DOE/ET/27196-T2

MASTER

IMPERIAL COUNTY

GEOTHERMAL DEVELOPMENT

SEMI-ANNUAL REPORT

OCTOBER 1, 1980/MARCH 31, 1981

DISCLAIMER

CONTENTS

IMPERIAL COUNTY

Geothermal Development Semi-Annual Report

October 1, 1980/March 31, 1981

IMPERIAL COUNTY

GEOTHERMAL SEMI-ANNUAL REPORT

October 1, 1980 to March 31, 1981

FORWARD

This semi-annual report will show the current progress on Cooperative Agreement DE-FC03-79ET27196 and Geothermal progress in Imperial County. It was prepared by the Director of Public Works and the Geothermal Coordinator as partial fulfillment of this Cooperative Agreement. The report will be broken down into three areas: Geothermal Administration, Geothermal Planning; and other Geothermal Activities.

Geothermal Administration will address the status of the Imperial Valley Environmental Project (IVEP) transfer, update of the Geothermal Resource Center, and findings of Geothermal field inspections. Field inspections will cover the two power plants that are on line in East Mesa and North Brawley and the two possible new Geothermal anomalies being developed; South Brawley and East Brawley. In addition, we will cover the cooperative efforts between industry and the County; Master EIR for the Salton Sea KGRA and the resurveying of the subsidence detection network. The status of Geothermal development throughout the County will cover existing and proposed facilities.

Geothermal Planning will address a Board of Supervisor action on the Union Oil Geothermal Production Permit for 16 wells in the Salton Sea KGRA and a permit for Southern California Edison 10 megawatts power plant in the Salton Sea KGRA. Planning Commission action will

cover: Amendment of Magma Power's 49 megawatts Geothermal Production Permit to 28 megawatt power plant and relocation of the plant and wells within the Salton Sea KGRA; Exploration permit to Occidental Geothermal for four exploratory wells in East Brawley; Geothermal Production Permit to Southern California Edison to operate a 10 megawatt power plant in the Salton Sea KGRA; and Geothermal production permit to Union Oil for 16 production-injection wells in the Salton Sea KGRA. Lastly, EIR exemptions to CEQA were granted to Chevron for 70 shallow temperature observation holes and Union for fifteen.

Other Geothermal Activity will address the County Direct Heat Development study; the solicitation for district heating and cooling proposals; the new Geothermal Class II-1 disposal site; the DOE Region IX meeting in Tucson; and USGA designating a new KGRA, the East Brawley KGRA, the Westmorland KGRA, and revising the southern border of the Salton Sea KGRA.

Lastly, it should be noted that in June, 1981, Cerro Prieto will bring on line their new 27.5 megawatt low-pressure turbine a year ahead of schedule and Imperial County will host an Imperial Valley Geothermal meeting.

IMPERIAL COUNTY

GEOTHERMAL DEVELOPMENT SEMI-ANNUAL REPORT

October 1, 1980 to March 31, 1981

This semi-annual report will cover all significant Geothermal development which has occurred in Imperial County during this period. It will follow the format suggested in the Department of Energy Cooperative Agreement DE-FC03-79ET27196 consisting of three major headings: Geothermal Administration; Geothermal Planning; and Other Geothermal Activities.

I. Geothermal Administration is the task of the Geothermal office based within the Department of Public Works under direction of the Director of Public Works. It is responsible for the transfer of the Imperial Valley Environmental Project (IVEP) updating of the Geothermal resource center conducting Geothermal field inspections, and monitoring Geothermal development. Progress in these areas is as follows:

   A. Status of IVEP transfer. Lawrence Livermore Laboratory's (LLL) summary is found in a two volume study tited, "An Assessment of Geothermal Development in the Imperial Valley of California, Volume 1 and 2" received November 10, 1980. The individual data that went into the report is still on file at LLL. An earlier report utilizing the air monitoring data is also on file. A plan is being developed to transfer the raw data for a future updating program. In addition, an Executive Summary of the two volume study was received March 19, 1981, (Available at the Department of Public Works).

   B. Update of the Geothermal resource center. Besides receiving and filing all current reports on the Imperial Valley, a review of LLL's previous documents was completed. They sent the documents

requested in January. These have also been cataloged and filed.

C. Results of field inspection. During this period there was a dedication of the Southern California Edison/Union dual flash 10 megawatt power plant at North Brawley, McCulloch Geothermal flow-tested their South Brawley well, Republic flow-tested near Niland, Phillips completed their third East Brawley well, and Magma's 10 megawatt binary power plant at East Mesa has some mechanical problems.

1. Dedication ceremonies were held October 15, 1980, at the Brawley Geothermal Power project. They were co-hosted by Fred L. Hartley, Chairman and President of Union Oil Company and William R. Gould, Board Chairman and Chief Executive Officer of Southern California Edison. The ceremony included a tour of the 10 megawatt plant and Geothermal field. Appendix A contains a fact sheet on the demonstration project.
2. After McCulloch Geothermal completed their second well, flow-testing was commenced by Vedder research. This 45 day flow test was interrupted due to scaling problems near the well head. After correcting the problem, testing was completed the first week in January. Results appear to be very favorable.
3. Republic has two wells east of the Salton Sea KGRA (Britz 3 and Fee 1) which were flow-tested by Vetter Research (30 day test) in March with good results.
4. Phillips Geothermal completed their first well (Borchard A-1, 13,404 ft.) in September and have completed two more wells (Borchard A-2, 11,800 ft. and Borchard A-3, 12,800 ft.). These wells are in East Brawley. They are designing test equipment for flow-testing now.

5. Magma Power's 10 megawatt binary plant at East Mesa is still experiencing mechanical problems. The binary process is functioning normally, but problems exist with the gas turbine. It had to be removed and sent back to the manufacturer for modification. It was returned and after two smaller problems was installed and operating toward the end of this reporting period.

D. Evaluation of cooperative efforts between industry and the County for Geothermal development in the area. The effort is typified by listing a few of the transactions for this period:

1. Geothermal subsidence detection network resurvey. Appendix B indicated who was on the Geothermal Subsidence Detection Committee and dollars committed. The survey commenced in November and involves three second order survey crews and two first order crews resurveying 438 miles. November 20, 1980, the County first order survey crew and the Imperial Irrigation District (IID) second order survey crew commenced work. The County first order survey crew completed 40 miles during this period. The IID crew completed their share (80 miles) in February. December 22, National Geodetic Survey (NGS) first order survey crew commenced work. They have completed 166 miles as of March 31. December 24th, Imperial County second order survey crew commenced work. They have completed 46 miles as of March 31. In January the Water and Power Resources Service (WPRS) second order survey crew commenced work. They have completed 40 miles as of March 31. The total resurvey is due to be completed in May, 1981.

2. Meeting with representatives of Mapco on feasability of ethanol

facility using Geothermal fluids cascading from the proposed Mapco power plant.

3. Meeting with representatives of Chevron for final approval of their proposed micro-seismic monitoring network at Heber.
4. Meeting with several developers about possible greenhouse siting in Imperial Valley.

E. Problems in Geothermal development and recommendations for action.

During this period three major concerns were looked into:

1. The problem of Geothermal direct heat development. As noted last period, the County Ethanol Committee made a Request for Proposal (RFP) to address the possible application suitable to the Imperial Valley and their impacts. VTN was selected, after competing with seven other mirs for the contract. It was awarded on December 17. The initial two phases are sub-contracted to the Ben Holt Company. Their status report shows 40% completed (Appendix C).
2. The problem of Geothermal district heating and cooling. At the end of October, we were advised of possible HUD/DOE Request for Proposals for district heating and cooling with a deadline of mid-January. We met with the cities and described the project to them. We then arranged for a Department of Energy representative and HUD representative to address the interested parties. From these efforts, there are three communities submitting proposals: Brawley, Heber, and Calipatria. Results are still unknown.
3. The problem of Class II-1 Geothermal hazardous site availability. On December 17, 1980, the IT Corporation opened a Class II-1 site for Geothermal hazardous wastes and a small amount of pesticides. Since that time, more than half of the waste

received has been from the oil industry in the Los Angeles area. This has caused public concern and opposition to the site.

The Board of Supervisors was halted from changing the Conditional Use Permit issued to IT by a restraining order from IT Corporation. A request from the County to the Regional Water Quality Control Board to modify their order has lead to several hearings, the last of which will be held April 29, 1981, in El Centro.

Concern over the IT situation and the possible removal of Class II-1 site available for the Geothermal community lead the Supervisors to request a study on possible II-1 site locations in Imperial County. The Geothermal Coordinator was given the lead in this project which consisted of meeting with local and state representatives and research for possible sites. The results of the study were seven sites being presented to the Board of Supervisors. Public concern about Class II-1 siting procedures lead the Board of Supervisors to request input from concerned citizens on the study before action was taken by the Board. The first of several meetings with the public has been set for May 6, 1981.

F. Status of Geothermal exploration, development, and production in the Imperial County. Currently there are two 10 megawatt power plants on line, with approval for five more. There are three companies drilling wells and three development companies expanding field development. The status of all these will be discussed in four sections: Power Plants; Field Development; Direct Heat Projects; and, Other Projects.

1. Power Plants

The Southern California Edison/Union 10 megawatt power plant in Brawley is operating as mentioned earlier. They are commencing

construction of a 10 megawatt plant near the Salton Sea. It will be on line in July, 1982. The Magma Power 10 megawatt binary plant is operating intermittently due to mechanical problems. The turbine has been rebuilt and they have repaired leaks in the heat exchanger. Magma Power has drilled four new wells and started construction of a 28 megawatt dual-flash power plant at the Salton Sea near the former loop facility (Geothermal Loop Experimental Facility). The facility has been torn down with the exception of the clarifier. San Diego Gas and Electric issued a letter of intent to buy the electricity from this 28 megawatt plant and Magma's future 50 megawatt plant. Southern California Edison has approval for a 45 megawatt power plant at Heber which is scheduled to be on line in 1984. San Diego Gas and Electric has approval for a 45 megawatt binary plant which is due to go on line in 1984. Republic Geothermal has wells at East Mesa for a power plant and is negotiating with Los Angeles Department of Water and Power for a 10 megawatt/48 megawatt plant.

