

3308

# SUMMARY OF 1980 GEOTHERMAL DRILLING WESTERN UNITED STATES

By W.J. Ehni

Republic Geothermal, Inc.

This summary is the sixth in a series written since 1975 by employees of Republic Geothermal, Inc. As in the past, the authors have listed herein all wells drilled to a depth of at least 2000 feet and which were begun (but not necessarily completed) in 1980. Tables 1, 2, and 3 present summaries of drilling by well type, category, state, and operator. Consistency with previous reports in this series readily permits evaluation of annual drilling activity relative to that accomplished in other years. For a tabulation of all

geothermal drilling activity, including holes less than 2000 feet deep, readers are referred to a compilation in Petroleum Information's "National Geothermal Service" issue of January 30, 1981.

In 1980, 82 geothermal wells were drilled in the western United States, five more than in 1979. Most of the activity was in The Geysers where 42 wells were drilled, and the remainder was in California, Idaho, Nevada, New Mexico, Oregon, and Hawaii.

TABLE #1 1980 GEOTHERMAL WELLS BY CATEGORY\*

Area	DEVELOPMENT WELLS			EXPLORATION WELLS			DIRECT USE	TOTAL
	Production	Injection	Workover	Step-out	Wildcat	Observation	Wildcat	
Southern California	3	1	--	4	3	--	--	11
Northern California	34	--	4	2	2	--	--	42
Idaho	--	--	--	--	1	--	1	3
Nevada	2	--	--	2	4	7	--	15
New Mexico	4	--	--	--	1	--	--	5
Oregon	--	--	--	--	1	4	--	5
Hawaii	--	--	--	--	1	--	--	1
TOTALS	43	1	4	8	13	11	2	82

\*Category determined by the original purpose of the well.

TABLE #2

SUMMARY BY STATES, 1980

GEOHERMAL DRILLING, WESTERN UNITED STATES

STATE, REGION	AREA	OPERATOR	WELLS	PROD.	SUSP.	ABD.	INJ.	OBS.	DIRECT	FOOTAGE	
CALIFORNIA											
Southern California	E. Brawley	Phillips	2	1	0	0	1	0	0	25,234	
		Union	1	1	0	0	0	0	0	11,167	
		Oxy	1	1	0	0	0	0	0	10,731	
	S. Brawley	TRW	1	0	1	0	0	0	0	10,003	
		MCR Geothermal	2	1	0	0	1	0	0	15,827	
	Brawley	Union	1	1	0	0	0	0	0	7,012	
	Niland	Republic Geothermal	1	1	0	0	0	0	0	10,370	
	East Mesa	Republic Geothermal	1	1	0	0	0	0	0	6,290	
	Westmorland	MAPCO	1	1	0	0	0	0	0	10,456	
	Northern California	Main Geysers	Oxy	2	2	0	0	0	0	0	16,225
Union			23	22	1	0	0	0	0	161,064	
GRI			1	1	0	0	0	0	0	13,977	
Thermogenics			2	2	0	0	0	0	0	28,296	
Shell			6	5	0	1	0	0	0	36,221	
Aminoil			5	5	0	0	0	0	0	37,810	
North Geysers		MCR Geothermal	1	1	0	0	0	0	0	9,996	
Wilbur Springs		Sunedco	1	0	1	0	0	0	0	9,698	
Round Mt.		Phillips	1	1	0	0	0	0	0	10,042	
HAWAII		Opihijao	Geothermal Expl. & Dev.	1	1	0	0	0	0	0	7,000
IDAHO		Boise	State of Idaho	1	0	0	0	0	0	1	2,152
	Madison	Madison Co. Energy Commission	1	0	0	0	0	0	1	3,946	
	Preston	Sunedco	1	0	0	1	0	0	0	7,981	
NEVADA	Dixie	Republic Geothermal	2	0	0	0	0	2	0	6,030	
		Sunedco	3	2	1	0	0	0	0	30,460	
	Carson Lake	Anadarko	1	0	1	0	0	0	0	8,500	
	McCoy	AMAX	2	0	0	0	0	2	0	4,520	
	Tuscarora	AMAX	2	0	1	0	0	1	0	8,579	
	Crescent Falls	Chevron	1	0	0	0	0	1	0	2,286	
	Beowawe	Chevron	1	0	0	0	0	1	0	5,927	
	Kyle	Chevron	1	0	0	0	0	1	0	2,104	
	Leach	Sunedco	1	0	0	1	0	0	0	8,565	
	Monte Neva	Hunt	1	0	0	0	0	1	0	11,017	
NEW MEXICO	Radium Springs	Hunt	1	0	1	0	0	0	0	8,000	
	Valles Caldera	Union	3	1	2	0	0	0	0	19,141	
	Fenton Hill	LASL	1	0	0	0	0	0	0	13,500*	
OREGON	Mt. Hood	USGS	2	0	2	0	0	0	0	3,853	
		NW Geothermal	1	0	0	0	0	1	0	6,027	
	S. Crump	Chevron	2	0	0	0	0	2	0	4,995	

