	26
1965	522	5,617	18
1966	389	6,006	19
1967	437	6,443	14
1968	437	6,880	13
1969	437	7,317	13
1970	328	7,645	11
1971	294	7,939	11
1972	266	8,205	9

Cumulative oil production at the start of injection was 744,000 barrels or 22.5 percent of the original oil in place. Through 1972, the cumulative oil production was 1,654,400 barrels or 50 percent of the original oil in place. Since the start of water injection, 910,400 barrels of oil was produced, and 419,200 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 19.6 to 1. Available data indicate a technically successful project.

Gary-North

The Gary-North field is in T 2 N, R 56 W, Morgan County. In July 1954, H. L Hunt Co. completed its No. 1 Huey, SE¼SE¼ sec 21, for an initial daily production of 30 barrels of oil from the D sand at 5,064 to 5,070 feet. Field development drilling occurred during 1954 and 1955, and during the development period, gas was discovered in the J sand at the No. 8 George E. Huey, NW¼NE¼ sec 27, in April 1955. The well flowed 1,972,000 cubic feet of gas daily on a test of the interval 5,122 to 5,128 feet and was shut in on completion. Range of initial daily production of the D sand wells was from 30 to 150 barrels.

One well in sec 21 is separated from the other producing wells of the D sand reservoir by a permeability pinchout. The reservoir contains 190 acres and averages 5.3 feet thick. Initial reservoir-producing energy was a solution gas drive.

A unit agreement was approved by the State for the wells in secs 22 and 27 on January 16, 1962, with H. L. Hunt the operator. Initially the unit contained three producing wells and one injection well.

Water injection was started in a well in the NW¼NW¼ sec 27 on February 25, 1962. The water supply is obtained from a shallow well near the injection well.

During December 1972, the unit contained one producing well and one injection well. Daily average production for the month was 5 barrels of oil and 147 barrels of water. Daily average water injection was 300 barrels at a pressure of 1,200 psig. The cumulative water injection through 1972 was 1,386,200 barrels.

Annual and cumulative water injection and annual oil production for Gary-North, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1954	-	-	7
1955	-	-	69
1956	-	-	30
1957	-	-	27
1958	-	-	22
1959	-	-	17
1960	-	-	12
1961	-	-	12
1962	219	219	14
1963	214	433	29
1964	142	575	19
1965	123	698	9
1966	101	799	6
1967	107	906	5
1968	100	1,006	4
1969	96	1,102	3
1970	88	1,190	3
1971	84	1,274	3
1972	114	1,388	2

Cumulative oil production at the start of injection was 186,000 barrels or 21.8 percent of the original oil in place. On January 1, 1973, the cumulative production was 291,700 barrels or 34.2 percent of the original stock tank oil in place. Since the start of injection, 105,700 barrels of oil was produced, including 51,700 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 26.8 to 1. Available data indicate a technically successful project.

Graylin-Northwest

The Graylin-Northwest field (fig. 9) is in T 8 N, Rs 53 and 54 W, Logan County, about 8 miles northwest of Sterling, Colo. British American Oil Producing Co.'s No. 2 Monroe-Rieke, SW¼SE¼SE¼ sec 1, T 8 N, R 54 W, pumped 100 barrels of oil and 4 barrels of water from the D sand on June 4, 1953. The perforated interval was from 4,935 to 4,940 feet. Eight days later the firm's No. 1 Monroe-Rieke, SW¼NE¼SE¼ sec 1, T 8 N, R 54 W, pumped 83 barrels of oil from the J sand interval of 5,077 to 5,083 feet. Initial ranges of daily oil production were 33 to 661 barrels for the D sand and 74 to 212 barrels for the J sand wells.

Water injection projects in the D and J sands are in operation. Source of the water is six water wells completed in the Arikaree sand, White River sand, and the Pierre transitional zone, at depths from 200 to 1,000 feet.

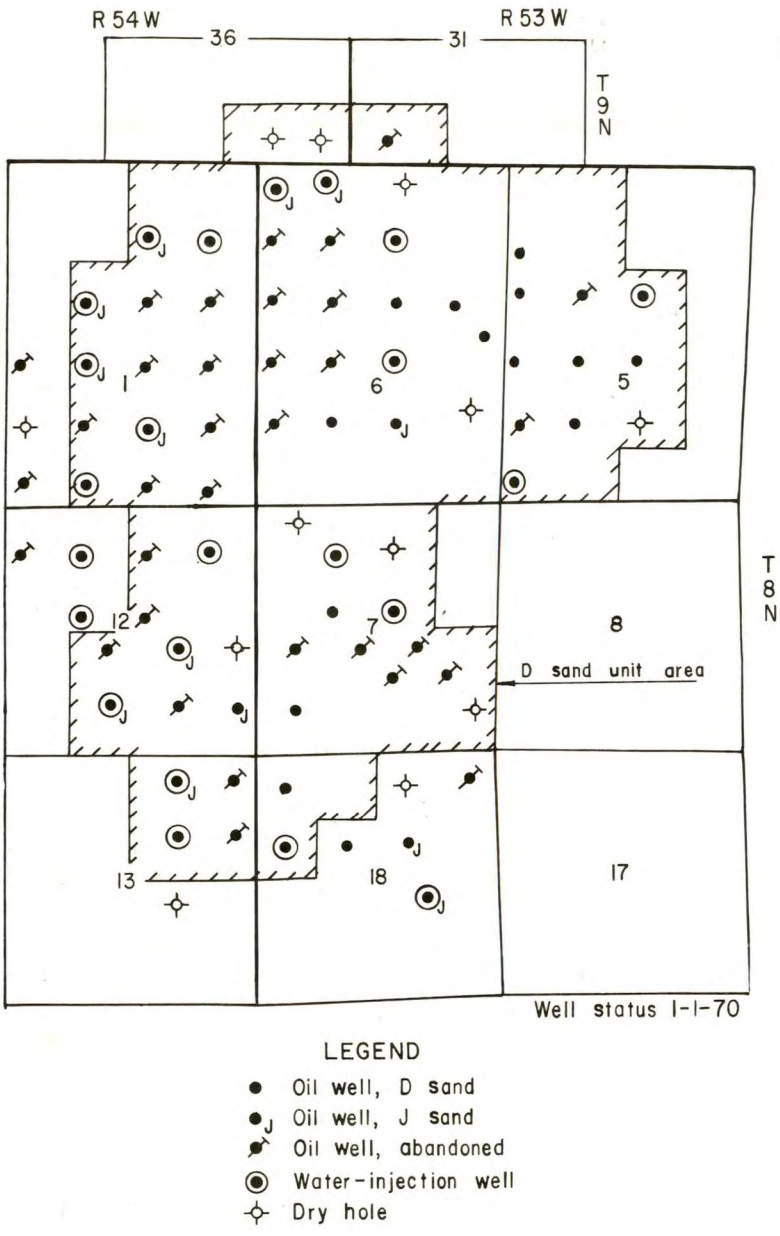


FIGURE 9. - Graylin-Northwest field.

D Sand Unit

Areal extent of the D sand reservoir is 3,810 acres, and the average thickness is 8.7 feet. The reservoir is a combination structural and stratigraphic trap. The initial producing mechanism was a solution gas drive.

British American's unit agreement for waterflooding the Graylin-Northwest D sand, including the former Graylin field, was approved by the State on December 15, 1959. Initially the unit contained 33 producing wells, 6 water wells, and 19 injection wells.

Water injection was started on August 26, 1960, on a semiperipheral injection pattern. The water is filtered before injection.

During December 1972, there were 8 producing wells and 12 injection wells. Daily average production for the month was 250 barrels of oil and 725 barrels of water. The daily average injection was 7,192 barrels at injection pressures from 485 to 835 psig. The cumulative water injection through 1972 was 43,265,400 barrels.

Annual and cumulative water injection and annual oil production for Graylin-Northwest, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	2,112	2,112	306
1961	5,516	7,628	520
1962	4,952	12,580	915
1963	4,563	17,143	973
1964	3,870	21,013	530
1965	2,418	23,431	367
1966	2,966	26,397	265
1967	3,296	29,693	185
1968	3,285	32,978	172
1969	2,943	35,921	145
1970	2,702	38,623	116
1971	2,252	40,875	92
1972	2,391	43,266	85

Cumulative oil production at the start of injection was 6,321,000 barrels or 23.2 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 10,874,800 barrels or 39.9 percent of the original oil in place. Since the start of injection, 4,553,800 barrels of oil was produced, including 2,703,200 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 16 to 1. Available data indicate a technically successful project.

J Sand Unit

The J sand unit was approved by the State on July 15, 1969. Initially the unit contained two producing wells and eight injection wells. The unit contained 700 acres and average thickness was 7.1 feet.

Water injection was started on November 19, 1969. The daily average injection during October 1972 was 4,600 barrels. The cumulative injection to January 1, 1973, was 4,376,100 barrels.

Annual and cumulative water injection and annual oil production for Graylin-Northwest, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	29
1961	-	-	25
1962	-	-	30
1963	-	-	17
1964	-	-	14
1965	-	-	12
1966	-	-	12
1967	-	-	10
1968	-	-	10
1969	54	54	12
1970	981	1,035	35
1971	1,833	2,868	23
1972	1,509	4,377	20

The average daily production from the three active wells in December 1972 was 21 barrels of oil and 12 barrels of water. Water injection was stopped in October 1972.

Oil production to start of injection was 1,054,300 barrels, or about 30.9 percent of the original oil in place. The cumulative production to January 1, 1973, was 1,134,900 barrels. Production credited to water injection was 63,800 barrels. The ratio of water injected to secondary oil recovered was 68 to 1, indicating a failure.

Greasewood

The Greasewood field is in T 6 N, R 61 W, Weld County. The field contains two reservoirs; one is in secs 11, 12, and 14, and the other, in secs 13, 24, and 25. Oil was discovered in the southern reservoir in 1930 when Platte Valley Petroleum Co.'s No. 1 Patterson, SW¼SW¼ sec 24, was completed pumping 150 barrels of oil daily from the Muddy Formation. The discovery well for the northern reservoir was Clifford Parker and J. G. Dyer's No. 2 Kirchoff, SE¼NW¼ sec 12. It was completed on November 14, 1951, for an initial potential of 27 barrels of oil per hour from the D sand at 6,740 to 6,748 feet. Development drilling resulted in seven producing wells in the north reservoir and four in the south reservoir. Range of initial daily oil production for the wells was from 22 to 648 barrels.

Both the north and south reservoirs were unitized. The north unit was approved by the State on May 22, 1962, with J. G. Dyer the operator. The south unit was approved by the State on December 21, 1962, with Union Texas Petroleum the operator. No water has been injected into the south unit.

Areal extent of the J. G. Dyer north unit is 240 acres, and the D sand has an average thickness of 8 feet. Initial reservoir-producing mechanism was a solution gas drive.

Water injection was started on September 27, 1962, in one well on the west side of the unit. The No. 3 Kirchoff, NE¼NW¼ sec 12, was recompleted as a water supply well from the interval 1,250 to 1,350 feet. Injection operations were suspended in July 1970, after a cumulative injection of 1,826,700 barrels.

Annual and cumulative water injection and annual oil production for Greasewood, J. G. Dyer north unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	10
1961	-	-	1
1962	86	86	-
1963	327	413	1
1964	314	727	1
1965	242	969	1
1966	222	1,191	1
1967	403	1,594	4
1968	140	1,734	7
1969	86	1,820	4
1970	8	1,828	2
1971	-	1,828	Plugged and abandoned

Cumulative oil production at the start of injection was 248,300 barrels or 20 percent of the original oil in place. On January 1, 1972, the cumulative production was 267,000 barrels or 21.6 percent of the original oil in place. The wells were plugged and abandoned during 1971. Since the start of injection, 18,700 barrels of oil was produced, including 14,150 barrels attributed to water injection. Available data indicate the project was unsuccessful.

Jackpot

The Jackpot field is in T 6 N, R 59 W, Morgan County, and T 7 N, R 59 W, Weld County. In January 1955, John L. Nelson completed his No. 1 Farnick, NW¼SW¼ sec 1, T 6 N, R 59 W, for an initial daily oil production of 150 barrels from the D sand at 6,474 to 6,480.5 feet. Amerada Petroleum Corp. discovered oil in the Greenhorn Formation at its No. 2 Mary-Farnick, SW¼NW¼ sec 1, T 6 N, R 59 W, in November 1956. The well produced 17 barrels of oil daily from the interval 6,300 to 6,350 feet. Range of initial daily oil production for the D sand wells was from 10 to 840 barrels.

Areal extent of the D sand reservoir is 1,440 acres, and the average thickness is 8 feet. The initial producing mechanism was a solution gas drive.

The Monsanto Co.'s unit agreement was approved by the State on November 19, 1959.

Water injection was started on August 24, 1960. The Farnick No. 5 well, NE¼SW¼ sec 2, T 6 N, R 59 W, is the injection water source. Injection was stopped in June 1968 after a cumulative injection of 3,567,800 barrels.

Annual and cumulative water injection and annual oil production for Jackpot, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	307	307	59
1961	737	1,044	66
1962	535	1,579	67
1963	488	2,067	52
1964	529	2,596	60
1965	587	3,183	43
1966	291	3,474	21
1967	72	3,546	15
1968	23	3,569	6
1969	-	-	5
1970	-	-	2
1971	-	-	2
1972	-	-	1

Cumulative oil production at the start of injection was 999,000 barrels or 18.1 percent of the original oil in place. On January 1, 1973, the cumulative production was 1,381,400 barrels or 25 percent of the original oil in place. Since the start of injection, 380,500 barrels of secondary oil was produced. The ratio of cumulative water injection to cumulative secondary oil production is 9.4 to 1. Available data indicate a successful project.