2. Field Development

During this period, Union and Phillips have both drilled wells in the East Brawley area. This area identified by USGS as a possible hot spot was just designated as a KGRA in March, 1981. Union drilled one well and Phillips drilled three deep wells to about 13,000 feet. Phillips is also requesting to drill six wells near Salton City in an area previously not explored. In the South Brawley area, McCulloch Geothermal now known as MCR Geothermal Corporation, has drilled two wells. The deepest to 13,000 feet. They have flow-tested the well and are currently analyzing the results.

3. Direct Heat Uses

The Holly Sugar Project (TRW consultant) completed their first well, which is also in the South Brawley area. The City of El Centro Heating and Cooling Project (Westec consultant) selected H & W Drilling to drill their two wells.

Pacific Gas and Electric and Southern California Gas have selected CH2M Hill to do a feasibility study for a commercial size methane plant in the Imperial Valley, using knowledge gained from the small methane plant which has operated for two years. The commercial size facility will require Geothermal heat for part of the process.

4. Other Projects

The Sperry Project (Appendix D), which will use a down hole pump and heat exchanger to drive a well head generator, is in the first phases of well development. They had trouble with leaks in the 30-inch diameter well casing which took special efforts to resolve. The casing is now repaired and they are proceeding with the build-up of the experiment. They had all the surface equipemnt in place in January, 1981. They will be installing and testing the down hole pump next quarter. They expect to have the gravity head system installed by January,, 1982. The National Supply Company, a division of Armco Inc., has opened a Geothermal supply office in Imperial Valley. Other Geothermal services/supply companies located in the Imperial Valley are Schlumberger Well Logging, Halliburton Cement, and Midway Fishing Tool Company. November 12, 1980, San Diego Gas and Electric signed an agreement for 150 megawatts of electricity over a ten year period from Mexico's

Geothermal energy center at Cerro Prieto and Southern California Edison signed for 70 megawatts.

II. Geothermal Planning

Geothermal planning is the task of the Geothermal Planner based within the Planning Department under the direction of the Planning Director. Responsibilities are: Geothermal applications; hearings permits; preparing draft environmental impact reports (EIR's); and, implementing the Geothermal element to the general plan. Progress this period was as follows:

A. Planning Commission actions

1. December 10, 1980, the Planning Commission issued an amendment to Magma Power's previously approved 49 megawatt Geothermal Production Permit authorizing instead a 28 megawatt power plant and relocation of the power plant and well sites within the Salton Sea KGRA.
2. December 10, 1980, Planning Commission issued an Exploration Permit to Occidental Geothermal for four exploratory wells in East Brawley resource area.
3. December 17, 1980, Planning Commission issued a Geothermal Production Permit to Southern CaliforniaEdison to operate the ten megawatt power plant in the Salton Sea KGRA.
4. December 17, 1980, Planning Commission issued a Geothermal Production Permit to Union Oil Company to allow 16 production/injection wells in Salton Sea KGRA.

B. Board of Supervisors Actions.

1. December 23, 1980, Board of Supervisors appealed Union Oil Company Geothermal Permit for 16 wells in the Salton Sea KGRA. It agreed to hear an appeal by Southern California Edison on their ten megawatt power plant in the Salton Sea KGRA. Hearing

date for these appeals was January 20, 1981, at which time they were permitted.

C. EIR Notice of Exemptions from CEQA

1. Chevron was granted a Notice of Exemption for 21 shallow temperature observation holes (500 feet in depth) on December 1, 1980.

2. Chevron was granted a Notice of Exemption for 25 shallow temperature observation holes (500 feet in depth) on December 22, 1980.

3. On March 30, 1981, Chevron was granted a Notice of Exemption for 24 shallow temperature observation holes (500 feet) and Union was granted a Notice of Exemption for 15 shallow temperature observation holes (1000 feet).

D. Other Geothermal Planning Activities.

1. The Planning Department, after suitable evaluation, selected Westec to prepare the Master EIR for the Salton Sea KGRA. This document will address the genaric accumulative impact of both field and power plant development resulting from up to 1400 megawatts of electrical generating capacity. This effort is jointly funded by CEC and the Geothermal lease holders. The draft is due to be completed by June, 1981.

III. Other Geothermal Activities. This period, five activities are addressed: The Geothermal Direct Heat Study; the Revision Report for the Solid Waste Management Plan; the opening of the Class II-1 disposal site; the Region IX meeting in Tuscon; and USGS designation of two new KGRA's and revision of the Salton Sea KGRA.

A. After competative selection, VTN, Inc. was selected to conduct a Geothermal Direct Heat Study mentioned last quarter. The study will

look at the practical direct heat applications that could be developed in the Imperial Valley and the impacts. The contract was awarded on December 17, 1980. The first part of the direct heat study is subcontracted to the Ben Holt Company. A Status Report indicates they are 40% complete (Appendix C).

B. The Imperial County Solid Waste Management Plan which needs to be updated to address Geothermal waste took the first step by having a revision report submitted on October 24, 1980, to the Solid Waste Management Board. This report will be reviewed and when approved, will form the basis for the changes to the Plan.

C. On December 17, 1980, the IT Corporation commenced operation of a Class II-1 disposal site for Geothermal hazardous waste disposal.

D. On October 28, 29, & 30, 1980, there was a Department of Energy (DOE) Region IX Geothermal Development meeting held in Tucson. This meeting hosted by the University of Arizona, Geothermal Division, provided an opportunity to share the knowledge learned in Geothermal development in each of five states - California, Nevada, Arizona, New Mexico, and Hawaii. In addition, Randy Stevens from the Department of Energy, Washington DC, described the HUD/DOE District Heating and Cooling Request for Proposal (RFP) which would be sent out in November, 1980.

In addition to updating the status of projects in the Imperial Valley, there were speakers who addressed the issues of ethanol, social geothermal concerns, and the problems of geothermal development. One of the presentations emphasized the fact that unlike oil, a bucket of Geothermal steam is not a salable commodity; therefore, even after the resource is identified, effort is needed to bring about ultimate development of the resource.

E. USGS advised us of two new KGRA's, East Brawley, Westmorland, and revision of the Salton Sea KGRA. These are identified in Appendix E. The greatest effect will be in East Brawley, where 70,211 acres will now be in the new KGRA's. Estimated electrical potential has not been determined yet. BLM has just completed an Environmental Assessment (EA) of East Mesa which extends north through the eastern third of the new KGRA. Therefore, competitive bids for the Federal land will be taken in the near future. Three companies are already drilling in the area, so this change could help remove obstacles to full field development. The Westmorland KGRA is 3,200 acres extending south and east of the city of Westmorland (Appendix E). The revision of the Salton Sea KGRA extended the southern border three miles to Walker Road between Benson Road and Forrester Road as shown in the map in Appendix E.

IV. SUMMARY

This semi-annual report was divided into three sections: Geothermal Administration; Geothermal Planning; and, Other Goethermal Activities.

The Geothermal Administration progress is as follows:

Volume 1 and 2 of LLL's summation of data titled An Assessment of Geothermal Development in Imperial Valley of California were received November 10, 1980. The Executive Summary was received in March.

Status of geothermal resource center - completed review of LLL publications and requested missing items. They were received in January and have been cataloged.

Status of field inspections and current progress - Southern California Edison/Union 10 megawatt power plant in Brawley on line. Magma Power 10 megawatt power plant at East Mesa intermittantly on line, mechanical problems with the turbine. McCulloch Geothermal, now called MCR Geothermal Corporation, flow-testing their well at South Brawley, some scaling problems during the tests but tests were completed January, 1981. Republic completed a 30 day flow-test of their wells near Niland east of the Salton Sea KGRA. Phillips Petroleum has completed three wells in East Brawley and plan to flow-test after they design a test system.

Evaluation of cooperative efforts between industry and the County for geothermal development - resurvey of Subsidence Detection Network damaged in the October 1979 earthquake

commenced in November. This will involve three second order leveling crews and two first order leveling crews working until May 1981, covering 438 miles of first and second order lines. This is an effort between many agencies and the County.

There were meetins with several developers on ethanol facilities and greenhouses in Imperial Valley and a final approval of micro-seismic monitoring network for Chevron at Heber.

Problems in geothermal development and recommendations for actions - direct heat development in Imperial Valley is being investigated by VTN, Inc.; feasability of geothermal district heating and cooling has been requested from HUD by three cities in Imperial County; Brawley, Heber, and Calipatria; and Class II-1 geothermal hazardous waste site availability is being studied by the County.

Status of geothermal exploration development and production in the County - two 10 megawatt power plants on line; Southern California Edison at North Brawley, Magma Power at East Mesa. Construction commencing on Magma's 28 megawatt power plant and Southern California Edison's 10 megawatt plant at Salton Sea. Both expected to be on line in 1982. Southern California Edison's 45 megawatt dual-flash plant permitted at Heber scheduled to be on line in 1984. San Diego Gas and Electric's 45 megawatt binary plant is permitted at Heber, construction will start next year and on line by 1984. Republic is working with Los Angeles Department of Water and Power on possible 10 megawatt/48 megawatt power plant at East Mesa.

