GL00538

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Report of the Second Quarter

FY 1987

July 1987

U.S. DEPARTMENT OF ENERGY
Office of Renewable Energy Technologies
Geothermal Technology Division

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Tenth Quarterly Progress Report:
Report of the Second Quarter
(January through March)
FY-1987

JULY 1987

U.S. Department of Energy
Office of Renewable Energy Technologies
Geothermal Technology Division

EXECUTIVE SUMMARY

Progress of the Salton Sea Scientific Drilling Program (SSSDP) has been documented in a series of quarterly reports. This tenth report covers the period from January 1 through March 31, 1987, the second quarter of fiscal year 1987. The Department of Energy, Geothermal Technology Division (DOE/GTD), has extended its prime contract with Bechtel National, Inc. Funds have been allocated, but not contracted, for wellbore repair and construction of facilities for performance of a long-term flow test (LTFT) and injection experiment. After Kennecott Corporation's management agreed to fund and drill the Wilson 1-12 well, key activities during this reporting period became the planning and scheduling of wellbore repair, reconditioning of brine treatment equipment, drilling the injection well, and performing the long-term production and injection test.

The Brookhaven National Laboratory's failure-analysis report provided observations and recommendations of significant value in planning the State 2-14 well repair. Assuming successful repair operations; reconditioning of flow-test equipment, construction of flow-test facilities, and connecting the Wilson 1-12 and State 2-14 wells by pipeline must be accomplished prior to the flow test. After drilling the Wilson 1-12 well to a depth of 3,500 to 6,500 feet, Kennecott plans to perform a short-term flow test, then allow the well to be used for injection of fluids produced during the flow test of the State 2-14 well. As of this quarter, the LTFT is planned for completion by the close of August.

Data from scientific experiments performed in the State 2-14 well and samples acquired from the well continue to be analyzed. Technical aspects of SSSDP field operations have been analyzed and reported by Robert W. Nicholson of Well Production Testing, Inc. Conclusions and recommendations for drilling future scientific wells have been set forth in his report. The first collective reporting of SSSDP scientific results is scheduled for the spring meeting of the American Geophysical Union in Baltimore, Maryland on May 19 and 20, 1987.

A meeting was held January 19, 1987 in Bechtel's San Francisco Office to discuss and define plans for continuation of SSSDP activities. This meeting was significant both as a SSSDP-update and discussion of key issues affecting the project's future. Present at the meeting were representatives from Kennecott, DOE/GTD, DOE/SAN, DOE/IDO and INEL.

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INTRODUCTION

A final report entitled, "Analysis of Operational Times and Technical Aspects of the Salton Sea Scientific Drilling Project," was prepared by Robert W. Nicholson of Well Production Testing, Inc. This analysis of SSSDP well operations can be used as a basis for planning future scientific drilling operations in thermal regimes of the earth's crust. Major objectives of the SSSDP, according to this report, were achieved, including; (1) drilling the well to a depth of more than 10,000 ft, (2) attempting to core 10-percent of the borehole and obtaining 722.1-ft of core, (3) conducting two successful flow tests, (4) obtaining downhole geophysical data from logging, and (5) testing new downhole wireline tools. The percentages of time spent on various activities, by depth range, are shown in Figure 1.

