FINAL SUMMARY REPORT

SCIENTIFIC OBSERVATION HOLE (SOH) PROGRAM

1988 - 1993

for

State of Hawaii

Department of Business, Economic Development & Tourism

Honolulu, Hawaii

by

Harry J. Olson
Principal Investigator
Hawaii Natural Energy Institute
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EXECUTIVE SUMMARY

The Department of Business, Economic Development, and Tourism (DBEDT) administers funding and provides direction for State energy programs including the Scientific Observation Hole (SOH) program. Prior to the initiation of the SOH program on July 1, 1988, the geothermal potential of the Kilauea East Rift Zone (KERZ) was assumed to be approximately 500 megawatts of electrical energy. To test this assumption, the Hawaii Natural Energy Institute (HNEI) proposed a plan to assess Hawaii's geothermal resource potential by core drilling small diameter observation holes along the KERZ and the Haleakala Southwest Rift Zone (HSWRZ). The goals of the SOH program, as defined by the enabling legislation, were to assess Hawaii's geothermal resource potential and stimulate geothermal exploration by the private sector. The objectives and original scope of the program were to assess and characterize the geothermal resource potential of the KERZ, and to aid in the evaluation and commercial development of the geothermal potential of the Geothermal Resource Subzones (GRS). Data gathered from the SOHs have assisted ongoing scientific research and State and County agencies in the regulation of geothermal development activities, and continues to provide an excellent data base for long term geothermal monitoring and testing.

In general, to conduct geothermal activities in Hawaii, approvals must be coordinated with the Department of Health (DOH)/Office of Environmental Quality Control (OEQC), the Department of Land and Natural Resources (DLNR) and the Planning Commission of the County in which the activity is planned. Required public hearings were held, and agency approvals coordinated to ensure that all necessary permits were issued. In implementing the program, HNEI administered SOH permitting, drilling, data collection, and monitoring; and DBEDT administered the funding and supervised program activities.

To assess the geothermal potential of the KERZ, an array of four holes, three of which were drilled, were sited along the long axis of the KERZ within existing GRSs. These holes were drilled by Tonto Drilling Services, Inc. using a Universal 5000 core/rotary drilling rig. Two holes were spaced to provide step-out drill coverage between or beyond existing and planned geothermal production wells, and two holes were located with the intent of "pairing" the SOHs with production wells to test for permeability across the rift zone.

Successful drilling techniques and casing procedures were devised as the geologic formation became known and its characteristics noted. Above 270°F, a complex stearate was added to the drilling fluids to maintain lubricity. Above 330°F, a mixture of soda ash, high temperature polymer, complex stearate, and sepiolite virtually eliminated the high torque and vibration problems frequently associated with high temperature drilling.

SOH-4 was the first hole drilled. This hole provided information regarding thermal and permeability conditions along the central portion of the Kamaili GRS. Data gathered from this SOH was later used by True/Mid-Pacific Geothermal Venture (TMPGV) in the site selection of TMPGV's proposed #2 well. SOH-4 was drilled to a total depth of 6,562 feet in 151 days at a direct drilling and testing cost of $1,466,848 or $223.54 per foot, and recorded a temperature of 583°F at a depth of 6,400 feet.

The second hole, SOH-1, was drilled along the axis of the KERZ at the western end of the Kapoho GRS. This hole effectively defined the northern extent of the HGP-A/Puna Geothermal Venture (PGV) geothermal reservoir and doubled the "proven" reserves of the then known reservoir. PGV was able to use this data to continue project funding. SOH-1 was drilled to a total depth of 5,526 feet in 217 days at a direct drilling and testing cost of $1,643,544 or $297.42 per foot, and recorded a bottom hole temperature of 403°F.

The third hole, SOH-2, also was drilled in the Kapoho GRS approximately a mile to the southwest of the Kapoho crater to a depth of 6,802 feet in 126 days at a direct drilling and testing cost of $1,106,684 or $162.70 per foot, recorded a bottom hole temperature of 662°F, and may have intersected a potential reservoir at a depth of approximately 4,900 feet.

The SOH program continued the geothermal assessment and characterization of the KERZ, which began in the early 1970s. Other rift zones with geothermal potential on the Big Island and other islands of the Hawaiian archipelago remain to be tested. Many more holes will be needed before an adequate picture of the Big Island's geothermal resource potential emerges. Nevertheless, the data collected by the SOH program has been important to the regulatory functions of the various State and County agencies, and has augmented the State's resource management program.

FINAL SUMMARY REPORT
SCIENTIFIC OBSERVATION HOLE (SOH) PROGRAM
1988 - 1993

BACKGROUND

Prior to the initiation of the Scientific Observation Hole (SOH) program on July 1, 1988, the "conventional wisdom" in Hawaii of parties interested in energy development assumed the geothermal potential of the Kilauea East Rift Zone (KERZ) on the Big Island of Hawaii to be approximately 500 megawatts of electrical energy. This assessment hypothesis was not proven by drilling. In support of this hypothesis, however, Dzurisin (1981) calculated a magmatic intrusion of 2,800 thermal megawatts into the KERZ, which indicated that the energy source was large and that the rate of convective heat loss to the shallow hydrologic system nearly balanced the heat recharge for magmatic intrusion. Thomas (1987) also estimated a continuous discharge of approximately 291 megawatts of thermal energy over a restricted area along 10 kilometers of the KERZ and 1,455 megawatts of thermal loss along a 50 kilometer stretch of the rift zone.

At the time the SOH program was initiated in 1988, geothermal activity in the state consisted of the continued operation of the 2-3 megawatt HGP-A electrical power plant by the Hawaii Electric Light Company, Inc. (HELCO); and legal, regulatory, and permitting activities by two geothermal developers, True/Mid-Pacific Geothermal Venture (TMPGV) and Puna Geothermal Venture (PGV). TMPGV held a state geothermal resource mining lease for property owned by The Estate of James Campbell in the Kilauea Middle East Rift Geothermal Resource Subzone (GRS) and had a permit with the State Department of Land and Natural

Resources (DLNR) to develop 25 megawatts of electrical power, and to explore for a maximum of 100 megawatts. TMPGV also held development rights on Maui in the Haleakala GRS along the western extent of the Haleakala Southwest Rift Zone (HSWRZ) on land owned by Ulupalakua Ranch. PGV held two geothermal resource mining leases within the Kapoho GRS, and had a contract to sell 25 megawatts of power to HELCO. In addition, the International Air Service Company (IASCO), which owns land along the southern extension of the Kilauea Southwest Rift Zone (KSWRZ) adjacent to the Volcano National Park, had applied for its land to be designated as a GRS, but was not actively pursuing the development of its property. Barnwell Geothermal Corporation (Barnwell) also held a state mining lease for property adjacent to the HGP-A site on which it had drilled three unsuccessful geothermal exploration wells in the early 1980s, but had suspended further geothermal exploration.

Much geothermal activity has taken place in the ensuing five years. Currently PGV is producing approximately 25 megawatts of electricity at its Puna Plant adjacent to the HGP-A facility, which was brought on line during April 1993. TMPGV, after drilling a multi-directional well, apparently has suspended operations in Hawaii. Barnwell has plugged and abandoned its Ashida #1 well and plans to plug and abandon Lanipuna #1, but continues to maintain its Lanipuna #6 well. Barnwell has no announced plans for further geothermal development at present. IASCO continues to hold its land position along the KSWRZ.

In 1988, HGP-A was producing in excess of 2 megawatts of geothermal energy, and had an on-line record of greater than 90% for approximately six years. At that time HGP-A represented one of the hottest geothermal wells that had been drilled. In the early 1980s, Barnwell drilled three unsuccessful geothermal wells to the south and west of HGP-A. Two of these wells, Lanipuna #1 and Ashida #1, were very hot, but dry; the other, Lanipuna #6, although somewhat productive, was considerably cooler, and not thought to be economically viable. Also in the early 1980s, PGV drilled three successful geothermal wells, KS-1, KS-1A, and KS-2, about a quarter mile to the north of HGP-A (Iovenitti and D'Olier, 1985). Although these wells appeared to be productive, they were not extensively flow tested, and because of casing damage, KS-1 and KS-2 were subsequently plugged and abandoned. KS-1A currently is utilized as an injection well by PGV.

The scientific research and findings of the private developers indicated that the assumption of power potential was reasonable. However, this work did not confirm the extent of the reservoir system nor provide the needed data that a developer would require prior to investing substantial funding toward exploration and development of an undiscovered geothermal resource.

Subsequently, the State elected to use the Hawaii Natural Energy Institute (HNEI), School of Ocean and Earth Science and Technology (SOEST), at the University of Hawaii at Manoa (University), to assess Hawaii's geothermal resource potential by core drilling slim observation holes along the KERZ and Maui's HSWRZ. In addition to collecting rock cores, these scientific observation holes were designed for the collection of groundwater and reservoir fluid samples to provide an estimate of the potential flow capability of the holes, and to monitor groundwater conditions. The SOHs were not designed or permitted as production wells.

In assessing the rift zone for resource potential, it is not possible or practical to test every square foot of the area. A decision must be made as to the coverage acceptable to define the features to be assessed. The GRSs in the KERZ cover an area roughly 9 miles in length by 1.5 miles in width. To assess this area by drilling, it was decided that the program would focus on maximizing core collection and drilling footage, as opposed to a detailed geologic study of the drill holes. It was decided that it was much more important to collect as much rock or core as possible rather than to study a limited amount of core in great detail.

Thus the SOH program was designed to assess Hawaii's geothermal resource potential by providing basic geologic and geothermal information. It was assumed this data would stimulate private sector exploration of geothermal resources within the KERZ. Based on this plan, HNEI proposed the SOH program to the 1988 State Legislature, which provided funding for the program. HNEI managed the SOH drilling, data collection, and monitoring; and DBEDT administered the funding and supervised program activities.

OBJECTIVES AND SCOPE

The major objectives and scope of the SOH program were:

- o to assess and characterize the geothermal resources potential of the KERZ, and
- o to aid in the evaluation and commercial exploration of the geothermal potential of the GRSs.

Secondary benefits from the program were:

- o to provide data for further geothermal research,
- o to provide long term geothermal monitoring and testing sites, and
- o to assist the State and County with their regulatory, resource management, and monitoring responsibilities.

Initially, the planned objectives were to be met by the drilling of six SOHs to a depth of 4,000 feet, the first two to be drilled on Maui in the GRS along the HSWRZ, then four on the Big Island in the GRSs along the KERZ. Subsequently, a decision was made to initiate drilling activities on the Big Island. The SOHs on the Big Island were numbered to be drilled consecutively, but permitting dictated that SOH-4 should be drilled first, followed by SOH-1, SOH-3, and SOH-2 in that order. After the completion of SOH-4 and SOH-1, several factors resulted in the decision to defer the drilling of SOH-3 and to drill SOH-2 next. After the completion of SOH-2, SOH-3 was not drilled due to insufficient funds remaining in the budget to complete the hole to its targeted depth.

During the drilling of SOH-4, it became evident that a depth of 4,000 feet would be insufficient to meet the drilling objectives. Therefore, the targeted depths of the SOHs were revised, and SOH-4 and the remaining SOHs were permitted to be drilled to a depth of 6,500 feet. Drilling experience also indicated that the casing requirements in the permitting provisions were grossly over designed. The casing program was subsequently modified for the remaining SOHs to provide adequate casing without compromising safety. Minor improvements in the drilling plan continued throughout the program.

The Electric Power Research Institute (EPRI) funded a separate but related project to test the feasibility of estimating potential flow capability similar to that of a production size well by injecting fluids into a slim hole, rather than by flow or pump tests. Consequently, injection testing of the SOHs was conducted at the completion of drilling and prior to instrumentation for pressure monitoring. Results of the EPRI/HNEI project were mixed. Although all of the SOHs intersected localized fracture intervals, none intersected obvious production zones. However, the drilling and injection data did indicate that even a limited slim hole drilling program can be useful in making preliminary estimates of commercial reserves, in defining the requirements and benefits of additional drilling, and in characterizing the degree of resource risk that exists when planning a commercial development. Results of the injection testing related to the EPRI project are discussed in greater detail in later sections of this report.

The Bonneville Power Administration (BPA) funded another separate but related project to test the feasibility of utilizing slim hole drilling data to purchase options from geothermal developers or independent power producers for the development of geothermal power generation. This project proved to be quite successful, and provisions for an optioning program were formulated that were used by BPA in offering a Request for Proposal (RFP) for three geothermal developments in the BPA service area. Results of the BPA project are described more fully later in the report.

PROGRAM SUMMARY

In designing a program to assess and characterize the geothermal resource potential of Hawaii, it was noted that previous work indicated that the active rift zones had the greatest potential for geothermal resources. Although the KERZ, and other rift zones associated with active volcanoes on the Hawaiian Islands were assumed to have subsurface temperatures in excess of the temperatures necessary to generate electrical energy, little was known of other conditions such as rock porosity and permeability, water quantity and quality, and reservoir and cap rock characteristics that are necessary for a viable resource to exist. Within the KERZ, available surface geological, geochemical, and geophysical surveys did not provide results that could be reliably interpreted as representing potential reservoirs. Besides geological mapping and the identification of fractured rift zones, surface exploration techniques had proven unreliable in the identification of geothermal reservoirs in Hawaii. Shallow gradient drilling also had proven unsuccessful in defining anomalous areas of elevated subsurface temperature, even in the area over the known HGP-A/PGV reservoir, because of the masking effect of downward percolating meteoric water due to the high rainfall in the area. The only exploration technique, at that time, that had been successful in the discovery and definition of geothermal reservoirs was the drilling of production wells to depths in excess of 6,000 feet at a cost of more than $2 million each. To assess the geothermal potential of Hawaii, ground truth, in the form of subsurface geologic information at a reasonable cost was needed. This data could be obtained only by drilling.

On the Big Island, preliminary geothermal surface exploration had been completed that resulted in the Geothermal Resources of Hawaii Map, (Thomas, et al., 1980, 1983). Active volcanoes were known and geothermal heat sources had been identified, rift zones had been recognized and mapped, and gross areas of geothermal potential defined. However, only the area in the vicinity of the HGP-A/PGV development within the KERZ had been drilled to sufficient depth and in sufficient detail to test the resource. A regional, deep drilling program at a reasonable cost was needed to assess subsurface conditions along the KERZ and other rift zones with active or recently active volcanoes such as the Kilauea Southwest Rift Zone, the Mauna Loa Southwest and Northeast Rift Zones, and the Hualalai Northwest Rift Zone on the Big Island; the Haleakala Southwest Rift Zone on Maui, and anomalous areas on other islands with geothermal potential within the State of Hawaii. Figure 1 shows the location of the volcanic features, the KERZ, and areas with geothermal potential on Maui and Hawaii.

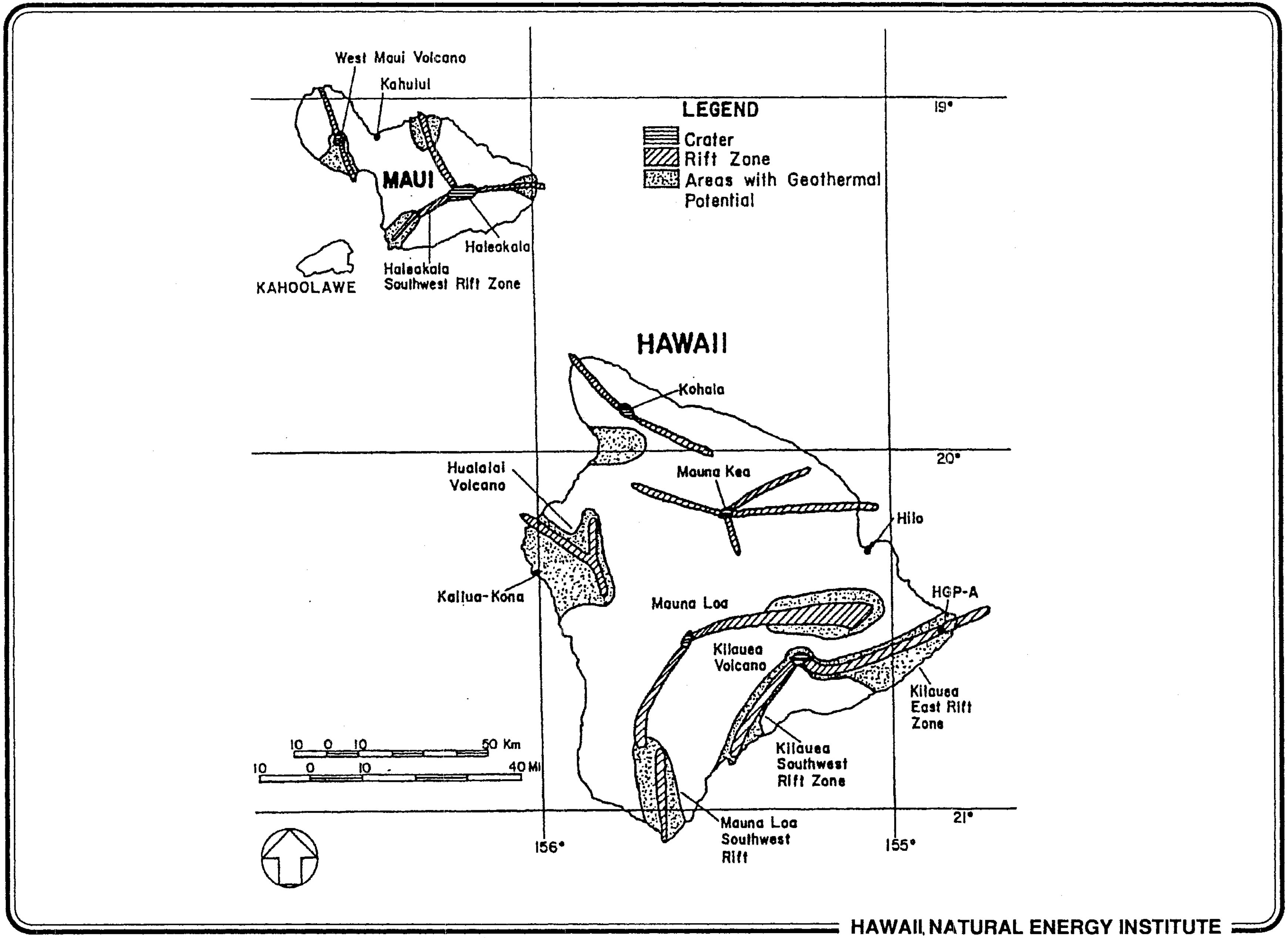

Figure 1. Location of Volcanic Features and Areas of Geothermal Potential on Maui and Hawaii

In the area surrounding the HGP-A/PGV development, exploration and production drilling suggested that nearly all indications of geothermal potential including elevated subsurface temperature and gradients, rock alteration, capping minerals, and reservoir fluid entries would be encountered at depths above 4,000 feet. Consequently, a diamond core drilling technique was selected to obtain rock samples capable of showing rock textures, contacts, fracture orientations, vein structures, etc. Core drilling was also selected because of anticipated loss circulation problems (diamond drilling can drill ahead without drilling fluid returns), and because core drilling below approximately 2,000 feet is normally cheaper than rotary drilling. This depth was well within the capabilities of truck mounted exploration drill rigs operating on the Mainland, and no problems were anticipated in retaining a good, well maintained rig and experienced crew to do the drilling. Drilling costs were assumed to be approximately $100 per foot, and that each 4,000 foot well would cost about $400,000 to complete.

PERSONNEL AND CONSULTANTS

The SOH program was conceived, planned, permitted, and managed by HNEI. University personnel were utilized wherever possible and professional consultants retained to conduct the specialized tasks involved with the environmental studies and monitoring, permitting, drilling, surveying, downhole electrical logging, and site and access construction. DBEDT entered into a contract with the University of Hawaii/HNEI to conduct the SOH program, and subsequently HNEI contracted with the Research Corporation of the University of Hawaii (RCUH) to manage the disbursement of program funds.

Personnel:

H.J. Olson (HNEI) was principal investigator and was responsible for permitting, the selection of proper drilling equipment and contractors, the drilling plan and operations, as well as the overall management and administration of the program. D.M. Thomas, Hawaii Institute of Geophysics (HIG), assisted with the permitting, and was the scientific investigator responsible for analysis of data and core collected during drilling operations. A.S. Seki (HNEI) was the administrative manager responsible for permitting and regulatory matters. The remainder of the program staff were associated with the University under contract with RCUH. A listing of the persons working on the SOH program follows:

- Technical

H.J. Olson*	Principal Investigator
D.M. Thomas	Scientific Investigator
A.S. Seki	Administrative Manager

- Administrative Support

L.C. Glenn	Program Officer
M.M. Higa	Support Specialist
P.C. Thompson*	Project Specialist

- Field Assistants

S.R. Evans	Research Associate
E.A. Novak	Research Associate
F.A. Trusdell	Research Technician
A.S. Vagelos	Summer Assistant

* Currently associated with the follow-on monitoring and testing of the SOHs

Consultants:

Consultants with professional experience were contracted for drilling, drilling supervision, and environmental and regulatory permitting, compliance, and monitoring.

MCM Planning, which had extensive experience in environmental and land use permitting with State agencies in Hawaii, was selected to prepare the necessary environmental and permitting documents. MCM Planning provided subcontractors for specialized studies and surveys covering fauna and flora, archeology, forestry, etc.

Darby and Associates, a qualified local acoustical consultant, was selected to advise the drilling contractor on methods to quiet the drill rig, and to conduct acoustical surveys and monitoring during the drilling phase of the SOH program.

John E. Deymonaz, a consulting geologist with extensive project management and drilling experience was selected to assist in the preparation of a Request for Proposal (RFP) for a drilling contractor, and to manage drilling operations once a drilling contractor was selected and permitting approvals obtained.

After potential drill sites were selected, a RFP was published and sent to all known drilling contractors in Hawaii, and to drilling contractors with geothermal and slim hole coring experience on the Mainland. The drilling contractors who responded to the RFP inspected the proposed sites and were provided with an opportunity to discuss the program with State and County regulatory agencies. A committee composed of interested or involved persons connected with the University, Hawaiian Electric Industries, and various State agencies selected Fred Page Drilling International to conduct the shallow

(0-1,000 feet) large diameter rotary and/or churn drilling phase, if necessary, and Tonto Drilling Services, Inc. to conduct the deep, core drilling phase. Both contractors were selected on the basis of their experience, capability, and low bid. However, Fred Page was not available at the time drilling was scheduled to commence. Tonto, having the capability to drill the large diameter holes, was requested to bid on that portion of the contract. Tonto submitted a bid at a cost equal to or less than the Page bid, and subsequently was approved to conduct all the drilling. Tonto provided the program with well qualified drill crews with geothermal experience, and a Universal 5000 rotary/core drilling rig, which proved to be uniquely suited for the requirements of the SOH program. A picture of the Tonto Universal 5000 drilling rig is shown on Figure 2.

PERMITTING

In general, State and County permitting approvals for geothermal activities in Hawaii must be obtained from the following lead agencies:

- Department of Health (DOH), Office of Environmental Quality Control (OEQC) - serves in an advisory capacity and is responsible in implementing Chapter 343, Hawaii Revised Statutes (HRS). OEQC reviews all documents pursuant to the EIS process. The proposing agency for government action prepares an environmental assessment (EA) and determines if significant criteria are met which require an environmental impact statement (EIS). If no significant effects are found, a Negative Declaration is filed by that agency. Generally, State regulations exempt research projects which involve temporary or casual land usage. Normally, such activities do not require submission of an EA or EIS.

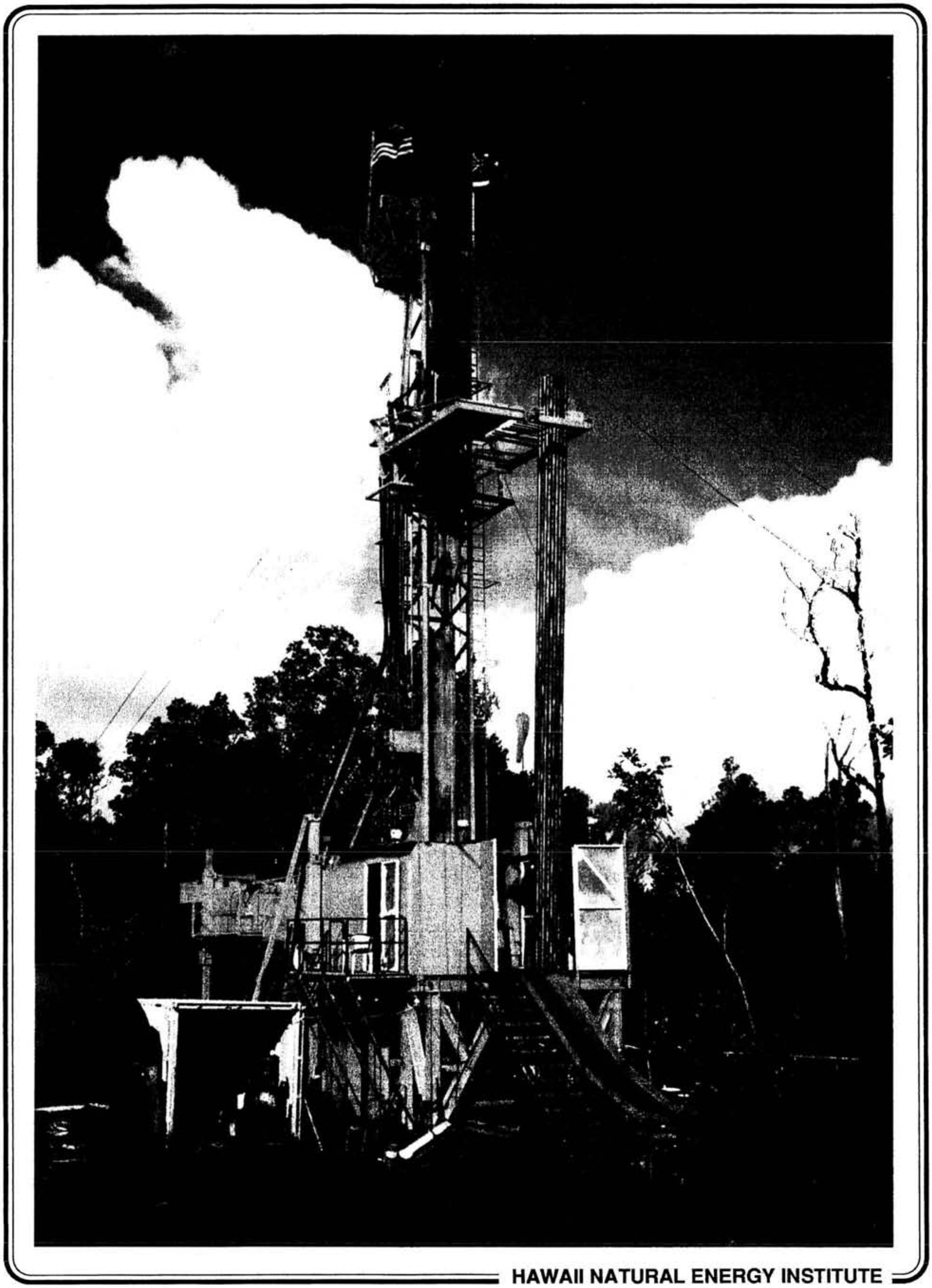

Figure 2. Tonto Universal 5000 Drilling Rig

However, documentation that the land impacted does not contain rare or endangered species, archeological sites, etc. is required. If any normally insignificant exempt action were proposed in a particularly sensitive environment, of if successive exempt actions could have a cumulative significant impact, the exempt status of such proposed actions would be invalid. Additionally, for projects utilizing State funds, State regulations provide that an EA/Negative Declaration or EIS must be prepared for such agency actions. Consequently, an environmental assessment was prepared for the SOH project and a Negative Declaration filed by the University of Hawaii.

o Department of Land and Natural Resources (DLNR) - evaluates the technical aspects of the project and determines the technical permit and land usage conditions for property classified as Conservation Land, and general conditions for all land usage. In addition, DLNR has the responsibility and authority for regulation of the GRSs and management of geothermal resources. DLNR's responsibilities include, but are not limited to, regulation of geothermal well drilling and operation to prevent waste, conserve resources, and for safety and protection of the environment. Applications for geothermal exploration and development, well drilling and modification, well abandonment, and monitoring of associated activities covered by the geothermal Plan of Operation must be reviewed and approved by DLNR. A copy of the DLNR Geothermal Well Drilling Permit is attached as Appendix I.

o County of Hawaii Planning Commission - evaluates permitted activities with regard to social impacts, land usage plans and provisions, zoning regulations, etc., and determines operational conditions on property located within agricultural, rural, or urban districts. Public hearings and mediation proceedings were held concerning the SOH application which resulted in the approval of a Geothermal Resource Permit for the SOH program, containing three general and 26 specific conditions to mitigate potential impacts of the SOH drilling. A copy of the Geothermal Resource Permit is attached as Appendix II.

Because the SOH program was conceived and implemented as a research project involving only temporary, casual land use, initially it was thought that permitting would be relatively uncomplicated and inexpensive, requiring only environmental operating conditions and minor land use permits. This, however, was not to be.

The permitting process started as soon as the project scope had been determined and the drilling sites identified. The DOH/OEQC was contacted and the environmental requirements for the project were identified. HNEI contracted MCM Planning to prepare an EA. Based on the assessment, the University filed a "negative declaration" with the OEQC. The EA was not contested, and permit applications were then submitted to the County of Hawaii for appropriate land use approvals and permits, and to DLNR for drilling permits.

Although permit applications are required to be acted upon within 180 days, over eight months passed before all the permits were issued. Public hearings on the Geothermal Resource Permit application conducted by the County of Hawaii drew large numbers of protestors and persons opposed to any geothermal activity in the Puna area. After the second public hearing, formal mediation proceedings were requested, and several mediation sessions held with parties who petitioned the Planning Commission to participate in the mediation. After the mediation report was submitted to the Planning Commission, two additional hearings were required before the permits were approved. Additional permits concerning grubbing and grading, ground water protection, and emergency response plans, which took several additional months to complete, were required to meet the conditions of the land use permit. The final permits were issued, approximately a year after permit applications were first submitted, just days before the drilling rig was scheduled to move on to the first site and commence drilling operations.

As the SOH program was an applied research project, permitting costs, and costs to comply with environmental and permitting regulations originally were estimated to involve only a relatively minor program expense. These expenses, however, soon developed into a significant cost factor. Although a detailed account of permitting and compliance costs was not kept, these expenses, nevertheless, can be conservatively estimated at more than $245,000, excluding salaries, and involved three staff members for a period of about 1.5 years.

The principal concerns of the geothermal opponents, the mitigation measures taken, and the effect of the permit conditions on the program are described in the following paragraphs.

- <u>Minimize Environmental and Social Impacts</u>: To the extent possible, the SOHs were sited away from residences, used existing access roads, and were located on fallow agricultural land or previously impacted forest areas. Clearing of drill sites was limited to slightly more than one-quarter acre thereby minimizing surface disturbance.
- <u>Safety</u>: OSHA safety regulations and conditions of the Emergency Response Plan were followed. Core drilling was

selected, not only for scientific and technical reasons, but also to reduce the risk of blow-outs or accidental or uncontrollable venting. Blow-out prevention equipment was utilized throughout the drilling process.

- <u>Distance from Residences</u>: The sites were located as distant from existing residences as possible. The nearest residences were slightly over one-quarter mile from SOH-1 and partially blocked by a narrow strip of vegetation, approximately one-third mile from SOH-2 and screened by trees which surrounded a farm house, and over one-half mile from SOH-4, which was totally surrounded by forest.
- <u>Traffic</u>: Truck traffic was limited to daylight hours between 7 a.m. and 7 p.m. This served to restrict operational flexibility and to increase the cost of the drilling operations, especially when drilling water had to be trucked to the site.
- <u>Road and Site Construction</u>: Existing roads were used to access the SOH-2 and SOH-4 sites. A temporary, short access road approximately 150 yards in length across a fallow papaya field provided access to SOH-1. All road and site work was conducted during daylight hours and was completed within a few days after initiation.
- <u>Noise</u>: Noise levels were restricted to 55 dBA during daylight hours and to 45 dBA at night. Noise restrictions were not violated during the SOH drilling program. Prior to mobilization, the rig was extensively modified to reduce operating noise. Modifications to reduce rig noise continued to be made throughout the program. Rig sounds were normally less than the ambient noise level and usually could not be heard by neighboring residents. However, during certain atmospheric conditions, and especially at night, rig noises could be heard at considerable distances, even though the sound level did not exceed the permit limitations. On a few occasions, drilling voluntarily was

shut down at night when high noise operations such as tripping or cementing were required. This action increased program costs.

- Visual: The rig was sited to be as unobtrusive as possible. Also, by selecting a core drilling rig, the size of the rig and area of impact was reduced to approximately one-tenth of that of a production size rotary drilling rig.
- Emissions: H_2S monitors were located at the wellhead, the end of the mud line, and on the drill floor primarily as safety precautions, and to detect possible emissions. H_2S monitors were also located on and surrounding the drill sites. Emissions were not recorded during the SOH program.
- Groundwater Contamination: Groundwater was protected by the installation of surface casing which was cemented into the hole to a depth of approximately 2,000 feet at all the SOH sites.

A detailed description of the environmental concerns and permitting conditions is given in Olson and Deymonaz (1992).

FUNDING

Funds for the SOH program were supplied by the State in several increments. Additional funds were provided by the Electric Power Research Institute (EPRI) to evaluate the feasibility of utilizing slim hole technology in geothermal reservoir analysis, and by the Bonneville Power Administration (BPA) to devise a generic optioning methodology applicable to BPA's service area in the Pacific northwest utilizing slim holes that would encourage private industry to develop and hold geothermal resources in anticipation of BPA's future energy requirements.

A listing of the funding sources and amounts is given in Table 1 below.

Table 1.
SOH Funding Sources

State of Hawaii		
1985	$ 250,000	
1988	$3,000,000	
1989	$2,601,000	
Private Sector		
1989	$ 400,000	EPRI/HNEI - Slim Hole Reservoir Analysis
1989	$ 148,320	BPA/HNEI - Slim Hole Optioning of Geothermal Resources
Total	$6,399,320	

In addition to the monies spent on the SOH program, PGV and TMPGV, each fulfilled commitments to provide drilling data to the appropriate State agencies, and to cooperate with the State and the University in their geothermal assessment of the KERZ. This data was deemed by the State to have a value of approximately four million dollars.

DRILLING ACCOMPLISHMENTS AND RESULTS

One of the requirements for a geothermal reservoir is a large zone of interconnected permeable fractures, such as would occur at the intersection of two or more fracture zones. Prior to the initiation of the SOH program, permeability was assumed to exist along the axis of the KERZ, because of the parallel fracturing and diking along the rift. The existence of cross-rift permeability was essentially unknown and untested, but was thought to be restricted to areas of cross fracturing or related to structures, such as subsurface plugs or buried volcanic necks, which could cause local fracturing across the rifts.

To efficiently assess the KERZ, the SOH drill array was laid out in a fence along the KERZ. Two of the SOHs were "step-outs" located away from any previous drilling to assess untested segments of the rift. The other two SOHs were "paired" with existing or planned production wells to test cross rift permeability conditions. The SOH program was designed to be practical, rather than academic, and focused on drilling as many holes and collecting as much footage of continuous rock core as possible within the provided budget. Rock core and direct measurements of rock temperatures and characteristics, represents "ground truth," upon which generalized rock characteristics and conditions can be extrapolated throughout the rift zone with some degree of confidence. In addition, injection tests were conducted to assess reservoir potential after the SOH had been drilled by calculating possible flow from a similar production sized well at the same site using the measured downhole temperature and the pressure required to pump a known volume of water down the slim hole during injection. The location of the SOHs within the GRSs are shown on Figure 3.