McCulloch at South Brawley is evaluating their wells. Phillips and Union are drilling wells at East Brawley. First well at Holly Sugar Plant completed. City of El Centro selects H & W Drilling for the geothermal wells needed for the Community Center Heating and Cooling Project. CH2M Hill is conducting a feasability study for a commercial scale methane facility in Imperial County for PG & E and, Southern California Gas. Sperry Corporation at East Mesa has completed all surface work for their down hole project and are awaiting the down hole pump. National Supply Company has opened a geothermal supply office in Imperial County.

The Geothermal Planning progress this period was as follows: Planning Commission approved amendment of the Magma Production Permit to 28 megawatt power plant and relocation of that plant and well sites within the Salton Sea KGRA and issued Exploratory Permits for four additional wells for Occidental Geothermal in the East Brawley resource area.

Board of Supervisors permitted the Union request for 16 wells and the Southern California Edison 10 megawatt power plant in the Salton Sea KGRA, January 20, 1981. EIR Notice of Exemptions were granted to Chevron for 70 shallow temperature observation holes (500 feet in depth) and Union for 15 shallow temperature observation wells (1000 feet). The Planning Department selected Westec to prepare the Master EIR for the Salton Sea KGRA (1400 megawatt capacity). This effort is jointly funded by California Energy Commission and geothermal lease holders and the draft is due to be completed June, 1981.

The Other Geothermal Activities were as follows:

The Geothermal Direct Heat Study was awarded to VTN (Phase 1 and 2 of the study are 40% complete - Appendix C). A revision report for the County Solid Waste Management Plan was submitted to the Solid Waste Management Board; IT Corporation opened their Class II-1 disposal site on December 17, 1980; Department of Energy Region IX, held a Geothermal Development meeting October 28, 29, and 30 in Tucson where the status of Imperial County Geothermal development was discussed. In addition, the Department of Energy Washington representatives discussed the new HUD/DOE District Heating and Cooling Request for Proposals which were due in January 16, 1981. Three proposals were submitted: Brawley, Heber, and Calipatria. Lastly, USGS designated two new KGRA's, East Mesa KGRA, Westmorland KGRA, and revised the southern border of the Salton Sea KGRA by extending part of it south three to four miles to Walker Road.

In conclusion, efforts both in electrical and direct heat applications are progressing with two more power plants beginning construction, two more within site, and drilling commencing on direct heat projects. The future of geothermal can be seen. Southern California Edison is deeply committed to geothermal as a viable alternate energy source and as Mr. Hadley, Chairman of Union Oil, said, Imperial County may become the Saudi Arabia of hydro-thermal energy (geothermal energy from hot water versus steam).

Union Oil Company of California
Southern California Edison Company

BRAWLEY GEOTHERMAL-ELECTRIC DEMONSTRATION PROJECT TECHNICAL FACT SHEET

Project Location:	Imperial County, California; two miles north of Brawley on Highway 111.
Union Leases:	Approximately 10,000 acres of potentially productive geothermal lands in the Brawley area. Total area for demonstration project is 12 surface acres.
Number of wells drilled to date in Brawley area:	Nine
Number of producing wells for this project:	Four producing, four injection wells and one alternate.
Deepest well drilled:	8,077 feet
Average production per well:	37,500 bbls/day of geothermal fluids.
Average steam production per well:	67,500 pounds/hour or roughly at 15 percent steam fraction.
Average drilling time per well:	30 days
Average cost per well:	$750,000
Average temperature of reservoir fluids:	475°F. to 525°F.
Total dissolved solids in reservoir fluids:	50,000 to 250,000 parts per million.
Steam production system:	Flashed steam
Average steam requirement:	209,000 lb/hr
Average temperature of steam at turbine:	340°F.
Average steam pressure:	115 lbs per square inch absolute

Fact Sheet - 2

Turbine type:	10,000 kilowatt, 3600 rpm, single flow, single cylinder unit with five impulse stages.
Condenser:	Shell and tube made of corrosion resistant stainless steel.
Cooling Water System:	Conventional two-cell, induced draft, counterflow, wet cooling tower with rated heat load of 200 MM Btu/hr.
Plant economics:	Net plant heat rate is 28,000 Btu/kwhr. Capital cost of the plant is $11 million and total project cost, including prior research work, is approximately $16.3 million. Cost of power generated by the plant is forecast to be about 17 cents per kilowatt hour (30-year levelized)
Customer for electricity:	Electricity generated by the demonstration project will be sold to the Imperial Irrigation District for use in the Imperial Valley.

STATE OF CALIFORNIA—RESOURCES AGENCY EDMUND G. BROWN JR., Governor

DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS
1416 – 9th STREET, ROOM 1316
SACRAMENTO, CALIFORNIA 95814
(916) 445-9686

October 10, 1980

Mr. Dutch Scholz
Imperial County Geothermal Coordinator
Courthouse
El Centro, CA 92243

Dear Mr. Scholz:

On September 22, 1980, the Geothermal Subsidence Detection Committee held a meeting at the Imperial County Airport Conference Room. The purpose of this meeting was to discuss and make recommendations concerning the proposed releveling of portions of the Imperial County Ground Movement Net. The meeting was called by the State Oil and Gas Supervisor and his representative, Mr. Doug Stockton. To date we have secured the following contributions:

PUBLIC AGENCY	FUNDS COMMITTED
Federal Emergency Management Administration (FEMA)	$ 60,000+
U.S. Geological Survey (USGS)	25,000+
Lawrence Berkeley Laboratory (LBL/DOE)	50,000
California Division of Oil and Gas (CDOG)	5,000
California State Lands Division (SLD)	5,000
California Department of Water Resources (DWR)	5,000
California Energy Commission (CEC)	5,000
Imperial Irrigation District (IID) (IN KIND)	10,000
Imperial County	?
Los Angeles Department of Water and Power	?
Bureau of Land Management (BLM)	?
Total Funds Committee, Public Agencies	$165,000

PRIVATE/UTILITY COMPANIES	FUNDS COMMITTED
MAPCO/Republic Geothermal	$ 15,000
Chevron USA, Inc.	15,000
Union Oil Company	15,000
Geothermal Kinetics Inc./MCR	15,000
Imperial Magma	?
Occidental Geothermal, Inc.	?

PRIVATE/UTILITY COMPANIES	FUNDS COMMITTED
Phillips Petroleum Company	7,500
Electric Power Research Institute	?
Southern Cal Edison/Mono Power Southern Pac. Lands	?
San Diego Gas & Electric (NARCO) (IN KIND)	?
Imperial Valley Farm Bureau	?
Total Funds Committed, Industry	$ 67,500

The costs of the first and second order surveys are as follows:

FIRST ORDER SURVEY

Surveying Agency/Company	Miles & Cost/Mile	Cost	FEMA Funds
National Geodetic Survey (NGS)	88 @ $700	$ 61,600	(17 mi. FEMA = $11,900)
Imperial County	69 @ $600	$ 41,400	(33 mi. FEMA = $19,800)
Riverside County	38 @ $650	$ 24,700	
TOTALS	195 miles	$127,700	(50 mi. FEMA = $31,700)

SECOND ORDER SURVEY

Imperial Irrigation District	92 @ $500	$ 46,000	
Water & Power Resource Services	56 @ $450	$ 25,200	
Private Company	53 @ $550	$ 29,150	
Private Company	*42 @ $550 (FEMA)	$ 23,100	
TOTALS	243 miles	$123,450	(42 mi. FEMA = $23,100)

* Total FEMA funds: 92 mi. @ $54,800

Totals for first and second order	438 miles	$251,150
Coordination cost		$ 6,000
Total Surveying Costs		$257,150

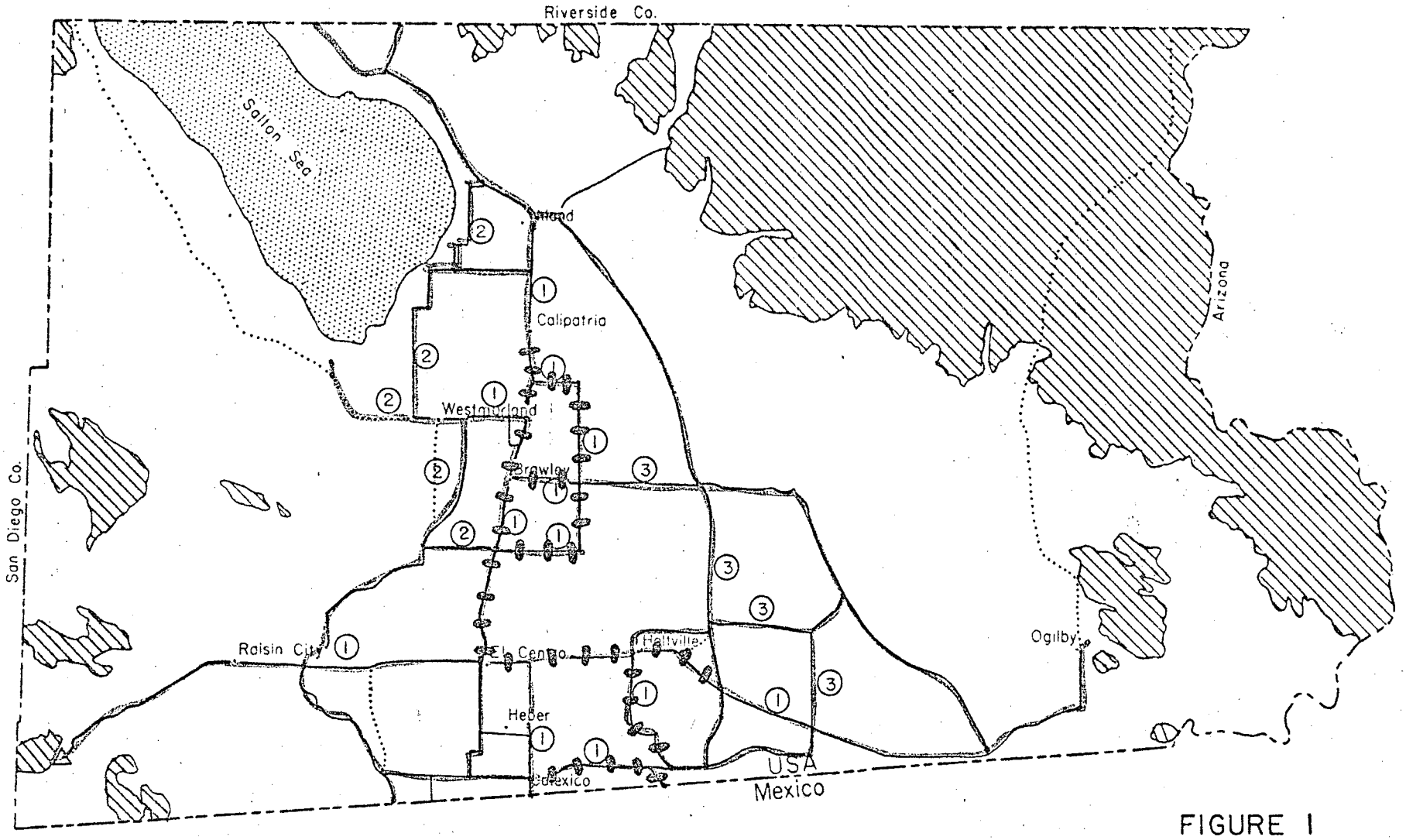
Subtracting the public agency funding from the total surveying costs of $257,150 - $165,000, a balance of $92,150 is needed from private sources. Currently, the private sector has committed funds in the amount of $67,500.

