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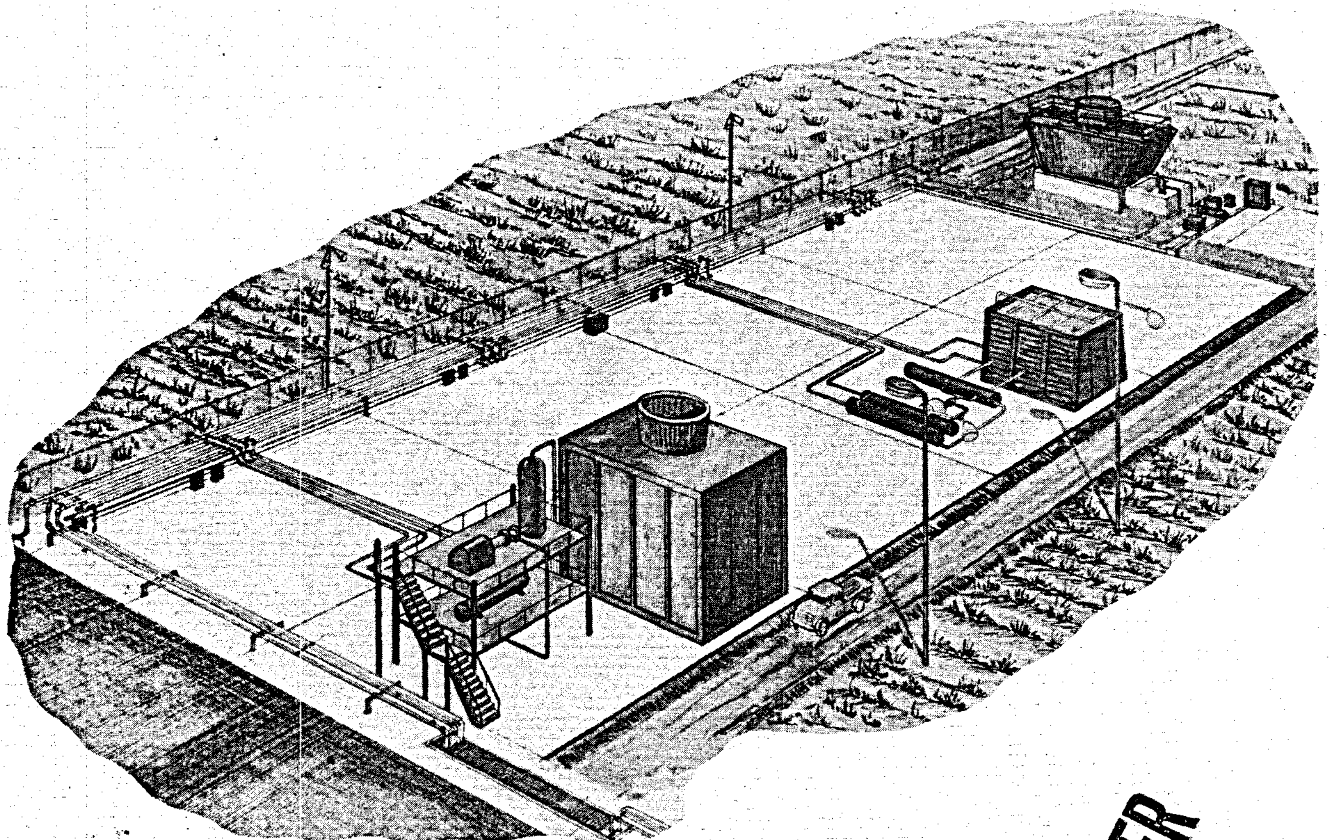
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

GEOTHERMAL COMPONENT TEST FACILITY



EAST MESA, IMPERIAL VALLEY, CALIFORNIA

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Operated for U.S. Energy Research and Development Administration under Contract W-7405-ENG-48