\*Projected total depth, well was drilling at time of this report.

Four power plants using geothermal steam to generate electricity began operations in California during 1980. Two of the plants are in The Geysers and two are in the Imperial Valley. These plants have a rated total capacity of 266 Mw.

CALIFORNIA

During 1980, 42 wells (Table 1) were

drilled in The Geysers region (Figures 1 and 2), a 27% increase over the 33 wells spudded in 1979. Two new power plants were put on line, increasing by 37% the total net generating capacity to over 900 Mw. PG&E's Unit 13 went on line in April using steam provided by Aminoil to generate 135 Mw. Steam PG&E's 110 Mw Unit 14 is supplied by Union Oil Company. This plant began producing electricity in September.

Union Oil Company drilled 19 development wells, three workover wells, and one step-out well in The Geysers in 1980 (Table 2). The 19 development wells were all reported to be potential geothermal producers, but the step-out well, "Frandsen Fed" 5232, was suspended due to drilling difficulties. Union's "Binkley Ranch" 1 was reworked by milling a window in the 9-5/8" casing and redrilled to 9,264 feet. Thereafter, the well was reported to be a successful producer. Union is said to be planning to increase its steam production to a level adequate to support generation of an additional 440 Mw at four power plants by 1985.

Aminoil drilled five wells in The Geysers in 1980, all of which were successful. PG&E's Unit 13 is the first to be supplied by Aminoil steam, and its start-up in 1980 increased the installed generating capacity of The Geysers by 135 Mw. Aminoil plans to provide steam for an additional 220 Mw of installed generating capacity in The Geysers by completing further infield drilling.

Shell Oil Company spudded five wells and reworked one well in 1980. Drilling difficulties forced abandonment of one of the new wells; however, the remaining four were successful. The steam from these wells is dedicated to the Northern California Power Agency (NCPA) 110 Mw plant that is scheduled to start power generating in 1982. Site construction for this power plant is proceeding on schedule.

MCR Geothermal Corporation (formerly McCulloch Geothermal) drilled one development well, "Francisco" 3-5, in the northern portion of The Geysers, bringing the total number of wells drilled within its prospect area to four. MCR plans to deliver its steam to a 55 Mw plant to be constructed by the California Department of Water Resources (DWR) in time for power generation by 1985. In order to meet its commitment to this power plant, MCR will need to drill at least six more wells.

Thermogenics completed two new wells

on its Rorabaugh lease in 1980. The steam from these wells will be used in PG&E's Unit 15 as make-up wells to compensate for flow rate declines commonly observed during the initial production of steam wells.

Sunedco drilled one wildcat well northeast of The Geysers near Wilbur Hot Springs. This well was drilled to a total depth of 9,104 feet but did not encounter commercial quantities of steam and was suspended with a fish in the hole.

Occidental Geothermal Corporation drilled two wells in The Geysers, both of which were said to have flow rates in excess of 200,000 pounds per hour. Occidental reportedly intends to build two 40 Mw power plants and to sell the electricity to PG&E under the Public Utility Regulatory Policy Act. Oxy plans to begin power generation by June 1984.