Kejr-North

The Kejr-North field is in T 2 S, R 56 W, Washington County. In April 1955, Dawson and Cramer, et al, completed the No. 1 Kejr "A," NW¼SW¼ sec 2, for an initial production of 33 barrels of oil in 12 hours from the D sand at 5,042 to 5,048 feet. Oil was discovered in the J sand at the No. 4 Kejr "C," NW¼NE¼ sec 11, on November 9, 1955. Initial daily production was 190 barrels from the interval 5,088 to 5,098 feet. Range of initial daily production was from 10 to 282 barrels for the D sand wells and 60 to 190 barrels for the J sand wells.

Areal extent of the D sand reservoir is 900 acres, and the average thickness is 9 feet. The initial reservoir-producing mechanism was a solution gas drive.

The Sohio Oil Co.'s unit agreement was approved by the State on September 26, 1958.

Water injection was started on January 15, 1959, on a peripheral pattern. Produced water from the J sand and water purchased from the Vaughey and Vaughey system are used.

During December 1972, three producing wells and three injection wells were in the unit. Daily average production was 9 barrels of oil and 151 barrels of water. The daily average injection was 87 barrels at zero pressure. The cumulative injection to January 1, 1973, was 7,904,300 barrels.

Annual and cumulative water injection and annual oil production for Kejr-North, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1959	905	905	316
1960	834	1,739	284
1961	873	2,612	222
1962	846	3,458	163
1963	742	4,200	129
1964	643	4,843	97
1965	532	5,375	69
1966	426	5,801	56
1967	466	6,267	28
1968	379	6,646	26
1969	372	7,018	21
1970	361	7,379	18
1971	320	7,699	13
1972	207	7,906	11

Cumulative oil production at the start of injection was 797,000 barrels or 13.5 percent of the original oil in place. On January 1, 1973, the cumulative production was 2,190,400 barrels or 37.1 percent of the original oil in place. Since the start of injection, 1,393,400 barrels had been produced, including 1,023,400 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 7.7 to 1. Available data indicate a technically successful project.

Keota

The Keota field is in T 9 N, R 61 W, Weld County. In November 1951, Wycolo Development Co. completed No. 1 Gillette, C SE¼ sec 4, for an initial daily production of 279 barrels of oil from the J sand at 7,322 to 7,365 feet. Development drilling during 1952 and 1953 resulted in 20 producing wells. Oil was discovered in the Lyons sand at the No. 8 Miles and Don Gillette well, NW¼NW¼ sec 9, in May 1953. Initial daily oil production was 279 barrels from

the interval 8,476 to 8,496 feet. The well was abandoned after producing 12,816 barrels. Range of initial production of the J sand wells was from 20 to 610 barrels.

Areal extent of the reservoir is 440 acres, and the average thickness is 13 feet. Initial producing mechanism was a solution gas drive.

The Pepper Tank Co.'s unit agreement was approved by the State on August 20, 1963.

Water injection was started in three wells on November 11, 1963. Two of the injection wells were in the SW¼ sec 4, and one was in the NE¼ sec 9. The water source is a shallow sand at a depth of 600 feet in the NE¼SE¼ sec 8. Injection was stopped in August 1971 after a cumulative injection of 831,500 barrels. A total of 720 barrels was injected in August at a pressure of 50 psig.

Annual and cumulative water injection and annual oil production in Keota field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	19
1961	-	-	12
1962	-	-	12
1963	20	20	11
1964	241	261	23
1965	41	302	11
1966	95	397	8
1967	155	552	7
1968	118	670	4
1969	147	817	2
1970	3	820	3
1971	11	831	6
1972	-	831	5

Cumulative oil production at the start of injection was 858,700 barrels or 26.3 percent of the original oil in place. On January 1, 1973, the cumulative production was 927,800 barrels or 28.4 percent of the original oil in place. Since the start of injection, 69,100 barrels had been produced, and 20,000 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 41.5 to 1. The project is considered technically unsuccessful.

Leader

The Leader field is in T 2 S, R 59 W, Adams County. Gas was discovered by the Ginther-Warren and Ginther No. 1 George Leasure well, SE¼SW¼ sec 17, in the southern part of the field on June 1, 1954. Initial daily gas production test was 2,500,000 cubic feet from the J sand at 6,263 to 6,309 feet. In September 1954, Ryan Oil-Davis Oil and Potter Drilling completed the oil discovery, No. 1 Doss, SE¼SW¼ sec 8. Initial oil production was 30 barrels per hour from the J sand at 6,254 to 6,262 feet. Development drilling resulted in five additional producers in the field by 1955. The range of initial daily production for the oil wells was from 100 to 768 barrels.

Areal extent of the reservoir is 280 acres, and the average thickness is 9.3 feet.

The Ginther-Warren and Ginther Co.'s unit agreement for injection of gas was approved by the State on February 18, 1958. The waterflood plan was approved on April 20, 1959.

Commission order 59-7 describes the gas injection project as conservation of gas rather than added oil recovery. Gas injection started in April 1957 and ended in August 1962. Daily injection rates were less than a million cubic feet. The records show no reservoir pressures or indicate any oil recovery resulting from the gas injection.

Water injection was started in one well on September 11, 1959. The water source was a shallow well 1½ miles from the field. Injection was stopped in August 1962 after a cumulative injection of 551,400 barrels.

Annual and cumulative water injection and annual oil production in Leader field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1954	-	-	44
1955	-	-	20
1956	-	-	1
1957	-	-	30
1958	-	-	26
1959	18	18	15
1960	208	226	15
1961	275	501	7
1962	50	551	1
1963	-	551	Plugged and abandoned

The cumulative oil production at the start of water injection was 66,700 barrels, and the cumulative production at abandonment in August 1962 was

158,200 barrels. After the start of injection, 91,500 barrels of oil was produced, of which 10,000 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 55.1 to 1. Although some secondary oil was recovered, data indicate a technically unsuccessful project.

Lewis Creek

The Lewis Creek field is in T 11 N, Rs 52 and 53 W, Logan County. Oil was discovered when British American completed the No. 1 Jorritsma well, SW¼SE¼ sec 12, T 11 N, R 53 W, on July 29, 1953. Initial daily production was 584 barrels of oil from the J sand at 5,360 to 5,370 feet. Development drilling resulted in 17 producing wells by the end of 1954. Range of initial daily production for the wells was 25 to 485 barrels.

Areal extent of the reservoir is 890 acres, and the thickness averages 17.2 feet. Originally the oil was produced by a combination of a solution gas drive and a limited water drive.

British American's unit agreement was approved by the State on October 31, 1958.

Water injection was started in five wells located near lease lines on May 13, 1959. The three water supply wells are completed in the Fox Hills sand.

During December 1972, one producing well and three injection wells were operative. Daily average production for the month was 132 barrels of oil and 1,200 barrels of water. The daily average injection was 1,742 barrels of water at a pressure of less than 200 psig. Cumulative water injection to January 1, 1973, was 26,422,000 barrels.

Annual and cumulative water injection and annual oil production for Lewis Creek, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953	-	-	158
1954	-	-	787
1955	-	-	655
1956	-	-	441
1957	-	-	347
1958	-	-	327
1959	1,346	1,346	304
1960	2,292	3,638	331
1961	2,885	6,523	380
1962	2,328	8,851	462
1963	2,389	11,240	363
1964	2,338	13,578	203
1965	1,954	15,532	192
1966	1,946	17,478	159
1967	1,606	19,084	63
1968	1,849	20,933	56
1969	2,075	23,008	38
1970	1,684	24,692	21
1971	972	25,664	7
1972	755	26,419	4

Cumulative oil production at the start of injection was 2,816,000 barrels or 16 percent of the original oil in place. On January 1, 1973, the cumulative production was 5,296,300 barrels or 30 percent of the original oil in place. Since the start of injection, 2,480,300 barrels of oil was produced, including 796,300 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 33 to 1. Although the project has a high water-oil ratio, data indicate a technically successful project.

Liberty

The Liberty field is in T 8 N, R 54 W, Logan County, about 13 miles northwest of Sterling, Colo. In February 1954 British American completed the No. 1 Ed A. Feik well, NE¼SW¼ sec 5, for an initial daily oil production of 141 barrels from the J sand at 5,324 to 5,328 feet. Development drilling occurred during 1954, 1955, and 1962. Here the J sand is divided into J-1 and J-2 zones. Range of initial daily production for the wells was from 40 to 300 barrels.

Areal extent of the reservoir is 654 acres, and the J-1 and J-2 sands (together) average 11 feet in thickness. Originally the oil was produced by a solution gas drive and gas cap expansion.

A unit agreement was approved by the State on December 18, 1962. British American Oil Producing Co. was the operator. Gulf Oil Corp. took over British American in July 1966.

Water injection started in two wells on May 22, 1963. The injection water was obtained from the Thayer and Buell Shale at a depth of 800 feet. Injection was stopped on June 21, 1967, after a cumulative injection of 3,288,500 barrels.

Annual and cumulative water injection and annual oil production for Liberty field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1954	-	-	94
1955	-	-	174
1956	-	-	162
1957	-	-	115
1958	-	-	98
1959	-	-	76
1960	-	-	53
1961	-	-	42
1962	-	-	39
1963	614	614	24
1964	866	1,480	14
1965	803	2,283	10
1966	716	2,990	11
1967	290	3,289	3
1968	-	3,289	3
1969	-	3,289	3
1970	-	3,289	3
1971	-	3,289	3
1972	-	3,289	4

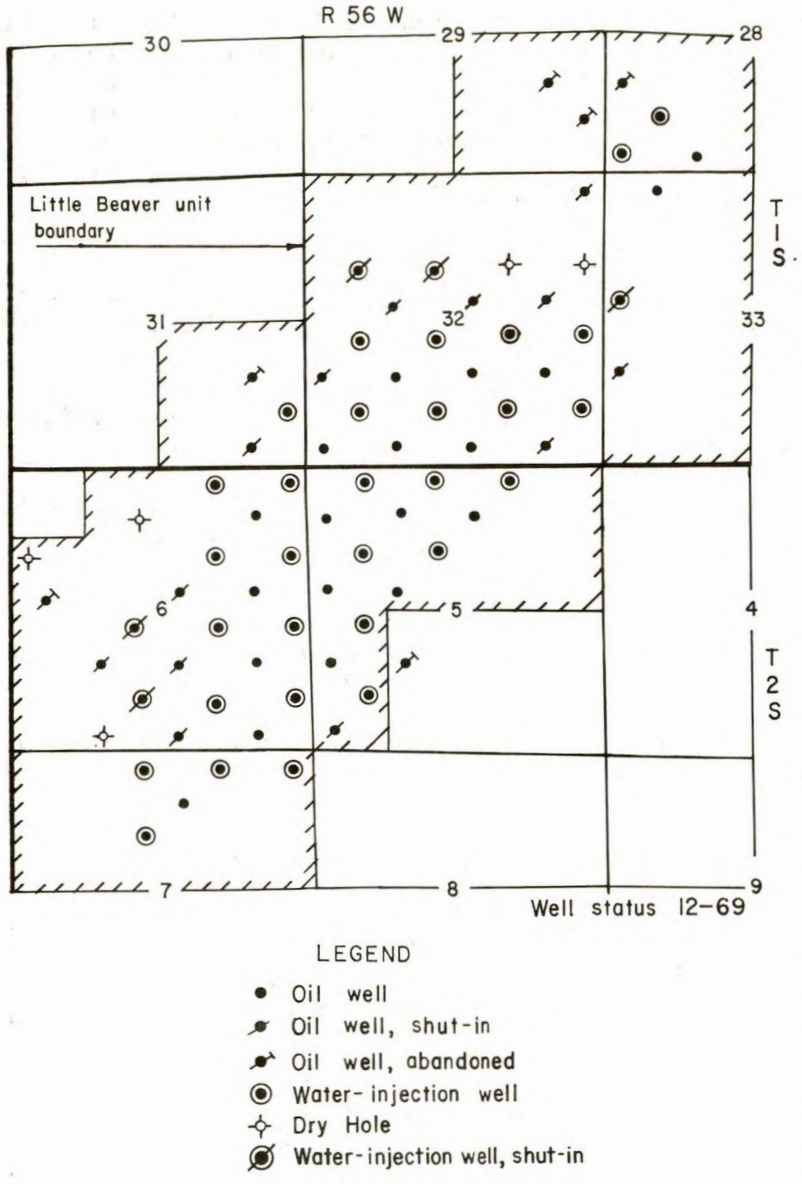


FIGURE 10. - Portion of Little Beaver field.

Cumulative production at the start of injection was 740,000 barrels or 14.8 percent of the original oil in place. On January 1, 1973, the cumulative production was 931,200 barrels or 18.6 percent of the original oil in place. Since the start of injection, 191,200 barrels of oil was produced, including 188,200 barrels attributed to water injection. The ratio of cumulative injection to cumulative secondary oil production is 17.5 to 1. Available data indicate a technically successful project.

Little Beaver

The Little Beaver field (fig. 10) is in Tps 1 and 2 S, R 57 W, Adams County, and Tps 1 and 2 S, R 56 W, Washington County. In May 1951, Oren Tucker, et al, completed the No. 1 Hough, NE¼NE¼ sec 1, T 2 S, R 57 W, Adams County, for a flow of 10.5 million cubic feet of gas daily from the J sand at 5,191 to 5,196 and 5,264 to 5,272 feet. Oil was discovered in the D sand in the Hubbard No. 1 well, SE¼SW¼NW¼ sec 6, Washington County, during May 1952. Initial daily production flowing was 130 barrels from the D sand at 5,252 to 5,258 feet. The D sand wells are located in the southeast portion of the field, and the J sand wells, in the northwest portion of the field. The ranges of daily oil production were from 28 to 983 barrels for the D sand wells, and 35 to 2,760 barrels for the J sand wells.