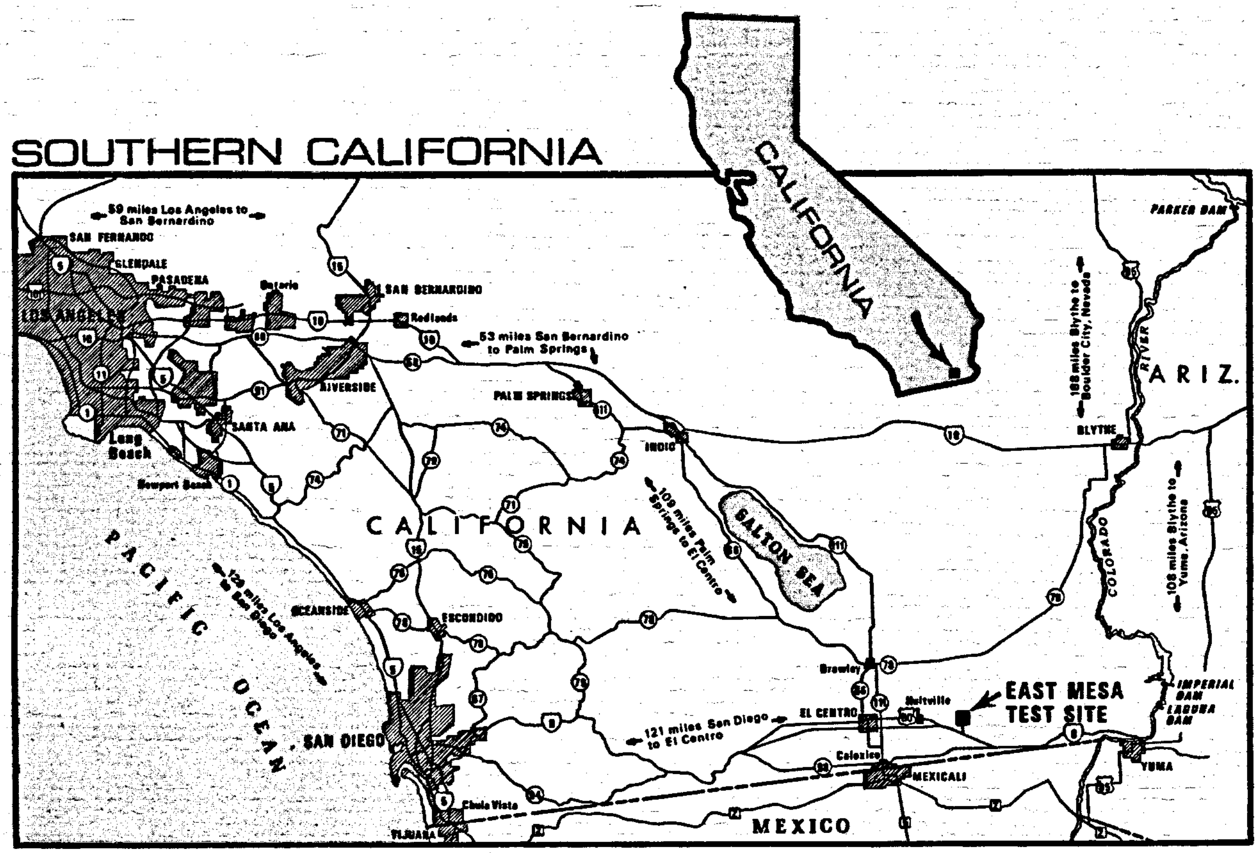

Figure 1. ERDA Geothermal Component Test Facility located at the East Mesa Test Site of the Bureau of Reclamation, Department of Interior.

COVER: Perspective of ERDA Geothermal Component Test Facility – test pad area, piping, and cooling equipment.

GEOTHERMAL COMPONENT TEST FACILITY

Geothermal energy, derived from the natural heat in the Earth's crust, has the potential for contributing significantly to U.S. energy needs within the next 25 years. This very large resource can consist of steam, hot water, hot rock, magma, or normal earth-heat gradients. The Geysers field north of San Francisco, for example, is a steam reservoir, now producing 502 MW of electricity with plans for future growth to over 1000 MW.

But steam reservoirs are rare. The liquid-dominated geothermal systems—hot water containing dissolved salts, and maybe some steam—could be the largest electricity-producing geothermal resource by 1985, if a concerted assault is made on the technical problems. These hot brines could generate tens of thousands of megawatts (electrical) by the year 2000.

Liquid-dominated geothermal sources vary considerably in their temperature and salt content. The most usable, according to a study by the Electric Power Research Institute, are those brines with a high temperature (greater than 180°C) and low salinity (less than 20,000 parts per million total dissolved solids). The study concludes that this resource could provide about 50% of the U.S. geothermal electrical production by 1985.

The potential size of the hot-water geothermal resource and its possible early utilization have motivated the U.S. Energy Research and Development Administration (ERDA) to establish the first geothermal test facility. It is located at East Mesa near El Centro in the Imperial Valley of California (Fig. 1). By providing experimenters with easy access to geothermal brines and by increasing the flow of information within the geothermal community, the Test Facility will enable industry, government, and individual innovators to obtain data relevant to the technical problems that must be solved before these hot brines can contribute to U.S. energy production.

HISTORY OF THE EAST MESA TEST SITE

Since 1971, the geothermal reservoir underlying the East Mesa Test Site has been under development by the Bureau of Reclamation, U.S. Department of the Interior, for a water-desalting demonstration plant. In this work, the Bureau has made extensive studies of the reservoir and has drilled four producing test wells and one injection well (Fig. 2).