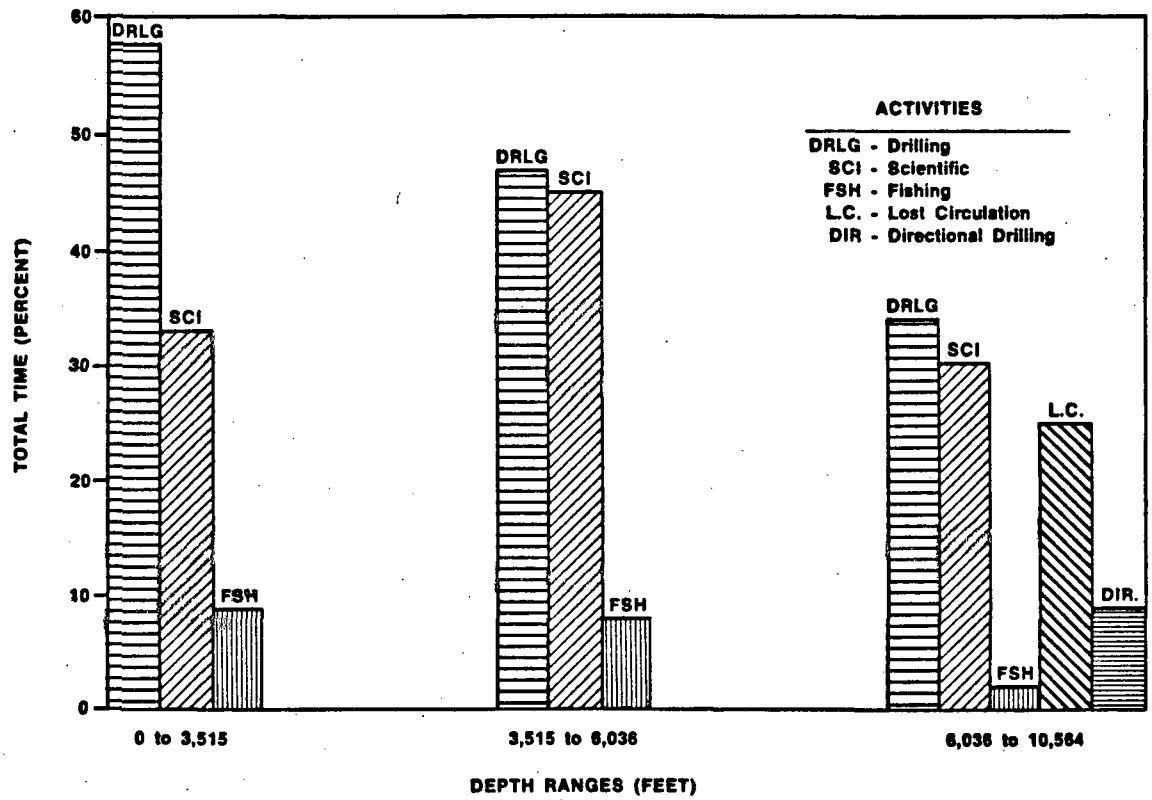

FIGURE 1: PERCENTAGES OF TIME SPENT ON STATE 2-14 WELL ACTIVITIES BY DEPTH RANGE

In August of 1986, the parted 7-inch, uncemented liner in the Salton Sea Scientific well was reamed clear to 8,000-ft and a temporary liner installed. However, access to the wellbore for technical and scientific experimentation is limited by the presence of viscous gelled-mud inside the liner-sections deeper than 5,822-ft. Repair of the State 2-14 wellbore was scheduled during this reporting period, since DOE's FY-1987 budget included funds for well repair and long-term flow testing. Kennecott Corporation received management approval to fund drilling, completion and testing of the Wilson 1-12 well. After flow testing, Kennecott will make the Wilson 1-12 well available for use as an injection well to receive fluids produced in a long-term flow test of the State 2-14 well. Without an injection well, the State 2-14 well can only be flowed for 3-days.

Access to the State 2-14 wellbore is required prior to conducting the long-term flow test and completing the remaining scientific experiments from the original program plan. These activities were precluded by lack of funds for a flow-test facility and brine injection well, and by liner-failure. The two previous flow tests indicated flow-zones with commercial reservoir potential. The first flow test produced essentially uncontaminated formation fluid, but the second test produced fluids from several zones that were contaminated by the large volumes of drilling-fluid and additives required to control lost circulation. A third flow test is expected to provide critically needed uncontaminated fluid samples from an isolated flow-zone at a depth greater than 8,000-ft. Well repair will also allow completion of SSSDP geophysical data sets needed for encouraging industry to exploit deeper, higher-quality geothermal resources in the Salton Sea Geothermal Field.

PROGRAM PLAN AND ACTIVITIES

Drilling and Engineering Program

Bechtel National, Inc., prime contractor for the SSSDP since September 1984, secured a contract extension from March 31 to April 30, 1987 during this reporting period. Granting Bechtel a sole-source contract, extending past April 30, 1987, is currently being implemented. Another option was to solicit a new contractor to repair the State 2-14 well.

In an effort to identify qualified contractors to continue work at the SSSDP site, an announcement was published in the January 23, 1987 edition of the Commerce Business Daily. The announcement solicited qualified organizations to submit written capability statements describing in-house technical capabilities, past and present work efforts demonstrating experience, available personnel and their qualifications, and cost estimate information. As a result of the announcement, two organizations submitted responses. However, the respondents failed to address properly the requirements outlined in the announcement.

Following this development, DOE/SAN management determined that acquiring a new contractor would require considerable duplication of effort, resulting in significant additional cost to the Government. Therefore, documentation for a sole-source contract with Bechtel National, Inc. was prepared and submitted. This contract extension, would require Bechtel to perform the necessary work to recomplete the State 2-14 well, recondition and construct facilities for long-term flow testing, and furnish site clean-up services after the test is terminated. Also, the contract modification would further extend the March to April contract extension already approved.

During this reporting period, planning, coordinating and scheduling repair of the wellbore, drilling the injection well, and performing a long-term flow test continued. The DOE Geothermal Technology Division (DOE/GTD) budgeted $1.3 million in FY-1987 to repair the well and construct facilities to perform the LTFT. DOE/SAN was given prime field responsibility for the effort. Kennecott Corporation, the leaseholder, received approval to drill and complete the Wilson 1-12 well, and agreed in principal to allow its use as an injection well for the LTFT of State 2-14.

Repair of the State 2-14 wellbore will be completed with full consideration of a recently completed failure-analysis of the parted well-casing. According to Bechtel's additions to the Brookhaven National Laboratory (BNL) failure-analysis report, several observations can be made regarding the liner:

1. The liner-hanger showed signs of erosion on the outside body, indicating leakage of seals which, upon examination, were all in-place, but badly charred.

2. Slip-segments had dislodged from the drag-springs, because Allen bolts connecting the slips to the drag-springs had completely corroded. Although the liner-hanger was designed for geothermal environments, the fasteners for the segments apparently were not.

3. Inspection of the polished-bore receptacle (PBR) revealed a high degree of pitting inside the bore.

4. Visual cracks were noted in the couplings, with extreme cracking in the coupling at the bottom of the fourth joint.

5. Cracks were not observed in the field in the bodies of the recovered casing. (Note: BNL indicated that no cracks were observed in the sample-sections of casing that they received).

6. Both collars and casing bodies showed signs of corrosion.

7. The wellbore was not entirely vertical. According to surveys, the well has about a 5^{o} "dogleg" near the location of initial separation (in the vicinity of the first flow-test zone). This is suspected of having increased the degree of stress in the liner-joints, resulting

from thermal cycling during flow testing and injection of produced fluids.

Recommendations made to Bechtel by tubing suppliers for minimizing well casing problems in the future are summarized below.

1. Buttress-thread casing should be used.
2. Apply less torque to the casing.
3. Heavier-weight casing and coupling should be considered for use in "dogleg" zones.
4. Use of L-80 grade casing is recommended for H_2S-rich environments at all temperatures. Maximum hardness is R_C23, which falls within recommended NACE standards for H_2S usage.
5. Premium joint-connections should be considered (i.e., Hydril connections seal threads from exposure to corrosion).