Areal extent of the D sand reservoir is 1,900 acres, and the average thickness is 14 feet. Initial reservoir-producing mechanism was a solution gas drive.

The Continental Oil Co.'s D sand unit agreement was approved by the State on August 20, 1957. Only one well in the SW¼ sec 5 was not included in the unit.

Water injection was started in 27 wells on October 16, 1958, using a five-spot injection pattern. The Vaughey and Vaughey pipeline system furnishes the injection water.

During December 1972, there were 15 producing wells and 22 injection wells. Daily average production was 181 barrels of oil and 7,700 barrels of water. The daily average injection was 7,700 barrels at pressures from 5 to 775 psig. The cumulative water injection to January 1, 1973, was 62,426,000 barrels.

Annual and cumulative water injection and annual oil production for Little Beaver field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958-59	-	10,958	-
1960	5,186	16,144	1,356
1961	4,651	20,795	759
1962	4,343	25,138	449
1963	4,227	29,365	344
1964	3,574	32,939	275
1965	3,445	36,384	221
1966	4,275	40,659	192
1967	4,646	45,305	173
1968	3,550	48,855	133
1969	3,834	52,689	116
1970	3,685	56,374	108
1971	3,318	59,692	95
1972	2,734	62,426	72

Cumulative oil production from the unit area at the start of injection was 8,057,000 barrels or 22 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 12,663,800 barrels or 34.6 percent of the original oil in place. Since the start of injection, 4,606,800 barrels of oil has been produced, including 3,263,800 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 19.1 to 1. Available data indicate a technically successful project.

Little Beaver-East

The Little Beaver-East field is in Tps 1 and 2 S, R 56 W, Washington County. Oil was discovered in November 1954, when Vaughey and Vaughey completed the No. 1 Downing well, NE¼NE¼ sec 34, T 1 S, R 56 W. Initial daily

production was 148 barrels of oil from the D sand at 5,060 to 5,066 feet. Most of the development drilling occurred during 1955, and the field was defined by the end of 1956. Continental Oil Co. discovered oil in the J sand at the No. 1 G. C. Adkins well, SW¼SW¼ sec 26, T 1 S, R 56 W, on January 22, 1955. Initial daily production was 75 barrels of oil and 90 barrels of water from the interval 5,150 to 5,155 feet. Only two wells have produced oil from the J sand. Range of daily production of the D sand wells was from 10 to 460 barrels.

Areal extent of the D sand reservoir is 1,160 acres, and the average thickness is 8 feet. Initial reservoir-producing mechanism was a solution gas drive.

The Monsanto Chemical Co.'s unit agreement for the D sand water injection was approved by the State on March 18, 1958.

Water injection was started on September 19, 1958, at the west side of the field in two wells. Produced water and water purchased from the Vaughey and Vaughey pipeline system are used for injection.

During December 1972, there were three producing wells and two injection wells. Daily average production was 8 barrels of oil and 824 barrels of water. The daily average injection was 824 barrels at a pressure of 85 psig. Cumulative water injection to January 1, 1973, was 14,225,100 barrels.

Annual and cumulative water injection and annual oil production for Little Beaver-East field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958	-	1,565	-
1959	1,086	2,651	255
1960	1,290	3,941	354
1961	1,294	5,235	417
1962	1,176	6,411	302
1963	1,081	7,492	212
1964	1,300	8,792	114
1965	976	9,768	79
1966	847	10,615	64
1967	973	11,588	50
1968	787	12,375	39
1969	670	13,045	31
1970	464	13,509	20
1971	361	13,870	13
1972	356	14,226	14

Cumulative oil production at the start of injection was 1,506,500 barrels or 16.2 percent of the original oil in place. On January 1, 1973, the cumulative production was 3,534,900 barrels or 38.2 percent of the original oil in

place. Since the start of injection, 2,028,400 barrels of oil has been produced, of which 1,220,900 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 11.7 to 1. Available data indicate a technically successful project.

Luft

The Luft field is in T 8 N, R 53 W, Logan County, about 8 miles northwest of Sterling, Colo. In April 1952, Plains Exploration Co. completed its No. 1 Luft well, NE¼SW¼ sec 17, for an initial daily oil production of 305 barrels from the D sand at 4,844 to 4,846 feet. Most of the development drilling occurred during 1952, 1953, and 1955. Range of initial daily production for the wells was from 5 to 677 barrels.

Texas Co.'s well No. 1 C. Luft, Jr., NE¼ sec 8, was completed in the J sand in 1954. Initial daily production was 40 barrels of oil and 55 barrels of water. A second J sand well was completed in 1955. The two wells produced a total of 225,642 barrels of oil before abandonment in 1969.

Areal extent of the reservoir is 720 acres, and the average thickness is 10 feet. The oil-producing mechanisms were a solution gas expansion and a water drive.

Shell Oil Co.'s unit agreement was approved by the State on July 22, 1958.

Water injection was started on January 23, 1959, in 13 wells on a peripheral pattern. The water source was a shallow sand well in the NW¼NW¼ sec 20, completed from intervals between 200 and 600 feet. Final injection was in February 1967 after a cumulative injection of 10,710,300 barrels. The one producing well in the field in December 1972 averaged daily 5 barrels of oil and 10 barrels of water.

Annual and cumulative water injection and annual oil production for Luft field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953	-	-	567
1954	-	-	367
1955	-	-	278
1956	-	-	200
1957	-	-	132
1958	-	-	76
1959	1,358	1,358	60
1960	2,028	3,386	188
1961	1,846	5,232	320
1962	1,649	6,881	128
1963	1,465	8,346	64
1964	1,431	9,777	43
1965	717	10,494	19
1966	206	10,700	7
1967	10	10,710	1
1968	-	10,710	Plugged and abandoned

Cumulative oil production at the start of injection was 821,000 barrels or 14.9 percent of the original oil in place. On January 1, 1973, the cumulative production was 2,484,400 barrels or 45.1 percent of the original oil in place. Since the start of injection, 1,663,400 barrels of oil was produced, and 930,000 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 11.5 to 1. Available data indicate the project was technically successful.

Luster

The Luster field is in secs 27 and 34, T 1 N, R 55 W, Morgan County. In August 1958, J. L. Cramer completed its No. 1 Evans well, SW¼SE¼ sec 27, for an initial daily production of 70 barrels flowing from the J sand at 4,893 to 4,895 feet. Development drilling was completed by the end of 1959. Range of initial daily production for the wells was from 20 to 403 barrels.

Areal extent of the reservoir is 360 acres, and the average thickness is 11.3 feet. Initial producing mechanism was a solution gas drive.

The Cramer Co., Ltd., unit agreement was approved by the State on August 9, 1960.

Water injection was started on October 28, 1960, on the southwest side of the field on a line-drive pattern. The water was purchased from the Vaughey and Vaughey pipeline system. Injection was stopped in October 1969 after a cumulative injection of 1,528,700 barrels.

Annual and cumulative water injection and annual oil production for Luster field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958	-	-	99
1959	-	-	147
1960	72	72	68
1961	395	467	93
1962	376	843	84
1963	214	1,057	68
1964	224	1,281	79
1965	103	1,384	31
1966	88	1,472	44
1967	24	1,496	48
1968	21	1,517	26
1969	12	1,529	14
1970	-	1,529	8
1971	-	1,529	3
1972	-	1,529	Plugged and abandoned

Cumulative oil production at the start of injection was 620,000 barrels or 23.3 percent of the original oil in place. Cumulative production to January 1, 1973, was 810,200 barrels or 30.4 percent of the original oil in place. Since the start of injection, 190,200 barrels of oil was produced, including 179,000 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 9 to 1. The field was abandoned during 1972. Although the response to water injection was not as large as anticipated, available data indicate a technically successful project.

Masters

The Masters field is in T 5 N, R 60 W, Morgan County, and T 5 N, R 61 W, Weld County. In August 1953, Harry Royster completed his No. 1 Porter well, NE¼NW¼ sec 25, T 5 N, R 61 W, Weld County, for an initial daily oil production of 160 barrels from the D sand at 6,452 to 6,476 feet. Development drilling was completed by the end of 1955. The range of initial daily production for the wells was from 50 to 318 barrels.

Areal extent of the reservoir is 360 acres, and the average thickness is 20.7 feet. The oil initially was produced by solution gas expansion.

The Frank H. Walsh unit agreement was approved by the State on October 18, 1960.

Water injection was started on December 20, 1960, in the No. 1 Furrows, NW¼NW¼ sec 30, T 5 N, R 60 W, Morgan County. The water source was a shallow well 1½ miles south of the field. Final injection was on August 15, 1963, after a cumulative injection of 1,421,900 barrels.

Annual and cumulative water injection and annual oil production for the Masters field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953	-	-	14
1954	-	-	150
1955	-	-	50
1956	-	-	25
1957	-	-	28
1958	-	-	20
1959	-	-	12
1960	12	12	10
1961	639	651	11
1962	532	1,183	7
1963	239	1,422	3
1964	-	1,422	Plugged and abandoned

Cumulative oil production at the start of injection was 333,400 barrels or 8.2 percent of the original oil in place. When the field was abandoned on June 2, 1964, the cumulative production was 354,300 barrels. Since the start of injection, 20,900 barrels of oil was produced, of which 19,300 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production was 73.7 to 1. Although some secondary oil was recovered, the project was considered unsuccessful.

McCallum-North

The McCallum-North field (fig. 11) is in Tps 9 and 10 N, Rs 78 and 79 W, Jackson County, about 4 miles northeast of Walden, Colo. In December 1926, the Sherman A-1 well, NW¼NW¼ sec 12, T 9 N, R 79 W, was completed for an initial daily production flowing of 500 barrels of 49° API condensate and 30 million cubic feet of gas containing 80 percent carbon dioxide from the Dakota sand. The well was produced intermittently, and the condensate was used for fuel in drilling operations in the North Park area. A development drilling program from 1942 to 1945 resulted in nine condensate-producing wells in the Dakota-Lakota zone. During 1952, Continental Oil Co. completed its No. A-6 Pollock as the Morrison discovery. Initial daily production was 224 barrels of condensate and 10.8 million cubic feet of 80 percent carbon dioxide gas from the interval 5,376 to 5,530 feet. Two additional Morrison wells were completed in 1955 and 1956, and in 1957 oil was discovered in the Muddy Formation in the No. 1-B Sherman well, NW¼SE¼ sec 13, T 9 N, R 79 W. Initial daily production from the well was 47 barrels of oil from the interval 6,184 to 6,214 feet. Further drilling did not occur until November 1960, when Continental Oil Co. completed the unit No. 22 well in what is now called the McCallum Unit Lakota oil ring. Initial daily production from the well was 103 barrels of oil and 63 barrels of water from the interval 6,132 to 6,170 feet. By the end of 1962, nine additional producers were drilled in the oil ring.

Areal extent of the Dakota Lakota reservoir is about 940 acres, and the average thickness is 30 feet. Initial drive mechanism was a gas cap expansion.

A Federal unit was approved on December 29, 1952, by the U.S. Geological Survey. Continental Oil Co. is the operator.

In May 1945, a gas cycling pressure maintenance program was started. Gas injection continued for 10 years and was stopped during 1955 because of economic factors.

A "water disposal" project was started September 20, 1964, in the Dakota-Lakota zone. Only one well has been used as an injection well.

North McCallum is unusual in the high carbon dioxide content of the natural gas. How to best produce the field and what to do with the carbon dioxide were problems. Recovery and cleaning the carbon dioxide proved to be expensive. Although the water injection is called "water disposal" additional oil has been recovered.

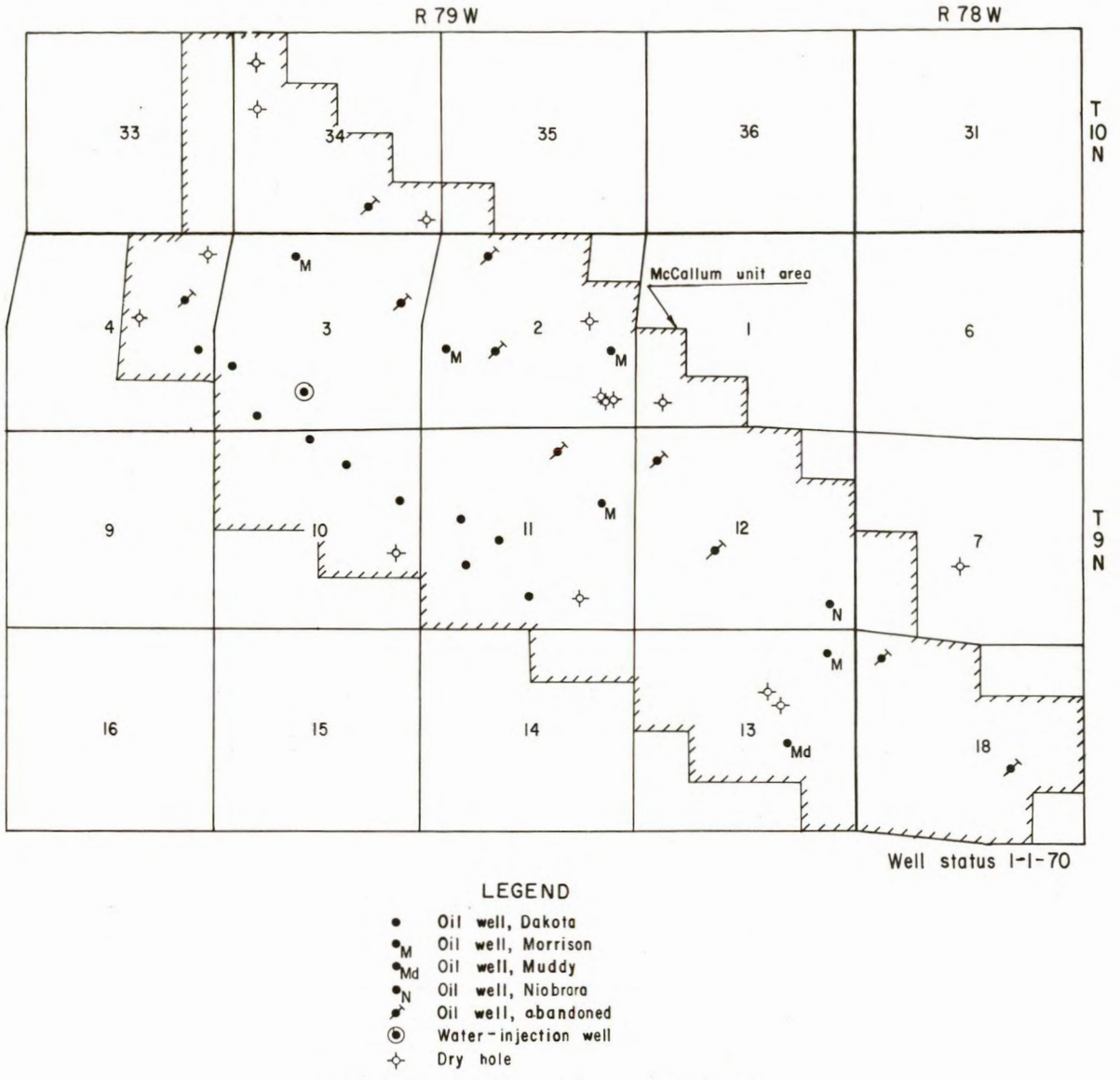


FIGURE 11. - McCallum-North field.