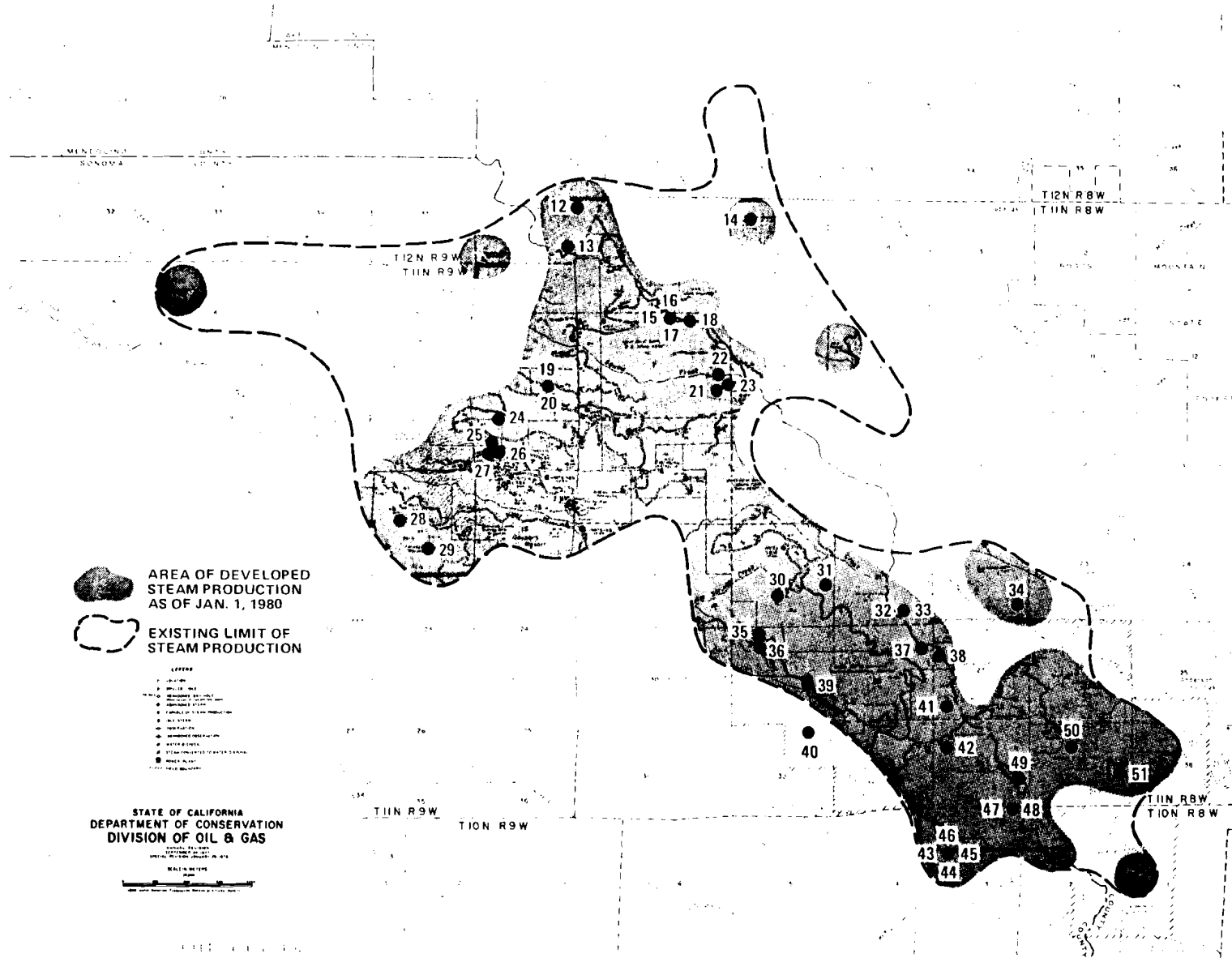
Geothermal Resources International (GRI) drilled a step-out well, "Prati" 1, in the northwest portion of The Geysers. This well is within one-half mile of proven production and is characterized as a potential geothermal producer.

In late 1980, Phillips Petroleum Corporation drilled a wildcat well more than 12 miles to the northeast of the main Geysers development. This well, "Audrey A", is relatively close to the old steam wells at Sulphur Bank Mine. It was drilled to a total depth of 10,042 feet and is currently being tested to determine the quality of the resource encountered.

### Imperial Valley

Eleven wells were drilled in the Imperial Valley during 1980 (Figure 3). Although plans exist for additional geothermal power plants, only two plants (Brawley and east Mesa) are currently generating electricity.