Kennecott Corporation's management, SOHIO, approved allocation and expenditure of funds for drilling the Wilson 1-12 well, and, thereby, participation by Kennecott in the LTFT of the SSSDP well. As indicated in Figure 2, Kennecott's preliminary schedule, drilling of the Wilson 1-12 well is to begin around May 15 and, after having drilled to a planned depth between 3,500 and 6,500 ft, the well is scheduled for completion by the end of June. Following well completion, Kennecott will perform a short-term flow test of about 3-days to determine the commercial resource potential of the well.

In order to test the Wilson 1-12 well and use it later for fluid injection during the LTFT of State 2-14, approximately 1 1/4-miles of pipeline connecting the two wells is scheduled to be in place by the end of June. Used materials for the pipeline may be acquired from the now-terminated Niland Geothermal Project, a part of the DOE Geothermal Loan Guaranty program. The USGS, Water Resources Division, is scheduled to run one or more suite(s) of logs in the State 2-14 well, after the old liner is removed.

A

	1986 NOV	DEC	1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
SITE PREPARATION												
Lease Review	WEEKS 1-2-3-4											
Title Abstract			2-3									
Drilling Opinion			3-4-1									
Survey	3-4											
I.I.D.												
Electric Service				1-2								
Water Availability							1-2					
Environmental Survey							1	2-3	3		1	
Well Pad						3-4						
Mud Sump						3-4						
PERMITS												
C.U.P.	1-2-3-4											
A.P.C.D.			1-2									
R/W Pipeline				1-2								
Health Department							1-2					
State Lands - Project				1-2		1-2						
State Lands - Well			3	4		2-3						
State Lands - 40 Ac Lease				1-2								
Fish & Game - Schedule				1-2								
D.O.G.						2-3						
R.W.Q.C.B.					1	3						
WELL DESIGN												
Drilling Consultant					1							
Geologist				1								
FLOW TEST DESIGN												
Flow Test Consultant					1							
Flow Test Program					1							
Minerals Test Program					1							

Explanation

I.I.D. = Imperial Irrigation District
C.U.P. = Conditional Use Permit
A.P.C.D. = Air Pollution Control District
R/W = Right of Way
D.O.G. = Division of Oil & Gas (CA)
R.W.Q.C.B. = Regional Water Quality Control Board

B

	1986 NOV	DEC	1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
DRILLING												
Drilling Consultant					1	1	3-4-1-2-3-4					
Geologist				1			2-3-4					
Set Surface Conductor							3-4					
Drill Rig							4-1-2-3-4					
Mud Company							1-2-3-4					
Solids Control								4-1				
Clean Out Mud Sump												
Pipe/Casing Purchase					1		1-2					
Pipe Inspection							1					
Tool Rental							1-2-3-4					
Blow Out Prevention Equipment							1-2-3-4					
Baker Tank-Rental							1-2-3-4-1					
Trailer Rental							1-2-3-4-1					
Casing Crew							2-3-4					
Cement Company							1-2-3-4					
Directional Company							3-4					
Bits							1-2-3-4					
Logging Company							2-3-4					
PIPELINE - 30 DAY												
Right of Way				1-2								
Construction						1-2-3						
3 DAY FLOW TEST												
Flow Test Consultant					1							
Equipment Order								1-2				
Construction									4-1-2			
Flow Test									2			
Injection									2-3			
Clean-Up									3-4			
Final Reports											4-1	
File for Lease w/State Lands												1-2

FIGURE 2: PRELIMINARY SCHEDULE PREPARED BY KENNECOTT FOR DRILLING THE WILSON 1-12 WELL

By the beginning of July, repairs to the production well (State 2-14) are planned to be completed and flow-test facilities installed, as shown in Kennecott's preliminary schedule, Figure 3. Reconditioning the flow-test equipment may require purchasing some long lead-time items, thereby posing possible delays to testing. A pert chart indicating critical paths and possible time-flexibility for field activities is pictured in Figure 4. Expenditures for flow-test facility construction will be deferred until well repair has been achieved. With the possibility that repair of State 2-14 cannot be accomplished, DOE must carefully schedule tasks to limit expenditure of funds.