During December 1972, nine producing wells and one injection well were operative. Daily average production was 210 barrels of oil and 71 barrels of water. The daily average injection was 87 barrels at atmospheric pressure. Cumulative water injection to January 1, 1973, was 821,200 barrels.

Annual and cumulative water injection and annual oil production for McCallum-North field, Dakota-Lakota unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1959	-	-	164
1960	-	-	120
1961	-	-	98
1962	-	-	219
1963	-	-	213
1964	37	37	166
1965	140	177	150
1966	151	328	131
1967	142	470	110
1968	127	597	99
1969	140	737	100
1970	33	770	97
1971	18	788	89
1972	34	822	73

Cumulative oil production at the start of injection was 3,205,800 barrels or 17.9 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 4,101,200 barrels or 22.9 percent of the original oil in place. Since the start of injection, an estimated 895,400 barrels of oil was produced, and 170,000 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 2.5 to 1. Available data indicate a technically successful project.

Middlemist

The Middlemist field is in T 2 S, R 57 W, Adams County. In May 1952, Roden, Darden, and McCrae completed their No. 1 Middlemist, NE¼SW¼ sec 20, for an initial daily production of 92 barrels of oil from the J sand at 5,516 to 5,520 feet. Development drilling occurred from 1952 through 1957 and again during the 1960's when wells were drilled along the east side of the field. Range of initial daily production for the wells was from 4 to 288 barrels.

Areal extent of the reservoir is 760 acres, and the average thickness is 14 feet. Initially oil was produced by solution gas expansion.

The Midwest Oil Corp.'s unit agreement was approved by the State on October 15, 1963.

Water injection was started on February 3, 1964, in three wells on the west side of the field. The water source well, NE¼SW¼ sec 20, is completed in the J sand.

During December 1972, four producing wells and four injection wells were active. Daily average production was 25 barrels of oil and 474 barrels of water. The daily average injection was 1,162 barrels of water. Cumulative water injection to January 1, 1973, was 5,879,400 barrels.

Annual and cumulative water injection and annual oil production in Middlemist field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1952	-	-	72
1953	-	-	128
1954	-	-	149
1955	-	-	173
1956	-	-	202
1957	-	-	216
1958	-	-	195
1959	-	-	152
1960	-	-	101
1961	-	-	82
1962	-	-	70
1963	-	-	74
1964	230	230	61
1965	519	749	49
1966	661	1,410	46
1967	749	2,159	52
1968	804	2,963	88
1969	872	3,835	66
1970	737	4,572	44
1971	726	5,298	29
1972	581	5,879	26

The cumulative oil production at the start of injection was 1,598,000 barrels or 20.7 percent of the original oil in place. On January 1, 1973, the cumulative production was 2,076,000 barrels or 26.9 percent of the original oil in place. Since the start of injection, 478,000 barrels of oil has been produced, including 210,200 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 27.9 to 1. Available data indicate a technically successful project.

Minto

The Minto field is in T 8 N, Rs 52 and 53 W, Logan County, about 8 miles northwest of Sterling, Colo. In December 1953, Sunray Oil Corp. completed its No. 1 Knudsen, NE¼NW¼ sec 6, T 8 N, R 52 W, for an initial daily production flowing of 207 barrels of oil from the J sand at 4,822 to 4,834 feet. One development well was drilled in 1954, and the rest, in the 1960's. Range of initial daily production for the wells was from 15 to 226 barrels.

Areal extent of the reservoir is 250 acres, and the average thickness is 15.4 feet. Initial producing mechanisms were a combination solution gas drive and a limited water drive.

The State approved Sunray Oil Corp.'s water injection program on June 18, 1963.

Water injection was started in one well on the west side of the field on October 10, 1963. The water source is a well completed in sand at a depth of 100 feet.

During December 1972, two producing wells and one injection well were operative. Daily average production for the month was 92 barrels of oil and 6,885 barrels of water. The daily average injection of water was 1,410 barrels at atmospheric pressure. The cumulative injection to January 1, 1973, was 4,318,600 barrels.

Annual and cumulative water injection and annual oil production in Minto field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953	-	-	2
1954	-	-	62
1955	-	-	58
1956	-	-	47
1957	-	-	56
1958	-	-	39
1959	-	-	44
1960	-	-	69
1961	-	-	78
1962	-	-	255
1963	114	114	196
1964	419	533	191
1965	374	907	162
1966	273	1,180	146
1967	794	1,974	176
1968	801	2,775	140
1969	240	3,015	69
1970	394	3,409	52
1971	420	3,829	41
1972	489	4,318	35

The cumulative oil production at the start of injection was 951,700 barrels or 24 percent of the original oil in place. On January 1, 1973, the cumulative production was 2,007,100 barrels or 50.6 percent of the original oil in place. Since the start of injection, 1,055,400 barrels of oil has been produced, of which 422,400 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 10.2 to 1. Available data indicate a technically successful project.

Moccasin

The Moccasin field is in sec 35, T 1 S, R 57 W, and sec 2, T 2 S, R 57 W, Adams County. Oil was discovered in November 1964, when Cardinal Petroleum Co. and Al Ward and Son's No. 1 R. M. Hough well, SE¼NW¼ sec 2, was completed flowing 274 barrels of oil daily from the J sand at 5,440 to 5,452 feet. Development drilling occurred from 1964 to 1966 and resulted in 10 producing wells. Initial range of daily production for the wells was from 60 to 274 barrels.

Areal extent of the reservoir is 380 acres, and the average thickness is 10 feet. Initial reservoir-producing mechanism was a solution gas drive.

Cardinal Petroleum Co.'s unit agreement for a water injection was approved by the State on September 19, 1967.

Water injection was started on December 2, 1967, in four wells on a peripheral pattern. Water source is Vaughey and Vaughey's pipeline system.

During December 1972, two producing wells and four injection wells were operated in the unit. Daily average production was 158 barrels of oil and 386 barrels of water. Daily average injection was 394 barrels. Cumulative water injection to January 1, 1973, was 2,071,700 barrels.

Annual and cumulative water injection and annual oil production in Moccasin field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1964	-	-	10
1965	-	-	247
1966	-	-	107
1967	54	54	61
1968	695	749	46
1969	609	1,358	109
1970	290	1,648	139
1971	236	1,884	91
1972	187	2,071	77

Cumulative oil production at the start of injection was 419,400 barrels or 14.5 percent of the original oil in place. On January 1, 1973, the cumulative production was 887,500 barrels or 30.7 percent of the original oil in place. Since the start of injection, 460,100 barrels of oil has been produced, and 353,600 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 5.9 to 1. Available data indicate a technically successful project.

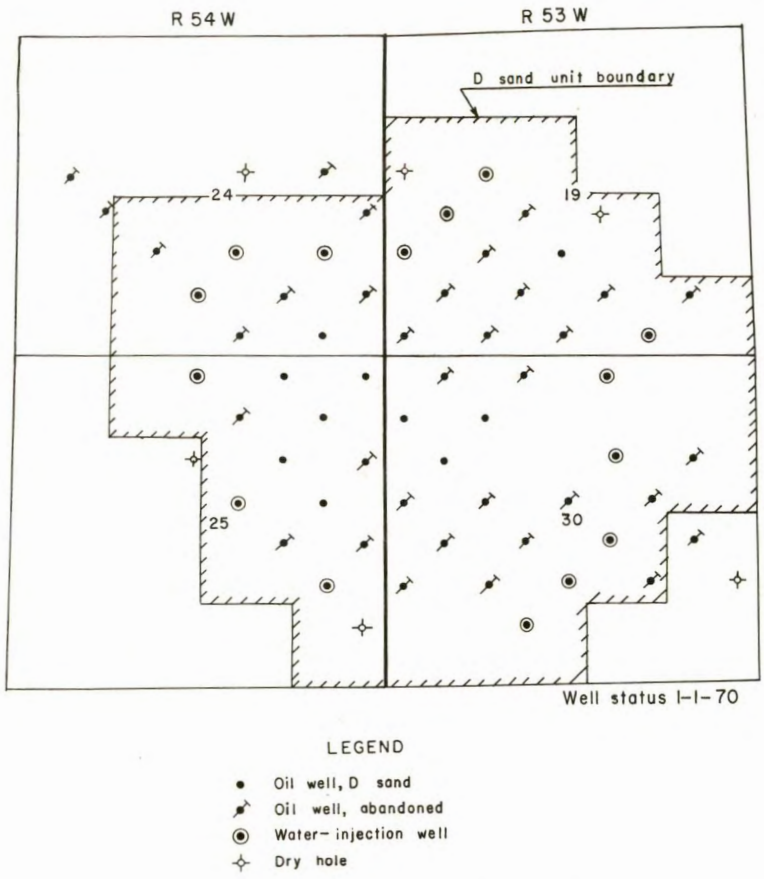


FIGURE 12. - Mount Hope field.

Mount Hope

The Mount Hope field (fig. 12) is in T 9 N, Rs 53 and 54 W, Logan County, about 11 miles northwest of Sterling, Colo. In November 1950, Shell Oil Co. completed its No. 1 Green, NW¼NW¼ sec 30, T 9 N, R 53 W, for an initial daily oil production flowing of 500 barrels from the D sand at 4,866 to 4,885 feet. Most of the development drilling occurred during 1951, 1952, and 1953. The range of initial daily production for the wells was from 35 to 711 barrels. The second well drilled in the field was completed as a J sand gas well, and J sand oil was produced starting in 1952.

Areal extent of the reservoir is 940 acres, and the average thickness is 14 feet. The reservoir has a gas cap located in the N½ sec 30, and in the SE¼ sec 19, T 9 N, R 53 W. The initial producing mechanisms are a solution gas drive, gas cap expansion, and a water drive.

The Shell Oil Co. unit agreement for a water injection project was approved by the State on December 19, 1961.

Water injection started on March 15, 1963, in 11 wells on a peripheral pattern. The injection water is obtained from five wells completed in alluvial sands and gravels at a depth of 600 feet.

During December 1972, there were 7 producing wells and 15 injection wells. Average daily production was 158 barrels of oil and 6,885 barrels of water. The daily average injection was 6,885 barrels at pressures from 640 to 850 psig. Cumulative water injection to January 1, 1973, was 32,088,900 barrels.

Annual and cumulative water injection and annual oil production in Mount Hope field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953	-	-	1,069
1954	-	-	678
1955	-	-	510
1956	-	-	413
1957	-	-	278
1958	-	-	174
1959	-	-	197
1960	-	-	208
1961	-	-	185
1962	-	-	155
1963	2,561	2,561	112
1964	3,201	5,762	181
1965	4,161	9,923	368
1966	4,050	13,973	311
1967	3,154	17,127	215
1968	2,648	19,775	115
1969	2,994	22,769	141
1970	3,248	26,017	116
1971	2,731	28,748	83
1972	3,341	32,089	63

Cumulative oil production at the start of injection was 2,212,000 barrels or 16.8 percent of the original oil in place. On January 1, 1973, the cumulative production was 6,506,100 barrels or 49.4 percent of the original oil in place. Since the start of injection, 4,294,100 barrels of oil has been produced, and 1,121,700 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 28.6 to 1. Available data indicate a technically successful project.

Nugget

The Nugget field is in T 1 S, R 56 W, Washington County. The No. 1 Barnes well, NE¼SW¼ sec 20, was completed in February 1959. Later the No. 3 Newton well, SW¼NW¼ sec 29, completed in June 1955, was moved from Little Beaver to Nugget field. Initial daily oil production for the No. 3 Newton was 160 barrels of oil and 84 barrels of water from the D sand at 5,287 to 5,295 feet. Development drilling did not start until 1959 and was completed by 1960. Range of initial daily oil production was from 45 to 500 barrels.

Areal extent of the reservoir is 730 acres, and the average thickness is 13.5 feet. Oil was produced initially by solution gas expansion.

The Monsanto Chemical Co.'s unit agreement for a water injection project was approved by the State on January 24, 1961.

Water injection started on April 14, 1961, in two wells on the west side of the field. The two water sources are the Vaughey and Vaughey pipeline system and produced water.

During December 1972, five producing wells and two injection wells were operative in the unit. Daily average production was 45 barrels of oil and 761 barrels of water. The daily average water injection was 873 barrels at 850 psig pressure. Cumulative water injection to January 1, 1973, was 9,617,000 barrels.

