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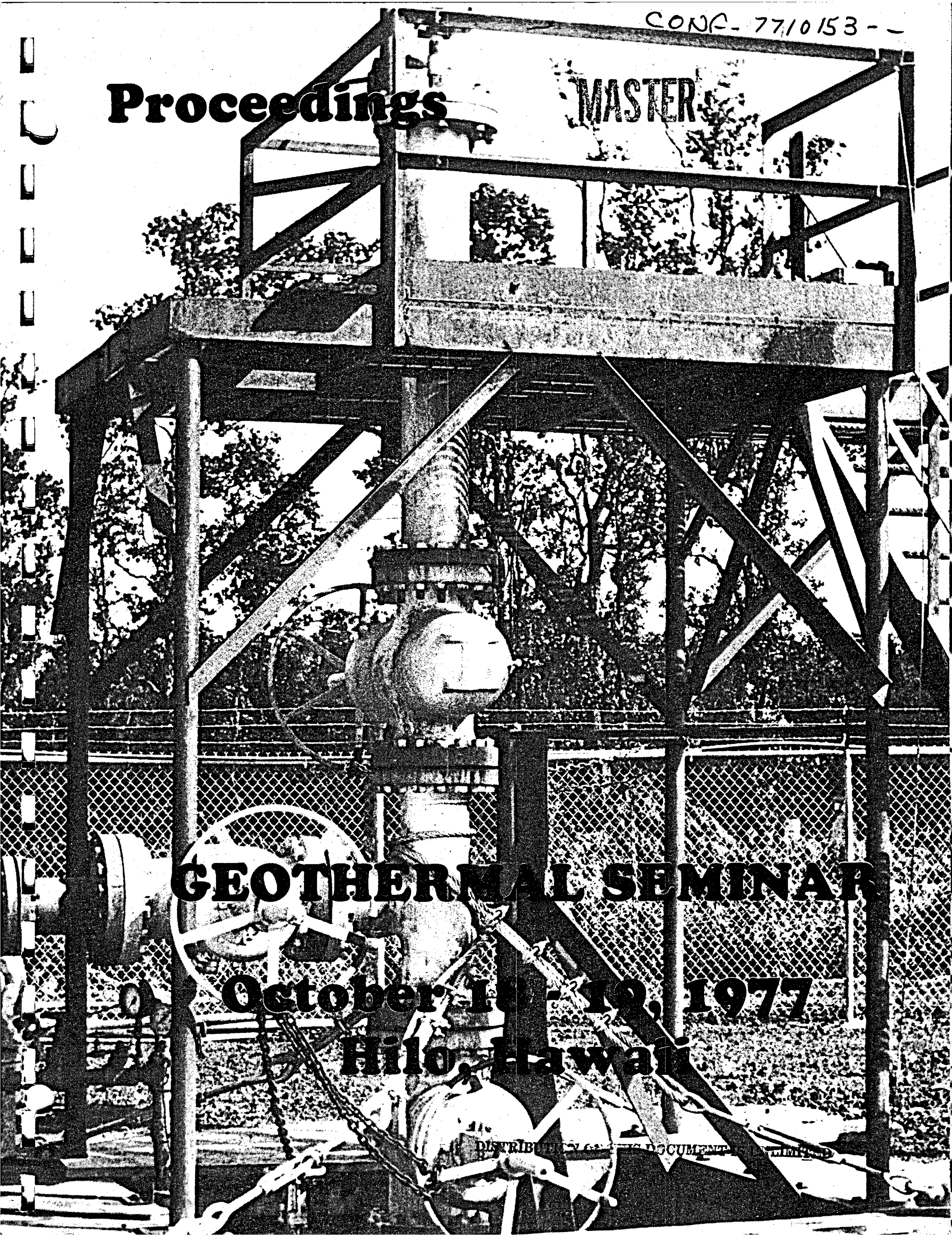

GEOTHERMAL SEMINAR

October 18 - 19, 1977
Hilo, Hawaii

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PROCEEDINGS

OF THE

SEMINAR ON GEOTHERMAL ENERGY

OCTOBER 18-19, 1977

HILO, HAWAII

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SPONSORED BY:

DEPARTMENT OF RESEARCH AND DEVELOPMENT, COUNTY OF HAWAII

IN COOPERATION WITH:

GEOTHERMAL RESOURCES COUNCIL
BISHOP ESTATE
U.S. DEPARTMENT OF ENERGY
CENTER FOR SCIENCE POLICY & TECHNOLOGY ASSESSMENT, DPED

HERBERT T. MATAYOSHI
MAYOR

Office of the Mayor

The County of Hawaii, realizing the need to alleviate the energy crisis we face at present, conducted a two-day seminar on the development of geothermal energy.

The Seminar on Geothermal Energy, held on October 18-19, 1977, in Hilo, provided an overview of the non-technical aspects of geothermal development in Hawaii. The main topics of discussion included the legal, regulatory and financial considerations of developing the alternative energy source.

The proceedings of the seminar include the pertinent information that the various experts shared with us.

To all of the speakers and industrious individuals who contributed their energies and expertise, and to the U.S. Department of Energy and the many organizations that helped to make this seminar possible, I extend my deepest gratitude. Your contributions have definitely added to the pool of knowledge needed to continue to explore and to implement this extremely valuable energy source.

HERBERT T. MATAYOSHI
MAYOR

FOREWORD

The Proceedings of the Seminar on Geothermal Energy contains discussions of financial, legal and environmental aspects of geothermal energy development in Hawaii. The non-technical aspects of geothermal development in Hawaii were discussed to address itself to the needs of the local community in understanding the impact on the Big Island community.

The seminar was coordinated by the County of Hawaii's Department of Research and Development. Funding assistance for the seminar was provided through a grant from the United States Department of Energy (#P 7800024: "Seminar on Geothermal Energy Resources").

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OPENING REMARKS
Herbert T. Matayoshi

The Honorable Herbert T. Matayoshi is Mayor of the County of Hawaii.

I'd like to thank all of you for coming here this morning and am very pleased with the warm reception we've received from the community. All of you here this morning certainly attest to your interest and our interest in the geothermal area. I'd like to, therefore, thank all of you for attending this seminar. I would also like to pay tribute to the Bishop Estate Trustees who have helped us in this area and would like to especially extend my gratitude to our speakers who have come a great distance to share their expertise with us. I would further like to acknowledge Rob Stern of the U.S. Department of Energy for his generous support and for the support of his department.

All of you recognize that we in the County of Hawaii are looking forward to economic development and feel that we have great potential here on the Big Island in terms of expanding our economic base. One of the areas of course is energy self-sufficiency which we feel is a significant part of our economic base. As you know, we are moving very rapidly toward that particular goal, and one of the most outstanding possibilities of energy self-sufficiency is that of geothermal energy. Therefore, we are putting all our efforts in geothermal at the present time. However, this is not to say that we are not looking at the other alternate energy resource potentials that we possess. The ocean thermal energy conversion factor, biomass conversion, (the plantations have been working on this for a good number of years), wind and solar power are some of the other alternate energy resources that we are interested in. But obviously, OTEC, biomass, wind and solar resources may not be developing as quickly as our geothermal resource. (But one never knows, and we welcome all surprises). In terms of the geothermal potential, however, we have great possibilities. As you know, this resource gives promise of a bright future for us here on the Big Island.

In developing geothermal energy we also recognize that there are technical aspects of this resource that our people in this County, and perhaps in the State, too, should know about. This is the legal, financial, and regulatory requirements of geothermal operations that form the basis of this seminar. So we're starting off on this basis right now to keep our people informed about these requirements. I know you will have a very fruitful two days of discussion in a very important area which may help to determine the economic future of this Island. I hope you will have all the questions that you have answered during this seminar. But if there are some areas you would like to explore further, I invite you to let us know, let the Department of Research and Development know, and we will do all we can to assist you in every way. We look forward to this seminar and others like it.

Thank you very much.

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EXTENT OF GEOTHERMAL RESOURCES

Patrick Takahashi

Dr. Patrick Takahashi is Acting Associate Dean of Engineering and Associate Professor in the Department of Civil Engineering, University of Hawaii at Manoa.

I. INTRODUCTION

Geothermal energy basically is energy from the earth's internal heat. Usually three elements must be available in a usable geothermal reservoir:

(1) a source of heat, which in Hawaii probably consists of underground magma at a temperature of 1200°C;

(2) a carrier which enables the heat energy to be brought to the surface; this is usually water and/or steam, the hotter the better;

(3) a rock formation which absorbs the heat from the source and transmits it to the water; the rocks must be sufficiently fractured to permit the water and/or steam to flow easily through it.

Drilling for geothermal energy in Hawaii started in the early 1960's on the Big Island. Four wells were drilled in the Puna region to depths of several hundred to a thousand feet; all were unsuccessful in locating geothermal steam. In 1973 a fifth hole was drilled near Halemaumau Crater to a depth of 4140 feet. The maximum temperature reached was only 279°F (137°C), but at bottomhole a high rate of temperature increase with depth suggested much higher temperatures at greater depths.

The sixth hole was completed in April of 1976. This well, HGP-A, which has the highest recorded temperature of any geothermal well, has raised hopes that in Hawaii geothermal energy might be a viable alternative to fossil fuel energy.

II. THE HAWAII GEOTHERMAL PROJECT (HGP)

The Hawaii Geothermal Project was organized by the University of Hawaii to locate and utilize geothermal energy resources in Hawaii. HGP came into being when the 1972 Hawaii State Legislature allocated $200,000 for geothermal research, contingent on the University's also obtaining federal funds, which it did. From the beginning this has been a cooperative project involving the Federal, State and County governments, the University, the electric utility and the private sector.

Research got underway in the early summer of 1973, with separate programs established for Geophysics, Engineering, and Environmental-Socioeconomics. Later an Experimental Drilling Program was added. The major emphasis initially was on geophysical surveys, but support activity was begun in the other programs as well. Since the Big Island, because of its active volcanoes, appeared to be the most promising island for locating geothermal resources, an initial reconnaissance was conducted there.

A. Geophysical and Drilling Summary

The geophysical program was designed to select a drill site with high potential for a geothermal resource and also to develop an understanding of the thermal processes of a basaltic volcano and its associated rift zones. Various geophysical surveys were utilized: infra-red, surface manifestations, gravity, magnetic, electrical, well temperature, seismic, geochemical and hydrological. Data from a self-potential survey by the U.S. Geological Survey were also used.

The HGP Site Selection Committee considered all geophysical, geological, and geochemical evidence which had been collected and selected as the most likely location for finding a geothermal resource an area in the Puna District near the eastern rift of Kilauea Volcano. Permission was obtained from the Kapoho Land and Development Company to drill a well on a four-acre plot approximately three miles southeast of Pahoa. Figure 1 contains a map showing the location of the site, which is 600 feet above sea level.

Drilling of the experimental well commenced on December 10, 1975. The well was completed to a depth of 6450 feet on April 27, 1976, with casing from the surface to 2230 feet and a variable-slot liner from the end of the casing to bottomhole. To obtain data on the subsurface geology, wellbore cores of the rock were taken at approximately 700-foot intervals and samples of drill cuttings were obtained for every five to ten feet of drilling. The well was logged twice to measure resistivity, self-potential, natural gamma ray count, slow neutron count, and cement bond. The depth of logging was limited by surprisingly high downhole temperatures, which caused measurement equipment to burn out from the heat.

B. Well Testing Program Results

The well, HGP-A, was first flashed briefly to produce a steam output on July 2, 1976. The rate of discharge of steam was impressively high but noisy -- resulting in DBA readings of 120, roughly equivalent to that of a 747 jet aircraft at takeoff. On July 22 steam was discharged continuously for four hours, verifying that natural fluid flow into the wellbore was taking place. The quality of the fluid from HGP-A was very good -- surprisingly low in chloride content, but with an expectedly high amount of silica since a bottomhole temperature of 676°F (358°C) had been measured, making HGP-A the hottest geothermal well in the world.

In order to proceed with a testing program a silencer/separator was installed to muffle the noise and also to separate the steam from the water, so that the amount of each component could be measured. In late December and early January muffling and stiffening were added to the silencer to reduce the noise further, after which a series of throttled flow tests was conducted to provide a better assessment of the well's possible output and to obtain preliminary design data for an electrical generator which could be connected to the well to produce electricity. Table 1 summarizes the test results and shows that a relatively wide range of operating pressures is available with relatively small change in steam output. Approximately 3.5 Mw of electrical power is available from this well.

Temperature and pressure profiles throughout the full 6450-foot well depth have been obtained. Figure 2 contains typical temperature profiles during quiescent and discharge periods. It is of especial interest that each succeeding test has resulted in increased steam output. Table 2 indicates this improvement and shows that the steam flow rate increased from 60.0 to 75.2 Klb/Hr, a 25% increase, between the November and March tests.

The results of these preliminary tests were sufficiently encouraging that a ninety-day flow test was begun in late March, 1977. However, the nuisance effects of very small hydrogen sulfide emissions combined with the fact that the wellhead pressure had begun to stabilize led to the termination of the test on May 9 after six weeks of flow.

C. <u>Present Status</u>

Figure 3 is a sketch of the present wellhead and silencer assemblies, including instrumentation installed to obtain important data about the performance of the well. Table 3 summarizes the characteristics of the well and the Kapoho Geothermal Reservoir as deduced from the tests and measurements made to date. Of importance are: the water/steam mixture is very clean, the bottomhole temperature is about the highest recorded in the world, a very large geothermal reservoir may exist in Puna, and about 3.5 Mw of electrical power can be obtained long-term from this well.

Figure 4 contains a possible model for the underground system in the vicinity of the well and also shows how an electrical generating system could be connected to the well. As shown, the heated weater/steam mixture enters the wellbore near bottomhole and flows quickly to the surface where it is sent to a separator, which discards the water and sends the steam to drive a turbine generator which produces electricity. It should be noted that once the wellhead turbogenerating system is installed with the proper hydrogen sulfide scrubbers, any noise and odor problems present will be remedied.

The early installation of a wellhead generator, both to provide power for the Big Island electric-grid network and to obtain additional information on the characteristics and the extent of the geothermal resource, is the next logical step for developing the Kapoho Geothermal Reservoir. To this end a consortium, the HGP-A Development Group, has been formed with the responsibility for constructing and operating an electrical generating plant using the steam from HGP-A. The consortium consists of the State of Hawaii through the Department of Planning and Economic Development, the County of Hawaii, and the University of Hawaii through the Hawaii Geothermal Project. The lead agent for the consortium is DPED. Although not legal members of the HGP-A/DG Consortium, the Hawaii Electric Light Company and the Hawaiian Electric Company are active participants in the program.

III. THE FUTURE OF GEOTHERMAL ENERGY IN HAWAII

The Hawaii Geothermal Project will continue into a Phase IV effort, concentrating on an assessment of the Kapoho Geothermal Reservoir. The thrust of the program is a better determination of the characteristics of the reservoir and its boundaries. Included will be an evaluation of the hazard of siting a power plant in the vicinity of an active volcano and/or rift zone and the methods by which this hazard can be minimized or eliminated.

Negotiations are currently in progress by the HGP-A/DG Consortium with the U.S. Department of Energy for funding of the wellhead generator. Current plans call for completion of the electrical power plant in two years. In addition to generating electricity, the facility will include a visitor information center and means for connecting to the well to perform experiments on the well or to use the well's output to test new geothermal devices.

With the installation of a 3.5 Mwe wellhead generator at HGP-A, the electrical needs of 3,500 people can be met. It is expected that relatively high-quality fluid can be expected from HGP-A for well over the 30-year life expectancy of the generating plant. Geoscientists have estimated that the Kapoho Geothermal Reservoir may have a capacity of 500 Mwe, or greater, for 100 years. If one theory which suggests that the entire rift zone is an immense reservoir proves to be true, 5,000 Mwe for 100 years might easily be possible for this rift zone alone. To exploit this vast potential, additional wells must be drilled and additional power plants constructed.

In addition to Puna, there are other potential geothermal areas on the Big Island such as the east rift of Kilauea and regions near South Point and Mt. Hualalai. Geothermal reservoirs are believed to be able to retain heat for hundreds of thousands, and even millions, of years. Since Haleakala on Maui erupted late in the 18th century, Maui, too, has potential. Furthermore, hot water sources have been found on Molokai, and in Lualualei and Waimanalo on Oahu. As the population center of the State is located on Oahu, discovery of geothermal energy in the City and County of Honolulu would be welcomed.

But how would geothermal energy be used? What does geothermal energy mean to the average citizen? What impact will this alternative have on the environment, economics and society in general?

Geothermal energy has been shown to be among the most economical of all fuels for producing electricity, and one of the cleanest. Pure steam wells are about the most competitive, while fluid containing only 20% steam, although presently exceeding fossil fuel power plants in cost, is still below nuclear power plant costs. The fluid from HGP-A is of 64% steam quality so its economics seem attractive at this time. However, the utilization of geothermal energy will not cause electrical rates to come plummeting down. As economies of scale improve, however, what should be possible is that rates will not rise as rapidly as those of energy derived from fossil fuels.

As the Big Island presently consumes only an average of 70 Mw of electricity, power in excess of this amount could be diverted to other uses. One possibility is to connect the major islands in the Hawaiian chain by means of a submarine power cable. This is technically feasible but the costs appear too great for implementation now. Another possibility is to use the geothermal energy for the processing of deep sea mining ores. Several hundred to a thousand megawatts can be used, depending on the size of the processing operations. It has been speculated that perhaps half a billion dollars in annual revenue can be approached at full production ... about the present annual value of petroleum used in Hawaii. Other minerals from land ores, such as aluminum and copper, have also been discussed as having potential. However, the possible negative impacts on the environment will have to be addressed.

Another thought is to produce hydrogen by the hydrolysis of water. Hydrogen is a good long-term possibility as a synthetic fuel. As Hawaii attempts to gain energy self-sufficiency, hydrogen could be a vital key, as hydrogen, in addition to residential and transportation use, can also be exported, allowing Hawaii to become an energy supplier.

Additional uses of geothermal energy could be for tourism -- health spas, resorts; agri-business -- aquaculture, sugar processing, papaya processing; and other non-electric applications. It is estimated that 90% of present worldwide uses of geothermal energy is non-electric.

In summary, then, geothermal energy can be relatively inexpensive. If proven to be in abundance, it could improve the State's economic picture, and definitely would reverse the bleak balance of trade situation on energy. At this time geothermal energy shows exciting promise as a feasible alternative to fossil fuels and nuclear energy. The next few years will be important ones in proving the extent of the resource and sensibly developing its potential.

PRACTICAL UTILIZATION
William Dolan

William Dolan is President of Geothermal Resources Council, Davis, California, and is a member of the National Geothermal Advisory Committee.

Thank you, Clarence. I'm always a little nervous when I'm introduced as an invited expert because it reminds me of Edward Teller's definition of an expert, someone who has made every mistake possible in a given endeavor. I haven't quite made it on that score. I hope not to.

I should have begun by saying, "Good morning, Mr. Mayor, ladies and gentlemen." Excuse me.

Thank you for inviting me to this seminar. I am gratified on a number of levels. The physical setting is, if nothing else, pleasing, if only it would stop raining. The Hawaiian Geothermal Project has revealed an interesting, and perhaps outstanding, geothermal resource. My passage was without cost to the AMAX shareholders. It has been indicated that Hawaii will make geothermal developers welcome. It is nice to communicate with people who try to make things happen. Also, you've invited some of my favorite people to share their wisdom, such as Bob Greider, Claire Heinzelman and Dave Anderson.

I joined AMAX in 1969 as chief geophysicist and I occupied that position quite contentedly until one day in January of '73 when we at AMAX Exploration were startled by our chief executive officer, Ian MacGregor requesting that we re-examine geothermal. I say re-examine because in 1964 AMAX took a brief look at geothermal.

One of our geophysicists, Art Lange, had some of the credentials necessary to effect a review of geothermal. As in all such matters he concluded that geothermal required further inspection and might indeed be of interest to AMAX. The corporate response was to encourage us. Soon, AMAX had two people working on geothermal, then three then a geothermal budget, then a space crisis. Following that we acquired leases and a lot of head scratching and headaches.

Figure 1, I think, better illustrates geothermal as we viewed it at that time than any others we've seen.

I'll now talk about AMAX, the company. It's a highly diversified multi-national mining company. We're the only major mining company involved in geothermal. I know that you largely associate geothermal with the oil companies. That's not completely untrue in our case. Since 1975 the largest shareholder of AMAX has been Standard of California at approximately the 20 percent level. The other major shareholders are Selection Trust of London, a mining company, and the Hochschild family who represent the founders.

AMAX has about 15,000 employees and had earnings in 1976 of approximately $150 million. AMAX operates in a multitude of countries. Its products, in approximate order of importance, are molybdenum, coal, iron ore, copper, potash, aluminum, lead, zinc, tungsten, wood, and nickel. It also has oil interests with a net world production that might approach the needs of the Volcano House. We don't want to compete with Standard of California!

I brought several copies of the AMAX Annual Report. Marvin Iida has them. They can be made available for those of you who will find them interesting.

Being a mining company, we have to justify why we're in geothermal. We noted the affinities shown in Figure 2. We think they make sense. Geological occurrence, hydrothermal characteristics, alteration, geochemistry, geophysics, and frequency of viable occurrences are certainly more associated with ore deposits.

Very large prospects, attendant property holdings, overall exploration costs, and production drilling procedures are all in the nature of oil practice. However, when it comes to capital or financing requirements, development and production timing, productive life, and marketing, we again see a stronger affinity with mining experience. Environmental impact, we'd like to think, is not much worse than oil but some people might dispute that. I will show you some slides that will support that dispute.

There is one other consideration that will be germane throughout my discussion and that is AMAX's role in aluminum. I've already been advertised as speaking on aluminum. In 1973 AMAX sold half of its aluminum interest to Mitsui. The result is a corporation now headquartered in San Mateo, California, known as Alumax. It operates as an independent corporation, though its directorship is made up of AMAX and Mitsui representatives. I hasten to note that Toshiba, one of the major manufacturers of geothermal generation equipment, and the prime supplier to the Geysers in California, is a subsidiary of Mitsui.

Alumax is a major aluminum producer with substantial bauxite reserves, principally in the Caribbean and Australia. Naturally, that is very high grade bauxite, which unfortunately Hawaii doesn't have. Alumax is also a major power consumer.

As probably most of you are aware, it takes 8 kilowatt hours (world-wide average) to produce one pound of aluminum. Alumax dominantly produces its aluminum in the northwestern United States, although recently it entered into a contract to purchase blocks of power out of the grid in South Carolina.

The power in the northwest (Washington and Oregon) is supplied by the Bonneville Power Authority at bargain prices reflecting times past when they had a surplus of power.

Several years ago, it crossed the minds of those of us in AMAX that Alumax might benefit from geothermal power. Alumax initially reacted by noting that they had grown accustomed to paying 2 to 4 mills/Kwh for power under the contracts with the BPA and were profoundly uninterested in geothermal power estimated at that time as being the order of 20 mills per kilowatt hour. However, in recent months, Alumax has indicated a somewhat more realistic appraisal of energy availability and pricing. That is perhaps prompted by the pending termination of the contracts with the Bonneville Power Authority in 1983 and 1984. Those contracts will undoubtedly be at least partially reinstituted but at a much higher price.

I should comment on some other AMAX experiences with electric power that have provoked our sustained interest in geothermal. In 1973 it became evident that the Tucson, Arizona, Gas and Electric Company would be unable to supply the expanded power needs of the giant Twin Buttes Copper Mine, jointly owned by AMAX and Anaconda. Accordingly, it was necessary to build a 50 megawatt diesel facility with great uncertainty as to oil supplies.

Then, there's Colorado. The Public Service of Colorado is the dominant utility in that state. AMAX, or rather the Climax Molybdenum Division of AMAX is the largest customer for the Public Service Company of Colorado with capacity demands the order of 100 megawatts. AMAX is also the largest supplier of fuel to the Public Service Company of Colorado from its Belle Ayr Coal Mine in Wyoming. That, incidently, is the largest coal mine in the nation.

Having mentioned a few of our associations with electric power, you have probably already perceived that we are naturally interested in electric power resources or rather fuel for power resources to match against future forecast shortages. Even though we're a major coal producer, we are concerned.

Needless to say, that has been a consideration in our pursuit of geothermal energy. Also, AMAX is a major power fuel supplier and operates in a number of states where the geothermal potential is significant.

Figure 3 is oversimplified. As you can see, the green dots are what we regard as the notably prospective geothermal areas on the western part of the mainland. The red color represents the geothermal resources that have been identified. I will call attention to two notable ones, the Geysers, and the Roosevelt Hot Springs area in Utah.

The blue dot in the northern part of New Mexico is known as the Valles Caldera (Baca Land Grant) where Union Oil has discovered geothermal.

That will give you a brief impression of how it looks in the western United States.

AMAX does not at present, and I emphasize present, view geothermal as being significantly profitable, unless of course you own a dry steam occurrence. However, it is not unreasonable to anticipate better conditions in the future. Tax legislation that will improve the business is pending before Congress right now as part of President Carter's energy package, though the Senate and House as you have probably noted don't seem to agree too well.

The cost of generating power from geothermal resources, or applying the heat directly, is bound to come down just through experience, apart from inflation.

I should now like to comment on our view of geothermal energy on the mainland, apart from what I've already said. I think that it would be useful for your overall appreciation.

Geothermal finally captured the attention of the federal government in the late 1960's as a result of the provocative efforts of a handful of visionaries. Unfortunately for geothermal, our society had by that time discovered that the environment was vulnerable. Hence, the 1969 Environmental Protection Act.

Our government seemingly also concluded that the natural resource companies universally subscribe to the rape and run principle. Amid that atmosphere, conventional free enterprise priorities tended to be dismissed. For some time, there appeared to be a belief that government was capable of great evolution in its thinking but that all elements of the private sector were rigidly locked into historical patterns or incapable of responding to changing needs.

As an aside, note that I am speaking of the same enlightened government that applied the operating principles established at our European Diplomatic Desk to the Far East with such disastrous consequences.

The circumstances that I have just described were compounded by geothermal oversell. By that I mean that those who had "contracted the geothermal disease" advertised promises for the resource that tended to place it in the same exalted category as a high grade gold mine.

The resulting Geothermal Leasing Act of 1970 was eventually implemented in 1974. That Act, in my estimation, has effectively set back the orderly development of geothermal energy on the mainland for at least six years.

Subsequently, provoked by the Arab action of 1973, Congress enacted the Research Development and the ERDA Act which has now been superseded by the Department of Energy.

The latter two acts have strongly benefited the Hawaiian geothermal program, fortunately.

Overhanging all else on the mainland, we've had substantially unrealistic goals for geothermal set by Project Independence which we've had to back away from repeatedly. First we were going to have 30,000 megawatts by 1985, then 20,000, then 6,000, now 4,000, now there's considerable doubt that we'll reach that.

Of course, Congress tends to dismiss the importance of geothermal when it contrasts 4,000 MW with the U.S.'s current capacity of 500,000 MW's. But 4,000 megawatts of geothermal power constitutes a major industry.

Among other things, we've witnessed an extreme shortage of qualified regulators.

Obscurely, but importantly to those of us on the mainland, we have the provisions of the 1916 amended Stock Raising Homestead Act to serve in a deleterious fashion. Is geothermal a mineral? The government reserves the "minerals" under that Act. You also have an ownership problem in Hawaii which we'll hear about later.

Compounding matters economically the IRS has seen fit to interpret its legislative mandate to the detriment of geothermal. In doing so they have even challenged favorable court action.

The last, but not the least, of our problems, is the tendency to ignore what goes on abroad. It's what we call the NIH syndrome -- "not invented here". I'm not sure if the U.S. has still discovered that the Mexicans have been generating power for some 5 years 20 miles south of our border from a hot water system.

To amplify that point, Figure 4 is a summary of world geothermal development. Worldwide, we expect a total of about 2,500 megawatts of geothermal power on stream in the next two years.

Now, I'd like to talk about the overall energy dilemma of the United States because that has to be kept in mind when we examine any component of energy. The major influencing factor that comes to mind when we consider the United States energy position is that since shortly after World War II, the Federal Power Commission has, by statute, regulated the price of interstate shipments of natural gas. As you're aware, that is a point of real controversy between the Administration and Congress right now. One need only examine the wholesale price index for fuels and power to observe the consequences.