Three SOHs were successfully drilled to depths ranging between 5,526 feet and 6,802 feet. Drilling results and important data collected from nearly three miles of continuous core from three SOHs, are available and are being utilized by the scientific community for basic and applied research, by the

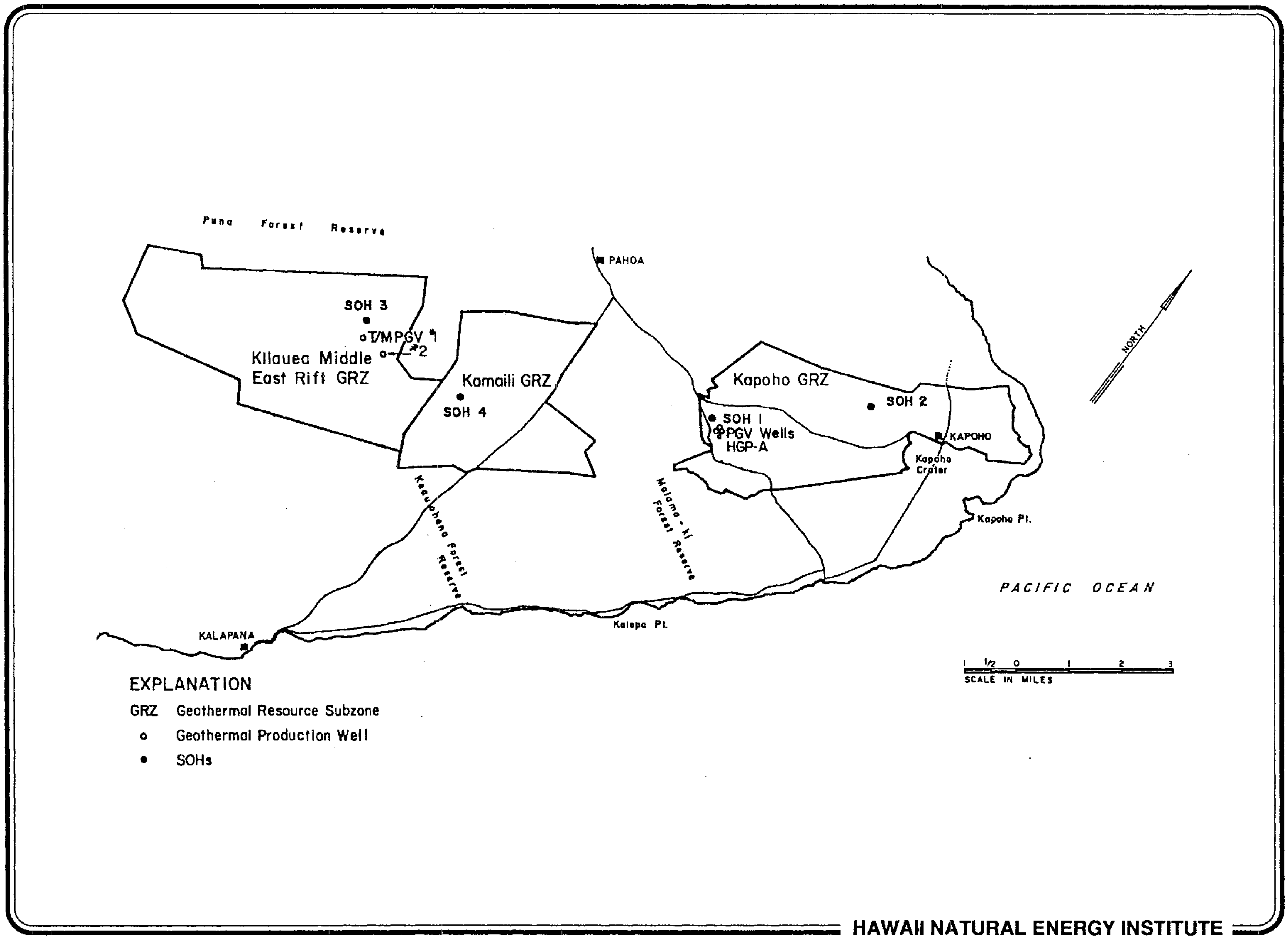

Figure 3. Location of SOH Drill Sites and the Puna GRSs

active developers in understanding subsurface geologic conditions, in siting and drilling of geothermal production wells, and in reservoir analysis. The data have been vital to State agencies for resource management and regulatory purposes. Moreover, the continuous core, resulting from 18,900 feet of drilling, represents a unique national resource as this work has produced the first continuous core from deep holes in basaltic volcanoes over an oceanic hot spot.

The SOH program was highly successful. The program met the University of Hawaii's stated mission of providing scientific information and technology transfer to the private sector for utilization and commercialization. Technology transfer has been accomplished by the publication of at least 12 papers, the writing of 16 unpublished reports, and the presentation of 18 talks at major industry and academic meetings, conferences, symposia, and workshops.

After completion of three holes:

- o effective techniques were developed to drill slim rotary and core holes to depths in excess of 6,800 feet,
- o thermal continuity was established at depth along the KERZ,
- o the northern boundary of the HGP-A/PGV reservoir was defined, effectively doubling the "proven" reservoir size and providing PGV's lending institution with justification to extend the project financing, and
- o a potential geothermal reservoir was discovered in a previously untested area.

Although all the necessary permits were approved for the fourth hole, SOH-3 was not drilled due to insufficient funds remaining in the program budget.

Drilling problems were anticipated with the possible high temperatures that were expected to be encountered, and much thought was given to designing a mud program capable of operating in these austere conditions. The initial mud program proved satisfactory, and only minor adjustments with a minimum of experimentation were required to design successful drilling techniques, casing procedures, and drilling fluid mixtures as the program progressed and the characteristics of the rock section became known. At relatively shallow drilling depths, above 2,000 feet and at temperatures usually below 212^{O}F, thin mixtures of bentonite and polymer with thicker mixtures of mud and loss circulation material (LCM) and/or cement in loss circulation zones, provided satisfactory drilling results. At temperatures above 270^{O}F a complex stearate was added to the drilling fluids to maintain lubricity. Above 330^{O}F a mixture of soda ash, high temperature polymer, complex stearate, and sepiolite virtually eliminated high torque and vibration problems frequently associated with high temperature drilling. This mixture produced satisfactory results in temperatures as high as 662^{O}F.

Even though the fractures within the KERZ which parallel the trend of the rift were thought to be vertical or steeply dipping, the SOHs were planned to be drilled vertically until drilling conditions were known and drilling techniques established in order to avoid drilling problems and to limit drilling costs. Information learned during the SOH program about drilling conditions in the KERZ, indicates that future SOHs should be drilled at an angle to cross-cut the trend of the rift fractures and to provide additional geologic information.

The SOHs were originally planned to be drilled in numerical order, i.e. SOH-1, SOH-2, SOH-3, SOH-4. SOH-1 was thought to have the greatest chance of intersecting high temperatures and a viable reservoir due to the proximity of SOH-1 to the successful HGP-A and KS wells on the PGV property. The SOH-1 site also was selected because subsurface geological conditions were thought to be known and the site had the greatest ease of access. SOH-2 was selected to be second, due to its proximity to the Kapoho eruption site in the early 1960s and the site's ease of access. SOH-3 was selected to be third, because it was expected that the first TMPGV well would have been drilled by then, and that SOH-3 would provide cross-rift geologic and permeability information to the north of the first TMPGV well and along the northern portion of the KERZ. SOH-4 was selected to be drilled last, to establish geologic, temperature, and permeability conditions along the KERZ between the TMPGV and the PGV/HGP-A wells.

However, as a result of the permitting and mediation process, the order of drilling was changed so that SOH-4 was required to be drilled first, followed by SOH-1, SOH-2, and SOH-3. The SOH-4 site was surrounded by trees and out of sight of the nearest neighbors who were more than 0.5 miles distant from the site, and the experience gained in sound suppression during the drilling of SOH-4 was subsequently applied to SOH-1, which was located in an open field. SOH-1 turned out to be the most time consuming, costly, and difficult to drill of the SOHs, and would have incurred more drilling costs, and perhaps would have had to have been abandoned, without the experience gained from drilling SOH-4.

SOH-4:

The first hole drilled, SOH-4, was drilled to a total depth of 6,562 feet, and recorded a bottom hole temperature of 583^{o}F. Although evidence of fossil geothermal reservoir conditions was found, no zones with obvious reservoir permeability were encountered. No problems were encountered in core drilling the upper section of subaerial basalt flows and dikes. However, severe rotary drilling problems with loss circulation and reaming were encountered in the upper 2,000 feet of the hole, resulting in large drilling cost overruns.

The initial drilling and casing plan called for opening the core hole to 17-1/2 inches in diameter to a depth of 100 feet and cementing 13-3/8 inch casing to the bottom of the hole. Because the drill rig was not thought to have sufficient torque to open the hole to full width in one pass, this was accomplished at first by opening the hole by drilling with an 8-1/2 inch bit and then opening the hole in successive passes with 12-1/2 and 17-1/2 inch bits. Each time circulation was lost, drilling stopped and circulation was regained with high viscosity mud and LCM. Subsequently, casing was set without trouble after straightening a dog-leg with a bottom hole assembly utilizing a 17-1/2 inch reamer.

The hole was then cored to a depth of 1,007 feet. This interval encountered multiple loss circulation zones which were plugged by high viscosity mud and LCM, or LCM and cement. Upon opening the hole to 12-1/4 inches, circulation was usually lost at the same intervals as encountered with the 8-1/2 inch bit, resulting in much lost time cementing and waiting for the cement to set. It was soon discovered that the rig had sufficient torque to open the hole to 12-1/2 inches in one pass, and that the hole would stay open after losing circulation for an additional 150 to 300 feet if drilling proceeded slowly ahead and the hole was conditioned carefully. Subsequently the hole was opened to 12-1/2 inches, and 9/-5/8 inch casing set and cemented in this manner. The hole was then cored to a depth of 2,000 feet and opened to 8-1/2 inches by slowly and carefully drilling blind for intervals of 150 to 300 feet through lost circulation zones instead of cementing whenever circulation was lost, and by using thin cement mixtures to regain circulation. A 7 inch surface casing was then set and cemented, and core drilling proceeded with only minor problems to the bottom of the hole in a gradually warming section of subaerial basalts and a heated section of submarine basalts. Figure 4 shows the drilling and casing plan used in drilling SOH-4.

At a depth of approximately 4,000 feet, State officials approved the deepening of the hole to a depth of approximately 6,500 feet because temperatures of 400^{O}F or higher had not been recorded during drilling. Based on this evidence, the other scheduled SOHs were targeted to depths of approximately 6,000 to 6,500 feet. SOH-4 was completed in 151 days at a total direct drilling cost of $1,466,848, or $223.54 per foot. As a result of the over engineered casing plan, approximately $250,000 in additional costs were incurred. The upper 2,000 feet of SOH-4 cost approximately $794,000 to drill, and the lower 4,562 feet, cost $672,848 to drill, complete, and log. Table 2 gives a summary of the SOH drilling activity costs, and Figure 5 gives a graphical presentation of the drilling activity cost breakdown. The summary drilling report and well history for SOH-4 is found in Appendix III.

As a rule, core drilling costs, usually expressed as footage charges, tend to increase with depth, even if hole size is reduced. Smaller diameter holes usually result in lower bit costs, but this is offset by higher footage charges due to increased trip time for core recovery and bit changes, and for other problems, such as increased risk of twist-offs associated with depth. Drilling performance is shown graphically for depth versus cost for all the SOHs in Figure 6, and for depth versus time for all the SOHs in Figure 7. The temperature gradient of SOH-4 and the other SOHs are shown in Figure 8.

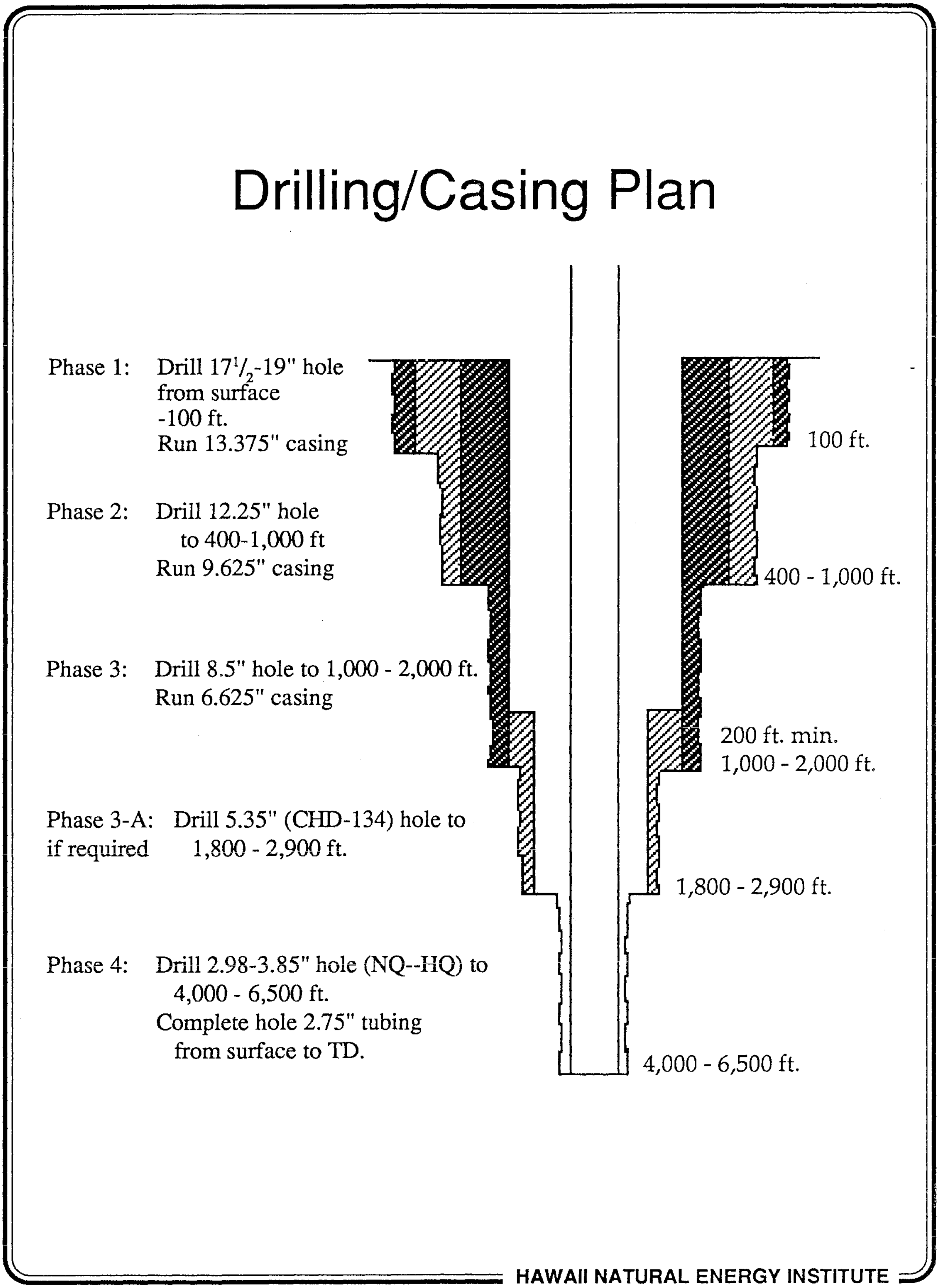

Figure 4. Initial SOH Drilling and Casing Plan

SOH Drilling Activity Cost Summary

SOH-4 Activity

Site construction, MOB & Setup		42,297
Core 101mm (0-112 ft) in Type II		13,703
Open hole to 17-1/2" (0-112 ft)		53,847
Casing (13-3/8" 0-112 ft) cmt/rig BOPE		31,886
Core 101mm (112-1,008 ft) in Type II		65,930
Open hole to 12-1/4" (112-992 ft)		283,609
Casing (9-5/8" 0-992 ft) cmt/rig BOPE		53,617
Core 101mm (1,008-2,000 ft) in Type II		89,452
Open hole to 8-1/2" (992-2,000 ft)		78,311
Casing (7" 0-2,000 ft) cmt/rig BOPE		82,249
Core HQ (2,000-5,290 ft) in Type II		326,956
Core NQ (5,290-6,562 ft) in Type II		205,311
Completion & testing		139,680
Total	$1,466,848	$223.54/ft

SOH-1 Activity

Site construction, MOB & Setup		42,916
Core, open to 12-1/4" (0-202 ft)		35,129
Casing (9-5/8" 0-202 ft) cmt/rig BOPE		31,843
Delay, County of Hawaii permits		29,061
Core 101mm (202-1,995 ft) in Type II		136,457
Open hole to 8-1/2" (0-1,996 ft)		175,593
Casing (7" 0-1,996 ft) cmt & rig BOPE		93,149
Core 101mm (1,996-2,671 ft) in Type II		84,463
Fish, ream over stuck drl rods & open hole to 5-5/8" (1,996-2,671 ft)		201,709
Core 134mm (2,671-3,022 ft) in Type I		73,047
Casing (4-1/2" 0-3,022 ft) & spot cmt		23,026
Core HQ (3,022-4,325 ft) in Type I		360,154
Core NQ (4,325-4,880 ft) in Type I		165,440
Core NQ (4,880-5,526 ft) in Type II		93,549
Completion & testing		98,008
Total	$1,643,544	$297.42/ft

SOH-2 Activity

SOH-2 Activity		Cost ($)
Site construction, MOB & Setup		66,170
Drl 12-1/4" hole (0-202 ft)		35,192
Casing (9-5/8" 0-202 ft) cmt/rig BOPE		18,548
Drl 8-1/2" hole (202-1,904 ft)		227,442
Casing (7" 0-1,896 ft) cmt/rig BOPE		98,555
Core HQ (1,909-2,044 ft) in Type I Rx		27,997
Rotary 5-7/8" hole (2,044-2,785 ft)		51,062
Core HQ (2,785-2,830 ft) in Type I Rx		18,261
Rotary 5-7/8" hole (2,830-4,103 ft)		89,978
Casing (4-1/2" 0-3,022 ft) uncemented		22,733
Core HQ (4,103-4,988 ft) in Type II Rx		97,760
Core NQ (4,988-6,802 ft) in Type II Rx		243,716
Completion & testing		109,259
Total	$1,106,684	$162.70/ft

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Table 2. SOH Drilling Activity Cost Summary

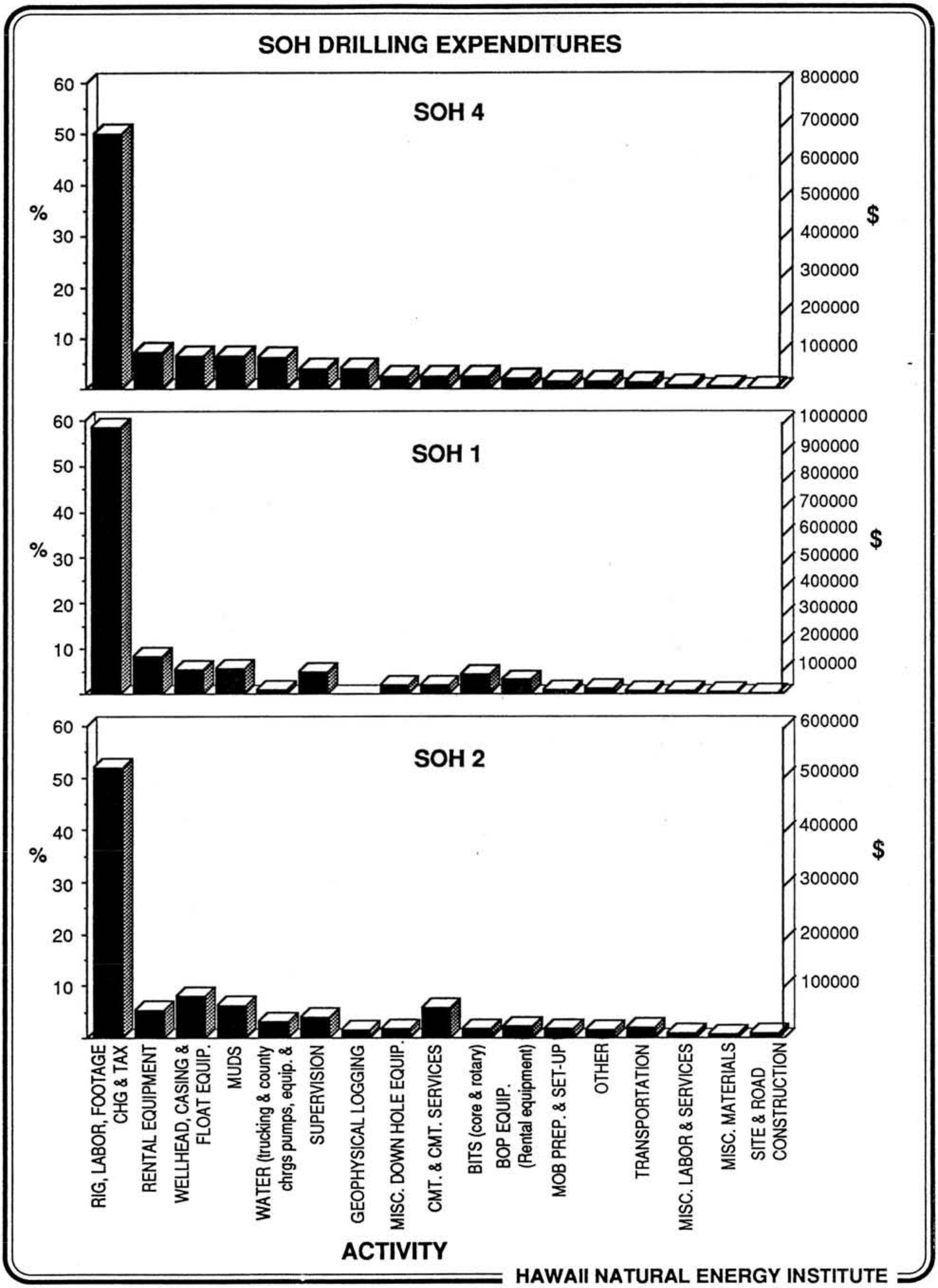


Figure 5. SOH Drilling Activity Cost Breakdown

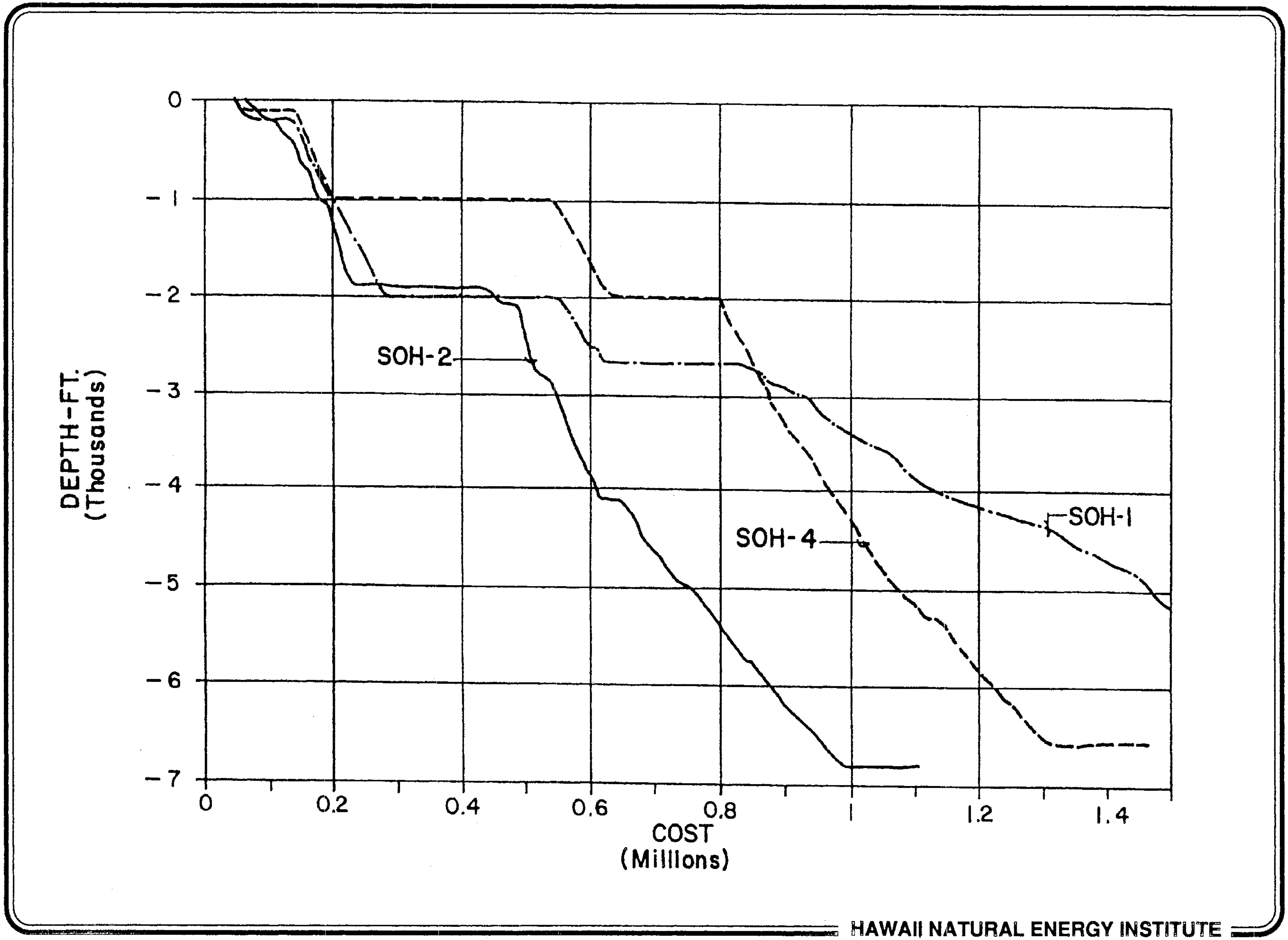


Figure 6. SOH Drilling Performance, Depth versus Cost

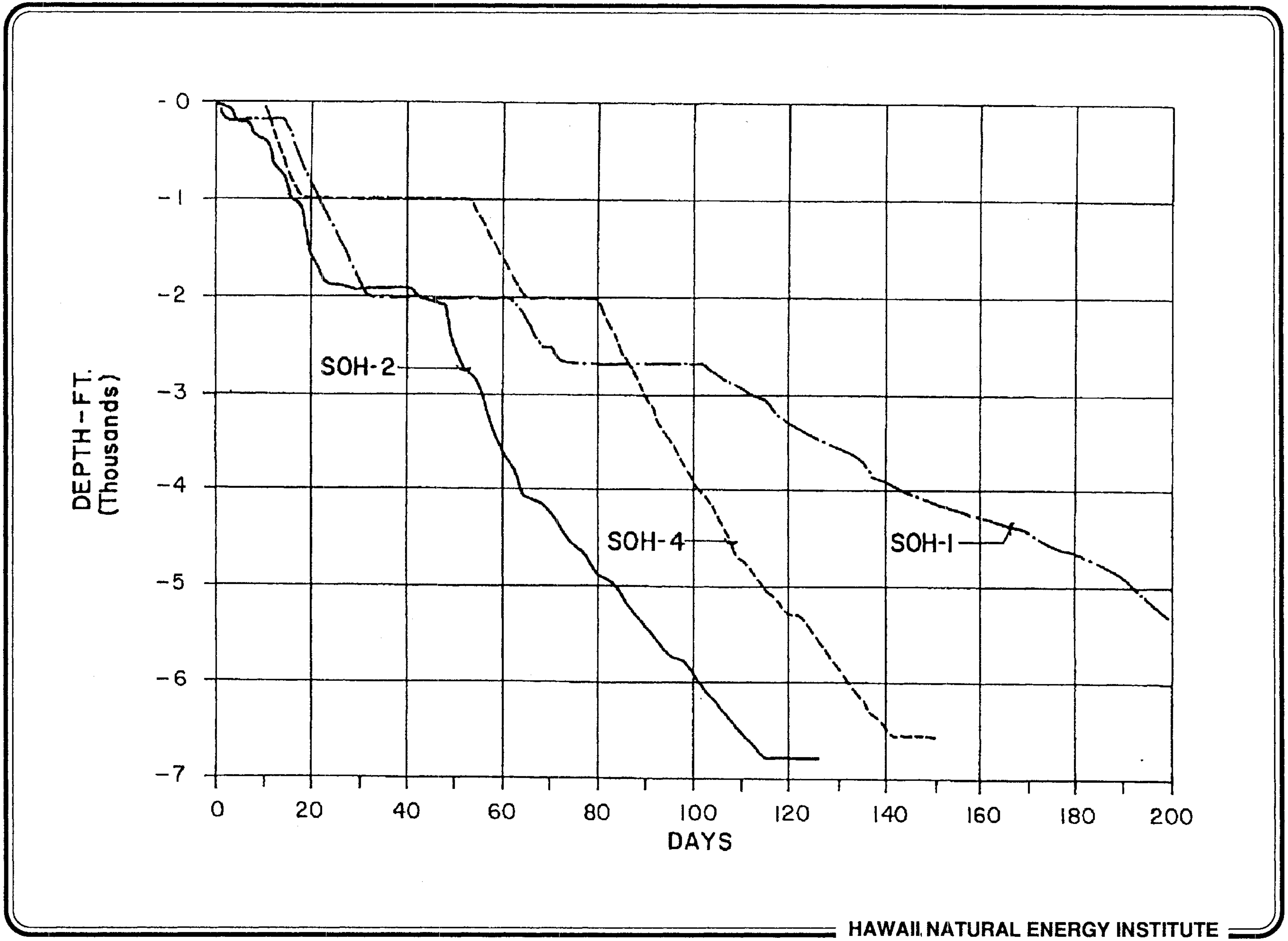


Figure 7. SOH Drilling Performance, Depth versus Time

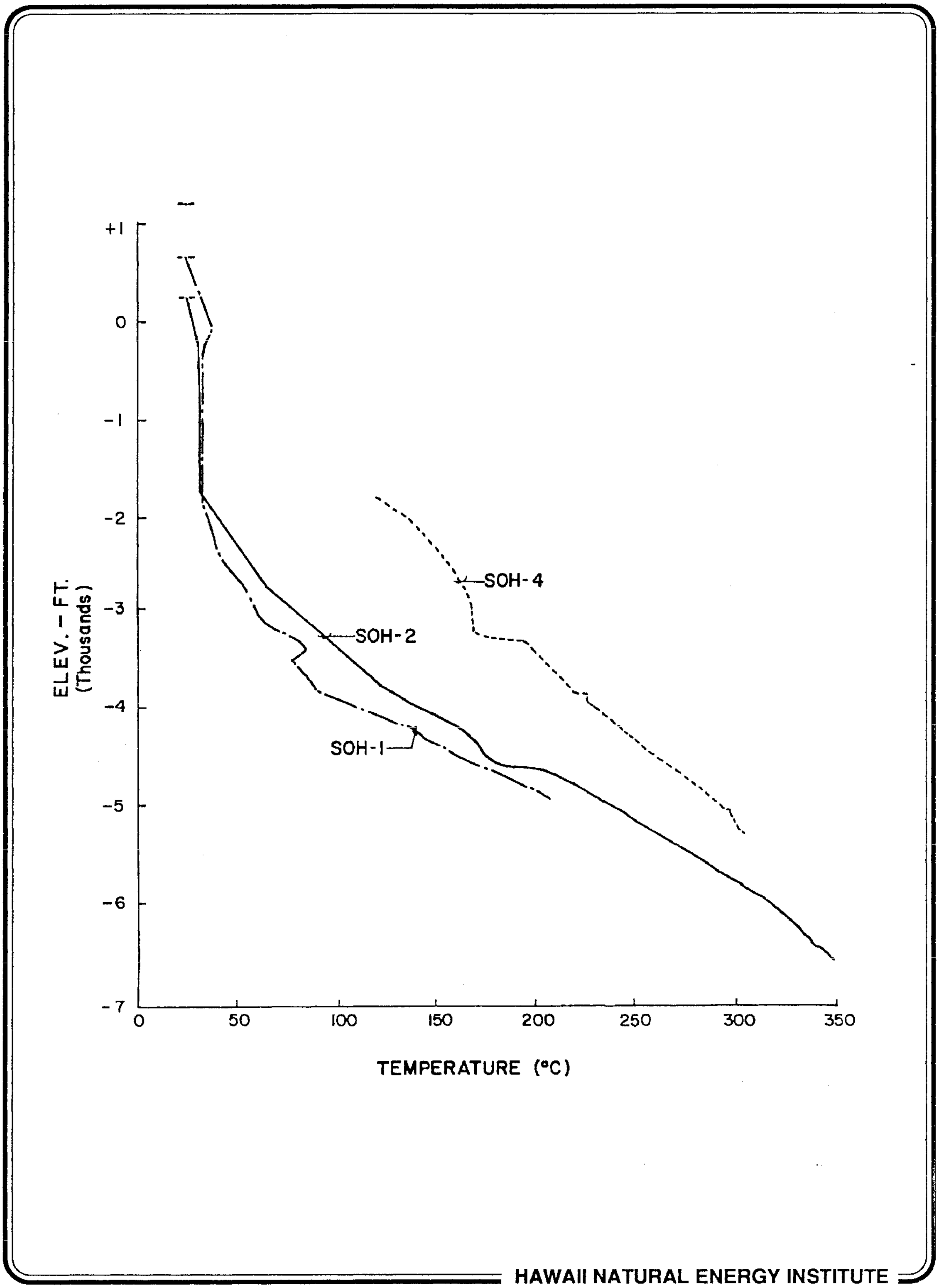


Figure 8. SOH Temperature Gradients

SOH-1:

The second hole, SOH-1, was drilled to a total depth of 5,526 feet in 217 days and recorded a bottom hole temperature of 403^{o}F. The drilling and casing plan for the upper 2,000 feet was modified, utilizing the experience gained in the drilling of SOH-4, by replacing the 13-3/8 inch casing with 9-5/8 inch casing to a depth of 200 feet, and using a single string of 7 inch casing from the surface to a depth of 2,000 feet. Figure 9 shows the revised drilling and casing plan used in drilling SOH-1 and SOH-2. The revised drilling and casing plan resulted in rapid progress with only infrequent and minor drilling problems, and cost savings of approximately $240,000 as compared to SOH-4 at a similar depth. When coring resumed below the casing, however, severe drilling problems were encountered due to highly fractured, cool (<100^{o}F), submarine basalt, sands, and dikes, in the interval between 2,000 and 4,500 feet, resulting in short bit life, short (6 to 18 inch) core runs, stuck drill rods, and massive cost and time overruns. The fractured submarine basalt and dikes broke off in front of the bit, and rolled about the drilling surfaces, wearing the bit face and matrix and gouging out the diamonds. The exterior gauge of the bits was reduced and the interior gauge enlarged resulting in short core runs which were caused by sticking drill rods and rock stuck in the core barrel. This resulted in the need for frequent redrilling of the hole to reach bottom. Bit life averaged between 10 and 20 feet, and required constant tripping of the rods to replace bits. Below 4,500 feet the temperature increased rapidly, resulting in normal drilling runs, core recovery of nearly 100%, and long bit life, due to fracture filling or bonding of the fractures by thermal metamorphism.

The drilling costs for SOH-1 were extremely high at $1,643,544 or 297.42 per foot, which caused the hole to be stopped approximately 975 feet short of its targeted depth. The

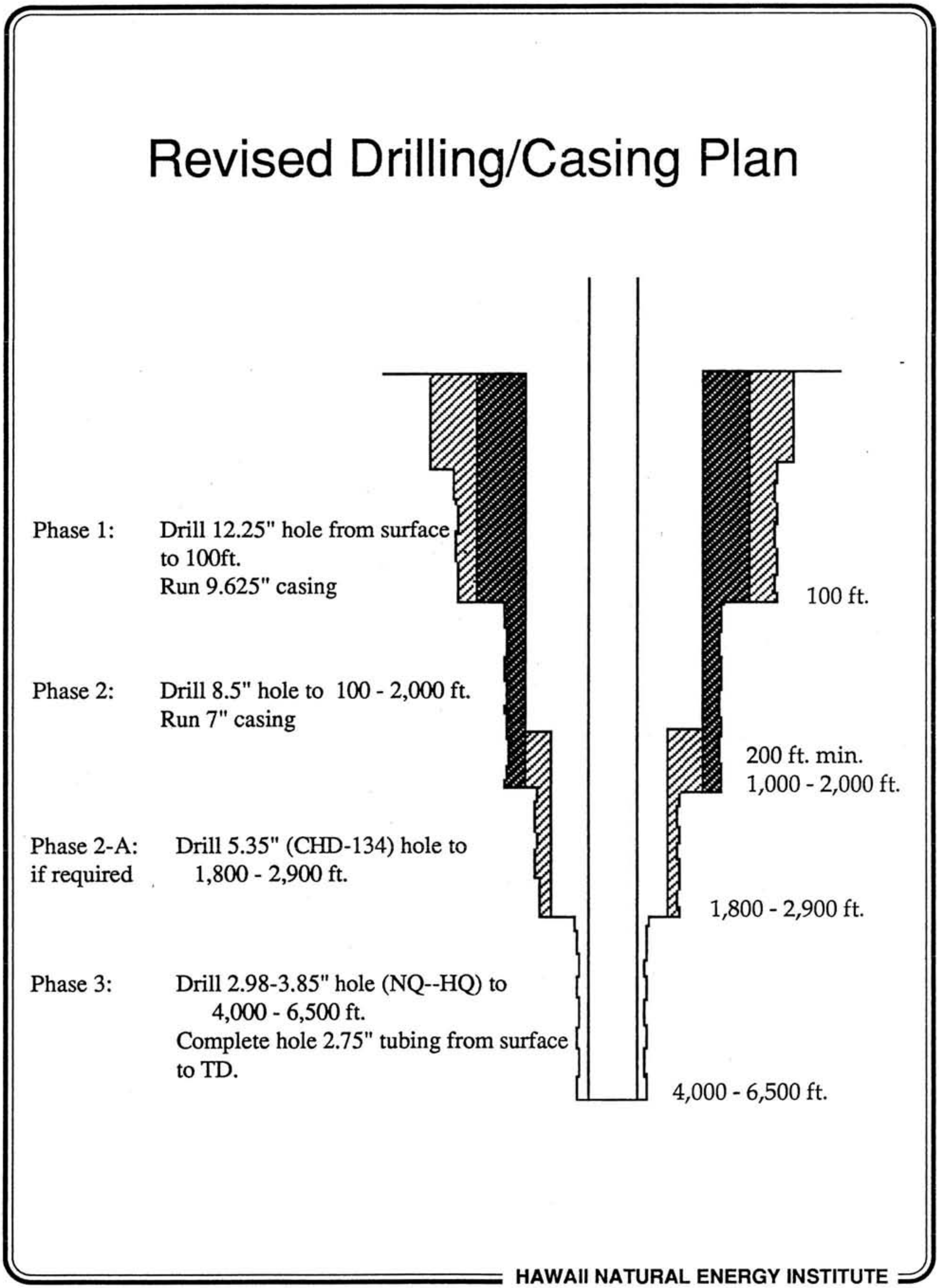


Figure 9. SOH Revised Drilling and Casing Plan

upper 2,000 feet of SOH-1 was completed at a cost of about $537,000. Drilling performance of the upper portion of the hole showed substantial improvement over the results from SOH-4. Core drilling of the lower portion of the hole below the casing, from 2,000 to 5,526 feet, however, encountered very difficult drilling conditions, and required 156 days to complete and log at a cost of $1,106,544. The summary drilling report and well history for SOH-1 are found in Appendix IV.