At Brawley, Union Oil supplies steam to the Southern California Edison Company for generation of power. This plant, which has been in operation since July 1980, uses the single-flash method



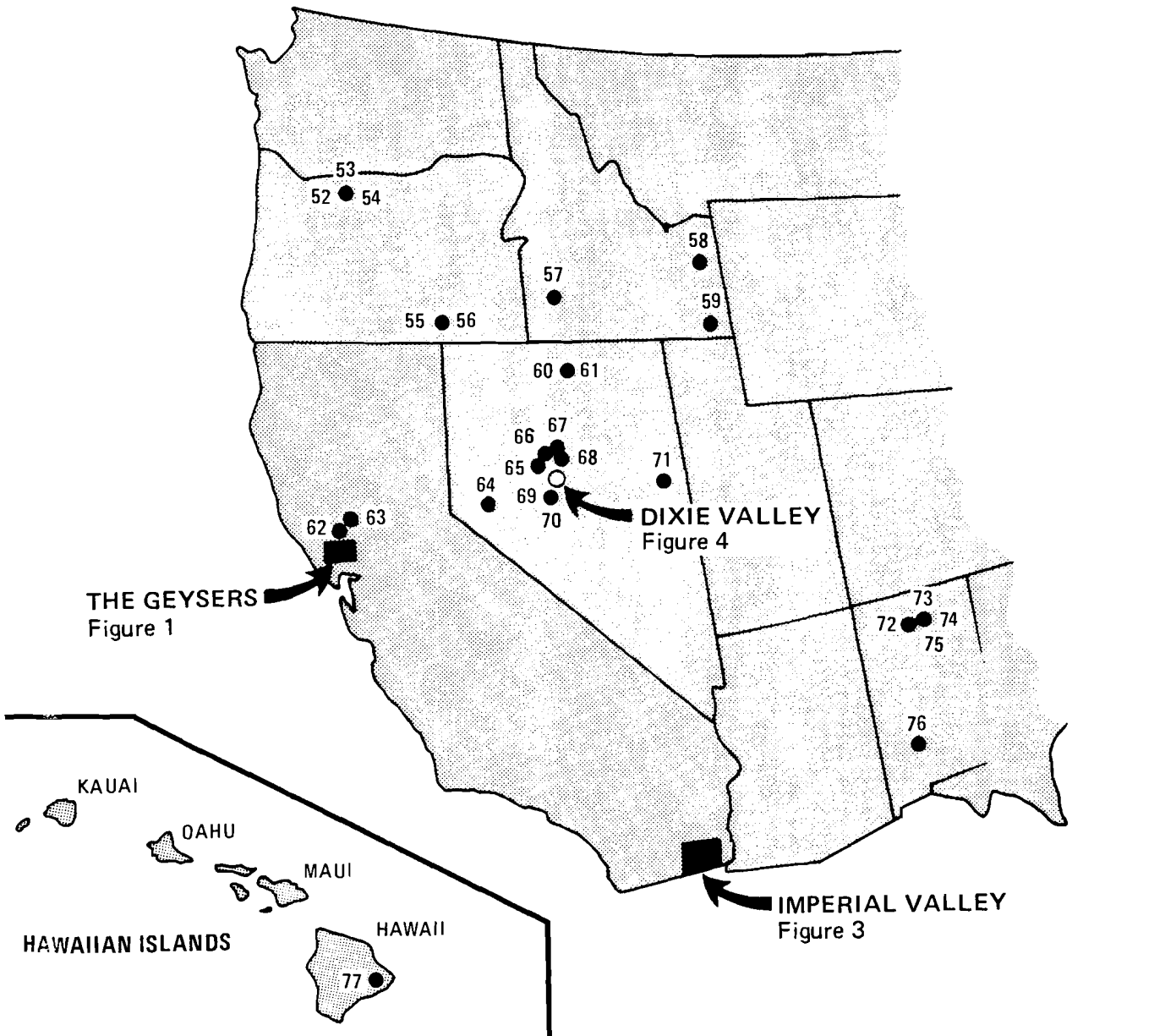
- 12-UNION "BINKLEY RANCH" 1
- 13-GRI "PRATI" 1
- 14-McCULLOCH "FRANCISCO" 3-5
- 15-UNION "DXS 4596" 50
- 16-UNION "DXS 4596" 46
- 17-UNION "DXS 4596" 51
- 18-UNION "DXS 4596" 47
- 19-UNION "OTTOBONI" 73A-12
- 20-UNION "OTTOBONI" 73-12
- 21-UNION "DXS 4596" 48