Figure 5 is a trend plot (ratio scale - not absolute) exemplifying the trends of various economic factors that might interest you. The one to note is the wholesale price index for fuels and power just mentioned. In contrast with most other economic trends over a twenty-year period from 1950 to 1970, it was effectively flat. It has risen dramatically since. Who knows where it will level off. Per capita energy consumption for the United States rose dramatically during that period. The message is: the artificial control of one energy component led to artificially cheap energy overall with excessive consumption.

Don't be too impressed by the geothermal capacity curve. It started from zero and on a ratio plot, so it has to look a little silly. In fact it's rolling over very rapidly because of environmental delays. The nuclear capacity follows a somewhat similar trend as is typical of newly introduced components of energy.

At any rate, a cheap price for natural gas provoked excessive industrial usage. That led to a condition where priorities that would have been provided by free market pricing must now be imposed by the federal government. That may not remain so however.

Balance in U.S. energy usage is an undeniably complex subject. Nonetheless, it doesn't require profound economic insight to realize that fixing a low price for one component of our energy supply effectively deterred healthy production of the other components. For example, coal production declined steadily from 1945 to 1960.

Our dependence on foreign petroleum also relates to the controlled pricing of domestic natural gas. Our oil companies were driven to seek cheap supplies at the expense of the development of the nation's resources.

The cost of foreign source energy, combined with the cost of complying with environmental over-kill has accounted for most of the inflation experienced in recent years -- not wage and price demands. The resulting severe economic dislocation equates to that of World War II, and the ramifications will extend far longer.

I think it's useful now to turn to geothermal prospecting procedures which have already been discussed.

Figure 6 is basically a laundry list of geothermal prospecting methods and considerations. Unfortunately, most of the methods shown do not have application in Hawaii. In fact, in no single place in the United States do they all have application. Many of the tools indicated don't work in Hawaii for the simple reason that the volcanic setting and tropical weathering produce masking effects. For instance, hydrogeochemistry is confused by excessive precipitation.

I should mentioned the term "geothermal discovery." Heat alone may fail to constitute discovery. A permeable reservoir, modest amounts of dissolved solids, and adequate fluid recharge will all be necessary to complete the requirements in the most ideal sense. The Hawaiian Geothermal Project appears to have identified those ingredients.

I should mention that we have estimated that the probability of geothermal discovery by drilling is the order of one in ten to one in 25. Hawaii has enjoyed one for one. Congratulations!

We might also turn to the United Nation's geothermal experience. In general, their projects have led to the discovery of geothermal fluids. Mind you, though, they have usually had the full cooperation of the local government in gaining access to the best targets. In the United States those tend to be in national parks!

Neglecting such matters as energy conversion equipment and marketing techniques, I will proceed to the piece de resistance of my discussion.

First, AMAX's interest in Hawaii? We were initially tantalized by the reported parameters of the Hawaiian Geothermal Project. The 600°F temperature, the dissolved solid content substantially below that of the water I drink in Denver, etc., all made it sound like the best geothermal discovery since dry steam. Furthermore, we were advised that owing to certain deficiencies in the completion procedures that the well might be understated.

We also considered the other favorable factors: It's in the United States, the climate is pleasant, development has been invited, the populace is well educated, very active volcanism bespeaks the presence of considerable heat, and it didn't require too much imagination to envision alumina shipped from Australia and being reduced to aluminum in Hawaii.

With not much more than those considerations in mind, I visited Hawaii during February and March, 1977 for purposes of acquainting AMAX with the situation.

I must note that I was very hospitably received by Dan Lum and many others. In fact, Dan was very instrumental in setting up meetings for me. The representations I received were intelligent, thorough, and useful, and I developed a viewpoint.

The viewpoint that I presented to AMAX was basically as follows. There is a propensity for natural catastrophe, such as earthquakes, volcanic eruptions and tsunamis. There is an absence of critical items of infrastructure. Taxes are a question. Land acquisition procedures can hardly be deemed attractive. Assuming that one might be totally successful in physically developing a resource, and discounting the first four items I mentioned, the economics would still fail to meet AMAX's requirements.

The consideration is that the current average price of electricity on the Big Island is the order of 75 mills/Kwh. It <u>is</u> probable that it will be practical for a producer to produce electricity and realize a price of 35 mills/Kwh.

It seems evident that Hawaiian Electric, as it retires its obsolete power plants serving the local market, can justifiably consider replacing them with geothermal power plants. In fact, that will be motivated by the price of oil. The role of geothermal producer in that setting has no appeal for AMAX because of the modest scale of the market.

An aluminum reduction installation cannot afford to pay more than 17 mills for power right now. A ferrochrome reduction installation, which I was obliged to consider, cannot afford to pay more than 11 mills. AMAX's experts on undersea mining advise that cheap electricity, no matter how cheap, is not going to attract manganese nodule processing in Hawaii in the near future.

Despite the previous observations we have continued to re-inspect matters. As a result, we must go beyond the realm of possibility and suggest that an aluminum producer can become interested in casting itself in the role of geothermal electricity producer and sell its electricity to itself to supply a plant erected in Hawaii.

I'm going to mentioned some numbers that I've examined but which are not to be regarded as sacrosanct. Nonetheless, it will give you some ideas.

The minimum size plant that Alumax is interested in constructing will produce 197,000 tons per year of aluminum. That necessitates the importation of twice that tonnage of alumina. So, it's not a large materials handling process (compared to mining).

Incidently, the gross value at the present price of aluminum of 197,000 tons per year is $200 million.

Alumax estimates that the cost of such a plant will be $440 million in Hawaii. It will need 350 megawatts of firm power. Since they usually can borrow power from a grid and such is not available on the Big Island, they contemplate that they will need the order of 50 percent standby capacity. That would result in a total of 525 megawatts of capacity.

We can casually estimate that the geothermal fuel supply will cost, providing it is discovered, the order of $2 million per ten megawatts for a result of $105 million.

The geothermal plant cost, we estimate, will be the order of $5 million per ten megawatts.

Thus, the total geothermal plant may total $263 million.

Adding $44 million, 263 million and 105 million yields a total of $808 million. That represents the capital cost neglecting the application of tax incentives.

Primary employment at the aluminum plant alone would be 800 with an estimated secondary employment of 2,800 anticipating. Ninety percent of those would likely be Hawaiians. The geothermal plant would probably need an additional 200 primary employees.

If one assumes a three-year pre-production period, full application of investment tax credits and intangible drilling deductions as they now exist, all equity financing, ten years straight line depreciation of the geothermal plant equipment, and annual operating costs for the geothermal facility of $25 million including G & A, the cost of power will be about 17 mills per kilowatt hour.

After ten years, because of the depreciation schedule I mentioned, that should be closer to 10 mills per kilowatt hour. Note that I have neglected measures that have significant potential for improving the economics. Among those are debt financing and percent depletion credits (if Congress enacts the right legislation). The sale of power from the standby capacity on an interruptible basis to another industry would also be very important. It could be sold at quite an attractive price and still improve the plant economics considerably.

On the other hand, I have also neglected several items that will damage the economics. Infrastructure costs such as port facilities, roads, major catastrophe abatement measures, housing, services, local taxation (which we haven't analyzed at all), and, unfortunately, cycles in the price of aluminum all will have negative effects.

I also note that the cost of 17 mills per kilowatt hour is the maximum Alumax can pay for power and hope to enjoy a 15 percent rate of return on its investment in the aluminum plant. Obviously, they can't invest in the geothermal facility and have it effectively earn nothing on the required investment. However, those concerns might be offset <u>if</u> it can be demonstrated that there is sufficient geothermal resource to satisfy the objectives, the geothermal supply will last at least 30 years, percentage depletion credits will be forthcoming, and the power from the standby capacity can be sold on an interruptible basis.

You've now seen the two ends of the spectrum. First, you have 3 1/2 megawatts. My remarks indicate where you might go. As to the steps in-between, I anticipate that some will be suggested during the course of this seminar.

Thank you for your attention.

01021

EXPLORATION AND DEVELOPMENT COSTS

Claire J. Heinzelman

Mrs. Claire J. Heinzelman is Vice President of Geothermal Resources Council, Davis, California.

INTRODUCTION

The suggested title of my talk, "What monies are required for the exploration and development of geothermal resources?" is a question my own senior management has been asking me for almost three years now, since the acquisition of Thermal Power Company. It is one that I spend a good portion of my working day addressing. It is a question that continues to make me nervous. Such reaction results from the implication in the question that a simple cost analysis can be run on various geothermal projects with some consistency from project to project. If there is one thought I would like to leave with you, it is that each and every geothermal prospect will experience costs relative to its geographical location, geologic environment by the philosophy of the developer working the prospect and, I cannot emphasize enough, by the regulatory environment in which it is developed.

The purpose to such a question is to reveal information about the "world of possibilities" regarding geothermal exploration and development costs and following that, a more selective view of the "world of probabilities" regarding drilling costs; in this instance, in an environment similar to that of Hawaii. Therefore, I plan to first review for you the world of possibilities; a fairly broad collection of exploration and development techniques, describing them and their functions in non-technical jargon that hopefully, both you and I can understand and then associate them with what I consider to be reasonable costs for such services. I will then review a comparable world of possibilities for exploratory drilling, development drilling, field development and then briefly address power plant design and construction costs. The cost of financing the exploration and development phases of a project will get a little much deserved attention in order to demonstrate one significant "hidden" cost associated with the development of a field. In closing I will focus on "world of probability" in a Case Study representing the exploration and development of a geothermal field and a 55 MW electric generating plant.

A WORLD OF EXPLORATION COSTS

Chart 1 presents a display of techniques available for use in targeting drilling prospects. An actual exploration program would be tailored by selection of a few such techniques to the specific geologic model of the target area. These tools are available for use with varying success depending on the geologic circumstances.

SURFACE TECHNIQUES

Geologic Investigation is the necessary ingredient that makes the other techniques useful. Broad reconnaissance of the surface data integrated into subsurface data is used to find an area of general interest. The ability of the prospector in finding and using available data largely determines speed and costs of exploration program progress.

Microseismicity Instrumentation measures very weak earthquakes which may occur in geothermal anomalies. These earthquakes may indicate the presence of faulting and fracturing that could allow deep hot fluids to rise to shallow depths and form an accumulation of heat in available reservoir rocks.

Gravity Measures contrast the density of material within the crust of the earth. Heat may cause the density of rocks in a geothermal area to change. This alteration may create a gravity anomaly near the geothermal resource.

Resistivity Surveys measure the ability of the near surface rocks to conduct electrical currents. The effects of heat may change the conductivity of rocks within a geothermal area causing a change in the measured resistivity.

Telluric and Magneto Tellurics Methods are used to map the deep and shallow zones of conductivity change. This technique is more useful than resistivity surveys. Zones of increased salinity, rock alterations, and heat can be detected over extensive areas. Actual heat or temperature changes cannot be directly measured but are inferred.

Magnetic Measurements are used to locate magnetic blanks or low spots called Curie Points. The magnetic properties of the rocks are destroyed if the rock is exposed to temperatures above 550°C. Computer programs are available to assist in the mapping of Curie Point effect.

Hydrologic Studies might include surface hydrology or ground water movement possibly with the aid of isotope studies. It would very likely include water sampling and analysis. The ratios of dissolved solids in water are used to determine the temperatures of rocks that were in equilibrium with the water. However, if the waters rise to a near surface acquifer and are mixed with cooler waters, their use as geothermometers is not as reliable.

Interpretation of geochemical data requires professional skill in geology and chemistry. If the geology is well known, useful information can be developed.

Self-Potential Survey is a method based on the assumption that fluids moving through porous rocks develop an electrical charge that can be measured. If a convective movement of water takes place around an unusually hot area, streaming potentials can be generated by gauging speed of water movement.

Heat Flow Measurements are used to define the areas of highest heat flow. The technique requires drilling and coring slim measurement holes usually between 200' and 500' in total depth. The technique is limited by its cost and by the necessity to obtain governmental approvals for drilling. Heat flow characteristics cannot be projected reliably beyond the depth of the holes.

Stratigraphic holes are a logical follow on to the shallow holes previously mentioned. Because of their substantially greater depth (2,000') and the resultant higher cost ($40-60) these holes are drilled in fewer numbers. They, too, are limited by the cost and permitting problems, but provide more reliable information regarding temperatures at depth.

Geologic techniques are used to identify surface manifestations that might indicate the presence of the subsurface resource. Geophysical techniques use instruments to interpret subsurface geologic conditions from survey data. Geochemical techniques are used to determine subsurface temperatures by analyzing the ratio of dissolved solids in water.

All techniques measuring data from the surface can only indicate prospective areas. Drilling into the potential reservoir is the only method that can reliably determine if an area is capable of producing geothermal energy.

DRILLING

Because drilling is the only reliable test of a prospect's commercial viability it shares the privileged position with that of geologic investigation as the only techniques that all developers utilize. This constant use however does not manage to positively effect the leveling of costs from prospect to prospect, which is totally contingent upon the geologic structure drilled, the resource properties and the experience of the drilling contractor. Cost projections are difficult to make even for wells within the same prospect. For example in 1976 TPC drilled two wells, the first of which was completed at a cost under $500,000. We then proceeded with another exploratory well less than three miles away. This well was completed after some complications at approximately one third the total depth and in considerable excess of twice the cost. To emphasize this point further, similar cost experiences are still commonplace at The Geysers, probably the best understood of geothermal fields. These are the costs and risks that anyone faces in drilling a geothermal prospect.

RESERVOIR TESTING

Reservoir assessments cannot be made without production testing of enough wells to obtain basic reservoir engineering data. Reservoir pressure draw-down analysis must be conducted to determine reservoir permeability, extent and recharge. Fluid characteristics and analysis of non-condensibles present require extensive flow tests. Injectivity testing is also required to develop plans for disposal and pressure maintenance systems. Rocks may produce fluids easily but may not accept them on return to the reservoir. This must be tested in the laboratory and confirmed in the field.

If each of these techniques were utilized in a three well exploration program you would experience costs in the range of $2,500,000-$4,750,000. In comparison, the single well HGP-A project costs totaled just under $3,500,000. With greater costs emphasis occurring for HGP-A in preliminary geological, geophysical and geochemical surveys (approx. $850,000), in higher drilling costs per well (approx. $1,500,000) and in well testing (approx. $500,000).

The next chart (#2) shows approximate costs for field development. As with exploration drilling, development wells may vary widely in cost throughout the field's development.

The spread in costs of both delivery and condensate pipeline are due primarily to the resource characteristics. The greater volume of resource to be handled the greater the costs. Therefore, the dry steam systems are at the low end of the cost scale while the low temperature water dominated systems will be at the high end.

A WORLD OF POWER PLANT COSTS

Because of the lack of experience in building and operating geothermal power plants the costs of these are even more theoretical than costs associated with exploration techniques and drilling. However, this chart will give you a look at a world of possibilities in power plant costs.

Dry Steam: This estimate comes from PG&E in a report published by the California Public Utilities Commission and represent anticipated costs of $320/KW for Unit 15 at The Geysers due to commence commercial operations in 1981.

Double Flash: These estimates come from our resident expert, Bob Grieder, with his considerable research revolving around Chevron's hot water field at Heber. Although I believe they selected a Binary System for Heber, he has estimated $429/KW for double flash system, where the water partially flashes at the wellhead and is flashed once again at the point of entry into the turbine. Rodgers Engineering estimates slightly higher costs at $450/KW.

Binary Systems: These systems vary most widely in cost estimates, in part due to the fact that there are none of these in actual existence. They break into two types. The first one noted is direct contact, where the secondary fluid is mingled directly with the geothermal fluids and then, when entering a gas phase at much lower temperatures than water, it alone enters the turbine. The second, a shell and tube type system retains the geothermal fluids, enclosed in a series of tubes which transfer heat, without direct contact with the working fluid. This type is advantaged with theorized lower operating costs due to conservation of working fluid by avoiding entrainment in the geothermal fluids -- but is somewhat disadvantaged by the noted higher cost of construction. Only experience will tell.

ENVIRONMENTAL COSTS: These costs are not previously covered in the exploration and development of the field nor in the design and construction of the plant but are required in order to proceed with both. These costs include the costs of environmental data gathering, analysis and document preparation. I am not going to attempt a cost estimate as the costs vary so widely depending on the location of the prospect, sensitivity to impact, and proximity to population centers as well as to state and local regulation. This cost is usually less in absolute dollars spent on environmental work than in costs due to delay imposed by regulatory requirements.

FINANCING COSTS: This is a little considered but important cost of any project utilizing large sums of capital invested over an extended period of time. It becomes increasingly important as the lag time or time after investment and before receipt of revenues lengthens. We will take a look at this cost in the example that follows.

CASE STUDY

Before we move into this case study, I must point out that in running such calculations I have a very optimistic case here, if one views it hoping for similarities with Hawaii. The capabilities of wells described here are in excess of twice the production experience in HGP-A well in the Puna district. I will venture forth with some trepidation reminding you that although the per well drilling costs used in Chart 4 are similar to expected costs for Puna drilling, the number of wells is substantially fewer than would be required for 55 MW plant if future wells compare to HGP-A.

In Chart 4, I have assumed wells that flow 143,000 lbm/hr of total mass flow with a 80:20 steam to water ratio. For ease of comparison to available costs, I also assume a 55 MW generating plant. The percentage of non-condensibles and type of gas ejector effect the pounds of vacuum and ultimately the heat rate and therefore are noted here. These become critical components in plant design.

Chart 5 presents the calculations which determine the number of producing wells which have these characteristics, that would be required to supply a 55 MW turbine/

generator. The calculations determine 11 wells would provide an excess of almost 1 well to function as back-up or stand-by energy and that 2 reinjection wells would be ample for return of fluids to the reservoir.

Chart 6 displays activities, scheduling and costs for an entire development costed by activity and totaling approximately $40,400,000 for the well field and plant. This equals $734/KW for well field and plant ($430/KW for plant; $304/KW for field).

At this point, I want to address the cost of financing such a development. If we assume financing this project at 9% (roughly comparable to ERDA guaranteed loans recently awarded) the cost of financing this development schedule would be in excess of $9,000,000 by the time production began early in the ninth year. This would raise costs from $40 million to just under $50 million. This is intended to emphasize the importance of keeping the project development moving ahead -- a 6 to 12 month delay could easily increase costs by another million dollars or more.

MISCELLANEOUS COSTS FOR PUNA

In passing, I must mention some costs unique to Hawaii because of its active volcanism. These pertain to special engineering for plant and surface facilities in the well field as protection from future lava flows. This particular hazard in an area of such capital intensive development might also require some sort of disruption insurance for field and plant. These services, if available, might easily add another million dollars or more in cost to a project located here.

SUMMARY

In summary, the costs used herein are approximate, at best. They will compare more or less closely to actuals depending on the similarity of exploration program design and execution of the designated schedule. The most significant effect on costs will be in the drilling of wells and the number of wells required to supply a plant in the Puna district. Plant costs will fluctuate as we witness the resource characteristics through flowing additional wells in the area. The additional cost of financing, especially with any significant delays are substantial and increase as development proceeds.

Hawaii has a very valuable resource in its geothermal deposits -- particularly if the deposits prove to be of substantial size. Hawaii also has certain disadvantages, such as distance from mainland suppliers, high labor costs, slow and difficult drilling on this lava isle in addition to the continuing extraordinary risk of volcanic disruption and new lava flows endangering a geothermal field. It is important to remember that geothermal may be price advantaged relative to future alternatives -- but it is not realistic to view any early geothermal production as the "cheap energy" it is often touted to be.

PRICING AND TAX CONSIDERATIONS

Robert Greider

Robert Greider is Vice President of Geothermal Resources Council, Davis, California.

This discussion will show the cost of new electricity generating plants using geothermal energy are competitive with other environmentally acceptable plants. The resultant price of electricity at the busbar is competitive for temperatures above 400°F. The cost comparisons between the various sources of energy that will be available and usable for electricity generation during the next decade should indicate the degree of geothermal energy's growth in the electricity generating industry. The economic desirability of the production or use of a fuel is sensitive to its price. It is extremely difficult to maintain currency in the price of fuel and the cost of electricity generation from the various fuels. The factors that make this difficult include the cost of acquiring prospects, producing facilities and operation, transportation, and cost of conversion to useful form for each fuel. Regulatory requirements have direct effect upon production and construction costs. The tax treatment for each fuel system is a dynamic one. This makes it very difficult to assess the resultant economics.

Oil is widely used in the United States for the generation of electricity. Coal is used to fuel the majority of kilowatts produced by the electricity generating plants. Electricity produced from oil fired plants is directly related to the cost of low sulfur fuel oil as the different plant configurations cost within $100 per kw of each other to build. For instance, an oil fired turbine generator plant costs between $385 and $400 per kw. A combined cycle plant is about $300 per kw so the difference in heat factor, operating cost, and available capital for these plants establish which will be used for meeting the increased demand and plant replacement schedule within a utilities service area.

The price of any fuel is the amount of money a willing buyer and a willing seller can agree upon in a free economy. Posted prices for commodities are the reflection of a seller's desired price and a customer's ability to pay for the quantity of heat that will meet his need. Government reports on fuel prices paid by utilities are reasonable evidence of the final fuel costs at the plant. To determine the actual sales price received by the producer for the fuel, the price reported as paid by the producing facility requires a careful analysis of fuel transportation, preparation, and handling charges. The concept of pricing are the same for electricity generation fuels and non-electric direct fuels. The principles of competition are the same. The fuel producer, in establishing his price, has several strong constraints such as his costs, the price of competing fuels, and the desire of potential customers to use his fuel. The supplier and user of geothermal energy must carefully consider if the price provides a reasonable return on investment to find and produce the energy. The customers must select the fuel to buy that will reliably provide a product at an attractive sales price. The amount of money needed to construct and operate plants to use the fuels is a strong component of how much the customer will pay per unit of fuel. The heat rate of the energy conversion system determines the amount of fuel needed to supply the plant. In electricity generating plants, the heat rate is the number of BTU's required to produce a net kilowatt hour. The average coal and oil burning plant uses 9,000 to 10,500 BTU/kwh. A nuclear plant uses about 14,000 BTU/kwh. Geothermal plants use between 21,000 to 33,000 BTU per net kwh.

OIL

The estimated cost of fuel oil in mills per kwh vary with the entity making the study. Data developed by Stanford Research Institute, a consensus of the fuel industry, and published utility estimates, are compared. SRI estimates fuel oil within the next four-year period will cost $2.30 to $2.50 per million BTU or approximately 23 mills per kwh. Fuel suppliers' published estimates of the cost of oil have anticipated ranges of 20.5 to 22.5 mills per kwh. This is a very narrow range and reflects the strong competition in oil markets. This strong competition between suppliers results in a stabilizing effect upon the overall price of oil. Utility planners have estimated the range of price of oil to be 20.5 to 21 mills per kwh. These cost ranges combined with new plant costs will produce electricity between 43 and 44 mills per kwh. Oil prices are relatively easy to predict in the near future as there is an active worldwide market, and the high transportability of oil allows a new source of supply to quickly move to areas of short supply. Thus posted prices around the world are not strongly area related.

COAL

Coal has a different pricing mechanism. Coal prices are more related to specific sources of supply and dedication of specific sources of coal to certain plants. Coal does not presently have the wide range of usefulness that oil enjoys today. This limits the substitution of one coal for another. Before a mine is opened, a major share of its production may be dedicated to certain plants designed for that specific coal. The demand for coal will continue to increase the price of this fuel as government orders coal to displace oil in new and old plants. The demand for this fuel will grow faster than new mines and transport facilities can be built unless capital formation is encouraged and the current environmental restraints are solved. Increasing the rate of leasing good federal lands would help increase the coal supply.

The cost of steam coal fuel and plant construction costs with the resulting estimated cost of electricity will probably produce electricity at $35 mills. Coal sales prices are determined through negotiations between the buyer and seller, and unlike oil, does not have a national or regional posted price. SRI estimates coal to be delivered for approximately 11 mills per kwh or $1.10 per million BTU. This price is dependent upon the distance from the mine mouth to the plant. SRI estimates new coal plants to cost about $600 per kw of capacity. Fuel suppliers currently estimate coal can be delivered within a one-thousand mile radius for 9 to 10 mills per kwh if surface mining methods are used. Plant costs vary with the precipitation and sulfur removal equipment used in the plant. New coal (including lignite) plants, announced this past year, have prices ranging from $580 to $950 per kw. Utility sources estimate coal will cost between 10 to 11 mills per kwh and the plants should have an average cost of about $630 per kw. An estimated cost of electricity using these parameters is between 35 to 36 mills per kwh.

NUCLEAR

Nuclear fuel plants appear to offer the least expensive electricity for a nonindigenous source. Exhibit 1 shows SRI estimates of fuel costs as 3 to 5 mills per kwh, and nuclear plant costs of $830 per kw. This is lower than the estimates of the fuel industry which place a cost of 6 to 7 mills per kwh as most likely.

The fuel industry estimates nuclear plants can be constructed to meet safety and health requirements for $700 to $1,000 per kw. The utility industry estimates they will be paying 6 to 6.5 mills per kwh for nuclear fuels and plant costs in 1977 dollars will be $800 to $1,000 per kw. The estimated cost of electricity from such plants will be between 32 to 34 mills per kwh.

The wide variation of estimates of fuel costs and plant costs derives from treatment of fuel processing and storage expense, income taxes, ad valorem taxes, insurance, interest during construction, return on investment required, and specific requirements for plants in the area of operation for the estimating companies. The project rate of return for these plant projects is dependent upon the debt to equity rate of the capital required. The utility usually expects to earn a minimum of 20 percent ROI on its equity portion. The interest charge for the debt capital brings the objective project ROI down to the 12 to 15 percent range.

To obtain a comparison of geothermal fuels with these more widely used fuels is quite difficult. The difficulty arises because each geothermal area is restricted to a plant design specifically useful for that local area. It is quite easy to find reference in current literature that geothermal energy should be obtainable for 5 to 50 mills per kwh.

As a point of reference, consider that the California Geyser's steam price of 14.5 mills per kwh is about as inexpensive as geothermal energy can be produced today. This is a dry steam fuel, and the operators have had more than a decade of experience of drilling, completions, and production operations. Optimum techniques have been developed to drill and complete the wells in such fashion that maximum steam production per dollar invested can be maintained. The high energy content of this fluid provides a competitive heat rate, allows smaller diameter lines for the collection system, and the most simple of plant and reinjection facilities. The actual cost of the wells are frequently as high as $750,000 - $1,000,000 but the operation and the high utility of the steam allows a minimal price for the energy.

Much like coal and uranium, geothermal fuel prices will be a negotiated price between the supplier and the user. Each field will have significant differences so a uniform price cannot be expected either for construction of the producing facilities of the design in construction of the utilities conversion plant.

The pricing system first used in The Geysers was directly related to the number of kilowatt hours of electricity produced. A second pricing system based on the energy delivered is now in use. The disadvantage of pricing energy by the kilowatt produced is that there is less incentive for the utility to invest money in making their plants more efficient. An increase in efficiency resulting in more kwh per pound of steam results in the steam producer being paid more because of the utility's investment. The dry steam electricity producing system of The Geysers is relatively low cost so an increase in efficiency is not needed for the steam to be competitive with other available fuels. Dry steam reservoirs are at a nearly constant temperature so there is little incentive for the producer to conduct research and explore new depths for higher temperature reservoirs.

The nature of the reservoir geometry and the ability of the reservoir to respond to changes in production, rates, and temperatures, will determine the final costs for producing electricity from each Geothermal Project.

The costs in hot water systems that will be developed with proper environmental controls are of such magnitude that incentives must be provided to encourage increased efficiency in generation and increased search for greater temperature water reservoirs at depth. This is necessary if these systems are to compete successfully (commercially) with other fuels.

It is good business to consider the revenue stream for the producer as being composed of two parts. The first is money for providing useful heat to the utility, and the second for disposing of the fluid after the useful heat has been extracted by their machines. By buying fuel on a BTU basis, incentive is provided for continued improvement in the electricity generating system. The more kilowatts produced per million BTU, the more competitive the geothermal busbar price becomes.