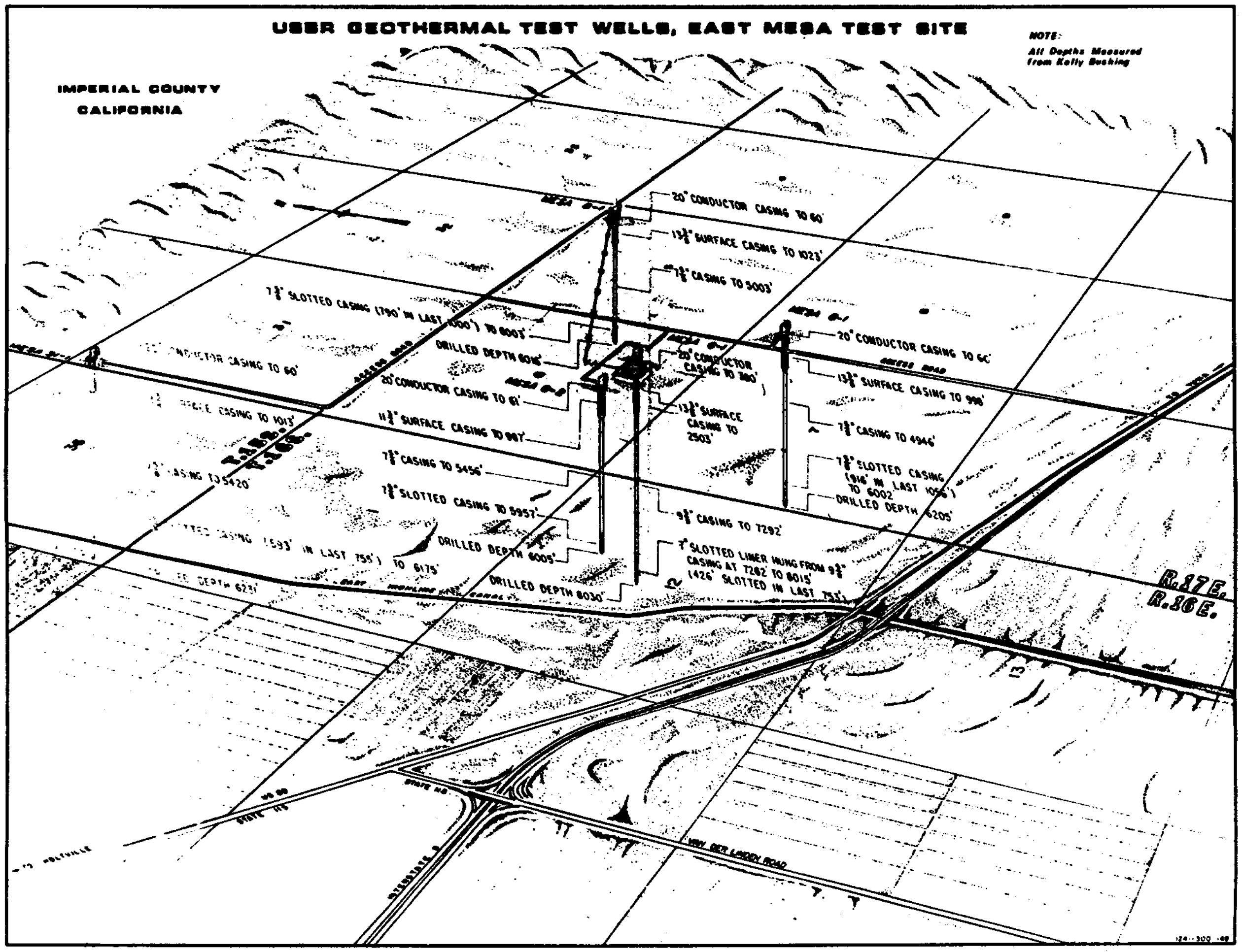

Figure 2. Phantom view of East Mesa geothermal wells. (Courtesy U.S. Department of Interior, Bureau of Reclamation)

The Bureau also has assembled support services and constructed surface plumbing, a brine-holding pond, desalting test installations, and a warehouse.

Although these facilities are being used as a field laboratory for desalting studies, the brines from the wells are also suitable for other geothermal research. The site provides an ideal setting for testing various types of geothermal energy-conversion equipment and materials under field conditions using actual geothermal fluids. In May 1975 ERDA agreed to fund the construction of a $1,040,000 geothermal component test facility that could be used by public, private, and academic scientists as a field laboratory.

Lawrence Berkeley Laboratory (LBL), an ERDA National Laboratory, was assigned the task of directing the design effort. Construction is being carried out by the Bureau of Reclamation. Further, LBL was placed in charge of planning the initial experimental program.

DESCRIPTION OF THE TEST FACILITY

The geothermal test facility, now under construction at the East Mesa Test Site, is expected to be in operation by September 1976 when the initial phase of construction will be completed. The following is a condensed description of the Test Facility and the services provided (Fig.3).

Test Pad

Tests and experiments will be set up on a concrete pad, 80 by 160 ft in size. The test pad is divided into four primary experimental areas, each served by one of four piping manifolds which are located at evenly spaced intervals along one of the 160-ft sides of the pad. The width of a typical manifold interface at an experimental area (including electrical equipment) is about 20 ft.