As shown in Table 3 on the following page, SOH-4 has a 5,554 foot thick section of subaerial volcanic rocks. The subaerial section of SOH-1, however, is only 2,551 feet thick. Drilling the subaerial volcanic rocks in SOH-1 and SOH-4 presented no exceptional problems in core drilling. The submarine volcanic rocks encountered at depth in SOH-4 were hot and sufficiently thermally altered to present no problems in coring. The submarine volcanic, sedimentary, and intrusive rocks in SOH-1, however, were relatively cool and had not undergone extensive thermal alteration. These rocks proved to be extremely difficult to core. The broken and abrasive nature of the formations resulted in a short bit life, poor recovery, and short core runs, which slowed progress to a few feet per day. Bottom hole temperature began increasing below a depth of approximately 4,500 feet and by 4,900 feet conditions for core drilling SOH-1 improved and were similar to those encountered in SOH-4.

SOH-2:

The third hole, SOH-2, was drilled to a total depth of 6,802 feet in 126 days and recorded a bottom hole temperature of 662°F. The drilling plan was again modified to incorporate the lessons learned in the drilling of the first two holes. To reduce drilling cost, the upper 1,900 feet of SOH-2 was rotary drilled without coring. Casing was set approximately 100 feet higher in SOH-2 than in the other two SOHs because of a sudden 4^{o} deviation in the hole over an 27 foot interval between a depth of 1,860 to 1,887 feet, which resulted in several drill collar twist-offs and fishing jobs. After the casing was set, coring encountered difficult, time consuming, and expensive drilling conditions similar to those encountered in SOH-1.

Table 3.
SOH Subaerial/Submarine Basalt Contact Depths
(Feet)

Hole	Surface Elev. of Subaerial Volcanic Rocks	Subaerial Volcanic Thickness	Subaerial/Submarine Volcanic Contact Depth & Temperature (M.S.L.)
SOH-4	1,195	5,554	-4,359/475°F
SOH-1	620	2,551	-1,931/ 95°F
SOH-2	270	1,680	-1,410/ 92°F

At that time a decision was made not to continue coring, and the hole, instead, was rotary drilled to approximately 4,100 feet. As circulation was lost at the surface, only a few scattered rock samples were collected in the upper rotary portion of the hole. However, the problems caused by the sudden hole deviation persisted even after the casing was installed, and drilling continued to be plagued by repeated twist-offs to the bottom of the hole. All the twist-offs occurred inside the casing and required fishing for the broken drill string which was time consuming and costly, but did not result in major delays or loss of the hole. Temperature at a depth of 4,100 feet was

271.9^{O}F which apparently was sufficient to bond the fractured submarine basalts (or the section previously had been subjected to higher temperatures with the same result), and coring proceeded smoothly to the bottom of the hole. Subsequent injection testing identified a permeable interval between 4,883 to 4,940 feet with a temperature of 410^{O}F, which was indicative of a potential geothermal resource. Based on this information, additional drilling in the vicinity of SOH-2 should intersect fracture permeability below a depth of about 6,000 feet with fluid temperatures in excess of 572^{O}F.

Expenditures directly related to drilling activities for SOH-2 totaled $997,000 or about $147 per foot. Logging and completion brought the total cost to $1,106,684 or $162.70 per foot, which represents a savings of greater than $300,000 while drilling 240 feet deeper than SOH-4, and savings of greater than $460,000 while drilling 1,276 feet deeper than SOH-1. The summary drilling report and well history for SOH-2 are found in Appendix V.

SCIENTIFIC FINDINGS AND RESULTS

Core Logging:

Core and rock chips from the SOHs when recovered from the portions of the holes that were rotary drilled, were logged on a scale of one inch equals 10 feet. The logging was accomplished by a team of three geologists including Elizabeth A. Novak, Frank A. Trusdell, and S. Rene Evans, who also managed the handling, processing, and curation of the core. The focus of the logging was directed at identifying the rock mineralogy and petrology, and the various lithologic units and their relationships. Except for establishing the subaerial/submarine sequence and an inconclusive attempt to differentiate the Kilauea - Mauna Loa - Mauna Kea lava sequences, little effort was directed at regional correlations. Descriptions of the rock units and their components were based on hand specimen mineralogy and petrology, and occasional x-ray diffraction identifications. During drilling, the samples were saved and stored in core boxes on shelves in modular shipping containers at the Puna Research Center (PRC). The core currently is being split, and will be stored in sequential order and identified as to hole number and depth. Approximately half is in safe storage in the main building at the PRC and the other half is in core boxes in the containers. The core in the boxes is available for inspection and analysis by qualified scientists.

The volcanic and sedimentary sequence penetrated by the SOHs is dominated by basaltic subaerial lava flows and submarine pillow lavas, with thin tephra units and rare, thin carbonate horizons interbedded between the flows. However, one carbonate sand section in SOH-4 at a depth of 5,718 feet has a thickness of approximately 34 feet, and vividly demonstrates the depth to which a portion of the southeastern section of the KERZ has sunk and/or slumped below sea level. Basalt and diabase intrusive bodies cut through these formations. The dikes intrude the earlier formations at dips between 50 and 80 degrees, and probably divide the rift zone into numerous hydrologic units which are separated by these impermeable dike barriers. The diabase unit was intersected only in SOH-2, and may constitute an important marker horizon if future holes are drilled in the lower KERZ. Sparse to common olivine and plagioclase are the most common phenocrysts in the basalts. The contact between the subaerial and submarine lava is transitional and is marked by hyaloclastite horizons between alternating subaerial and submarine flows. Figure 10 summarizes the gross subaerial/submarine lithologic sections and their relation to the geothermal gradient in the various areas of the KERZ.

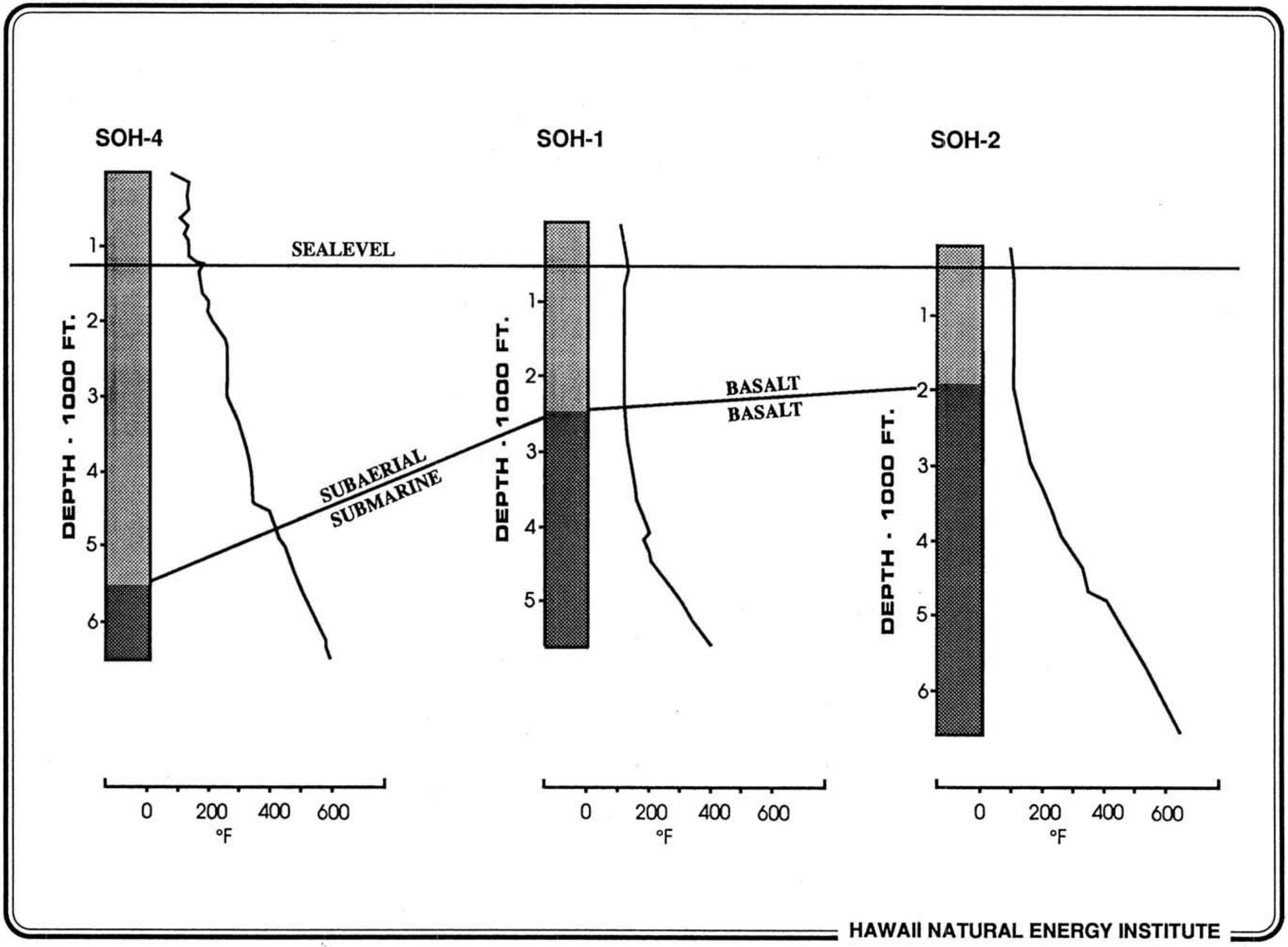


Figure 10. SOH Thermal - Lithologic Sections

Normal geothermal gradients cannot be measured along the upper 2,000 to 4,000 feet due to downward percolating meteoric water in the KERZ, which cools the rocks to these depths. Below these depths the temperature gradient increases rapidly in a relatively straight line reflecting conductive heat flow and a tight, relatively impermeable rock section even though most of this section was drilled without or with only limited drilling fluid returns.

In the higher temperature zone, argillic alteration grades into propylitic alteration with increasing depth. Secondary minerals occur as fracture fillings, amygdules, and replacements after glass and primary groundmass minerals, and mainly include smectite clays, zeolites, analcime, gypsum, anhydrite, calcite, secondary feldspars, sulfides including pyrite and rare pyrrhotite, chalcopyrite, and sphalerite, and a variety of silica minerals including amophorous silica, crystalline quartz, chlorite and epidote. Other noticeable indications of alteration encountered while drilling include a decrease in rock hardness, increasing drill penetration rates, longer bit life, greater core recovery, and a change in rock color from medium gray to a dirty green (Evans, 1992).

The SOH field core logs currently are being revised and presented on a scale of 1 inch equals 10 feet in a computerized graphical format with core descriptions and a log of researchers who have sampled the core (Hulsebosch, Okano, and Trusdell, 1993). The computerized core descriptions and graphical logs are based on the original core logging by Frank Trusdell, Rene Evans, and Elizabeth Novak. Computer files provided by Frank Trusdell were modified from their original format and annotated with the current sampling record. An illustration of the detailed lithologic core log and sampling record is given in Figure 11.

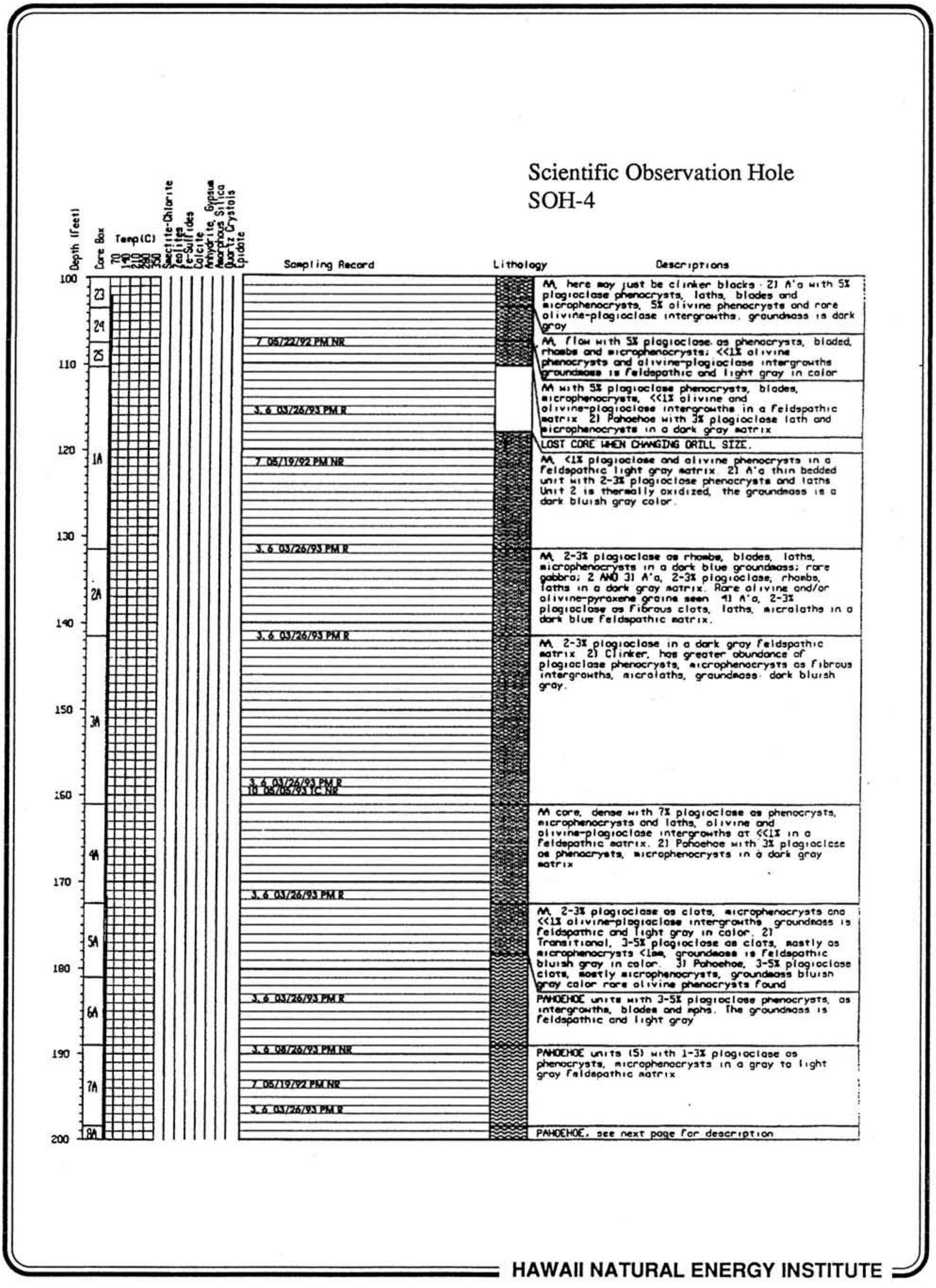


Figure 11. Illustration of the Detailed SOH Lithologic Core Log and Sample Record

Core Sampling Policy:

SOH core samples are available to individual investigators to provide material with which to conduct detailed studies, and to provide educators samples for teaching purposes. Researchers wishing to visit the SOH core facility to view or sample the SOH core are requested to submit a written request at least one week in advance of the desired sampling date, specifying their name, affiliation, address, purpose of sampling, and a description of the proposed analyses.

Funding for sample-related activities must be obtained by the investigator independently, as no funds will be available from the core facility. A SOH Research Technician at the PRC will be responsible for administrating all core archival and sampling activities, and will maintain a record of all samples taken for inspection and analysis. The SOH Research Technician will instruct the researchers as to sampling policy and procedures and may assist with core sampling. All samples that are not destroyed during analysis should be returned to the PRC along with reprints of any published papers or reports resulting from the investigation of SOH core for the PRC on-site library.

Sampling requests should be sent to:

Dr. Thomas Hulsebosch
Dept. of Geology & Geophysics
2525 Correa Road
Honolulu, Hawaii 96822
(808) 956-6193 Phone
(808) 956-2538 Fax

-or-

Research Technician
Puna Research Center
P.O. Box 1488
Pahoa, Hawaii 96778
(808) 965-9699 Phone
(808) 965-9274 Fax

EPRI Project:

The Electric Power Research Institute (EPRI) funded a research program entitled, "Geothermal Reservoir Assessment Based on Slim Hole Technology" with the Hawaii Natural Energy Institute of the University of Hawaii to test the feasibility of using slim holes to evaluate geothermal resources, and to determine if useful reservoir data could be obtained by injection testing of slim holes which otherwise could not be flow tested. GeothermEx, Inc. was chosen to conduct the study because of their recognized expertise in geothermal reservoir analysis, probability studies, and economic modeling and forecasting. The following project description is excerpted from GeothermEx (1992, Vols 1 & 2).

> The methodology used by GeothermEx included the compilation of downhole data of the slim holes and other existing geothermal wells, construction of subsurface maps and cross sections displaying geological and reservoir characteristics, analysis of well test data to determine well and reservoir response characteristics, and chemical analysis of fluid samples with compilation and graphical display of the analytical data.
>
> The initial phase of data reduction and analysis led to the estimation of the primary resource parameters, such as reservoir area, thickness, depth, temperature, and flow capacity; temperature and pressure distribution; fluid chemistry; and rock density, porosity, and specific heat. An important feature of this resource classification is that reservoir volume is defined on the basis of commercially extractable heat that does not require that commercially productive wells be drillable at all locations. The degree

to which heat may be extracted is taken into account in the reserve assessment process by a recovery factor estimated on the basis of a number of the primary resource parameters.

These parameters are treated as quantities that vary in three dimensions or as average quantities over the reservoir volume. Data derived from slim holes are inevitably imperfect and associated with uncertainty, the level of which is dependent on the quantity and quality of the slim hole data and inhomogeneities of the reservoir. The uncertainty of any particular resource parameter is treated as a probability distribution that can be modeled as one of a number of standard functions, with a specific mean, standard deviation, and other statistical properties. Other data, such as the known geological conditions of the resource area, statistical information from previously developed geothermal fields, and theoretical limitations on reservoir temperature and pressure, rock density and specific heat, and limits on well performance based on the laws of fluid dynamics are used in the analysis.

The final stage in the assessment methodology is the estimation of field wide reserves of recoverable energy, and forecasts of field performance under one or more development and operating scenarios. Energy reserves are estimated by a methodology that yields a probability distribution of recoverable reserves and related parameters. Using this technique, it is possible to estimate overall reserves of recoverable energy, the field capacity, and field lifetime at a variety of confidence levels, which constituted the most important resource data used in subsequent stages of economic feasibility assessment.

Three SOHs are insufficient to fully characterize a resource as extensive as the KERZ, and results of the injection testing are inconclusive because the SOHs did not intersect any obvious reservoirs. Because of the general lack of data, GeothermEx considered several other important aspects of the program such as the extent to which the available data are adequate for resource assessment, the quality of the data collected during drilling and testing of the slim holes, and the potential integration of information from existing production sized, deep geothermal wells in the KERZ, besides the results of the slim hole program in the assessment methodology.

Conclusions of the GeothermEx report on the reservoir assessment of the KERZ include:

- Existing downhole surveys in the SOHs are adequate to characterize the stable temperature profiles of the slim holes. All the holes exhibit a similar profile: a cold, isothermal zone extends to a depth of several thousand feet, below which temperatures increase linearly, reaching $400^{o}F$ to $660^{o}F$ below elevations of -4,000 feet msl.

- Temperature data from the slim holes, in combination with data from other deep wells in the lower KERZ, are sufficient to develop a model of subsurface temperature distribution along a portion of the rift zone. The model shows higher temperatures occurring along the rift axis, decreasing rapidly with distance away from the axis to the northwest and southeast. A high temperature zone a mile or more in width may be present at drillable depths along the rift.

- Evidence from downhole surveys indicates that permeability in the deep subsurface near the rift axis is restricted to localized zones of tectonic or volcanic fracturing. Analysis of injection testing suggests that reservoir permeability is typically low, yielding well flow capacities in the range of 1,000 to 6,000 md·ft.

- Probability distributions have been estimated for reservoir area, thickness, volume, depth, average temperature, rock matrix density, rock porosity, rock heat capacity, and the energy recovery factor which can be characterized by the available slim hole data.

- Probability distributions based on data from the slim holes, and on the slim holes plus data available from other lower-KERZ wells were calculated. Both estimated distributions are asymmetric, due to uncertainty as to the maximum possible size of the reservoir; and the addition of more well data increases the overall estimate of the reservoir area. This means that the geothermal resource of the lower KERZ is still far from completely defined by drilling.

- Calculations based on the slim holes indicate a recoverable energy reserve whose probability distribution has a mean of 173 megawatts, with a mode or most likely value of about 100 megawatts, and a standard deviation of 116 megawatts, assuming a power plant of typical efficiency with a 25 year lifetime and an average capacity factor of 90%.

- Calculations based on all wells in the area indicate a recoverable energy reserve whose probability distribution has a mean of 288 megawatts, a mode or most likely value of about 180 megawatts, and a standard deviation of 177 megawatts.

- The application of the methodology to the data from the KERZ slim hole program indicates that even limited slim hole drilling can be useful in making a preliminary estimate of commercial reserves, defining requirements for and benefits of additional drilling, and characterizing the degree of resource risk that exists when planning commercial development. The resource assessment process itself is useful in assessing the relative benefits of different drilling methods, well designs and well locations, and therefore may assist in planning further drilling.

Results of the SOH injection tests and the geothermal reservoir assessment are given in unpublished University of Hawaii, EPRI reports by GeothermEx (1990, 1991, and 1992).

<u>BPA Project</u>:

The Bonneville Power Administration (BPA) funded a research program entitled "Optioning Geothermal Resources Utilizing Slim Hole Technology" with the Hawaii Natural Energy Institute (HNEI) to provide BPA with a generic method which would provide a viable means for developers to identify, prove and hold geothermal resources in reserve in anticipation of BPA's future demand for geothermal electricity in its service area. GeothermEx was chosen to conduct the study because of their familiarity with the geothermal industry and because of their recognized expertise in geothermal project financing. Results of the optioning research are given in an unpublished University of Hawaii, BPA report by GeothermEx (1990).

<u>Monitoring and Testing Project</u>:

After the drilling phase of the SOH program was completed, continuous monitoring of the SOHs and the HGP-A well commenced to record any possible communication between producing wells at the PGV development in a form that would permit reservoir analysis, and to record long term changes in the hydrology of the KERZ that could be related either to geothermal development or natural causes. This is but one of the benefits of the SOH program, and a step to develop essential baseline data regarding the KERZ that will allow the State to manage and regulate the geothermal resource on the basis of fact rather than upon conjecture and speculation.

Pressure data for the Monitoring and Testing program are collected by the Pruett Mini Max/Blue Max capillary tubing monitoring system that is installed in the SOHs and the HGP-A well. The data is stored on computer disks, and graphs of the data are inspected on a monthly basis to note any variations that could be attributed to pressure interference at the SOHs and the HGP-A well by PGV's production. The graphs also are sent to GeothermEx on a monthly basis for further reservoir analysis.

This pressure monitoring system has the capability to measure and record pressure build-ups and drawdowns, injection and fracture information, and flowing step rate and interference data, at temperatures in excess of 700°F. The system has all the advantages and benefits of data recorded and stored at the surface in real time at selectable intervals with no electronics in the hole and calibration at the surface.

To provide a period of baseline data collection prior to the commencement of PGV's production, the instruments and monitoring systems were installed in March 1992, and data collected prior to the testing and production at PGV's KS-9 well on April 20, 1993. During baseline data collection, only diurnal tidal pressure fluctuations were recorded with no significant pressure increases or decreases which could indicate magma intrusion into the KERZ or fracture related changes in the groundwater hydrological system. Magma intrusion into the KERZ in the vicinity of the SOHs could cause a corresponding rise in groundwater temperature and pressure, and changes in the fracture system could cause either pressure increases or decreases depending upon changes in permeability.

During testing and start-up of production at PGV's wells, no indications of interference between the production wells and the monitoring stations at SOH-1 and the HGP-A well were noted. Also, during well shut-downs and start-ups, pressure build-ups or draw-downs were not noted. Due to the complex interactions between reservoir temperature, pressure, and the liquid/steam fraction, early estimates of reservoir producibility have been inconclusive, and reliable estimates of reservoir producibility probably will not be available until the KS wells have been produced for six months to a year. The absence of interference at the monitoring sites, however, is encouraging in that it suggests that the reservoir may be of sufficient size and producibility to sustain the existing power plant and possibly to power additional electrical generation. If interference had been immediately detected, it could have indicated a small reservoir with rapid reservoir pressure decline.

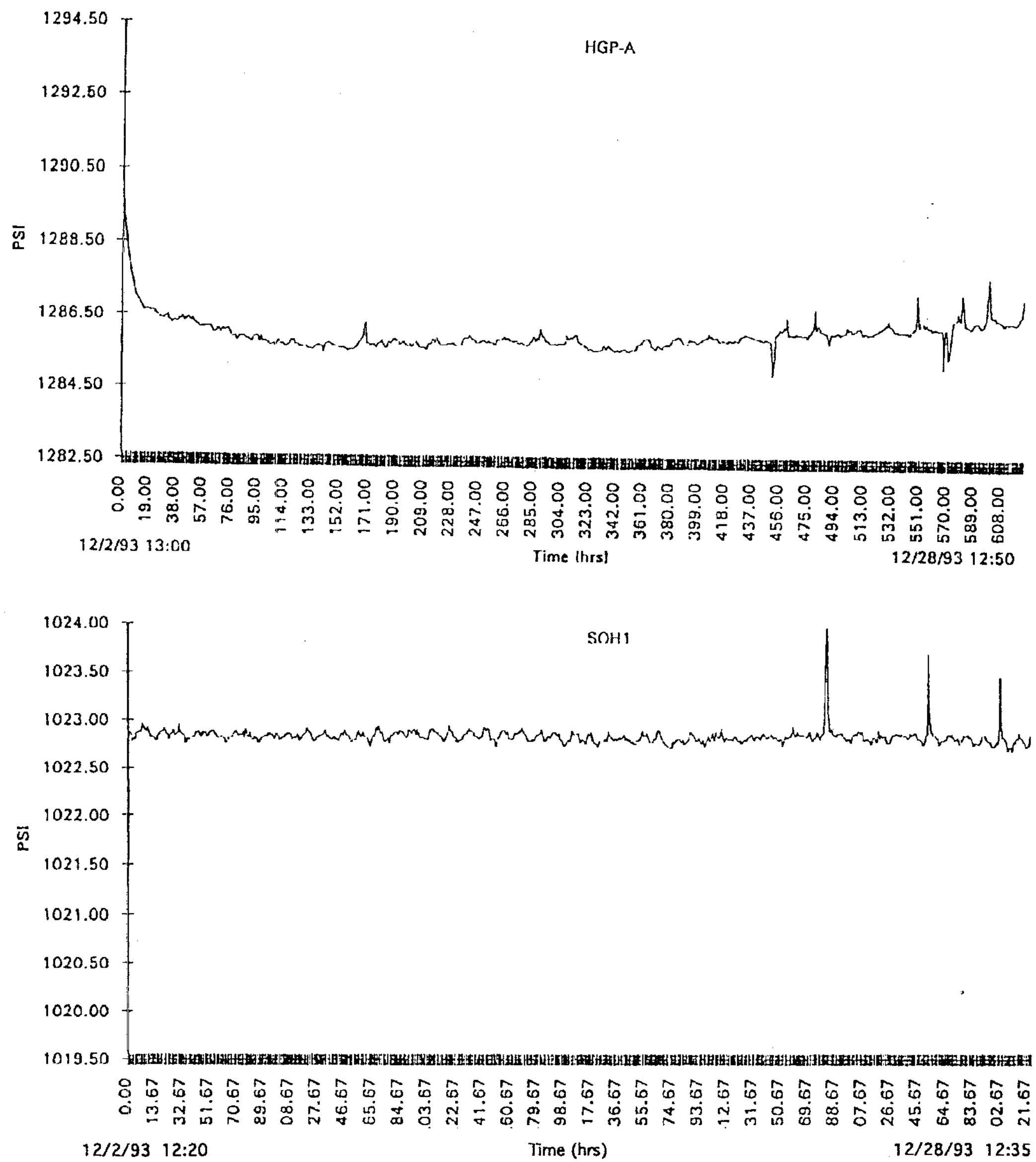
Pressure measurements from the SOHs and the HGP-A well are recorded at hourly intervals in a digital format that can be displayed and printed. These data are automatically converted to a graphical format by the instrument and printed in the field as soon as the data from the wellhead instrument is downloaded into the computer. An example of the SOH graphical pressure printout is given in Figure 12.

Results of the continued monitoring and testing will be reported in the final report of the follow-on Monitoring and Testing project.

CONCLUSIONS

The SOH program advanced the geothermal assessment and characterization of the KERZ which began in the early 1970s. However, more data must be collected and additional drilling completed before an adequate assessment of the geothermal resource potential of the KERZ can be made. Moreover, other potential rift zones on the Big Island and other islands of the Hawaiian Chain remain to be similarly assessed to determine their geothermal resource potential. Many more test holes will be needed before a reasonable estimate of Hawaii's geothermal potential emerges.

In addition to a better understanding of the resource potential, the data collected during the SOH program have been vital to the regulatory function of the various State agencies and have augmented the State's resource management program.



HAWAII NATURAL ENERGY INSTITUTE

Figure 12. Graph Illustration of SOH Pressure Monitoring Data

The three SOHs are widely spaced along the KERZ. Measurements from the SOHs and the HGP-A well, together with those from the commercial wells concentrated in the HGP-A/PGV area, provide a more comprehensive data base of the geothermal resource within the rift zone. This additional baseline information has advanced the understanding of the resource characteristics.

Curation of the core samples collected from the SOHs provides an integrated data base that is available to State and County regulatory agencies and independent investigators for analysis and evaluation. Moreover, the SOH core provides new data on the geology, hydrology, and subsurface temperatures of the KERZ. The chemical and mineralogical analyses of the core give data on concentrations of elements and minerals within the rift. Analysis of the mineral composition permits definition of the temperature and fluid characteristics that have occurred in the geothermal system. This information can provide an understanding of the ability of the resource to sustain high temperatures for extended periods of time and the nature of the salinity and pH of the groundwater fluids. This data is useful to State regulators in identifying and recognizing potential impacts associated with reservoir development and production, and in managing the resource to insure safety and long term viability of the reservoir.

The preliminary scientific and economic conclusions of the SOH program are summarized as follows:

SCIENTIFIC

o A total of 18,890 feet in three holes were drilled by the SOH program with nearly 15,000 feet of core samples collected. This core collection from the KERZ is the first and only continuous core sections through a deep section of oceanic volcanic flows emanating from a mid-oceanic "hot spot" in the earth's mantle. This core currently is available for study and analysis, and represents a truly unique national scientific resource (R. Reynolds, Personal Communication, 1993).

- Although passive seismic monitoring appears to be promising, drilling remains the only exploration technique in which ground truth can be obtained along the KERZ. Surface exploration techniques may be devised or adapted in the future that may reliably target potential subsurface geothermal reservoirs, but none exist at present.

- Small diameter (slim) core holes can be successfully drilled to depths in excess of 6,800 feet in the KERZ, and can be used to assess geothermal resource potential at substantial savings in drilling and permitting costs and with less environmental impact. Drilling results indicate that SOHs in Hawaii can be most efficiently drilled by a combination of rotary and core drilling techniques.

- The geothermal potential of the KERZ has not been proven, and additional production and assessment holes must be completed before an estimate of the size and characteristics of the resource can be made based on fact rather than inferences and probabilities.

- High subsurface temperatures probably are continuous along the KERZ. Except where open fractures extend to or near to the surface, a rain curtain of cool meteoric water will depress subsurface temperatures and thermal gradients to depths of approximately 2,000 feet; and reservoir temperatures, except in locally restricted areas, probably will not occur above a depth of about 4,000 feet.

- Although high temperatures probably are continuous at depth along the KERZ, a single large geothermal reservoir probably does not exist within the KERZ. At present, at least two types of high temperature, geothermal reservoirs are indicated by SOH and PGV drilling:
  - a deep (>6,000 feet), relatively small and discontinuous HGP-A type reservoir with limited permeability, which will support 2 to 3 megawatt, liquid dominated (liquid > steam) production wells, and
  - a shallow (<4,000 feet), fairly large, PGV type reservoir, which will support highly productive (25 megawatts plus or minus), liquid dominated (steam > liquid) production wells.

- Although the HGP-A well produced between 2 and 3 megawatts of electrical power with a plant factor of greater than 90% for over 7-1/2 years, the productivity and life of the reservoir for production rates greater than 2+ megawatts has not been adequately tested or recorded, and the full reservoir potential is not known. Similarly, the PGV reservoir has not been produced for an adequate length of time to determine the drawdown rate at its present productivity level, and its potential can only be inferred. The PGV wells may have intersected, open fractures that tap a large, fairly continuous reservoir at depth, but because of the high compressibility of steam, it may be some time before a reasonable estimate of reservoir size can be made.

- If the SOHs are sampled and flow tested, these holes, alone or in combination with production wells, can discover and define geothermal resources. SOH-2 may have discovered a 400^{o}F plus reservoir in the Kapoho area to the east of the HGP-A/PGV development. SOH-1 data helped to define the northern boundary of the HGP-A/PGV reservoirs. Based on published data from existing wells and SOH-1, reservoir conditions at a depth of 4,100 feet and a cutoff temperature of 392^{o}F defined a narrow, easterly dipping resource approximately 2,600 feet wide that opens to the west as shown in Figure 13. GeothermEx (1991, Sept 1992) using this data as well as Barnwell's Ashida #1 well, SOH-2, and SOH-4, projected subsurface temperatures over a distance of greater than 8 miles, and a "most likely" probability that the KERZ shown on Figure 14, has the potential to support 319 megawatts of electrical generation. The isotherm map shown in Figure 14 does not reflect the shallow reservoir intersected by PGV's KS-7, KS-8, KS-9, and KS-10 wells. Sufficient data currently are not available to predict the vertical size and extent of the HGP-A, PGV, and other possible reservoirs.