The sale of geothermal energy can be based on a price per million BTU of "Usable Heat" delivered to plant inlet or the plant's pipeline. "Usable Heat" would be the total energy difference between the delivered fluid mixture and the fluid returned to the producer at a specified temperature for disposal. Energy sales agreements should include clauses that provide for energy sales at a fair market value with escalation determined by negotiations between buyer and seller. If you have a wizard employed, you can develop a formula that will always recognize the true value of energy. If you don't have such capability, negotiations at reasonable intervals of time should provide the most equitable escalation factors.

The basic structure of price must provide an attractive rate of return to the prospector. To achieve this, the prospector's risk capital investment and time at risk before income must be minimized.

The BTU's provided should be priced on BTU's delivered above a reference temperature. These will be known as "useful BTU's." A useful BTU per pound of brine is the remainder of the difference between the enthalpy of the fluid at delivery temperature and the enthalpy of the fluid at a reference temperature such as 200°F. (Reference temperature depends upon agreement with purchaser and is limited by composition of the geothermal fluid and injection plans.)

The simple calculation to determine the useful BTU's at differing delivery temperatures is as follows:

USEFUL BTU

(1)	Delivery temperature from field engineering	365°F	340°F	330°F
(2)	Enthalpy (Inlet) BTU/Lb from heat tables	337.5	311.1	300.7
(3)	Enthalpy @ Ref Temp 200°F from heat tables	168	168	168
(4)	H = Useful BTU/Lb of Brine (2) - (3)	169.5	143.1	132.7

The calculation of price is dependent on the amount of fluid that must be produced. This depends upon design parameters of the utilities' plants. The number of pounds of geothermal brine per kwh multiplied by the useful BTU's per pound has a product that is the number of useful BTU's per kilowatt hour of electricity. Heat rates (BTU per kwh) of geothermal plants vary from 21,000 to 32,000 BTU per kwh. The quality of the steam or heat increases as the temperature rises.

BRINE LBS

(5)	Delivery temp from field engineering	365°F	340°F	330°F
(6)	Flow for 50 MW (M Lbs/Hr) from plant design	7.58	9.25	10.2

(7)	Net MW produced from plant design	45.5	45.2	45.0
(8)	Brine required LB/Net kwh (6) - (7)	167	205	227

CALCULATION USEFUL BTU's/KWH

Brine required X useful BTU/lb (8) multiplied by (4)	28,300	29,300	30,000

The useful BTU's per kwh is divided into the fuel price in dollars per million BTU's to obtain the cost of fuel in mills per kwh.

HAWAII GEOTHERMAL PROJECT

Let us examine now the details of the cost of drilling and producing a geothermal well in Hawaii. The site preparation preceding actual erection of drilling equipment - $46,000. Mobilization of drilling equipment - $120,000. These are not unusual figures because geothermal anomalies exist in areas remote to a concentration of oil field drilling equipment though the equipment is similar and normally is moved long distances and certain adaptations must be completed. Drilling of this well cost - $734,000. This includes labor and standby rig time while decisions as to the operations were made. Materials and services on the well cost - $578,000. Electric logging - $17,000. Tearing down and moving out the drilling equipment after completion of the well is $10,000. This resulted in a net cost of $1,505,000. With increased experience on the requirements for drilling in this general area, it is estimated field development wells could be drilled for around $1 million each. The cost of drilling a well is a significant amount of money but in this case does not represent the greatest amount of money spent to determine if a geothermal resource worthy of development existed at the site of the HGP-A well. Recapitulation of these are shown on Exhibits 2 and 3.

These costs will be encountered by all geothermal development programs. The exact disposition of cost will not be the same but the overall total should be similar. Exploration survey phase one and related research - $827,000. Experimental drilling, well testing, and interpretation of results - $2,077,000. Well testing and analysis of flow and shut-in tests - $513,000. Total expended through the initial well analysis - $3,417,000.

The Hawaiian geology project appears to be a liquid, dominated, reservoir of very high temperatures. The extent of the reservoir, and an estimate of field development cannot be made until at least 3 to 5 wells have been drilled. A geographic spread of test positions within the reservoir are necessary to establish the type of flow that can be expected over a 30-year period. The nature of the reservoir geometry and the ability of the reservoir to respond to changes in production, rates, and temperatures, will determine the final costs for producing electricity from the Hawaiian Geothermal Project.

PROSPECT DEVELOPMENT COSTS

A review of the costs associated with developing geothermal areas was presented by C. Heinzelman in Hilo, Hawaii, October 15, 1977. These costs illustrate that changes in costs are still being experienced in dry steam, high temperature flash, and moderate temperature flash or binary systems. The costs to find geothermal systems continue to increase as geologists learn there are cold holes very near hot areas; there are hot areas within an overall cold area; there can be a steam zone within a hydrothermal area; and there can be two different types of geothermal systems, vapor, and liquid dominated, vertically separated within the same geographic area.

Table 1 is from C. Heinzelman's presentation and illustrates exploration techniques and associated costs. The overall amount of money (per successful prospect) required is $2.5 million to $4.75 million. This provides for limited failure and follow up costs, but does not include the other exploration failures and land costs.

Table I

EXPLORATION TECHNIQUES & APPROXIMATE COSTS

(Small Prospects)

Objective	Technique	Approximate Cost ($)
Heat Source & Plumbing	Geology	15,000
	Microseismicity	15,000
Temperature Regime	Gravity	20,000
	Resistivity	25,000
	Tellurics & sagnetotellurics	40,000
	Magnetics	15,000
	Geochemistry (Hydrology)	12,000
	Temperature Gradient 20 holes	100,000
	Stratigraphic Holes (4)	160,000 - 240,000
Reservoir Characteristics	Exploratory Wells (3)	1,800,000 - 4,000,000
	Reservoir Test	250,000
Total to Establish a Discovery		$ 2,472,000 - 4,752,000

To arrive at this stage, about $12 to $13 million will be spent on related projects in search for a field large enough to produce 200 MW or more.

Upon deciding a significant geothermal anomaly exists, the rate of engineering expenditures increases rapidly to determine how the development can proceed. Essentially, there are no set figures for what it costs to develop a geothermal field. The basic reason for this is that each depends upon engineering the development to the geology of the accumulation and the requirements of the electricity generating system. The electricity generating system must be designed within the constraints of available temperature, rate of production, and ambient conditions of the field site. The key variables are:

Temperature of the fluids produced.

Composition of the reservoir fluids.

Composition of surface or near surface fluids.

Geology of the reservoir framework.

Flow rates that can be sustained by the reservoir.

Cost of drilling in the prospect area.

Well spacing and geometry of the producing and injection sites.

Turbine system to be used.

General operating costs in the area.

Development wells are being drilled and completed for $500,000 - $1,500,000. Injection wells are in the same cost range. The ratio of producers to injectors depends upon reservoir characteristics. Water steam lines from the producers to the plant can be estimated to cost $35 to $100/kw capacity. This cost is dependent upon the development pattern and plant location in relation to the producing wells. Condensate return pipelines' design and cost depend upon the use of the condensate. If the condensate is mixed with the brine that is not flashed, a mixture similar to the produced fluid can be returned to the injection sites and return lines will be similar in size to the production lines. If the condensate is used in the cooling system and allowed to evaporate, a small diameter pipeline can be used to return cooled water to injection line. If this is so, the condensate pipeline can be as cheap as $4 - $15 per kw.

Power plant costs published pre 1975 cannot be used in estimating the expected cost to develop generating facilities. Each geothermal area now under development has unique costs that were provided for when their application to build was approved. Changes in effluent treatment, atmospheric discharge regulation, and visual impact mitigation, affect historical concepts of costs. The following costs for power plants should be considered as a range of costs being achieved today. The delay of a field development and power plant project introduces significant costs because the sums of money committed to these phases have grown to ten times the 2.5 to 4.75 million dollars spent on the exploration techniques.

Plants built to use steam produced directly from a dry steam reservoir are the lowest in cost to build. PG&E's plant number 15 is expected to cost $320/kw with provisions for H_2S treatment. This is an increase of 250 percent over the average of the 1961-1974 period. In the same period, the cost of electricity generated averaged about 5.6 mills per net kilowatt hour. 1979 costs will have increased to 25 to 30 mills per kilowatt hour.

Hot water flash plants have an extremely wide cost range. This is because the temperature and chemical characteristics of the produced fluids and unit size have a wide range. It is this range of characteristics that create a range in costs of from $400 per kilowatt to as much as $700 per kilowatt. Double flash 45 net MW operating on low solids fluids at temperatures around 450°F most likely can be constructed for $450 to $475 per net kilowatt. Fluids 100°F cooler will require plants costing $100 more per kilowatt capacity.

Binary units designed for using the low boiling point fluid to drive the turbine are experimental designs. No plant greater than 5 MW has been operated so cost criteria are tenuous. Research on this system may provide sufficient data to more accurately forecast their costs. Present estimates for approximately 50 MW plants range from Ben Holt Engineering's estimate of $500 per kilowatt to Ford Bacon & Davis shell and tube system at $655/kwh. A small 10 MW binary system is being constructed by Imperial Magna. This has a reported cost of $1,000 per kw.

A summary of estimated development costs after exploration expenses for the field supply, power plant, and ancillary equipment for a 50 megawatt hot water flash unit is as follows:

Table II

Development Wells (12)	$ 10,800,000
Injection Wells (6)	5,400,000
Pipelines	2,800,000
Miscellaneous Field Expense (includes interest and working capital)	9,000,000
Power Plant	25,000,000
Total	$ 53,000,000

ECONOMICS OF GEOPRESSURE - GEOTHERMAL RESERVOIRS

Tertiary basins around the world have been discovered to have reservoirs at greater than normal pressure gradients. These geopressured zones frequently have higher than normal geothermal gradients. Exploration and field developments for oil and gas production in Texas and Louisiana have outlined an area of interest extending several hundred miles from the Rio Grande River to the Delta of the Mississippi parallel to the Gulf Coast.

The economics of developing this combination of kinetic energy, low grade heat energy, and methane, is unfavorable at this time. Uncertainty as to the producibility is caused by the knowledge that to have geopressure, the sand formations must be discontinuous and the reservoirs must be confined in a limited areal configuration. Without such limits, normal temperatures and pressures would exist. A very detailed economic analysis by C. F. Riemann, L. Rios-Castellon, and G. K. Underhill for the Second Geopressure and Geothermal Energy Conference in 1976 covers all aspects of the economics of this resource. This analysis was for a 25 MW system costing $101 million to convert 325°F geothermal fluid containing 40 SCF of methane per barrel. Even though a moderate depth of 14,000 feet was used and 40,000 barrels per day per well spaced only one-half mile apart, the project is not economic. This analysis included a very low ad valorem tax and sales revenue from the contained methane was estimated at a price of $2 (20 percent greater than now allowed by the federal regulated price).

This economic analysis was for a 25 MW module that could be applied to a larger size field. Serious workers should read this carefully and adjust the author's assumption to actual field cases. Care must be exercised to 1) establish minimum well spacing to reduce surface facilities, 2) provide sufficient separation at point of production of producing wells to avoid interference, 3) establish the injection well pattern to effectively couple the producing wells allowing the mining of the heat from the rock framework as the water moves through the reservoir, and 4) realistically establish costs, operating expenses and product prices.

In the deeper reservoirs of the geopressured areas, higher temperatures have been reported by Louisiana State University. These deeper reservoirs (18,000 feet to 19,000 feet) are at temperatures above 400°F. The low permeabilities reported with the moderate reservoir thickness (400 feet) will require a maximum producing rate of 20,000 bbls per day (instead of the 40,000 bbls usually used) per well if excessive draw-down is to be avoided. The wells would probably require 640-acre spacing to eliminate well interference effects. The producer-injector ratio should be planned for 1:1. However, an initial testing period for the first modules can confirm this assumption.

The Department of Energy plans a deep $6,000,00 well test of this type of geo-pressured prospect. The results will be valuable in trying to design a workable method to recover and use this very expensive submarginal energy accumulation. The following summary statements synthesize my opinions on this resource.

Table III

GEOPRESSURE ECONOMICS

BASIS

Reservoir Thickness	400 feet
Permeability/Ft.	Less than 10 md
Surface Pressure	3,000 PSI - 4,000 PSI
Flow Before Injection Required	1.0 - 1.1 billion bbls
Time Before Injection	Less than two years
Minimum spacing producers (interference)	640 acres
Draw Down Limit	3,500 PSI
Injection Pressure	5,000 PSI
Net Methane in Solution	75 SCF/bbl

Table IV

GEOTHERMAL ECONOMICS

SCOPE FACILITIES

Field Size	200 MW
Barrels/year	600 Million
Barrels/Day/Well	20,500

10 Wells each	25 MW Unit
80 Producers	80 Injectors
Plant Net	200 x .85
Plant Load Factor	70 percent

Operating costs and taxes can only be estimated. It is certain they will not be less than those experienced in keeping a gas or oil field in operation for thirty years.

Table V

INVESTMENT AND REVENUE

160 Wells @ \$6 $\overline{M}$ Ea. - \$960 $\overline{M}$
(includes surface facilities)

Heat @ .020/kwh	Gas @ \$ 1.75 $\overline{MCF}$
Energy Revenue	21.25 $\overline{M}$/Yr
Gas Revenue	85.75 $\overline{M}$/Yr
Revenue Total	\$ 107.00 $\overline{M}$/Yr

Table VI

GEOPRESSURE ECONOMICS

EXPENSE

Operating Costs \$200/Well/Day	=	\$ 12 $\overline{M}$/Yr
Property and State Tax 15% x Gross/Yr	=	16 $\overline{M}$
Total Expense	=	\$ 28 $\overline{M}$
Income - (\$107 $\overline{M}$ - \$28 $\overline{M}$)	=	\$ 79 $\overline{M}$
Net \$79 M x 50% (Income Taxes)	=	39.5 $\overline{M}$
Payout \$960/\$39.5 = 24 Years +		

There are adequate problems to solve in utilization of geopressured-geothermal reservoirs. These are primarily related to geologic problems. Discontinuous sands form the reservoir rocks in geopressured systems. The lack of continuity prevents fluid moving to lower pressured zones in a natural adjustment to normal pressure results in the abnormal geopressures. This very discontinuity results in limited reservoirs of restricted areal extent.

As pressures reach normal due to production, the sand grains will be more closely packed and the space between them will be reduced. As this is the space the gas and gas-carrying fluids must move within, the ease of movement is restricted. This loss in permeability will seriously affect the rate of production.

In many geologic situations, faulting and fracturing provide the plumbing that allows geothermal fluids to move into the producing reservoirs. The vertical movement of fluids along these faults is thought to be an important factor necessary for high production rates over the long life required for energy production.

Geopressured reservoirs have no such plumbing, otherwise, their pressures would be normal. The sealed faults in the geopressured areas will cause rapid pressure decline unless produced volumes are compensated by having equal volumes reinjected into the same sand bodies.

A summary of economic problems geopressured and geothermal producers must live with include:

1. Competitive fuels are too cheap and available.
2. Competitive fuels can be transported to areas of use.
3. Reserves cannot be adequately measured for less than \$50 - \$60$\overline{M}$ per 200 MW.
4. Coal, oil, and gas field reserves can be measured for a fraction of the cost.

NEW DEVELOPMENTS

Economics of hot water flash to steam projects continue to be impressive in the areas outside of the USA. Cerro Prieto's development is very encouraging as exploratory work confirms this development can exceed 500 MW. The improvement in heat recovery with double flash units would reduce the cost of electricity and increase the reserve size significantly.

The Republic of Nicaragua's Mototombo field development has progressed rapidly under its new management instituted in 1974. By the end of 1975, seven wells with a capacity of 26 MW had been completed. Two of these were non-commercial and may provide utility as an injection well. At the end of 1976, 15 wells had been completed, and the capacity had been increased to 45 MW. By December of 1977, 26 wells had been completed, and one well was drilling. Eight wells have been drilled that failed to confirm commercial power potential. These may be useful for field performance observations disposal, or injection wells. DeGolyer McNaughton, the international consulting firm, has completed its examination of all the field test data from Mototombo. Test using bottom hole pressure detecting devices in selected wells were combined with full field flowing tests. The firm concludes that double flash turbines can produce 96 MW for more than 30 years using the portion of the reservoir now developed. Turbine specifications are now being prepared to have 80 psig first and 20 psig second stage. The power plant for this 225°C field may have two 45 MW units in operation by mid 1980 or sooner. The estimated cost for the electricity generating plant installed will be \$460/kw for these modern double flash units. In the State of the Union Address by President Somoza on December 1, 1977, it was announced that the development of 100 MW at Mototombo would be completed. This would provide an increase in revenues of \$34 million. A savings of \$26 million in foreign exchange would be the result of this development. This will be strong competition for oil fired generation in Nicaragua.

SUMMARY

As you review presentations on geothermal resources, remember the field costs and the resulting costs to generate electricity are affected by a list of interrelated variables. These are:

Table VII

GEOTHERMAL FIELD COSTS

Variables

- Temperature of Fluids
- Composition of Fluids
- Geology of Reservoir
- Cost Drilling
- Flow Rate Per Well
- Well Spacing
- Turbine System
- Operating Costs

For this reason, it is difficult to present a specific cost of electricity produced by the broad types of resource. The following table presents the probable range of prices for electricity generated from steam and hot water reservoirs today. Prices in 1980 will be higher.

Table VIII

GEOTHERMAL GENERATION

ELECTRICITY PRICE

	Mills/KWH
Steam 450°F and above	22.5 - 24
Hot water flash - Below 400°F	36 - 50
Above 400°F	25 - 30
Binary	40 - 48

Geothermal energy can compete with the other types of energy now being used in the U.S. To do so, the energy must be available from its reservoir at a temperature above 400°F. Below this temperature, operating cost rise significantly as the number of wells to produce and reinject the fluid increases. The cost of the plants rise rapidly as the temperature decreases as the volume of fluid moving through the system increases rapidly. There are economic limits established by temperature that must be recognized. If the BTU content of a ton of coal drops, there is a point where it is not usable for power production. The same is true for oil and gas fluids as their associated water or inert gas ratio increases. Geothermal fluids quality and usefulness is also dependent upon its BTU content per unit volume.

Research must continue on making temperature below 400°F useful. The technology is now mature. There are vast quantities of heat in this resource awaiting the solution to the economic problems of using this low grade heat.

	Nuclear FUEL COST Mills / KWH	PLANT COST $ / KW
SRI	3-5	830
FUEL INDUSTRY	6-7	700-1000
UTILITY	6-6.5	800-1000
EST. COST ELECTRICITY	32-34	

EXHIBIT 1

B.G
Sept. 77

Cost HGP-A Well (Dollars)

Site Prep.	46,000
Mobilization	120,000
Drilling	734,000
Materials & Services	578,000
Logging	17,000
Demobilization	10,000
Total	1,505,000

EXHIBIT 2

B.G.
Sept 77

EXHIBIT 3

Budget Summary for HGP-A Well

Phase I	Exploratory Surveys & Related Research	$ 827,000
Phase II	Experimental Drilling, Initial Well Testing, & Related Research	$ 2,077,000
Phase III	Well Testing & Analysis	$ 513,000
	Total	$ 3,417,000

Source: Report Phase III
July 1, 1977

B.G
Sept 77

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ENVIRONMENTAL REGULATIONS

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CONCLUSIONS

Following is a list of conclusions that hopefully will help to provide some perspective and direction to those who now are or will be involved in the regulation of geothermal development in Hawaii. To provide clarity, they have been separated as to State and County.

State of Hawaii

1. The State geothermal leasing and operating regulations should be finalized as soon as possible. These regulations should not be considered as a complete and/or final document but as the first step in an evolutionary process to develop the optimum regulatory position that will allow development within the environmental and social restrictions imposed by government.
2. The State Department of Land and Natural Resources (DLNR) should continue its geothermal regulatory training program. Plans should be made to expand it as the need develops.
3. The Board of Directors of the State DLNR should schedule an annual hearing on the development of geothermal energy. This will allow them to track the rate of geothermal development, identify problems delaying its development and develop solutions to mitigate them, for example, legislation to lower the royalty rate to 5 percent for the first 100 MW's of power capacity installed.
4. The State DLNR should develop an ongoing mechanism to fund the State geothermal regulatory program. It should be based on the actual operating cost of the Department's geothermal regulatory effort and partially financed by the geothermal developers.

County of Hawaii

1. The County should draft a policy toward the development of geothermal energy. The more favorable the policy toward geothermal energy, the more willing operators will be to invest. The policy should reflect the desires of the people of the County, not advocate the development of the resource for the sake of development.
2. The County should develop a preliminary land use plan specific to geothermal energy and incorporate it into the present County land use plan. This plan

should contain the preliminary framework for geothermal development and address the major peripheral ramifications, e.g., environmental, economic, social and religious aspects.

3. The County should develop a set of regulations specific to geothermal energy. Some of the items that should be considered are: proximity of geothermal development to residences, towns, schools, hospitals, etc.; restrictions on the use of County roads, bridges, etc.; and construction and sanitation requirements.
4. The County should plan to develop a waste disposal site if and when needed by geothermal developers (if such a site does not already exist) that could be used for the disposal of drilling and power-plant wastes. Once constructed, the facility could be used by other industries on the island.
5. The County should implement a geothermal development/regulatory training program for at least one of its employees. This could be accomplished by assigning one person on a part-time basis to track development, attend all local geothermal meetings and occasionally travel to selected meetings in Honolulu and on the mainland.

INTRODUCTION

Throughout most of the history of this country's industrial revolution, industry totally disregarded the protection and preservation of the environment. In its headlong rush to develop, rivers were polluted, the surface and the subsurface were stripped of their wealth and several species of plants and animals were severely stressed or eliminated. Government generally supported industry and the people, at best, had only a weak voice in how and where development would or would not take place.

Gradually the public came to recognize that the quality of their life and their environment was steadily decreasing. They also recognized that this problem was aggravated by the continued rise in the population and the subsequent, constantly increasing demand for energy. Eventually the efforts of the concerned portion of the public began to bear fruit. Among the things that did happen was the passage of the National Environmental Protection Act (NEPA, 1969) which was followed shortly by the enactment of various state environmental laws and a decline in the birth rate.

These events, which came of age and/or happened in the late 1960's and early 1970's, have and still are having a dramatic effect on the history of this country.

Next to the public realization that our energy resources are finite and man landing on the moon, the environmental revolution will probably be one of the most significant historical events of the latter half of the twentieth century.

REGULATIONS AND ENVIRONMENTAL PROTECTION

Protection of the environment is one of the major purposes for regulating development activities. This is of prime importance in Hawaii with its unique fauna, flora and scenic beauty.

The authority to regulate is a public trust that should be given to only the most realistic of persons as they are often called upon to provide the balance between the development of a resource and the protection of the environment. To impress regulations just for the sake of regulating is a common, unfortunate and wasteful practice that serves neither the people nor industry.

True regulation is more than imposing words written on paper. It is the positive and realistic interaction between government and industry. A regulator must strive to develop confidence and rapport with those he regulates and the public whom he serves. The government must, in turn, provide the regulator with the leadership and timely decisions upon which he is compelled to act. If government wants development to occur in a specific area, the regulator must strive to protect the rights of the people in a manner which is consistent with the terms developed by the governing body. If government wants development to take place, it should be aware of the ramifications of such action and be prepared to accept the consequences. Conversely, if it does not want development to take place, it should expeditiously develop and publicly state the reasons and stand fast on its decision.

GEOTHERMAL DEVELOPMENT ON THE ISLAND OF HAWAII

The people of Hawaii are fortunate in that they may have a choice in the selection of how their future energy requirements will be met. Geothermal energy may be an alternative (indications are positive, but much work must be done) before the production of electrical power now being generated from fossil fuel can be replaced. It is also fortunate that the most promising geothermal areas are located not only close to one of the major load centers, but are in an area that is geologically unstable. This second aspect greatly lessens the possibility of serious environmental impact. This is not to say that there will be no environmental effects, but those environmental problems that have been identified can be easily mitigated.

Planning for the development of geothermal energy on Hawaii should take place as soon as possible. It is extremely critical at this time to make the up-front land use decisions that will be vital to the reasonable economic development of the resource. In this regard, the long-range questions that must be asked and answered are:

1. Where should or shouldn't geothermal field development be allowed?
2. Where should the service corridors be located?
3. What types of industry could be expected and where should or can it be located?
4. What are the socio-economic ramifications of the above considerations?
5. What are the overall environmental/economic trade-offs?
6. Ultimately how much geothermal energy do the people of Hawaii want to have developed?, and
7. How will the regulatory activities of the county and state governments be financed?

Before continuing, I would again like to dwell on the fact that geothermal energy is not as yet an alternative. Much work must be done; funds obtained; risks taken and, above all, the resource must be economically exploitable. In addition, one cannot lose sight of the fact that the most potential area is located on the Puna Rift, which is among the most unstable areas in the United States and without doubt the most unstable on the island of Hawaii. Therefore, the basic decisions on the type of power plants to be constructed and their locations will tax the ability of the most astute decision makers.

DEVELOPMENT OF A REGULATORY PROGRAM

In my opinion, the people of Hawaii are fortunate to have far-sighted individuals who, early on, saw the need for a well developed geothermal regulatory program. I have worked with representatives of the County, the State and the University of Hawaii, and have found them to be capable and concerned individuals. A great deal has been done: drilling regulations are essentially completed and leasing regulations are now being promulgated. In any event, due to the high risks involved and the risk capital needed for development, every possible incentive should be provided to prospective developers.

The county government (County of Hawaii) should at this time develop a strong land use plan for geothermal development, along with a set of regulations that deal specifically with county problems. A great deal has been done in this area on the mainland in the County of Imperial in California that may be useful as a model.

SPECIFIC ENVIRONMENTAL PROBLEMS

Hydrogen Sulfide. The occurrence of hydrogen sulfide during the development and production of geothermal energy can be one of the most adverse of impacts. Not only is it a poisonous gas at high concentrations, but its odor is very annoying at low levels. This non-condensable gas is usually present in production from geothermal wells, however, in widely varying concentrations.

The years of production experience at The Geysers geothermal field in California have provided the time for the developmental evolution and application of several hydrogen sulfide abatement processes. I can report that a process developed by the Union Oil Company can eliminate up to 98 percent of the hydrogen sulfide being produced from a well being drilled or a completed well under test in a dry steam reservoir. This process involves the injection of hydrogen peroxide and sodium hydroxide into the production line with a resulting by-product of salts that cannot revert back to hydrogen sulfide.

Existing power plants at The Geysers are now being retrofitted with an iron catalyst process which removes between 90 and 92 percent of the gas. Unfortunately, this process produces a by-product of an iron sludge that must be trucked from the plant site to an authorized disposal site.

All new plants at The Geysers are or are being equipped with hydrogen sulfide abatement equipment using the Stretford process, which removes up to 99 percent of the gas from the steam and produces a by-product of elemental sulfur. It should be noted that this process requires a shell and tube heat exchanger. All of the older plants have direct contact heat exchangers.

At this point I would like to say that the hydrogen sulfide problems discussed above are those related to the production of a dry-steam reservoir, which are very rare. The exploitation of hot-water reservoirs, which are far more numerous, requires the use of different drilling and production techniques that allow a high degree of control over hydrogen sulfide that all but eliminates it from being a problem.

Noise. Noise was a major problem in the development of dry-steam reservoirs, primarily in the drilling and testing phase; however, the development of cyclone mufflers has all but eliminated this problem. Noise problems associated with the development and production of hot-water reservoirs are rare due again to the manner in which the reservoir is exploited. Two possible sources of noise associated with the development and exploitation of hot-water reservoirs are testing of wells and uncontrolled venting of steam at the well heads and power plants. Both of these noise sources can be eliminated by the use of mufflers or drag valves.

Water Pollution. Ground water pollution is most often caused by poorly trained personnel or inadequate drilling and production methods. Ground water, if it is present, can be protected by proper regulatory and operating procedures, e.g., the cementing of casing in the drill hole to prevent the upward or downward migration of low-quality water which could possibly pollute a good fresh water aquifer (see Figures 8 and 9). I would like to inject a note of caution here and say that subsurface conditions on the Puna Rift, and possibly in other areas of Hawaii due to the porous nature of the basaltic rocks, are far from the normal and may require regulatory caution until the best method of protecting subsurface water is developed.