Annual and cumulative water injection and annual oil production in Nugget field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958	-	-	242
1959	-	-	467
1960	-	-	363
1961	1,396	1,396	232
1962	1,223	2,619	115
1963	1,334	3,953	120
1964	1,434	5,387	130
1965	921	6,308	142
1966	684	6,992	101
1967	631	7,623	59
1968	533	8,156	41
1969	369	8,525	25
1970	354	8,879	20
1971	380	9,259	17
1972	358	9,617	16

Cumulative oil produced to the start of injection was 1,148,000 barrels or 13.7 percent of the original oil in place. On January 1, 1973, the cumulative oil production was 2,090,200 barrels or 24.9 percent of the original oil in place. Since the start of injection, 942,200 barrels of oil has been produced, including 593,000 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 24.4 to 1. Available data indicate a technically successful project.

Orchard

The Orchard field is in T 4 N, R 60 W, Morgan County, about 15 miles northwest of Fort Morgan, Colo. Oil was discovered by F. Landauer and C. E. Nation on April 8, 1956, in their No. 1-A Rocchio well, NW¼NE¼ sec 9. Initial daily production was 60 barrels of oil and 50 barrels of water from the J sand at 6,297 to 6,303 feet. On April 9, 1956, Diversified Industries Corp. completed its No. 1 Buttons well, NW¼NW¼ sec 10, as the D sand discovery. Initial production flowing was 42 barrels of oil per hour from the interval 6,187

to 6,199 feet. Most of the development drilling occurred during 1956, but two wells were completed in 1958. Production from the J sand was limited to the 1-A Rocchio well, and it was abandoned in 1960. Range of initial daily average production for the D sand wells was from 30 to 600 barrels. Because of different land and mineral ownership, two units were formed.

Orchard-East Unit

Areal extent of the unit reservoir is 360 acres, and the average thickness is 6.1 feet. Oil accumulation is in a stratigraphic trap. The initial producing mechanism was a solution gas expansion.

The East unit in secs 2 and 3, of Producers Gas Equities, Inc., was approved by the State on September 21, 1965.

Water injection was started on June 15, 1966, and was stopped in December 1968, after a cumulative injection of 628,000 barrels.

Annual and cumulative water injection and annual oil production in Orchard field, D sand East unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	17
1961	-	-	13
1962	-	-	8
1963	-	-	8
1964	-	-	9
1965	-	-	6
1966	159	159	4
1967	274	433	5
1968	195	628	1

Water injection resulted in only 7,000 barrels of secondary oil. The ratio of cumulative water injection to cumulative secondary oil production is 88.7 to 1. Available data indicate the project was unsuccessful.

Orchard-West Unit

Areal extent of the unit reservoir is 200 acres, and the average thickness is 6.1 feet. Oil accumulation is in a stratigraphic trap. The initial producing mechanism was a solution gas expansion.

The unit agreement of Producers Gas Equities, Inc., was approved by the State on September 21, 1965. Initially the unit contained one producing well and one injection well.

Water injection was started on June 3, 1966, and was stopped in February 1968 after the injection of 259,600 barrels.

Annual and cumulative water injection and annual oil production in Orchard field, D sand West unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	2
1961	-	-	1
1962	-	-	2
1963	-	-	1
1964	-	-	½
1965	-	-	½
1966	91	91	½
1967	149	240	½
1968	19	259	-

No secondary oil was recovered by the water injection, and the project was unsuccessful.

Phegley

The Phegley field is in T 1 S, Rs 55 and 56 W, Washington County. In June 1955, Dawson and Cramer completed their No. 1 Morgan, SE¼SE¼ sec 30, T 1 S, R 55 W, for an initial daily production of 134 barrels of oil from the D sand at 4,850 to 4,861 feet. Development drilling resulted in 16 producing wells, and most of the wells were drilled during 1955 and 1956. Range of initial daily production for the wells was from 1 to 140 barrels.

Areal extent of the reservoir is 1,060 acres, and the average thickness is 7 feet. The oil was originally produced by a solution gas drive.

The Champlin Petroleum Co.'s unit agreement was approved by the State on April 30, 1959.

Water injection was started on October 8, 1959, in 10 wells on a five-spot pattern. The injection water was purchased from the Vaughey and Vaughey pipeline system.

During December 1972, there was one producing well. Water injection stopped in January 1972. Daily average oil production was 5 barrels in December 1972. The cumulative water injection to January 31, 1972, was 11,878,400 barrels.

Annual and cumulative water injection and annual oil production in Phegley field, D sand unit, are listed:

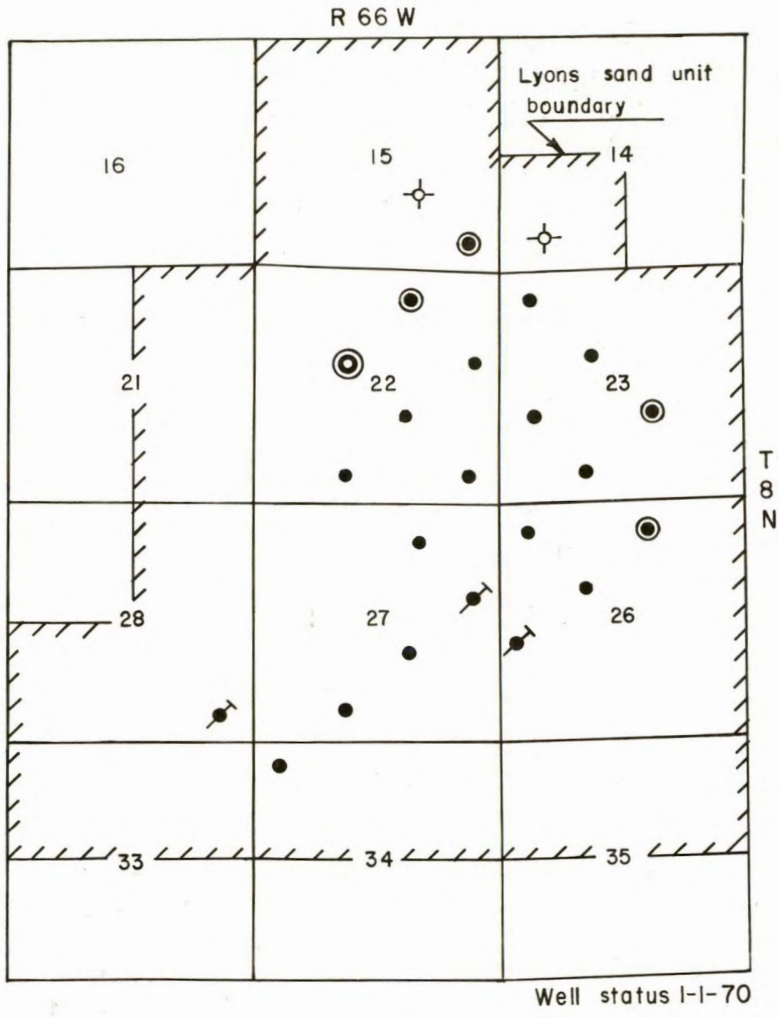
Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1955	-	-	78
1956	-	-	222
1957	-	-	175
1958	-	-	174
1959	217	217	117
1960	1,237	1,454	541
1961	1,204	2,658	453
1962	1,217	3,875	168
1963	1,236	5,111	110
1964	799	5,910	68
1965	-	5,910	64
1966	-	5,910	126
1967	-	5,910	78
1968	777	[1]9,320	42
1969	898	10,218	39
1970	827	11,045	29
1971	792	11,837	21
1972	42	11,879	-

[1]Adjusted cumulative in Colorado Oil and Gas Statistics 1968.

Cumulative oil production at the start of injection was 701,000 barrels or 12.3 percent of the original oil in place. On January 1, 1973, the cumulative production was 2,508,600 barrels or 44 percent of the original oil in place. Since the start of injection, production totaled 1,807,600 barrels of oil, including 1,267,200 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 9.4 to 1. Available data indicate a technically successful project.

Pierce

The Pierce field (fig. 13) is in T 8 N, R 66 W, Weld County, about 15 miles east of Fort Collins, Colo. In July 1955, Chevron Oil Co. completed its No. 1 Priddy well, NW¼SW¼ sec 23, for an initial daily production of 317 barrels from the Lyons sand of Permian age at 9,201 to 9,210 feet. This was the second field in the Denver-Julesburg basin to produce from a pre-Cretaceous formation; the first was the Black Hollow field. Development drilling occurred primarily in 1956 and 1957, but two wells were drilled in 1958. Range of initial daily production from the wells was from 10 to 385 barrels.



LEGEND

- Oil well, Lyons sand
- Oil well, abandoned
- Water injection well
- Water disposal well
- Dry hole

FIGURE 13. - Pierce field.

Areal extent of the reservoir is 5,120 acres, and the average thickness is 27 feet. The oil accumulation is in a structural trap. Initial producing mechanisms were a solution gas drive and a partial water drive.

The Chevron Oil Co.'s unit agreement was approved by the State on May 17, 1966.

Water injection was started in one well on June 28, 1966. The water supply includes both produced water and freshwater from two wells completed in a sand at a depth of 50 feet.

During December 1972, there were seven producing wells and six injection wells. Daily average production for the month was 1,103 barrels of oil and 100 barrels of water. The daily average injection was 5,930 barrels at pressures from 625 to 2,300 psig. The cumulative water injection to January 1, 1973, was 11,144,100 barrels.

Annual and cumulative water injection and annual oil production for Pierce field, Lyons sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1955	-	-	30
1956	-	-	163
1957	-	-	743
1958	-	-	830
1959	-	-	751
1960	-	-	708
1961	-	-	660
1962	-	-	557
1963	-	-	472
1964	-	-	426
1965	-	-	331
1966	357	357	267
1967	1,215	1,572	263
1968	1,951	3,523	289
1969	2,159	5,682	244
1970	1,823	7,505	247
1971	1,796	9,301	478
1972	1,842	11,143	384

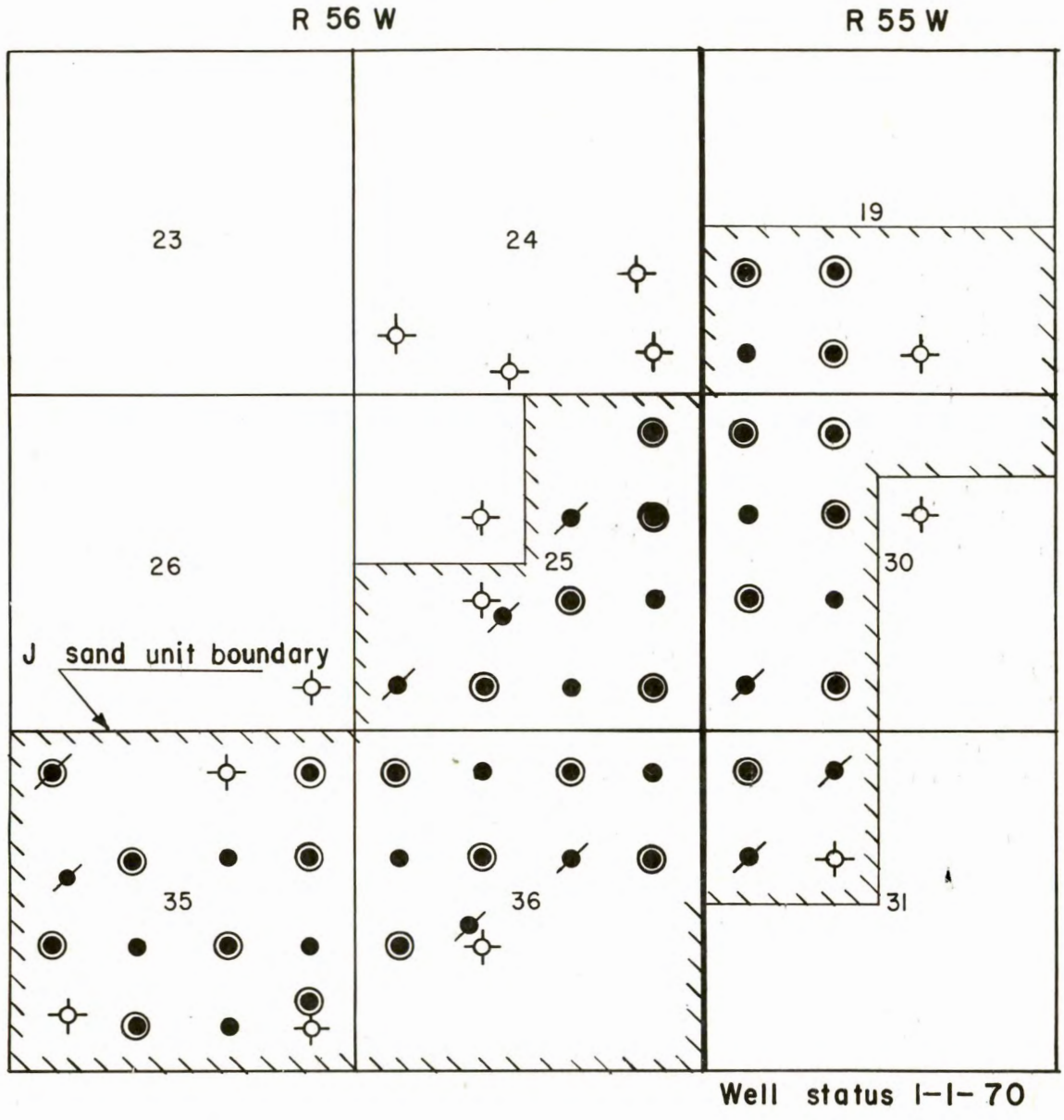
Cumulative oil production at the start of injection was 5,801,100 barrels or 16.8 percent of the original oil in place. On January 1, 1973, the cumulative production was 7,842,300 barrels or 22.7 percent of the original oil in place. Since the start of injection, 2,041,200 barrels of oil was produced, including 1,302,300 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 12.3 to 1. Available data indicate a technically successful project.