- 22-UNION "DXS 4596" 49
- 23-UNION "DXS 4596" 23
- 24-UNION "OTTOBONI" 45A-12
- 25-UNION "SULPHUR BANK" 15
- 26-UNION "SULPHUR BANK" 11
- 27-UNION "SULPHUR BANK" 16
- 28-THERMOGENICS "RORABAUGH" A-13
- 29-THERMOGENICS "RORABAUGH" A-14
- 30-UNION "LF STATE" 4597-30
- 31-UNION "ANGELI" 2

- 32-OCCIDENTAL "CA-5631" 68A-21
- 33-OCCIDENTAL "CA-5631" 68-21
- 34-AMINOIL "M&W" 1
- 35-UNION "GDC" 10
- 36-UNION "GDC" 11
- 37-AMINOIL "CA-1862" 82-28
- 38-UNION "TOCHER" 1
- 39-UNION "BEIGEL" 1
- 40-UNION "FRANSEN" FED5232
- 41-UNION "MODINI" 1

- 42-UNION "D&V" 2
- 43-SHELL "C-950" F-8
- 44-SHELL "CA-950" F-4
- 45-SHELL "CA-950" F-3
- 46-SHELL "CA-950" F-2
- 47-SHELL "US GEO" C-5
- 48-SHELL "US GEO" C-4
- 49-AMINOIL "CA-958" 86A-34
- 50-AMINOIL "CA-958" 43-35
- 51-AMINOIL "CA-958" 84-35

FIGURE 1. 1980 GEOTHERMAL WELLS, THE GEYSERS FIELD, CALIFORNIA



52-USGS "PUCCI CHAIRLIFT"  
 53-USGS "McGEE CREEK" 47-1  
 54-NW GEOTHERMAL "OLD MAID" 54-17  
 55-CHEVRON "FEDERAL" 46-4  
 56-CHEVRON "FEDERAL" 31-8  
 57-HIDDLESTON "BOISE" 1  
 58-MADISON COUNTY "MADISON" 1  
 59-SUNEDCO "BURTWINN" 1  
 60-AMAX "NI2247" 51-9

61-AMAX "TUSCARORA" 66-5  
 62-PHILLIPS "AUDREY A" 1  
 63-SUNEDCO "BAILEY MINERAL" 1  
 64-ANADRKO "36" 14-36  
 65-CHEVRON "KYLE" 84-2  
 66-SUNEDCO "USA" 11-36  
 67-CHEVRON "NV10916" 85-18  
 68-CHEVRON "CRESENT FALLS" 2979  
 69-AMAX "McCOY" 66-8

70-AMAX "McCOY" 14-7  
 71-HUNT "SCHELLBOURNE" 74-23  
 72-LASL EE-3  
 73-UNION "BACA" 21  
 74-UNION "BACA" 20  
 75-UNION "BACA" 22  
 76-HUNT "FEDERAL 25557" 25-34  
 77-GEOTHERMAL E&D "ASHIDA" 1

FIGURE 2. 1980 GEOTHERMAL WELLS, WESTERN UNITED STATES

of steam separation to generate 10 Mw. The plant initially produced electricity at a steady average rate of 55% of capacity (5.5 Mw) with periodic shutdowns for minor engineering work for a few days each month. Currently, problems are minor and the average power output has increased to slightly over 8 Mw.

At East Mesa, Magma Energy Corporation produces power using a binary cycle with isobutane and propane working fluids. Maximum power capacity is 11 Mw, all of which is sold to the Imperial Irrigation District. The isobutane has had a series of technical problems and has had numerous shutdowns with a maximum sustained electricity pro-

duction period of 90 days occurring in autumn 1980. Since March 1981, the plant has been consistently producing 7 Mw.