ECONOMIC

- The SOH program indicated that deep, small diameter (slim) observation holes for the assessment of geothermal resources can be drilled to depths of 6,000 to 6,500 feet for approximately $900,000 to $975,000 or about $150 per foot with experienced drilling crews as more drilling experience is gained and more efficient drilling techniques are developed. This is a considerable savings compared to the $2,000,000 to $5,000,000 cost to drill an exploratory production sized well. It is possible in the future that

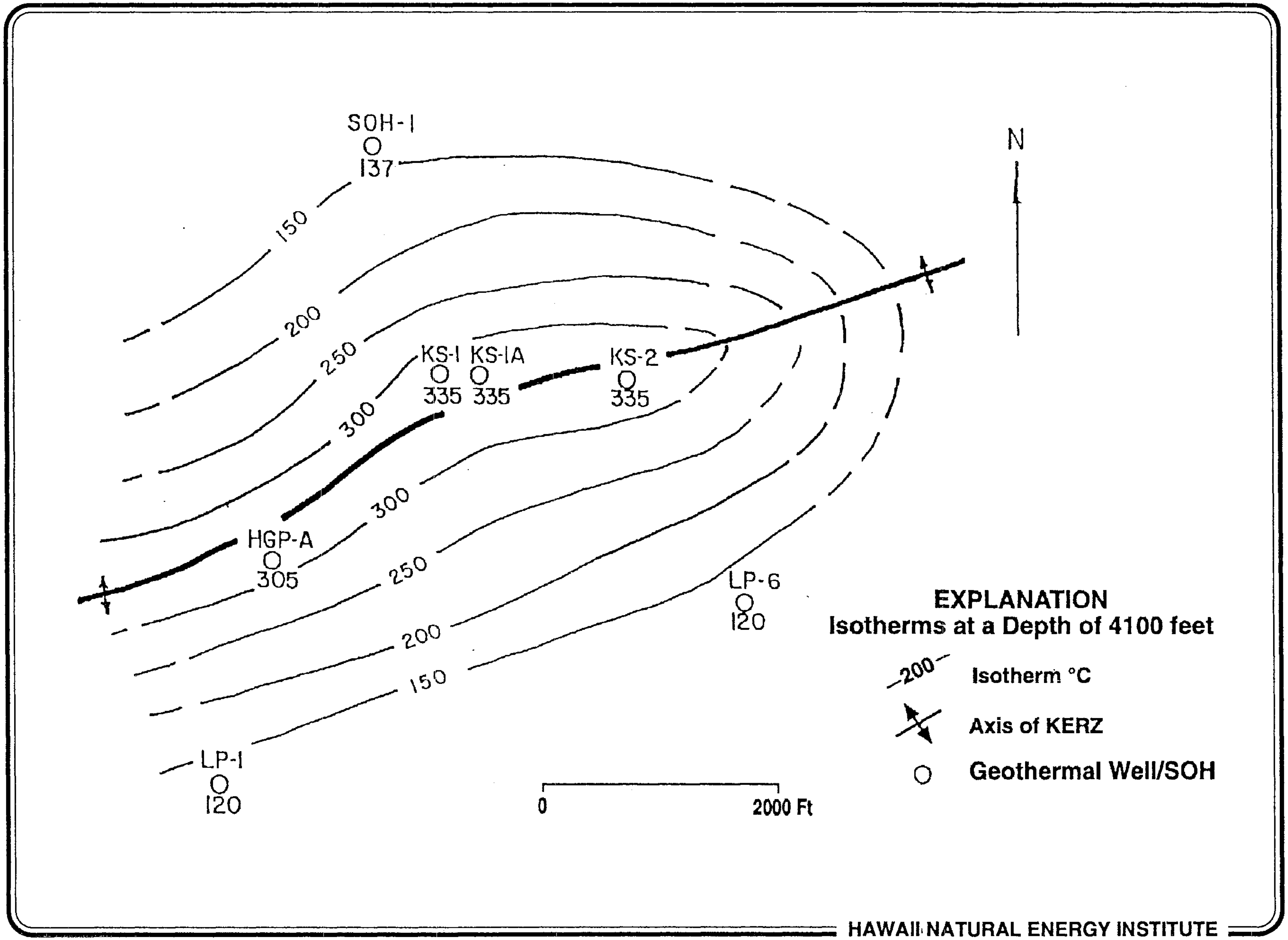
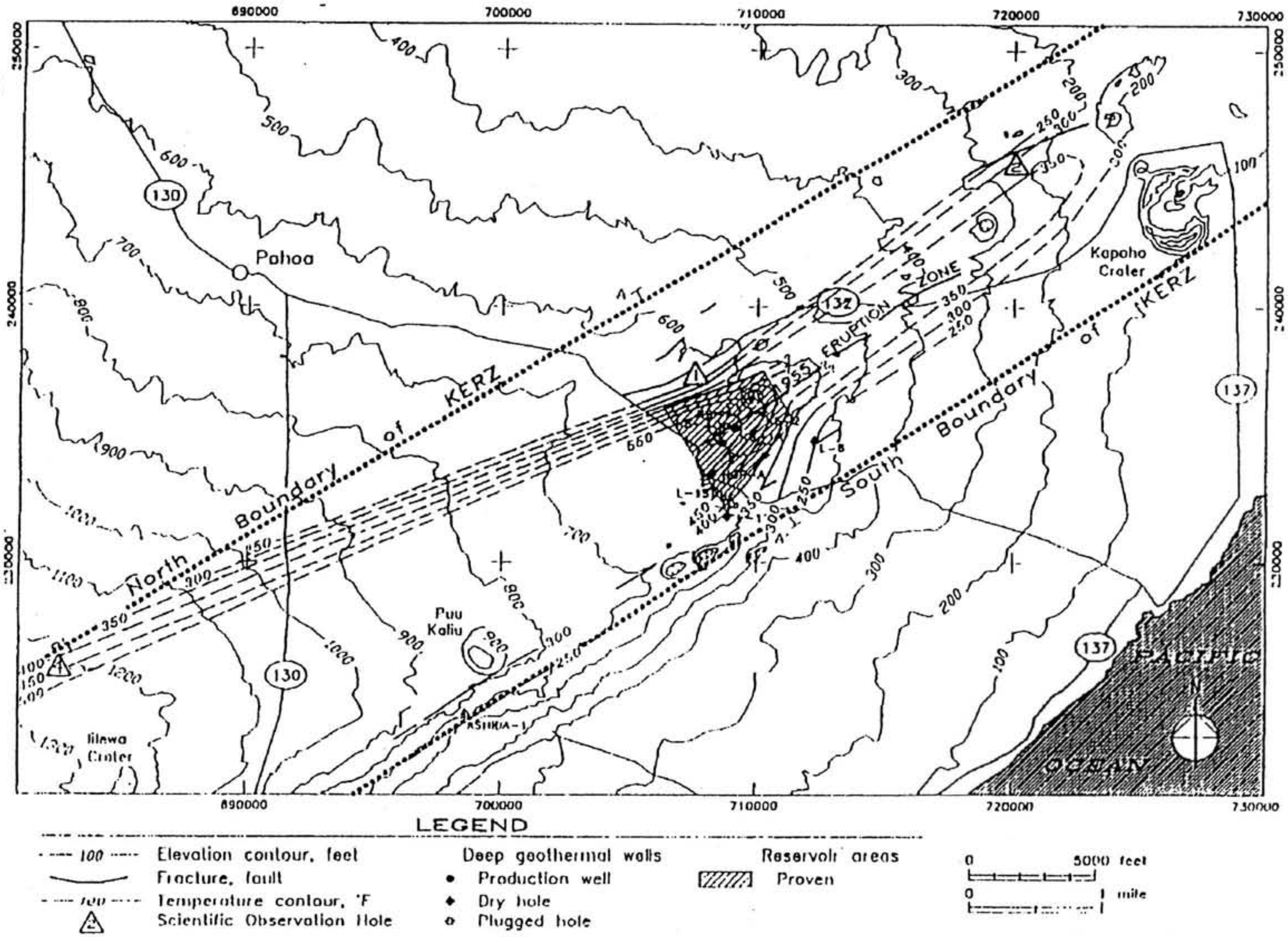


Figure 13. Isothermal Map of HGP-A/PGV Reservoirs at a Depth of 4,100 Feet



After GeothermEx, 1991

Figure 14. Subsurface Temperatures along the KERZ

SOH drilling using a combination of rotary and core drilling techniques with casing programs, which conform to US Bureau of Land Management standards, could be drilled to a depth of 6,000 feet for approximately $100 per foot.

- SOHs can be drilled on sites smaller than 0.5 acre as compared with the 3 to 5 acres normally required for a production sized rotary drill. This can result in considerable savings in site preparation costs. Smaller sites can reduce potential environmental impacts, and limiting the SOHs to monitoring and testing only can represent large potential savings in permitting costs over exploratory production sized wells.

- Analysis of the drilling results indicates that the key to reducing costs involves more than just drilling faster. Over the long run, avoiding drilling problems usually results in faster penetration rates and lower drilling costs. Consequently, after the experience with the twist-offs in SOH-2, it may have been more prudent to core-drill the cool, unmetamorphosed, subaerial basalts, and then to open the hole by rotary drilling. This technique probably would have resulted in a straighter hole and more data, than attempting to reduce costs by not coring and running the risk of twist-offs and possible loss of the hole. Alternatively, more time could have been spent in straightening the doglegged portion of the hole, and reducing or eliminating the risk of twist-offs. However, more drilling experience is needed before a risk/cost- reward analysis can made to address this drilling problem.

- It was not possible to collect uncontaminated groundwater or reservoir fluids in the SOHs in a timely, cost effective manner by bailing. To obtain reliable fluid samples in a timely, cost effective manner, the holes must either be pumped or caused to be flowed. Flow testing would require appropriate wellhead mufflers and abatement equipment to reduce noise and possible H_2S emissions, which would increase sampling costs, but would provide information vital to the assessment of the resource.

RECOMMENDATIONS

The SOH program has continued the assessment and characterization of the geothermal resource potential of the KERZ, but more work needs to be done and more scientific observation holes need to be drilled before an adequate assessment of the geothermal potential of the KERZ, and the Big Island can be made. However, before additional SOHs are drilled, surface resource assessments, regulatory modifications, and other preparations should take place.

1. Several discrete reservoirs have been identified in the HGP-A/PGV area. Surface geophysical surveys including gravity, magnetics, seismic, self potential, electromagnetic (EM), resistivity, etc. should be conducted over and adjacent to the area to determine if any unique signals emerge. Every opportunity should be taken to obtain downhole geophysical information to identify reservoir conditions that would be useful in interpreting surface surveys.

2. Should additional funding be appropriated for future SOH drilling, surface geophysical surveys should be conducted over and in the vicinity of any new and existing SOH sites prior to drilling to establish the relationship between the geophysical results and the actual rocks in the area tested.

3. Additional SOHs should be sited in the GRSs and along the KERZ to continue assessment of the potential geothermal resources. Future SOH sites that should be considered include:

   - o At least two holes should be drilled to the north and south of the True/Mid-Pacific project area in the Kilauea Middle East Rift Zone GRS to test for permeability conditions to the north and to test temperature and permeability to the south along the axis of the recent cinder cone alignment.

   - o Another SOH should be drilled to the west of the True/Mid-Pacific project area and to the east of SOH-2 in the Kapoho GRS to determine subsurface geological conditions and to establish monitoring sites to the east and west of existing data points.
   - o At least two holes should be drilled to the north and south along the line formed by SOH-1, PGV, and HGP-A to test conditions of the KERZ near the northern and southern boundaries of the rift.
   - o Several fill-in holes should be drilled between existing SOHs and production wells.
   - o At least one, shallow (500 feet), SOH and preferably more SOHs should be drilled to the south of the KERZ to test water quality and temperature for possible direct utilization or spa applications, and to serve as possible observation stations to monitor the effects, if any, of geothermal production.

4. Future SOHs should be designed and permitted to be drilled to depths of 7,500 feet, although depths of 6,000 to 6,500 feet may be sufficient to test and assess the geothermal potential.

5. Consideration should be given to drilling future SOHs as directional (angle) holes designed to cut across the axis of the KERZ. This can be accomplished by drilling the SOHs vertically to casing depth, and then directionally, across the geologic section to be tested.

6. If possible, future SOH drilling sites should be divided between GRS and non-GRS areas to provide the geological information across GRS boundaries necessary for resource assessment and management.

7. The SOHs should not be designed as production wells. However, it is imperative that all future SOHs should be permitted to be pumped or flow tested to obtain groundwater and reservoir fluid samples for analysis. Too much time, effort, and cost are expended in drilling SOHs not to collect this last measure of vitally important data, which can define reservoir chemistry and minimum temperatures, and other resource characteristics needed to better delineate the geothermal reservoir.

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mt2/c/SOHFSR6R
3/9/94

APPENDIX I.

DLNR GEOTHERMAL WELL DRILLING PERMIT

JOHN WAIHEE
GOVERNOR OF HAWAII

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES

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MANABU TAGOMORI
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STATE PARKS
WATER AND LAND DEVELOPMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

GEOTHERMAL WELL DRILLING PERMIT

SCIENTIFIC OBSERVATION HOLE (SOH) 4

(AMENDED)

TO: Research Corporation of the
University of Hawaii (RCUH)
Hawaii Natural Energy Institute (HNEI)
University of Hawaii at Manoa
2540 Dole Street, Holmes Hall #246
Honolulu, Hawaii 96822

In accordance with Administrative Rules 13-183, your original application, dated March 7, 1989, as amended by your letter dated August 17, 1989, for a permit to drill a scientific observation hole on lands included in the Kamaili Section of the Kilauea Lower East Rift Geothermal Resource Subzone is approved:

Well Designation: SOH 4
Location: TMK 1-2-10:01, Kamaili, Puna, Hawaii
Ground Elevation: 1,220 ft.±
Bottom Hole Diameter: 3 inches
Total Depth: 4,000 to 6,500 feet (maximum)

You are hereby granted permission to drill the geothermal scientific observation hole described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, and the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupier of the land, the Drilling and Completion Procedures submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184), and all other applicable Federal, State, and County laws, ordinances, rules and regulations;

(2) The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

(3) The applicant shall observe and comply with all valid requirements of municipal, state, and federal authorities, and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws, and those relating to the environment;

(4) The applicant shall secure approval and issuance of a County Geothermal Resource Permit (GRP) from the Planning Commission prior to commencement of drilling activities;

(5) If there are any contemplated changes in the proposed drilling program, the applicant shall obtain the Chairperson's approval prior to the execution of any such contemplated changes of work;

(6) The applicant shall file with the Chairperson prior to the start of the permitted activity, an indemnity bond as required under the Department's Administrative Rules, Chapter 13-183;

(7) The SOH shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling unless modified by the Chairperson upon request;

(8) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified with reasonable time allowed for travel to the site, to obtain a representative groundwater sample and to measure the static water level;

(9) The SOH surface casing (9.625") shall be set to a minimum depth of ten percent of the proposed total depth of the well or five hundred feet, whichever is greater.

(10) All Blowout-Prevention Equipment (BOPE) and cemented casing strings, shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes.

(11) The drilling permit shall be valid for a period of one year from the date of issuance;

(12) The applicant shall submit to the Chairperson, the results of the exploration, all drilling and testing records, date of completion, and a survey of the hole location by a Hawaii licensed surveyor within six months after completion of the SOH operations;

(13) The applicant shall notify the Division of Water and Land Development of the date of the start of work;

(14) During use of the SOH for monitoring purposes, the hole and site shall be properly maintained until the well is plugged and abandoned in accordance with Administrative Rules, Chapter 13-183;

(15) The site shall be restored as near as possible to their original condition after operations are completed.

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

AUG 31 1989

Date of Permit

cc: Land Board Members
Hawaii County Planning Dept.
DBED
Department of Health
OEQC

JOHN WAIHEE
GOVERNOR OF HAWAII

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

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AQUACULTURE DEVELOPMENT PROGRAM
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LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

GEOTHERMAL WELL DRILLING PERMIT

SCIENTIFIC OBSERVATION HOLE (SOH) 1

(AMENDED)

TO: Research Corporation of the
University of Hawaii (RCUH)
Hawaii Natural Energy Institute (HNEI)
University of Hawaii at Manoa
2540 Dole Street, Holmes Hall #246
Honolulu, Hawaii 96822

In accordance with Administrative Rules 13-183, your original application, dated March 7, 1989, as amended by your letter dated August 17, 1989, for a permit to drill a scientific observation hole on lands included in the Kapoho Section of the Kilauea Lower East Rift Geothermal Resource Subzone is approved:

Well Designation: SOH 1
Location: TMK 1-4-01:02, Kapoho, Puna, Hawaii
Ground Elevation: 620 ft.±
Bottom Hole Diameter: 3 inches
Total Depth: 4,000 to 6,500 feet (maximum)

You are hereby granted permission to drill the geothermal scientific observation hole described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, and the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupier of the land, the Drilling and Completion Procedures submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184), and all other applicable Federal, State, and County laws, ordinances, rules and regulations;

(2) The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

(3) The applicant shall observe and comply with all valid requirements of municipal, state, and federal authorities, and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws, and those relating to the environment;

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(5) If there are any contemplated changes in the proposed drilling program, the applicant shall obtain the Chairperson's approval prior to the execution of any such contemplated changes of work;

(6) The applicant shall file with the Chairperson prior to the start of the permitted activity, an indemnity bond as required under the Department's Administrative Rules, Chapter 13-183;

(7) The SOH shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling unless modified by the Chairperson upon request;

(8) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified with reasonable time allowed for travel to the site, to obtain a representative groundwater sample and to measure the static water level;

(9) The SOH surface casing (9.625") shall be set to a minimum depth of ten percent of the proposed total depth of the well or five hundred feet, whichever is greater.

(10) All Blowout-Prevention Equipment (BOPE) and cemented casing strings, shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes.

(11) The drilling permit shall be valid for a period of one year from the date of issuance;

(12) The applicant shall submit to the Chairperson, the results of the exploration, all drilling and testing records, date of completion, and a survey of the hole location by a Hawaii licensed surveyor within six months after completion of the SOH operations;

(13) The applicant shall notify the Division of Water and Land Development of the date of the start of work;

(14) During use of the SOH for monitoring purposes, the hole and site shall be properly maintained until the well is plugged and abandoned in accordance with Administrative Rules, Chapter 13-183;

(15) The site shall be restored as near as possible to their original condition after operations are completed.

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

AUG 31 1989

Date of Permit

cc: Land Board Members
Hawaii County Planning Dept.
DBED
Department of Health
OEQC

JOHN WAIHEE
GOVERNOR OF HAWAII

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES

LIBERT K. LANDGRAF
MANABU TAGOMORI
RUSSELL N. FUKUMOTO

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

GEOTHERMAL WELL DRILLING PERMIT

SCIENTIFIC OBSERVATION HOLE (SOH) 2

(AMENDED)

TO: Research Corporation of the
University of Hawaii (RCUH)
Hawaii Natural Energy Institute (HNEI)
University of Hawaii at Manoa
2540 Dole Street, Holmes Hall #246
Honolulu, Hawaii 96822

In accordance with Administrative Rules 13-183, your original application, dated March 7, 1989, as amended by your letter dated August 17, 1989, for a permit to drill a scientific observation hole on lands included in the Kapoho Section of the Kilauea Lower East Rift Geothermal Resource Subzone is approved:

Well Designation: SOH 2
Location: TMK 1-4-02:32, Halekamahina, Puna, Hawaii
Ground Elevation: 270 ft.±
Bottom Hole Diameter: 3 inches
Total Depth: 4,000 to 6,500 feet (maximum)

You are hereby granted permission to drill the geothermal scientific observation hole described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, and the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupier of the land, the Drilling and Completion Procedures submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184), and all other applicable Federal, State, and County laws, ordinances, rules and regulations;

(2) The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

(3) The applicant shall observe and comply with all valid requirements of municipal, state, and federal authorities, and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws, and those relating to the environment;

(4) The applicant shall secure approval and issuance of a County Geothermal Resource Permit (GRP) from the Planning Commission prior to commencement of drilling activities;

(5) If there are any contemplated changes in the proposed drilling program, the applicant shall obtain the Chairperson's approval prior to the execution of any such contemplated changes of work;

(6) The applicant shall file with the Chairperson prior to the start of the permitted activity, an indemnity bond as required under the Department's Administrative Rules, Chapter 13-183;

(7) The SOH shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling unless modified by the Chairperson upon request;

(8) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified with reasonable time allowed for travel to the site, to obtain a representative groundwater sample and to measure the static water level;

(9) The SOH surface casing (9.625") shall be set to a minimum depth of ten percent of the proposed total depth of the well or five hundred feet, whichever is greater.

(10) All Blowout-Prevention Equipment (BOPE) and cemented casing strings, shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes.

(11) The drilling permit shall be valid for a period of one year from the date of issuance;

(12) The applicant shall submit to the Chairperson, the results of the exploration, all drilling and testing records, date of completion, and a survey of the hole location by a Hawaii licensed surveyor within six months after completion of the SOH operations;

(13) The applicant shall notify the Division of Water and Land Development of the date of the start of work;

(14) During use of the SOH for monitoring purposes, the hole and site shall be properly maintained until the well is plugged and abandoned in accordance with Administrative Rules, Chapter 13-183;

(15) The site shall be restored as near as possible to their original condition after operations are completed.

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

AUG 31 1989

Date of Permit

cc: Land Board Members
Hawaii County Planning Dept.
DBED
Department of Health
OEQC

JOHN WAIHEE
GOVERNOR OF HAWAII

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES

LIBERT K. LANDGRAF
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AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
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CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

GEOTHERMAL WELL DRILLING PERMIT

SCIENTIFIC OBSERVATION HOLE (SOH) 3

TO: Research Corporation of the
University of Hawaii (RCUH)
Hawaii Natural Energy Institute (HNEI)
University of Hawaii at Manoa
2540 Dole Street, Holmes Hall #246
Honolulu, Hawaii 96822

In accordance with Administrative Rules 13-183, your original application, dated March 7, 1989, as amended by your letter dated August 17, 1989, for a permit to drill a scientific observation hole on lands included in the Kilauea Middle East Rift Geothermal Resource Subzone is approved:

Well Designation: SOH 3
Location: TMK 1-2-10:03, Kaimu, Puna, Hawaii
Ground Elevation: 1,480 ft.±
Bottom Hole Diameter: 3 inches
Total Depth: 4,000 to 6,500 feet (maximum)

You are hereby granted permission to drill the geothermal scientific observation hole described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, and the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupier of the land, the Drilling and Completion Procedures submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184), and all other applicable Federal, State, and County laws, ordinances, rules and regulations;

(2) The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

(3) The applicant shall observe and comply with all valid requirements of municipal, state, and federal authorities, and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws, and those relating to the environment;

(4) The applicant shall observe and comply with all valid requirements and conditions, as set forth in the Board of Land and Natural Resources' Decision and Order dated April 11, 1986;

(5) If there are any contemplated changes in the proposed drilling program, the applicant shall obtain the Chairperson's approval prior to the execution of any such contemplated changes of work;

(6) The applicant shall file with the Chairperson prior to the start of the permitted activity, an indemnity bond as required under the Department's Administrative Rules, Chapter 13-183;

(7) The SOH shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling unless modified by the Chairperson upon request;

(8) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified with reasonable time allowed for travel to the site, to obtain a representative groundwater sample and to measure the static water level;

(9) The SOH surface casing (9.625") shall be set to a minimum depth of ten percent of the proposed total depth of the well or five hundred feet, whichever is greater.

(10) All Blowout-Prevention Equipment (BOPE) and cemented casing strings, shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes.

(11) The drilling permit shall be valid for a period of one year from the date of issuance;

(12) The applicant shall submit to the Chairperson, the results of the exploration, all drilling and testing records, date of completion, and a survey of the hole location by a Hawaii licensed surveyor within thirty days after completion of the SOH operations;

(13) The applicant shall notify the Division of Water and Land Development of the date of the start of work;

(14) During use of the SOH for monitoring purposes, the hole and site shall be properly maintained until the well is plugged and abandoned in accordance with Administrative Rules, Chapter 13-183;

(15) Upon proper abandonment of the SOH, Applicant shall restore all denuded areas in a manner acceptable and approved by the Department.

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

AUG 31 1989

Date of Permit

cc: Land Board Members
Hawaii County Planning Dept.
DBED
Department of Health
OEQC

APPENDIX II.

COUNTY OF HAWAII GEOTHERMAL RESOURCE PERMIT

Planning Commission

Bernard K. Akana
Mayor

25 Aupuni Street, Rm. 109 • Hilo, Hawaii 96720 • (808) 961-8288

RECEIVED
AUG 17 1989
MMTC-OBD

CERTIFIED MAIL

August 15, 1989

Dr. Harry Olsen
HEI/Spark Matsunaga Fellow
in Geothermal Research
Hawaii Natural Energy Institute
Holmes Hall 240
2540 Dole Street
Honolulu, HI 96822

Dear Dr. Olsen:

Geothermal Resource Permit Application (GRP 89-1)
Hawaii's Scientific Observation Hole (SOH) Program
Lilewa, Kapoho, and Halekamahina, Hawaii
TMK: 1-2-10: 01; 1-4-01: 2; and 1-4-02: 32

The Planning Commission at its duly held meeting on August 8, 1989, considered this Geothermal Resource Permit Application and approved this request based on the following findings:

(1) The proposed geothermal development activities would not have unreasonable adverse health, environmental, or socio-economic effects on residents or surrounding property.

Approximately a quarter acre of land will be cleared and leveled for each drill site. Each drill site will be constructed so that surface water runoff is contained within the site and will drain into the mud pit.

There are no surface streams or ponds in the vicinity of the proposed drill sites. Groundwater will be protected by cementing casing into the hole to depths below sea level.

There are no habitats for aquatic life in the area; however, other wildlife and natural resources will be affected by loss of habitat at the drill site and along any access roads that will be constructed. This habitat loss will be limited to the duration of drilling, testing, and monitoring operations, after which the site will be restored. The area at SOH 4 will be surveyed for rare and endangered species and archaeological remains prior to clearing activity, and, if necessary, the site will be relocated to avoid undesirable impact. Similarly, the area affected by SOH 1 and SOH 2 will be surveyed by an ornithologist. To minimize any adverse impacts to the endangered 'I'o, the ornithologist's recommendations will be sought.

Geothermal emissions will not be vented to the atmosphere, and no other aspects of drilling should affect public health. The sites have been located in agricultural areas away from urban population concentrations. The sites will also be located to take advantage of existing vegetation to muffle or block noise from the drilling operations. The drilling area will be within an area designated as a "hard hat" area. The general public will not be permitted within this area.

The drill operator will bring into the area three crews composed of two men each plus a drilling foreman. Other technical personnel associated with the project will include a drilling supervisor, a mud technician, various suppliers and subcontractors, the principal investigator, and several researchers and field supervisors. These people will rent housing in the Hilo-Pahoa-Kalapana area. The maximum number of persons at the project at one time should not exceed twenty. Local suppliers and contractors will be used wherever possible. Drilling the SOH's should take approximately twelve to sixteen months to complete, depending upon drilling conditions and the depth to which the holes are drilled.

As previously stated, the socio-economic impacts of this activity would not be unreasonable. The economic benefits and security implications of reducing Hawaii's dependence on imported fuels for energy production have been recognized for a long period of time at all levels of government. This has resulted in a general policy of support for alternative energy research and development. The establishment of Geothermal Resource Subzones, where exploration and development are allowable activities, acknowledges the potential higher use of the lands in volcanic rift zones which are generally of marginal value for agriculture and other cultural uses. Results of these scientific observations could lead to development of indigenous geothermal resources for the general social and economic well-being of the residents of Hawaii.

(2) The proposed geothermal development activities would not unreasonably burden public agencies to provide roads and streets, sewers, water, drainage, school improvements, and police and fire protection.

There should be negligible impact on public infrastructure and services. Personnel associated with the drilling operations will be temporary and small in number. Most of the personnel will be on temporary duty and will not bring their families. These people will utilize existing facilities and will not require additional services that are not already provided by the County.

Fire extinguishers are standard equipment on drilling rigs to control fires associated with drilling operations. The rig will utilize either a pipeline or water haulage truck to supply water for the drilling fluids. This water can be used to extinguish any fires that may develop. In addition, drilling muds can be pumped onto any fire that may develop in the vicinity of the rig.

Drilling operations will require no provisions from public agencies in the form of roads or streets, sewers, drainage, or school enlargement or improvements, and only the normally afforded police and fire protection will be expected. Any necessary access roads will be constructed by the applicant, and water for drilling will be purchased and supplied by temporary pipeline or transported to the site in tank trucks by the drilling contractor.

(3) There are reasonable measures available to mitigate the unreasonable adverse effects or burdens referred to above.

Hydrogen sulfide monitors will be operable at the drill site during rotary and core drilling operations. The applicant will comply with all federal, state, county, or local rules regarding environmental monitoring.

During drilling operations, noise levels will be monitored at several sites at and adjacent to the drilling rig, and mitigating measures will be taken if noise levels exceed acceptable levels.

The drillers will receive safety instructions and instructions on how to contact emergency facilities in the area. Phone numbers for police, fire department, hospital, and other emergency services will be posted in a prominent place at the drill rig, together with phone numbers for the drill supervisor, principal investigator, field manager, and appropriate state and county regulators.

As drilling will be conducted on a 24 hours-a-day, 7 days-a-week basis once the core drilling commences, the drill site will be lighted during the hours of darkness to permit continuous operations and to provide safe working conditions. The rig will be sited so as to be as unobtrusive as possible and will conform to all Hawaii outdoor lighting regulations. Copies of Hawaii Outdoor Lighting Regulations will be provided to the drilling contractor to insure compliance. After the rig is operational, a lighting survey will be made, and lights adjusted or shielded as necessary to cause the minimum impact.

Approval of this request is subject to the following conditions:

1. The petitioners, its successors, or assigns shall be responsible for complying with all of the stated conditions of approval.

2. Prior to the commencement of any grubbing or grading activity, the petitioner shall:

    a. Mark the boundaries of the designated SOH site(s), and the access road right-of-way(s), and no construction or transportation equipment shall be permitted beyond the prescribed boundaries of the said SOH site(s) and road right-of-way(s);

    b. Conduct an archaeological reconnaissance survey and an endangered flora and fauna survey at all SOH Holes and the access road right-of-way leading to them and submit the results of the surveys to the County Planning Department for review; and

    c. Comply with all requirements of the County grading ordinance.

3. Prior to any drilling activity, the petitioner shall submit and secure approval from the Planning Department or its designee a noise monitoring plan to be implemented when the SOH drilling and testing period begins. This plan shall

include the monitoring of noise at the specific sites at least one week prior to the start of drilling to establish a site specific baseline. This plan should allow the coordination of noise complaints with noise measurements, the meteorological conditions, and the type of operations which occurred at the SOH site. The data obtained shall be available upon request by the appropriate governmental agencies including the Planning Department. The noise monitoring program shall be in operation during all active phases of the project.

The applicant shall meet the guidelines for noise included as Condition No. 12 below for all aspects of this project including all rigs used at the respective sites; however, the applicant shall also make every attempt to make drilling as quiet as possible to reduce noise to meet community concerns. The applicant shall schedule cable rig drilling during daylight hours which is defined as the hours between 7:00 a.m. and 7:00 p.m.

The applicant shall make available one mobile noise monitoring station to do site specific monitoring.

4. Prior to any drilling activity, the petitioner shall submit and secure approval from the Planning Department or designee an air quality monitoring plan to be implemented when the SOH drilling period begins. The plan shall include provisions for installation, calibration, maintenance, and operation of recording instruments to measure air contaminant concentrations. The specific elements to be monitored, the number of stations involved, and the frequency of sampling and reporting shall be specified by the Planning Department or its designee. The air quality monitoring program shall be in operation during all phases of the project.

5. Prior to any drilling activity, the petitioner shall submit and secure approval from the Hawaii County Civil Defense Agency a plan of action to deal with emergency situations which may threaten the health, safety, and welfare of the employees/persons in the vicinity of the proposed project. The plan shall include procedures to facilitate coordination with appropriate State and County officials as well as the evacuation of affected individuals. The plan shall also include provisions for the applicant to provide

alternate transportation from the area for those affected in the event of a hazard associated with well drilling operations; for training the drill crews to handle emergencies; and to have available on site cement batching to plug the SOH in the event of an emergency.

6. The petitioner shall maintain a record in a permanent form suitable for inspection and five (5) copies shall be filed with the Planning Department on a monthly basis during drilling and for six (6) months after the completion of drilling to establish a hole specific baseline and such record shall be available to the community. The record shall include:

   a. Occurrence and duration of any start-up, shut-down, and operation mode of any SOH/facility.

   b. Performance testing, evaluation, calibration checks, and adjustment and maintenance of the continuous emission monitor(s) that have been installed.

   c. Emission measurements reported in units compatible with applicable standards/guidelines.

7. The petitioner, its successors, or assigns shall apply the "Best Available Control Technology" (BACT) with respect to geothermal emissions during all phases of the project, including SOH drilling and testing. "Best available control technology" means the maximum degree of control for noise and air quality concerns taking into account what is known to be practical but not necessarily in use. BACT shall be determined by the Planning Department in consultation with recognized experts and other appropriate governmental agencies involved in the control or regulation of geothermal development. Should it be determined that BACT is not being employed, the Planning Department is authorized to take any appropriate action including suspension of any further activities at the project site or referral of the matter to the Planning Commission for review and disposition.

8. Unabated open venting of geothermal steam shall be prohibited.

9. The petitioner shall provide, install, calibrate, maintain, and operate a meteorological station and conduct continuous meteorological monitoring at the site(s) or at another location as may be mutually agreed to by the petitioner and the Planning Department. The data shall be provided in a format agreeable to the Planning Department on a monthly basis and shall include temperature, wind velocity, wind direction, and other information deemed necessary by the Planning Department.

10. The petitioner shall publish a telephone number for use by local individuals in case of noise or odor complaints and have an employee available at the drill site, 24 hours a day, to respond to any local complaints.

11. The petitioner shall submit five (5) copies of a status report to the Planning Department on a quarterly basis (by the first day of January, April, July, and October of each year), or, within 30 days of the completion of any SOH. The status reports shall be available to the public. The status report shall include, but not be limited to:

    a. A detailed description of the work undertaken during the current reporting period including drilling activity report;

    b. A description of the work being proposed over the next reporting period;

    c. The results of the environmental/noise monitoring activities;

    d. A log of the complaints received and the responses thereto;

    e. The current status of exploration activities in the context of long-range program goals; and

    f. Any other information that the Planning Department may require which will address environmental and regulatory concerns involving the requirements of the Geothermal Resource Permit.

    g. This condition shall remain in effect until all of the conditions of approval have been complied with, then after which these reports shall be every six (6) months for the duration of the project.

h. These reports shall include a financial accounting of the resources expended by the project.

12. Until such time as noise regulations are adopted by the State or County, the petitioner shall comply with the following guidelines which shall be enforced by the Planning Department:

a. A general noise level of 55 dba during daytime and 45 dba at night shall not be exceeded except as allowed under b. For the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m.;

b. The allowable noise levels may be exceeded by a maximum of 10 dba; however, in any event, the generally allowed noise level should not be exceeded more than 10% of the time within any 20 minute period;

c. The noise level guidelines shall be applied at the existing residential receptors which may be impacted by the geothermal operation; and

d. Sound level measurements shall be conducted using standard procedures with sound level meters using the "A" weighting and "slow" meter response unless otherwise stated.

13. A disposal site or sites approved by the State Department of Health, prior to any disposal activity covered by this permit, shall be provided for sump contents and other waste materials to be disposed of from the drilling activity.

14. All sumps/ponds shall be purged in a manner meeting with the approval of the State Department of Health. In the event there are no DOH requirements, the applicant and the Planning Department shall request for guidelines from the DOH for the purging of sumps and ponds. Said guidelines shall be available to the community.

15. When SOH's are completed or abandoned, all denuded areas on and around the drilling site shall be revegetated in a

manner meeting with the approval of the Planning Department upon consultation with the Forestry Division of the Department of Land and Natural Resources and the property owners.

16. The petitioner shall grant unrestricted access to the subject property(ies) to authorized governmental representatives or to consultants or contractors hired by governmental agencies for inspection, enforcement, or monitoring activities. A designated employee shall be available at all times for purposes of supplying information and responses deemed necessary by the authorized governmental representative in connection with such work.

17. Large vehicle deliveries to the drill site shall be limited to daylight hours. For the purposes of this condition, daylight hours is defined as the hours between 7:00 a.m and 7:00 p.m. The applicant shall make every attempt to confine water deliveries between the hours of 8:00 a.m. and 5:00 p.m. This condition shall not apply for vehicles responding to emergencies.

18. The lighting used shall not interfere with the operations at the observatories located on Mauna Kea. To meet this requirement, the petitioner shall comply with the requirements of Chapter 14, Article 9 of the Hawaii County Code, relating to outdoor lighting.

19. This Geothermal Resource Permit shall be effective until December 31, 1991.

20. All other applicable rules, regulations and requirements, including those of the Hawaii County Department of Water Supply, State Department of Health and the State Department of Land and Natural Resources shall be complied with.

21. An extension of time for the performance of conditions within the permit may be granted by the Planning Director upon the following circumstances: 1) the non-performance is the result of conditions that could not have been foreseen or are beyond the control of the applicants, successors or assigns, and that are not the result of their fault or negligence; 2) granting of the time extension would not be contrary to the general plan or zoning code;

3) granting of the time extension would not be contrary to the original reasons for the granting of the Geothermal Resource Permit; and 4) the time extension granted shall be for a period not to exceed one (1) year and 5) if the applicant should require an additional extension of time, the Planning Director shall submit the applicant's request to the Planning Commission for appropriate action.