Plum Bush Creek

The Plum Bush Creek field (fig. 14) is in T 2 S, Rs 55 and 56 W, Washington County. In December 1954, Kimbark Co., Ltd., and Sterling Drilling Co. completed their No. 1 Porter well, SW¼SW¼ sec 30, T 2 S, R 55 W, for an initial daily oil production of 120 barrels from the J sand at 4,984 to 4,987 feet. Most of the development drilling occurred between 1954 and 1957, but four additional producing wells were drilled during 1962 and 1963. Oil production is from three benches (sand stringers) in the J sand. The first bench is productive throughout the field, the second bench is productive in the southeast portion, and the third bench is productive in the northeast portion. The range of daily production of the wells was from 28 to 1,015 barrels.

Areal extent of the reservoir is 1,870 acres, and the average thickness is 19.8 feet. Oil initially was produced by fluid expansion.

The Continental Oil Co.'s waterflood unit agreement was approved by the State on July 22, 1958.



LEGEND

- Oil well, J sand
- Water injection well
- Dry hole
- Oil well, shut-in
- Water injection well, shut-in

FIGURE 14. - Plum Bush Creek field.

Water injection started on June 15, 1959, in 20 wells on a five-spot pattern. The injection water is purchased from the Vaughey and Vaughey pipeline system.

During December 1972, there were 11 producing wells and 24 injection wells. Daily average production for the month was 392 barrels of oil and 13,344 barrels of water. The daily average injection was 15,185 barrels at pressures from 325 to 1,467 psig. The cumulative injection to January 1, 1973, was 71,971,800 barrels.

Annual and cumulative water injection and annual oil production for Plum Bush Creek field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil injection, thousand bbl
1954	-	-	2
1955	-	-	770
1956	-	-	1,227
1957	-	-	1,134
1958	-	-	1,127
1959	2,237	2,237	724
1960	3,976	6,213	1,164
1961	3,995	10,208	2,988
1962	5,239	15,447	2,789
1963	5,593	21,040	1,780
1964	5,445	26,485	1,145
1965	5,285	31,770	759
1966	5,303	37,073	645
1967	6,978	44,051	539
1968	5,349	49,400	389
1969	5,442	54,842	293
1970	5,752	60,594	219
1971	5,798	66,392	172
1972	5,579	71,971	149

Cumulative production at the start of injection was 4,712,000 barrels or 12.1 percent of the original oil in place. On January 1, 1973, the cumulative production was 18,014,200 barrels or 46.3 percent of the original oil in place. Since the start of injection, 13,302,200 barrels of oil was produced and 6,314,200 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 11.5 to 1. Available data indicate a technically successful project.

Powder Wash

The Powder Wash field is in Tps 11 and 12 N, R 97 W, Moffat County, about 4 miles from the Colorado-Wyoming border. In April 1931, Mountain Fuel Supply Co. completed the No. 1 Musser, NW¼NE¼ sec 5, T 11 N, R 97 W. Initial daily

production was 34,188,000 cubic feet of gas from the Wasatch Formation at 2,152 to 2,182 feet. The well was shut in after running production tests. Development drilling began in the late 1940's and continued into the 1960's. Oil was found in the Fort Union Formation on completion of the No. 5 J. C. Donnell well, NE¼NW¼ sec 29, T 12 N, R 97 W, in August 1949, by Mountain Fuel Supply Co. Initial daily production from the well was 10 barrels of oil and 917,000 cubic feet of gas. Both oil and gas are produced from the Wasatch Formation.

The Wasatch zone is over 1,000 feet thick here. Numerous oil, gas, or water sands occur in the zone. Horizontal or lateral extent of these sands is difficult to determine.

Areal extent of the project area is 200 acres and has an average thickness of 23 feet. The oil reservoir being flooded is called the "A-4H" sand of the Wasatch Formation.

Mountain Fuel Supply Co.'s pilot water injection project in the SW¼ sec 29 and the NW¼ sec 32, T 12 N, R 97 W, was approved by the State on September 19, 1967.

Water injection started on May 29, 1968, in one well in the SW¼SW¼ sec 29. The injection water is obtained from the "A-4G" sand of the Wasatch Formation and was initially treated with a bactericide before injection into the "A-4H" sand. The project area contained four producing wells and three injection wells in December 1972.

During 1972, the daily average production from the four wells was 25 barrels of oil and 106 barrels of water. The daily average water injection was 474 barrels at 3,780 psig. The cumulative injection to January 1, 1973, was 636,400 barrels.

Annual and cumulative water injection and annual oil production for Powder Wash field, "A-4H" sand test area, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1963	-	-	19
1964	-	-	16
1965	-	-	15
1966	-	-	12
1967	-	-	9
1968	46	46	8
1969	103	149	7
1970	181	330	9
1971	150	480	43
1972	156	636	9

The cumulative oil production at the start of injection was 762,200 barrels or 24.3 percent of the original oil in place. On January 1, 1973, the cumulative production was 838,900 barrels or 26.7 percent of the original oil in place. Since the start of injection, 76,700 barrels of oil was produced, and 13,000 barrels was attributed to water injection. The complex reservoir conditions make interpretation of the results of water injection questionable.

Rake

The Rake field is in T 4 N, R 60 W, Morgan County, about 14 miles northwest of Fort Morgan, Colo. Oil was discovered in October 1958 when Tom Vessels, Jr., and Strain Drilling Co. completed their No. 1 Alles well, NW¼NW¼ sec 26. Initial daily production from the well was 114 barrels of oil and 114 barrels of water from the D sand at 6,199 to 6,204 feet. Six additional producing wells were drilled. The range of initial daily production of the wells was from 114 to 312 barrels.

Areal extent of the reservoir is 380 acres, and the average thickness is 7 feet. The initial producing mechanisms were a solution gas drive and a water drive.

The Colorado Oil and Gas Corp.'s water injection project was approved by the State on April 19, 1966.

Water injection started on December 24, 1966, in one well in the NE¼NW¼ sec 26. The injection water was purchased from Mrs. Elizabeth Alles. Injection stopped in November 1969 after a cumulative injection of 1,087,200 barrels.

Annual and cumulative water injection and annual oil production for Rake field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958	-	-	9
1959	-	-	110
1960	-	-	72
1961	-	-	61
1962	-	-	74
1963	-	-	38
1964	-	-	27
1965	-	-	27
1966	3	3	24
1967	397	400	15
1968	444	844	9
1969	243	1,087	10
1970	-	1,087	6
1971	-	1,087	4
1972	-	1,087	Abandoned

Cumulative oil production at the start of injection was 429,800 barrels or 28.5 percent of the original oil in place. On January 1, 1972, the cumulative production was 485,100 barrels or 32.2 percent of the original oil in place. Since the start of injection, 46,500 barrels of oil was produced, including 26,900 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production was 60.1 to 1. Although some secondary oil was produced, the project is considered unsuccessful. The field was abandoned in 1970.

Rangely

The Rangely field (fig. 15) is in Tps 1 and 2 N, Rs 101, 102, and 103 W, Rio Blanco County. Oil was discovered in the Mancos Shale, Upper Cretaceous age, about 1902 near the crest of the structure. In August 1933, Chevron Oil Co. completed the Weber sand discovery well, No. A-1 Raven, NW¼SE¼ sec 30, T 2 N, R 102 W. Initial daily production flowing was 213 barrels of oil from the open hole interval, 5,657 to 6,335 feet. The well was shut in due to the geographic isolation and low price of crude oil. Development drilling began in 1944. More than 480 producing wells were completed in the Weber sand. Oil was found in the Shinarump Formation in 1946 and in the Morrison Formation in 1956. The Weber reservoir is the largest producing reservoir in the State.

Areal extent of the Weber sand reservoir is 20,000 acres, and the average thickness is 150 feet. Initially the oil was produced by a combination of gas cap expansion, solution gas expansion, and limited water drive mechanisms.

Gas injection started in one well on November 26, 1950, and in December a second injection well was added. In November 1952, a dispersed gas injection program was started using 18 producing wells converted to injection wells. After the field was unitized the program was changed to a crestal gas injection program. Gas injection was stopped in April 1969, after a cumulative injection of 401,841,688 cubic feet.

Chevron Oil Co.'s waterflood unit agreement was approved by the State on August 21, 1957.

Water injection started in one well on December 25, 1957, then expanded to 13 injection wells in 1958 and to 34 injection wells in 1959. The water supply was initially from wells completed in the Navajo and Enrada Formations, and later the operator began to use water from the White River. The injection is on a mixed pattern.

During December 1972, there were 318 producing wells and 212 injection wells. Daily average production for the month was 45,500 barrels of oil and 95,800 barrels of water. The daily average injection was 227,000 barrels. Cumulative water injection to January 1, 1973, was 832,256,700 barrels.

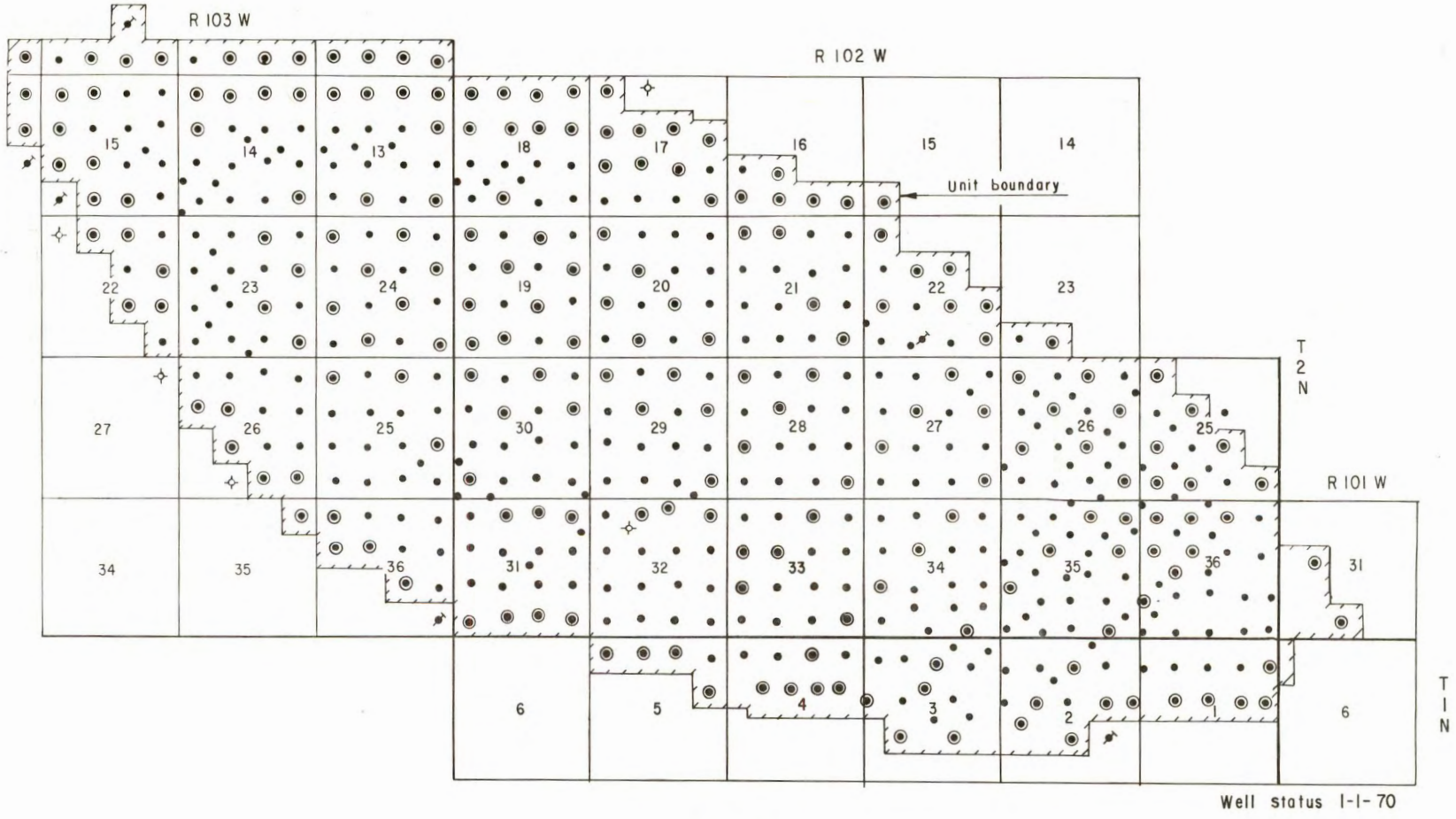


FIGURE 15. - Rangely field.

Annual and cumulative water injection and annual oil production for Rangely field, Weber zone unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1947	-	-	11,333
1948	-	-	13,677
1949	-	-	19,259
1950	-	-	18,507
1951	-	-	21,860
1952	-	-	22,194
1953	-	-	22,601
1954	-	-	22,772
1955	-	-	23,717
1956	-	-	27,921
1957	3	3	25,611
1958	1,426	1,429	20,454
1959	7,316	8,745	17,172
1960	21,705	30,450	16,386
1961	32,264	62,714	15,906
1962	32,934	95,648	15,699
1963	38,880	134,528	15,204
1964	67,947	202,475	14,713
1965	63,973	266,448	14,693
1966	66,482	332,930	16,182
1967	77,420	410,350	16,049
1968	74,794	485,144	14,759
1969	82,691	567,835	11,785
1970	87,515	655,350	9,971
1971	87,002	742,352	10,041
1972	89,891	832,243	13,544

Cumulative oil production at the start of water injection was 240,712,000 barrels or 12 percent of the original oil in place. On January 1, 1973, the cumulative production was 461,347,400 barrels or 22.9 percent of the original oil in place. Since the start of injection, 220,635,400 barrels of oil has been produced, including 111,347,400 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 8.1 to 1. Available data indicate a technically successful project.