The accompanying map shows the proposed first (green) and second (red) order survey lines and their respective priorities. The hachured lines will be funded by FEMA. The funds committed for the resurvey will be disbursed according to the priorities established by the Imperial Valley Subsidence Detection Committee on December 6, 1979.

The California Division of Oil and Gas and the members of the sub-committee of the Imperial Valley Subsidence Detection Committee urge all members to phone in their pledge by October 15 and send in their respective contribution by November 1, 1980 to Bob Estes, County of Imperial, Department of Public Works, Courthouse, El Centro, California. The money will be deposited in a trust account which can only be used for the resurvey of the level net agreed upon by the committee members in December 1979. Any excess funds will be disbursed in accordance with conditions approved by the committee. The contracts written for each participating member will incorporate the appropriate language. The County, acting as the repository for the trust account, will write contracts with each contributing company/agency and each party doing the surveying.

A. D. Stockton
Division of Oil and Gas

Robert C. Erickson
Chevron USA, Inc.



LEGEND

FIRST ORDER SURVEYS
SECOND ORDER SURVEYS
(1) PRIORITY
ESTABLISHED LINE SURVEYED
ESTABLISHED LINE NOT SURVEYED
△ DATUM BENCH MARK Y58

FIGURE 1
IMPERIAL COUNTY
LOCATION OF PRECISE LEVEL TRAVERSE LINES FOR THE YEAR 1976-1977

0 5 10 15 20

GEOTHERMAL SUBSIDENCE DETECTION COMMITTEE

October 7, 1980

A. M. Cooper
Chevron, USA
575 Market Street, Room 1986
San Francisco, CA 94105
(415) 894-2116

Robert C. Erickson
Chevron, USA
575 Market Street, Room 1986
San Francisco, CA 94105

Alan V. Lattanner
Union Oil Company of California
2099 Range Avenue
Santa Rosa, CA 95401
(707) 542-9543

Jesse Silva
Imperial Irrigation District
P. O. Box 937
Imperial, CA 92251
(714) 355-1112

Terry Paxton
Imperial Irrigation District
P. O. Box 937
Imperial, CA 92251

Olin Whitescarver
Union Geothermal
135 Main Street
Brawley, CA 92227
(714) 344-7170

T. C. Hinrichs
Magma Electric
P. O. Box 325
Holtville, CA 92250
(714) 356-4635

Don Lande
Division of Oil and Gas
5199 Pacific Coast Highway
Long Beach, CA 90804
(213) 590-5311

E. J. Woody Ennis
California Energy Commission
1111 Howe Avenue
Sacramento, CA 95825
(916) 920-7313

J. F. Dietz
San Diego Gas & Electric Company
P. O. Box 1831
San Diego, CA 92112
(714) 235-7767

Richard D. Mitchell
Imperial County Planning Director
Courthouse
El Centro, CA 92243
(714) 352-8184

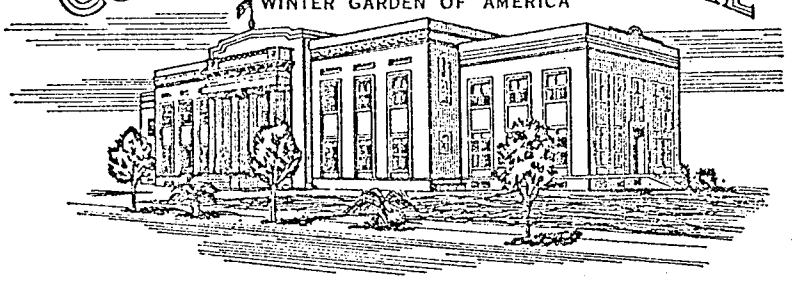
Dutch Scholz	Imperial County Geothermal Coordinator Courthouse El Centro, CA 92243 (714) 352-2851
David E. Pierson	Imperial County Public Works Director Courthouse El Centro, CA 92243 (714) 352-2851
Bob D. Estes	Imperial County Assistant Surveyor Courthouse El Centro, CA 92243 (714) 352-2851
Ken Doering	U.S. Department of the Interior Bureau of Reclamation Bin 5569 Yuma, AZ 85364 (602) 726-2531
D. E. Pyle	Union Oil Company P. O. Box 7600 Los Angeles, CA 90051 (213) 486-7600
Eric Stenstedt	Southern Pacific Land Company 65 Market Street San Francisco, CA 94105 (415) 362-1212 Ext. 22051
Neil Crow	Lawrence Livermore Laboratory P. O. Box 808 Livermore, CA 94550 (415) 422-6467 or 422-0926
Russ H. Robinson	Mono Power Company P. O. Box 800 Rosemead, CA 91770 (213) 572-2992
Ray Chantler	McCulloch Geothermal Corporation 10880 Wilshire Blvd. Los Angeles, CA 90024 (213) 879-5252
Francis S. Riley	U.S. Geological Survey Bldg. 25, M.S. 404 Federal Center Lakewood, CO 80225 (303) 837-4169
Bruce L. Massey	U.S. Geological Survey P. O. Box 25046, M.S. 404 Federal Center Denver, CO 80225 (303) 234-2700 or (home) 331-7915

Dwight Carey	Republic Geothermal, Inc. 11823 E. Slauson Avenue, Suite 1 Santa Fe Springs, CA 90670 (213) 945-3661
James L. Mulloy	Los Angeles Department of Water and Power P. O. Box 111, Room 1155 Los Angeles, CA 90051 (213) 481-8679
Sam Sugine	Los Angeles Department of Water and Power P. O. Box 111, Room 1155 Los Angeles, CA 90051
Kent Murray	California Energy Commission 1111 Howe Avenue Sacramento, CA 95825 (916) 924-2323
Richard Foss	Magma Energy, Inc. 631 S. Witmer Street Los Angeles, CA 90017 (213) 483-5542
Norman Goldstein	Lawrence Berkeley Laboratory Building 90, Room 1012B One Cyclotron Road Berkeley, CA 94720 (415) 486-5961
Bob Sterrett	Lawrence Berkeley Laboratory Building 90, Room 1012B One Cyclotron Road Berkeley, CA 94720
Don Everitts	State Lands Division 100 Oceangate, Suite 300 Long Beach, CA 90802 (213) 597-5205
Garry Dobbs	MAPCO Geothermal, Inc. 1800 S. Baltimore Avenue Tulsa, OK 74119 (918) 584-4471
Roger Haskins	Bureau of Land Management 1629 Main Street El Centro, CA 92243 (714) 352-5842
Joe Edney	Bureau of Land Management 1629 Main Street El Centro, CA 92243

Bruce Wyant	Occidental Geothermal, Inc. 5000 Stockdale Highway Bakersfield, CA 93309 (805) 327-7351
Paul English	Phillips Petroleum Company P. O. Box 239 Salt Lake City, UT 84110 (801) 364-2083
Larry Grogan	New Albion Resource Company P. O. Box 168 San Diego, CA 92112 (714) 232-4252 Ext. 2156
Henry Struckmeyer	Department of Water Resources 1416 Ninth Street, Room 445 Sacramento, CA 95814 (916)322-0447
Tom Greene	Department of Water Resources 1416 Ninth Street, Room 445 Sacramento, CA 95814

DAVID E. PIERSON
DIRECTOR OF PUBLIC WORKS
COUNTY ROAD COMMISSIONER
COUNTY SURVEYOR
COUNTY ENGINEER

COUNTY OF IMPERIAL
THE WINTER GARDEN OF AMERICA



TELEPHONE
714-352-2851

DEPARTMENT OF PUBLIC WORKS
COURTHOUSE
EL CENTRO, CALIFORNIA

March 31, 1981

Board of Supervisors
Imperial County
Courthouse
El Centro, CA 92243

SUBJECT: Status Report on VTN, Geothermal Direct Heat Study

Gentlemen;

As you will recall the contract for this Department of Energy Funded Study, was awarded to VTN on December 16, 1980. This is the first status report on the study.

The first phase of the study was subcontracted to the Ben Holt Company, It consisted of two parts: 1. Compulation of the master list of direct heat uses relevant to Imperial Valley. 2. Compute potential capitol and operating cost and estimated energy savings. A preliminary catagorical list was prepared and submitted to the ethanol committee last month. After discussion and minor modification the enclosed topics were agreed upon for investigation.