During 1980, the East Brawley area was the most actively explored part of the Imperial Valley with a total of four wells drilled by three companies. Phillips Petroleum Company drilled one wildcat well and one step-out confirmation well and plans to run long-term flow tests in 1981 to evaluate the reservoir discovered. The step-out well was originally intended to be a producer, but mechanical problems prevented drilling to the depth originally planned, and the well was therefore completed as an

OPERATOR	TOTAL WELLS	CALIFORNIA		HAWAII	IDAHO	NEVADA	NEW MEXICO	OREGON	FOOTAGE
		NORTHERN	SOUTHERN						
AMAX	4	0	0	0	0	4	0	0	13,099
Aminoil	5	5	0	0	0	0	0	0	37,810
Anadarko	1	0	0	0	0	1	0	0	8,500
Chevron	5	0	0	0	0	3	0	2	15,312
Geothermal Expl. & Dev.	1	0	0	1	0	0	0	0	7,000
GRI	1	1	0	0	0	0	0	0	13,977
State of Idaho	1	0	0	0	1	0	0	0	2,152
Hunt	2	0	0	0	0	1	1	0	19,017
LASL	1	0	0	0	0	0	1	0	13,500*
Madison Co. Energy Commission	1	0	0	0	1	0	0	0	3,946
MAPCO	1	0	1	0	0	0	0	0	10,456
MCR Geothermal	3	1	2	0	0	0	0	0	25,823
NW Geothermal	1	0	0	0	0	0	0	1	6,027
Oxy	3	2	1	0	0	0	0	0	26,956
Phillips	3	1	2	0	0	0	0	0	35,276
Republic Geothermal	4	0	2	0	0	2	0	0	22,690
Shell	6	6	0	0	0	0	0	0	36,221
Sunedco	6	1	0	0	1	4	0	0	56,704
Thermogenics	2	2	0	0	0	0	0	0	28,296
TRW	1	0	1	0	0	0	0	0	10,003
Union	28	23	2	0	0	0	3	0	198,384
USGS	2	0	0	0	0	0	0	2	3,853
TOTALS	82	42	11	1	3	15	5	5	595,002

\*Projected total depth, well was drilling at time of this report.

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injector. Occidental Geothermal Corporation drilled a wildcat well in the same area to a total depth of 10,731 feet. The results were encouraging enough to justify drilling a second well which was spudded in 1981 and is currently being tested. Union Oil Company's "East Highline" 1 was drilled to a total depth of 11,167 feet. Union is currently evaluating the results of a five-day flow test of this wildcat well.

In 1980, two production wells and one injection well were drilled at South Brawley. TRW and MCR drilled the deep production wells. MCR also re-entered the 4,147-foot-deep "Mercer" 2-28, originally drilled as an injector, and completed it at 13,398 feet as a potential producer. MCR then drilled "Lacey" 1-28 to 6,600 feet, ran 13-3/8" casing to total depth, and completed it as an injector. TRW drilled "Holly Sugar" 44P to a total depth of 10,003 feet. The fluid from this step-out well was to be used by Holly Sugar for processing sugar; however, preliminary results do not indicate the existence of a resource with flow rates and temperatures adequate for the intended use.

In the northern portion of the Imperial Valley near Niland, Republic Geothermal drilled "Britz" 3, a step-out confirmation well, on its Niland prospect. Both the "Britz" 3 and the "Fee" 1 wells (1979) are successful geothermal producers.

One well, "East Mesa" 87-6, was drilled to a total depth of 6,290 feet at East Mesa by Republic Geothermal and completed as a producer. This well was funded by the DOE and was to be used to test the "downhole pump" and gravity head binary heat exchanger developed by Sperry Research. Unfortunately, problems have delayed completion of the equipment test, and due to DOE budget reductions, the program may be prematurely curtailed.

In 1980, MAPCO drilled a step-out confirmation well, "Currier" 2, at its Westmorland prospect. This well was drilled to a total depth of 10,456 feet where "commercial" temperatures were encountered.

## IDAHO

During 1980, three geothermal test wells were drilled in Idaho, one more than in 1979. Sunedco drilled a 7,981-foot test on its Preston prospect in Franklin County, Idaho. This wildcat well, "Burtwinn" 1, was unsuccessful and was abandoned. Two wells intended for direct utilization were completed. One was at Rexburg in Madison County where the Madison County Energy Company drilled to 3,948 feet, and another was at Boise where a 2,152-foot well was successfully completed.