Surface water pollution, like ground water pollution, is also caused by poorly trained personnel or inadequate field procedures, e.g., materials are dumped on the surface, sumps are inadequately lined, or harmful substances are allowed to enter streams or other water bodies. Heavy rains can cause improperly constructed sumps to wash out and pollute streams and other bodies of water. In general, surface pollution can be prevented by using proper construction, grading and drainage techniques. Again conditions on Hawaii, and in particular the Puna Rift, may require the development of a new regulatory approach.

In addition, a state- or county-authorized dump site should be developed for the disposal of drilling mud, sludge and other waste materials. This dump could also be used by other industries.

Visual Pollution (Aesthetics). Visual pollution is very difficult to regulate as beauty is in the eye of the beholder. However, natural scenic areas and vistas of real merit can generally be agreed upon with little difficulty.

The important point here is that once government commits an area to be developed, it must accept the consequences of its own action within the restrictions of the regulations. Roads, drill pads, power plants and lines constructed in high rainfall, wooded areas are hardly visible, but development in a dry, sparsely vegetated area will be visible for miles. Remember that economic tradeoffs will have to be determined, i.e., is it better to have visible power lines than to pay the cost of undergrounding them or, more basic, paying the ever-escalating cost of fossil fuel?

Blowouts. Geothermal well blowouts have occurred in several geothermal fields. The last blowout in California occurred in 1975. Blowouts of geothermal wells, however, are far less serious than those of oil or gas wells: 1) geothermal fluids are not flammable and, 2) they therefore are generally easier to control.

The California Division of Oil and Gas has made an extensive study of blowouts and has identified five types, all of which can be prevented by the proper regulation of the siting, drilling and completion of wells. The key items in the prevention of blowouts are trained regulators and a cautious attitude in a new area. Blowouts are spectacular but not the hazards that they appear to be (see Figures 10-14).

Geologic Hazards. In at least one geothermal field, geologic hazards, e.g., landslides, slumping and soil creep have caused severe problems. This problem is associated with specific geologic conditions which are not present in the Puna Rift area. In areas where geologic hazards exist, care must be taken to properly site wells and power plants and related structures (see Figure 11).

Subsidence. Subsidence can occur in at least three different ways, each of which requires the existence of certain physical conditions. However, in the case of the Puna Rift, it makes little sense to even consider subsidence as a problem. If and when development takes place in other areas where subsidence could be a problem, steps should be taken to develop the proper environmental background data, a regulatory monitoring system and a plan for action if subsidence takes place.

Seismic. The island of Hawaii by its very nature is earthquake prone and the Puna Rift-Kilauea area is without doubt more earthquake prone than the rest of the island. Although no record of hazardous seismic activity can be directly attributed to geothermal development, this aspect should not be ignored. A sound regulatory plan which includes monitoring of earthquakes should be developed to aid in the determining of whether ground movement is attributable to the production and/or the injection of geothermal fluids or is from natural causes. In this regard, the Hawaiian regulatory agencies are fortunate to have geothermal development in an area that has an extensive, in-place seismic net that has been operated by the volcano observatory for a number of years. This seismic net has accrued the background data that will be needed for future comparisons in the event that earthquakes take place in an area under production.

Socio-Economic Aspects. Socio-economic changes are directly related to the size, intensity and duration of the geothermal development and production activities. In general, geothermal development occurs in phases:

- Exploration: The exploration phase has little impact in that the major portion of the work will be done by temporary residents. There will be a temporary rise in some commercial activities in nearby towns.

- Development: The development phase, which includes well drilling and power plant construction will have a larger impact in that more workers will reside locally and the transport of materials will cause a rise in the traffic on local roads and highways. Conversely, commercial activities will rise accordingly in nearby towns.
- Production: The production phase requires a permanent operating staff and occasional maintenance activities that will cause the temporary influx of workers. The impact of the production phase, once the permanent operating staff has been accommodated, will be minimal, only a fraction of that of the development phase.

If the development takes place in stages (as it surely will) and as many local people are employed as possible, an adverse impact should not be experienced. Note: some thought should be given to the training of local people for employment in geothermal development.

Flora and Fauna. The Hawaiian Islands have more than their share of rare and endangered species of plants and animals; however, the study made for the preparation of the environmental impact report clearly describes the Puna Rift area as having very low impact potential on critical plant and animal life. If development is undertaken in other areas, great care must be taken to identify critical environmental problem areas prior to serious activities to enable their exclusion from development or to employ mitigation measures.

Power Plant Siting. The siting of power plants is a regulatory problem which must be addressed in the near future. Fortunately, the Hawaiian regulatory agencies will not have to break new ground in this area. In California, power plants at The Geysers have been sited by the Public Utilities Commission since the late 1950's. This function has now been transferred to the State Energy Resources Conservation and Development Commission; however, this new agency has yet to site a plant, primarily due to a granddaddy clause in the law. In addition, both the U.S. Geological Survey and the Bureau of Land Management have developed an integrated siting procedure which is now being used for the first time on the federal lands of the East Mesa of the Imperial Valley, California.

The important point here is that there is available a working procedure and three other procedures, two of which are being used for the first time and one that will be initiated in the next year. I strongly recommend that the Hawaiian regulatory agencies thoroughly evaluate these procedures in light of the specific conditions in Hawaii and develop their own power plant siting regulations.

APPENDIX

The appendix has been included to provide a visual background of some of the more important aspects of geothermal development for the regulator, administrator and other readers. It consists of 14 figures of power plants (one dry-steam type not applicable to Hawaii but included for general information and four hot-water type power plants), four figures showing well completions and abandonments applicable to the Hawaiian resource and, finally, five figures showing various well blowout cases.

Description of Figures

1. Dry Steam Power Plant

Dry steam power plants are now in operation at The Geysers Geothermal Field in California. Note: shell and tube condenser needed for hydrogen sulfide control (older units have direct contact condensers); absence of a separator (see hot water power plants below), and centrafix that knocks rock particles out of the steam. Approximately 70 percent of the steam produced is exhausted to the atmosphere.

2. Flash Steam Plant

Hot-water type power plant now in use at the Cerro Prieto Geothermal Field in Mexico. Note: use of the separator and facility in the brine disposal system for secondary use of hot waste brine.

3. Double Flash Plant

Hot-water type power plant now in use at the Wairakei Geothermal Field in New Zealand. Note: first stage (high pressure) and second stage (low pressure) separators and turbines, and facility for secondary use of hot waste brine. This or a derivation is generally considered to be the optimum of the flash-type power plants.

4. Binary Cycle Power Plant

Hot-water type power plant, not as yet in use in North America; however, pilot plants are operating in Russia and Japan. A 10 MW plant is now under construction at the East Mesa Geothermal Field in the Imperial Valley of California, and a 50 MW plant has been designed for a proposed demonstration plant at the Heber Geothermal Field, also in the Imperial Valley. Note: the two separate systems (Iso-Butane and hot brine), the total confinement of the spent brine, and the down hole pump. Pumping is required to maintain pressure to prevent flashing of the brine to limit scaling and corrosion problems.

5. Flash Binary Power Plant

Hot-water type power plant, not as yet in commercial operation. A 10 MW pilot plant has been constructed near Niland at the Salton Sea Geothermal Field in the Imperial Valley of California (this unit is equipped with a throttle valve which simulates a turbine). Note: the plant operates on steam that is produced in a separator, not hot water as in the case of the binary plant above. This type of system was specifically designed for the utilization of brine with a very high dissolved solids content, which normally cause severe corrosion and scaling.

The next four Figures (6-9) are from Campbell 1974.

6. Hot Water System, Two-Phase Flow Production Well, Imperial Valley

This well-head configuration is in use in several geothermal fields throughout the world. Note: well-head bracing which allows the well head to withstand internal force of two-phase flow (steam and water), and massive concrete cellar which is used to anchor the bracing.

7. Hot Water System, Controlled-Production Well for a Binary Cycle Power Plant

This well-head configuration is now being used at the East Mesa and Heber Geothermal Fields in the Imperial Valley of California. Note: lack of cellar and bracing which are not needed because the well is pumped, thus preventing a two-phased flow and subsequent internal forces on the well head.

8. Typical Abandonment of Former Geothermal Production Well in the Imperial Valley

Note: burial of the well head for restoration of surface use and placement of cement plugs (Xed portions of well). Abandonment features such as these should be covered by regulations and administered by an experienced regulator.

9. Typical Abandonment of Exploratory Well, Imperial Valley, California

Note: burial of well head for restoration of surface use; lack of casing and liner in bottom of hole, and cement plugs (Xed portions of well).

The following portion of the Appendix was taken directly from a Geothermal Resources Council publication authored by Glen E. Campbell in 1974. It has been included to provide a basic understanding of the causes of blowouts and related mitigation measures.

<u>Blowouts</u>

The Geothermal Unit of the California Division of Oil and Gas has identified five types of blowouts. Not all of the five have occurred in California; however, all types could occur when and where certain conditions are present or when drilling and completion practices are lax and not properly regulated. Specific dates, location, and names have been purposely omitted.

A brief description of the five types of blowouts and the measures that can be taken to prevent or contain them follows:

1. <u>Type No. 1 - Punky Earth (Figure 10)</u>

The Punky Earth blowout can occur when a combination of the following subsurface conditions are present and certain drilling procedures are used:

a. Hydrothermally altered rock (incompetent, sheared, crumbly and fracat depth;

b. Shallow reservoir pressures in excess of hydrostatic pressure;

c. Inadequate conductor and/or surface casing.

A blowout occurs when steam or hot water under pressure is allowed access to the punky earth below the shoe of the casing or surface pipe, and its pressure is great enough to break through to the surface outside of the casing.

<u>Prevention Measures</u>

a. Grout the location through several shallow holes to a point below the proposed depth of the surface casing;

b. Carefully observe drill mud return temperatures to allow the running and cementing of surface casing at the deepest possible depth before drilling into the pressurized zone.

c. The disallowance of the drilling of a well in this type of rock.

<u>Containment Measures</u>

a. Kill well, if possible, through the casing and abandon with cement, or

b. Drill a relief well from a suitable location and kill well and abandon with cement.

2. <u>Type No. 2 - Landslide (Figure 11)</u>

The causes of a landslide blowout are readily apparent and can be best categorized as:

a. Failure to recognize unstable surface conditions prior to and during the construction of the drilling location.

b. Failure to construct the drill site in accordance with acceptable soils engineering standards.

<u>Prevention Measures</u>

a. Thoroughly map unstable terrain prior to the construction of drill sites to locate possible landslides or unstable conditions.

b. Either don't drill hazardous sites or prepare sites through soils engineering techniques to eliminate the unstable condition.

<u>Containment Measures</u>

a. Kill the well, if possible, through the casing and abandon or recomplete, or

b. Excavate slide area, if possible, attach well-head equipment, recomplete or abandon.

3. Type No. 3 - Improper Well-Head Completion (Figure 12)

Only one known blowout of this type has occurred and it was attributed to the practice of welding the well-head completion equipment onto the surface casing, not the production casing. Every time the well was put into or taken out of service the steel production casing expanded and contracted, causing the cement in the surface-production casing annulus to crack and become permeable. When the well was shut in, water under pressure would pass from the production string down through the fractured cement in the annulus and eventually charged a shallow aquifer that subsequently blew out. Note: Cementing the shoe of the surface pipe in a sand is considered by this Division to be bad practice.

Prevention Measures

a. Weld well-head completion equipment to the production casing.

b. Do not set surface casing in a shallow aquifer.

Containment Measures

a. Kill the well, if possible, through the casing and recomplete or abandon, or

b. Drill a relief well, kill the well, and recomplete or abandon.

4. Type No. 4 - Inadequate Well-Head Bracing (Figure 13)

Only one known blowout of this type has occurred and it was attributed to inadequate well-head bracing on a well being used to produce a two-phased flow of hot water and steam. The unbraced well-head was subjected to tremendous internal pressure differentials and eventually cracked and broke off the casing below the landing flange.

Prevention Measures

a. Brace well head if well is to be subjected to a two-phased flow (Figure 6).

Containment Measures

a. Weld a blowout preventer onto the broken stub, kill well, and recomplete.

5. Type No. 5 - Inadequate Casing (Figure 14)

Blowouts of this type occur when little or not surface casing is set and abnormally high, shallow reservoir pressures are encountered. The prime example of this type occurred when a well drilled to a depth of about 100 feet in a hot springs complex with less than ten feet of casing blew out.

Prevention Measures

a. Don't drill wells in a hot springs complex, but if you must:

b. Watch return mud temperatures and set as much surface pipe as possible;

c. Keep the hole full of good quality mud.

Containment Measures

a. Containment is not considered practicable or hardly feasible. The shallow reservoir will eventually unload and come back into equilibrium and the drilling equipment can be removed.

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2. County of Imperial, "Geothermal Element Imperial County, California," County of Imperial, 1977.

3. State of California, "Analysis of Requirements for Accelerating the Development of Geothermal Energy Resources in California," California Energy Resources Conservation and Development Commission, Jet Propulsion Laboratory and Department of Energy, 1978.

4. ____________________, "Report on the Status of Development of Geothermal Energy Resources in California," California Energy Resources Conservation and Development Commission, Jet Propulsion Laboratory and Department of Energy, 1976.

5. ____________________, "Report of the State Geothermal Task Force," Department of Conservation, 1977.

DRY STEAM POWER PLANT

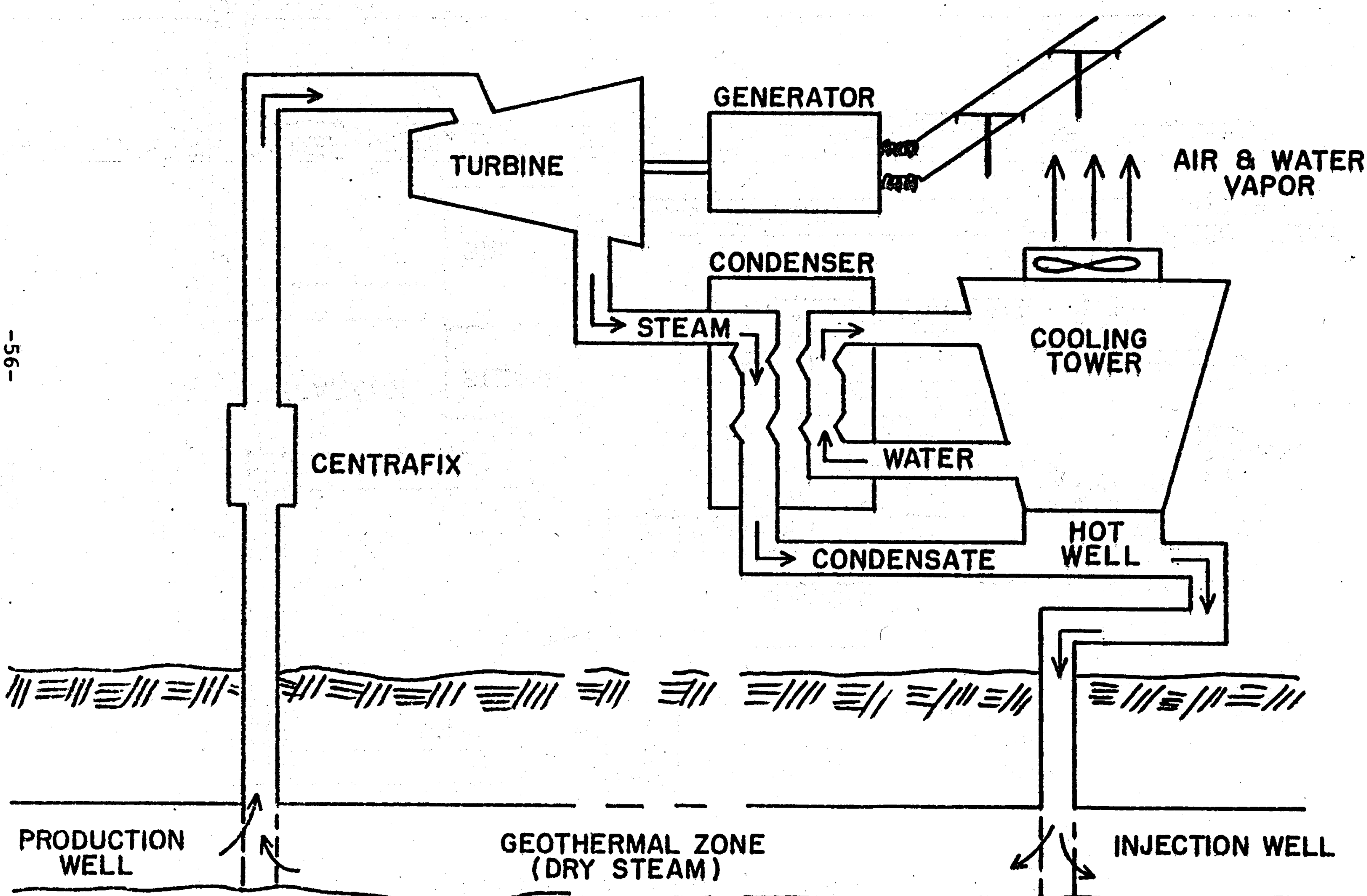


FIGURE 1

FLASH STEAM POWER PLANT

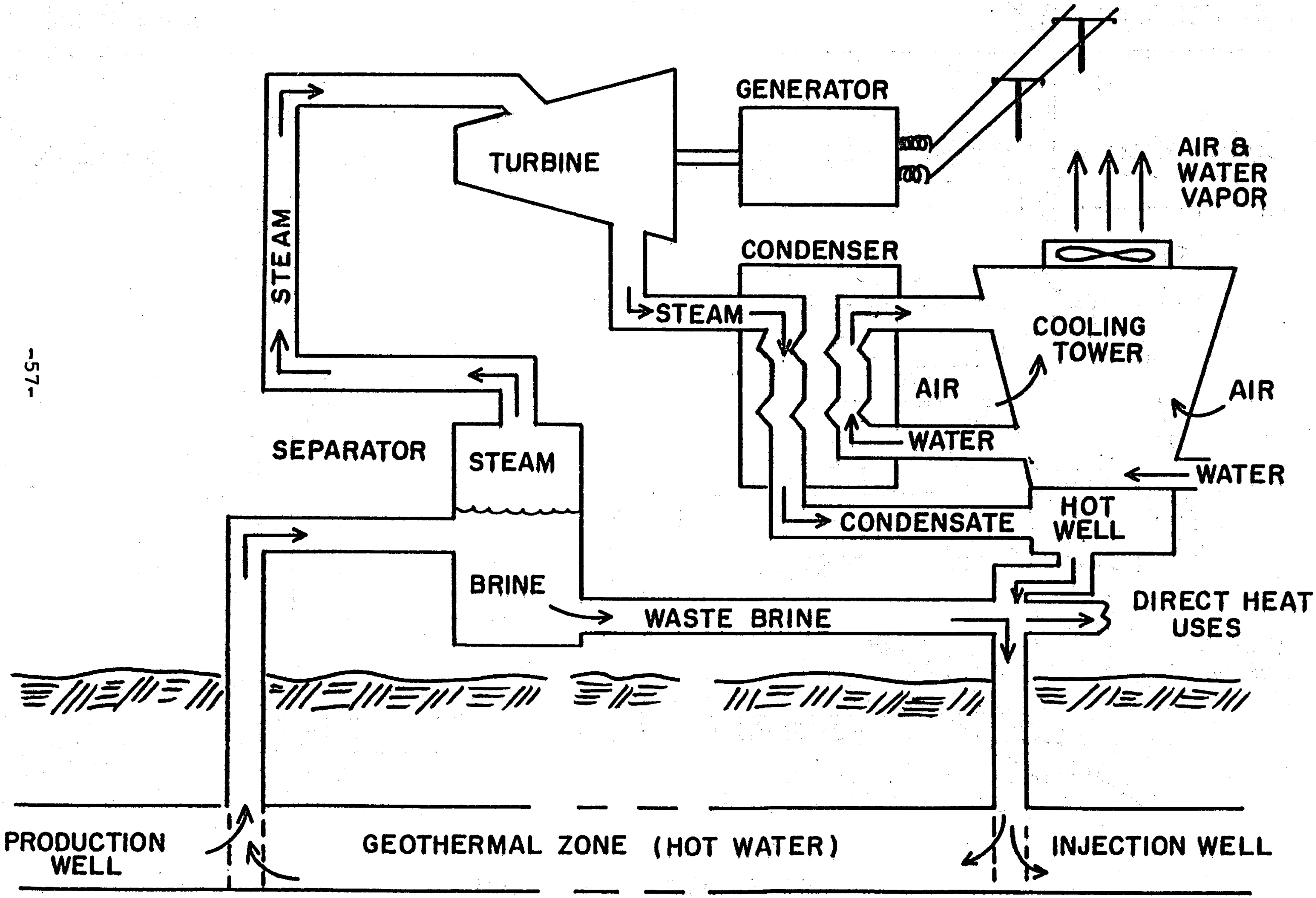


FIGURE 2

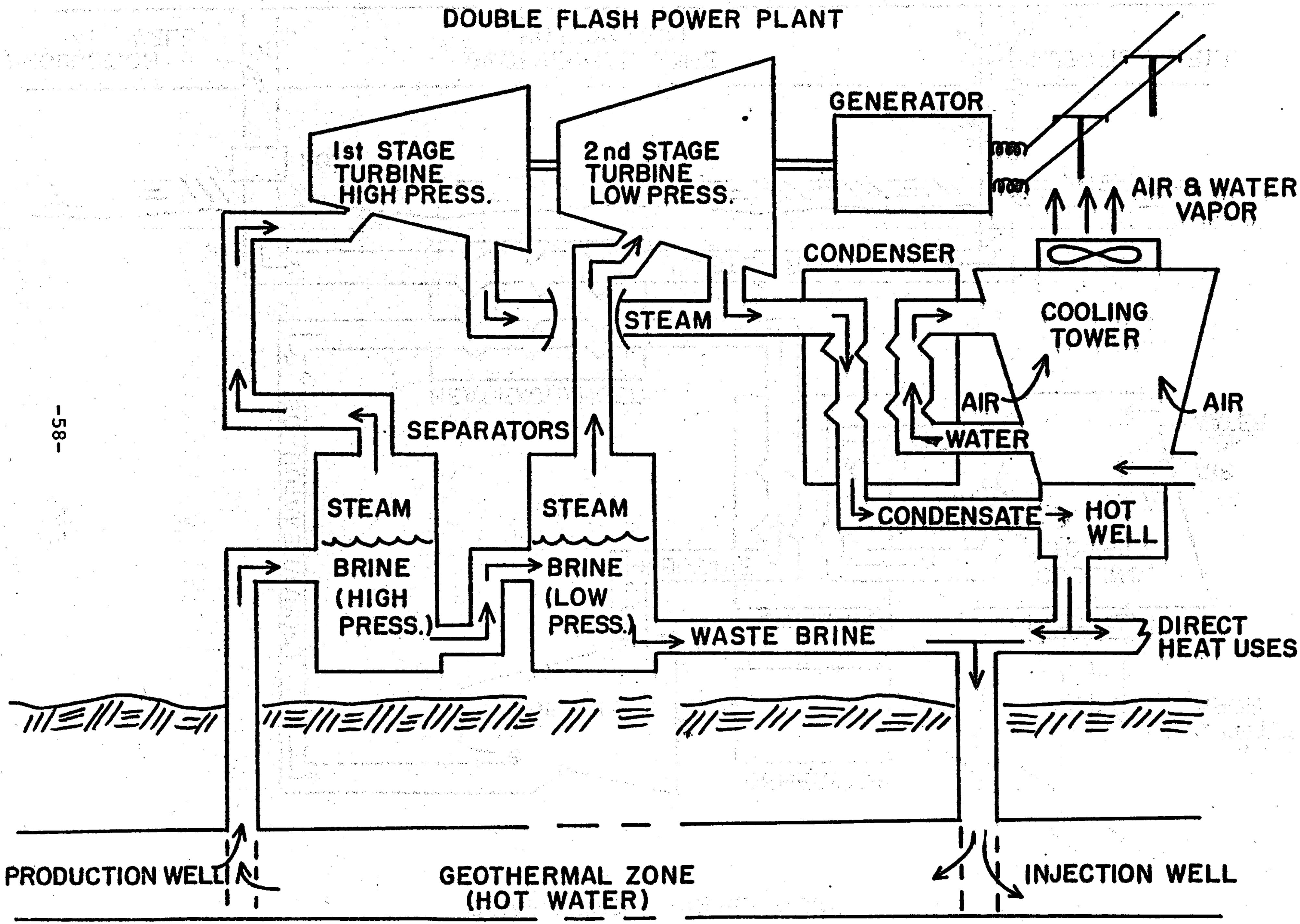

DOUBLE FLASH POWER PLANT
1st STAGE TURBINE HIGH PRESS.
2nd STAGE TURBINE LOW PRESS.
GENERATOR
AIR & WATER VAPOR
CONDENSER
COOLING TOWER
STEAM
AIR
AIR
WATER
SEPARATORS
STEAM
BRINE (HIGH PRESS.)
STEAM
BRINE (LOW PRESS.)
CONDENSATE
HOT WELL
WASTE BRINE
DIRECT HEAT USES
PRODUCTION WELL
GEOTHERMAL ZONE (HOT WATER)
INJECTION WELL