Piping. Each manifold installation provides:

- Brine supply and return; supply valve is 4-in. and waste brine valve is 6-in., both with a 300-psi standard flange.
- Cooling water supply and return; valves are 6-in. with 300-psi standard flanges.
- Blow-down to the holding pond; 4-in. valve with a 300-psi standard flange.

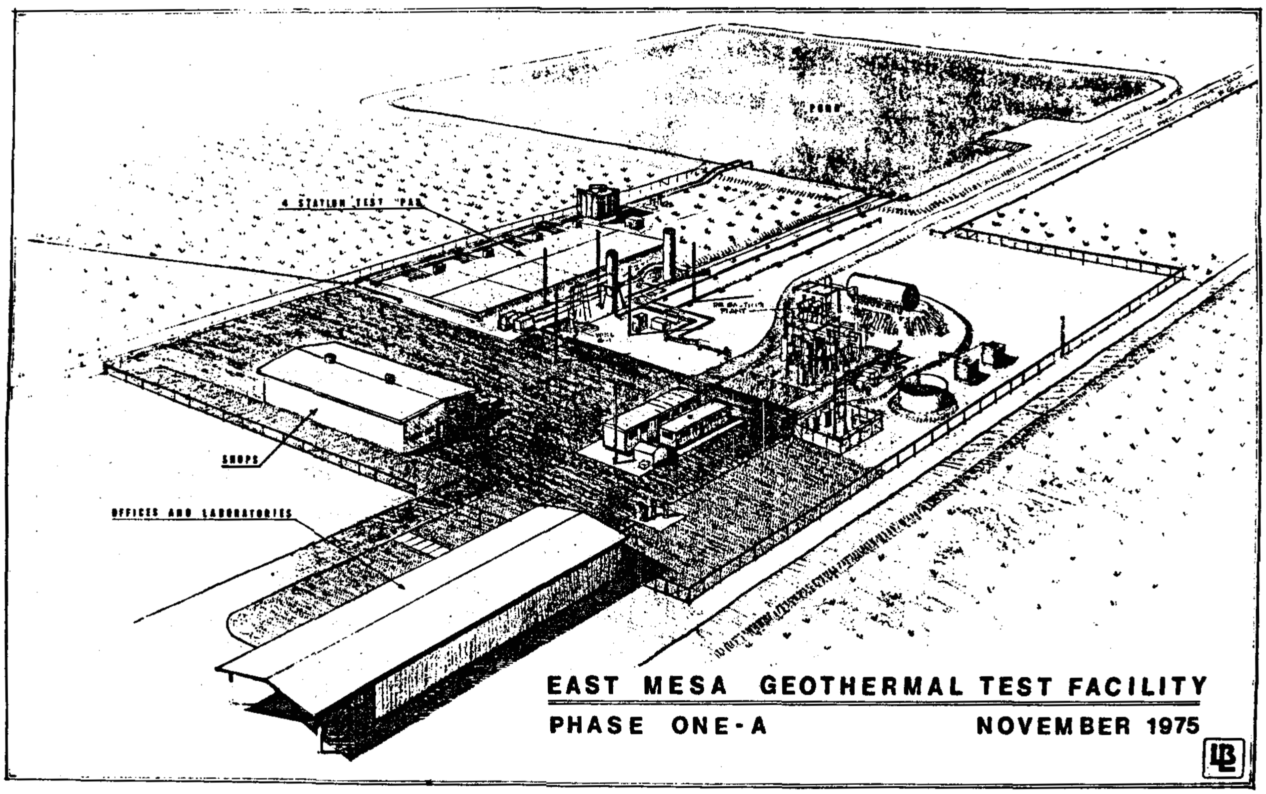

Figure 3. Perspective of the East Mesa Site.

- Domestic water at flow rates up to 50 gpm.
- Compressed air at 100 psig, 50 scfm total; 1.5-in. valve.

Cooling. The cooling tower has a heat rejection capacity of 5 MW, with provision for expansion to 10 MW when needed. It supplies 800 gpm of water at 90°F to the test pad.

Electrical Service. Electrical supply to the Test Facility has a total capacity of 430 kVA. Service at each of the four experimental stations on the test pad consists of:

- 480 V ac, three-phase; two 100-A and one 30-A capacity service switches
- 208 V ac, three-phase; two 30-A receptacles
- 120 V ac, single-phase; four 20-A duplex receptacles

Production Wells

Three existing geothermal wells, each with distinctive characteristics, will supply brines to the Test Facility (see Table I). The Facility has been designed to accommodate pumped production wells with wellhead brine temperatures between 180 and 200°C and flows up to 400 gpm. Wellhead pressure will be 50 psi above the saturation pressure. Initially, however, the Test Facility will not have downhole pumps; thus for a time, unflashed flows will be limited to 100 gpm or less from each well, at temperatures up to 170°C.