The Rexburg well was to be used to supply thermal waters for space heating; however, the water temperatures encountered were substantially lower than expected ( $\pm 65^{\circ}\text{F}$ ), and present plans are to rework the well in 1981 in order to prevent shallow ground water from mixing with hotter geothermal fluids. Fluids from the Boise well will be used to heat several buildings near the state capital. The first well proved to have the capability of producing  $155^{\circ}\text{F}$  water at 750 gallons per minute. Several more wells will be drilled in the capital district and in the Warm Springs residential area in 1981.

## NEVADA Dixie Valley

Sunedco drilled two development wells and one step-out well in Dixie Valley in 1980. The two development wells bring the number of successful Sunedco completions in Dixie Valley to six. Sun drilled "USA" 62-21, the step-out well two miles southeast of production, to a total depth of 12,461 feet (Figure 4). This well was not as productive as the previously drilled wells to the west; however, Sun is still evaluating test data.

Republic Geothermal drilled two 3000-foot observation holes on its federal leases in Dixie Valley. One well was within 1-1/2 miles of proven production. The results from these wells will be used to evaluate the potential of the Republic leases and to choose site(s) for deep drill hole(s).

Ten wells were drilled in the remainder of Nevada (Figure 2). Sunedco

drilled a wildcat well at Leach Hot Springs which was abandoned at 8,565 feet after running logs. Hunt Energy drilled an 11,017-foot wildcat well near Monte Neva Hot Spring in White Pine County. After running logs, this well, "Schellbourne" 74-23, was converted to an observation hole. Chevron drilled "NV-10916" 85-18 to a total depth of 5,927 feet at Beowawe. After running numerous temperature logs, this hole was converted into an observation hole by running 2-7/8" tubing to total depth.

Chevron also drilled a 2,286-foot-deep observation hole south of Beowawe in its Crescent Falls prospect and a 2,104-foot-deep observation hole near Kyle Hot Springs.

AMAX drilled two observation holes on its McCoy prospect. "McCoy" 66-8 was completed at 2,510 feet, and "McCoy" 14-7 was drilled to a total depth of 2,010 feet. AMAX also drilled two holes at its Tuscarora prospect. Well "N12247" 51-9 was an observation hole