John Brugman, the project manager for Ben Holt Company, stated that phase one was 40% complete and on budget. The literature search for all applications in our areas of concern is complete. 70% of the reference bibliographies are on hand now and the rest are on order. Phase one should be completed in June, 1981.

The study completion date is December, 1981. Since the Department of Energy funds for this project are obligated even if it goes into the next fiscal year the time schedule is not as critical as the budget ceiling. If there are any major changes in this budget, you will be advised immediately.

Sincerely yours,

DAVID E. PIERSON
Director of Public Works

kk

VTN

Engineers · Architects · Planners

VTN CONSOLIDATED, INC.
Post Office Box C-19529
2301 Campus Drive
Irvine, California 92713
(714) 851-5200

March 31, 1981

AG 657-3

Mr. David E. Pierson
Director of Public Works
County of Imperial
Courthouse
El Centro, CA 92243

Subject: Quarterly Progress Report for the Period Ending March 31, 1981 Geothermal Heat Application Study

Dear Mr. Pierson:

The following summarizes the work which has been completed through March 31, 1981, on the Direct Geothermal Heat Application Study.

Introduction

The VTN/Ben Holt Team initiated work on the study in the latter part of January. The initial work has been undertaken by Ben Holt Co. for Tasks 1 and 2.

Tasks Completed

1. Study Outline/Table of Contents

The Table of Contents for the study has been completed. The initial Table of Contents was revised based on our informal discussion of February 17, 1981. The Table of Contents outlines the work which will appear in both Tasks 1 and 2 and is attached.

The VTN/Ben Holt Project Team is proceeding based on the outline.

2. Literature Search and Bibliography

A comprehensive literature search and bibliography compilation has been completed. The purpose of this task was to review all currently available literature on direct use applications of geothermal energy. The Ben Holt Co. internal library was utilized as an initial source for this search. The primary listing of literature was developed from the Department of Energy Geothermal Update publications. The literature search was completed and categorized by the topics shown in the Table of Contents. Approximately 70% of the material referenced in the bibliography is currently on file in the Ben Holt Co. library.

3. Initiation of Project Contacts

For each major area of interest defined in the Table of Contents, the VTN/Ben Holt Co. Team will be contacting firms and agencies in the specific area of study. Initial contact was made with Colorado State University, which is conducting research on ethanol production. This study is significant because it focuses on use of agricultural waste products, such as straw and corn stover in the production of ethanol. Focus on this area is important because a high percentage of the cost of production of ethanol is in the feedstock. The Colorado State University study focused on the direct application of geothermal fluid to break down the cellulose in the straw to glucose which can later be fermented into ethanol. Potentially, the use of low cost agricultural waste products would decrease the overall cost of the ethanol produced.

The Colorado State University study has been primarily directed to the theoretical aspects of this process and has not focused on the practical engineering concerns which may be encountered. Additional information and completed study papers to date are being sent from Colorado State University.

Tasks to be Completed

1. Other Project Contacts

Contacts with other firms and agencies doing studies using geothermal heat will be completed in the coming quarter. The initial effort will be directed toward food processing. Contact will be made with Magma Power Company, which has a project in Nevada to dry onions from geothermal.

Contacts will be made with firms and agencies doing work in the aquaculture area. Based on initial review, it appears as if water quality is a critical issue in the use of geothermal fluid in certain aquaculture production. This factor is especially important with catfish production where controlled water quality conditions are critical. The use of aquaculture for prawn production may be more feasible since water quality does not appear to be such an important factor.

Contact will be made with the firm doing aquaculture studies in Mecca near Indio, California.

2. Other Tasks

In addition to these project contacts, other research in the areas set forth in the Table of Contents will be undertaken in the coming quarter.

Very truly yours,

VTN CONSOLIDATED, INC.

John L. Sakaguchi

JLS:glw

cc F.A. Scholz
J. Brugman, Ben Holt Co.

GEOTHERMAL HEAT APPLICATION STUDY

PRELIMINARY TABLE OF CONTENTS

Preliminary Table of Contents (continued)

Geothermal Resources Council, **TRANSACTIONS**, Vol. 3, 9/3/79

GRAVITY-HEAD GEOTHERMAL ENERGY CONVERSION SYSTEM

Hugh B. Matthews
Warren D. McBee

Sperry Research Center
100 North Road
Sudbury, MA 01776

Project sponsored by
U.S. Department of Energy
Division of Geothermal Energy

ABSTRACT

A novel electric power generating system for low-temperature hot water geothermal resources is described. This so-called "gravity-head" system is a binary plant with the primary heat exchanger in the production well to a depth of 2000 feet. This configuration results in a novel heat-engine cycle which eliminates the "pinch effect" in the primary heat exchanger and the working fluid feed pump and provides a major decrease in brine pumping power. The net effect is a 37% increase in net electric output power over a "conventional" binary plant under equivalent conditions and costs.

INTRODUCTION

Hot-water geothermal resources in the 250°F to 400°F temperature range have been little-used for electric power generation. A major reason for this is the low efficiency of existing utilization technology, which leads to high plant and well costs per kilowatt and large brine consumption per kilowatt-hour. This is so even for binary plants, which offer the best efficiency.

Sperry Research Center is engaged in a program under DOE sponsorship to experimentally test a novel concept called a "gravity-head system" for a binary plant, which promises a 37% increase in net electric output power over a conventional binary plant under equivalent conditions at the same, or somewhat less, cost for plant plus wells.

In this paper we first describe a "conventional" binary plant and discuss some of the limitations on its output power. Then we will describe the gravity-head system and its features which increase net output power.

THE "CONVENTIONAL" BINARY PLANT

For purposes of discussion, assume a hot water geothermal resource capable of providing 1000 GPM of brine flow rate from one production well with a down-hole pump at about 1500 ft. depth adding 250 psi pressure at a brine temperature just below the pump of 350°F. Also assume a wet-bulb temperature of 50°F. Further, assume reinjection of brine with an additional 250 psi pressure added to the brine on the surface for transport and reinjection.

A schematic diagram for this plant is shown in Fig. 1.

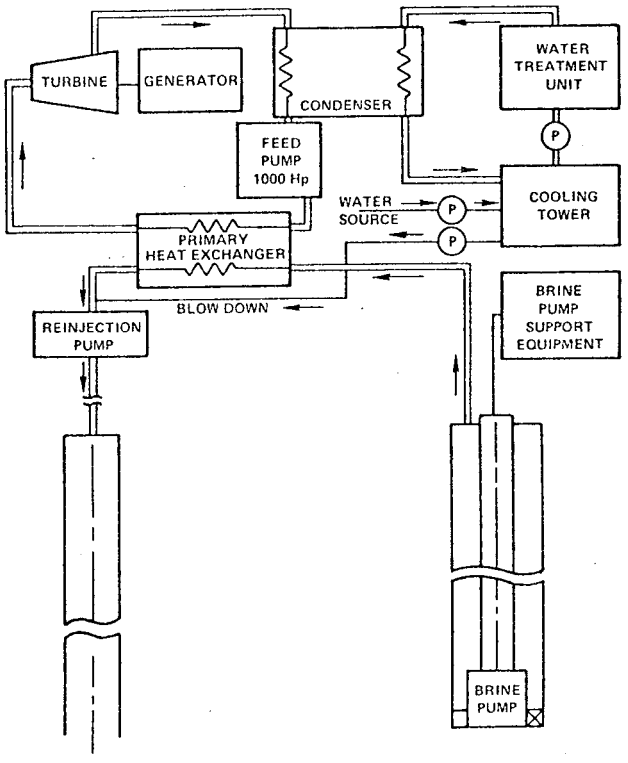


Fig. 1 Conventional organic Rankine cycle

There is a brine pump in the production well and support equipment for it on the surface. The purpose of the pump is to add pressure to the brine to prevent its flashing into steam or evolving CO_2 as it loses its pressure in approaching the surface.

The brine then passes through the primary heat exchanger where its heat is transferred into an organic working fluid. The cooled brine is then reinjected into the ground in another well, after additional pressurization from a surface reinjection pump.

Matthews et al.

The principal components of the organic fluid cycle are, as shown, the feed pump, one side of the primary heat exchanger, the turbine, and the condenser.

The feed pump increases organic pressure from 30 psi at condenser-outlet to 900 psi into the heat exchanger. It typically consumes 20% of the gross output power of the system.

The turbine, because of the high energy density of the organic fluid, will be a fraction of the size of an equivalent steam turbine operating at the same low temperatures.

The condenser is a conventional shell and tube design with the organic condensing on the outside of the tubes and the cooling water inside the tubes. The cooling tower is also conventional.

Fig. 2 is a pressure-enthalpy diagram of R-114 fluid ($C_2Cl_2F_4$) with a supercritical Rankine cycle superimposed. R-114 is used here, since it has qualities desirable for the gravity-head system to be described later, and we wish to be able to make direct comparisons. Isobutane was analyzed under the same circumstances, and was somewhat less efficient. The operating parameters assumed are as follows:

Well Flow	1,000 GPM
Brine Temperature	350°F
Wet-Bulb Temperature (This would be an average throughout the West, not the worst case which would be over 80°F).	50°F

The processes are as follows:

1-2	Feed pump work
2-3	Heat added at constant pressure
3-4	Expansion in turbine
4-1	Heat rejected to atmosphere

The turbine, of course, drives the alternator which, in turn, furnishes the energy for the auxiliaries including the feed pump, cooling pumps and fans , and the brine pump (except in the case of a Sperry pump, which is a self-contained system).

Fig. 3 is a heat transfer diagram of the Fig. 1 system. It has the normal design goals of 20° mean effective temperature difference in the primary heat exchanger; 20° average temperature difference in the condenser; a 10° approach of the exit cooling tower water to the wet-bulb temperature; and 20° ΔT between the brine entering the heat exchanger and the working fluid leaving at the peak of its cycle.