Chemistry Laboratory

The Bureau of Reclamation will operate a chemistry laboratory at the Test Site equipped to perform analyses of brines and deposits.

Table I. Well characteristics at East Mesa (from K. Mathias, 1975, Bureau of Reclamation, U.S. Department of the Interior).

Well	Shut in		100% liquid flow (typical)			Maximum natural flow		Distance to test pad (ft)	Total dissolved solids (ppm)
	Bottom-hole temperature (°C)	Wellhead pressure (psig)	Flow rate (gpm)	Wellhead pressure (psig)	Wellhead temperature (°C)	Flashing temperature of wellhead fluid (°C)	Flow rate (lbs/hr)		
6-1*	204	50.6	90	95	166	130	211,000	100	25,000
6-2*	188	92.7	85	145	168	134	150,000	1575	2500
5-1	157	52	-	-	-	-	-	-	-
8-1*	179	54.9	45	100	152	127	184,000	2700	2500
31-1	154	52	-	-	-	-	-	-	-

*Piped to test pad area.

An atomic absorption unit and a gas chromatograph are available; other instrumentation is being planned.

Machine Shop

Fabrication, assembly and repair work may be done at the on-site machine shop. Existing machine tools include lathes with capacity up to 35 in., a 36-in. milling machine, a 16-in. capacity power saw, a 4-ft radial drill, miscellaneous smaller items, and welding equipment.

Space

A limited amount of office space as well as temporary storage and parking for transports and trailers will be provided for experimenters.

Costs

Costs to the user will be determined on a case-by-case basis and may vary from "absolutely no charge" to "full cost recovery for the Government." The degree of information made public by the user, the importance of the experiment in terms of state-of-the-art frontiers, and its relevance to ERDA's mission to develop the use of geothermal energy are the primary factors which affect the cost borne by the user.

EXPERIMENTAL PROGRAMS

Geothermal brines can be used not only to produce electricity but also to accomplish various tasks in industry and agriculture; both the electric and the nonelectric applications use much the same basic equipment. To develop these uses, technological improvements are needed in the following areas:

- Prevention of erosion, corrosion, and scale deposition in pipelines, pumps, and process equipment (Fig. 4).
- Increased efficiencies of conversion for various power cycles.
- Improved instrumentation for use in direct contact with geothermal brines.
- Development of direct-use processes, such as might be used in wood-pulp plants, agricultural processes, absorption-cycle refrigeration, and the food-processing industry.

Heat Exchangers

A high-priority activity in geothermal energy application is the development and testing of brine heat exchangers. Emphasis in this area will be on solving the critical problem of scale formation (usually calcium carbonate and silica) on heat exchanger surfaces and developing reliable heat-transfer data.

A number of possible ways to control deposition could be investigated at the ERDA Geothermal Component Test Facility, including the use of scale inhibitors, ion exchange, and precipitation accelerators; these

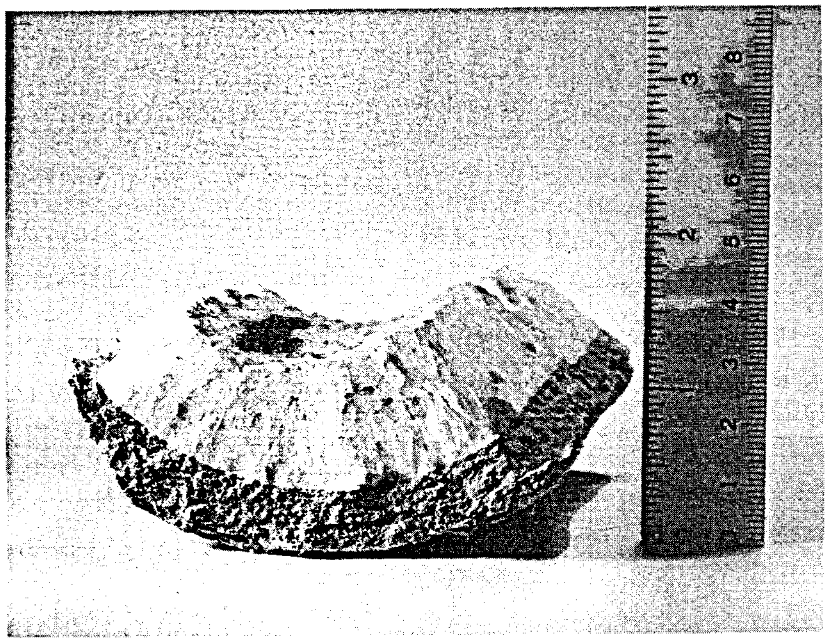

Figure 4. Calcium carbonate scale deposited in a transite pipe by a geothermal brine.

tests to find out how and why scale forms on pipes and equipment require a continuous supply of fresh brine over a long period of time. Geothermal brines are also needed to check laboratory data on the chemistry and thermodynamics of simulated brines, since the experimental results are often affected by the presence of trace elements. Improved data will make it possible to design heat exchangers with confidence.