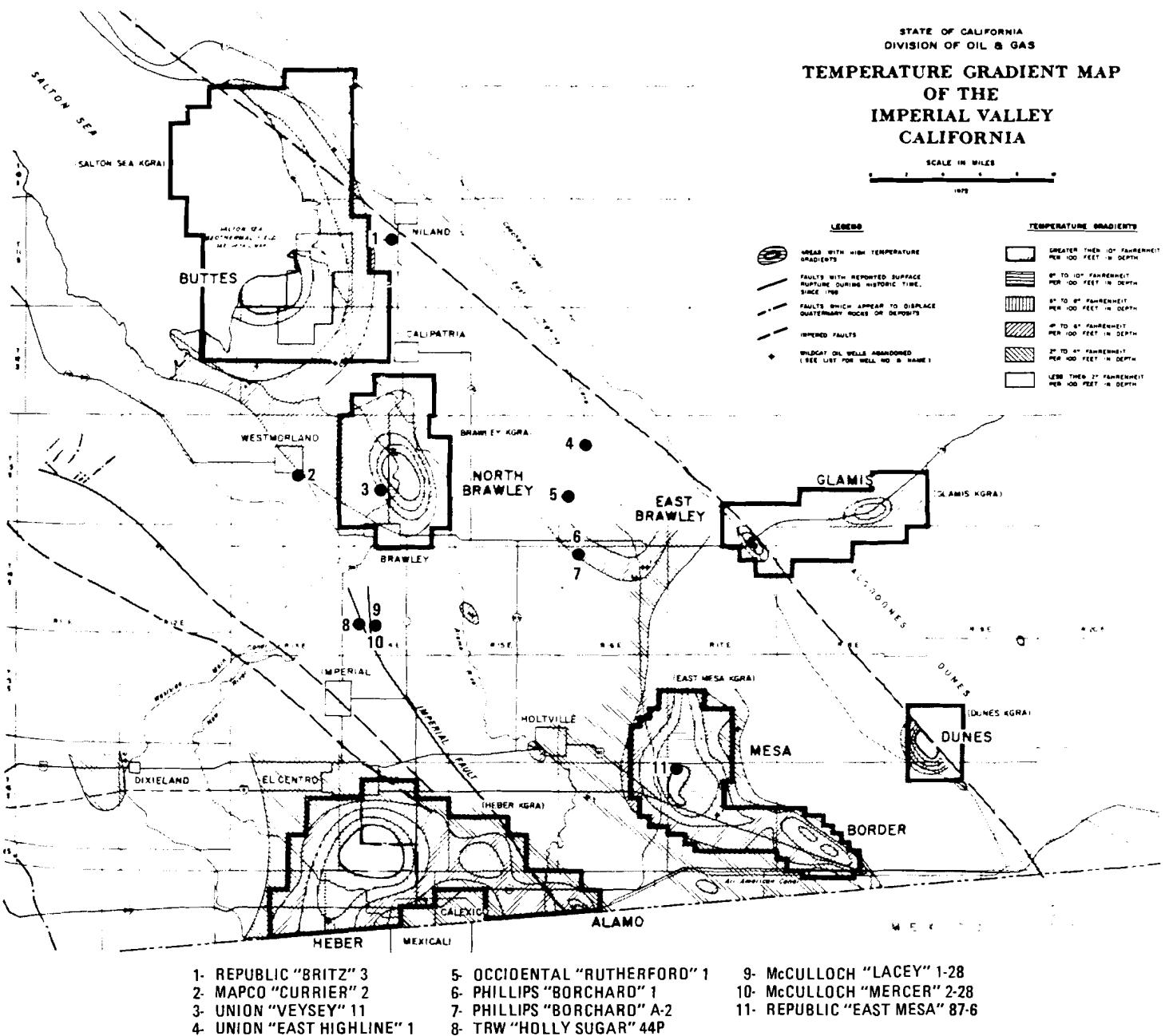


FIGURE 3. 1980 GEOTHERMAL WELLS, IMPERIAL VALLEY, CALIFORNIA





completed to a depth of 3,125 feet, and "Tuscarora" 66-5 was suspended at a depth of 5,454 feet. Anadarko spudded its Carson Lake well "36" 14-36 in November. It suspended operations on this well at 8,500 feet pending reevaluation of data.

#### NEW MEXICO

Five wells were drilled in New Mexico in 1980, one more than in 1979. Union Oil Company drilled three development wells at Baca. "Baca" 20 and 21 were successful; however, "Baca" 22 was suspended at a depth of 6,485 feet due to considerable drilling difficulty.

Hunt Energy Company drilled an 8,000 foot wildcat well near Radium Springs, New Mexico, and is currently drilling its second well on the same prospect. No information regarding these wells is available.

At Fenton Hill, the Hot Dry Rock well "EE" 3, was spudded in May 1980. It is being drilled below 9,884 feet and has a projected total depth of 13,500 feet.

#### OREGON

Five wells were drilled in Oregon during 1980, two more than in 1979. Northwest Geothermal drilled a 6,027-foot wildcat well on Mt. Hood, "Old Maid Flat" 54-17, in which bottomhole temperatures of 230°F were recorded. This well was originally intended to be productive, but it has since been reclassified as an observation well. In two other 1980 operations on Mt. Hood, the USGS deepened preexisting holes. The test well, "Pucci Chairlift", originally drilled to 2,002 feet in 1979, was deepened to 4,003 feet. "McGee Creek" 47-1, drilled to 770 feet in 1979, was deepened to 2,000 feet and completed as an observation hole. In southern Oregon, Chevron completed two observation holes in the South Crump area with "Federal" 46-4 being drilled to 2,975 feet and "Federal" 31-8 drilled to 2,020 feet.

#### HAWAII

In Hawaii, Geothermal Exploration & Development Company completed one wildcat well to a total depth of approximately 7,000 feet. The well, which is rumored to be a potential geothermal producer, is located 2-1/2 miles south of the "HGP-A" well which has a reported bottom-hole temperature of 676°F at 6,450 feet.




#### WILLIAM J. EHNI, Exploration Geologist

Mr. Ehni joined Republic in August 1979 and has over seven years of experience in evaluating geothermal prospects in the US and Japan. Prior to joining Republic, he worked in The Geysers for Thermogenics from 1974 to 1977 and with Aminoil, USA, Inc. in the western United States from 1977 to 1979. He holds a bachelor's degree in Geology from Humboldt State University.

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