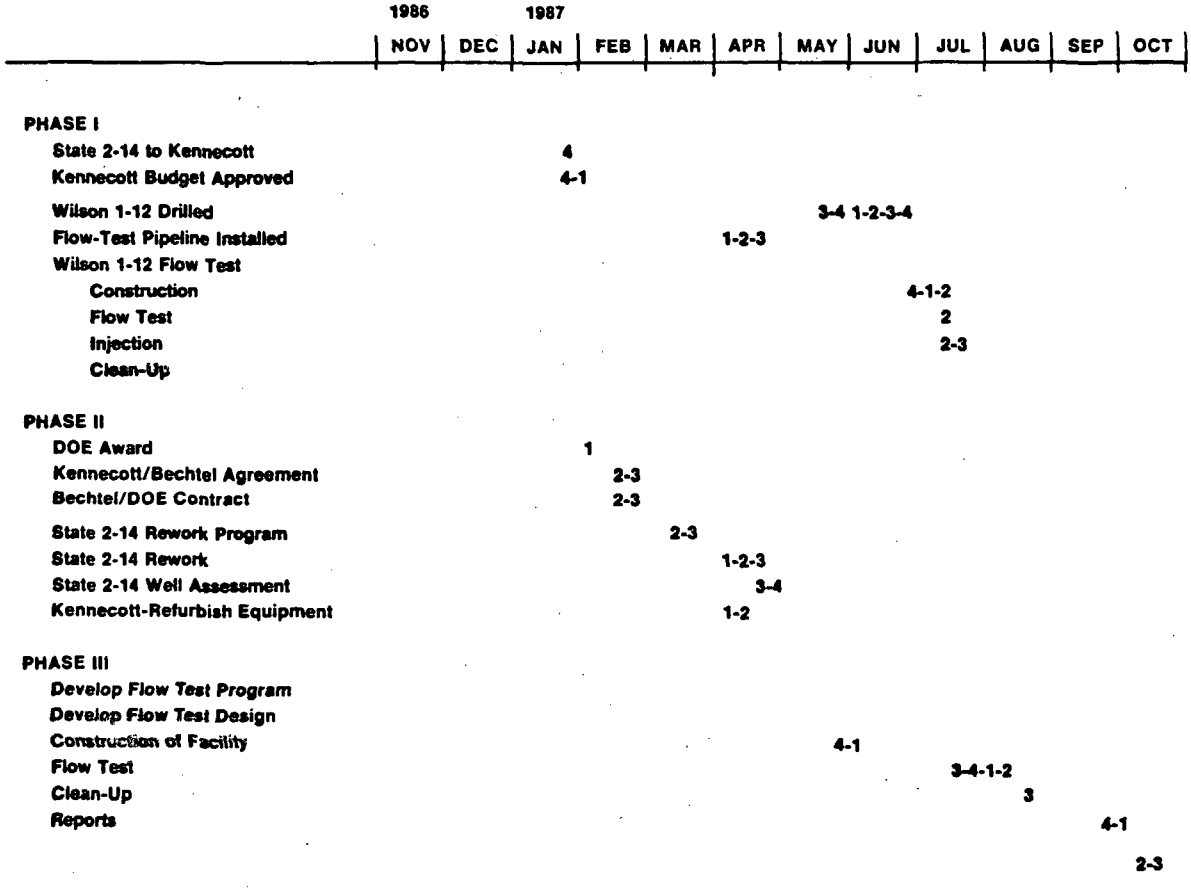

FIGURE 3: PRELIMINARY SCHEDULE PREPARED BY KENNECOTT FOR REPAIRING THE STATE 2-14 WELL AND PERFORMING THE LONG-TERM FLOW TEST

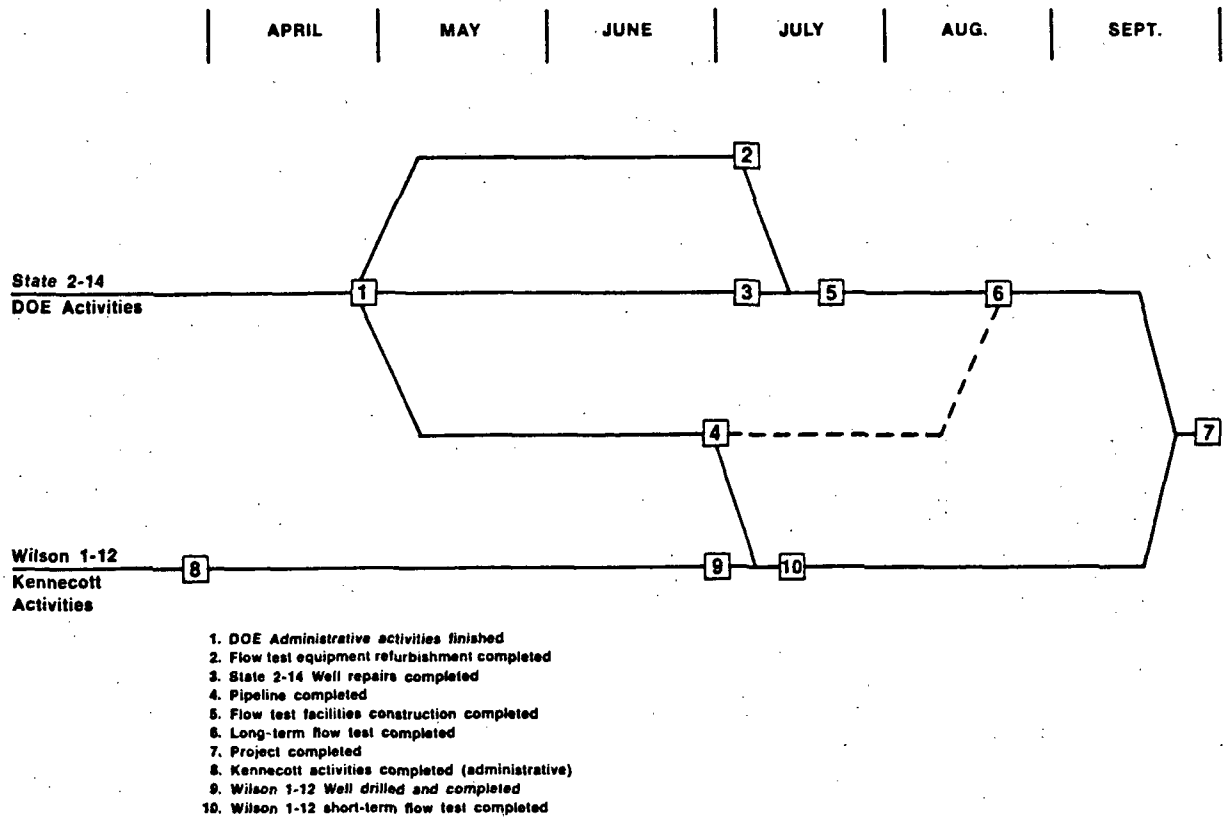

FIGURE 4: MODIFIED PERT CHART INDICATING THE CRITICAL PATH AND POSSIBLE TIME-FLEXIBILITY AVAILABLE FOR EACH FIELD ACTIVITY

According to DOE/SAN, the long-term flow test should begin around mid-July, unless the reconditioning of flow test equipment requires additional time. Planning and management of the long-term flow test and brine injection experiment will be handled by DOE/Idaho Operations Office (IDO). The electronic memory temperature and pressure tool is scheduled to be run by USGS in the State 2-14 well prior to repair. During the flow test, time will be allocated for testing the LANL/Sandia and LBL fluid sampling tools.