22. Should the Department of Water Supply's water well near SOH 2 be used as a water source during the drilling of SOH 2, the water well shall be monitored for increases in the saline level of the water.

23. Within 48 hours after an earthquake registering 6 or above on the Richter Scale and/or within 48 hours after an eruption has occurred, all SOH's within 10 kilometers of the epicenter or eruptive center, shall be examined for any physical changes which would alter its downhole integrity. A report of this examination shall be filed with the Planning Department within 48 hours of the examination.

24. As each SOH is drilled, each SOH will be precisely logged to determine the precise location of the pipestring to facilitate its plugging in the event of a blowout.

25. SOH 4 shall be the first drill site. A status report for the completion of the second stage (of three stages) of SOH 4 shall be submitted to Planning Commission prior to drilling more than 200 feet below ground level at either SOH 1 or SOH 2. Within thirty (30) days after submission of said report, the Planning Commission shall meet to review said status report to verify compliance of the initial drilling activities related to the first and second stages with all above conditions. The Planning Commision reserves the right to call a public hearing, if necessary, to gather additional input regarding the impact of the activities at SOH 4.

26. Should any of the foregoing conditions not be met or substantially complied with in a timely fashion, the Planning Director may immediately and temporarily suspend the permit and operations allowed thereunder. Notice of a temporary suspension shall be provided in writing or orally with subsequent written confirmation within three days to

the permittee and shall set forth the reasons for the temporary suspension.

Sincerely,

Gary Mizuno, Chairman
Planning Commission

cc: Dee Dee Letts
Kem Lowry
Christine Batista
Jim Blakey
Department of Business and Economic Development, Energy Division (Attn: Maurice Kaya)
Civil Defense Agency (Attn. Harry Kim)
W. R. Craddick
Jane Hedtke
Richard F. and Lou Ann K. Jones
Kapoho Community Association (Attn: Lou Rankin)
Kapoho Community Association (Attn: Barbara Bell)
Kapoho Grown (Attn: Delan Perry)
Kapoho Grown (Attn: Jennifer Perry)
Fernando Javier/Lois J. West
David Laughlin
Alice Medeiros
Pele Defense Fund (c/o Paul W. Y. Takehiro)
Steve Philips
Gregory C. Pommerenk
Puna Community Council, Inc. (Attn: Ronald C. Phillips)
Helene Shinde
Yoshio Shinde
Ralph Matsuda

APPENDIX III.

SOH-4 SUMMARY DRILLING REPORT AND WELL HISTORY

-by-

John E. Deymonaz
Geothermal Drilling Consultant

SOH-4 Drilling Summary

General

The Scientific Observation Hole drilling project was designed to gather information for scientific research and provide information on the geothermal potential on Hawaii. Core drilling was chosen because of the additional information provided by the core which will provide a tremendous amount of information to geologists studying the evolution of the island. Knowledge of the geothermal resource will increase from information gathered on mineralization, lithology, alteration and fracture permeability which cannot be provided by typical rotary drilling techniques.

Tonto Drilling Company was chosen as the drilling contractor. Tonto has had an excellent history of core drilling geothermal exploration holes has invested in equipment to accomodate the particular problems associated with core drilling high temperature holes. The drilling rig used is somewhat unique. It is a Universal 5000 built in Australia, and one of only two in existence. The rig has been extensively modified for geothermal work and to meet noise limitations mandated by the county of Hawaii.

A jack-up system permits elevating the rig and placing a 10.5 foot high substructure under the mast. The substructure then carries the weight associated with drilling and serves as a working floor. To minimize noise, the mud pumps, mixing pumps and light plant were outfitted with hydraulic motors which are powered by the rig hydraulic system. This eliminates nearly all of the ancillary combustion engines associated with drilling operations. The rig engine, a GM 12V-7 (410 HP) is completely enclosed in a sound insulating compartment and outfitted with hospital type mufflers. Noise levels at the perimiter of the drill site are less than 65 db.

The main hoist has a lifting capacity of 88,000 pounds and the rotation head has a maximum output torque of 6,630 ft lbs. Depth rating is variable depending on the size of drill rods used, in the case of NQ rod which was used to complete SOH-4, the theoritical maximum depth is over 17,000 feet.

DRILLING OPERATIONS

SOH-4 was spud at 5 PM on December 13, 1989 and completed to 6,562 feet on May 15, 1990 on the 141st day of drilling operations. A brief summary of drilling activities is given below and graphically presented in Figure 10.

Table 1. SOH-4 Drilling Summary

Dates	Day #	Activity
12/13 - 12/14	1 - 2	Core 134mm 0 - 112 ft.
12/14 - 12/21	2 - 8	Open hole to 17-1/2" 0 - 114 ft.
1/3 - 1/5	9 - 11	Run & cmt. 13-3/8 casing, nipple up BOPE
1/6 - 1/13	12 - 19	Core 101mm 114 - 992 ft.
1/13 - 1/14	19 - 20	Survey, make up rotary drilling assembly
1/15 - 2/14	21 - 51	Open hole to 12-1/4" 114 - 992 ft.
2/15 - 2/17	51 - 54	Run & cmt. 9-5/8" casing, nipple up BOPE
2/17 - 3/1	54 - 65	Core 101mm 992 - 2,000 ft.
3/1	65 - 66	Survey, run sleeve, make up rotary drilling assembly
3/2 - 3/11	66 - 75	Open hole to 8-1/2" 992 - 2,000 ft.
3/11 - 3/15	75 - 79	Run 7" csg, wait on HOWCO, cmt, nipple up BOPE, drill out float equipment
3/16 - 4/25	80 - 121	Core HQ 2,000 5,290 ft.
4/25 - 4/27	121 - 123	Stick HQ rods, rig up for NQ
4/27 - 5/16	123 - 142	Core NQ 5,290 - 6,562 ft. TD hole.
5/16 - 5/25	142 - 151	Survey, injection test, lay down d/p, rig down.

Drilling commenced by coring with 134mm (5.27 inch diameter) from the surface to 112 ft. and circulation was promptly lost at a depth of less than one foot. The hole was then opened to 17.5 inches in three passes with 8.5 inch, 12.25 inch and 17.5 inch hole openers. Total reaming time was 5 days. The hole had one or more doglegs due to the alternating hard/soft nature of numerous thin basalt flows (averaging less than 10 feet in thickness) consisting of a few feet of competent basalt and several feet of interflow rubble and cinder. An unsuccessful attempt to run 13-3/8" casing was made on December 18. A 17.5 inch roller reamer was obtained and run behind the hole opener to straighten the hole on December 20 - 21. The site was secured on December 21 for Christmas break.

Operations resumed on January 3. The 17.5 inch drilling assembly was run to TD to check the hole then 13-3/8 inch casing (K-55, 61 #/ft) was run open ended to TD and the hole bailed dry. The casing was cemented on January 4 with redimix (6 sk. mix w/ 1/2 inch minus aggregate). After approximately 1 cubic yard of concrete was poured down the annulus, the casing was picked up from bottom several times allowing the cement to flow into the casing and clean out any debris. The casing was then set back on bottom and the annulus filled with concrete to the surface.

On January 5 BOP equipment was nippled up. The wellhead consisted of a 13-3/8 inch slip on wellhead with two 2 inch flanged outlets, a 13-5/8 inch double-gate with pipe and blind rams, rotating head and 2 inch choke and kill lines (Figure 2). The pipe and blind rams were pressure tested to 600 psi.

A coring "sleeve" of 5 inch K-55 15#/ft casing with flush joint left hand threads (modified buttress) was run to TD and hung from the wellhead. On January 6 at 7 AM core drilling using 101mm tools (3.98 inch hole) commenced. The hole reached a depth of 1,007 feet at 10 AM on January 13 (7 days and 3 hours). The core barrel was retrieved and a deviation survey was run with a Sperry-Sun single-shot camera suspended 18 feet below the bit (hung from a bushing setting on crown of bit) while tripping out of the hole. Survey points were at 120 foot intervals. The hole deviates less than one degree from vertical in a southerly direction (Table 2).

The 101mm drill rods were laid down in singles and 134mm drills rods were picked up for the rotary portion of the hole. the hole was back filled with cinder, bagasse (sugar cane waste), cotton seed hulls and multiseal through drill rods while pumping a small volume of bentonite mud. Total used to fill hole: 6 cubic yards of bagasse, 1 yard of cinder, 15 bags multiseal and 11 bags cottonseed hulls. It was intended that the LCM together with cuttings would help seal permeable zones while opening the hole. This technique had proved successful in the top section of the hole.

The drilling contractor had reservations about the ability of the rig to open the hole to 12.25 inches in a single pass. Therefore the hole was opened in two passes, using a 8.5 inch hole opener with 3-15/16 inch pilot bit, followed with a 12.25 inch hole opener with a 8.5 inch pilot bit. Loss of circulation occured every few feet and numerous attempts were made to regain circulation by spotting LCM pills or dumping cinder, bagasse, paper sacks, bagged bentonite, etc. from surface. Often, fluid was lost to the bottom of the hole. Regaining circulation proved to be both expensive and temporary.

Small volume cement plugs were used in an attempt to seal problem intervals as the drilling progressed. Cement was batched in on-site grout mixing equipment (10 bbl and a 20 bbl capacities) and either pumped down open ended drill rods or batched and poured down the open hole. Both efforts had early successes with decreasing results as depth increased. Variations of these efforts continued from January 14 to February 4 (21 days) and the 12.25 inch hole was advanced from 107-579 feet.

During this period two fishing jobs occured: the first was on January 22 when an inexperienced rig hand dropped a 16 inch cresent wrench down the hole. The wrench was milled up and drilling resumed after 21.5 hours. On January 24 three cones and shanks were lost in the hole when a 8.5 inch hole opener failed. Each piece was about 6 inches long and fishing efforts were complicated as the junk moved down the 4 inch core hole (filled with bagasse, cuttings and cinder) and wedged, destroying various junk baskets and a 134 mm bit and SHR casing shoe which were used in attempts to core over the junk. The SHR attempt involved coring a 7 inch hole around the existing 4 inch hole. While it failed to retrieve any steel it did result in a large enough diameter hole for the junk to lay flat in the hole and most of the it was retrieved by numerous runs of a small magnet on January 28.

Following the failure of the 8.5 inch hole opener the drill plan was modified and reaming was completed to 12.25 inches in a single pass using a rotary bit and near-bit blade stabilizer. Rather than attempting to cure circulation problems as they occured, the hole was advanced in stages of approximately 200 feet without returns. During this portion of drilling the hole was often dry to bottom. Next it was backfilled with low strength redimix (2.5 sacks per yard w/ 3/8" minus gravel) and drilled out. On February 4 a Hughes X-33, 12.25 inch bit arrived and was used to open the hole from 579 - 992 feet. When pulled, the bit was still in good shape and was used on the next hole. Opening the hole in a single pass and cementing back larger segments of hole substantially increased the progress on the hole (Figure 3) and reaming advanced to 992 feet in 10 days.

9-5/8 inch K-55, 40#/ft buttress casing (Range III) was run to 990 feet with a guide shoe and float collar at the top of the first joint. Centralizers were run every third joint. The casing was cemented by HOWCO. First attempt failed to get returns to surface. Cementing was completed by HOWCO with 4 top jobs. The third top job brought cement to surface before it slowly drained away.

9-5/8 Inch Casing Cementing

Cmt. thru casing:	332 c.f. w/ 40% SiO2 & .65% CFR-3
First top job:	40 c.f. w/ 40% SiO2, .65% CFR-3 & 2% CaCl
Second top job:	81 c.f. w/ 40% SiO2, .65% CFR-3 & 2% CaCl
Third top job:	40 c.f. w/ 40% SiO2, .65% CFR-3 & 2% CaCl
Fourth top job:	29 sks. cmt. w/ 40% SiO2, 1,450# spherelite, 5% CFR-3, 4% gel and 3% CaCl.

A ring was welded between the 9-5/8 inch and 13-5/8 inch casings and the 13-5/8 inch BOP equipment described above was nippled up. A 8-1/2 inch bit was run in the hole and tagged cement at 937 feet. The cement and float equipment were drilled out to 992 feet and the rotary tools tripped out and laid down. Five inch K-55 casing (coring sleeve) was run in and hung from the wellhead and coring commenced with a 101mm (3.98 inch diameter hole w/ 2.50 inch core) drilling assembly. Core drilling advanced to 2,000 feet in 11 days, averaging about 88 feet per day.

The 101mm rods were tripped out and a deviation survey was run, with survey stops every 120 feet using a Sperry-Sun single shot tool suspended 18 feet below the bit. The hole deviates less than 1 degree from the surface to 2,000 feet in a southerly direction.

After the 5 inch casing sleeve was removed, the 134mm drill rods were picked up and a 8-1/2 inch drilling assembly consisting of a Hughes ATJ33 bit and near bit blade stabilizer made up. Reaming proceeded without returns and the hole was cemented back to casing at 1,130 feet with 54 sacks of neat cement. Cement was tagged at 990 feet, reaming advanced to 1,390 feet with returns decreasing from 100% at 1,130 to 60% at 1,390 feet. The hole was cemented back with 121 sack mix of neat cement. Cement was drilled out and the hole reamed to 2,000 feet with 80 - 90 percent returns. After conditioning the hole, the drill rods were tripped out and 7" L-80, 35# buttress casing with guide shoe and float collar at top of first joint was run. Centralizers were set on every third joint (approx. 120 feet).

Cementing was scheduled to be done by HOWCO, however, the pumper truck was shipped to Oahu for another project and missed the barge returning to Hawaii. This resulted in a delay of 26 hours.

HOWCO was unable to circulate through casing on first attempt, after pressuring up to 2,800 psi circulation was regained with approximately 90% returns. Cementing was accomplished by pumping through casing with returns to surface which slowly drained away. Cementing was completed with one top job.

7 Inch Casing Cementing

34 bbls of clear water pumped ahead of lead slurry.
Lead slurry: 225 c.f. (75 sk. cmt., 2,850 # SiO2, 3,750 # pherlite, 95 # CFR-3 & 75 sks. bentonite.
Tail slurry: 126 c.f. (78 sk. cmt., 2,900 # SiO2, 37 # CFR-3 & 3 sks. CaCl
Lead & tail slurry total 125% of theoretical.
Top job #1: 40 c.f. neat cement w/ 2% CaCl.

After waiting 12 hours on cement, a BOP assembly was nippled up consisting of: 6 inch drilling valve, 7 inch LWS double-gate BOP, 6 inch Regan and rotating head (Figure 3). Seven inch casing was utilized to permit the running of an additional string of casing if down hole conditions warranted, and still permit core drilling with HQ equipment. In order to core drill out of the 7 inch casing, a temporary "sleeve" of 4-1/2 inch casing was run to TD with a packer at the top of the first joint (approx. 40 feet off bottom) and centralizers on every third coupling. The purpose of the sleeve is to minimize lateral movement of the core drilling rods during rotation.

The hole was advanced to 5,290 feet with HQ coring equipment (3.78 inch hole, 2.50 inch core) from March 16 to April 25, a total of 41 days. Average daily footage was 80.5 feet. Several sandy, unstable intervals were encountered between 5,000 and 5,200 feet which required numerous redrills. At 5,290 feet the rods suddenly stuck, probably as a result of the sandy intervals below 5,000 feet caving in around the drill rods. Attempts by the driller to free the rods continued for 12 hours without success. The decision was made to reduce to NQ coring equipment. A "donut" was fabricated and welded on the HQ drill rods at the top of the wellhead to prevent cuttings from building up in the annular space between the HQ rods and 4-1/2 inch casing and the HQ rods were cut off below the drilling valve. An NQ coring assembly (2.98 inch hole with 1.875 inch core) was made up and drilling resumed on April 27. The hole was advanced to 6,562 feet on May 16, 1990. With NQ coring, daily footage averaged 67 feet from 5,290 feet to TD at 6,562 feet.

Below 5,692 feet problems with rod "vibration" resulted from heat causing a failure of the drilling fluids to provide adequate lubrication between the drilling rods and the wall of the drill hole. The subsequent vibration caused by excessive drag on the drill rods forced a reduction in drill rod rotation RPM from 200 - 300 RPM to less than 100 RPM. At this depth bottom hole mud temperatures were approaching 450 F (Figure 9). The elevated temperature was causing the polymer mud to break down and lose its' lubricating properties. Even "high temperature" polymer alone did not improve the vibration problem. The combination of high temperature polymer and a lubricating agent (brand name TORKease) reduced torque to normal levels.

Except for rod vibration problems, the core drilling progressed without incident to a depth of 6,562 feet where drilling operations were suspended. Although the permitted depth of the hole was between 4,500 feet and 6,500 feet, permission was obtained from Hawaii Department of Land and Natural Resources ("DLNR") to deepen the hole. The hole was over-drilled 62 feet to insure access to the full 6,500 feet depth, allowing for some fill to settle to the bottom as the drill rods were removed and tubing installed.

The NQ drill rods were tripped out and stood in 40 foot stands. Open hole logs were run below the HQ rods set to 5,290 feet (induction, SP and gamma).

An attempt to recover the HQ drill rods was then made. During the NQ drilling they had settled approximately 12 feet into the hole. They were recovered with a tap and pulled free with a 60,000 lb pull. The HQ rods separated at a connection 760 feet above the bit and 4,530 feet of HQ rods were recovered leaving 750 feet of HQ rods, an outer core barrel and bit in the hole. The 4-1/2 inch sleeve was removed and NQ rods were tripped in to check the hole and lay down NQ drill rods in singles.

Slotted tubing, consisting of used NQ drill rod (2.75 inch OD x 2.376 inch ID) capped on bottom with 1/2 inch holes drilled on 6 inch centers) was run to TD and hung from the wellhead. The completed wellhead assembly is shown in Figure 4. The completed well schematic is shown in Figure 1.

Injection testing, temperature and pressure logging was supervised by Geothermex Inc. and continued for several days following completion. Hot Hole Instruments Inc. ran an induction, SP and gamma log in addition to four temperature profiles and a spinner survey. W.T. Howard (GeothermEx) and John Deymonaz (Consultant for the University of Hawaii) ran four temperature/pressure surveys during and following injection testing.

The equipment was rigged down and operations at SOH-4 were formally ended on May 25, 1990, the 151st day of operations.

Coring Footage

Figure 12 and Table 4 detail footages per shift (two 12 hour shifts per day). As would be expected, average footage declined slightly with increasing depth from over 50 feet per shift in the upper portions of the hole to about 35 feet per shift below 5,000 feet. This was largely due to the length of time required to recover core and resume drilling (nearly one hour below 5,000 feet). Rock competency never reached a point where the 10 foot core barrel could be replaced with a 20 foot barrel to reduce the number of core runs. The 20 foot barrel tends to vibrate in the outer tube, and unless the rock is very competent, the length of runs will actually be reduced by utilizing a longer core barrel.

Core Recovery

Core recovery averaged from 85 - 100 percent (Figure 11 and Table 4). Shift recoveries of less than 80 percent are aberations resulting from shifts with very limited footage during which core dropped from a tube during recovery or one poor run greatly skewed the short footage for the shift. Figure 11, which plots shift core recovery vs. hole depth graphically reflects the improvement in drilling conditions below 2,000 feet, and below 2,500 feet core recovery averages nearly 100 percent. The sharp downward spikes below 5,000 feet reflect unusual occurances on shifts with low footages (ie. 6 feet cored and 5 feet dropped from barrel at 5,648 for 17% shift recovery) and not increased fracture permeability. Unfortunately the good core recovery appears to be an excellent correlation to the lack of formation permeability which is very low below 2,500 feet.

Core Bit Footages

Core bits and rotary equipment experienced similar problems with the fractured basalts. While the rock was medium in hardness and drilled relatively easily, it was extremely abrasive. This resulted in rapid loss of gauge on rotary bits without extensive gauge protection and rapid deterioration of matrix material on the core bits. As can be seen in Figure 13 and Table 5, core bit life increases substantially below 2,000 feet as the formations become less fractured, softer and apparently less abrasive. While bit life averaged less than 100 feet above 2,000 feet, this rapidly extended to 500 - 700 feet at greater depths.

Ground Water Sampling

Given the 1,195 foot surface elevation at SOH-4, ground water was anticipated at 1,000 - 1,200 feet. The hole was bailed at 1,135 ft. for 4 hours with no improvement in water quality over the course of bailing. The sample appeared identical to the bentonite drilling fluid used prior to this period. If a dynamic aquifer system existed at this depth, the fluid sample should have become less contaminated with drilling fluid as the hole was bailed and/or as time passed and the drilling fluids were carried away by the ground water movement (at SOH-1 the sampled fluids became markedly less contaminated during the sampling period).

Although core samples indicated numerous fractures and rubble zones in the upper 2,000 feet, the fluid sampling, erratic nature of the fluid level in the hole while drilling and frequent dikes suggest little lateral permeability. This may be a result of numerous magmatic intrusions into vertical fractures forming vertical impermeable zones. This would have the effect of creating hydrologic cells with limited lateral fluid movement. When drilling fluids are introduced into this type of structure they collect around the bore hole rather than being carried "downstream" with the prevailing groundwater flow. Bailing simply retrieves much of the same fluid, which apparently occured in SOH-4.

Drill Hole Fluid Level

Beginning at a depth of 2,122 feet fluid level in the hole was measured each time the overshot was run in the hole to retrieve the core barrel (Table 2 and Figure 14). Depending on the depth to the fluid level, this would occur 3 - 10 minutes after the mud pumps were cut off. When temperature measurements were taken the interval between cutting off the pumps and impacting the fluid level could be in excess of 15 minutes. Measurements recorded on temperature runs are marked with a

"T". These are generally at a greater depth than the normal runs and indicate a slow decline in the fluid level after pumping ceased. By contrast, fluid level measurements in SOH-1 are consistently at 620 feet (approximately sea level).

From 2,122 - 2,271 feet fluid levels ranged from 300 to 700 feet. Below 2,271 feet fluid levels dropped to a maximum of 1,100 feet and slowly rose to 350 feet. The shallower readings were made when the hole depth was below 5,800 feet and partial returns of drilling fluids to the surface were being observed while the pumps were engaged. The rise in fluid level was most likely due to the sealing of small fractures below the 2,000 foot casing depth by drill cuttings and the lack of significant permeable intervals below 2,500 feet.

Bottom Hole Temperature Measurements

Maximum reading mercury filled thermometers ("MRT's") were used to obtain bottom hole temperatures ("BHT's) beginning at a depth of 3,210 feet (Figure 9 and Table 3). The thermometers were placed in a sealed pressure vessel (1/4 inch steel pipe nipple, capped on both ends) which was run in a perforated cage and suspended approximately one foot below the drill bit for 10 minutes. This gave a reading near bottom approximately one hour after circulation ceased. Beginning at 5,280 feet, measurements were made by placing the thermometer vessel above the overshot while retrieving the core barrel and left on bottom for 5 minutes. This gave a reading 20 feet off bottom approximately 30 minutes after pumping ceased. Both methods appear to give similar results.

A comparison of the BHT's to a temperature profile run 17.75 hours after an injection test on June 22 shows a good correlation to temperature trends in the relatively equilibrated hole. Absolute temperatures vary from 50 to 122 degrees F higher than BHT's above 4,700 feet to 15 to 33 degrees F higher than BHT's below 4,700 feet. The 4,700 foot interval appears to be a somewhat permeable zone below which no significant permeability is indicated by the logs. As is common in core drilled holes, the BHT's were excellent indicators of changes in formation temperature, and in less permeable intervals correlate closely with actual formation temperatures. This was a result of the low pump rate (10 - 15 gallons per minute) and small hole diameter which have a minimal cooling effect on the surrounding rock.

Water Requirements

One of the advantages of core drilling non-producing test holes rather than drilling with rotary methods is the relatively small fluid injection rates required while coring. This is a major advantage when drilling without returns. Unfortunately, after the drilling contractor and equipment were selected for this project, the drilling program was modified to include larger and deeper strings of casing (Figure 1) requiring more extensive rotary drilling then originally planned for. Since the site was designed primarily for core drilling operations, and to minimize surface disturbance, a small (100 feet by 125 feet) site was cleared. Space for water storage was limited. Water storage consisted of 23,000 gallon and 3,500 gallon storage tanks and two grout tanks. On site storage totaled about 28,000 gallons.

Water for drilling was transported in from a stand pipe located 5 miles from the drill site in 5,000 gallon tanker trucks. Water consumption while core drilling without returns was 10 - 15 gallons per minute and one truck could keep the rig supplied with sufficient water. Although 3 - 4 trucks could keep up with rotary drilling under the worst of conditions, Hawaii County regulations for this project prohibited all truck traffic to the site from 7 AM to 7 PM. Standby periods for waiting on cement and drilling out cement, during which time full returns were obtained, was scheduled for night shift when water hauling was not permitted; 3 - 5 hours of standby each night due to lack of water was common while reaming the 12.25 inch hole.

Figures 5, 6, 7 and 8 graph various aspects of water consumption with depth, time and cost. In Figure 5, the period from Day 40 to Day 51 illustrates the increase in water (ie. drilling fluid) consumption while reaming with the 12.25 inch bit. Fluid consumption averaged 70,000 - 100,000 gallons per day. By contrast, core drilling during days 12 - 19 and 80 - 142 are reflected by a uniform fluid consumption of 15,000 to 20,000 gallons per day. The erratic nature of water consumption during rotary operations was due to periods of cementing, waiting on cement and drilling out cement with returns interspersed between periods of reaming without returns.

Drilling Fluids

Environmental concerns are of primary importance in the SOH program. While drilling fluids in general are not considered to be a health hazzard, certain items in concentrated forms must be handled with care (ie. caustic soda, etc.). The drilling fluids selected for the SOH project are acceptable for drilling domestic water wells in many states. A representative from the state of Nevada Water Resources Division was asked to review the list of drilling fluids to be used on the SOH program as it would pretain to a domestic water well drilling program.

Since circulation was not expected during the coring portion of SOH-4, the drilling fluids were designed to be as inexpensive as possible and still maximize drilling characteristics. In the upper, cooler portions of the hole a bentonite mud was used with 1.5 ounces of 35% polyacrilamide and 12 pounds extra high yield bentonite per barrel. Below 5,000 feet, as bottom hole temperatures exceeded 400 F high temperature polymer (in this case Nova Mud Company's Thermovis) together with high temperature lubricants, surfactants and corrosion control additives were incorporated into the mud system.

Drilling Costs

Total drilling costs for SOH-4 were $1,468,049. This is exclusive of transportation from Salt Lake City to Hilo and equipment modifications prior to arrival in Hilo. Table 6 presents a brief breakdown of the major costs by activity and item. Figure 17 is a graphic representation of drilling costs vs. hole depth.

Figures & Tables

Figure 6
SOH-4
Completed Well Schematic

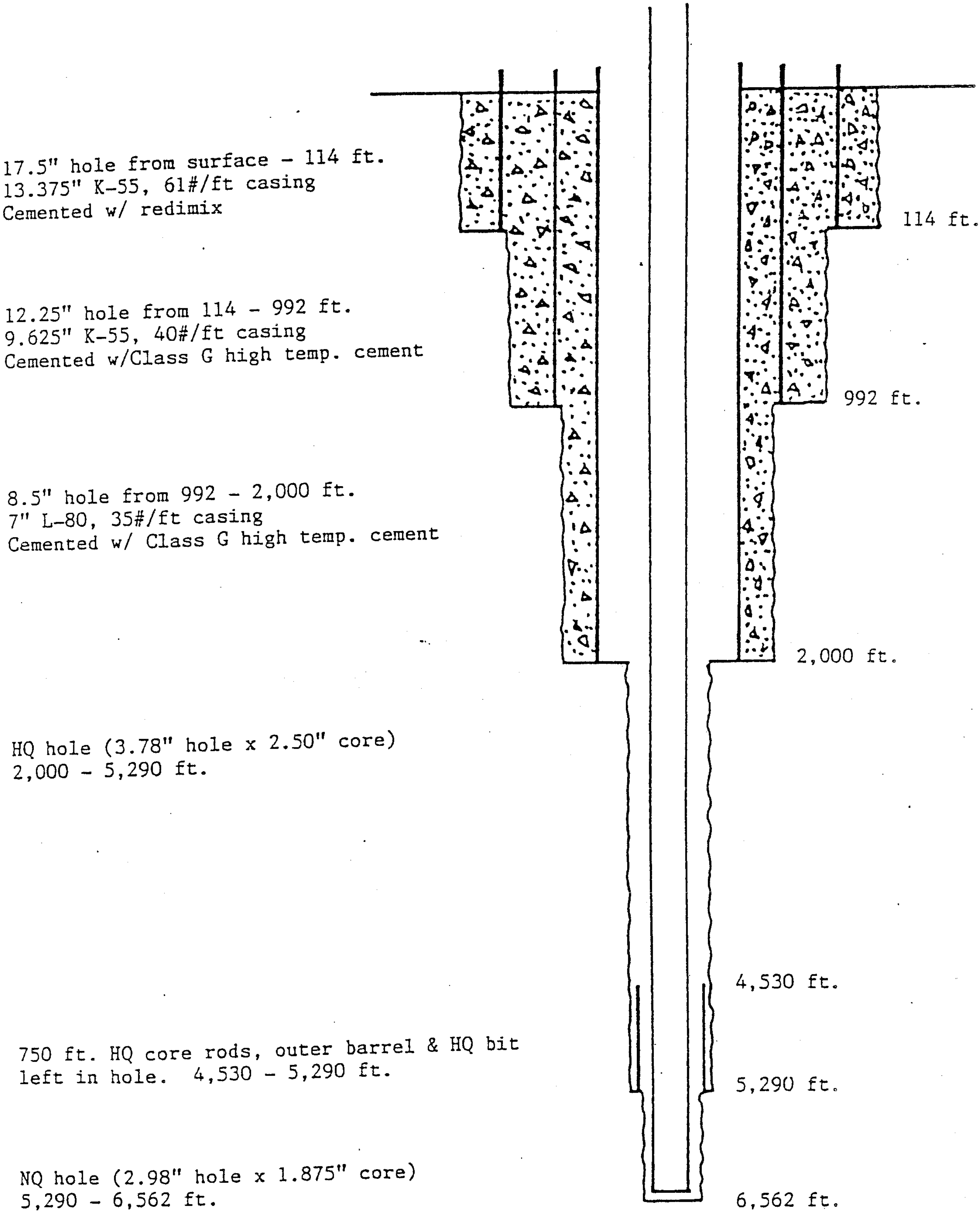


Figure 1
SOH-1
Completed Well Schematic

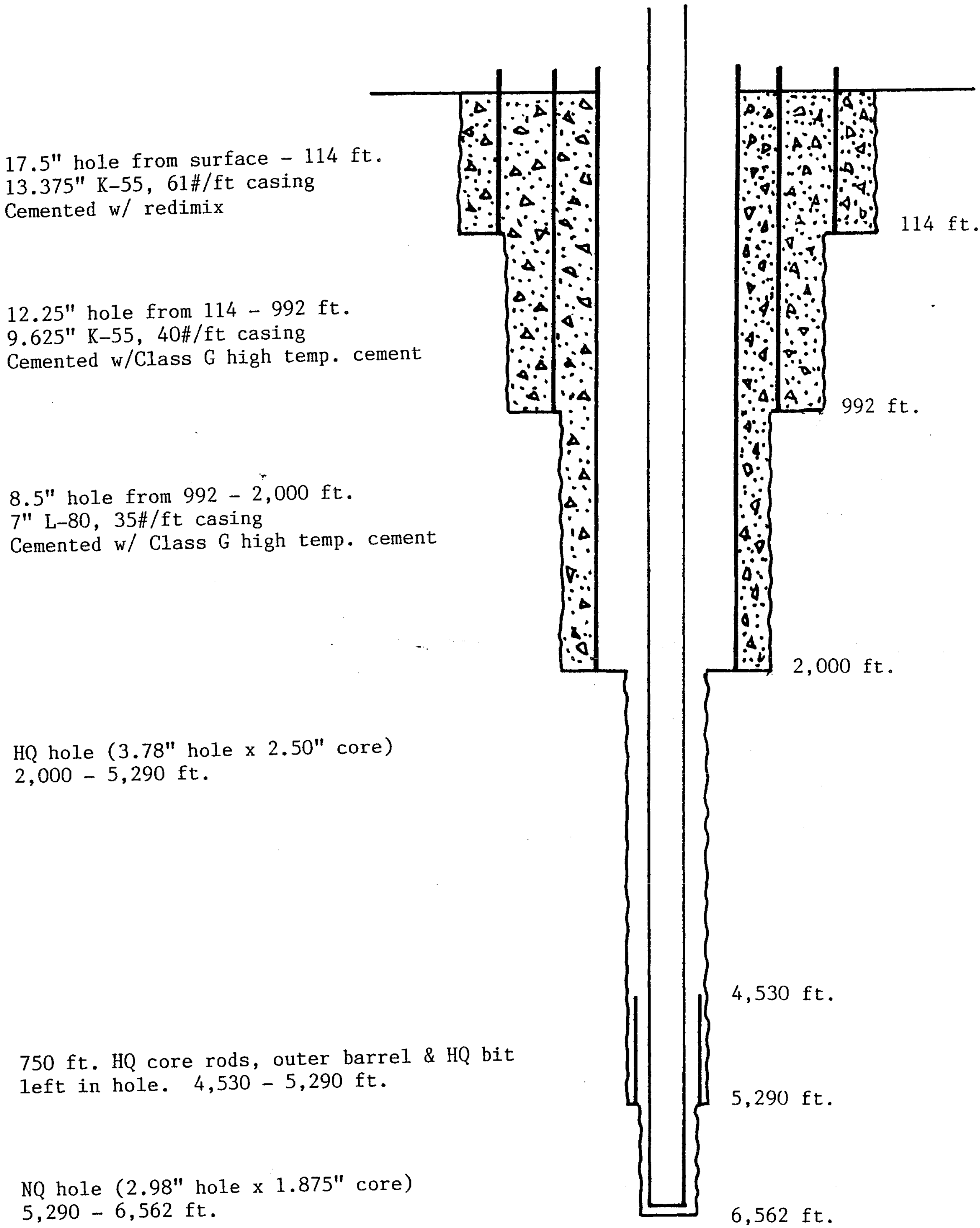
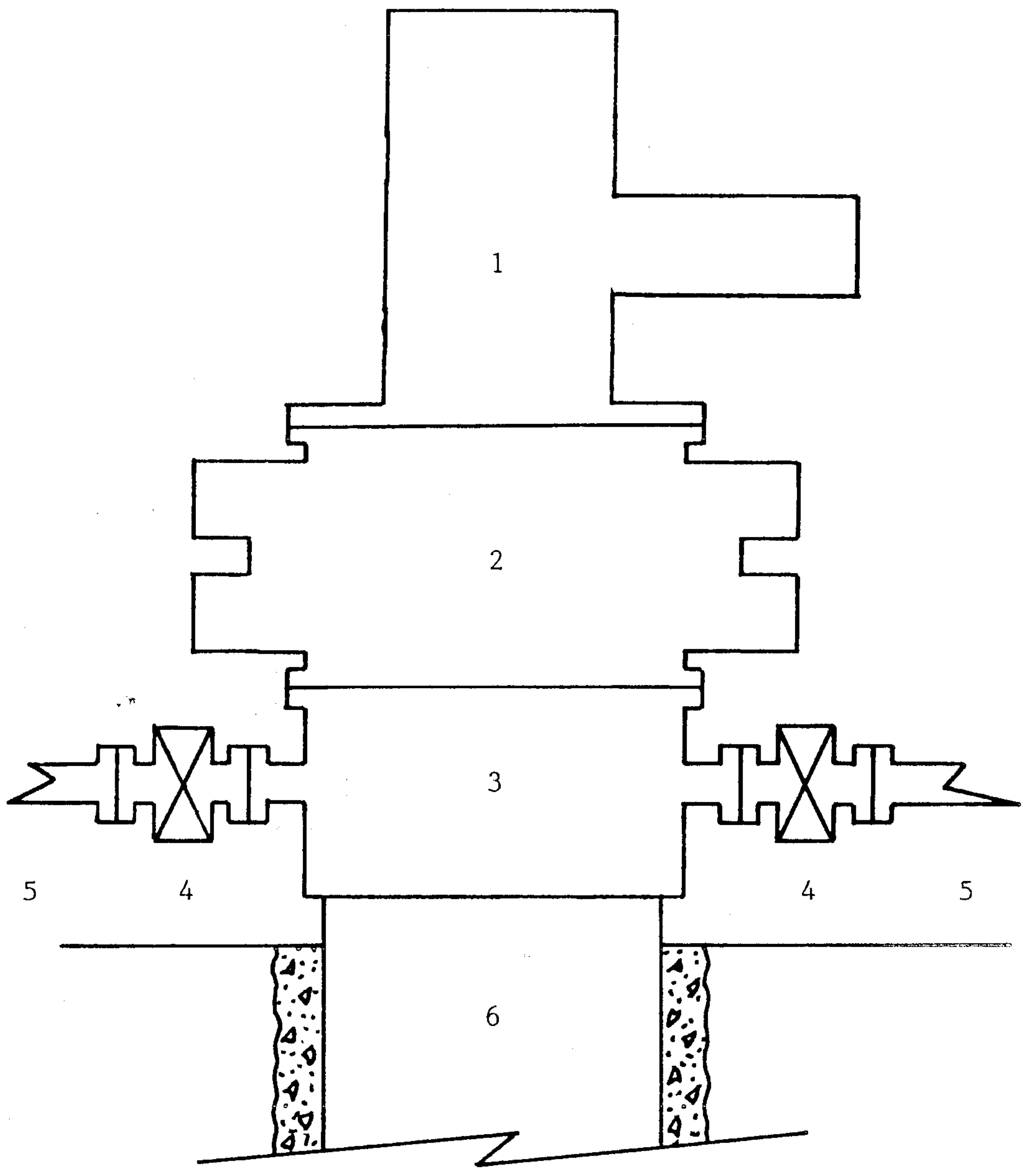
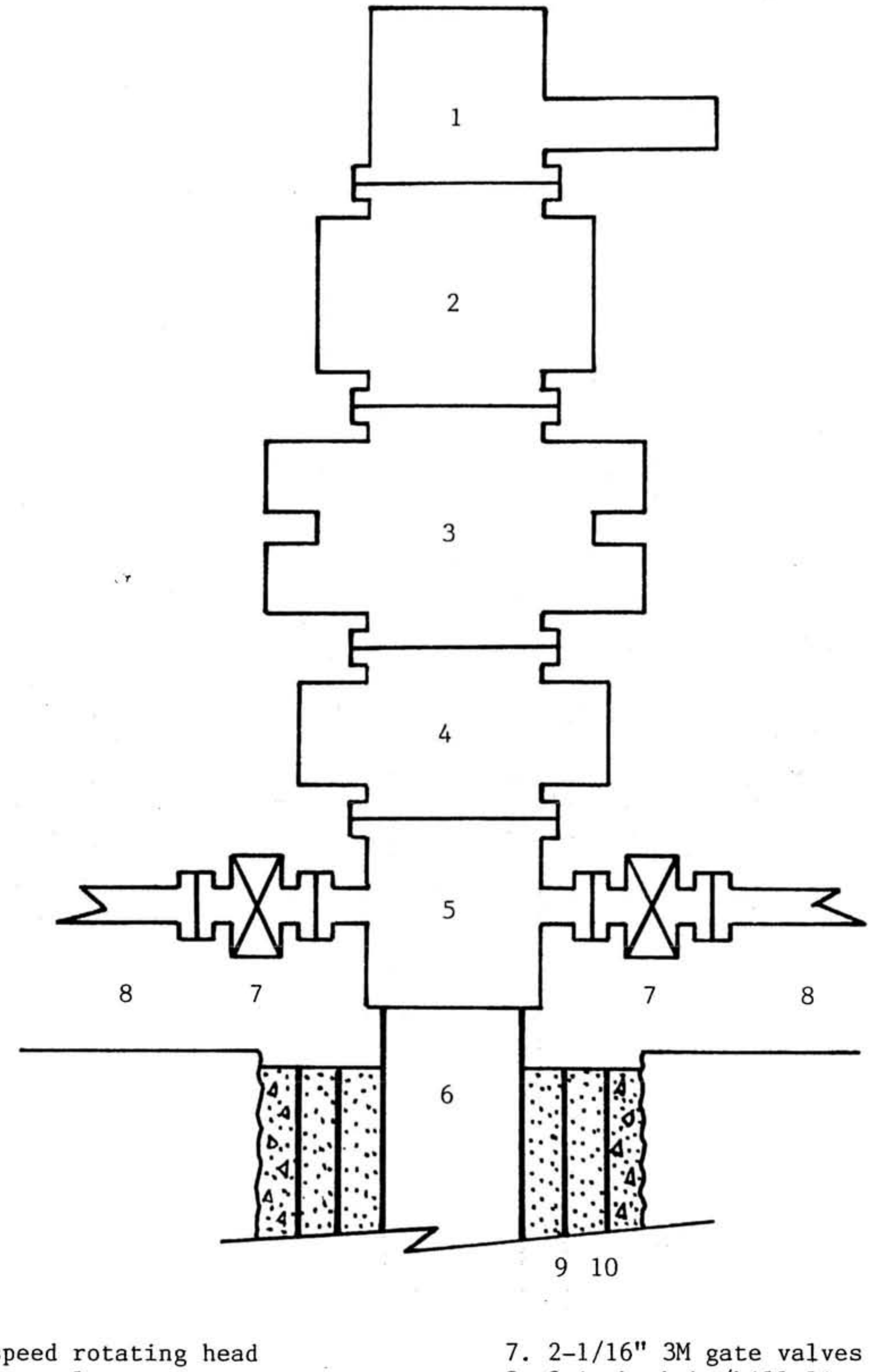