Eventually, the problems of heat-exchange with geothermal brines may be resolved by use of innovative types of heat exchangers such as fluidized beds or direct-contact configurations. The Test Facility will provide brines, cooling water, and work space for evaluating these alternatives as they are developed.

Power Cycles

Although several energy conversion systems (power cycles), and combinations of systems, have been suggested for exploiting geothermal brines to generate electricity, only the single-flash system has been thoroughly tested under field conditions. Few conclusions can be reached concerning relative operating economies of these various proposed systems until assumed values of operating parameters are verified by realistic experiments. Alternate systems that hold promise, and which should be tested, are the following:

- Binary fluid cycles. Potential binary fluids, such as isobutane, Freon and ammonia, will be evaluated to determine optimum oper-

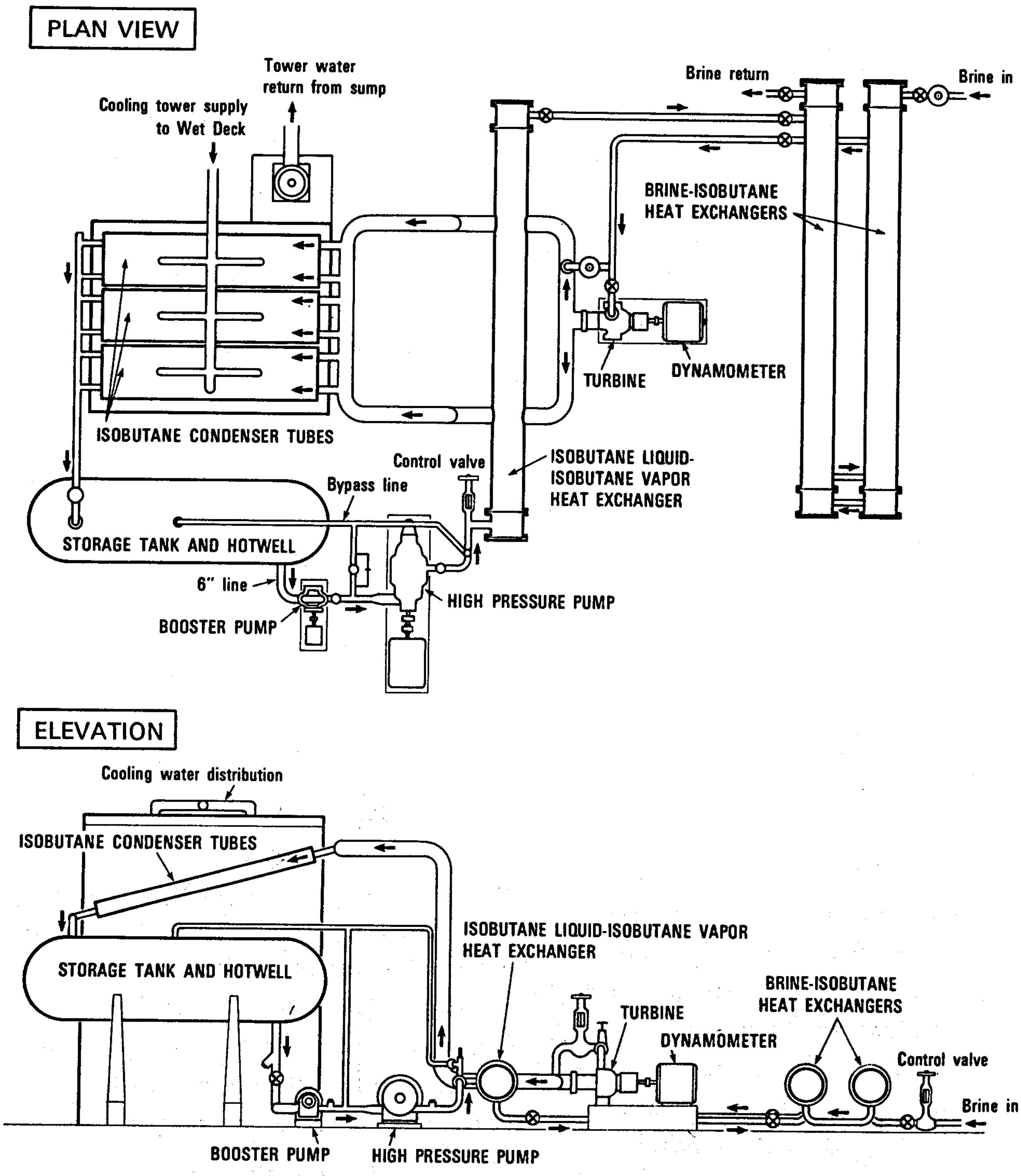

Figure 5. Proposed arrangement of equipment for a binary fluid cycle test.

ating ranges for pressure, temperature, and flow rate (Fig. 5). A binary cycle, operating at geothermal temperatures which are lower than those in fossil fuel or nuclear plants, is necessarily less efficient. Improvements in geothermal power cycles so that they perform closer to the Carnot efficiency limit will provide for more efficient resource utilization, better use of capital investment, and less generation of waste heat.