Reservoir Scientific Experiments

In addition to completion of temperature and other geophysical logging planned for the State 2-14 well, plans have been made for conducting a production and injection flow test, using the State 2-14 well as the fluid source and the Wilson 1-12 well to receive injection. Long-term flow testing of the Salton Sea Scientific well, coupled with injection into the Kennecott, Wilson 1-12, will provide a mechanism to test and evaluate hydrologic properties of the geothermal reservoir in this part of the Salton Sea Geothermal Field. Testing of these wells will also provide the opportunity to validate several innovative reservoir engineering techniques developed under the DOE Geothermal Research Program. The Geothermal Reservoir Technology Program of DOE/GTD will use five laboratories to conduct the experiments and measurements: Idaho National Engineering Laboratory (INEL), Lawrence Berkeley Laboratory (LBL), Lawrence Livermore National Laboratory (LLNL), Stanford University (Stanford), and the University of Utah Research Institute (UURI).

There are a greater number of unknowns associated with fluid-injection into a geothermal system than there are with fluid-production. This test program is designed to examine reservoir injection properties in this part of the Salton Sea Geothermal Field and will quantify the capability of the reservoir to accept injected fluids. The flow test is expected to provide both early-time pressure changes and long-term pressure recovery of the reservoir. Emphasis will be placed on injection studies, and the test is planned to last at least twenty days.

The long-term test also will provide the opportunity to complete several associated scientific tasks. Downhole fluid samples will be collected under

flowing and static well-conditions from an isolated production zone at a depth greater than 8,000-ft. Collection of downhole samples after completion of the flow test is advantageous to geochemists, because it provides the opportunity to sample after most, if not all, of the drilling contaminants have been removed from the well. Pressure and temperature logging will also be conducted during flowing conditions to evaluate the thermodynamics of the fluid.

The Geothermal Injection Technology project will test techniques for evaluating and predicting the thermal, chemical and hydrologic effects of injection. Techniques developed may lead to control of adverse thermal and chemical effects through effective well placement and wellfield operation. Research activities included in the program were developed in response to priorities identified by industry advisors. Project emphasis is on research and development not performed by private industry. The injection test will address the flow of injected fluids by downhole and surface measurements of pressure and temperature. These measurements will be coupled with a program of testing geophysical techniques in an attempt to track injectate movement. The research will include a non-isothermal injection and pressure fall-off test, an injection-backflow test, tracer evaluation, microseismic monitoring, and collection of fluid and solid samples to determine the scaling properties of the hypersaline brine.

Non-isothermal Injection and Fall-off Test

The injection test to be conducted in conjunction with the SSSDP long-term test provides an excellent opportunity for validating and demonstrating the usefulness of new analytical techniques. Recent theoretical advances at LBL have improved the ability to interpret non-isothermal injection test data from

both porous and fractured reservoirs. Theoretical studies indicate that by conducting and interpreting these tests in a systematic manner, it is possible to track the movement of thermal fronts, detect fracture-controlled thermal sweep, detect and measure thermally-induced permeability enhancement, and in some cases, quantify fracture spacing. This powerful diagnostic tool has not been fully used, because proper field validation is lacking.

Microseismic Monitoring

As part of the DOE Geothermal Brine Injection Research program, Lawrence Livermore National Laboratory has been studying the occurrence of microseismicity for application to monitoring the migration of injected fluids. Microseismicity is known to occur at some geothermal development sites, but more case studies are needed to correlate its occurrence with fluid injection and establish its value for the study of injection.

The planned long-term flow test at the Salton Sea Geothermal Field provides an excellent opportunity to collect case history data on injection-induced microseismicity. Because it is part of an integrated flow test, survey results can be related to the structure and hydrology of the geothermal system. Relations will be investigated between seismicity, and pressure and flow distributions estimated from reservoir engineering models, and tracer studies of the injected fluid. The approach is to instrument the injection site for approximately one-month prior to injection, then continue to observe seismic events for about three months. This will provide an idea of background seismicity and allow observation of events that may occur during and shortly after the flow test. Events will be located and studies conducted to discriminate injection-induced events from natural events. The rate of

occurrence and spatial distribution of induced events will be compared with estimates of flow paths from reservoir engineering studies to determine the degree to which seismicity reveals information about flow in the reservoir.

Injection-backflow Test

An injection-backflow test will be conducted in the Wilson 1-12 well near the end of the flow test. The injection segment of the test will be designed as a slug-injection with tracers. Sufficient fluid will be injected after the slug to move the tracer away from the wellbore. After a quiescent period, the injected fluid will be withdrawn from the Wilson 1-12 well and analyzed for thermal characteristics, chemistry and tracer recovery. Analytical techniques, newly developed at INEL and Stanford University, will be used to determine the heat transfer that has occurred between the formation and the injected fluid. This information will be extrapolated to provide an estimate of heat-transfer rates in the reservoir. In addition, the tracer-return profiles will be analyzed by UURI, using methods previously developed at East Mesa, to determine near-wellbore formation properties and transport characteristics. The chemistry of the injected fluid and of the return fluid from Wilson 1-12 will be analyzed for conservative and varying species, and correlated with the tracer data to identify geochemical reactions. If successful, this technique could provide the basis for predicting formation plugging, a possible long-term effect of injection that is presently poorly understood.

Tracer Evaluation

It is now generally recognized that tracers and tracer data interpretation can play an important role in well-field development. Few tracers are currently available to the geothermal operator. During the last several years,

UURI has identified a number of derivatized hydrocarbons for tracking liquid and gas phases that appear to be more suitable as geothermal tracers than currently used chemical species. The stabilities of these hydrocarbons have been experimentally determined under conditions closely approximating those expected in geothermal reservoirs. However, no field tests have yet been conducted. Such tests are needed before these compounds can be confidently used by geothermal developers.