Figure 2
SOH-4
13-3/8" Wellhead



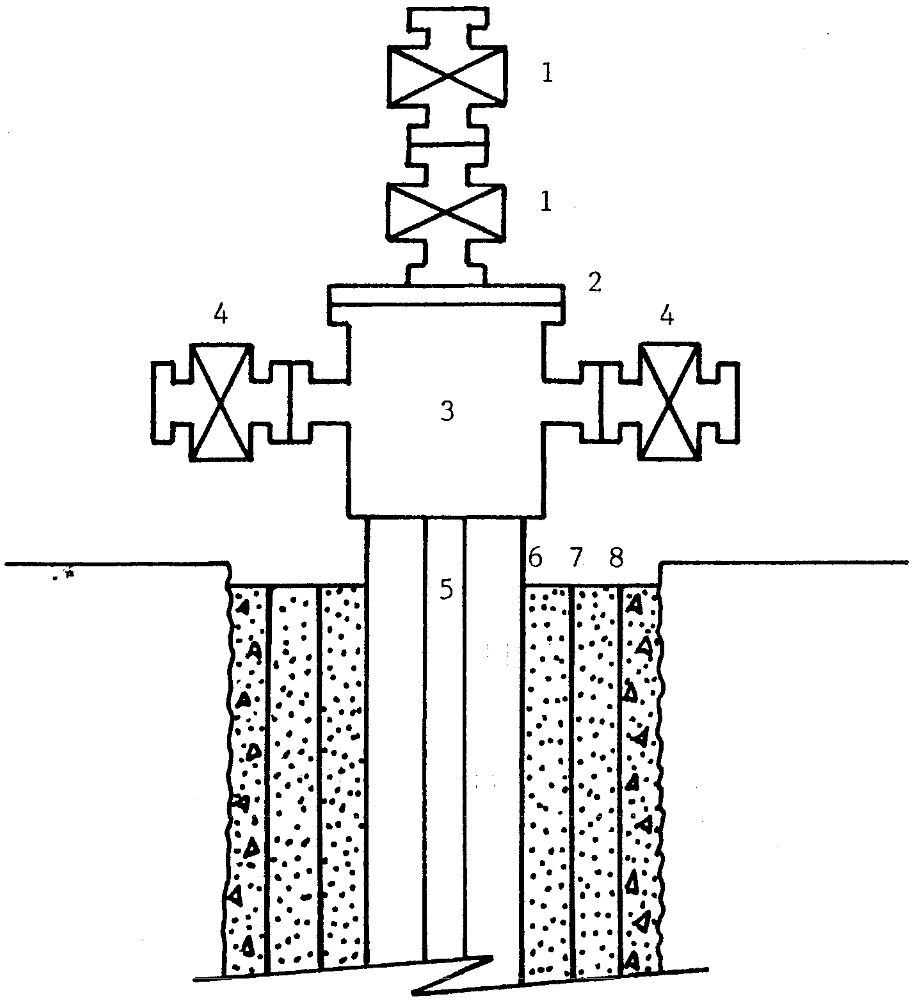
1. High speed rotating head
2. Hydraulic 3M double-gate 12 inch preventer
3. Series 900 slip-on wellhead
4. 3M 2-1/16 inch gate valves
5. 2 inch choke/kill lines
6. 13-3/8 inch K-55 casing

Figure 3
SOH-4
7 Inch Wellhead



1. High speed rotating head
2. 6 inch annular preventer
3. Hydraulic 3M double-gate
4. 6 inch 3M gate valve
5. Series 900 7 inch slip on wellhead
6. 7 inch L-80 casing
7. 2-1/16" 3M gate valves
8. 2 inch choke/kill lines
9. 9-5/8" K-55 casing
10. 13-3/8" K-55 casing

Figure 4
SOH-4
Completion Wellhead



1. 2-9/16" 3M gate valves
2. Reducing flange
3. 7 inch Series 900 slip-on wellhead
4. 2-1/16" gate valves
5. NQ (2.75") slotted tubing
6. 7 inch L-80 casing
7. 9-5/8" K-55 casing
8. 13-3/8" K-55 casing

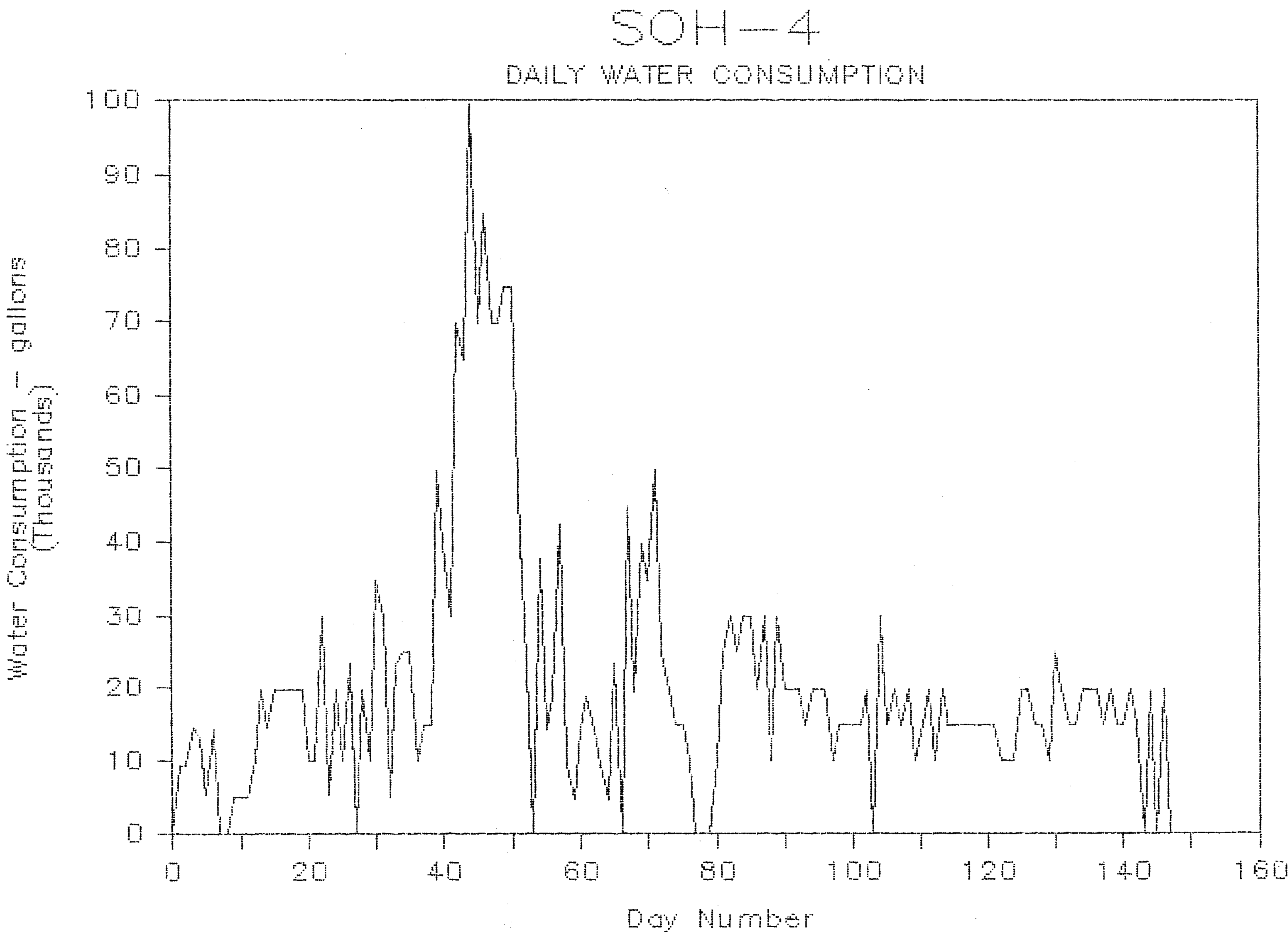

SOH-4
DAILY WATER CONSUMPTION
Water Consumption - gallons (Thousands)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
Day Number

Figure 5

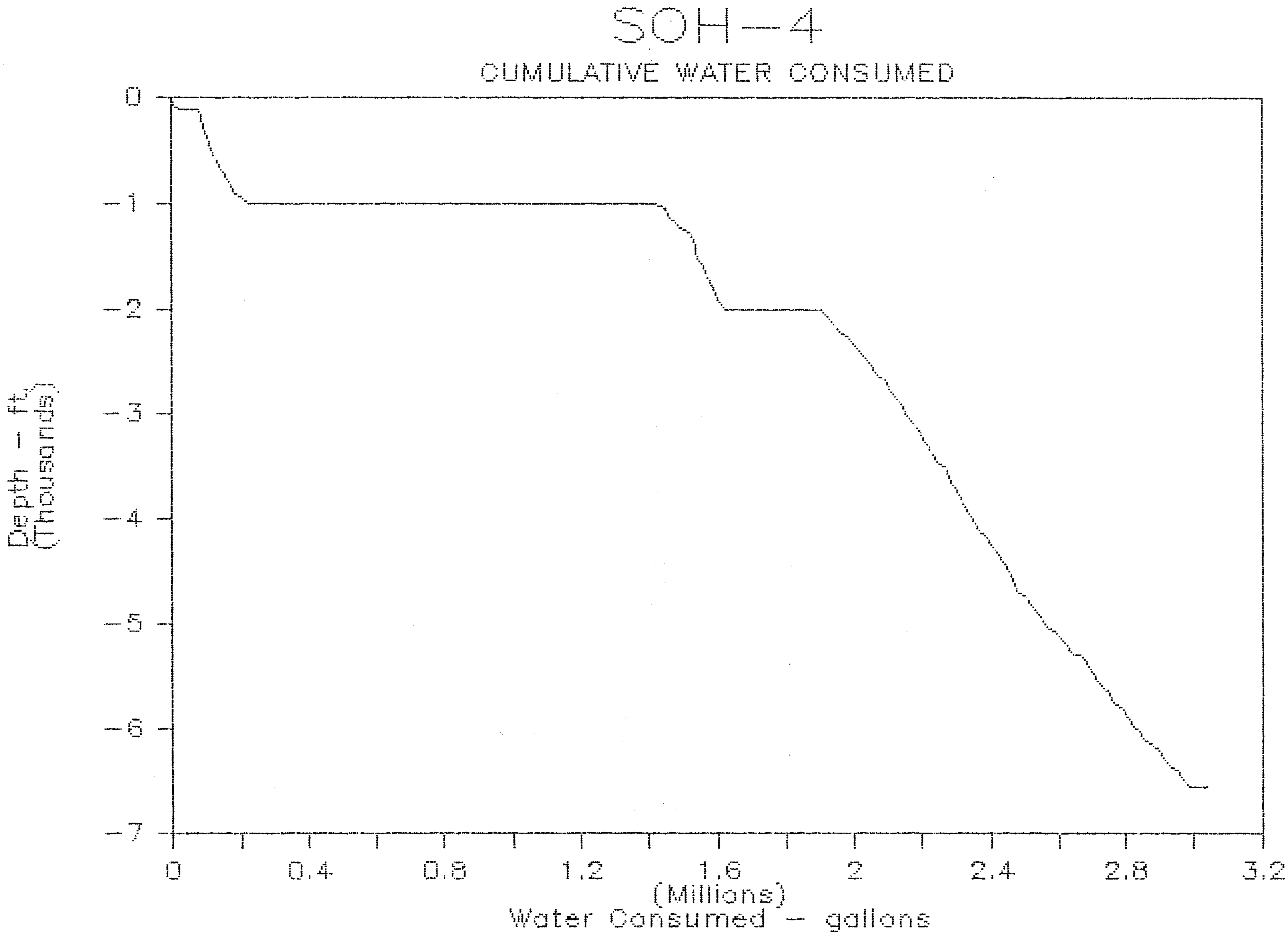

SOH-4
CUMULATIVE WATER CONSUMED
Depth - ft.
(Thousands)
0
-1
-2
-3
-4
-5
-6
-7
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
(Millions)
Water Consumed -- gallons

Figure 6

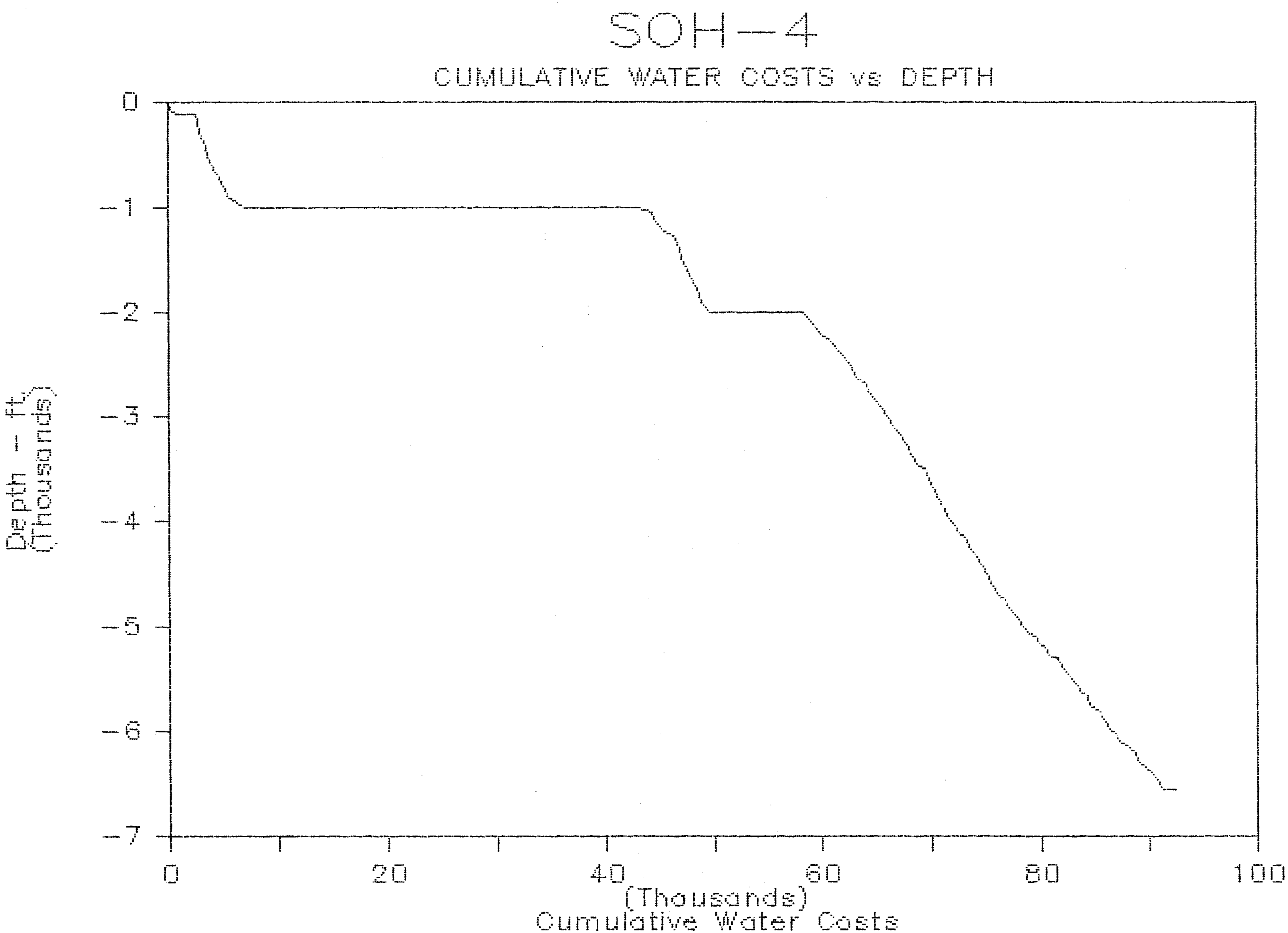

SOH-4
CUMULATIVE WATER COSTS vs DEPTH
Depth - ft.
(Thousands)
0
-1
-2
-3
-4
-5
-6
-7
0
20
40
60
80
100
(Thousands)
Cumulative Water Costs

Figure 7

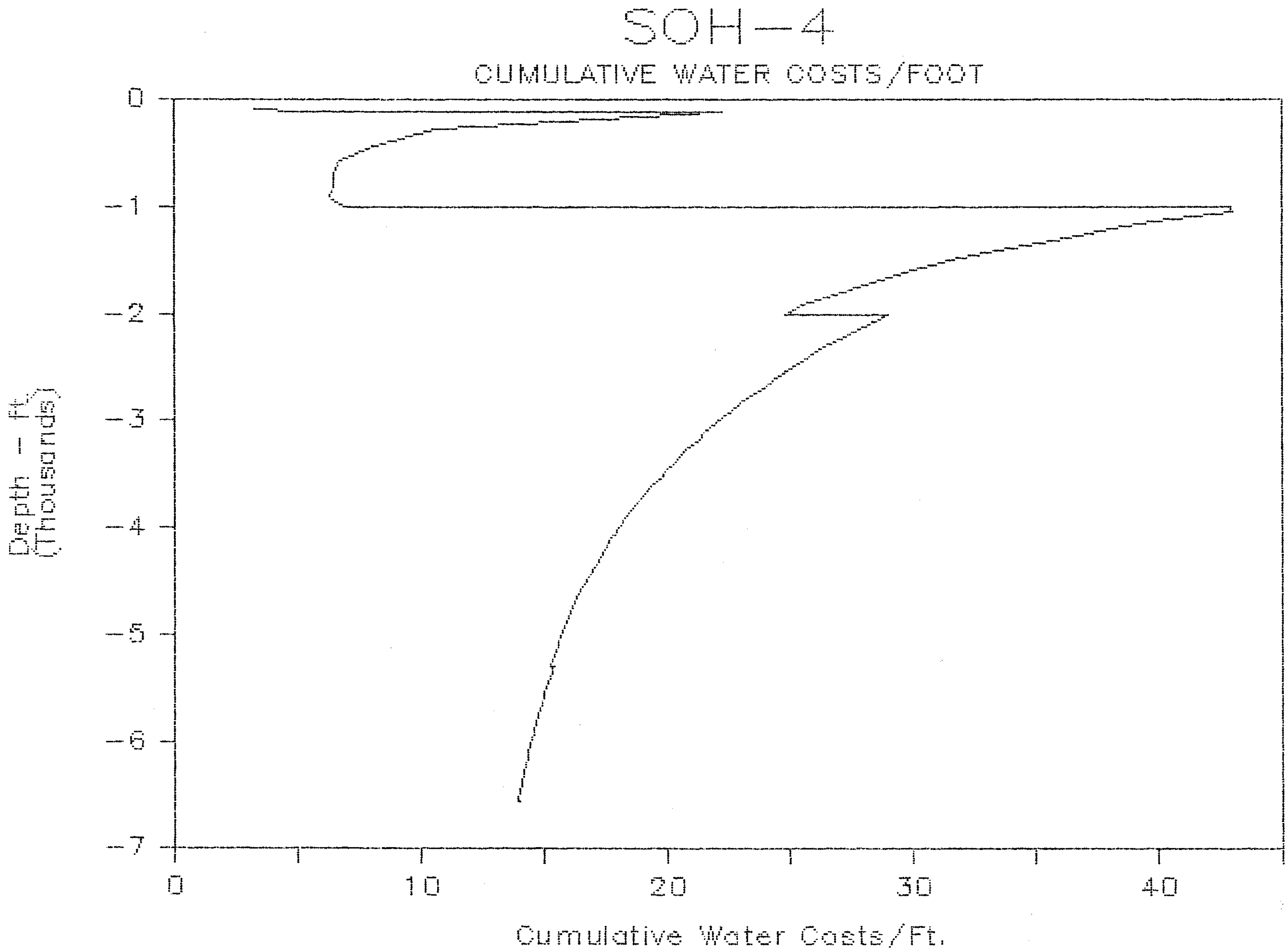

SOH-4
CUMULATIVE WATER COSTS/FOOT
0
-1
-2
-3
-4
-5
-6
-7
Depth - Ft.
(Thousands)
0
10
20
30
40
Cumulative Water Costs/Ft.

Figure 8

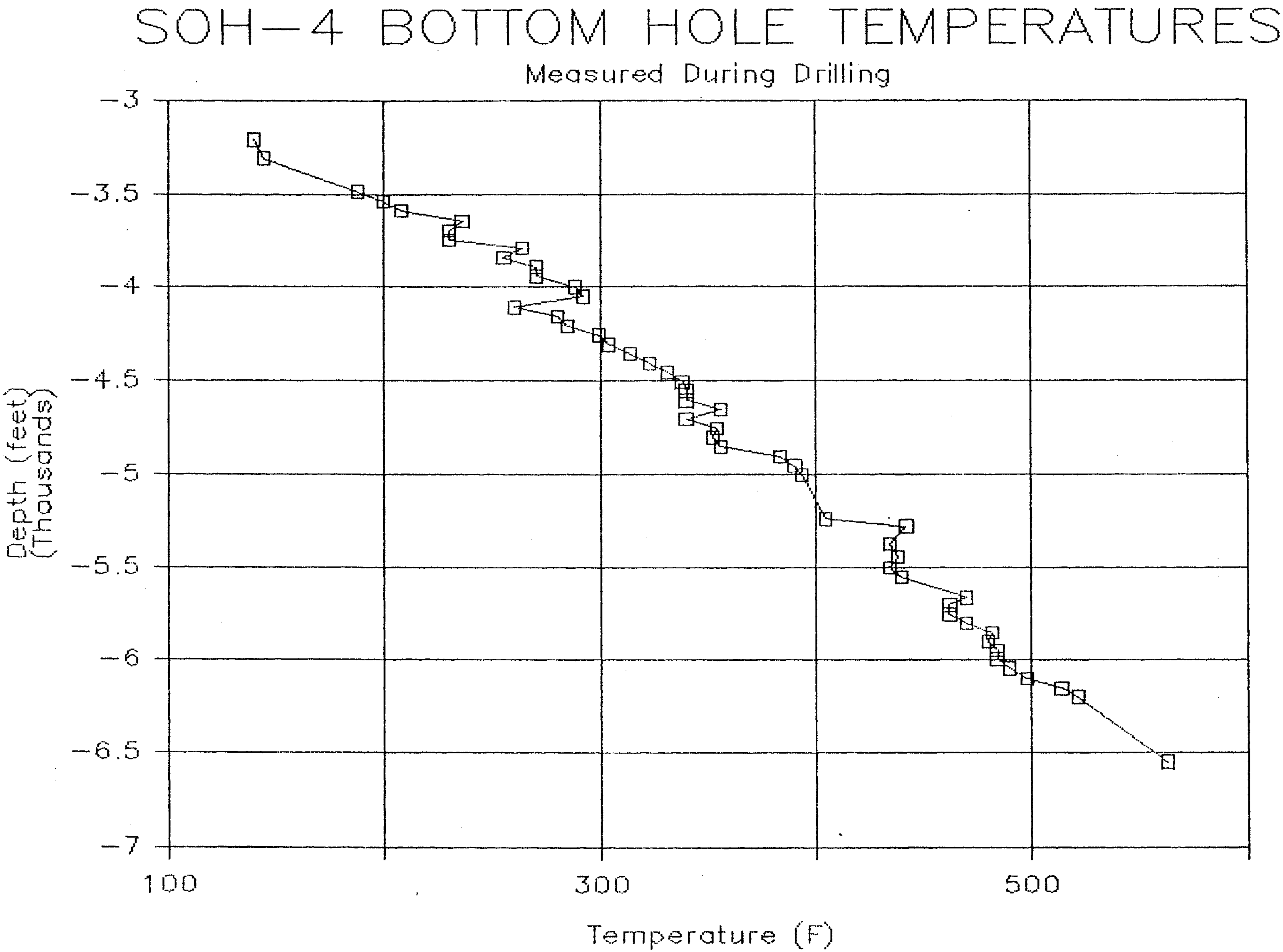
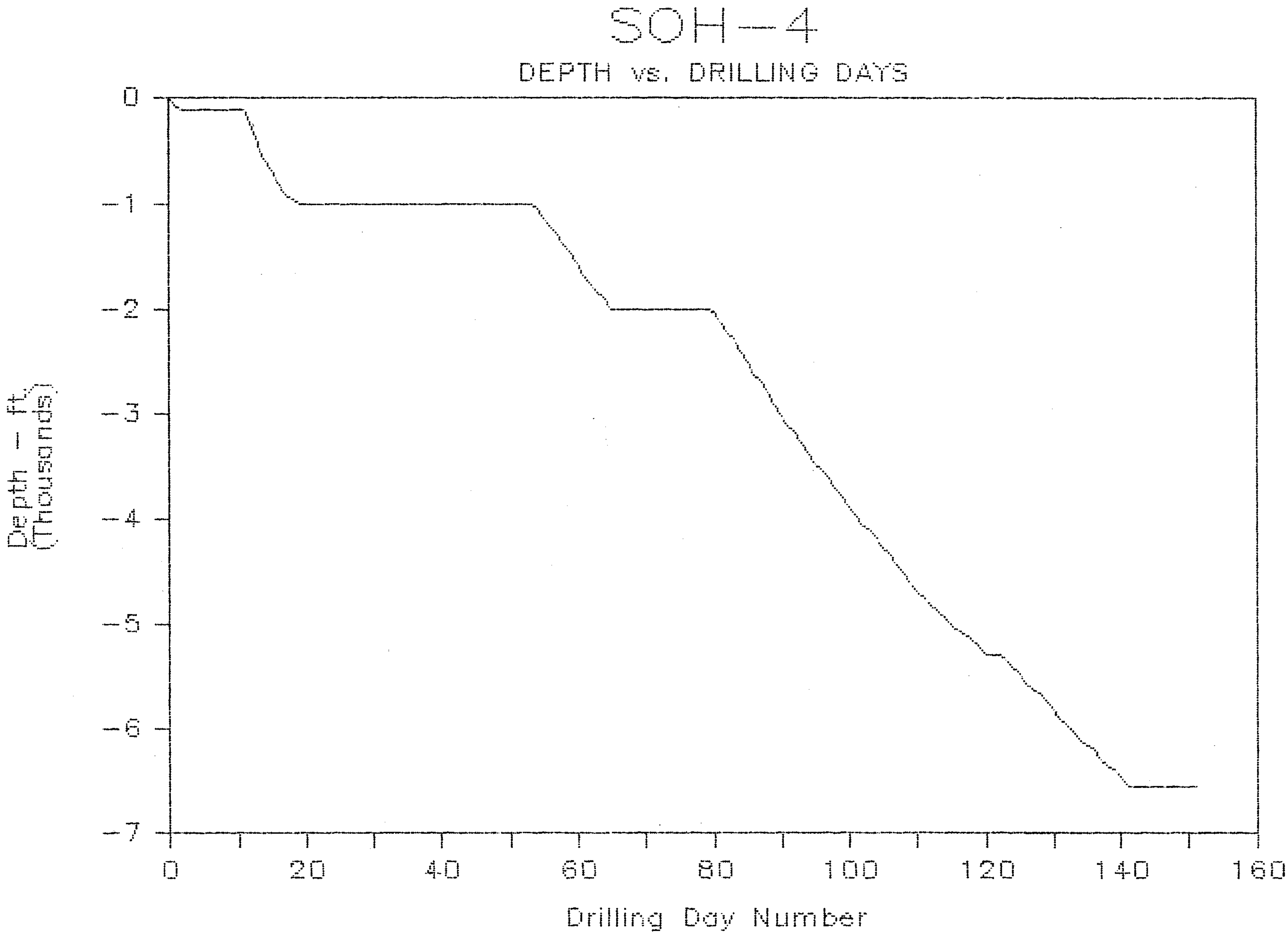

SOH-4 BOTTOM HOLE TEMPERATURES
Measured During Drilling
Depth (feet)
(Thousands)
-3
-3.5
-4
-4.5
-5
-5.5
-6
-6.5
-7
100
300
500
Temperature (F)

Figure 9



SOH-4
DEPTH vs. DRILLING DAYS
Depth - ft.
(Thousands)
0
-1
-2
-3
-4
-5
-6
-7
0
20
40
60
80
100
120
140
160
Drilling Day Number

Figure 10

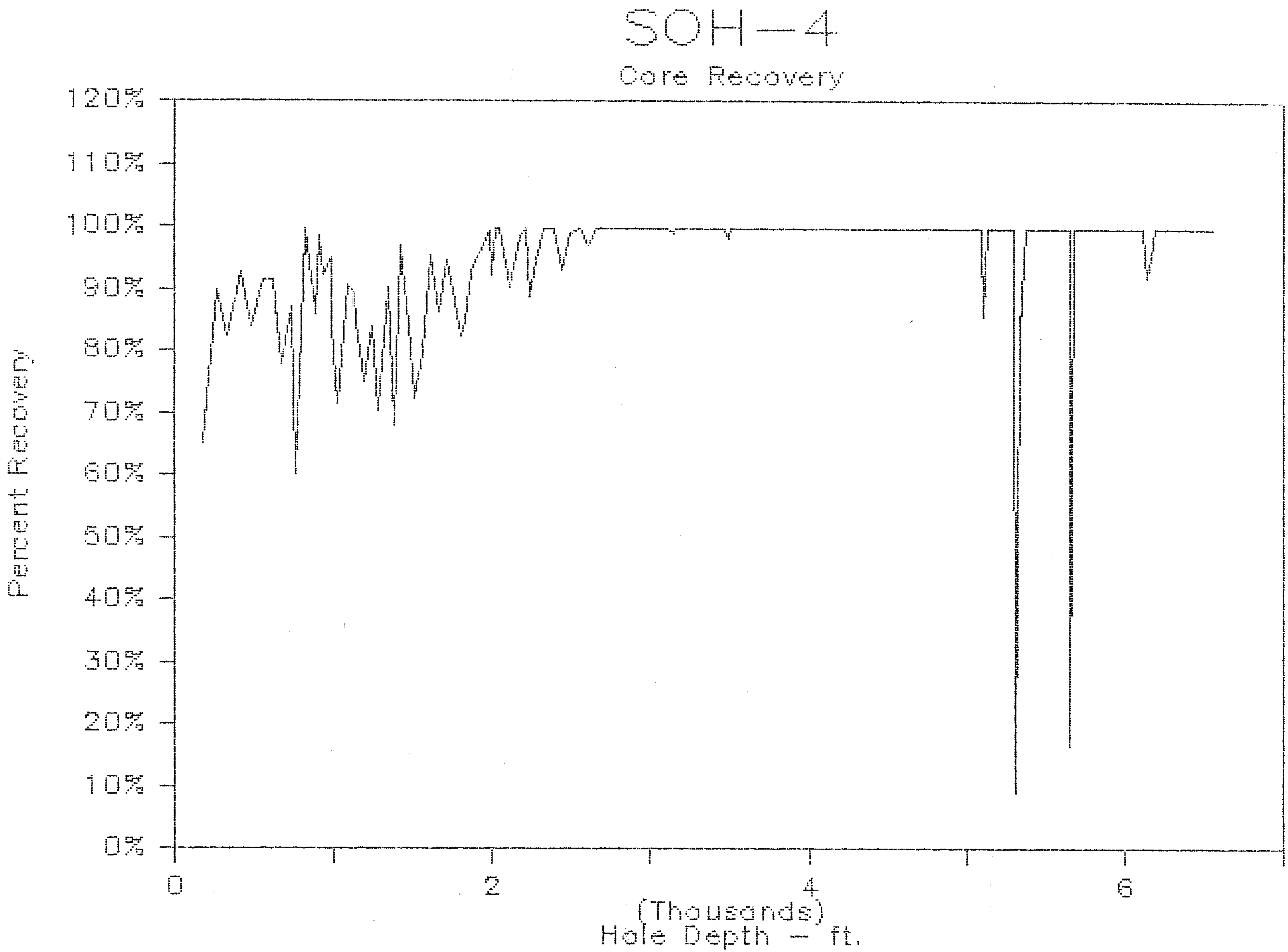

SOH-4
Core Recovery
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Recovery
0
2
4
6
(Thousands)
Hole Depth - ft.