FIGURE 3

BINARY CYCLE POWER PLANT

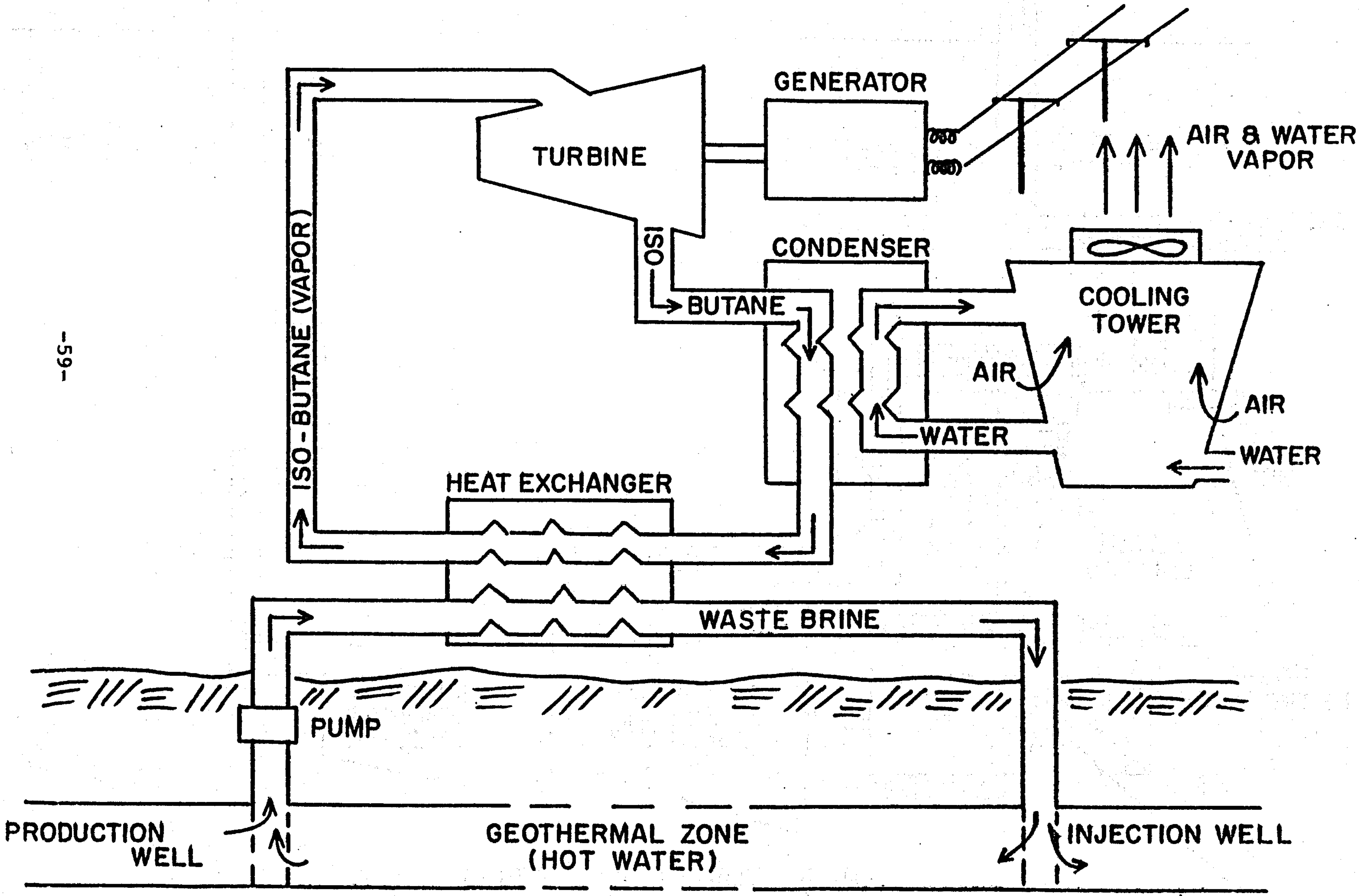


FIGURE 4

FLASH BINARY POWER PLANT

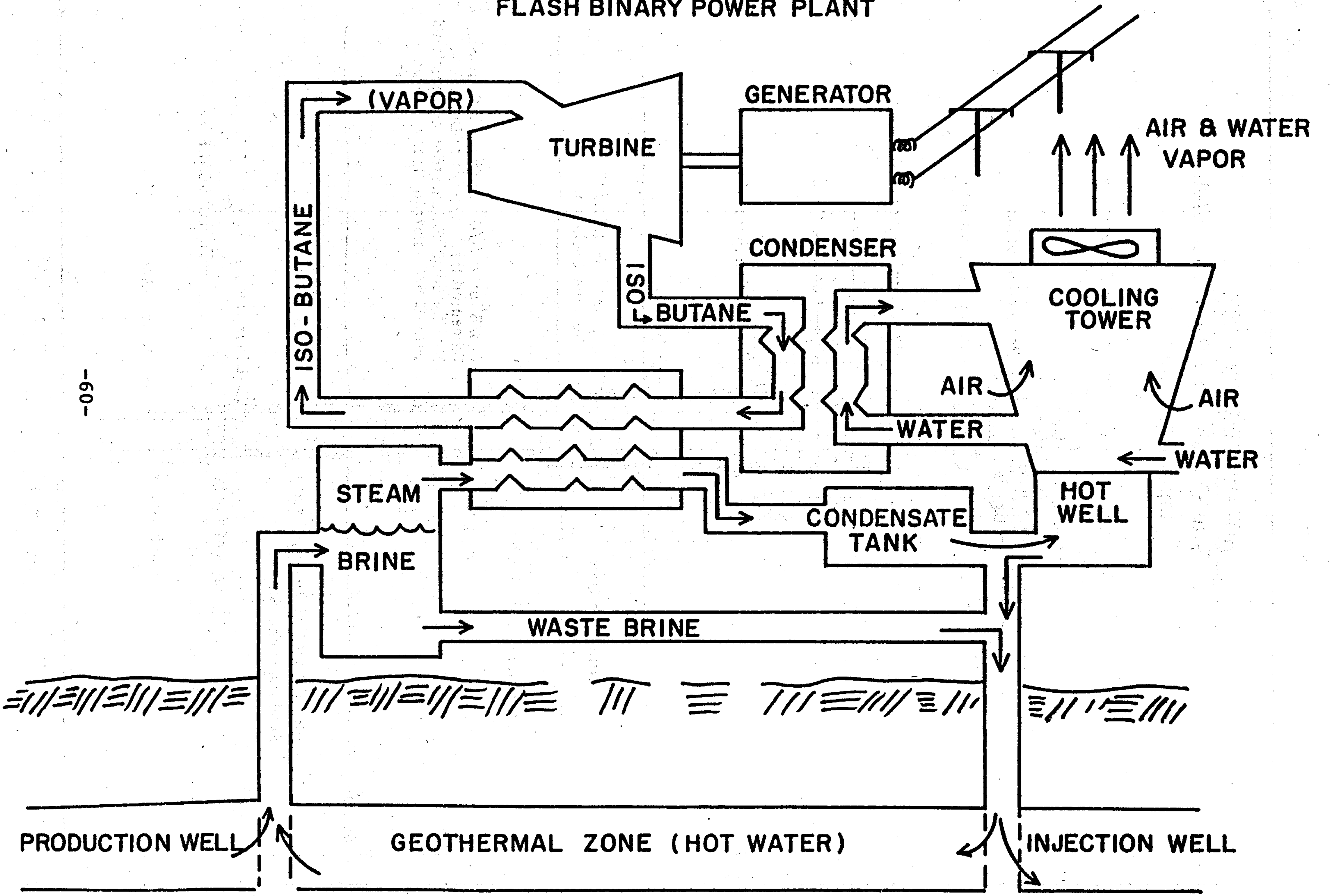
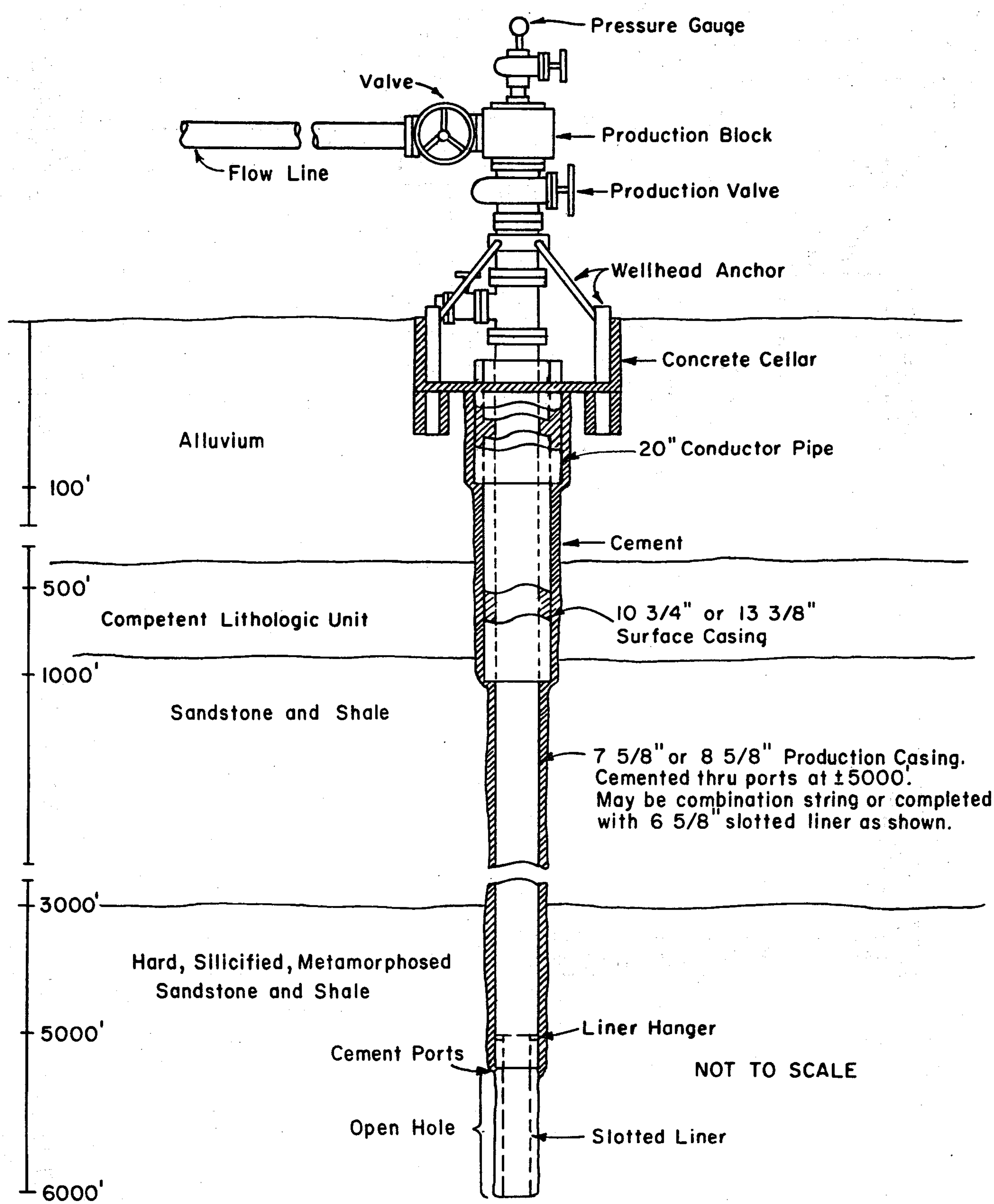


FIGURE 5

HOT WATER SYSTEM
Two-Phase Flow Production Well
Imperial Valley



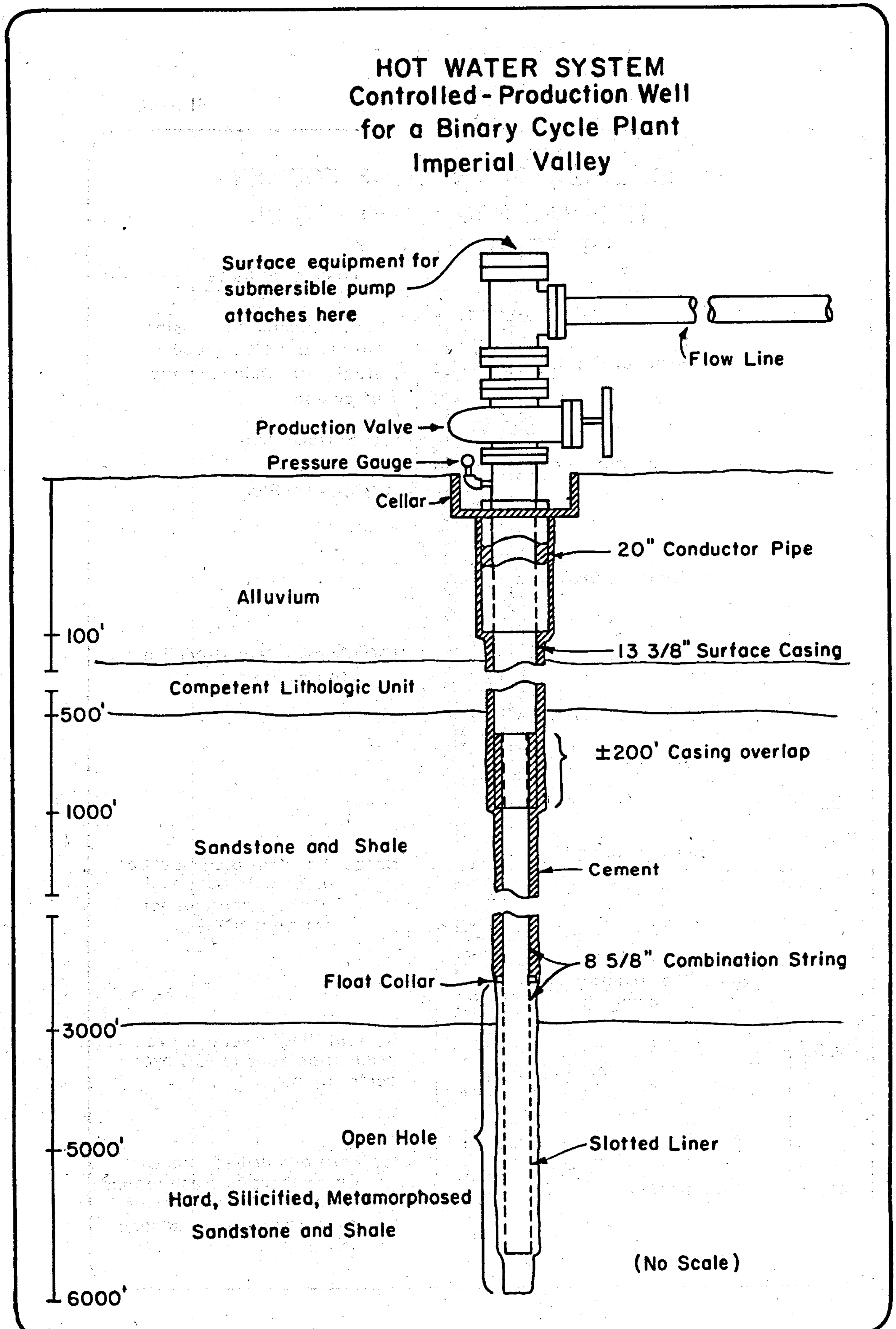

HOT WATER SYSTEM
Controlled-Production Well
for a Binary Cycle Plant
Imperial Valley
Surface equipment for
submersible pump
attaches here
Flow Line
Production Valve
Pressure Gauge
Cellar
20" Conductor Pipe
Alluvium
100'
13 3/8" Surface Casing
Competent Lithologic Unit
500'
±200' Casing overlap
1000'
Sandstone and Shale
Cement
8 5/8" Combination String
Float Collar
3000'
Open Hole
5000'
Slotted Liner
Hard, Silicified, Metamorphosed
Sandstone and Shale
(No Scale)
6000'

FIGURE 8

TYPICAL ABANDONMENT OF FORMER GEOTHERMAL PRODUCTION WELL IMPERIAL VALLEY

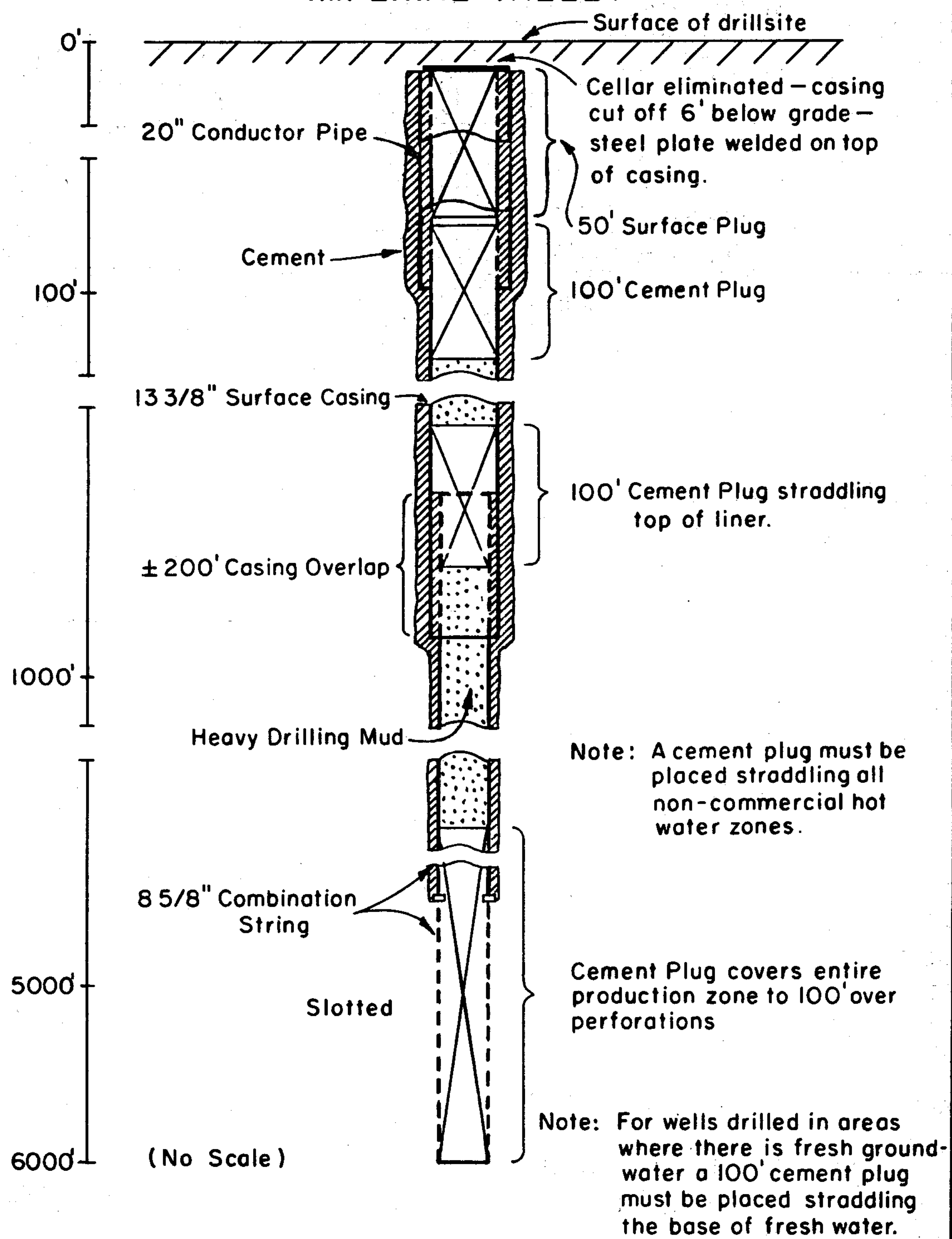


FIGURE 9

TYPICAL ABANDONMENT OF EXPLORATORY WELL IMPERIAL VALLEY

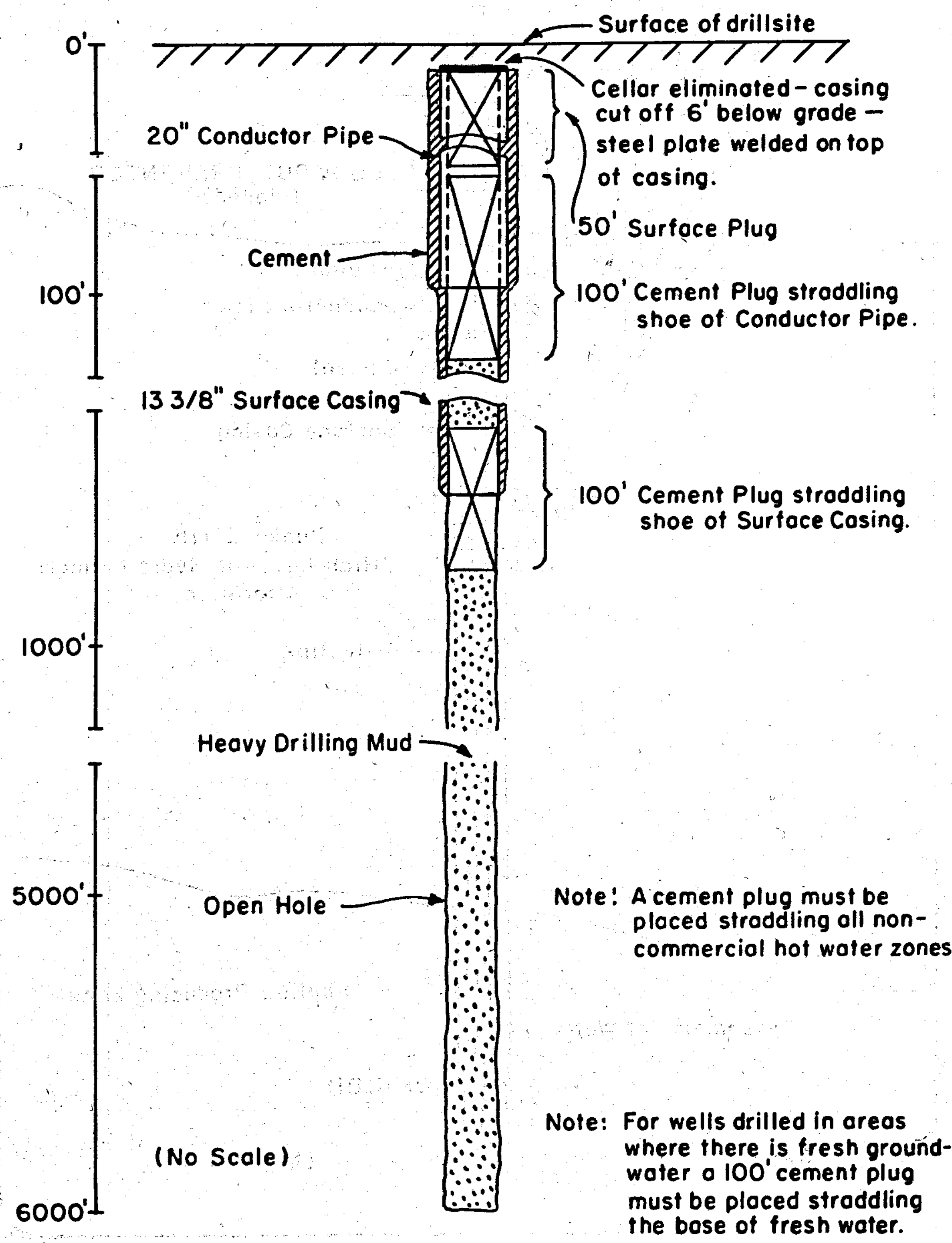
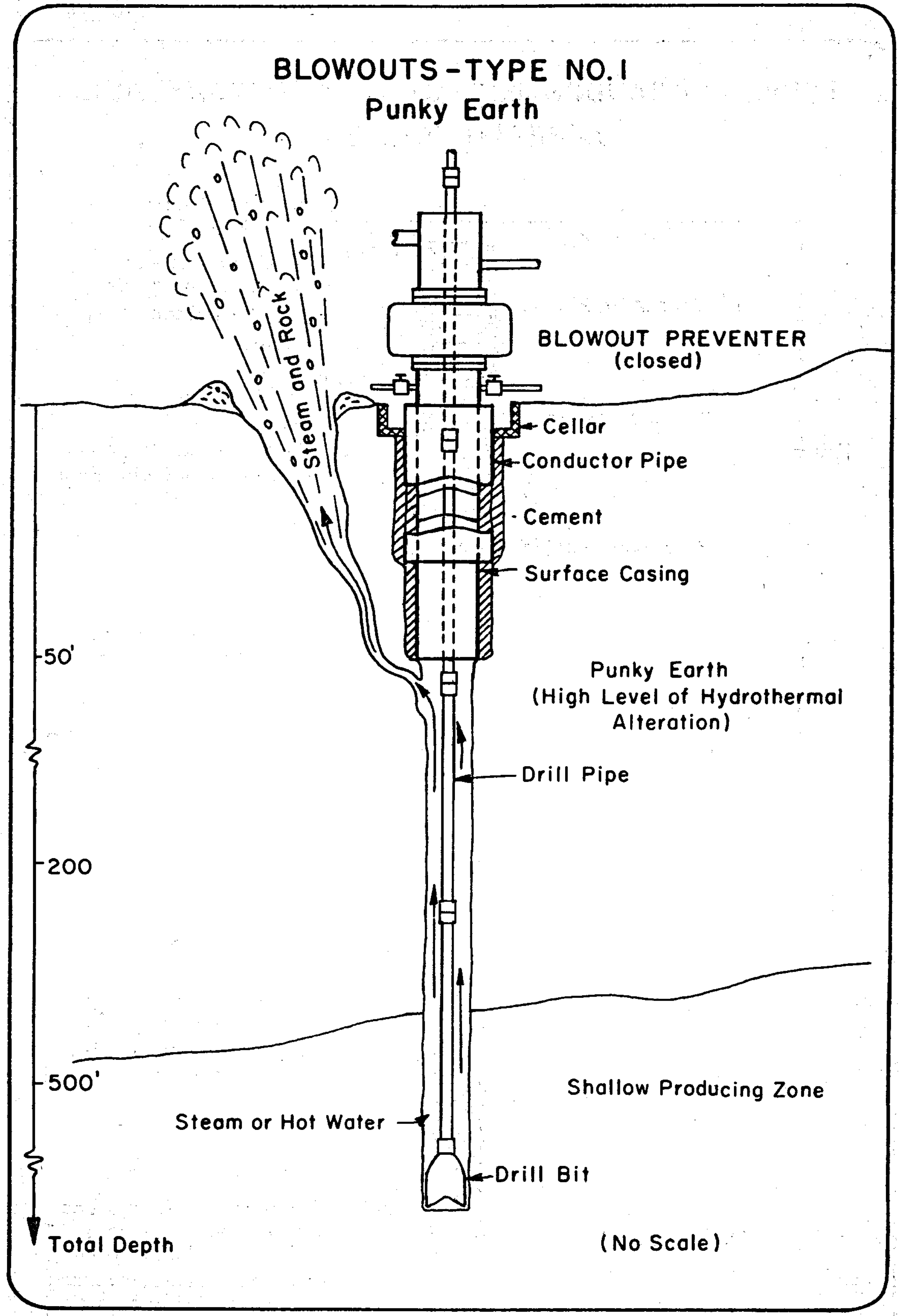


FIGURE 10



BLOWOUTS-TYPE NO. I
Punky Earth
Steam and Rock
BLOWOUT PREVENTER
(closed)
Cellar
Conductor Pipe
Cement
Surface Casing
50'
Punky Earth
(High Level of Hydrothermal
Alteration)
Drill Pipe
200
500'
Shallow Producing Zone
Steam or Hot Water
Drill Bit
Total Depth
(No Scale)