Methods for interpreting tracer-return profiles are being developed at Stanford and INEL. UURI will provide Stanford and INEL with chemical analyses and information concerning tracer stabilities. Tracers can be used to quantify chemical changes occurring in injected fluids as they move away from the wellbore. Because these chemical changes are frequently related to deposition or precipitation of specific minerals, chemical data can provide information on the potential for plugging or permeability enhancement in the reservoir rock around the injection well. In the Salton Sea Geothermal Field, dissolution and precipitation reactions are likely, because the fluids are extremely saline. Fluid samples will be collected during injection and backflow of the injection well to characterize the chemical changes that have occurred during injection.

Scientific Experiments -- Results, Conclusions and Recommendations

Analysis of data from scientific experiments performed in the State 2-14 well and samples acquired from the well, continues. Fluid temperature, thermal gradient and thermal conductivities have been approximated, based upon the initial thermal-equilibrium profiles and other data. Results from other investigations are being compiled and prepared for dissemination.

and reported by John H. Sass, John D. Hendricks, Susan S. Priest, and Lori C. Robison of the U.S. Geological Survey (USGS), Flagstaff, AZ. During breaks in drilling, downhole temperatures were measured and later used to establish an equilibrium-temperature profile. Prior to well-casing failure, the well could be logged to 3,109 meters. Currently, logging is restricted to the upper 1,800 meters of the well. The best estimate of fluid temperature below 1,800 meters is 305 $\pm$ 5^{o}C at a depth of 1,890 meters and 355 $\pm$ 10^{o}C at a depth of 3,170 meters.

According to the USGS report, "Temperatures and Heat Flow in the State 2-14 Well," an impermeable, thermally conductive "cap" on the Salton Sea hydrothermal system extends to depths greater than 900 meters. Thermal gradients were found to decrease from approximately 250^{o}C/km in the upper few hundred meters to slightly less than 200^{o}C/km near the base of the conductive cap. In general, thermal conductivities increase with depth in response to an overall decrease in porosity.

The USGS has also released the report entitled "Preliminary Report on Geophysical Well-Logging Activity on the Salton Sea Scientific Drilling Project, Imperial Valley, California" (Open-File Report 86-544). The majority of USGS activities reported relate to preparing geophysical equipment for logging the SSSDP well, obtaining the logs, and providing log analysis. The publication includes additional information, such as details of well construction, lithologic data from cuttings, and records of drilling progress that could be useful in log interpretation.

A study of seismic-velocity characteristics of geothermal alteration in

sediments of the SSSDP well is being conducted and reported jointly by F.L. Paillet of the USGS and C.H. Cheng of the Massachusetts Institute of Technology (MIT). The study includes examination of USGS acoustic-waveform logs, examination of raw vertical seismic profile (VSP) data obtained by E.J. Majer of Lawrence Berkeley Laboratory (LBL), and core analysis to derive an indication of velocity-structure. Preliminary results of this study are scheduled for presentation at the March 1987, USGS McKelvey Forum in Denver, Colorado, and the spring American Geophysical Union meeting, Salton Sea Scientific Drilling Program session in Baltimore, Maryland.

As mentioned previously, an analysis of technical aspects of Salton Sea Scientific Drilling Project field operations was completed by Robert W. Nicholson of Well Production Testing, Inc. The major conclusions Nicholson reported are listed below.

1. Adaptation of common, commercial drilling methods for scientific data collection worked reasonably well. The major objectives of the project were met, with 33 percent of field operations-time spent acquiring scientific data (Figure 5).

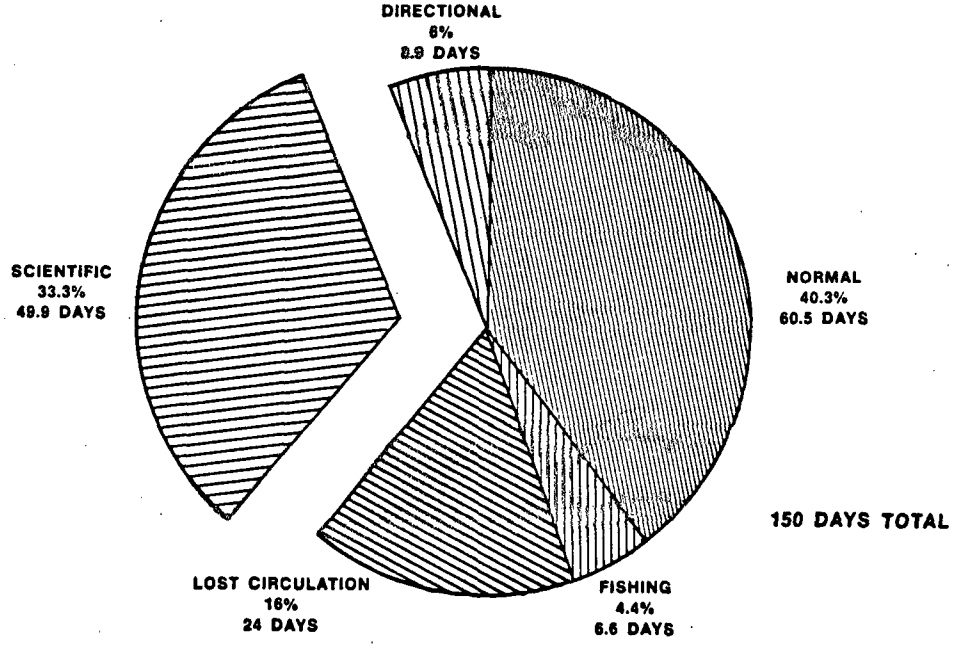

FIGURE 5: FIELD OPERATIONS ACTIVITIES FOR DRILLING THE SALTON SEA SCIENTIFIC WELL BY NUMBER OF DAYS AND PERCENTAGES OF TOTAL TIME

2. Although unusual well conditions presented difficult technical problems, these were effectively overcome.

3. Downhole problems increased with depth, directly reducing the amount of time spent on scientific data collection (Figure 1).