Figure 11

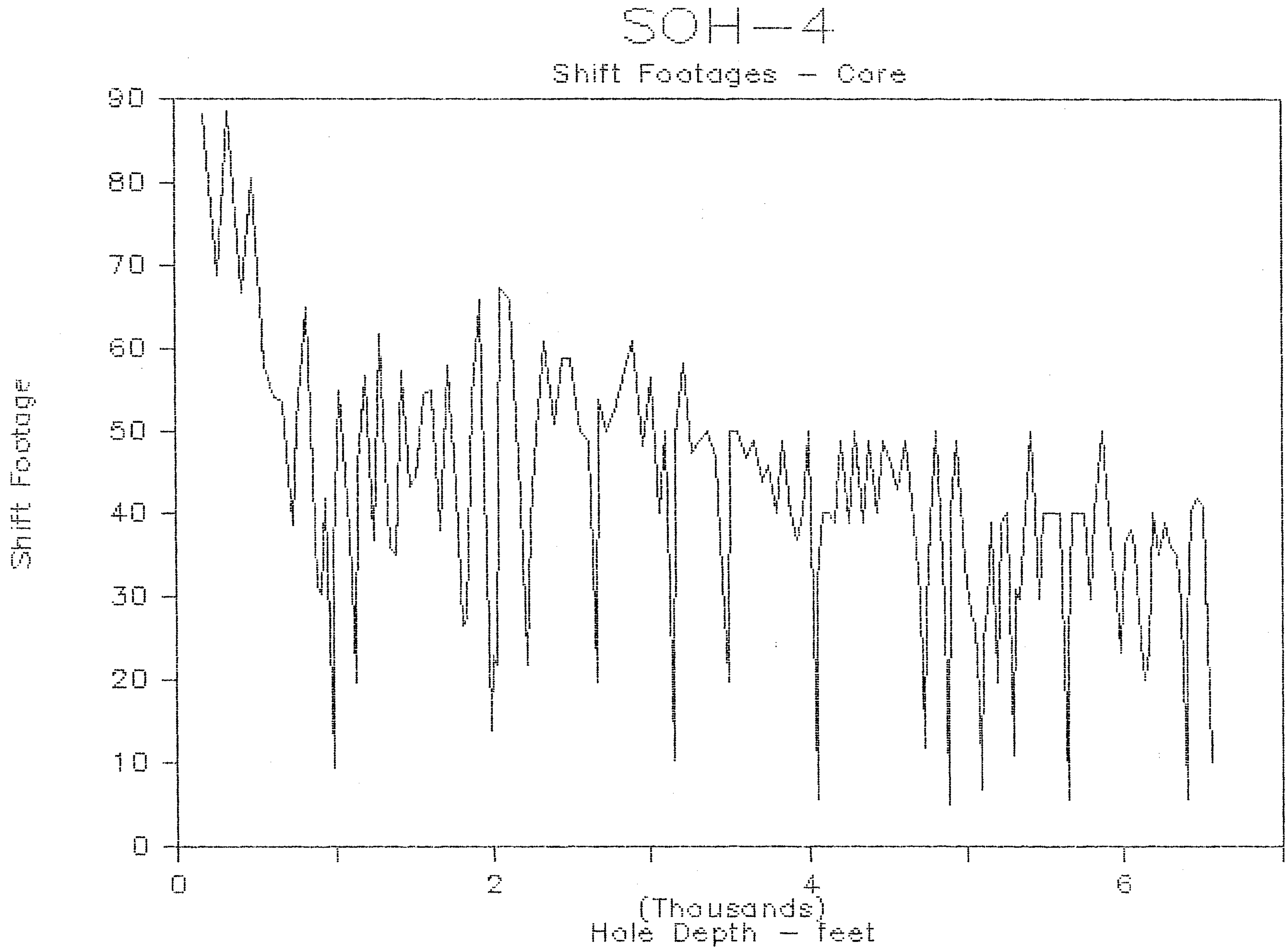

SOH-4
Shift Footages - Core
Shift Footage
90
80
70
60
50
40
30
20
10
0
0
2
4
6
(Thousands)
Hole Depth - feet

Figure 12

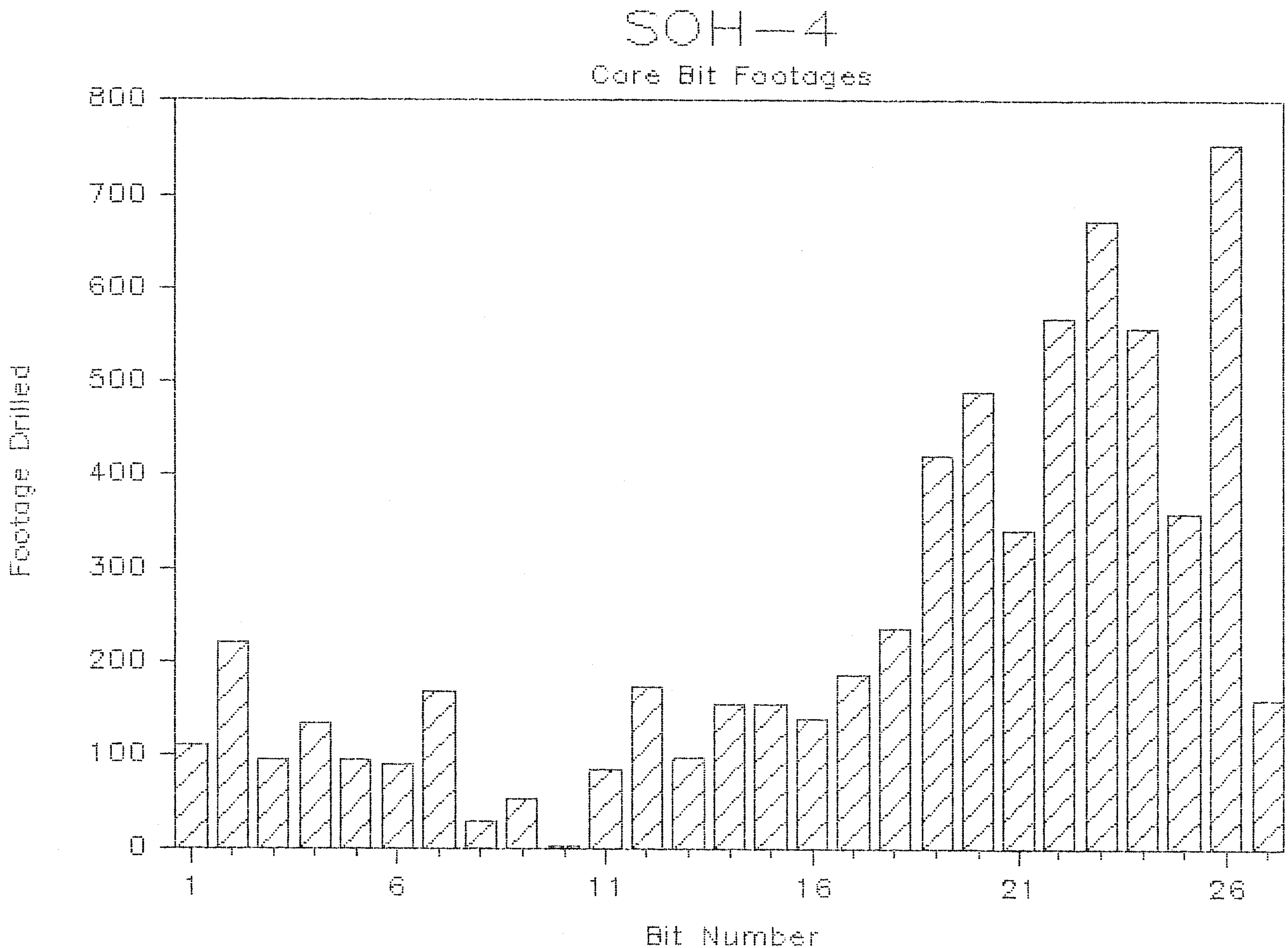

SOH-4
Core Bit Footages
Footage Drilled
0
100
200
300
400
500
600
700
800
1
6
11
16
21
26
Bit Number

Figure 13

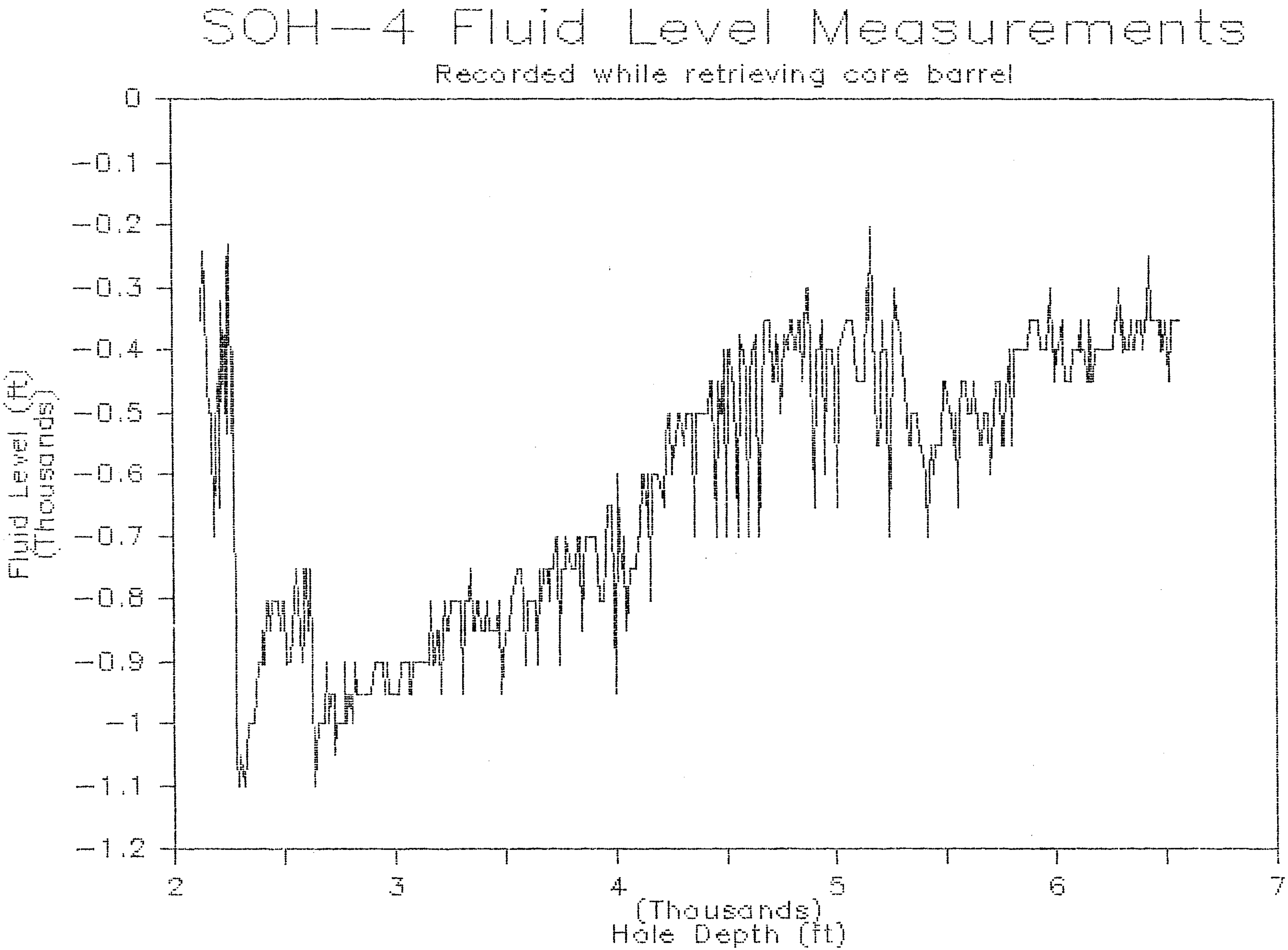

SOH-4 Fluid Level Measurements
Recorded while retrieving core barrel
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
Fluid Level (ft)
(Thousands)
2
3
4
5
6
7
(Thousands)
Hole Depth (ft)

Figure 14

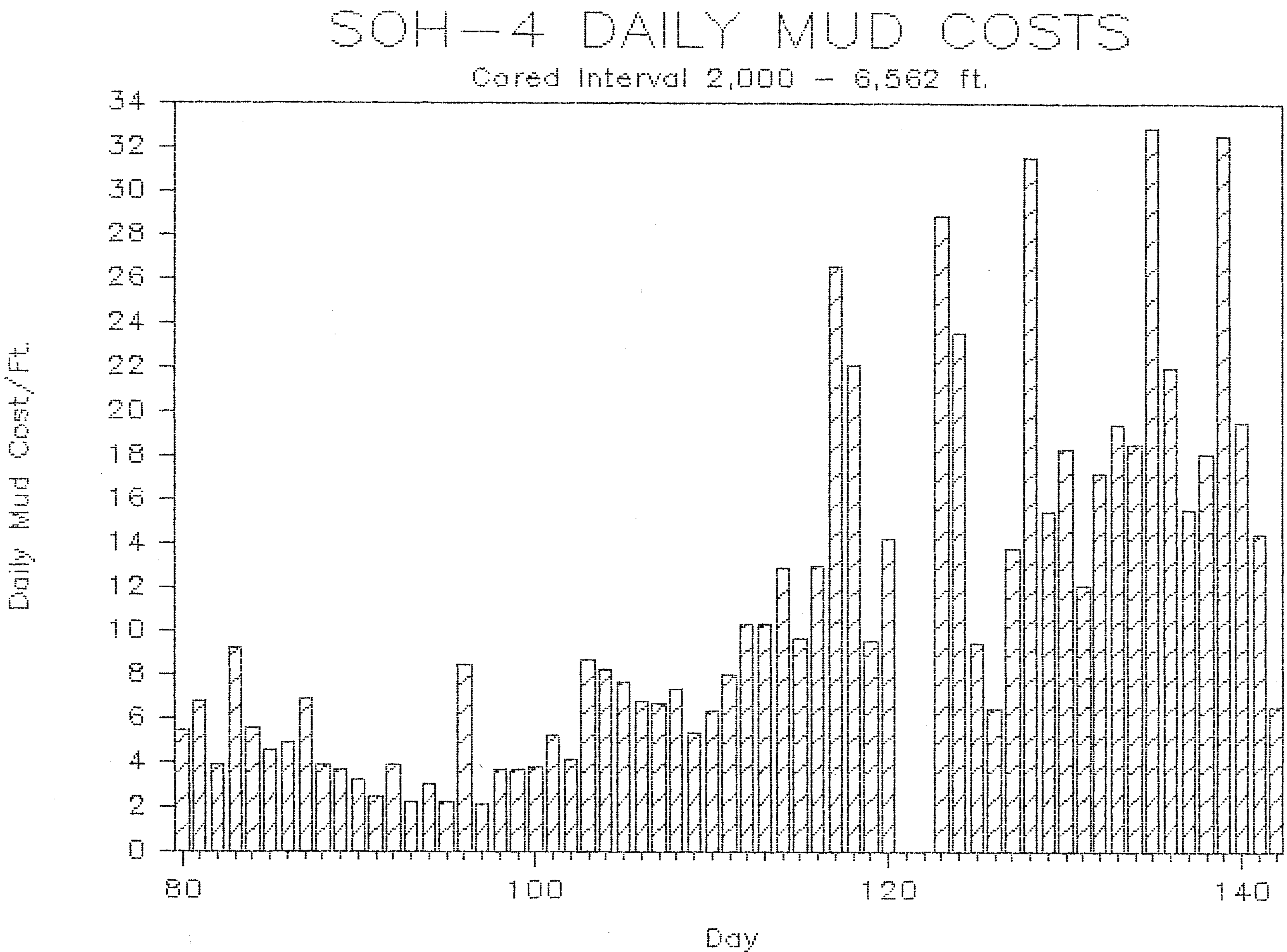

SOH-4 DAILY MUD COSTS
Cored Interval 2,000 - 6,562 ft.
Daily Mud Cost/Ft.
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
80
100
120
140
Day

Figure 15

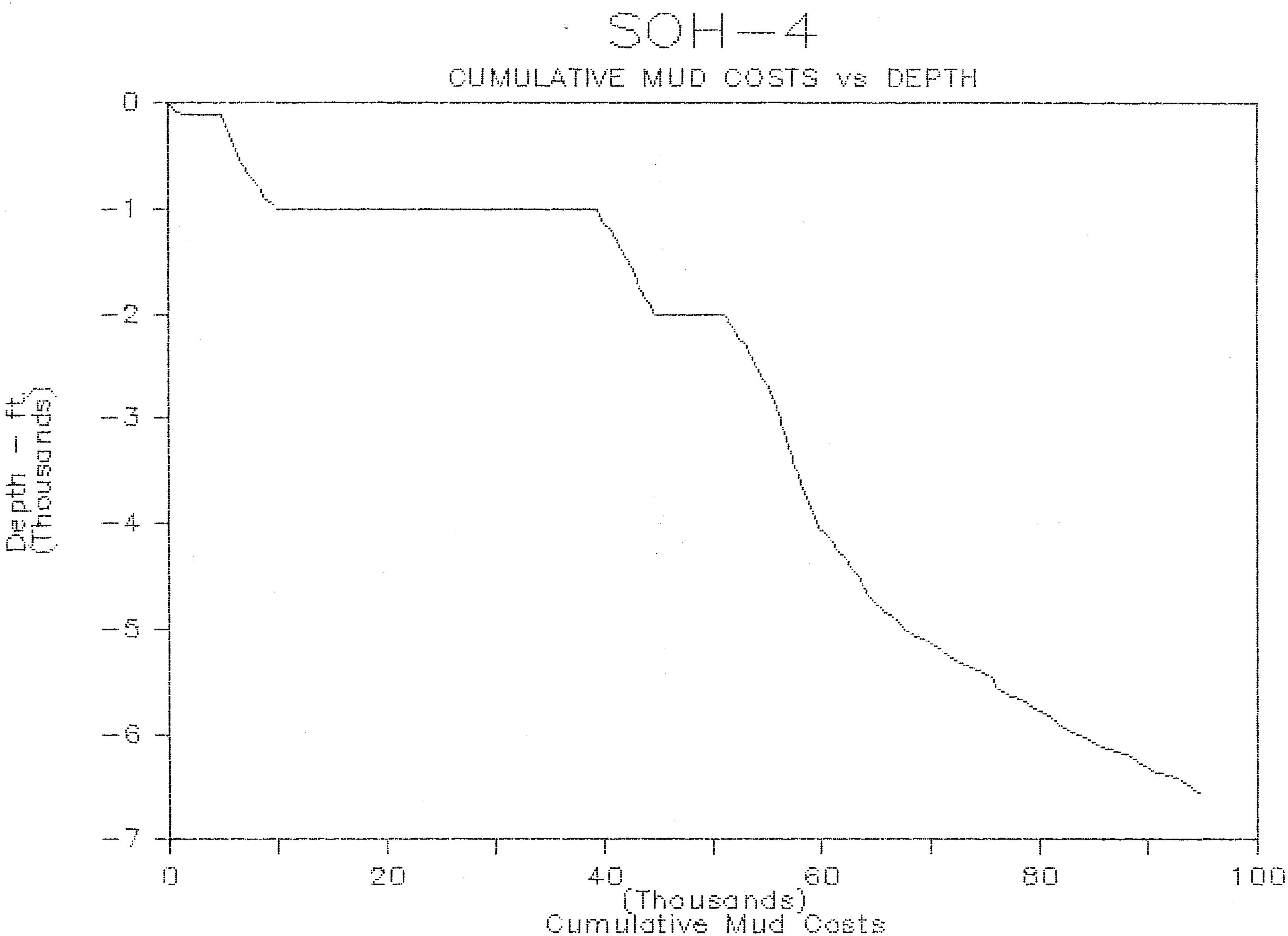

SOH-4
CUMULATIVE MUD COSTS vs DEPTH
Depth - ft.
(Thousands)
0
-1
-2
-3
-4
-5
-6
-7
0
20
40
60
80
100
(Thousands)
Cumulative Mud Costs

Figure 16

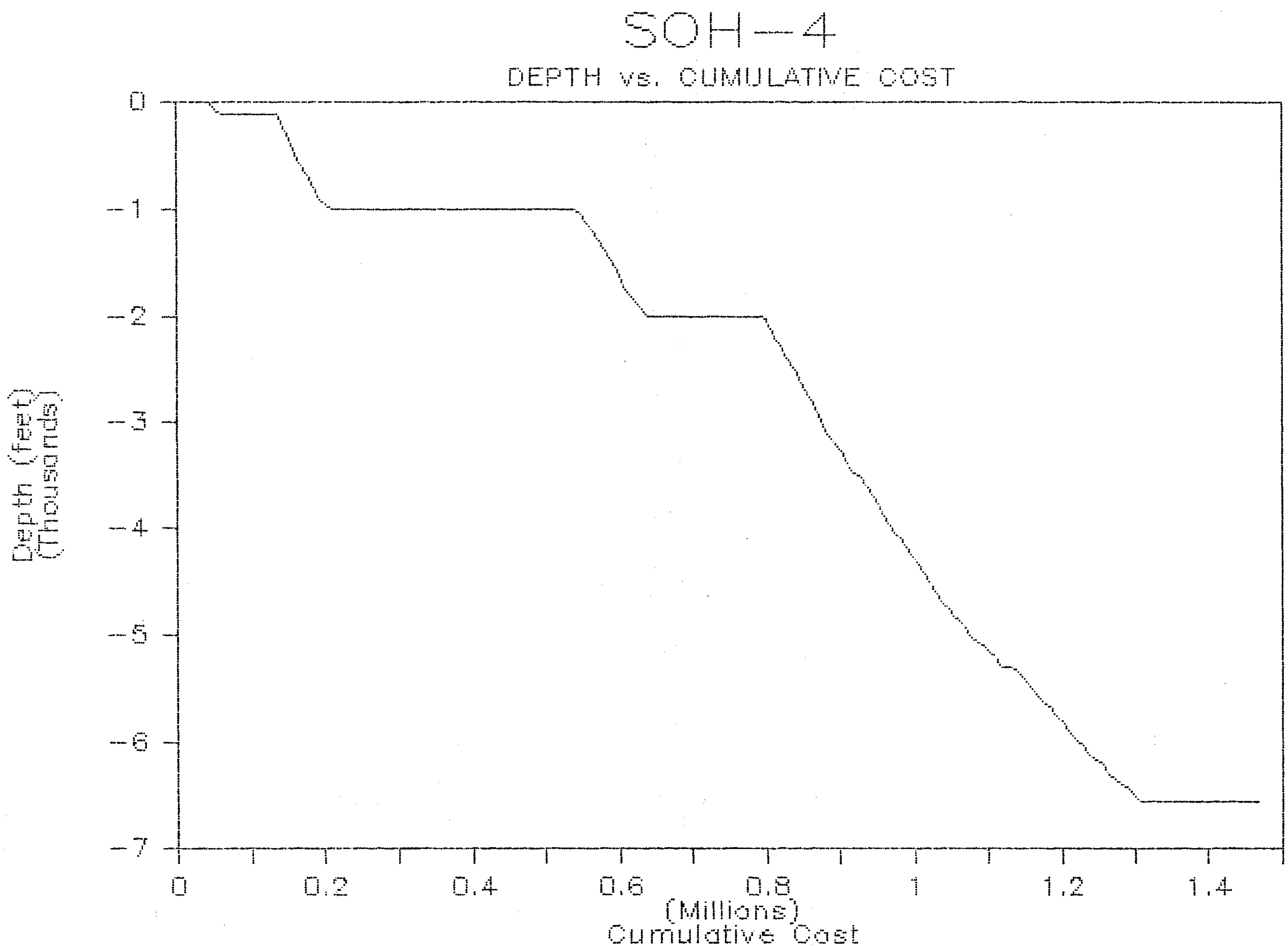

SOH-4
DEPTH vs. CUMULATIVE COST
Depth (feet)
(Thousands)
0
-1
-2
-3
-4
-5
-6
-7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
(Millions)
Cumulative Cost

Figure 17

Table 2
SOH-4

Fluid Level Recorded While Retrieving Core Barrel

Hole Depth	Fluid Depth		Hole Depth	Fluid Depth		Hole Depth	Fluid Depth		Hole Depth	Fluid Depth	
2,122	350		2,571	850		3,040	900		3,570	750	
2,129	240		2,581	900		3,050	900		3,580	800	
2,139	300		2,587	850		3,060	900		3,590	900	T
2,149	450		2,592	750		3,063	950		3,600	800	
2,158	500		2,601	750		3,073	950		3,610	800	
2,168	500		2,611	850		3,083	900		3,619	800	
2,179	700		2,618	750		3,090	900		3,627	800	
2,185	570		2,625	900		3,100	900		3,637	800	
2,192	530		2,631	1100		3,110	900		3,647	900	T
2,197	470		2,641	1050		3,120	900		3,657	750	
2,203	430		2,650	1000		3,130	900		3,667	800	
2,211	650		2,670	1000		3,140	900		3,677	750	
2,220	320		2,680	1000		3,150	900		3,688	750	
2,230	500		2,689	900		3,161	800		3,698	800	
2,240	250		2,699	1000		3,171	900		3,706	750	
2,242	500		2,704	950		3,180	900		3,716	750	
2,244	530		2,714	950		3,190	850		3,726	700	
2,252	230		2,724	950		3,200	850		3,736	700	
2,254	250		2,728	1050		3,210	950	T	3,743	700	
2,264	530		2,734	1000		3,220	850		3,750	900	T
2,271	400		2,741	1000		3,230	800		3,757	750	
2,281	1050		2,751	1000		3,239	850		3,766	750	
2,292	1100		2,758	1000		3,248	850		3,775	750	
2,302	1050		2,768	1000		3,258	800		3,779	700	
2,311	1100		2,776	900		3,269	800		3,806	750	
2,320	1100		2,778	1000		3,279	800		3,816	750	
2,331	1000		2,784	1000		3,289	800		3,826	700	
2,335	1000		2,787	950		3,297	800		3,836	700	
2,342	1000		2,787	950		3,306	950	T	3,846	850	T
2,352	1000		2,797	950		3,316	800		3,856	750	
2,362	1000		2,807	1000		3,326	800		3,865	700	
2,372	950		2,817	900		3,336	800		3,875	700	
2,383	900		2,827	950		3,345	750		3,885	700	
2,392	900		2,837	950		3,355	850		3,905	700	
2,396	900		2,847	950		3,365	850		3,915	700	
2,400	850		2,853	950		3,375	800		3,925	800	
2,409	900		2,863	950		3,385	800		3,934	800	
2,419	800		2,874	950		3,395	850		3,944	800	T
2,427	800		2,884	950		3,405	850		3,952	800	
2,437	850		2,894	950		3,415	800		3,962	650	
2,443	800		2,904	900		3,425	850		3,972	650	
2,453	800		2,914	900		3,435	850		3,982	650	
2,463	800		2,924	900		3,442	850		3,992	800	
2,473	800		2,935	900		3,452	850		4,002	950	T
2,482	850		2,945	900		3,462	850		4,012	600	
2,492	800		2,955	950		3,471	800		4,022	700	
2,502	800		2,965	900		3,476	800		4,032	750	
2,512	900		2,975	950		3,485	950	T	4,042	700	
2,522	900		2,985	950		3,500	850		4,052	850	T
2,532	850		2,993	950		3,510	850		4,061	750	
2,542	800		3,014	950		3,520	850		4,071	750	
2,552	750		3,020	950		3,530	800		4,081	750	
2,561	800		3,030	900		3,560	750		4,090	750	

SOH-4

Fluid Level Recorded While Retrieving Core Barrel

Hole Depth	Fluid Depth	Hole Depth	Fluid Depth	Hole Depth	Fluid Depth	Hole Depth	Fluid Depth
4,100	700	4,613	450	5,152	350	5,682	500
4,110	700 T	4,622	400	5,162	200	5,692	500
4,120	600	4,632	400	5,171	350	5,702	600 T
4,130	600	4,642	375	5,181	450	5,722	450
4,140	650	4,652	700 T	5,191	550	5,732	450
4,150	600	4,671	500	5,198	550	5,742	450
4,160	800	4,681	350	5,201	500	5,752	550 T
4,170	600	4,691	350	5,205	450	5,762	550
4,179	600	4,701	350	5,211	350	5,772	450
4,189	600	4,711	450	5,220	400	5,782	450
4,199	600	4,721	450	5,230	400	5,792	400
4,219	650	4,731	400	5,240	700 T	5,802	550 T
4,229	550	4,733	375	5,260	400	5,812	400
4,238	500	4,743	400	5,270	300	5,822	400
4,248	500	4,753	500 T	5,280	350	5,832	400
4,258	600	4,763	450	5,290	350	5,842	400
4,258	600	4,772	375	5,322	500	5,852	400
4,268	550	4,782	400	5,332	550	5,862	400
4,278	550	4,792	350	5,339	550	5,872	400
4,288	500	4,802	350	5,344	500	5,882	350
4,297	500	4,811	400	5,352	500	5,892	350
4,307	550 T	4,821	400	5,362	500	5,902	350
4,317	500	4,831	350	5,372	500	5,912	350
4,327	500	4,841	350	5,382	550	5,922	350
4,337	500	4,851	450 T	5,392	550	5,929	350
4,347	500	4,871	300	5,402	600	5,939	400
4,357	700 T	4,880	300	5,412	700	5,949	400
4,367	500	4,905	650 T	5,422	600	5,959	400
4,377	500	4,915	400	5,432	550	5,969	350
4,386	500	4,925	400	5,442	600 T	5,979	300
4,396	500	4,935	400	5,452	550	5,989	400
4,406	500	4,945	350	5,462	550	5,993	400
4,416	500	4,954	600 T	5,472	550	5,997	400
4,425	500	4,964	400	5,482	550	6,000	400
4,435	450	4,974	400	5,492	450	6,003	450
4,445	450	4,984	400	5,502	450	6,012	400
4,455	700 T	4,994	450	5,512	500	6,022	400
4,465	450	5,004	650 T	5,522	500	6,032	350
4,475	500	5,014	450	5,532	550	6,039	400
4,485	500	5,018	400	5,542	500	6,048	450
4,494	400	5,046	350	5,552	650 T	6,057	450
4,504	700 T	5,053	350	5,562	500	6,067	450
4,514	400	5,059	350	5,572	450	6,077	400
4,524	400	5,063	350	5,582	450	6,087	400
4,534	450	5,073	350	5,592	450	6,092	400
4,543	450	5,081	350	5,602	500 T	6,102	400
4,553	700	5,095	450	5,612	500	6,110	400
4,563	375	5,098	450	5,622	450	6,113	350
4,570	375	5,103	450	5,632	500	6,122	400
4,575	400	5,113	450	5,642	500	6,132	400
4,583	400	5,123	450	5,655	550	6,134	400
4,593	450	5,133	450	5,662	550	6,148	450
4,603	700 T	5,142	300	5,672	500	6,154	450

Fluid Level Recorded While Retrieving Core Barrel

Hole Depth	Fluid Depth	Hole Depth	Fluid Depth	Hole Depth	Fluid Depth	Hole Depth	Fluid Depth
6,156	400						
6,158	350						
6,160	400						
6,164	450						
6,166	450						
6,172	450						
6,182	400						
6,192	400						
6,202	400						
6,212	400						
6,222	400						
6,232	400						
6,242	400						
6,252	400						
6,257	400						
6,262	400						
6,272	350						
6,282	350						
6,286	300						
6,296	350						
6,306	400						
6,312	350						
6,313	400						
6,322	400						
6,332	400						
6,342	350						
6,352	400						
6,362	400						
6,367	400						
6,376	350						
6,382	350						
6,390	350						
6,396	400						
6,402	400						
6,409	350						
6,419	350						
6,429	250						
6,439	350						
6,449	350						
6,459	350						
6,469	350						
6,479	400						
6,481	350						
6,491	400						
6,501	350						
6,511	400						
6,521	450						
6,531	350						
6,541	350						
6,552	350						
6,562	350						

T: Measured during temperature surveys

Table 3
SOH-4 Bottom Hole Temperatures

Depth (ft.)	Temp (F)	Depth (m)	Temp (C)	Notes
3,210	140	979	60	Near bottom, 1 hr. after circ.
3,306	144	1,008	62	Near bottom, 1 hr. after circ.
3,485	188	1,063	87	Near bottom, 1 hr. after circ.
3,540	200	1,079	93	Near bottom, 1 hr. after circ.
3,590	208	1,095	98	Near bottom, 1 hr. after circ.
3,647	236	1,112	113	Near bottom, 1 hr. after circ.
3,698	230	1,127	110	Near bottom, 1 hr. after circ.
3,750	230	1,143	110	Near bottom, 1 hr. after circ.
3,796	264	1,157	129	Near bottom, 1 hr. after circ.
3,846	255	1,173	124	Near bottom, 1 hr. after circ.
3,895	270	1,188	132	Near bottom, 1 hr. after circ.
3,944	270	1,202	132	Near bottom, 1 hr. after circ.
4,002	288	1,220	142	Near bottom, 1 hr. after circ.
4,052	292	1,235	144	Near bottom, 1 hr. after circ.
4,110	260	1,253	127	Near bottom, 1 hr. after circ.
4,160	280	1,268	138	Near bottom, 1 hr. after circ.
4,209	285	1,283	141	Near bottom, 1 hr. after circ.
4,258	299	1,298	148	Near bottom, 1 hr. after circ.
4,307	304	1,313	151	Near bottom, 1 hr. after circ.
4,357	314	1,328	157	Near bottom, 1 hr. after circ.
4,406	323	1,343	162	Near bottom, 1 hr. after circ.
4,455	331	1,358	166	Near bottom, 1 hr. after circ.
4,504	338	1,373	170	Near bottom, 1 hr. after circ.
4,553	340	1,388	171	Near bottom, 1 hr. after circ.
4,603	340	1,403	171	Near bottom, 1 hr. after circ.
4,652	356	1,418	180	Near bottom, 1 hr. after circ.
4,701	340	1,433	171	Near bottom, 1 hr. after circ.
4,753	354	1,449	179	Near bottom, 1 hr. after circ.
4,802	352	1,464	178	Near bottom, 1 hr. after circ.
4,851	356	1,479	180	Near bottom, 1 hr. after circ.
4,905	383	1,495	195	Near bottom, 1 hr. after circ.
4,954	390	1,510	199	Near bottom, 1 hr. after circ.
5,004	393	1,526	201	Near bottom, 1 hr. after circ.
5,240	404	1,598	207	Near bottom, 1 hr. after circ.
5,280	442	1,610	228	10 ft. off bottom 12 hours after circ.
5,372	434	1,638	223	20 ft off bottom, 30 minutes after circ.
5,442	438	1,659	226	20 ft off bottom, 30 minutes after circ.
5,502	434	1,677	223	20 ft off bottom, 30 minutes after circ.
5,552	440	1,693	227	20 ft off bottom, 30 minutes after circ.
5,662	470	1,726	243	20 ft off bottom, 30 minutes after circ.
5,702	462	1,738	239	20 ft off bottom, 30 minutes after circ.
5,752	462	1,754	239	20 ft off bottom, 30 minutes after circ.
5,802	470	1,769	243	20 ft off bottom, 30 minutes after circ.
5,852	482	1,784	250	20 ft off bottom, 30 minutes after circ.
5,902	480	1,799	249	20 ft off bottom, 30 minutes after circ.
5,949	484	1,814	251	20 ft off bottom, 30 minutes after circ.
5,997	484	1,828	251	20 ft off bottom, 30 minutes after circ.
6,048	490	1,844	254	20 ft off bottom, 30 minutes after circ.
6,102	498	1,860	259	20 ft off bottom, 30 minutes after circ.
6,154	514	1,876	268	20 ft off bottom, 30 minutes after circ.
6,202	522	1,891	272	20 ft off bottom, 30 minutes after circ.
6,546	563	1,996	295	16 ft off bottom, 3.5 hrs after circ.