FIGURE 11

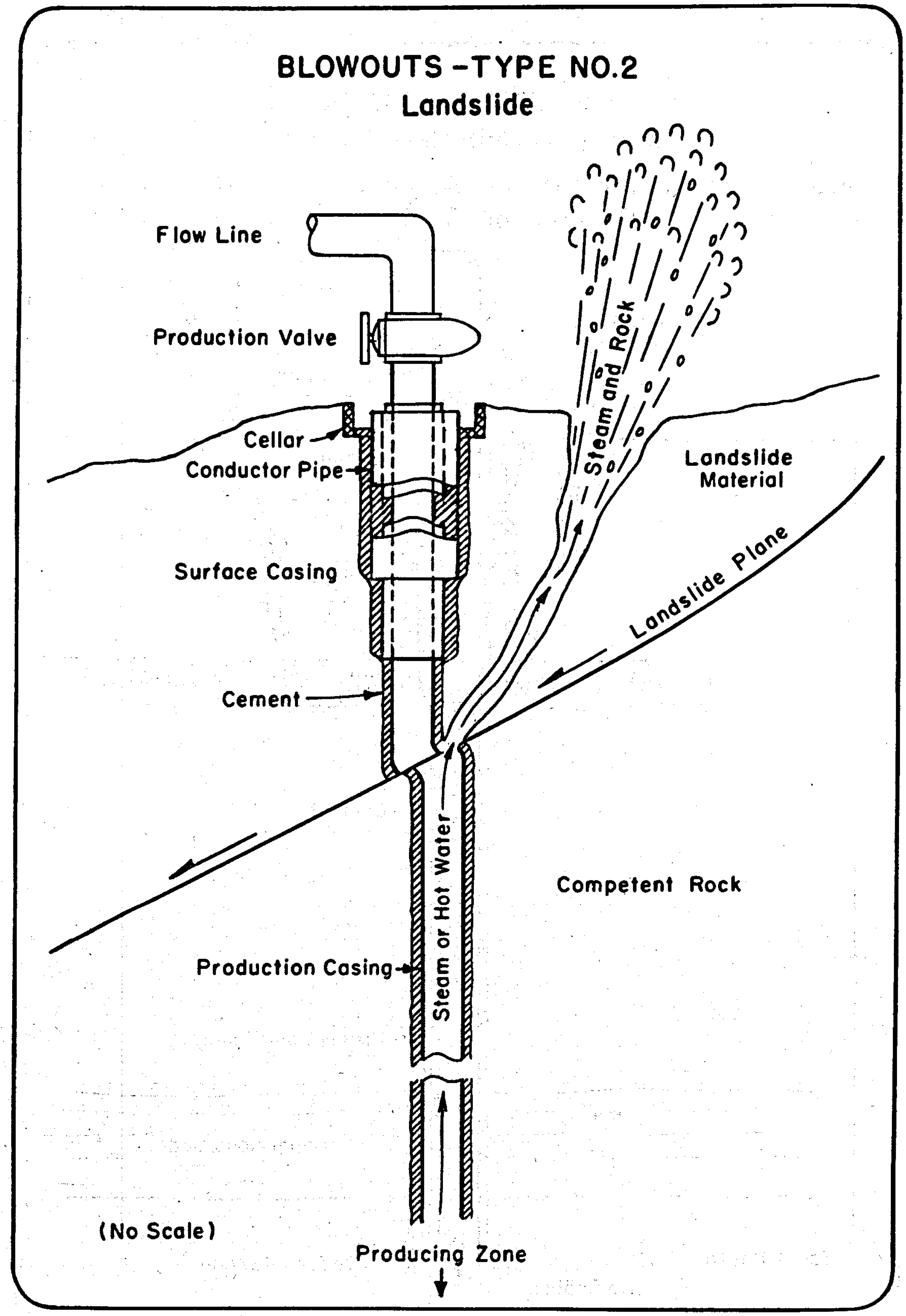
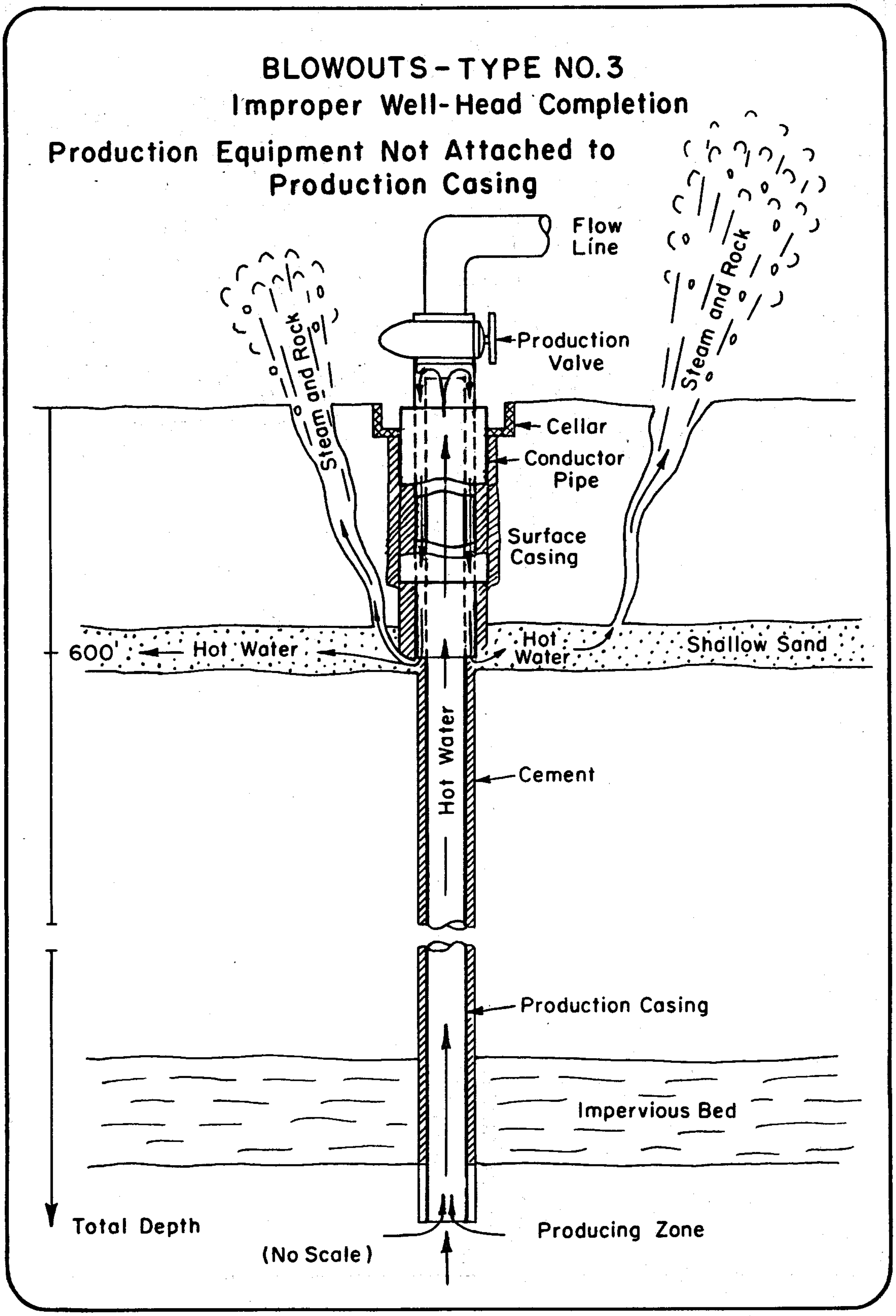

BLOWOUTS - TYPE NO.2
Landslide
Flow Line
Production Valve
Cellar
Conductor Pipe
Surface Casing
Cement
Steam and Rock
Landslide Material
Landslide Plane
Steam or Hot Water
Competent Rock
Production Casing
(No Scale)
Producing Zone

FIGURE 12



BLOWOUTS - TYPE NO. 3
Improper Well-Head Completion
Production Equipment Not Attached to Production Casing
Flow Line
Production Valve
Steam and Rock
Steam and Rock
Cellar
Conductor Pipe
Surface Casing
600'
Hot Water
Hot Water
Shallow Sand
Hot Water
Cement
Production Casing
Impervious Bed
Total Depth
(No Scale)
Producing Zone

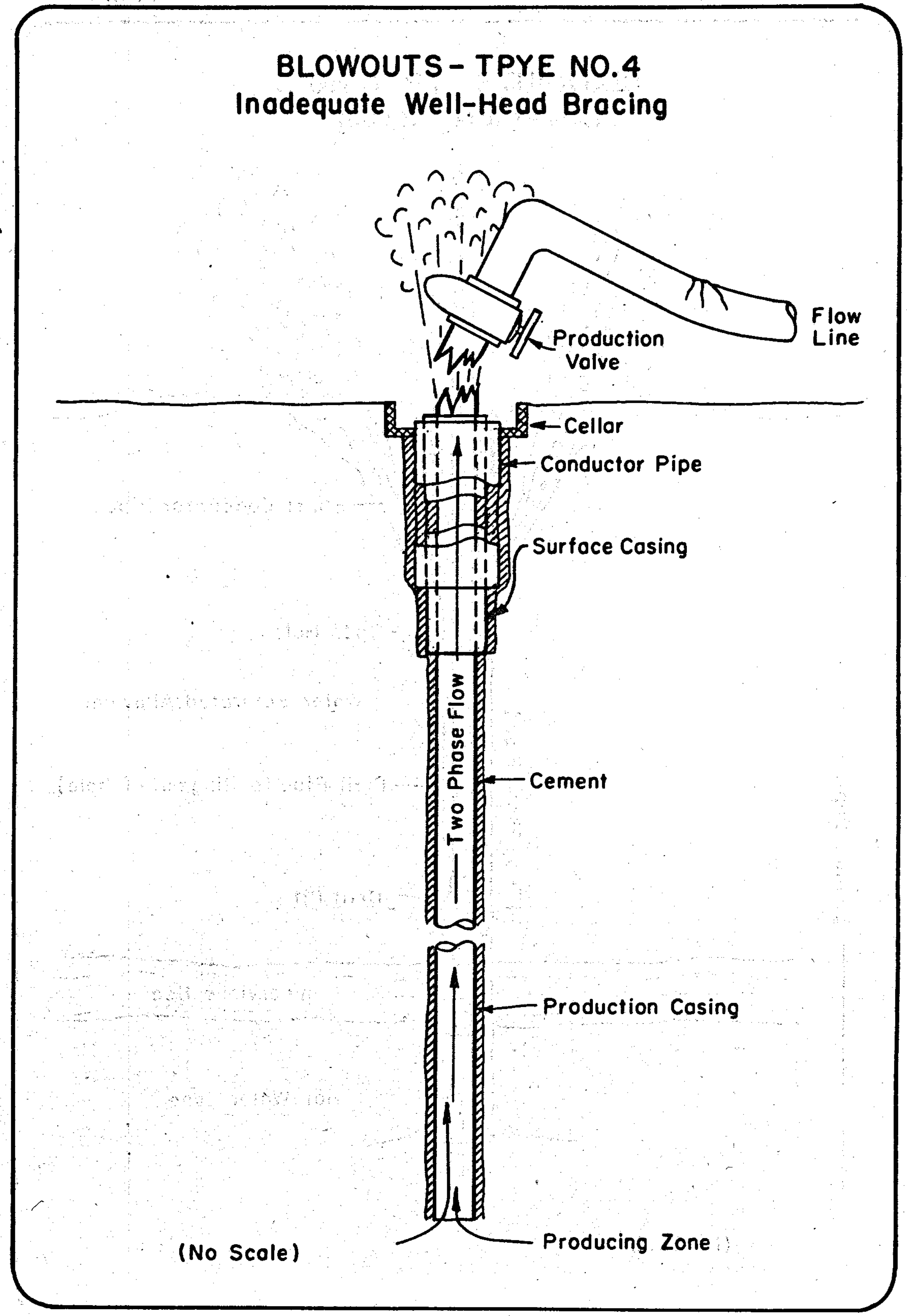
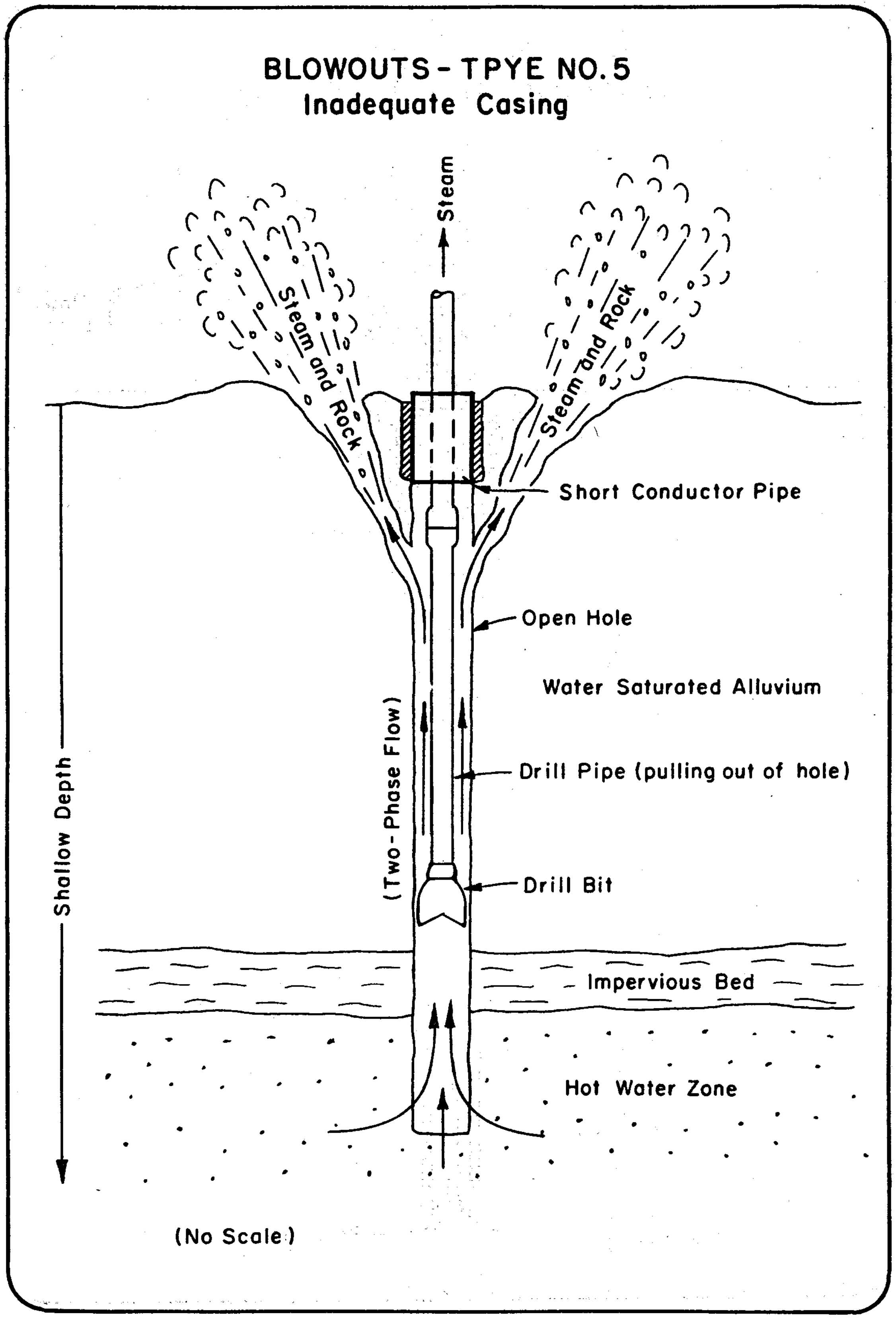

BLOWOUTS - TPYE NO.4
Inadequate Well-Head Bracing
Flow Line
Production Valve
Cellar
Conductor Pipe
Surface Casing
Two Phase Flow
Cement
Production Casing
Producing Zone
(No Scale)

FIGURE 14


BLOWOUTS - TPYE NO. 5
Inadequate Casing
Steam
Steam and Rock
Steam and Rock
Short Conductor Pipe
Open Hole
Water Saturated Alluvium
(Two-Phase Flow)
Drill Pipe (pulling out of hole)
Shallow Depth
Drill Bit
Impervious Bed
Hot Water Zone
(No Scale)

01024

LAND USE REGULATIONS
Sidney Fuke

Sidney Fuke is Director of Planning Department, County of Hawaii.

Thank you very much, Clarence. Before beginning I'd like to extend my appreciation to Dave for taking up 15 minutes of my time because I think my presentation is 5 minutes.

I have passed out within your handouts a list of regulations relating to geothermal developments. I'd like to briefly run through them; and if there's any questions relating to the specific regulation, just glancing through the audience I can see a number of competent individuals who can respond to the more specific questions as they responded to some of the earlier questions relating to Dave's presentation.

The first one, of course, is the State Land Use law which was passed in 1961, and I did have in parenthesis the appropriate legal reference, Hawaii Revised Statutes, Chapter 205. Essentially, this law is to further State and County objectives by classifying all lands in the State into one of four major land use districts. The districts have been identified.

One is the Conservation District which is under the jurisdiction of the State Board of Land and Natural Resources. That Board has adopted a regulation, otherwise known as Regulation 4, which governs the kinds of uses which can be considered within a conservation district. In addition to that, another law, Chapter 343, Hawaii Revised Statutes, requires that environmental impact statement be prepared and considered in conjunction with any uses within the conservation district.

The other two districts which are kind of overlapping are agricultural and rural districts. Within those districts there are certain uses which are expressly allowed. Then all uses which are not clearly stated as permissible within the State Land Use law and regulations, then a special permit would have to be issued. In terms of the special permit requirement, the County Planning Commission would be the initial reviewing agency, and should the County Commission agree with the special permit, then it would forward its favorable recommendation with conditions to the State Land Use Commission for ratification. The County Planning Commission on the other hand has the initial denial powers. If a permit request is denied on the County level, then of course, the permit stops there and the applicant's recourse would be to appeal directly to the local Circuit Court of the appropriate jurisdiction.

Within an urban district, all land uses come exclusively within the control of the County. The County Zoning Ordinance is the primary regulatory tool. Specifically as it relates to geothermal activity, the only zone within it is allowed right now is within the industrial zone. In addition to the zoning requirements, what we normally would require is a plan approval review. How we'll review the plans for structured considerations such as setback, whether there are sufficient areas for parking, so on, and so forth.

The other major requirement, as I touched upon earlier, is the Environmental Impact Statement requirement. David referred to that in California as an Environmental Impact Report, here in Hawaii it's called the EIS. The governing provision is found in Chapter 343 of the Hawaii Revised Statutes. It was adopted back in 1973 by the State Legislature. And essentially, the impact statement requirement is to assist decision makers, whether they fall on the County or the State level, in the review and evaluation of all projects from a comprehensive-environmental standpoint. Comprehensive in a sense that it would review not only the economic impacts, but also the social and the physical environmental impacts of the proposed project. The EIS requirement would be applicable in one of the five different categories I listed below. One is, I touched upon earlier, within the conservation district. The other one is--if a site is on the State Register of Historic Sites--then an impact statement would also be required. If it's within the 40-foot shoreline setback area--an impact statement would also be required. If a general plan amendment is required, then an impact statement would be required. And finally, if any State or County funds or lands are involved, then an environmental impact statement would also be required.

The other major category of regulatory control would be the Shoreline Management Area, or Shoreline Management Act, which was adopted back in 1975. It is otherwise known as Chapter 205A, Hawaii Revised Statutes. Essentially this law is to preserve, protect, and where possible, to restore the natural resources of the coastal zone of Hawaii. The County Planning Commission established the boundaries of the Shoreline Management Area. And if the proposed project, in this case, the geothermal activity or its ancillary facilities are within the Shoreline Management Area, then of course, a permit would have to be issued by the County Planning Commission.

The other ordinance is the Grading Ordinance which was passed in conjunction with the State Statute of Soil and Sedimentation Control Act. This was passed in 1975 by the County Council and otherwise known as Ordinance 168. Essentially the Grading Ordinance is designed to provide standards to safeguard property, control erosion and sedimentation and to promote the public welfare by regulating and controlling excavations, fills, grading, grubbing and stockpiling operations. The controlling agency here is the County Department of Public Works.

And I think it was mentioned earlier by Dave, that the State Department of Land and Natural Resources right now is in the process of developing the appropriate geothermal rules and regulations. This is done, as I understand, pursuant to Chapter 182, 177, 178 of the Hawaii Revised Statutes. The purpose is to provide for the leasing of State and reserve lands for the purpose of geothermal resources exploration, development and production, and to provide for the regulation of all drilling for geothermal resources in Hawaii in order to prevent waste and to consent and to provide for optimum use of geothermal resources, to prevent wastes, pollution and degradation of surface and ground water and other natural resources, to protect the environment, and to prevent injury to life and property. Of course, the controlling agency here is the State Department of Land and Natural Resources.

That's all I had listed down, but as I was sitting in the back listening to Dave, he somewhat juggled some other permit requirements which I overlooked and I'd like to now briefly go over them.

One is, of course, if the intent is to have an area subdivided out, whether it's for leasing purpose or for fee simple, then of course, it would have to comply with the County Subdivision Code. The other one is that if there are any structures involved, then they would have to comply with the County Building Code. Lastly, as I could detect, was with the State Department of Health regulations whether they are related to the water area and waste disposal requirements and those are done pursuant to Chapters 37 and 38 of the Department of Health regulations.

My department has been designated the central coordinating agency pursuant to a law which was passed this past legislative session, and we are in the process right now, of assembling all of the different laws relating to land development; and of course geothermal would fall into that kind of category. We will come up with a roster of permits required for any kind of developmental activity whether they are geothermal, resort project, a single-family residence--and we should have the regulations and the roster completed before December 31 of this year.

What I've done is to briefly gloss over the local regulatory requirements for geothermal development. But over and beyond the question of what these requirements are, I think the basic question is how will these requirements be applied. And regulations are designed to fulfill or implement policies. And as such, they're usually developed after the development and acceptance of clearly articulated community objectives. In planning, for example, regulatory or implemented rules like zoning and subdivision are developed or at least adjusted after the adoption of the plan like the general plan or a community development plan.

I realize, Clarence, that my focus today is really the identification of land use requirements for geothermal development. However, since David didn't use up all of my time, and I do have some time available, I'd like to repeat some of my thoughts which were expressed at the recently held energy symposium in May which may have some relevance I think to the regulations that I just rattled off.

For one, is it all clear that we have an understanding of the purposes behind our pursuit of alternate energy resources? That is, are we looking at geothermal, ocean thermal conversion and so forth as ends in and of themselves? In other words, do we see those resources as commodities like how oil has become in some parts of the world, where it is exported and has become an industry in and of itself?

On the other hand, these energy resources like geothermal can be regarded as a means to end with the end being more economic development and a higher standard of living. From that perspective, geothermal could suggest lower fuel cost for consumers and a greater incentive for other industrial developments. Plus these resources could serve as catalyst for the further economic development of the State and County and for the growth or the maintenance of, at the very least, of our present standard of living. Then, too, the search for alternate energy resources can also serve both as a means to an end as well as ends in and of themselves, like how oil has become in some parts of the country.

While we do have different regulations governing geothermal development, I think as Dave pointed out earlier, none of them, with the exception of the proposed rules and regulations of the State Department of Land and Natural Resources, deal directly with geothermal uses. And undoubtedly, I think, as we progress, we might have to contact the Geothermal Council for further assistance in that regard. But I think that newer amendments, amendments to existing regulations may have to be eventually developed. But whether we apply existing regulations or develop new ones to govern geothermal development, we must all have a clear understanding of where and why we are moving with geothermal development. Geothermal and other alternate energy resources are still in their most infantile stages here, and even nationally. We are still carving out alternate energy resources paths and like pioneers we may have to muddle through a while as we travel through uncharted areas. But because we are charting into unfamiliar territory, a clear understanding of the objectives and possible consequences of this alternate energy resources trail, is even more urgent, and would be helpful to the various decision makers and the people who would have to live by those decisions. True, we may have to define and re-define policies as we move along. But they should not take away the need for some definitive policies to begin with. And in that I am encouraged by the recent formation of the Mayor's Energy Advisory Committee which will advise the County on the formulation of public policy relating to alternate energy resources. But the formation of the Committee is only the beginning. And as Dave mentioned, I think this is one of the highest of high priority that needs to be done. But still much work awaits the Committee, the State, and the County, and the citizens of this County and State. We have to get involved in the training aspects, and in addition to that, I think time is also very critical as various applications for geothermal and other alternate energy developments have and will be shortly considered by various public agencies.

Now my other thought relates to the role of energy development and our way of living. That is, if we were to look at alternate energy resources as a vehicle to continue the growth of the State and County, we have to be mindful of the question--what if it fails? I'm not a pessimist but as a planner I would be professionally remiss in not evaluating all possibilities. From that standpoint, we may need to critically assess our energy consumption pattern. Perhaps we cannot proceed merrily with the assumption that we have an inexhaustible supply of energy resources. And instead, to harbor an ethic of conservation. Such a reassessment is needed for, if our resources are depleted and we refuse to make the sacrifice, government will have to intervene. Government intervened in California to ration water. We saw that in 1974 during the gas crisis. The role of government as a facilitator may then have to change to one of a super regulator. And the regulations I mentioned earlier may have to be adjusted to encompass our consumption pattern. We have seen appearances of this, the fixing of price for oil. But government has intervened only when its citizens have failed to police themselves. We've all heard the facetious reference to James Schlesinger as the nation's energy czar. The joke may really be on us if in fact the need for such a czar becomes a reality, then at what price--energy.

Thank you.

01025

OWNERSHIP OF RESOURCES

Johnson Wong

Johnson Wong is Chief of the Land/Transportation Division of the Attorney General's Office, State of Hawaii.

I. INTRODUCTION

The nature of geothermal resources has made the determination of ownership somewhat complex. Is it water, mineral or what?

In any event, my presentation today will be addressed to the question of legal ownership of such resources under a mineral reservation clause or, in the absence thereof.

II. RESERVATION CLAUSE

Before turning to such a clause found in Hawaii land titles, let us consider three recent significant case decisions in California involving such a clause.

A. In the case of the United States v. Union Oil Company of California, 369 F. Supp. 1289 (N.D. Ca. 1973), the federal district court ruled that under the Stock-Raising Homestead Act of 1916, full title was conveyed and not just the use of the surface. The United States in that case had filed a complaint claiming ownership of the geothermal resources under a reservation clause of "all coals and other minerals" in patents issued pursuant to the Homestead Act of 1916. Union Oil had acquired the leases to produce and sell goethermal resources. The district court apparently equated geothermal resources with water and therefore concluded that it belongs to the owner of the surface estate. It rejected the argument that it was a "mineral." The court also gave great weight to the Department of Interior administrative interpretation that geothermal steam is not subject to reservation of the Stock-Raising Homestead Act.

On January 31, 1977, the Ninth Circuit Court of Appeals reversed the decision on the basis that Congress did not intend to convey title to subsurface resources, particularly energy resources, which do not serve to support the raising of livestock by homesteaders. The court also concluded that such geothermal resources are depletable subsurface reservoirs of energy akin to deposits of coal and oil and accordingly should be included in the reservation clause of the Act. (549 F.2d 1271 (1977)).

B. The case of Geothermal Kinetics, Inc. v. Union Oil Company of California, decided by the Sonoma County Superior Court, Case No. 75314, which decision was filed on August 31, 1976, involved a quiet title action where the surface and mineral rights to the land in The Geysers had been severed in 1951 by the fee owner's grant of "all minerals." The Superior Court for the County of Sonoma in a written opinion filed on June 1, 1976, refused to follow the Federal District Court in the Union Oil case which was still then pending and held that the owner of the mineral estate is entitled to extract and exploit the geothermal resources.

C. In the case of Pariani v. State of California, Superior Court of the City and County of San Francisco, No. 657-291, which was tried in 1976, the same issue was raised. That case involved land at The Geysers patented by the State of California to private parties subject to the reservation of all other mineral deposits. The patentees contended that geothermal resources belonged to them by virtue of their water rights. They also argued that geothermal resources are basically heat or energy and could not have been reserved by the State since neither heat nor energy is a mineral. The court took the case under advisement in 1976. It appears that this case would also be guided by the Ninth Circuit decision.

D. Hawaii cases. In Hawaii there has been no cases so far which involved geothermal resources specifically. There are other cases, however, involving our natural resources. In the case of City Mill Co. v. Honolulu Sewer & Water Commission, 30 Haw. 912 (1929), the Supreme Court ruled that the owners of various pieces or parcels of land under which there is an artesian basin are the owners of the artesian waters of the basin. As such owners, they have correlative rights therein. Each is entitled to a reasonable use of the waters with due regard to the rights of his co-owners in the same waters. The Court further ruled that under the police power, the Territory at that time may prescribe reasonable regulations for the boring and maintenance of artesian wells on the lands of private owners, to the end that the safety and the health of the community may be protected and the rights of co-owners of the waters of the same basin preserved from violation. The Court therefore adopted the correlative rights theory and rejected the reasonable use theory on the basis that the water does not remain perfectly stationary and that accordingly an owner should not be entitled to draw off as much water as he wants or to waste it as it would be affecting the rights of other individuals.

In the case of In re Title of Robinson, 49 Haw. 429 (1966), our Supreme Court ruled that although the Land Commission Award did not contain a mineral reservation clause, the Royal Patents which were issued subsequently and which contain such a reservation, were valid for the reason that the law at the time the Awards were made, did provide for such a reservation of mineral rights.

By Act 241, Session Laws of Hawaii, 1974, the definition of "minerals" in Section 182-1, H.R.S., was amended to include all geothermal resources. "Geothermal resources" was defined to be "the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas or other hydrocarbon substances." This definition followed California's Geothermal Resources Act of 1967. California thus claims the resources to be minerals subject to the reservations in its land patents. Montana defines it as water as under its Constitution, waters belong to the State.

This amendment raises the question of its retroactive application. As stated in Palea v. Rice, 34 Haw. 150, 158 (1937), it is well established that statutes generally are to be construed as prospective in meaning, intent and operation and not retroactive, unless the contrary clearly appears or is necessarily implied.

What, therefore, was the intent of the Legislature? Standing Committee Report No. 875-74, re H.B. No. 2197-74 which was enacted as Act 241 states that the purpose of the Bill was to establish in law the definition and ownership of geothermal resources and to provide for the orderly management and disposition of these resources. The Report further states that the people of Hawaii have a direct and primary interest in the development of geothermal resources. There is no expressed reference, however, as to its retroactive application.

It appears, however, that by amending the definition of "minerals" in Section 182-1, H.R.S., to include geothermal resources, it was the intent to give it retroactive application, as the Legislature could very well have treated it as a new resource, i.e., sui generis, as Idaho does.

III. PRIVATE OWNERSHIP OF GEOTHERMAL RESOURCES

Is the surface owner the owner of geothermal resources in the absence of any mineral reservation clause?

First of all, in view of the Robinson case, supra, you must go back to the Land Commission Award and the date thereof and not rely upon the deeds or Royal Patents which may have left out such a mineral reservation clause. It has also been held that a general conveyance without any mineral reservation carries with it the minerals as well as the surface. 54 Am. Jur. 2d, § 108, Mines and Minerals.

In the case of McBryde Sugar Company v. Robinson, 54 Haw. 174 (1973), the court stated that the right to water is one of the most important usufruct of lands, and it appears clear to the court that under the principles adopted by the Land Commission (L. 1846, p. 85), the right to water was specifically and definitely reserved for the people of Hawaii for their common good in all of the land grants and the King ought not, and ergo, he cannot surrender. The Court disregarded the argument made in the Robinson case that the Second Act of Kamehameha III in 1846, which required the reservation of minerals, was repealed. This case, of course, involves the ownership of water in the natural water courses, streams and rivers.