Roggen-Southwest

The Roggen-Southwest field is in T 2 N, R 63 W, Weld County. In November 1953, the Spears Free Clinic and Hospital for the Poor, completed their No. 1 Henry Zimbleman well, SE¼NE¼ sec 22, for an initial daily flowing production of 100 barrels of oil from the D sand from 7,038 to 7,063 feet. The field consists of two reservoirs. Development drilling occurred in the northwest reservoir from 1953 to 1957 and in the southeast reservoir during

1962 and 1963. The range of initial daily production of the field wells was from 48 to 840 barrels.

Northwest Project

Areal extent of the northwest reservoir is 200 acres, and the average thickness is 9.6 feet. Oil originally was produced by a solution gas expansion drive.

The State approved the McElroy Ranch Co.'s water injection project on October 22, 1957. In June 1961, Franco-Western Oil Co. became the operator.

Water injection started on November 14, 1957, as a pressure maintenance operation. The injection water was obtained from irrigation wells in the area. Injection stopped in May 1962, after a cumulative injection of 873,700 barrels.

Annual and cumulative water injection and annual oil production for Roggen-Southwest, Northwest project, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1953	-	-	9
1954	-	-	97
1955	-	-	114
1956	-	-	74
1957	48	48	126
1958	289	337	75
1959	288	625	55
1960	152	777	44
1961	47	824	44
1962	50	874	72
1963	-	874	64
1964	-	874	34
1965	-	874	18
1966	-	874	4
1967	-	874	Plugged and abandoned

The cumulative production at the start of injection was 203,900 barrels or 13.9 percent of the original oil in place. The total production at abandonment was 241,300 barrels or 16.5 percent of the original oil in place. Of the 37,400 barrels of oil produced since the start of injection, 28,400 barrels was attributed to water injection. The ratio of cumulative water to cumulative secondary oil production is 29 to 1. Available data indicate a technically successful project, but a probable economic failure.

Southeast Project

Areal extent of the reservoir is 1,050 acres, and the average thickness is 9.6 feet. Oil originally was produced by a solution gas expansion drive.

Nebraska Drillers, Inc.'s unit agreement was approved by the State on January 18, 1966.

Water injection started in one well on April 26, 1966. The water source is a well completed in sands from a depth of 200 to 400 feet.

During December 1972, two producing wells averaged daily 15 barrels of oil and 6 barrels of water. Water injection stopped in May 1970 when the cumulative water injection was 1,938,200 barrels.

Annual and cumulative water injection and annual oil production for Roggen-Southwest, Southeast project, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1962	-	-	197
1963	-	-	153
1964	-	-	75
1965	-	-	61
1966	476	476	62
1967	581	1,057	38
1968	467	1,524	27
1969	310	1,834	23
1970	104	1,938	17
1971	-	1,938	11
1972	-	1,938	8

Cumulative oil production to the start of injection was 378,400 barrels or 6 percent of the original oil in place. On January 1, 1973, the cumulative production was 551,500 barrels or 8.8 percent of the original oil in place. Since the start of injection, 173,100 barrels of oil was produced, including 55,600 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 34.8 to 1. Although some secondary oil has been produced, available data indicate a probable failure.

Saber

The Saber field is in Tps 10 and 11 N, R 55 W, Logan County, and T 10 N, R 56 W, Weld County. In December 1962, Bright and Schiff completed their No. 1 Cervi well, NE¼NW¼ sec 7, T 10 N, R 55 W. Initial daily production flowing was 60 barrels of oil and 12 barrels of water from the D sand at 5,614 to 5,617 feet. Development drilling occurred from 1962 to 1968, but most of

the wells were drilled in 1963. The range of initial daily production for the wells was from 21 to 144 barrels.

Areal extent of the reservoir is 1,400 acres, and the average thickness is 13.5 feet. Oil initially was produced by a solution gas drive and a gas cap expansion.

A gas pressure maintenance operation started on November 23, 1964, with Bright and Schiff as operator.

Bright and Schiff's unit agreement was approved by the State on September 16, 1969. Two wells in the SW¼ sec 31, T 11 N, R 55 W, Logan County, were not included in the unit.

Water injection started in one well at the southern end of the field on August 13, 1969, as the second phase of the pressure maintenance operation. The injection water is obtained from a well, SE¼SW¼ sec 13, T 10 N, R 56 W, Weld County, from a depth of 585 to 1,200 feet.

During December 1972, there were four producing wells, three gas injection wells, and one water injection well. The daily average oil production was 25 barrels of oil and 29 barrels of water. The daily average injections were 737,000 cubic feet of gas and 6,545 barrels of water at atmospheric pressure to 1,200 psig. The cumulative injections to January 1, 1973, was 6,160,800 barrels of water and 8,974,500,000 cubic feet of gas.

Annual and cumulative water injection and annual oil production for Saber field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1962	-	-	1
1963	-	-	38
1964	-	-	144
1965	-	-	395
1966	-	-	751
1967	-	-	1,080
1968	-	-	1,388
1969	271	271	1,664
1970	1,316	1,587	1,870
1971	1,876	3,463	1,995
1972	2,697	6,160	2,068

Oil production to the start of water injection was 1,656,900 barrels or 15.6 percent of the original stock tank oil in place. To January 1, 1973, the oil production was 2,275,600 barrels. Of the 618,700 barrels of oil produced since water injection started, 185,600 barrels is credited to the injection. The waterflood may be a "break even" project.

Swan (South Kejr)

The Swan (South Kejr) field is in T 2 S, R 56 W, Washington County. In December 1955, Anderson-Prichard Oil Co. and Delta Drilling Co., completed their No. 1 Howard Swan well, SW¼SE¼ sec 21, for an initial daily production of 257 barrels of oil from the D sand at 5,157 to 5,162 feet. Development drilling occurred from 1955 to 1957, and in May 1956, oil was discovered in the J sand at the No. 1 "G" Kejr well, NE¼SW¼ sec 15, by Dawson and Cramer. Initial daily production from the well was 120 barrels from the interval 5,109 to 5,115 feet. The J sand wells are in the southwest portion of the field. Range of initial daily production was from 15 to 257 barrels for the D sand wells and 6 to 216 barrels for the J sand wells.

Areal extent of the D sand reservoir is 660 acres, and the average thickness is 8.8 feet.

The Sinclair Oil and Gas Co.'s (now Atlantic Richfield Co.) D sand unit agreement was approved by the State on May 27, 1958.

Water injection started in three wells on September 18, 1958. The water source is from the Vaughey and Vaughey pipeline system and produced water.

Injection stopped during January 1968, after a cumulative injection of 5,896,500 barrels.

Annual and cumulative water injection and annual oil production for Swan (South Kejr) field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1958	128	128	102
1959	515	643	130
1960	671	1,314	168
1961	887	2,201	48
1962	835	3,036	54
1963	828	3,864	45
1964	757	4,621	35
1965	542	5,163	23
1966	451	5,614	21
1967	271	5,885	21
1968	12	5,897	15
1969	-	5,897	11
1970	-	5,897	13
1971	-	5,897	13
1972	-	5,897	14

Cumulative oil production at the start of injection was 425,000 barrels or 9.3 percent of the original oil in place. When waterflooding was stopped

in September 1969, the cumulative production was 1,716,500 barrels or 37.6 percent of the original oil in place. Since the start of injection, 1,291,500 barrels of oil was produced, including 873,500 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 6.8 to 1. Available data indicate a technically successful project.

Westfork

The Westfork field is in T 3 S, Rs 55 and 56 W, Washington County. In July 1956, New Drilling Co. completed its No. 1 Smith well, SE¼NE¼ sec 24, T 3 S, R 56 W, for an initial production of 127 barrels of oil in a 20-hour test from the J sand at 4,949 to 4,950.5 feet. Development drilling occurred between 1956 and 1959. Range of initial daily production for the wells was from 50 to 183 barrels.

Areal extent of the reservoir is 900 acres, and the average thickness is 6.3 feet. The reservoir rock is the first bench of the J sand. The initial producing mechanisms were a solution gas drive and a water drive.

Champlin Petroleum Co.'s unit agreement was approved by the State on December 15, 1964.

Water injection started in five wells on February 19, 1966, along the west side of the field. The water injection was to supplement the natural water drive. The water sources are the Vaughey and Vaughey pipeline system and produced water.

During December 1972, there were five producing wells and seven injection wells in the field. Daily average production for the month was 117 barrels of oil and 1,040 barrels of water. The daily average injection was 2,976 barrels at pressures from 0 to 205 psig. Cumulative water injection to January 1, 1973, was 10,914,700 barrels.

Annual and cumulative water injection and annual oil production for Westfork field, Champlin Petroleum Co.'s J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1956	-	-	90
1957	-	-	274
1958	-	-	369
1959	-	-	406
1960	-	-	299
1961	-	-	201
1962	-	-	151
1963	-	-	104
1964	-	-	71
1965	-	-	66
1966	980	980	74
1967	1,507	2,487	232
1968	1,834	4,321	248
1969	1,764	6,085	383
1970	1,881	7,966	204
1971	1,662	9,628	103
1972	1,287	10,915	60

Cumulative oil produced at the start of injection was 2,041,600 barrels or 29.8 percent of the original oil in place. On January 1, 1973, the cumulative production was 3,335,300 barrels or 48.7 percent of the original oil in place. Since the start of injection, 1,293,700 barrels of oil was produced, including 1,093,300 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 9.5 to 1. Available data indicate a technically successful project.

Willard

The Willard field is in the SW¼ sec 19, T 7 N, R 54 W, Logan County. In October 1951, Sinclair Oil and Gas Co. (now Atlantic Richfield Co.) completed its No. 1 Phillips well for an initial daily production of 230 barrels of oil and 7 barrels of water from the D sand at 5,114 to 5,145 feet. The field contained four wells; three drilled in 1951 and one drilled in 1952. Range of initial daily oil production for the wells was from 98 to 456 barrels.

Areal extent of the reservoir is 160 acres, and the average thickness is 11.6 feet. The oil was initially produced by solution gas expansion.

The Sinclair Oil and Gas Co.'s water injection project was approved by the State on August 7, 1956. Injection water was obtained from a sand at 960 to 970 feet in the No. 3 Phillips well. Injection was started on September 18, 1956, and was stopped on October 19, 1960, after a cumulative injection of 320,800 barrels.

Annual and cumulative water injection and annual oil production for Willard field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1951	-	-	3
1952	-	-	40
1953	-	-	12
1954	-	-	14
1955	-	-	12
1956	20	20	9
1957	81	101	17
1958	81	182	21
1959	81	263	15
1960	56	319	6
1961	-	319	1
1962	-	319	Plugged and abandoned

Cumulative oil production at the start of injection was 90,100 barrels or 7.2 percent of the original oil in place. The cumulative oil production on June 1, 1961, was 150,200 barrels. Since the start of injection, 60,100

barrels of oil was produced, of which 33,300 barrels was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 9.6 to 1. The field was abandoned in 1962. Available data indicate the project was technically successful.

Wilson Creek

The Wilson Creek field (fig. 16) is in Tps 2 and 3 N, R 94 W, Rio Blanco County, about 12 miles north of Meeker, Colo. Oil was discovered in June 1938,

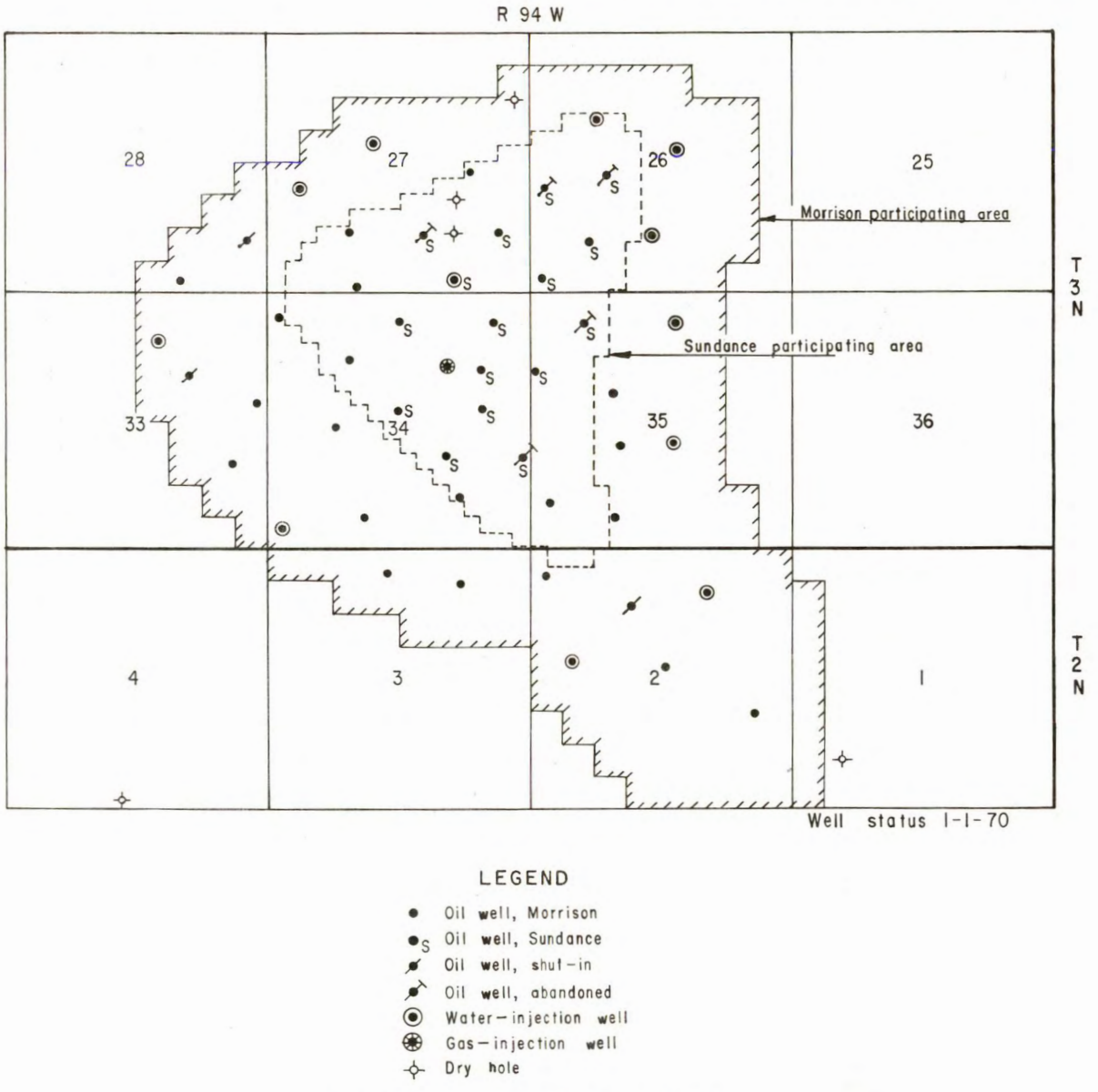


FIGURE 16. - Wilson Creek field.