4. Unfortunately, budgetary concerns limited scientific efforts, especially toward the end of the project.

5. Spot-coring operations were very successful in the shallower section of the hole.

6. Core-footage recovered and coring efficiency decreased drastically with increased depth and increased well problems, as shown in Figure 6.

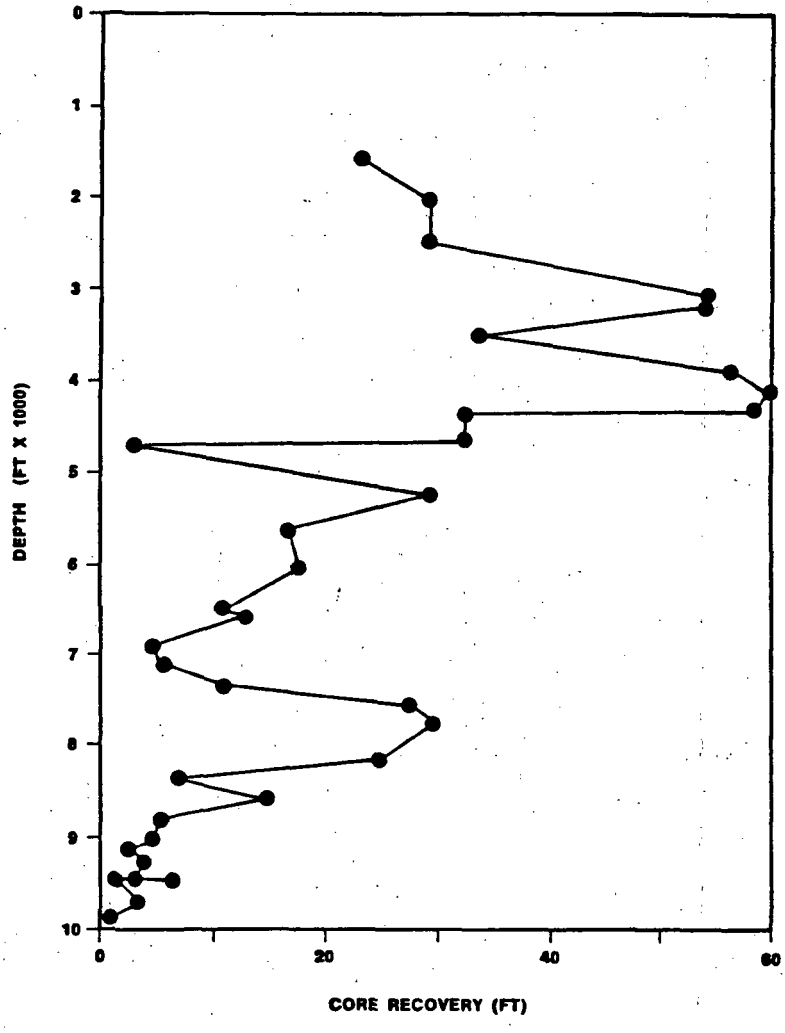

FIGURE 6: CORE RECOVERY VS. DEPTH IN THE SALTON SEA SCIENTIFIC WELL

7. As presented in Figure 5, solving major downhole problems (lost circulation, directional control and fishing) consumed about 26 percent of project time. These problems consumed 38 percent of the time at depths greater than 6,000 ft and contributed to limiting the amount of scientific data acquired.

8. High-temperature contributed directly and indirectly to difficulties in acquiring scientific data, conducting normal drilling operations and wellbore problems.

9. The final flow-test of the well provided neither pristine fluid-samples nor definitive reservoir data, because the well completion was insufficient to isolate a single uncontaminated zone.

10. The need to control natural deviation of the wellbore toward the eastern lease-boundary, 230-feet from the surface location, significantly increased project-time and downhole difficulties (Figure 7).