The 10° ΔT which results from the feed pump work represents a loss in overall efficiency.

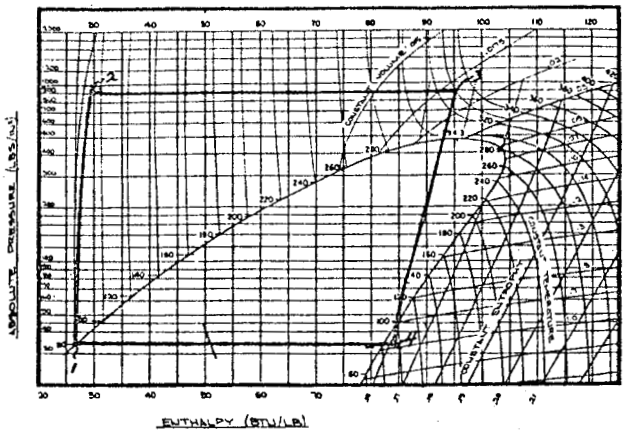


Fig. 2 Cycle diagram for conventional Rankine cycle-R114 fluid

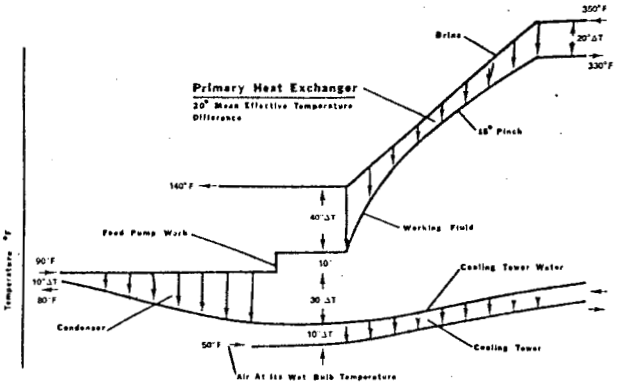


Fig. 3 Heat transfer diagram Conventional binary system

The pinch effect in the primary heat exchanger is caused by the heat capacity variation of the R-114 at constant pressure.

The problems in the binary system which are alleviated by the gravity-head system are as follows:

- The large portion of the available power used by the brine pumps and feed pump in a binary system.
- The "pinch effect" - a loss in available energy in transferring heat from water to an organic fluid at constant pressure.
- The cost of the feed pump and heat exchanger shell.
- The lost temperature rise in working fluid produced by feed pumping.

THE GRAVITY-HEAD SYSTEM

Fig. 4 is a simplified schematic of the gravity-head cycle. In this system, heat transfer between the brine and the organic takes place entirely in the production well from the brine flowing upward in the outside annulus to organic fluid flowing downward in the second annulus. Thus, the brine arrives at the surface cold, requiring no pressurization to prevent it from flashing, but merely sufficient pressure to reinject it into another well. The organic arrives at the bottom of its downward path hot. The organic is then routed through a small turbine driving a brine pump, where a small portion of its thermal power is extracted. It then returns to the surface in an insulated riser, drives the power generating turbine on the surface, condenses in an evaporative condenser, and then returns to the primary heat exchanger input at well-head.

Fig. 5 shows the gravity-head cycle superimposed on the same R-114 pressure-enthalpy diagram of Fig. 2. The assumed operating parameters are the same. An important difference between the two cycles is obvious. In the Rankine cycle, the heat is added at constant pressure, whereas in the gravity-head cycle, the heat is added at a constantly increasing pressure. In other words, heat is added to the fluid as it flows down the 2000-foot vertical heat exchanger with a constantly increasing pressure due to the gravity head.

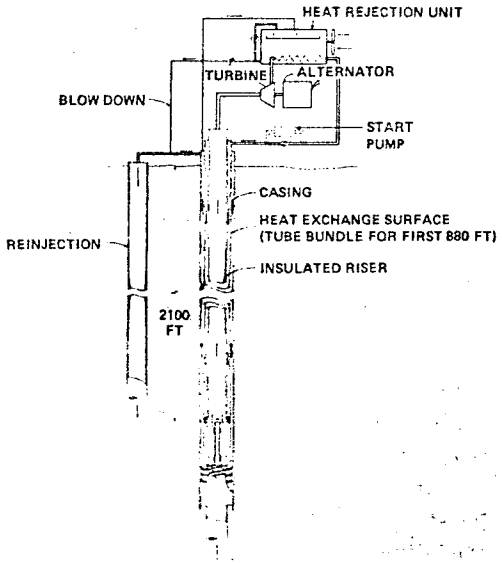


Fig. 4 Gravity-head system schematic

The processes are as follows:

1-2 Heat input to working fluid from brine. Also, there is an added enthalpy (heat energy) contribution due to the potential energy of the fluid (energy due to height) being transferred into heat energy as the fluid flows down. This is the Z/J term in the general energy equation.

2-3 Down-hole brine-pump turbine work.

3-4 Lift work. This is the inverse of the process of 1-2 in which enthalpy is being transferred back into potential energy.

4-5 Expansion in surface turbine to drive alternator.

5-1 Heat rejected to atmosphere in an evaporative condenser.

The path of process 1-2 can be altered within limits by varying the amount of heat transfer surface per foot of depth. The one shown has a nearly constant heat capacity for the R-114. This means that the pinch effect with its attendant loss in available energy is eliminated.

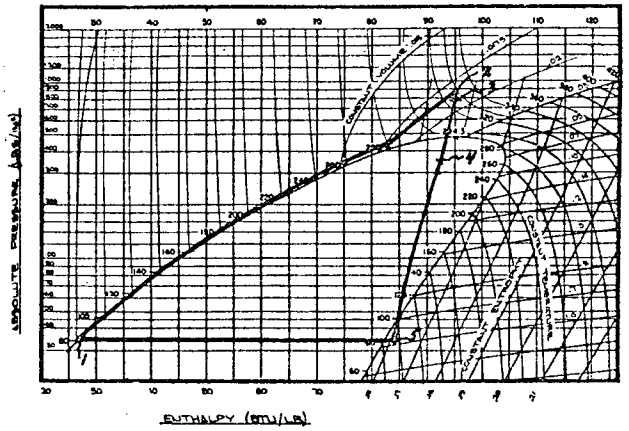


Fig. 5 Cycle diagram for Gravity-head system - R114 fluid

Fig. 6 is the heat transfer diagram of the gravity-head system, showing the elimination of the pinch effect and the 10° ΔT during feed pumping and a total 30° ΔT between wet bulb and condensing temperature rather than the 40° ΔT, which is the reasonable minimum of a heat rejection system composed of a separate cooling tower and condenser. The net effect is that the brine is rejected at 100°F, compared with 140°F for the conventional binary system.

The down-well heat exchanger design may be of interest. The system parameters on which the design is based are as follows:

Well Flow	1,000 GPM
Well Temperature	350°F
Wet-Bulb Temperature	50°F
Working Fluid (Dichlorotetrafluoroethane)	R-114
Working Fluid Flow	479 lbs./sec.
Flow Losses	50 psi in all three conduits

As mentioned previously, the desired curve on the heat transfer diagram is obtained by varying

the heat transfer surface per foot of depth. Fig. 7 is a table listing this variation. The design fouling factor was .0015 on the brine side and .0005 on the organic side. Fluid velocities were chosen as a compromise between low flow losses, high heat transfer coefficients, low fouling rates and small well casing size; they vary from 1.75 ft./sec. at the top to 5 ft./sec. at the bottom for the brine and approximate 5 ft./sec. in all sections for the organic. Heat transfer coefficients approximate 150 BTU/HR-FT^2-^{o}F in all sections.

Fig. 8 is the design of one of the tube bundle sections. It has been checked with heat-exchanger manufacturers and seems quite feasible.

The planned well casing profile to accommodate this heat exchanger design is 30" O.D. to 1000 ft., then 24" O.D. to 2200 ft., then conventional size to well bottom.

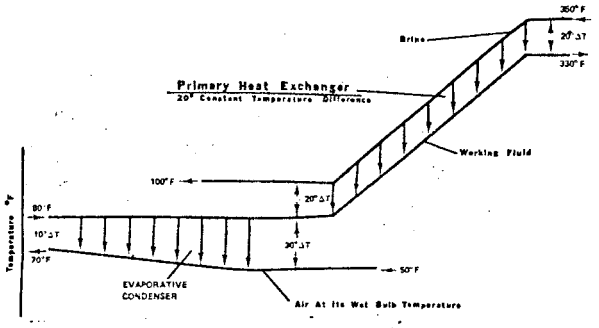


Fig. 6 Heat transfer diagram Gravity-head system

	Length of Heat Exchanger Section	Surface Area Per Foot of Depth	Cumulative Depth of Sections	Cumulative Surface Area
Tube Bundles	200 ft.	102 ft.^{2}/ft.	200 ft.	20,500 ft.^{2}
	160 ft.	51 ft.^{2}/ft.	360 ft.	29,700 ft.^{2}
	240 ft.	16 ft.^{2}/ft.	600 ft.	32,400 ft.^{2}
	280 ft.	13 ft.^{2}/ft.	880 ft.	36,000 ft.^{2}
Annular Sections	1,120 ft.	5.5 ft.^{2}/ft.	2,000	42,200 ft.^{2}

Fig. 7 Gravity-head heat exchanger Design parameters

SYSTEMS COMPARISONS

The performance comparison between the gravity-head system and the conventional binary system is shown in Fig. 9. Note the 37% larger net electric output power from the gravity-head system. This is almost entirely due to four advantages:

- o Elimination of pinch effect
- o More efficient brine pumping
- o Elimination of mechanical feed pump
- o Use of evaporative condenser for heat rejection.