- Two-phase expansion cycles. (Total Flow Concept). Operating a turbine on a mixture of brine and steam from a geothermal well offers the possibility of increased thermodynamic efficiency. Turbines that can be operated with two-phase conditions at the turbine inlet will require significant departures from present turbine design. Several designs are being actively studied. All of these candidates will require testing on real geothermal brines.

Because these two-phase expansion cycles probably will require a direct-contact condenser (where brine and cooling water actually meet), scaling and corrosion are likely to be severe in both the condenser and the cooling tower. Studies at the Test Facility of scaling, corrosion, cycle efficiencies, and non-condensable gas disposal will provide the materials, component, and process data needed to explore this approach to using geothermal energy.

- Combination cycles. Suggestions for combining binary and steam-flash cycles into one system are numerous. As these new cycles and components are developed, the Test Facility will be available for detailed testing of their performance under realistic field conditions.

Brine Delivery and Reinjection Systems

Other problem areas that can profitably be examined at the test facility are brine delivery and reinjection systems. Downhole pumps that can increase the flow of brine from a well and prevent flashing in the well bore can be tested here.

Brine-treatment processes also should be studied, since it has been observed that the rate of reabsorption of brines decreases as the pores in the rock surrounding the reinjection well become plugged with minerals.

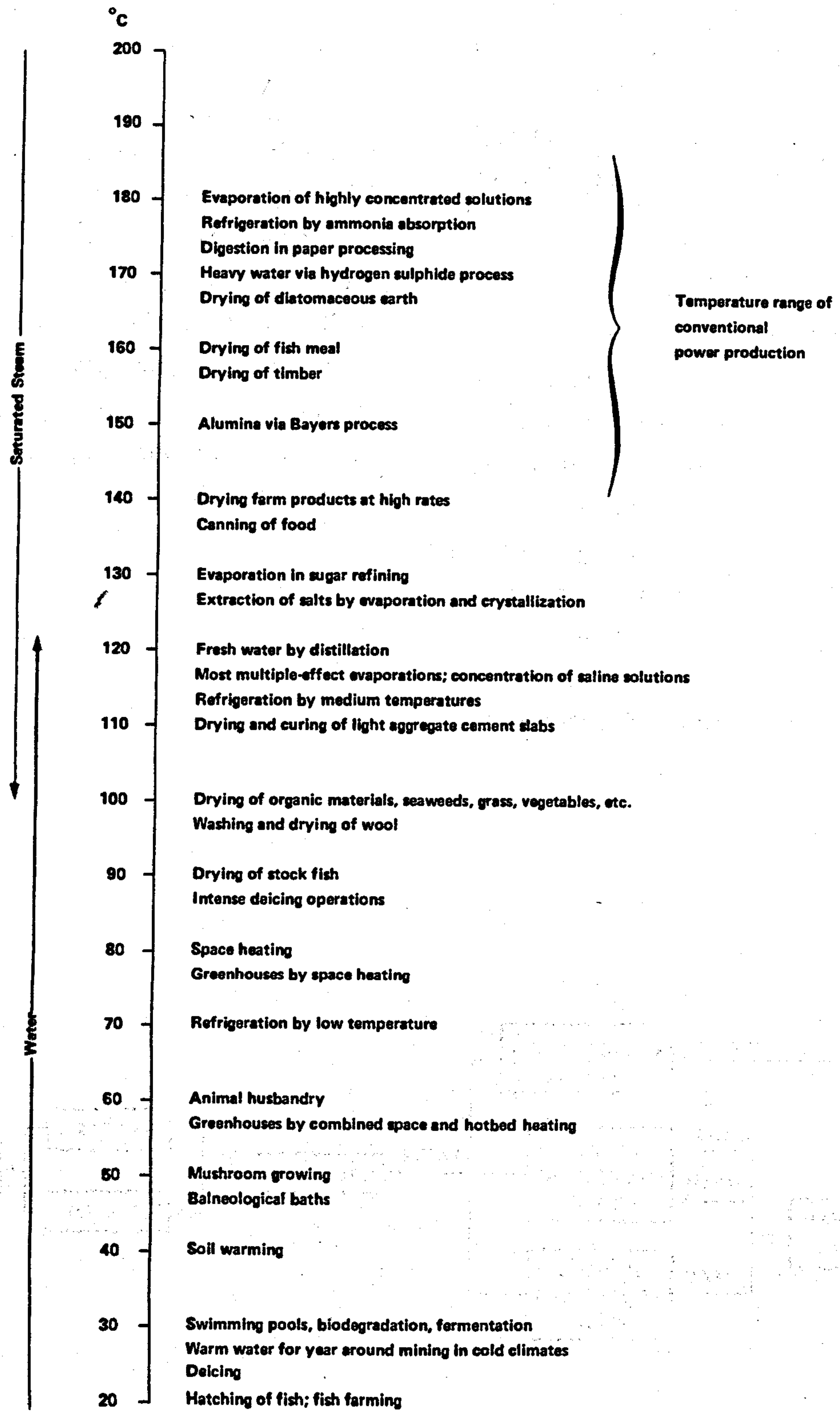

Figure 6. Required temperatures of geothermal fluids for various direct-use applications.