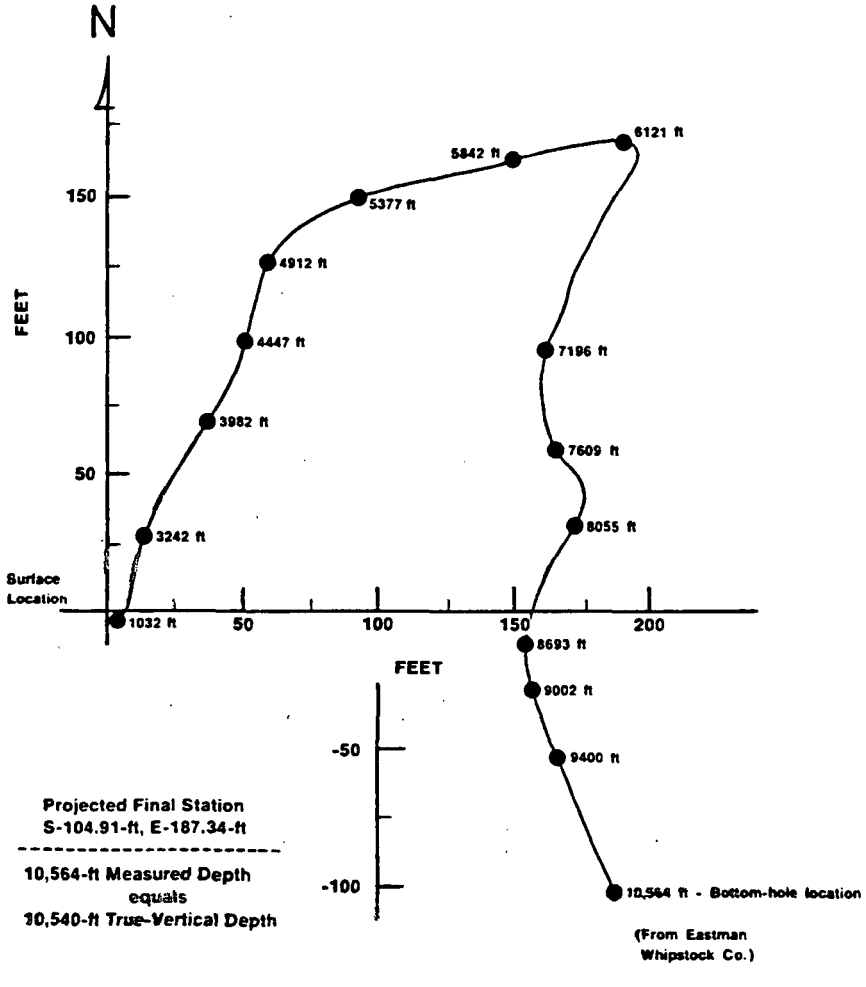

FIGURE 7: MAP-PROJECTION OF VARIATIONS IN THE DEPTH-LOCATIONS OF THE SALTON SEA SCIENTIFIC WELLBORE

11. The hardness and abrasiveness of formations deeper than 9,000 feet became a major problem, especially during coring with essentially full-sized core-heads.

For future scientific drilling activities, Nicholson made several recommendations, based upon results of this project:

1. Close coordination should be established, early in project planning, between the operational, scientific, institutional and funding agencies.

2. An integrated well-design should be planned between scientists and engineers to establish specific project goals.

3. Development of improved coring systems for continuous coring in full-sized wellbores will greatly enhance the success of future scientific drilling operations.

4. Improved core-heads (greater penetration-rate and longer life) for very hard formations need to be developed.

5. Techniques and equipment for successfully coring hot, complex, fractured formations, normally encountered in active geologic areas, need to be developed for future operations to enhance scientific return for funds expended.

6. Improved directional control must be employed for drilling effectively to great depths.

Although this project was successful, it is apparent that improvements must be made to drill (core) economically and successfully to the depths contemplated by proponents of the Continental Scientific Drilling Program (50,000 feet or more), through hard, abrasive, fractured formations. Problems similar to those encountered in the SSSDP, specifically extremely high borehole-temperatures, deviation control, control of lost circulation and fishing for equipment lost downhole, will be encountered and become more difficult and costly to overcome at greater depths.

Reporting of SSSDP Results

Documentation and dissemination of SSSDP results continued in accordance with established protocol during this reporting period. A summary of SSSDP activities, including FY-1987 plans, was presented by Charles A. Harper (Bechtel National, Inc.) at the Northern California chapter of the Geothermal Resources Council meeting on February 26, 1987. Informal letter summaries, reporting preliminary findings, have been distributed among the Principal Investigators. Formal presentations of papers, providing preliminary scientific results, are scheduled for May 19 and 20, 1987 at the spring American Geophysical Union meeting in Baltimore, Maryland. The full-day session of oral presentations, chaired by Wilfred A. Elders (U.C. Riverside) and John Sass (USGS), will include five invited papers. Poster presentations are also planned, according to Donald Klick, Chairman of the Science Coordinating Committee.

The updated bibliography of SSSDP reports follows:

Aducci, A.J., Klick, D.W., and Wallace, R.H., Jr., 1986, Management of the Salton Sea Scientific Drilling Program: Geothermal Resources Council Transactions, v. 10, p. 445-448.

* Pub.

Andes, J., Jackson, J. Lilje, A., Sullivan, R., and Herzig, C.T., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Visual Core Descriptions; Herzig, C.T. and Mehegan, J.M., eds: Institute of Geophysics and Planetary Physics, University of California, Riverside, UCR/IGPP-86/1, v. 2, April, 93 p.

* Pub.

Bechtel National, Inc., 1987, Salton Sea Scientific Drilling Program, Drilling and Engineering Program, March 1987, Vol. 1.

* Draft - in Review

Bechtel National, Inc., 1987, Salton Sea Scientific Drilling Program, Drilling and Engineering Program, March 1987, Vol. 2

* Draft - in Review

Carson, C.C., 1986, Development of Downhole Instruments for Use in the Salton Sea Scientific Drilling Project: Geothermal Resources Council Transactions, v. 10, p. 449-453.

* Pub.

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Flow Test of Well State 2-14, 28-30 December, 1985; for Bechtel National, Inc., San Francisco, California, June, 40 p.

* Draft - in Review

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SIGNIFICANT MEETINGS

Bechtel Project Review Meeting - January 19, 1987

A meeting was held in the San Francisco Offices of Bechtel on January 19, 1987 to review the SSSDP and discuss key issues regarding continuation of project activities. Senior management from DOE, Kennecott and Bechtel were in attendance at this meeting. These attendees were John Mock, Director of DOE's Geothermal Technology Division, Robert Dimock, Vice-President of Kennecott Corporation, Harold Forsen, Senior Vice-President and Manager of R&D for Bechtel and Jim Selover, Vice-President and Manager of the Research Program, also for Bechtel. Other participants included: Raymond Wallace and Marshall Reed of DOE/GTD, Harold Lechtenberg of DOE/SAN, Susan Prestwich and Susan Stiger of DOE/Idaho, Roger Andrews, Earl Tingey, Tom Probert and Larry Grogan of Kennecott, and Gus Benz, Charles Harper, Sherman May, Janet Owen and Neal Harlan of Bechtel.

SOHIO's preliminary approval of Kennecott's plan to drill a new well for eventual use as an injection well for the State 2-14 LTFT was reported. Final approval was expected by March 1987, at the latest. The Salton Sea Scientific Drilling project was summarized and future activities planned. The new Bechtel project team was announced and included:

- o A.D. Benz replaced Sam Fleming as Management Sponsor,
- o Janet Owen replaced Charles Harper as (Acting) Project Manager,
- o Sherman May replaced David Rabb as Project Engineer.

Rescheduling well abandonment and site clean-up activities were also topics for discussion.

Bechtel reported that progress continued on their Phase-I, final report. Both DOE/GTD and DOE/SAN comments had been incorporated. Liner failure-analysis data, as reported by Brookhaven National Laboratory, had also been added.