Cost comparisons are inexact. However, the increased cost of the larger production well required for the gravity-head system is offset by elimination of the mechanical feed pump, the primary heat exchanger shell, and the brine pump support equipment. We think the combined cost of plant and wells will be less for the gravity-head plant per unit of brine flow rate, in which case the $/KW advantage would be greater than 37%. Another way of looking at the comparison in cost-performance between the gravity-head plant and the conventional binary plant is that if one assumes equal cost per unit brine flow rate and equal brine flow rate, the gravity-head plant would produce with a brine temperature of 350^{o}F the same net electric output power as a conventional binary plant with a brine temperature of 400^{o}F.

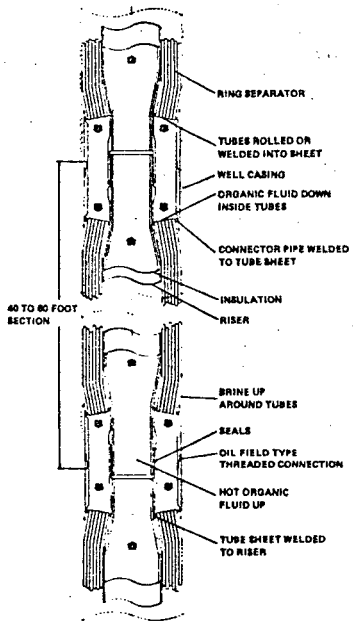


Fig. 8 Gravity-head heat exchanger schematic of one tube bundle section

	Binary Plant (Fig. 1)	Gravity-Head Plant (Fig. 5)
Well Flow	1,000 GPM	1,000 GPM
Well Head Temperature	350^{o}F	100^{o}F
Heater Inlet Temperature	350^{o}F	352.7^{o}F
Log Mean Temperature Difference in Heater	20^{o}F ΔT	20^{o}F ΔT
Working Fluid	R-114	R-114
Wet Bulb Temperature	50^{o}F	50^{o}F
Condensing Temperature	90^{o}F	80^{o}F
Brine Pump Type	Hydraulic, shaft or electric	Sperry
Brine Pump ΔP	250 psi	400 psi
Brine Pump Efficiency	28%	56%
Reinjection Pump ΔP	250 psi	100 psi
Reinjection Pump Efficiency	56%	56%
Surface Turbine Efficiency	85%	85%
Alternator Efficiency	96.2%	96.2%
Cooling Tower Work	.312 MW	.354 MW
Working Fluid Flow	419 lbs./sec	481 lbs./sec.
Net Electrical Output	3.08 MW	4.21 MW

Fig. 9 Performance comparison Gravity-head vs conventional binary

IMPERIAL COUNTY

INTER-OFFICE MEMO

DATE May 12, 1981

TO: Files

FROM: Fm. "Dutch" Scholz

SUBJECT: Locations of East Brawley and Westmorland KGRA's, and additions to Salton Sea KGRA.

The enclosed maps and plats show the locations of the East Brawley and Westmorland KGRA's and the additions to the Salton Sea KGRA. These were received May 11, 1981, from USGS.

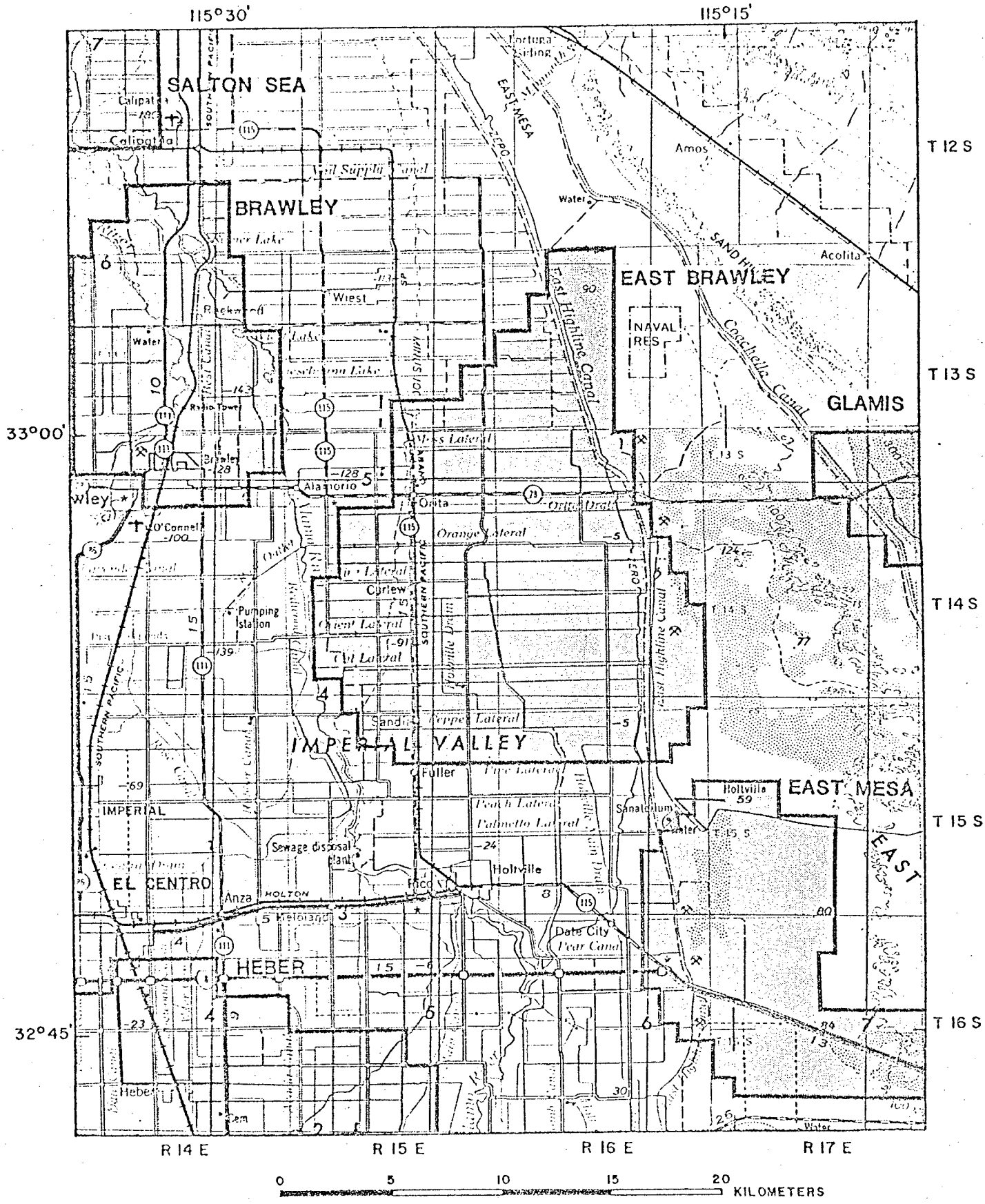
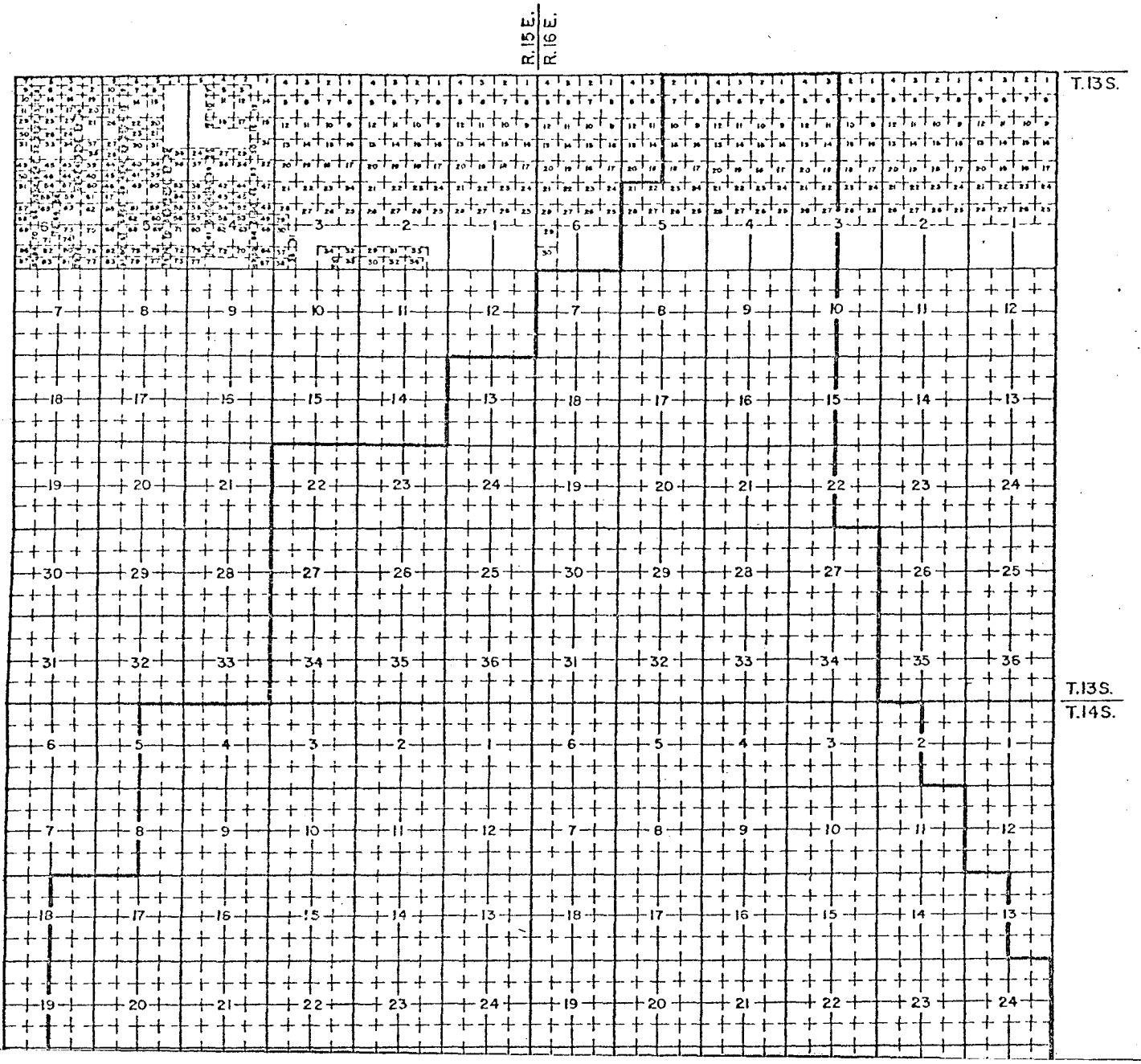


Figure 1. Location of the East Brawley KGRA and neighboring KGRA's (shaded pattern) in the Imperial Valley of the Salton Trough, southern California.