In County of Hawaii v. Sotomura, 55 Haw. 176, 182 (1973), the Supreme Court stated that public policy, as interpreted by that Court, favors extending to public use and ownership as much of Hawaii's shoreline as is reasonably possible.

In the Matter of the Application of Walter F. Sanborn to Register Title to Real Property at Hanalei, Kauai, Supreme Court No. 5553, March 23, 1977, our Supreme Court, in ruling on the line of high water mark for registered property, states that land below high water mark is held in public trust by the State whose ownership may not be relinquished, except when consistent with certain public purposes; and thus any purported registration of the land in the instant case below the upper reaches of the wash of the waves was ineffective. In basing its decision on the public trust doctrine, our Court further stated that such a doctrine existed prior to the enactment of the Land Court statute. The Court further considered the constitutional aspect as to whether it would be a taking of private property without just compensation and concluded that the absence of a clear legal standard at the time of the Land Court decree in 1951 tends to disprove the existence of any reasonable explanation in 1951 that the Land Court would be able to fix conclusively the distance and azimuth of high water (p. 13 of Slip Opinion).

In the case of State of Hawaii v. Molly Zimring, et al., Supreme Court No. 5522, dated June 22, 1977, our Supreme Court on page 16 of the advance sheet, again adopted the public trust principles and stated that the State as trustee has the duty to protect and maintain the trust property and regulate its use. The Court thus held that lava extensions vest, when created, in the people of Hawaii, held in public trust by the government for the benefit, use and enjoyment of all the people particularly in the absence of common law precedent or Hawaiian usage.

IV. CONCLUSION

Based on the foregoing discussion and the current thinking of our Supreme Court, it appears that the ownership of all geothermal resources may be considered to be vested in the State based on the doctrine of public policy, public trust and usufruct which was never contemplated when Land Commission Awards were made and that, accordingly, under the Union Oil case, which is a Ninth Circuit Court of Appeals case, there was never any intention nor need to convey the same to the surface owner.

V. RECOMMENDATION

Notwithstanding the State's possible claim of ownership, and based on the urgent need to develop and make available such geothermal resources, to attract risk capital as well as substantial investments, the State of Hawaii must, therefore, provide the necessary incentives to encourage and attract private industries, one of which would be the establishment of different amounts of royalties to be paid based on the extent of the State's ownership or claim of ownership to such resources.

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LEASING ARRANGEMENTS
William Byrd

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GEOTHERMAL LEASING

(The basic document utilized in the geothermal industry is the geothermal lease.) It permits the Lessee (or one who succeeds to his interest) to:

(1) enter on the land;

(2) explore for; and,

(3) develop the resource.

For a variety of reasons geothermal lease practices which are presently in use have originated and in many respects parallel oil and gas leasing practices.

(Exhibit 1)

The oil and gas lease in its more modern form is the product of the conflicting interests of the landowner and the Lessee or operator who seeks to develop the resource. The same interests apply to the landowner and the Lessee/operator in the development of geothermal resources.

Some of the basic interests of the Lessor-landowner would be:

(1) Immediate exploration and rapid development of the resource thus producing royalties for the landowner;

(2) In lieu of, or perhaps in addition to drilling and development, the payment of money, which might come in the form of bonus, rent, delay rentals, shut in royalties, minimum royalties and, perhaps, advance royalties;

(3) Retaining the maximum utilization of surface rights which is compatible with development of the resource; and,

(4) Protection of present and future uses of the property.

Some of the basic interests of the Lessee would be:

(1) To secure and keep the lease with the smallest capital investment possible;

(2) To have a lease term long enough to provide for exploration and development of the resource within:

(a) Budget and personnel constraints; and,

(b) Other development commitments.

(3) To have unrestricted use of the surface rights in order to develop the resource;

(4) To keep the lease as long as it is productive, or has speculative value; and,

(5) To terminate the lease without liability if it is unprofitable.

As a result of these conflicting interests different forms of the habendum, drilling and rental clauses have developed, some of which we will discuss later.

As was pointed out by Johnson Wong, the State of Hawaii claims the mineral resource associated with most, if not all, of the land in the State. Through regulations which have been proposed the landowner may be entitled to a geothermal lease covering the mineral resource under the surface of the land which he owns. As a result, the interests of the owner, as a Lessee, may parallel in many respects the usual interests of the operator or oil company who will explore and develop the resource.

At this juncture it should be noted that it is unlikely that the average individual landowner will want to, or be in a position to explore for and develop the resource, since it

(1) takes a competent and knowledgeable manager;

(2) a highly trained technical staff;

(3) a great deal of capital;

(4) enough acreage; and,

(5) a market for the product to make it all worthwhile.

Those who sat in on Bob Greider's discussion relating to geothermal development costs will have the benefit of his insight in that area. As you may know, the HGPA well has a cost in excess of $3,000,000. There is some indication that the cost of each development well will approximate $1,000,000. The current costs of drilling and completing a well at the Geysers is in the neighborhood of $1,000,000. (Exhibit 2)

Generally, then, the landowner will be thinking in terms of an assignment, a sublease, or some other form of nonoperating interest which we discuss in more detail later, under which an oil company or a resource development company will explore and develop the resource. I personally think it is to the landowner's interest to obtain a lease from the State of Hawaii on the broadest possible terms to prevent loss of the leasehold interest, especially if the landowner negotiates a more favorable arrangement with the resource developer.

Assuming for a moment we are the Lessee of a geothermal lease from the State of Hawaii, what should be done with it? For the reasons mentioned above we may not want to assume the responsibility of exploration and development. If that in the case, what are some of the things that we can do with the lease?

ASSIGNMENT

One of the things that we can do is to assign the lease to a party who is willing and able to explore and develop the property. An assignment is a transfer of the

Lessee's entire working interest in the property. One of the consequences of an assignment relates to the continued liability of the Lessee to his Lessor when the Lessee assigns his working interest to another who, in turn, breaches an express or implied covenant. From a drafting point of view, to protect the Lessee who assigns, the lease should include an express provision relieving the assignor after an assignment is made and an express assumption clause should be included under which the assignee agrees to be bound by the lease and to hold the assignor harmless.

(1) Consent to Assignment: In many lease forms assignment is expressly permitted, but if there is some limitation - as in the lease from the State of Hawaii - the consent of the Lessor is required. As I understand the intention of the Hawaii State Lease and regulations, once the assignment is properly made and approved the landowner-Lessee will be relieved of liability for breaches of express and implied covenants.

(2) Partial Assignment: The Lessee might assign his interest in the lease which covers a designated part of the acreage or as another alternative he might assign an undivided share in the working interest. In both instances the problems already discussed relating to assignments must be considered as well as the impact of a partial assignment on a number of other provisions in the lease, especially the habendum clause, rental provisions, production, drilling and royalty clauses.

(3) Sublease: Another method of approaching the transfer of an interest in a lease would be to make a sublease which might have a shorter primary term, with additional duties imposed on the transferee.

(4) Retention of Nonoperating Interests: When a transfer of a working interest has been made there are a number of nonoperating interests which may be retained. These are interests which have been severed from the working interest and include the following:

Nonoperating Interests

(a) Overriding royalties;

(b) Net profits interests;

(c) Carried interests; and,

(d) Options of one kind or another;

(e) Convertible interests; and,

(f) Production payments.

<u>Overriding Royalties</u>:

An overriding royalty is generally defined as a royalty carved out of the working interest. For example, where the original Lessee transfers or assigns his lease and reserves an additional royalty which is in excess of the royalty required to be paid to the Lessor. Under the terms of the lease the Lessee might also grant an overriding royalty to a third person. As an illustration, if we assume for a moment that the State of Hawaii is involved as the Lessor, the State would be entitled to its share of royalties under the lease agreement and the Lessee-landowner would, of course, negotiate with the transferee-operator of his working interest such matters as the amount of the override, its duration and other terms.

Consequences:

Generally, termination of the lease will extinguish the overriding royalty. The owner of the overriding royalty is not entitled to the benefits of implied covenants which might apply as between a Lessor and Lessee, such as the implied covenant to

(1) protect against drainage;

(2) develop and explore;

(3) for proper and diligent operation; and,

(4) obtain a market.

Clearly, under these circumstances, protective drafting measures should be considered for the benefit of the holder of the overriding interest who assigns a working interest to the operator.

Finally, the overriding royalty is a share of gross production usually free of cost. In this respect the overriding royalty should be distinguished from the net profits interest and the carried interest.

Net Profits and Carried Interests:

Both represent fractional parts of the working interest. Usually the holder of the net profits interest, or his counterpart, the carried party, where there is a carried interest, has:

(1) no obligation to personally pay for his share of operating costs;

(2) in the case of net profits interests profits are payable from net production after costs have been satisfied. The arrangement is often continued for the life of the lease;

(3) in the case of a carried interest, and there are a number of different forms which the carried interest may take. The carried party's share of production is used to pay up his share of the costs after which the carried interest becomes a full working interest and the carried party then bears his share of the costs and is entitled to his share of the receipts.

(4) frequently detailed accounting procedures will accompany these interests.

Convertible Interests:

In this case the owner of the convertible interest is entitled to convert the type of interest which he holds, for example, an overriding royalty, into another type of interest, for example, a working interest, which will become effective after he has contributed his share of the costs. In some cases the conversion may be made at the option of one of the parties.

Production Payment:

A production payment comes from a dollar share of the resource at the surface, free of cost. Generally, the payment is made from the income stream. The timing and amount would depend upon the transaction. It is generally of limited duration.

The production payment has a variety of uses. In the oil and gas business particularly it has been used as a tool to finance the costs of exploration and development. It could be used to provide payment to a Lessor in lieu of a bonus or larger royalty share. In addition, when a lease is assigned the assignor (in the case of a lease from the State of Hawaii we are talking about the Lessee who is also the landowner), may reserve a production payment in lieu of, or in addition to, an overriding royalty or cash. As between the owner of the production payment and the operator a debtor-creditor relationship is not created and payment is dependent on production. The operator normally has no duty to the owner of the production payment to develop the resource. Finally, the owner's protection must come from the instrument which creates the production payment.

Surface Use:

Where leases from the State of Hawaii are held by the landowner one should give particular thought to appropriate grants and reservations in the transferring instrument which affect the right of surface use. For example, assuming that the State of Hawaii is the owner of the mineral resource the general rule is that in the absence of an express covenant the owner of the mineral resource has an implied right of entry and the implied right to reasonably use the surface of the premises for the purpose of developing the resource. Generally the following rights are included by implication:

*(1) he may cut trees at the site of a well or appurtenant installation;

*(2) he may take water necessary for the exploitation of the mineral rights;

*(3) he may house employees on the premises who work there; and,

*(4) he may construct roads to drill sites.

In addition to the foregoing it may be necessary to locate pipelines, power plants, extraction and manufacturing plants, power lines, ponds and other buildings on the premises. It may be that the owner of the surface has other uses, both present and future,

*Williams & Meyers

which need to be reserved, but keeping in mind the requirements of the geothermal developer. Care must be taken to insure appropriate surface user for both the owner of the surface and the developer of the geothermal resource.

Outstanding Leases:

Where there are outstanding farm or commercial leases covering the use of the premises, which do not contain a clause reserving the right entry for the purpose of developing the geothermal resource, it is appropriate to consider the tenant's use of the property and appropriate amendments to the leases and to provide for reservations in future leases. In addition to these matters the following may also be considered.

PROTECTION OF NONOPERATING INTERESTS:

As indicated earlier, the owner of the nonoperating interest must take affirmative action to protect his interest by including appropriate contract provisions. The following are some of the typical contractual provisions which have been designed to protect the nonoperating interest in production. (See Williams & Meyers, Oil and Gas Law, abridged, Sec. 428.8, Matthew Bender.)

*(1) Extension and Renewal Clause:

"This reservation (e.g., of an overriding royalty) shall likewise apply as to all modifications, renewals of such lease or extensions that the assignee, his successors or assigns may secure."

Washout of nonoperating interests.

*(2) The assignment or reassignment clause may require the operator to give notice in advance of his intention to permit the lease to lapse and may provide for reassignment to the nonoperator before termination; lapse of lease terminates nonoperating interests.

(3) First refusal clause permitting purchase before either party disposes of any interest in the premises;

(4) An option to share in future acquisitions in the same general geographic area;

*(5) Forfeiture or reverter provisions upon failure of the assignee to perform as required by the contract;

(6) A contractual privilege for the nonoperator to take over operating rights in the event the operator fails or neglects to develop the property or upon other breach of the agreement;

(7) A covenant to assign some additional interest to the nonoperator in the event of failure to engage in specified operations;

*Williams & Meyers

*(8) The requirement to pay rentals when due;

*(9) Give the nonoperator the benefit of any express and implied covenants in the lease;

*(10) To keep and perform all the terms, provisions, conditions and covenants of the lease;

*(11) To make prompt payment of royalties, overriding royalties and other payments which may become due and payable;

*(12) To prosecute specific drilling obligations;

*(13) To operate to the economic limit as if the interest burdening the lease did not exist;

*(14) To reasonably develop the premises, observe customary geothermal field practices and modern methods;

(15) To unitize in compliance with reasonable rules and regulations;

(16) To protect the premises from drainage;

(17) To render appropriate periodic statements and reports;

(18) To allow the owner of the nonoperating interest access to wells and to furnish data thereon;

(19) To conform to all valid laws, rules and regulations regarding the drilling operation and development of the premises;

(20) Not to assign, in whole or in part, without the written consent of the owner of the operating interest;

*(21) To keep the premises free of liens or encumbrances;

*(22) To hold the owner of the nonoperating interest harmless and protect him from any and all claims arising out of the use, occupation or operation or the premises;

(23) Not to sell or use the resources without written consent and approval;

(24) To pull casing and plug the well in accordance with the requirements of State law;

(25) To prescribe the methods to be used in measuring production; and,

*(26) Provision for the appointment of a receiver to operate the premises in the event of a failure to carry on required operations on the premises.

It should be noted that some instruments contain express clauses relieving the operator from any duties to the owner of the nonoperating interests. Typical of these clauses would be the following provision:

*Williams & Meyers

"Development of, and operations on the premises, if any, and the extent and character thereof, as well as the preservation or forfeiture of the leasehold, shall be solely at the will of the assignee or its successors or assigns, and, upon termination of the leases covering the lands above described, for any cause whatsoever, there shall be no further liability hereunder."

The instrument may expressly negate any duty on the part of the operator to drill, pay rentals, or to preserve the lease.

At this point in time perhaps we should consider some of the typical provisions found in geothermal leases. To aid us in that endeavor I have prepared a topical index which may be used to head up various paragraphs in the geothermal lease. We will first run quickly through the topical index which we will now project on the screen then following that brief review we will discuss in more detail some of the clauses which deserve particular attention.

(At this point in time we will put on the screen the Geothermal Lease Index and go through it briefly.) (Exhibit 3)

Turning now to a more detailed examination of some of the provisions and putting aside for a moment the usual preliminary matters such as the date, the names of the parties and their capacities, we will first consider:

<u>THE GRANTING CLAUSE</u>: (typical language)

The Lessor *"grants, leases and lets unto the lessee:"*

(1) *"Geothermal resources"* [broadly described];

(2) *"Additional rights are granted for use and occupancy"* which is required to explore and develop the resource [this means wells, ponds, roads, pipe lines, power plants, power lines, etc.];

(3) Frequently these rights are expressed as sole and exclusive.

One of the most important parts of the lease in my view relates to the Lessor's reservation rights for surface use.

<u>RESERVATION OF RIGHTS</u>: (typical language)

"The possession by a lessee of said land shall be sole and exclusive for the purposes hereof and for purposes incident or related thereto, excepting that lessor reserves the right to use and occupy or to lease the surface of the said land for agricultural, horticultural or other surface uses, except those granted to lessee hereunder, which uses

shall be carried on by lessor subject to and with no interference with the other rights or operations of lessee hereunder."

The effect of this language is to subordinate the owner's present and future use to the Lessee's uses and rights under the lease.

The need, of course, is for accommodation, and less restrictive drafting for the uses and purposes of the parties may, in fact, conflict. To avoid misunderstandings and problems it is important for the owner to clearly express the reservations which he intends and if, for example, he expects to improve some portion of the property he should clearly state that fact and include it in his reservation.

Express Covenants:

A landowner may want to include in his lease or sublease an express covenant that the operator will diligently

(1) Explore;

(2) Drill a well or wells;

(3) Develop the resource;

(4) Protect against drainage;

(5) Obtain a market.

The term of the lease. Frequently, the term of the lease will be stated in the following language:

> *"This lease shall be for a term of five (5) years from and after the date hereof (herein called 'primary term') and so long thereafter as leased substances, or any one of them, be derived or produced in commercial quantities from the leased land."*

From a Lessor's point of view it is probably desirable to include what has been referred to as a determinable interest. Such language would be:

"This Lease shall terminate unless the Lessee

(1) drills, or

(2) pays [a delay rental]."

If the Lessee does neither the lease automatically terminates.

However, if the Lessee simply covenants that he will commence drilling or pay rent (a delay rental) and he does neither, then the lease does not automotically terminate and the Lessor must

(1) Give notice of default and election to forfeit, and,

(2) He may sue to forfeit the lease and collect the rent.

SAVINGS CLAUSES

Frequently there is added to these clauses a group of clauses called Savings Clauses for the Lessee/Operator in order to preserve the lease. Such provisions are

(1) the dry-hole clause

(2) cessation of production clause

(3) drilling operations clause

(4) continuous drilling operations clause

(5) extensions obtained while the obligations of the Lessee are suspended

(AMPLIFY AND EXPLAIN EACH ONE OF THESE CLAUSES)

THE HOOK-UP CLAUSE - a method of extending the Primary Term

In geothermal leases it is appropriate to include a so-called *"hook-up"* clause.

If we were dealing with oil and gas, after discovery almost immediate use can be made of the product unless it is in some remote area where extensive gathering or transporting facilities are required to be made, such as on the north slope and in offshore drilling operations.

The problem with the development of geothermal resources is simply that a considerable delay occurs between the time when discovery is made and the time when the resource can be developed and marketed. Some of the things which need be done are:

(1) Discovery;

(2) Test and drill for more wells;

(3) Determine the extent of the field;

(4) Construct pipe lines and injection wells;

(5) Obtain permits to build power plants;

(6) Build the power plants;

(7) Transmission lines.

Some three years ago it was generally concluded that five years would be required between discovery and full-scale production; however, in the Geysers area, when CEQA, the California Environmental Quality Act, became effective production in the area stopped and it took 44 months to obtain the next permit to build a geothermal steam plant. Consequently, the time can, on occasion, be excessive. It is to the mutual advantage of both the Lessor and the Lessee to provide a reasonable period of time coupled with deligence on the part of the operator to develop and market the resource.

One variety of hook-up clause in a geothermal leases would be as follows:

Unless within five (5) years from the date of expiration of the primary term hereof Lessee shall have made arrangements for, by executed contract or contracts, a bona fide commercial sale of one or more leased substances in commercial quantities this lease shall terminate.

Between discovery and sale the lease may provide for the payment of rents, minimum royalties which may not be recoverable by the Lessee from earned royalties, or advance royalties which may be recovered against future production.

Rental clauses - varieties:

(1) Often, as noted above, a delay rental is paid to avoid termination of the lease for failure to drill.

(2) However, the lease can provide for the payment of rent even though the Lessee has satisfied the drilling commitment.

(3) In some cases the Lessee will guarantee the payment of rent (or a minimum or advance royalty) for an agreed period, such as:

(a) A definite number of years; or,

(b) Until and so long as earned royalties exceed the rent payment; or,

(c) The Lessee quitclaims the lease

[1] In its entirety, or there is

[2] A partial surrender when the rent may be reduced, depending upon the terms of the instrument.

(d) Some leases contain escalation clauses which automatically increase the rent by the percentage increase of the cost-of-living index for the wholesale price index or other similar index.

(4) What about the amount of the rentals? I gather that the State of Hawaii in its leasing of reserved lands is asking for $1.00 a year in the form of rent, which is no doubt designed to encourage the development of the geothermal lease. If a sublease is made by a Lessee who has obtained such a lease he could, of course, ask for additional rent in his negotiations with the operator.

By way of background information in the Geysers I made a brief survey with a colleague who does a number of geothermal leases in the Geysers area. He advised me that the lowest amount being paid was $10 per acre per year in rather speculative areas. In prime areas the rental escalated to as much as $100 per acre per year with a 4-year guaranty. In Imperial Valley there has been no proven discovery in the sense that power is being produced, as is the case of the Geyers, although there are hopeful signs that this may occur in the not-too-distant future and currently leases are going for a minimum of, I would say, $5.00 per acre and up to $25 per acre per year. I suspect this figure will go higher in some areas in the not-too-distant future.

Royalty Provisions - Steam. The typical lease provision would be as follows:

> *"Lessee shall pay lessor _______ percent (___%) of the gross proceeds received by lessee from the sale of hot water, steam or thermal energy."*

What is the effect of this type of provision, i.e., *"gross proceeds received by Lessee?"*

The question is what kind of a sale did the Lessee make?

Suppose it is:

(1) a sale at 15 mills per kilowatt hour of power produced at the power plant, i.e., at the bus bar. The effect is both the Lessee and Lessor are paying:

[a] all of the costs of transmission of the steam or hot water from the wells through the transmission lines and the power plant;

[b] the costs of power consumed in the plant; i.e., to run the plant, cooling towers and produce electricity; and,

[c] for any inefficiency in the plant operation or design.

But suppose:

(2) the Lessee makes the sale *"for pounds of steam delivered to the power plant."* The effect is that the utility pays for the steam delivered to the plant and also pays for in-house plant costs, which encourages efficient use and, provides greater revenue for both the Lessor and the Lessee. A couple of years ago I understood that the equivalent value for high-grade fuel oil would cost over 20 mills per kilowatt hour. So, as you can see, the amount of revenue which the Lessor can expect will depend upon the type of contract and, also, the lease provisions which he has negotiated with the operator.

AS BETWEEN THE LESSOR & LESSEE

As a matter of further interest let's take a look at the same clause we started with which you will recall read as follows:

> *"Lessee shall pay lessor ____ percent (____%) of the gross proceeds received by lessee from the sale of hot water, steam or thermal energy ... "*

and add to it this type of a clause:

> *" ... at and as of the point of origin on the leased land."*

The effect here is that the Lessor must pay his royalty share of the transmission cost from the well to the point of sale.

Suppose, instead, we add to our paragraph:

> *" ... at and as of the point of delivery 'to a transportation system other than a gathering system on the leased land.'"*

The effect here is that the Lessor would not have to pay his royalty share of the gathering system costs which were located on his own land but would have to pick them up between his land and the power plant.

Now, suppose we use another phrase instead of either of these two by tacking onto our initial clause the phrase

> *" ... at and as of the point of delivery to the power plant."*

The effect here is that the lessor does not pay a royalty share for delivery cost of leased substances from his wells to the power plant.

USE OF LEASED SUBSTANCES

Use of Leased Substances by the Lessee. A fairly typical provision is the following:

> *"Lessee shall not be required to account to lessor for or to pay any royalty on hot water, steam, thermal energy, or extractable minerals, produced by lessee on the leased land which are not utilized, saved and sold or which are used by lessee in its operations on or with respect to the leased land or in connection with the developing, recovering, producing, extracting, and/or processing of hot water, steam and/or minerals in solution, or in facilities used in connection therewith, including operations of facilities for the generation of electric power or which are unavoidably lost."*

As noted above, this represents a significant cost item to the Lessee or operator. However, from the point of view of the Lessor it will result in a reduction of the income which is payable to him.

It is interesting to note that the Hawaii State Lease in its proposed form contains a provision requiring royalty payments to be made for leased substances *"used by the Lessee and not sold."*

Of course, it is a matter of negotiation when a Lessee/Landowner makes an assignment reserving an overriding royalty. He must decide whether he wants a similar provision governing his relationship with the assignee or to absorb a portion of those costs.

ROYALTY PERCENTAGE

You will notice that we did not fill in the royalty percentage. Almost all the early leases called for a 10 percent royalty and today I think the standard proposal in industry would be for 10 percent. Initial leases between the State of California, for example, where State lands are concerned, provide for a 10 percent royalty as do a number of other state leases. As you probably know, here in Hawaii under the proposed regulations the royalty will remain at 10 percent during the first 25 years but may be readjusted upwards at that point in time. Federal leases contain similar provisions for an escalation in royalties over a period of years.

By way of comparison, in the Geysers area I understand that leases today almost uniformly provide for a 12 1/2 percent royalty. I suspect that our friends in industry will point out that in the Geysers we are dealing with (1) hot, dry steam and (2) there is a ready market in the San Francisco area for power produced.

It has been said the geothermal industry can be compared to the early days of the oil and gas industry. Initially a 1/8 royalty was common and is still common in many midwestern areas. In California oil royalties have increased in some cases to 1/6 and in some cases 1/4 and, in fact, in one instance went to 100%. (The oil company wanted the oil for its nearby refinery.)

REAL PROPERTY TAXES

In the Geysers area the County Tax Assessor has in some instances commenced taxing certain areas on the basis of "minerals in place," even though the minerals are not yet produced. Under the usual lease provisions the Lessor (Landowner) is at least obligated to pay his royalty share of the tax on geothermal resources. In some cases the way the lease is drawn the landowner might have to pay all of the tax imposed on minerals in place and not yet produced.

Under these circumstances the landowner would not be receiving royalties if the mineral is not being produced. The result has been a very real financial hardship for the landowner in some instances.

From the landowners' point of view a careful drafting of the tax clause is required to protect him from this eventuality. Different approaches have been taken.

> In some of our leases the owner has agreed to pay as his share of the taxes an amount not exceeding the royalty share of actual money received under the lease, whether in the form of rent, minimum, advance or earned royalties.
>
> I've seen some leases where the lease provides that the Lessee may advance such funds to be recovered against royalties.

Unitization and Pooling:

Traditionally there have been several situation where pooling or unitization was desirable. For example:

(1) Where a number of small parcels in a metropolitan area have had to be combined in order to produce the resource the pooling concept was devised.

(2) The concept of unitization which normally relates to larger parcels is of importance where two situations occur:

(a) Where the reservoir is known; and,

(b) Where expensive facilities are necessary to produce the resource. For example:

[1] In areas where expensive facilities for secondary recovery are needed;

[2] On the north slope where expensive gathering and transmission facilities are required to exploit the resource.

(c) Another factor to be considered relates to the most efficient placement of wells and facilities to permit the economic draw down of the resource.

These are all valid concepts for the geothermal element. There are important considerations, however:

(1) If the size of the leasehold bloc is large enough there may be no need for a unit;

(2) Before the unit is designated the reservoir should be first identified;

(3) Allocation must then be made on a reasonable and fair basis as among all of the owners of the unit and this regardless of the royalty burden which may be different for various people within the unit.

Consequently, considerable care must be exercised in drafting the unitization clause.

For discussion of these and other topics relating to leasing, see references listed on Appendix A.