when the No. 1 Freemen unit well, SE¼NW¼ sec 35, T 3 N, R 94 W, was completed by Texaco, Inc., and Chevron Oil Co. Initial daily production was 490 barrels of oil from the Morrison Formation at 6,664 to 6,707 feet. Development drilling was slow and continuous, and one development well was drilled as late as 1969. Oil was discovered in the Sundance (Entrada) Formation at the No. 5 unit, NE¼NE¼ sec 34, T 3 N, R 94 W, by Texaco, Inc., and Chevron Oil Co. in March 1941. Initial daily oil production was 300 barrels.

Morrison Unit

Areal extent of the reservoir is 3,000 acres, and the average thickness is 71 feet. Initial producing mechanisms were fluid expansion and natural water drives.

The Wilson Creek unit was approved by the Secretary of the Interior on November 24, 1936. Texaco, Inc., was the first operator. Texaco, Inc., and Chevron have alternately operated the field since 1936.

A gas injection program started on May 14, 1946, in one well. The daily average injection during December 1972 was 1,332,355 cubic feet at a pressure of 840 psig. Cumulative injection to January 1, 1973, was 30,446,029,000 cubic feet.

A water injection program started on January 20, 1959, in one well. Produced water from the Morrison and Sundance Formations was used.

During December 1972, there were 16 producing wells and 10 injection wells. Daily average production for the month was 4,316 barrels of oil and 10,264 barrels of water. The daily average water injection was 28,307 barrels at pressures from 125 to 925 psig. Cumulative water injection to January 1, 1973, was 50,636,900 barrels.

Annual and cumulative water injection and annual oil production for Wilson Creek field, Morrison unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1955	-	-	1,775
1956	-	-	1,765
1957	-	-	1,740
1958	-	-	1,680
1959	739	739	1,835
1960	828	1,567	1,914
1961	765	2,332	1,776
1962	752	3,084	1,507
1963	590	3,674	1,949
1964	400	4,074	2,266
1965	687	4,761	2,148
1966	770	[1]5,418	1,998
1967	704	6,122	1,858
1968	1,480	7,602	1,516
1969	7,933	15,535	1,872
1970	9,910	25,445	874
1971	13,172	38,617	1,910
1972	12,020	50,637	1,770

[1]Adjusted cumulative in Colorado Oil and Gas Statistics 1966.

Cumulative oil production at the start of water injection was 23,999,300 barrels or 15 percent of the original oil in place. On January 1, 1973, the cumulative production was 49,212,100 barrels or 30.7 percent of the original oil in place. Since the start of injection, 25,212,800 barrels of oil was produced, including 7,712,100 barrels attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 6.6 to 1. Available data indicate a technically successful project.

Sundance Unit

Areal extent of the reservoir is 960 acres, and the average thickness is 52 feet. Oil is produced by a water drive.

Water injection started on March 7, 1961, in one well. The water source is the Morrison and Sundance Formations.

During December 1972, 10 producing wells and 1 injection well were operative. The daily average oil production for the month was 691 barrels of oil and 25,884 barrels of water. The daily average injection was 7,325 barrels. The cumulative water injection on January 1, 1973, was 93,516,800 barrels.

Annual and cumulative water injection and annual oil production for Wilson Creek field, Sundance unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1957	-	-	785
1958	-	-	753
1959	-	-	918
1960	-	-	858
1961	4,625	4,625	708
1962	9,336	13,961	759
1963	10,186	24,147	736
1964	10,113	34,260	607
1965	8,038	42,298	412
1966	12,257	[1]54,529	511
1967	13,428	67,957	485
1968	14,541	82,498	402
1969	6,472	88,970	328
1970	2,180	91,150	282
1971	1,035	92,185	293
1972	1,331	93,516	250

[1]Adjusted cumulative in Colorado Oil and Gas Statistics 1966.

Cumulative oil production at the start of injection was 17,672,500 barrels or 34.6 percent of the original oil in place. On January 1, 1973, the cumulative production was 23,316,700 barrels or 45.7 percent of the original

oil in place. Since the start of injection, 5,644,200 barrels of oil was produced, of which 1,891,700 barrels was attributed to water injection. The ratio of injected water to secondary oil recovered was 49.4 to 1. The project is primarily for water disposal and is considered technically successful. This is a good example of water injection to supplement a natural water drive to accelerate oil recovery.

Winston

The Winston field is in sec 6, T 10 N, R 52 W, Logan County, about 16 miles north of Sterling, Colo. In May 1955, Calvert-Zoch and Campbell completed their No. 1 Roper well, SW¼NE¼ sec 6, for an initial daily oil production of 240 barrels from the J sand at 5,237 to 5,249 feet. The field's five producing wells were drilled during 1955 and had an initial daily range of oil production from 60 to 240 barrels.

Areal extent of the reservoir was 365 acres, and the average thickness is 7 feet. The initial producing mechanism was a solution gas drive.

A unit agreement was approved by the State on September 15, 1964. Paul R. Turnbull was the operator.

Water injection started on December 12, 1964, in a well in the NE¼SW¼ sec 6. The water source was the Pierre or Hygiene Formation at a depth of about 1,000 feet. Injection stopped in February 1967 after a cumulative injection of 497,000 barrels.

Annual and cumulative water injection and annual oil production for Winston field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1955	-	-	108
1956	-	-	137
1957	-	-	90
1958	-	-	41
1959	-	-	26
1960	-	-	21
1961	-	-	16
1962	-	-	12
1963	-	-	11
1964	3	3	9
1965	317	320	8
1966	157	477	2
1967	21	498	Plugged and abandoned

Cumulative production at the start of injection was 471,500 barrels, and at the field abandonment on April 6, 1967, was 482,800 barrels. From the start of injection, 11,300 barrels of oil was produced; none was attributed to water injection. The ratio of cumulative water injection to cumulative secondary oil production is 55.8 to 1. The project is considered unsuccessful.

Xenia-West

The Xenia-West field is in T 2 N, R 54 W, Washington County. In December 1954, Kingwood Oil Co. completed its No. 2 Snyder well, SW¼SE¼ sec 2, for an initial production of 27 barrels of oil per hour from the J sand at 4,808 to 4,814 feet. Most of the development drilling occurred during 1955, but four producers were drilled on the west side of the field in 1959. The range of initial daily production from the J sand wells was from 55 to 750 barrels.

Minkler No. 1 well, NW¼NE¼ sec 11, flowed 120 barrels of oil in 24 hours on June 12, 1955, from the D sand. Minkler No. 5 well, NE¼SE¼ sec 11, was completed in the D sand October 14, 1955. These were the only D sand wells in Xenia-West field. They produced a combined total of 49,529 barrels of oil before abandonment in 1966.

Areal extent of the J sand reservoir is 560 acres, and the average thickness is 10 feet. Initial producing mechanisms were a solution gas drive and a water drive.

The Kingwood Oil Co.'s unit agreement for a J sand water injection project was approved on October 20, 1959. Not included in the unit were two wells in the NE¼ sec 10.

Water injection started on November 6, 1959, on a peripheral pattern. The injection water was obtained from a well completed in a sand at a depth of about 42 to 44 feet. Injection stopped in May 1965 after a cumulative injection of 3,489,600 barrels.

Annual and cumulative water injection and annual oil production for Xenia-West field, J sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1959	44	44	-
1960	612	656	130
1961	695	1,351	113
1962	730	2,081	94
1963	514	2,595	85
1964	625	3,220	74
1965	270	3,490	68
1966	-	3,490	56
1967	-	3,490	52
1968	-	3,490	48
1969	-	3,490	47
1970	-	3,490	42
1971	-	3,490	39
1972	-	3,490	33

Four wells remained in the field in December 1972. Average daily production was 95 barrels of oil and 1,990 barrels of water.

Oil production to start of water injection was 1,046,800 barrels or 20.9 percent of the original oil in place. Cumulative oil production through 1972 was 1,902,300 barrels. Of the 855,500 barrels of oil produced since water injection started, 458,000 is credited to the waterflood. The ratio of water injected per barrel of secondary oil was 7.2 to 1. The project is a technical success.

Zorichak

The Zorichak field is in T 2 N, R 55 W, Morgan County. In October 1954, Sanford Production Co. completed its No. 1 Atkinson well, SW¼SW¼ sec 10, for an initial daily production of 5,500,000 cubic feet of gas from the D sand at 4,955 to 4,958 feet. The field development occurred between 1954 and 1958. Originally the field was known as the Pinneo field but was changed to Zorichak in 1958. During the development drilling, oil was discovered in the J sand at the No. 3 Menke well, NW¼NW¼ sec 22, by Texaco, Inc., in August 1958. Initial daily production flowing was 196 barrels from the interval 5,031 to 5,041 feet. The J sand wells are in the southwest portion of the field. Range of daily production for the wells was from 7 to 408 barrels for the D sand and 13 to 196 barrels for the J sand.

Areal extent of the D sand reservoir is 520 acres, and the average thickness is 10 feet. Initial producing mechanisms were a solution gas drive and a limited water drive.

The South Texas Development Co.'s D sand unit agreement was approved by the State on April 21, 1964. Originally 8 of the 15 field wells were in the unit.

Water injection started in two wells on July 1, 1964, on a line-drive pattern. The injection water was obtained from wells completed in a shallow sand about 3 miles west of the unit. The cumulative water injection was 3,970,500 barrels when injection stopped in May 1970. The unit was abandoned in May 1970.

Annual and cumulative water injection and annual oil production for Zorichak field, D sand unit, are listed:

Year	Annual water injection, thousand bbl	Cumulative water injection, thousand bbl	Annual oil production, thousand bbl
1960	-	-	23
1961	-	-	15
1962	-	-	27
1963	-	-	8
1964	280	280	10
1965	613	893	10
1966	707	1,600	10
1967	839	2,439	13
1968	658	3,097	20
1969	659	3,756	10
1970	215	3,971	3
1971	-	3.971	Plugged and abandoned

Cumulative oil production at the start of injection was 576,400 barrels or 10.8 percent of the original oil in place. On January 1, 1971, the cumulative production was 648,300 barrels or 12.1 percent of the original oil in place. Since the start of injection, 72,000 barrels of oil was produced, including 40,300 barrels attributed to water injection. Available data indicate the project was a failure.

SUMMARY

The first waterflood in Colorado was in the Willard field, Logan County, in 1956. Three projects were started in 1957, seven in 1958, six in 1959, and five in 1960. So, 22 of the State's total of 63 waterflood projects, or one-third, began in the first 5 years.

The Continental Divide partitions Colorado into an east slope and west slope. The authors found 55 projects on the east slope and 8 on the west slope. Using January 1, 1973, as a cutoff date, there were 36 active and 27 inactive waterflood projects in Colorado.

Brandon, Moffat, and Sand River projects are considered water disposal operations and thus are not included in the report. The Canadian River project was gas injection only. Both the Peoria and McCallum Pierre "B" Shale projects were started after January 1, 1973.

The Weber zone of the Rangely oilfield is the giant of Colorado and dominates any statistics of the State's oil and gas production. Rangely (Weber zone) had 62 percent of the oil production, 51 percent of the water injection, and 71 percent of the total oil reserves. Waterflood projects, by geologic age of the producing sands, number as follows:

Geologic age	Number of projects
Tertiary	1
Cretaceous	54
Jurassic	4
Permian	2
Pennsylvanian	2
Total	63

Part of the injection water is produced from shallow sands or alluvial deposits. Water produced with the oil is reinjected in many cases.

A summary of all Colorado waterfloods for December 1972 shows

Number of active oil wells	590
Number of active injection wells	425
Daily oil production	56,000 bbl
Daily water production	197,000 bbl
Daily water injection	357,000 bbl

At that time, the State had a total of 831 active oil wells averaging 86,000 barrels a day. So, the waterflood projects were producing 65 percent of the State's oil. Estimated total injection water required will be 4.5 billion barrels. About 36 percent or 1.6 billion barrels had been injected to January 1, 1973.

A question arises, "What bearing will the energy shortage have on the number of waterflood projects undertaken in the future?" The authors believe that new waterfloods in the older fields will not be attempted. Fields discovered since 1970 are likely prospects. Increased crude oil prices could extend the life of some of the projects.

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