T.13 - 15 S., R.15 - 16 E., San Bernardino Meridian, California

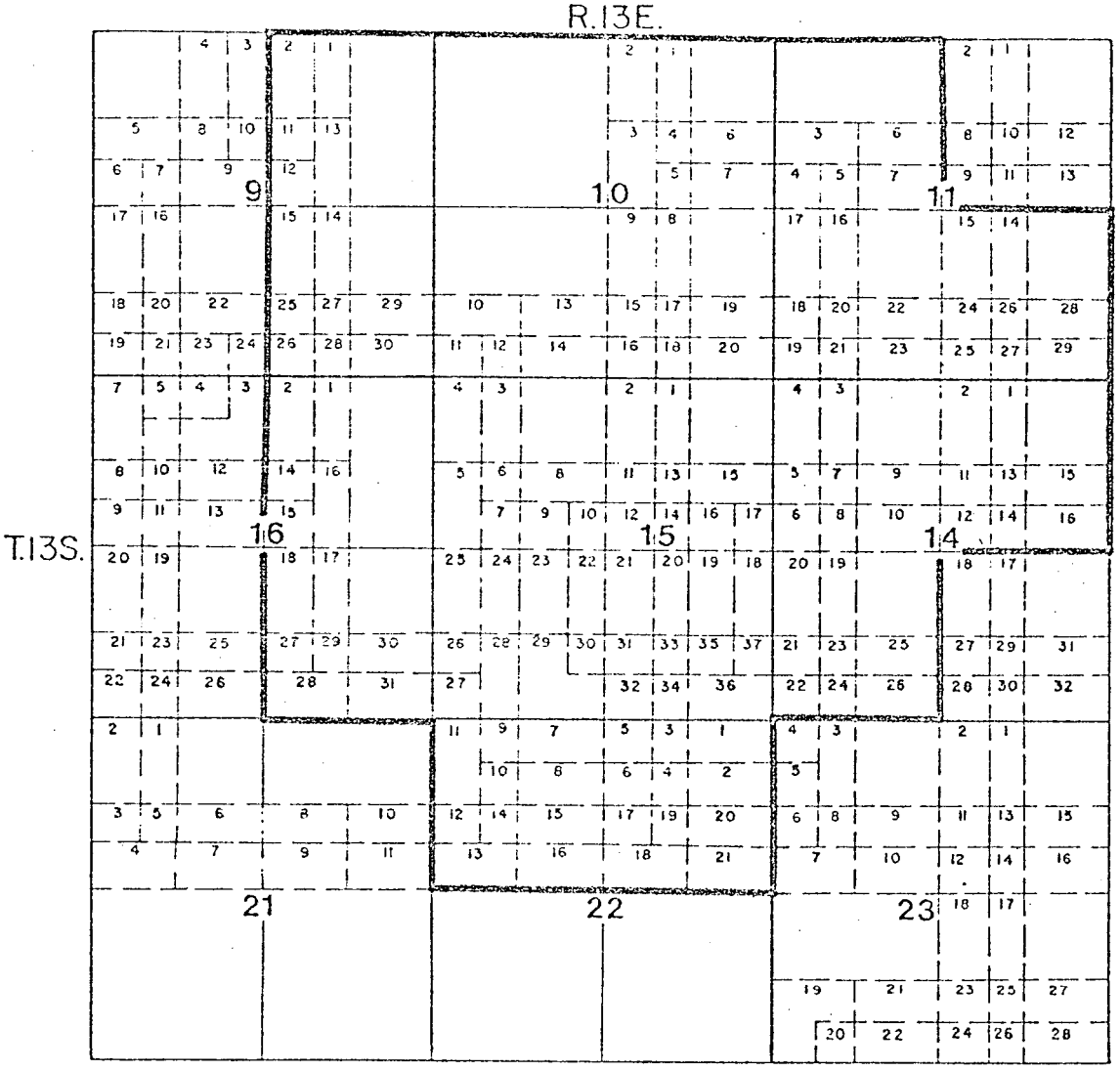
Appendix E-3

East Brawley KGRA



WESTMORLAND K.G.R.A.

T.13S., R.13E., San Bernardino Meridian, California



Pursuant to the authority vested in the Secretary of the Interior by Sec. 21(a) of the Geothermal Steam Act of 1970 (84 Stat 1566, 1572; 30 U.S.C. 1020), and delegations of authority in 220 Departmental Manual 4.1H. Geological Survey Manual 220.2.3, and Conservation Division Supplement (Geological Survey Manual) 220.2.1G, I define the

WESTMORLAND

known geothermal resources area as indicated hereon, effective July 30, 1980

Previously defined	0
Defined this action	3,200
Total defined acres	3,200

Acting Conservation Manager
U.S. Geological Survey
Aug. 25, 1980 Date

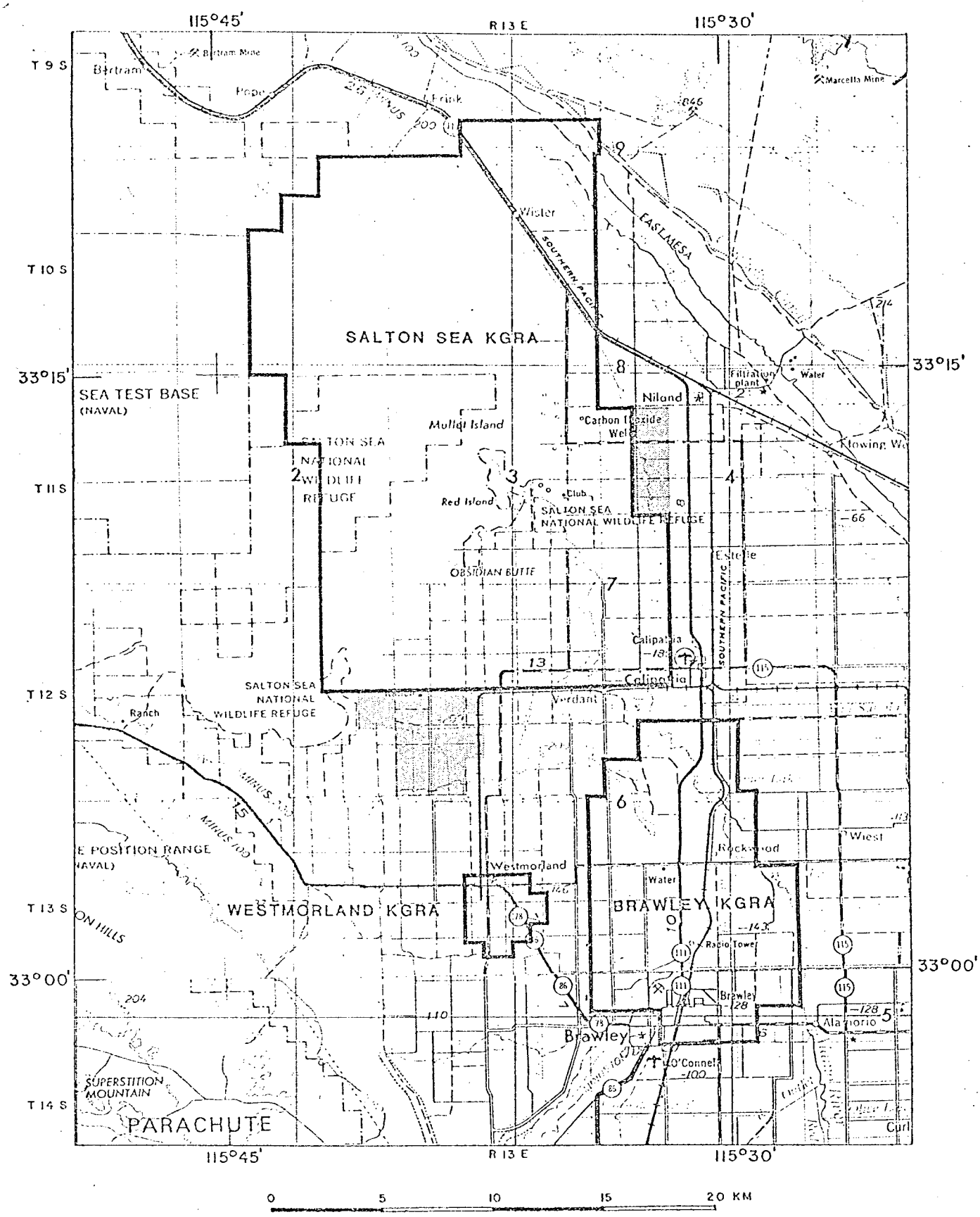


Figure 1. Location of the Brawley, Salton Sea, and Westmorland KGRAs, Imperial County, California. Lands added to the Salton Sea KGRA are shaded.