EXHIBIT 1

CATEGORY	INDUSTRY	
	Mining	Petroleum
Geologic Occurrence	0	
Hydrothermal Characteristics	0	
Alteration	0	
Geochemistry	0	
Geophysics	0	
Frequency of Viable Occurrences	0	
Prospect Size		0
Property Acquisition		0
Overall Exploration Costs		0
Exploration & Production Drilling		0
Production Engineering		0
Capital Requirements	0	
Expenditure Timing	0	
Development & Production Timing	0	
Productive Life	0	
Marketing	0	
Environmental Impact		0

Gerald Kitchen, General Counsel AMAX, Geothermal Leasing (Paper, Presentation meeting of the Rocky Mtn. Min. Law Foundation, Jan. 27-28, 1977, Salt Lake City, Utah)

EXHIBIT 2

COST OF COMPLETED STEAM WELL

Build road, location, & cellar	$ 50,000
Move rig in & out	65,000
Rig operating for 70 days	315,000
Air compressor rental	40,000
Fuel for rig & air compressors	34,000
Excessive drill pipe wear	25,000
Hardbanding drill pipe	3,000
Drill pipe & drill collar inspection	6,000
Water	15,000
Waste Disposal	20,000
20" Conductor Pipe	4,500
13-3/8" Casing	52,500
9-5/8" Casing	67,500
Cement & Services	50,000
Rent 20" Hydril & Rotating Head	10,000
Rent shock sub & stabilizer	10,000
Rent monel drill collar & directional instruments	10,000
Drilling mud	30,000
Well head & muffler & flow line	20,000
Miscellaneous transportation	10,000
Logging	8,000
Mud well logging	25,000
Bits	55,000
Miscellaneous	50,000
Direct supervision & overhead	28,000
	$1,003,500

Figure 3

1977 Drilling Methods and Costs at the Geysers, California.
William A. Glass

EXHIBIT 3

GEOTHERMAL LEASE INDEX

[16] Payment for Land Used

[17] Acquisition of Land by a Public Utility

[18] Surrender, Use of Easements if not in Default

[19] Payment for Easements - Conditions of Use

[20] Subsidence

[21] Operations Preventing Use for Agricultural Purposes, Damages

(f) Arbitration

(g) Restoration of the Premises

(h) Insurance and Liability

(i) Removal of Lessee's Property

(j) Inspection of Premises

(k) Breach-Provisions for Termination

(l) Nonwaiver Clause

(m) Compliance With Laws, Rules and Regulations

(n) Right of Surrender, Obligation to Restore Premises

(o) Title, Disclaimer of Warranty, Defense of Title

(p) Taxes

(q) Assignment

(r) Force Majeure

(s) Method of Payment, Provision for Depository if Interests are Fragmented

(t) Notice

(u) Savings Clause [if part is invalid remainder is binding]

(v) Unitization and Pooling

(w) Execution by Less Than All Parties

(x) Counterpart Execution

(y) Applicability to Heirs, Successors and Assigns

REFERENCES: APPENDIX A

Articles:

1. Aidlin - Representing Geothermal Resources Client, 20 Rocky Mtn. Min. Law Inst. 27

2. Olpin - The Law of Geoth. Resources, 14 Rocky Mtn. Min. Law Institute 123

3. Thomas Root - Contents of a Geothermal Leasesome suggestions, ABA, the Natural Resource Lawyer, Vol. VIII No. 4

4. Gerald Kitchen, General Counsel AMAX, Geothermal Leasing (Paper, Presentation meeting of the Rocky Mtn. Min. Law Foundation, Jan. 27-28, 1977, Salt Lake City, Utah)

Books:

1. Geothermal Energy - Kruger & Otte

2. Williams & Meyers, Stanford University, Oil & Gas Law, Matthew Bender

01027

INSTITUTIONAL RELATIONSHIPS

Robert Bethea

Robert Bethea is Partner of Carlsmith, Carlsmith, Wichman and Case, Attorneys at Law, Hilo, Hawaii.

Good morning. Does everybody hear me?

I should begin by telling you a little bit how I backed into this topic, dealing with what's called in the program, "Institutional Relationships." When I was approached by Marvin Iida of the County about this seminar, he talked about various topics that might be coming up, and he mentioned land use regulation and I said, "Well, gee, I know a little bit about that." And he said, "No, Sidney Fuke is going to talk about that." Then he said, "Well, we'll also want to get into the question of the ownership of the resource." And I said, "Oh, I've done a lot of struggling with the ownership question in Hawaii, and I think I can talk quite a while on that." But he said, "No, Johnson Wong's talking about that." So then he mentioned the topic of geothermal leasing, what a geothermal lease should contain, and I said, "Well, gee, I know something about that." And he said, "No, Bill Byrd's going to talk about that." And he said, "What we'd like you to talk about are institutional relationships." And I said, "Marvin, what are institutional relationships?" So, we kind of hammered that around for a while and what it ended up was that he said, "Well, there must be some leftover topics that you could talk about." And so I guess I'm a leftover speaker.

One topic I can't omit, although it wasn't part of this "leftover topic" that I came into by default, has to do with the question of the ownership of geothermal resources in the State of Hawaii. I'm afraid I'm not going to be able to simply leave Johnson Wong's claim of total state ownership alone. I'm going to have to get into that a little bit because I think it's an important area--it's been touched on by Bill Byrd, but there's a lot more to be said about the ownership question. What Johnson said may be what ultimately our Supreme Court will come to but it's a long, tortuous path to such a decision. Somewhere along the line in this little talk, I want to talk about the ownership question and indicate that there are a lot of good operational theories that would indicate that the mineral resource is, in some instances, owned by private landowners.

By way of personal background, until fairly recently, I was generally ignorant of anything to do with geothermal resources. I knew something about the geysers field, etc. My ignorance, I think, was shared in general by the legal and business community. I think this type of seminar will do a lot to dissipate that ignorance. In any event, one of my functions is to try to tie together what various experts have been telling us about geothermal prospects and development.

I think this tying together is a difficult job, especially in Hawaii because it is a complex matter. There are many varying interrelationships between the parties, and a varying number of parties involved. And, although there are many similarities in the problems involved in the development and utilization of geothermal energy resources that are similar in the development and utilization of gas and oil resources, the problems are different, especially in Hawaii. We're dealing in a different environment.

When you are dealing with oil and gas resources in Oklahoma, Texas, and elsewhere, although there's been a lot of litigation on a lot of subjects, I think all parties generally have a pretty good understanding of what goes on. That's not the situation with geothermal in Hawaii particularly. As a business community, we have generally ignored the subsurface estate in dealing with land matters. And the same has been true of our State government. We've had no real mining experience. Even now the people in government are struggling with the problems of trying to set up an appropriate regulatory regime for geothermal leasing and development. They're struggling with the problem of trying to develop regulations. Dan Lum has done a lot of work in that area, and I think personally that the regulations are pretty well under way, especially with regard to technical requirements. There was considerable input in that area from Dave Anderson, and I think there's been a genuine effort to work out a regulatory structure that will permit the commercial exploitation of this resource. I think that in some areas, there is certainly need for change in proposed regulations. Hopefully, the people involved in developing the regulations will be responsive to change.

One thing that has become very clear to me, and I think it should be clear to all of us here after listening to all the speakers, is that the determination that geothermal resources exist, and a further determination that the resource may exist in commercial quantities, is only the tip of the iceberg as far as the resolutions of geothermal problems is concerned.

Problems beyond the mere existence of the resource as discussed by Dr. Takahashi, have been outlined and dealt with by Mr. Dolan, Mrs. Heinzelman, and Mr. Greider, and they have analyzed for us some of the practical financial aspects involved in the utilization of geothermal energy. Mr. Anderson and Mr. Fuke have talked about the regulatory aspects; Mr. Wong and Mr. Byrd have talked about certain legal aspects involved in the development of geothermal energy. I think the crucial fact that has become abundantly clear is that if the overall climate is not right, if there is a community failure to resolve the problems inherent in any one of these major areas of concern, then the simple fact is that even though the resource is there, it cannot be utilized. If the financial aspects don't pan out, if it's too costly, then it's no go situation. Likewise, if the regulatory structure is not such as to permit the reasonable commercial exploitation of the resource, that also results in a situation where the resource simply sits there.

When we start looking at the institutional relationships; that is, the relationship between the owner and the developer, between the financial user and the government, etc., I think it's best to start with the last in the chain, that is with the relationships that are going to exist between the government and all other parties. I also want to talk about what this relationship should be, because there's been some talk, and I hope it's on a very minor level, about government development of this resource. So, let's talk about the government function; taking full note of the fact that there is an ownership question; that is, a question of whether the resource is owned entirely by the State of Hawaii or in part by private citizens who own land without a mineral reservation or who may have a water rights claim to geothermal energy. Further, there may be claims by the Hawaii people based upon the events at the time of annexation. Maybe this would be an appropriate time to talk about the ownership question, and perhaps give you a somewhat different view on this matter, or at least a view which conflicts in part with the views expressed by Johnson Wong.

A claim of private ownership would be premised essentially on the fact there were many coveyances by the State and its governmental predecessors which did not contain a mineral reservation. For example, when Bill Byrd talked about a landowner who has mineral rights, that landowner acquired such rights by a deed which did not contain a mineral reservation. In other words, he received a deed where the granting clause says, I, the grantor, "hereby bargain, sell and convey;" then there is a property description; then there is a habendum clause "to have and to hold, etc., etc.," together with all and singular and all that fancy language; but nowhere in the deed is there a specific reservation of mineral rights. The traditional law, in my opinion, has been that such a deed conveyed the entire estate in the property; that is, both the surface estate and the mineral estate. Now in 1846, the Hawaiian government promulgated an Act to Reorganize the Executive Department. That act contained a provision which required conveyances to have a mineral reservation. However, in 1859, for the first time, there was a civil code promulgated and that civil code, among other things, specifically got rid of a lot of provisions in the 1846 act, which was the act to reorganize the executive department of the Hawaiian government. One of the provisions that was omitted was the requirement that the government reserve mineral rights. This condition existed through annexation up until about 1962. Therefore, during that time period, there was no express statutory requirement; that is, there was no legal requirement that the government reserve mineral rights. As a matter of practice, from about 1859 and to about 1900 and these are approximate dates, there were a lot of conveyances that simply did not reserve mineral rights. In some cases, mineral rights were reserved in royal patents that were issued upon land commission awards, and this raised the issue in the Robinson case which was cited by Johnson Wong. There were two dissenting judges in that case. The character of the court has changed--I'm not suggesting necessarily that Robinson would be overruled--but the Robinson case was a limited case. When you got a land commission award, which historically gave you what we think of as full fee title to the property, the only thing remaining was to pay the government commutation fee upon which the government quitclaimed its interest. The patents that were issued on the land commission award, which was the subject matter of the Robinson case, contained a mineral reservation although the land commission award itself did not contain such a reservation. Well, the Supreme Court, in this 3-2 decision, held that the language of the patent issued upon the land commission award prevailed even though the reservation wasn't in the land commission award itself. This was a fairly tortured decision. I mean, you had to go a little bit out of your way to arrive at such a conclusion, and there were vigorous, well reasoned dissenting opinions. That case left open specifically the question of ownership where neither the land commission award nor the patent issued on the land commission award reserved any mineral rights.

The traditional law has been that when you don't reserve mineral rights, you convey them. As a matter of fact, and I don't say this to embarrass the Attorney General's Office, but there was a sort of preliminary opinion by the Attorney General's Office which in fact discussed this subject, and the concluding paragraph states that unless a reservation was made in an award granted between 1859 and 1963, the mineral rights would not be explicitly reserved to the State. In conclusion, then, it would appear that any grant conveyed between 1859 and 1963 which did not contain a mineral reservation to the State transferred the mineral rights to the grantee. I think the Attorney General's Office has the right to look at the law again and change its mind. Further, I think that there are a number of theories that the State may use to claim the ownership of the entire resource. You could follow the "public trust doctrine." Or you say, hey, they made a mistake--they didn't mean to do that in 1859 when they forgot to continue that requirement about reserving mineral rights. I don't know what our Supreme Court will do. We know from the cases that have had to do with where the line is along the ocean that there have been decisions using the public trust doctrine. Further, you have what Johnson Wong referred to as the Molly Zimring case where you had lava flows that extended the seaward boundary. That case was a use of the public trust doctrine.

I also suggest that the legal situation is complicated further by the fact that you have federal questions involved in this situation. In other words, we all have a right under the federal constitution not to be deprived of property without due process. Therefore, even if the Supreme Court of Hawaii were to deny private ownership where minerals were not reserved, such a decision could be declared invalid by the federal courts. So, I guess I have said enough about that topic. I did want to spell out that there is good position for an opposing view. I'm not trying to predict what the outcome would be, but on accepted common law real property principles, there is a litigable position that the State of Hawaii has in fact granted mineral rights and therefore geothermal rights, if geothermal is defined to be a mineral.

The Union Oil case in California involved in federal court decision. The Geothermal Steam Act of 1970 declared that geothermal was a mineral. There was litigation as to the validity of a mineral reservation in lands granted under the Stockraising Homestead Act. The Federal district court dismissed the government's claim and said geothermal was not a mineral. This wasn't a particular well reasoned decision, and on appeal the 9th Circuit Court said, well, yes, geothermal is a mineral.

The answer depends on how you approach the question. If you try and look at what was reserved, you might get one result. If you try to look what was intended to be granted, you could get another result. Well, in any event, I guess I had my say on this issue. And we can get back to institutional relationships and the position of the government. And when I say government, I mean the State or County government, as may be applicable.

I think what the government does is going to be determinative of whether or not this resource is going to be developed. We must always keep in mind that the government regulatory blanket covers all of these actions. Even if the resource is determined, under particular lands, to be owned by private citizens, the regulatory and tax structure imposed by the government can permit or can prohibit the development of the resource. And we have to keep in mind, and of course, this is just basic, that governmental structures, whether they are in the form of taxes or indirectly through regulatory compliance are cost items, just like exploration costs, drilling costs, and all other capital costs that go into a project of this nature. I think it should be clear to us that on balancing all of these factors--the ecological, the social factors, the political factors, even if there is a broad community decision that the resource should be developed, then whether it will be developed is going to be determined in large part by a cost equation. And these costs are staggering.

Bill Dolan has given us some of these costs. Claire Heinzelman has talked about the cost of developing a 55 megawatt plant. So I think it's wrong to think of this geothermal resource as a plum that is just going to be plucked out of the earth; it will come down to a cost question sooner or later.

If the geothermal resource is owned by the State then of course the State is going to have the discretion to decide whether it's going to develop the resources, the extent of share or royalty they're going to demand, etc., etc. The government function, whether it's in private ownership or whether the government owns the resource, in my opinion, can only be that of a regulatory. I don't think the government intends to be a working partner or a developer. I don't think that they can be--I think that's politically impossible. The State government is not in the risk capital business and we know from what previous speakers have told us that geothermal is a risk capital venture.

People are going to put up a lot of money and they're going to be putting it up at risk. For the State to put up that kind of money, I think, raises an impossible political situation. Just as a brief aside since we're all familiar with it, look at what has happened to the Kohala Task Force. My feeling was that here we had a sincere effort by government to stimulate a depressed area. The government put in some money and depending on how you look at it, it was a success or a failure. But the amount of money that the government put in there was really miniscual compared to the type of costs we're talking about. So you have this, I think, well intentioned efforts--some successes, some failures, and yet if you look at what the media says about it, they're getting down to questions of accountability on very minute details. So when you're talking about the type of risk capital--and I'll get rid of this very quickly, this subject--I don't think that any administration is going to want to take the risk of spending millions of dollars in what may turn out to be a dry hole. Just one further thought. Bob Greider, who had spent 31 years with Chevron told me that it's the type of business where a guy can do a good job, do a lot of research and put in 10 million dollars and it just doesn't pan out. He doesn't lose his job and the vice president who approved it doesn't lose his job. That's the way the situation has got to be because it's a risky thing.

QUESTION:

ANSWER: I really don't know but when you're talking about... depends what you're talking about. When you're talking about sums like Bill Dolan was talking about, when you're talking about the sums involved in that and I can't speak for the Department of Energy, I don't see it in a function.

QUESTION:

ANSWER: Well, I don't see the Department of Energy as in that role, but we have people here I think who can specifically answer that question. Well, anyway, talking about the regulatory aspects, the numbers are simply going to have to come out right, financially, and they're going to have to come out right for some private entrepreneur or some consortium of entrepreneurs who are in the risk capital business. The entrepreneur in my opinion, is going to have to be that type of business that is oriented to take enormous capital risks. In summary, talking about the government's relationships with all these other institutions, I think that whether the government owns the resource, or whether the resource is owned privately, whether the resource is developed is going to be determined by the regulatory structure and by the type of tax structure that the government creates. And in addition to a pure cost items, regulation, leasing arrangements, etc., I believe are going to have to be certain enough that a private developer can have substantial predictability in the future as to what his costs are going to be.

Let's go back to this chain of institutional relationships, as it's been called, and deal with the relationship between the owner and, in Hawaii particularly, the occupier of the surface of the land. And I'm not getting into the area deeply that Bill talked to us about but we should note that the "occupier" of the surface of the land has a special status under the present State law; that is, that a lease can be issued to an "occupier" without public auction. When you think of this relationship from the developer's point of view, it means that the developer may have to deal not only with the State, if it owns the resource, but with the owner of the surface estate. The relationship between the owner and the developer of the resources is going to be essentially governed by the geothermal lease. I say "essentially" because perhaps even how they may deal with each other will in part depend upon the nature of the regulatory structure.

Bill has covered that area very carefully, and I don't think I'll go into it further.

Let's consider the institutional relationship that exists between the developer and the financial user. And by financial user, we mean the person who is going to utilize the geothermal energy by converting it to electric power or some other direct application or use. The financial user could also be the developer; that is the person who has gone in and developed a geothermal resource and who is going to put a plant into operation and then utilize the energy.

I think most of us have been conditioned to think in terms of a public utility when you talk about utilizing geothermal energy. You convert the energy to electric energy and then it's distributed by a public utility company. In this area, you have particular problems of course, when you're talking about the situation in Puna. In that area you could make a hundred million dollar investment and have it wiped out by a lava flow. I don't think of a public utility company as being in that sort of a risk capital business either.

We keep talking about Puna but there may be other areas where the resource can be developed, and depending on the location, you might have a better climate for an electric utility type of operation. I don't think now that there is any predictability as to who the financial user might be. We keep talking about electricity generation but there may be other uses for this energy; in agriculture processing, in sugar processing and the like. And when you talk about the interrelationships, that's going to be covered by very, very complicated legal documentation setting forth all the various rights of the parties, etc.

To summarize, I think we have to look at the development of geothermal energy in Hawaii not as a single problem, but as a whole series of different problems involving a number of different parties, different individuals, different institutions. What's required, if you want development, is a sort of a unified solution. Each one of these problems is going to have to be resolved in such a manner as to enable the resolution of that problem to tie in with the resolution of all other problems. I think a unified solution is possible--the Alaska oil situation had to be one of the most complex types of interrelationships between government, private entrepreneurs, landowners, etc. The North Sea oil thing had to be an enormous thing. But they worked it out. Perhaps not to everyone's satisfaction but it worked out.

And so, despite all these problem areas, I think that assuming that cost equations are favorable, things can be worked out. I would suspect that the private parties involved, whether it be the owner, the developer, the financial user, will probably be able to resolve their problems on a financial basis. As Bill Byrd said, in geothermal leasing, everything is a give and take situation. What you try to get is a balancing of interests. And most of the time, private parties, businessmen between themselves with their lawyers, etc.; they hammer at each other and if the stakes are high enough, you get a solution. It's not a solution usually that everybody's happy with because it's been a give and take situation. But you get a solution. I think the overriding question will be whether or not the government, which I think of as a balnket that covers this whole field, can be responsive to all of these private considerations. I believe that the government wants to be responsive; that there's a community feeling in favor of planned growth--planned development; the problem is whether political considerations will permit the type of government response that will enable the resource to be developed. So the product is there. I think we know that, and we know that it may be there in commercial quantities. That looks pretty good for Puna. It may be just as true elsewhere.

The final issue, then, is whether the private and public interests, the private and public sectors are going to be able to come up with a solution, if as a community we desire this sort of growth potential for Hawaii. I suggest that the private and public interests are really going to have to listen hard to each other. The government is going to have to be responsive to the private concerns of a developer. And on the other hand, the developers are going to have to accept a reasonable regulatory structure. If all of that can be put together, then my feeling is that we may have a resource that can really be used and used in a proper way to further the economic development of this County.

So that's my leftover topic. If there are any particular questions I could answer, I'll try.

01028

FEDERAL GEOTHERMAL PROGRAMS

Richard I. Gerson

Richard I. Gerson is Manager of Institutional Programs, Division of Geothermal Energy, Department of Energy, Washington, D. C.

The Division of Geothermal Energy's budget increased this year by 100 percent, to approximately $101 million. That is the largest growth program in the Department of Energy, and I think that is an acknowledgement of the importance of geothermal.

Some of the issues that have been raised here this morning focus squarely on philosophy and money. In Washington, we spend a great deal of time philosophizing and a great deal of time looking for money: money for projects. In the program that we are discussing here, some money is available, but it is not a lot and it must go to many places. In this context let me say that the President has acknowledged the importance of the geothermal program, in his April 20 message on energy. He says: "Additional funding will be provided to identify new hydrothermal resources which could be tapped for near term generation of electricity and for direct thermal use." I would like to talk with you about direct thermal, which can be used in addition to an electricity generation program. In areas where non-electric geothermal resources have not been exploited, there will be occasions where the government will support them for direct utilization for residential space conditioning and for industrial and agricultural process heat.

Most of you know that the Department of Energy is working to encourage utilization of hydrothermal geothermal resources. This has been our first emphasis. The Federal government is confident that our economy will put electricity on line based on this resource as widely and as quickly as possible. To help bring it on line in the last year, the federal geothermal development budget was increased by 50 percent and that will double in fiscal year 1978, the present year. The immediate goal is to help the private sector take advantage of the country's hydrothermal resources as soon as possible, and the government is looking down the road to the U.S. geopressured, hot dry rock and other resources in the foreseeable future.

In the last few months, there have been discoveries of geothermal resources in parts of the United States outside of the west, mostly low- and moderate-temperature resources. At the same time as this has become known, DOE's geothermal program has been reorganized into a series of regional efforts. One of our regions encompasses 35 States, all of those east of the 13 western states. Should all of those resources be utilized, present estimates suggest that geothermal energy on line could go as high as one million megawatts. That it is approximately 6 to 7 times present estimates of available hydrothermal resources. But aside from that, the private sector is moving ahead with more commitments mostly in respect to high temperature hydrothermal resources. Let me give you a few examples.

Magma Power Company will build a ten megawatt power plant at the south end of the East Mesa field of Southern California. This will be the first plant based on a liquid dominated resource in the United States. It is projected to be on line early next year. Republic Geothermal is drilling an exploratory well using the first Department of Energy loan guarantee for energy development, and it hopes to have its power plant operating by the early 1980s, if the field proves satisfactory. An experimental thermal loop is operating at the north edge of the Imperial Valley cultivated area near Niland. This has all the characteristics and features of a 10 megawatt plant based on the liquid resource, except for a turbine generator. Problems there relate primarily to reinjection. A decision will be made in the present fiscal year on whether or not to build a 50 megawatt commercial power plant. This would be a jointly funded demonstration, with complete reporting of results. It is hoped that other commercial units will follow.

Having mentioned the Loan Guarantee Program, I should refer to its provisions here. The Geothermal Loan Guarantee Program allows the Department of Energy to provide guarantees for up to 75 percent of the cost of projects for the purpose of determining and evaluating the resource base, research and development with respect to extraction and utilization technologies, acquiring rights in geothermal resources, or development, construction and operation of commercial scale energy production using geothermal resources. The program has been open for business since June of last year, and three loan guarantees have been awarded so far.

But not all geothermal energy will be used to generate electric power. In some places, the geothermal energy surplus is usable for process heat. Since clearly, nonelectric geothermal energy cannot be economically moved to its consumers, a number of communities and companies are seriously considering becoming geothermal users on the spot.

Let's discuss industry for a moment. What industries? One proposal to us suggests that any industry that evaporates or boils large amounts of water at pressures near atmospheric is a prime candidate for geothermal energy. In New Zealand, there is a large scale utilization of geothermal energy in paper manufacturing. In Iceland, heavy water production and diatomite production, as well as large scale greenhouse heating and air conditioning, are going on.

One review of industrial process uses of geothermal by MIT reports that production costs for these and other processors can probably end up lower if they use geothermal energy than if any alternative energy source is used. Other observers suggest that creation of multipurpose geothermal installations will prove to be technically and economically sound. Hawaii has shown interest getting some facts on the possibility that power can be generated by geothermal heat that is also used in conjunction with large consumption of medium temperature resources for process heat. The idea needs to be explored that industries that are both power and heat intensive might benefit maximally from combined use of geothermal energy that the recovery system could be optimally tailored to their use. A governmental role is to show industry and the public that a given site is technologically feasible for these and similar purposes. It still remains for industry to convince itself of the long term payoff from building a manufacturing facility tied to a geothermal site. Just as it must convince itself of the same thing as this relates to an electricity generating plant. Candidate industries can be brought into technological and economic feasibility studies near their start in order to encourage commitments to geothermal by the private sector. The government can encourage and help institutions to get together.

This prospect can affect how older manufacturing processes might be rearranged in several industries. In looking at what would likely be the most suitable industries, MIT has concluded that they would have the following characteristics: they would be expanding or modernizing, or preparing to move their production facilities. They would use heat energy in such volumes that would be significant parts of their production costs. They would be prepared to match the profile of quality and quantity of the energy they need to geothermal sites that would be suitable for the industry from other viewpoints. Specific companies in the industry must be willing to collaborate in meaningful ways on projects of this magnitude. They need to be willing to provide money and information.

From a first look MIT has concluded that about fifteen manufacturing processes can benefit from the availability of geothermal energy. Now we plan to look at these industries more closely: paper manufacturing from wood pulp, sugar processing, salt production, heavy water production, polymer processing, horticulture, textiles, fruit and vegetable canning, fish drying, fish meal production, certain mineral element recovery processes, freezing and refrigeration. Mention of several of these will strike responsive chords in Hawaii.

So far there is no well-structured cooperative program between relevant industries and research groups that are focusing on geothermal energy. And there is precedent for Federal support of cooperative public-private structuring. Up to the present we have started some studies relating to certain manufacturing industries and we are considering mechanisms through which we might work with others. At the same time we are doing a number of other things to resolve institutional barriers. We are better defining our quantitative goals in a series of regional studies that are organized as joint efforts with State governments, to develop coordinated goals agreed to by industry, public groups, and government at all levels. We have tried to help various parties resolve issues of Federal land leasing to perform resource assessment and to disseminate scientific and technical information in useful ways. We have supported formation of data banks on geothermal resources. We are trying to motivate more private sector commitments to development, and we recognize that the plea for new incentives is relevant. Up to now, geothermal has not been favored in the field of taxation. That has come up in these two days many times. But it appears that the legislature and the courts are now close to agreement on the principle that expending intangible costs associated with drilling should be allowed, and that percentage depletion allowances are logical for geothermal exploration as well as for oil, gas, coal and uranium mining. We hope that this approach will be reflected in the 1978 legislation.

To this end the Inter-Agency Geothermal Coordinating Council has recommended amendments to the tax code that provide for special tax treatment permitting expensing as R&D, the costs that are associated with exploration of geothermal energy and that are incurred prior to the commercial development phase. This has now been introduced into Congress. The number and extent of environmental reviews for leasing are also of concern, since the number of competitive leases issued is far less than the backlog awaiting action. Very few wells have been drilled on Federal land, largely because of leasing problems, and most of the leases have been issued rather recently. The Geothermal Coordinating Council has an Institutional Barrier Panel which has recommended issuance of leases without environmental review, with the stipulation that no activity may take place which would disturb the land surface until an environmental review has been made.

The same panel has recommended other changes in the leasing program, since that program presently limits acreage leased to any individual, company or person to 20,480 acres in any one State. A legislative change being proposed would increase that limit to 51,200 acres. Under a regulatory change in administration of the Steam Act, developed acreage would be exempted from limitation. Requirements for post-leasing activity are also under review. A task force is examining ways to reduce the redundancy in regulatory requirements for exploratory and developmental activity. Regulations have been drafted that allow siting of geothermal power plants or other utilization facilities on Federal land, even in cases where the geothermal resource to be tapped is not on Federal land.

We are working with the States in search of greater uniformity of their regulations. The Geothermal Resources Council has been working closely with us on this. Based on some community geothermal utilization scenarios, the Department of Energy has begun to work with Federal agencies that have the capability of affecting markets. These include the Veterans Administration, General Services Administration, HUD, the Rural Electrification Administration, Farmers Home Administration and the Public Health Service. We are interested in how federally owned and managed space can contribute to markets for geothermal space heating. In considering incentives needed to motivate public-private partnerships that can put geothermal energy on line, we are engaging in activities meant to stimulate formation of structures that encourage interaction, and that eliminate and resolve things that impeded geothermal development. In search of a realistic environmental balance, other nongovernmental groups are evolving management structures and commending some of them to us. The Federal geothermal program is based on a strategy meant to nurture a geothermal industry on hydrothermal resources, while simultaneously improving our knowledge of the extent and characteristics of the various geothermal resource types and beginning development of technologies needed for utilization of more extensive geothermal resources.

By your efforts, you in Hawaii are contributing to the total program.

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