Various treatments of the brine are possible to decrease its interaction with rock formations. These need to be evaluated to see if any can appreciably extend the lifetime of reinjection wells.

Direct-Use Processes

Geothermal energy in its natural state is simply heat. Any residential, commercial, or industrial process requiring heat is a candidate for utilization of this energy source (Fig. 6). Applications that make direct use of geothermal heat do not incur the losses of efficiency that result when energy has to be converted and transported. They also can utilize relatively low-temperature brines.

High-temperature brines can be most efficiently used in integrated systems in which direct applications of geothermal energy and electricity production stand side-by-side. In such a system, the waste heat from a high-temperature process provides the energy input for a process requiring a lower temperature—and so on down the temperature scale (Fig. 7).

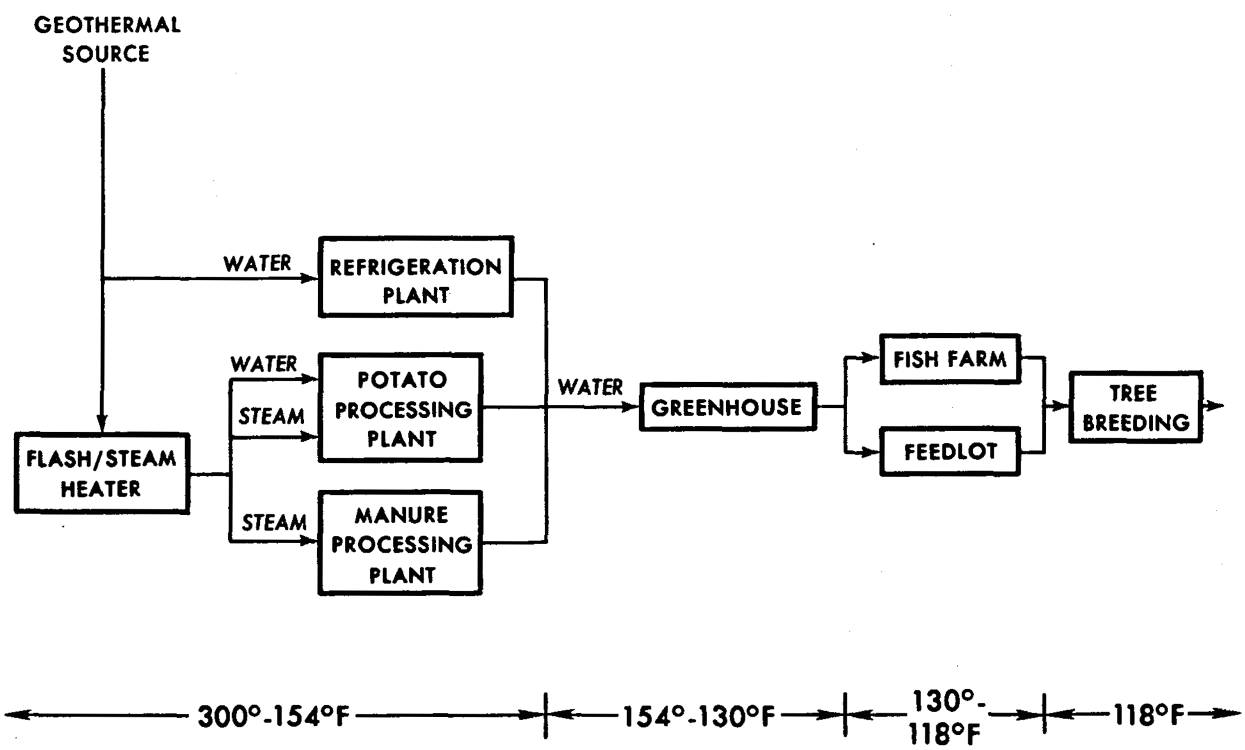

Figure 7. Conceptual integrated geothermal system.

FUTURE OF THE TEST FACILITY

Further development of the Test Facility is planned. Included in these plans are additional wells, expansion of the test pad and increased cooling capacity to permit larger-scale experiments, and installation of additional instrumentation.

When the present construction work is completed, the ERDA Geothermal Component Test Facility at East Mesa will be able to provide industry with a convenient and relatively inexpensive means for testing prototype processes.

Engineers and manufacturers of equipment interested in using the Test Facility, or in finding out more about it, should contact Eric Festin, Facilities Coordinator, Lawrence Berkeley Laboratory, Berkeley, California 94720. Telephone: (415) 843-2740, ext. 5036.