Table 4
SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
	1	114.2	120.1	5.9	4.0	68%
12 ML (D)	2	120.1	129.9	9.8	7.0	71%
55.1 ft. tot	3	129.9	139.8	9.9	7.0	71%
36.0 ft. recov	4	139.8	149.6	9.8	6.0	61%
65%	5	149.6	159.4	9.8	5.0	51%
	6	159.4	169.3	9.9	7.0	71%
12 JG (N)	1	169.3	179.1	9.8	9.8	100%
88.5 ft. tot	2	179.1	189.0	9.9	9.0	91%
79.7 ft. recov	3	189.0	198.8	9.8	9.5	97%
90%	4	198.8	208.6	9.8	9.8	100%
	5	208.6	218.5	9.9	7.0	71%
	6	218.5	228.3	9.8	6.0	61%
	7	228.3	238.2	9.9	9.8	99%
	8	238.2	248.0	9.8	9.8	100%
	9	248.0	257.8	9.8	9.0	92%
13 ML (D)	1	257.8	267.7	9.9	9.0	91%
68.9 ft. tot	2	267.7	277.5	9.8	6.0	61%
56.8 ft. recov	Trip for bit					
82%	3	277.5	287.4	9.9	9.8	99%
	4	287.4	295.2	7.8	6.0	77%
	5	295.2	304.2	9.0	7.0	78%
	Broke overshot, trip out					
	6	304.2	310.0	5.8	4.0	69%
	7	310.0	316.9	6.9	6.0	87%
	8	316.9	326.7	9.8	9.0	92%
13 JG (N)	1	326.7	336.6	9.9	9.8	99%
88.6 ft. tot	Broke overshot, trip out					
82.2 ft. recov	2	336.6	340.6	4.0	3.0	75%
93%	3	340.6	344.4	3.8	3.8	100%
	4	344.4	356.2	11.8	9.8	83%
	5	356.2	366.1	9.9	8.5	86%
	6	366.1	375.9	9.8	9.8	100%
	7	375.9	385.8	9.9	9.8	99%
	8	385.8	395.6	9.8	8.0	82%
	9	395.6	405.4	9.8	9.8	100%
	10	405.4	411.4	6.0	6.0	100%
	11	411.4	415.3	3.9	3.9	100%
14 ML (D)	1	415.3	425.1	9.8	5.0	51%
66.9 ft. tot	2	425.1	427.1	2.0	0.5	25%
56.2 ft. recov	Trip for bit					
84%	3	427.1	430.1	3.0	2.0	66%
	4	430.1	435.0	4.9	4.9	100%
	Sand in tube, trip					
	5	435.0	444.8	9.8	8.0	82%
	6	444.8	452.6	7.8	7.8	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
	7	452.6	463.5	10.9	10.2	94%
	8	463.5	472.3	8.8	8.0	91%
	9	472.3	482.2	9.9	9.8	99%
14 JG (N)	1	482.2	490.7	8.5	8.5	100%
80.7 ft. tot	2	490.7	496.0	5.3	4.0	75%
74.0 ft. recov	3	496.0	503.8	7.8	7.0	90%
92%	4	503.8	505.8	2.0	0.0	0%
	Sand in tube, trip					
	5	505.8	513.7	7.9	7.0	89%
	6	513.7	523.5	9.8	9.8	100%
	7	523.5	533.4	9.9	9.0	91%
	8	533.4	542.2	8.8	8.0	91%
	9	542.2	549.2	7.0	7.0	100%
	10	549.2	559.0	9.8	9.8	100%
	11	559.0	562.9	3.9	3.9	100%
	Trip for bit					
15 ML (D)	1	562.9	566.9	4.0	3.0	75%
58.0 ft. tot	2	566.9	572.7	5.8	5.0	86%
53.2 ft. recov	3	572.7	582.6	9.9	9.8	99%
92%	4	582.6	592.4	9.8	9.8	100%
	5	592.4	602.2	9.8	9.8	100%
	6	602.2	612.1	9.9	9.8	99%
	7	612.1	620.9	8.8	6.0	68%
	Trip for bit, ream & wash to bottom from 430 ft.					
15 JG (N)	1	620.9	631.3	10.4	10.4	100%
54.2 ft. tot	2	631.3	636.8	5.5	3.0	55%
42.2 ft. recov	3	636.8	641.6	4.8	4.8	100%
78%	4	641.6	649.1	7.5	6.0	80%
	5	649.1	654.4	5.3	4.0	75%
	6	654.4	656.4	2.0	0.0	0%
	Trip for bit, ream & wash at 300 ft & 430 ft.					
	7	656.4	660.8	4.4	3.0	68%
	Stuck tube, trip					
	8	660.8	669.1	8.3	7.0	84%
	9	669.1	675.1	6.0	4.0	67%
16 ML (D)	1	675.1	683.0	7.9	7.0	89%
53.6 ft. tot	2	683.0	689.3	6.3	6.0	95%
46.8 ft. recov	3	689.3	693.8	4.5	4.0	89%
87%	4	693.8	698.6	4.8	4.5	94%
	5	698.6	704.6	6.0	6.0	100%
	6	704.6	708.1	3.5	3.5	100%
	7	708.1	711.5	3.4	3.0	88%
	8	711.5	716.5	5.0	5.0	100%
	9	716.5	721.3	4.8	4.8	100%
	10	721.3	724.8	3.5	2.0	57%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
	11	724.8	728.7	3.9	1.0	26%
16 JG (N)	1	728.7	738.0	9.3	3.0	32%
38.8 ft. tot	2	738.0	745.0	7.0	0.0	0%
23.4 ft. recov	Pull up 20 & redrill					
60%	3	745	745.5	0.5	0.0	0%
	Trip for bit					
	4	745.5	749.3	3.8	3.0	79%
	5	749.3	757.7	8.4	8.4	100%
	6	757.7	767.5	9.8	9.0	92%
17 ML (D)	1	767.5	771.0	3.5	3.5	100%
51.2 ft. tot	2	771.0	773.5	2.5	2.5	100%
51.2 ft. recov	3	773.5	779.4	5.9	5.9	100%
100%	4	779.4	789.2	9.8	9.8	100%
	5	789.2	799.0	9.8	9.8	100%
	6	799.0	808.9	9.9	9.9	100%
	7	808.9	818.7	9.8	9.8	100%
17 JG (N)	1	818.7	828.6	9.9	9.9	100%
65.1 ft. tot	2	828.6	838.4	9.8	9.8	100%
56.4 ft. recov	3	838.4	848.2	9.8	9.8	100%
87%	4	848.2	852.7	4.5	3.0	67%
	5	852.7	859.0	6.3	3.0	48%
	6	859.0	867.9	8.9	7.0	79%
	7	867.9	872.9	5.0	3.0	60%
	8	872.9	877.8	4.9	4.9	100%
	9	877.8	883.8	6.0	6.0	100%
18 ML (D)	1	883.8	894.1	10.3	10.3	100%
31.3 ft. tot	2	894.1	901.4	7.3	7.3	100%
30.8 ft. recov	3	901.4	907.3	5.9	5.9	100%
98%	4	907.3	910.3	3.0	2.5	83%
	Trip for bit & ream back to bottom					
	5	910.3	915.1	4.8	4.8	100%
18 JG (N)	1	915.1	926.5	11.4	10.5	92%
30.5 ft. tot	2	926.5	933.0	6.5	5.0	77%
28.1 ft. recov	3	933.0	935.3	2.3	2.3	100%
92%	4	935.3	939.8	4.5	4.5	100%
	5	939.8	940.3	0.5	0.5	100%
	Trip for bit & wash to bottom					
	6	940.3	945.6	5.3	5.3	100%
19 ML (D)	1	945.6	952.6	7.0	7.0	100%
41.9 ft. tot	2	952.6	959.5	6.9	6.9	100%
39.9 ft. recov	3	959.5	965.3	5.8	5.8	100%
95%	4	965.3	970.3	5.0	5.0	100%
	5	970.3	974.2	3.9	3.9	100%

SOH-4

Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
	6	974.2	976.7	2.5	2.0	80%
	7	976.7	980.2	3.5	3.0	86%
	8	980.2	984.5	4.3	4.3	100%
	9	984.5	987.5	3.0	2.0	67%
19 JG (N)	1	987.5	991.0	3.5	2.0	57%
3.5 ft. tot						
2.0 ft. recovery						
57%	Total for interval			876.8	758.9	87%
54 BC (N)	1	997.0	1,003.0	6.0	5.0	83%
35.0 ft. tot	2	1,003.0	1,015.0	12.0	10.0	83%
25.0 ft. recov	3	1,015.0	1,023.0	8.0	4.0	50%
71%	4	1,023.0	1,032.0	9.0	6.0	67%
55 JG (D)	1	1,032.0	1,037.0	5.0	3.0	60%
55.0 ft. tot	2	1,037.0	1,042.0	5.0	3.0	60%
50.0 ft. recov	3	1,042.0	1,052.0	10.0	9.0	90%
91%	4	1,052.0	1,062.0	10.0	10.0	100%
	5	1,062.0	1,066.5	4.5	4.5	100%
	6	1,066.5	1,072.0	5.5	5.5	100%
	Bail hole for water sample					
	7	1,072.0	1,078.0	6.0	6.0	100%
	Rig repairs					
	8	1,078.0	1,087.0	9.0	9.0	100%
55 BC (N)	1	1,087.0	1,093.0	6.0	2.0	33%
38.0 ft. tot	2	1,093.0	1,098.5	5.5	5.5	100%
34.0 ft. recov	3	1,098.5	1,109.0	10.5	10.5	100%
89%	4	1,109.0	1,119.0	10.0	10.0	100%
	5	1,119.0	1,125.0	6.0	6.0	100%
56 JG (D)	1	1,125.0	1,130.0	5.0	5.0	100%
20.0 ft. tot	2	1,130.0	1,133.0	3.0	3.0	100%
17.0 ft. recov	3	1,133.0	1,135.0	2.0	2.0	100%
85%	Rig repairs, bail hole for water sample					
	4	1,135.0	1,141.0	6.0	3.0	50%
	5	1,141.0	1,145.0	4.0	4.0	100%
56 BC (N)	1	1,145.0	1,152.0	7.0	5.0	71%
46.0 ft. tot	2	1,152.0	1,160.0	8.0	7.5	94%
34.5 ft. recov	3	1,160.0	1,164.0	4.0	3.0	75%
75%	4	1,164.0	1,168.5	4.5	2.0	44%
	5	1,168.5	1,173.0	4.5	3.0	67%
	6	1,173.0	1,178.0	5.0	4.5	90%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
	7	1,178.0	1,184.0	6.0	4.0	67%
	8	1,184.0	1,191.0	7.0	5.5	79%
57 JG (D)	1	1,191.0	1,200.0	9.0	6.0	67%
57.0 ft. tot	2	1,200.0	1,210.0	10.0	9.0	90%
48.0 ft. recov	3	1,210.0	1,216.0	6.0	6.0	100%
84%	4	1,216.0	1,222.0	6.0	6.0	100%
	5	1,222.0	1,232.0	10.0	6.0	60%
	6	1,232.0	1,241.0	9.0	8.0	89%
	7	1,241.0	1,248.0	7.0	7.0	100%
57 BC (N)	1	1,248.0	1,254.5	6.5	4.0	62%
37.0 ft. tot	2	1,254.5	1,260.5	6.0	4.5	75%
26.0 ft. recov	3	1,260.5	1,266.5	6.0	4.0	67%
70%	Trip for bit					
	Ream in 55 ft, 3.5 ft fill					
	4	1,266.5	1,267.0	0.5	0.5	100%
	5	1,267.0	1,272.5	5.5	4.5	82%
	6	1,272.5	1,277.0	4.5	3.0	67%
	7	1,277.0	1,285.0	8.0	5.5	69%
58 JG (D)	1	1,285.0	1,292.0	7.0	7.0	100%
62.0 ft. tot	2	1,292.0	1,302.0	10.0	8.0	80%
56.0 ft. recov	3	1,302.0	1,308.0	6.0	6.0	100%
90%	4	1,308.0	1,315.0	7.0	5.0	71%
	5	1,315.0	1,322.0	7.0	6.0	86%
	6	1,322.0	1,327.0	5.0	5.0	100%
	7	1,327.0	1,337.0	10.0	10.0	100%
	8	1,337.0	1,347.0	10.0	9.0	90%
58 BC (N)	1	1,347.0	1,352.0	5.0	1.5	30%
36.0 ft. tot	2	1,352.0	1,360.5	8.5	8.5	100%
24.5 ft. recov	3	1,360.5	1,363.0	2.5	0.5	20%
68%	Trip for bit					
	4	1,363.0	1,368.0	5.0	3.0	60%
	5	1,368.0	1,373.0	5.0	2.5	50%
	6	1,373.0	1,380.0	7.0	5.5	79%
	7	1,380.0	1,383.0	3.0	3.0	100%
	Trip for broken wireline					
59 JG (D)	1	1,383.0	1,389.0	6.0	6.0	100%
35.0 ft. tot	2	1,389.0	1,399.0	10.0	10.0	100%
34.0 ft. recov	3	1,399.0	1,407.0	8.0	8.0	100%
97%	4	1,407.0	1,418.0	11.0	10.0	91%
59 BC (N)	1	1,418.0	1,424.0	6.0	3.5	58%
57.5 ft. tot	2	1,424.0	1,431.0	7.0	7.0	100%
48.7 ft. recov	3	1,431.0	1,438.0	7.0	5.0	71%
85%	4	1,438.0	1,447.0	9.0	8.0	89%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
	5	1,447.0	1,450.0	3.0	2.5	83%
	6	1,450.0	1,460.5	10.5	10.2	97%
	7	1,460.5	1,471.0	10.5	10.0	95%
	8	1,471.0	1,475.5	4.5	2.5	56%
60 JG (D)	1	1,475.5	1,486.0	10.5	3.5	33%
43.5 ft. tot	2	1,486.0	1,488.0	2.0	1.0	50%
31.5 ft. recov	3	1,488.0	1,498.0	10.0	9.0	90%
72%	4	1,498.0	1,503.0	5.0	2.5	50%
	5	1,503.0	1,507.5	4.5	4.0	89%
	6	1,507.5	1,516.0	8.5	8.5	100%
	7	1,516.0	1,519.0	3.0	3.0	100%
	Pull rods for bit change					
60 BC (N)	Change bit, run in hole					
44.5 ft. tot	1	1,519.0	1,527.5	8.5	8.5	100%
35.5 ft. recov	2	1,527.5	1,531.5	4.0	1.5	38%
80%	3	1,531.5	1,535.5	4.0	1.0	25%
	4	1,535.5	1,541.0	5.5	5.5	100%
	5	1,541.0	1,550.0	9.0	7.0	78%
	6	1,550.0	1,558.0	8.0	7.0	88%
	7	1,558.0	1,563.5	5.5	5.0	91%
61 JG (D)	1	1,563.5	1,572.0	8.5	7.0	82%
54.5 ft. tot	2	1,572.0	1,582.0	10.0	10.0	100%
52.0 ft. recov	3	1,582.0	1,592.0	10.0	9.0	90%
95%	4	1,592.0	1,596.0	4.0	4.0	100%
	5	1,596.0	1,605.0	9.0	9.0	100%
	6	1,605.0	1,614.0	9.0	9.0	100%
	7	1,614.0	1,618.0	4.0	4.0	100%
61 BC (N)	1	1,618.0	1,625.0	7.0	7.0	100%
55.0 ft. tot	2	1,625.0	1,631.0	6.0	3.5	58%
47.5 ft. recov	3	1,631.0	1,640.0	9.0	9.0	100%
86%	4	1,640.0	1,646.0	6.0	4.0	67%
	5	1,646.0	1,650.0	4.0	3.0	75%
	6	1,650.0	1,655.0	5.0	4.5	90%
	7	1,655.0	1,663.0	8.0	6.5	81%
	8	1,663.0	1,673.0	10.0	10.0	100%
62 JG (D)	Trip for bit change					
38.0 ft. tot	1	1,673.0	1,682.0	9.0	9.0	100%
36.0 ft. recov	2	1,682.0	1,692.0	10.0	9.0	90%
95%	3	1,692.0	1,700.0	8.0	8.0	100%
	4	1,700.0	1,711.0	11.0	10.0	91%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
62 BC (N)	1	1,711.0	1,721.0	10.0	10.0	100%
58.0 ft. tot	2	1,721.0	1,732.0	11.0	9.0	82%
51.0 ft. recov	3	1,732.0	1,739.0	7.0	5.0	71%
88%	4	1,739.0	1,749.0	10.0	9.0	90%
	5	1,749.0	1,753.0	4.0	4.0	100%
	6	1,753.0	1,760.0	7.0	6.0	86%
	7	1,760.0	1,769.0	9.0	8.0	89%
63 JG (D)	Trip for bit change					
43.0 ft. tot	1	1,769.0	1,777.0	8.0	8.0	100%
35.5 ft. recov	2	1,777.0	1,779.0	2.0	1.5	75%
83%	3	1,779.0	1,782.5	3.5	2.0	57%
	4	1,782.5	1,792.0	9.5	9.5	100%
	5	1,792.0	1,800.0	8.0	6.0	75%
	6	1,800.0	1,806.0	6.0	3.5	58%
	7	1,806.0	1,812.0	6.0	5.0	83%
63 MC (N)	Trip for mislatch					
26.5 ft. tot	1	1,812.0	1,822.0	10.0	8.5	85%
22.5 ft. recov	2	1,822.0	1,829.0	7.0	5.0	71%
85%	3	1,829.0	1,832.0	3.0	2.5	83%
	4	1,832.0	1,838.5	6.5	6.5	100%
64 ML (D)	Repair hydraulic leak					
27.5 ft. tot	1	1,838.5	1,844.0	5.5	5.5	100%
25.5 ft. recov	2	1,844.0	1,851.0	7.0	6.5	93%
93%	3	1,851.0	1,856.0	5.0	4.5	90%
	4	1,856.0	1,863.0	7.0	7.0	100%
	5	1,863.0	1,866.0	3.0	2.0	67%
64 BC (N)	1	1,866.0	1,871.0	5.0	4.5	90%
54.0 ft. tot	2	1,871.0	1,877.5	6.5	6.0	92%
51.8 ft. recov	3	1,877.5	1,881.5	4.0	3.5	88%
96%	4	1,881.5	1,889.0	7.5	7.5	100%
	5	1,889.0	1,899.0	10.0	10.0	100%
	6	1,899.0	1,910.0	11.0	10.3	94%
	7	1,910.0	1,920.0	10.0	10.0	100%
65 ML (D)	1	1,920.0	1,931.0	11.0	10.5	95%
66.0 ft. tot	2	1,931.0	1,941.0	10.0	10.0	100%
65.5 ft. recov	3	1,941.0	1,951.0	10.0	10.0	100%
99%	4	1,951.0	1,961.0	10.0	10.0	100%
	5	1,961.0	1,971.5	10.5	10.5	100%
	6	1,971.5	1,976.0	4.5	4.5	100%
	7	1,976.0	1,986.0	10.0	10.0	100%
65 BC (N)						
14.0 ft. tot	1	1,986.0	1,995.0	9.0	8.0	89%
13.0 ft. recov	2	1,995.0	2,000.0	5.0	5.0	100%
93%	Trip out, run dev. survey					

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
80 ML (N)	1	2,000.0	2,009.0	9.0	9.0	100%
23.0 ft. tot	2	2,009.0	2,013.0	4.0	4.0	100%
23.0 ft. recov	3	2,013.0	2,023.0	10.0	10.0	100%
100%						
81 JG (D)	1	2,023.0	2,024.0	1.0	1.0	100%
22.0 ft. tot	2	2,024.0	2,027.0	3.0	3.0	100%
22.0 ft. recov	3	2,027.0	2,030.0	3.0	3.0	100%
100%	4	2,030.0	2,032.0	2.0	2.0	100%
	5	2,032.0	2,041.0	9.0	9.0	100%
	6	2,041.0	2,045.0	4.0	4.0	100%
		Trip rods, mislatch				
81 ML (N)	1	2,045.0	2,055.0	10.0	10.0	100%
67.5 ft. tot	2	2,055.0	2,065.0	10.0	10.0	100%
61.0 ft. recov	3	2,065.0	2,068.0	3.0	2.5	83%
90%	4	2,068.0	2,078.0	10.0	10.0	100%
	5	2,078.0	2,082.0	4.0	3.0	75%
	6	2,082.0	2,084.0	2.0	1.0	50%
	7	2,084.0	2,092.0	8.0	4.0	50%
	8	2,092.0	2,102.0	10.0	10.0	100%
	9	2,102.0	2,110.0	8.0	8.0	100%
	10	2,110.0	2,112.5	2.5	2.5	100%
82 JG (D)	1	2,112.5	2,121.5	9.0	9.0	100%
66.0 ft. tot	2	2,121.5	2,128.5	7.0	5.5	79%
65.0 ft. recov	3	2,128.5	2,138.5	10.0	10.0	100%
98%	4	2,138.5	2,148.0	9.5	10.0	105%
	5	2,148.0	2,158.0	10.0	10	100%
	6	2,158.0	2,168.0	10.0	10.0	100%
	7	2,168.0	2,178.5	10.5	10.5	100%
82 ML (N)	1	2,178.5	2,185.0	6.5	6.5	100%
41.5 ft. tot	2	2,185.0	2,192.0	7.0	7.0	100%
41.5 ft. recov	3	2,192.0	2,197.0	5.0	5.0	100%
100%	4	2,197.0	2,203.0	6.0	6.0	100%
	5	2,203.0	2,210.5	7.5	7.5	100%
	6	2,210.5	2,220.0	9.5	9.5	100%
83 JG (D)	1	2,220.0	2,230.0	10.0	10.0	100%
22.0 ft. tot	2	2,230.0	2,237.0	7.0	7.0	100%
19.5 ft. recov		Trip rods, add HMQ & change bit.				
89%	3	2,237.0	2,240.0	3.0	1.5	50%
	4	2,240.0	2,242.0	2.0	1.0	50%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
87 JG (D)	1	2,611.0	2,618.0	7.0	7.0	100%
49.0 ft. tot	2	2,618.0	2,625.0	7.0	7.0	100%
49.0 ft. recov	3	2,625.0	2,631.0	6.0	6.0	100%
100%	4	2,631.0	2,641.0	10.0	10.0	100%
	5	2,641.0	2,650.0	9.0	9.0	100%
	6	2,650.0	2,660.0	10.0	10.0	100%
87 ML (N)						
20.0 ft. tot		Trip rods to add 101mm & change bit, clean cave.				
20.0 ft. recov	1	2,660.0	2,670.0	10.0	10.0	100%
100%	2	2,670.0	2,680.0	10.0	10.0	100%
88 JG (D)	1	2,680.0	2,689.0	9.0	9.0	100%
54.0 ft. tot	2	2,689.0	2,699.0	10.0	10.0	100%
54.0 ft. recov	3	2,699.0	2,704.0	5.0	5.0	100%
100%	4	2,704.0	2,714.0	10.0	10.0	100%
	5	2,714.0	2,724.0	10.0	10.0	100%
	6	2,724.0	2,728.0	4.0	4.0	100%
	7	2,728.0	2,734.0	6.0	6.0	100%
88 ML (N)	1	2,734.0	2,741.0	7.0	7.0	100%
50.0 ft. tot	2	2,741.0	2,751.0	10.0	10.0	100%
50.0 ft. recov	3	2,751.0	2,758.0	7.0	7.0	100%
100%	4	2,758.0	2,767.5	9.5	9.5	100%
	5	2,767.5	2,775.5	8.0	8.0	100%
	6	2,775.5	2,778.0	2.5	2.5	100%
	7	2,778.0	2,784.0	6.0	6.0	100%
89 JG (D)	1	2,784.0	2,787.0	3.0	3.0	100%
52.5 ft. tot	2	2,787.0	2,797.0	10.0	10.0	100%
52.5 ft. recov	3	2,797.0	2,807.0	10.0	10.0	100%
100%	4	2,807.0	2,817.0	10.0	10.0	100%
	5	2,817.0	2,827.0	10.0	10.0	100%
	6	2,827.0	2,836.5	9.5	9.5	100%
89 ML (N)	1	2,836.5	2,846.5	10.0	10.0	100%
57.5 ft. tot	2	2,846.5	2,853.0	6.5	6.5	100%
57.5 ft. recov	3	2,853.0	2,863.0	10.0	10.0	100%
100%	4	2,863.0	2,873.5	10.5	10.5	100%
	5	2,873.5	2,884.0	10.5	10.5	100%
	6	2,884.0	2,894.0	10.0	10.0	100%
90 JG (D)	1	2,894.0	2,904.0	10.0	10.0	100%
61.0 ft. tot	2	2,904.0	2,914.0	10.0	10.0	100%
61.0 ft. recov	3	2,914.0	2,924.0	10.0	10.0	100%
100%	4	2,924.0	2,934.5	10.5	10.5	100%
	5	2,934.5	2,944.5	10.0	10.0	100%
	6	2,944.5	2,955.0	10.5	10.5	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
83 ML (N)	1	2,242.0	2,243.5	1.5	1.5	100%
39.0 ft. tot	2	2,243.5	2,252.0	8.5	8.5	100%
37.0 ft. recov	3	2,252.0	2,254.0	2.0	0.0	0%
95%	4	2,254.0	2,264.0	10.0	10.0	100%
	5	2,264.0	2,271.0	7.0	7.0	100%
	6	2,271.0	2,281.0	10.0	10.0	100%
84 JG (D)	1	2,281.0	2,291.5	10.5	10.0	95%
50.0 ft. tot	2	2,291.5	2,301.5	10.0	10.0	100%
50.0 ft. recov	3	2,301.5	2,311.0	9.5	10.0	105%
100%	4	2,311.0	2,320.5	9.5	9.5	100%
	5	2,320.5	2,331.0	10.5	10.5	100%
84 ML (N)	1	2,331.0	2,335.0	4.0	4.0	100%
61.0 ft. tot	2	2,335.0	2,341.5	6.5	6.5	100%
61.0 ft. recov	3	2,341.5	2,352.0	10.5	10.5	100%
100%	4	2,352.0	2,362.0	10.0	10.0	100%
	5	2,362.0	2,372.0	10.0	10.0	100%
	6	2,372.0	2,382.5	10.5	10.5	100%
	7	2,382.5	2,392.0	9.5	9.5	100%
85 JG (D)	1	2,392.0	2,396.0	4.0	3.0	75%
51.0 ft. tot	2	2,396.0	2,400.0	4.0	4.0	100%
47.5 ft. recov	3	2,400.0	2,409.0	9.0	8.5	94%
93%	4	2,409.0	2,419.0	10.0	10.0	100%
	5	2,419.0	2,426.5	7.5	6.0	80%
	6	2,426.5	2,436.5	10.0	10.0	100%
	7	2,436.5	2,443.0	6.5	6.0	92%
85 ML (N)	1	2,443.0	2,453.0	10.0	10.0	100%
59.0 ft. tot	2	2,453.0	2,463.0	10.0	10.0	100%
58.5 ft. recov	3	2,463.0	2,473.0	10.0	10.0	100%
99%	4	2,473.0	2,481.5	8.5	8.0	94%
	5	2,481.5	2,492.0	10.5	10.5	100%
	6	2,492.0	2,502.0	10.0	10.0	100%
86 JG (D)	1	2,502.0	2,512.0	10.0	10.0	100%
59.0 ft. tot	2	2,512.0	2,522.0	10.0	10.0	100%
59.0 ft. recov	3	2,522.0	2,532.0	10.0	10.0	100%
100%	4	2,532.0	2,542.0	10.0	10.0	100%
	5	2,542.0	2,552.0	10.0	10.0	100%
	6	2,552.0	2,561.0	9.0	9.0	100%
86 ML (N)	1	2,561.0	2,571.0	10.0	10.0	100%
50.0 ft. tot	2	2,571.0	2,581.0	10.0	10.0	100%
48.5 ft. recov	3	2,581.0	2,586.5	5.5	5.0	91%
97%	4	2,586.5	2,591.5	5.0	4.0	80%
	5	2,591.5	2,601.0	9.5	9.5	100%
	6	2,601.0	2,611.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
90 ML (N)	1	2,955.0	2,965.0	10.0	10.0	100%
48.5 ft. tot	2	2,965.0	2,974.5	9.5	9.5	100%
48.5 ft. recov	3	2,974.5	2,984.5	10.0	10.0	100%
100%	4	2,984.5	2,993.0	8.5	8.5	100%
	5	2,993.0	3,003.5	10.5	10.5	100%
91 BC (D)	1	3,003.5	3,013.5	10.0	10.0	100%
56.5 ft. tot	2	3,013.5	3,020.0	6.5	6.5	100%
56.5 ft. recov	3	3,020.0	3,030.0	10.0	10.0	100%
100%	4	3,030.0	3,040.0	10.0	10.0	100%
	5	3,040.0	3,050.0	10.0	10.0	100%
	6	3,050.0	3,060.0	10.0	10.0	100%
91 ML (N)	1	3,060.0	3,063.0	3.0	3.0	100%
40.0 ft. tot	2	3,063.0	3,073.0	10.0	10.0	100%
40.0 ft. recov	3	3,073.0	3,083.0	10.0	10.0	100%
100%	4	3,083.0	3,090.0	7.0	7.0	100%
	5	3,090.0	3,100.0	10.0	10.0	100%
92 BC (D)	1	3,100.0	3,110.0	10.0	10.0	100%
50.0 ft. tot	2	3,110.0	3,120.0	10.0	10.0	100%
49.5 ft. recov	3	3,120.0	3,130.0	10.0	10.0	100%
99%	4	3,130.0	3,140.0	10.0	9.5	95%
	5	3,140.0	3,150.0	10.0	10.0	100%
92 ML (N)						
10.5 ft. tot		Trip rods to add 101mm & change bit				
10.5 ft. recov	1	3,150.0	3,160.5	10.5	10.5	100%
100%						
	1	3,160.5	3,170.5	10.0	10.0	100%
93 BC (D)	2	3,170.5	3,180.0	9.5	9.5	100%
49.5 ft. tot	3	3,180.0	3,190.0	10.0	10.0	100%
49.5 ft. recov	4	3,190.0	3,200.0	10.0	10.0	100%
100%	5	3,200.0	3,210.0	10.0	10.0	100%
93 ML (N)	1	3,210.0	3,220.0	10.0	10.0	100%
58.5 ft. tot	2	3,220.0	3,229.5	9.5	9.5	100%
58.5 ft. recov	3	3,229.5	3,239.0	9.5	9.5	100%
100%	4	3,239.0	3,248.0	9.0	9.0	100%
	5	3,248.0	3,258.0	10.0	10.0	100%
	6	3,258.0	3,268.5	10.5	10.5	100%
94 BC (D)	1	3,268.5	3,278.5	10.0	10.0	100%
47.5 ft. tot	2	3,278.5	3,288.5	10.0	10.0	100%
47.5 ft. recov	3	3,288.5	3,297.0	8.5	8.5	100%
100%	4	3,297.0	3,306.0	9.0	9.0	100%
	5	3,306.0	3,316.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
94 ML (N)	1	3,316.0	3,326.0	10.0	10.0	100%
49.0 ft. tot	2	3,326.0	3,336.0	10.0	10.0	100%
49.0 ft. recov	3	3,336.0	3,344.5	8.5	8.5	100%
100%	4	3,344.5	3,354.5	10.0	10.0	100%
	5	3,354.5	3,365.0	10.5	10.5	100%
95 BC (D)	1	3,365.0	3,375.0	10.0	10.0	100%
50.0 ft. tot	2	3,375.0	3,385.0	10.0	10.0	100%
50.0 ft. recov	3	3,385.0	3,395.0	10.0	10.0	100%
100%	4	3,395.0	3,405.0	10.0	10.0	100%
	5	3,405.0	3,415.0	10.0	10.0	100%
95 ML (N)	1	3,415.0	3,425.0	10.0	10.0	100%
47.0 ft. tot	2	3,425.0	3,435.0	10.0	10.0	100%
47.0 ft. recov	3	3,435.0	3,441.5	6.5	6.5	100%
100%	4	3,441.5	3,452.0	10.5	10.5	100%
	5	3,452.0	3,462.0	10.0	10.0	100%
96 BC (D)						
28.0 ft. tot	1	3,462.0	3,471.0	9.0	9.0	100%
27.5 ft. recov	2	3,471.0	3,476.0	5.0	5.0	100%
98%	3	3,476.0	3,485.0	9.0	9.0	100%
	4	3,485.0	3,490.0	5.0	4.5	90%
96 ML (N)	Trip rods for bit change					
20.0 ft. tot	1	3,490.0	3,500.0	10.0	10.0	100%
20.0 ft. recov	2	3,500.0	3,510.0	10.0	10.0	100%
100%						
	1	3,510.0	3,520.0	10.0	10.0	100%
97 BC (D)	2	3,520.0	3,530.0	10.0	10.0	100%
50.0 ft. tot	3	3,530.0	3,540.0	10.0	10.0	100%
50.0 ft. recov	4	3,540.0	3,550.0	10.0	10.0	100%
100%	5	3,550.0	3,560.0	10.0	10.0	100%
	1	3,560.0	3,570.0	10.0	10.0	100%
97 ML (N)	2	3,570.0	3,580.0	10.0	10.0	100%
50.0 ft. tot	3	3,580.0	3,590.0	10.0	10.0	100%
50.0 ft. recov	4	3,590.0	3,600.0	10.0	10.0	100%
100%	5	3,600.0	3,610.0	10.0	10.0	100%
	1	3,610.0	3,619.0	9.0	9.0	100%
98 BC (D)	2	3,619.0	3,627.0	8.0	8.0	100%
47.0 ft. tot	3	3,627.0	3,637.0	10.0	10.0	100%
47.0 ft. recov	4	3,637.0	3,647.0	10.0	10.0	100%
100%	5	3,647.0	3,657.0	10.0	10.0	100%
	1	3,657.0	3,667.0	10.0	10.0	100%
98 ML (N)	2	3,667.0	3,677.0	10.0	10.0	100%
49.0 ft. tot	3	3,677.0	3,687.5	10.5	10.5	100%
49.0 ft. recov	4	3,687.5	3,698.0	10.5	10.5	100%
100%	5	3,698.0	3,706.0	8.0	8.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
99 BC (D)	1	3,706.0	3,716.0	10.0	10.0	100%
44.0 ft. tot	2	3,716.0	3,726.0	10.0	10.0	100%
44.0 ft. recov	3	3,726.0	3,736.0	10.0	10.0	100%
100%	4	3,736.0	3,743.0	7.0	7.0	100%
	5	3,743.0	3,750.0	7.0	7.0	100%
99 ML (N)	1	3,750.0	3,757.0	7.0	7.0	100%
46.0 ft. tot	2	3,757.0	3,766.0	9.0	9.0	100%
46.0 ft. recov	3	3,766.0	3,775.0	9.0	9.0	100%
100%	4	3,775.0	3,779.0	4.0	4.0	100%
	5	3,779.0	3,787.0	8.0	8.0	100%
	6	3,787.0	3,796.0	9.0	9.0	100%
100 BC (D)	1	3,796.0	3,806.0	10.0	10.0	100%
40.0 ft. tot	2	3,806.0	3,816.0	10.0	10.0	100%
40.0 ft. recov	3	3,816.0	3,826.0	10.0	10.0	100%
100%	4	3,826.0	3,836.0	10.0	10.0	100%
100 ML (N)	1	3,836.0	3,846.0	10.0	10.0	100%
49.0 ft. tot	2	3,846.0	3,856.0	10.0	10.0	100%
49.0 ft. recov	3	3,856.0	3,865.0	9.0	9.0	100%
100%	4	3,865.0	3,875.0	10.0	10.0	100%
	5	3,875.0	3,885.0	10.0	10.0	100%
101 BC (D)	1	3,885.0	3,895.0	10.0	10.0	100%
40.0 ft. tot	2	3,895.0	3,905.0	10.0	10.0	100%
40.0 ft. recov	3	3,905.0	3,915.0	10.0	10.0	100%
100%	4	3,915.0	3,925.0	10.0	10.0	100%
	Splice wireline					
101 ML (N)	1	3,925.0	3,934.0	9.0	9.0	100%
37.0 ft. tot	2	3,934.0	3,944.0	10.0	10.0	100%
37.0 ft. recov	3	3,944.0	3,952.0	8.0	8.0	100%
100%	4	3,952.0	3,962.0	10.0	10.0	100%
102 BC (D)	1	3,962.0	3,972.0	10.0	10.0	100%
40.0 ft. tot	2	3,972.0	3,982.0	10.0	10.0	100%
40.0 ft. recov	3	3,982.0	3,992.0	10.0	10.0	100%
100%	4	3,992.0	4,002.0	10.0	10.0	100%
102 ML (N)	1	4,002.0	4,012.0	10.0	10.0	100%
50.0 ft. tot	2	4,012.0	4,022.0	10.0	10.0	100%
50.0 ft. recov	3	4,022.0	4,032.0	10.0	10.0	100%
100%	4	4,032.0	4,042.0	10.0	10.0	100%
	5	4,042.0	4,052.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
103 BC (D)						
6.0 ft. tot	1	4,052.0	4,058.0	6.0	6.0	100%
6.0 ft. recov	Trip for bit					
100%						
	1	4,058.0	4,061.0	3.0	3.0	100%
103 ML (N)	2	4,061.0	4,071.0	10.0	10.0	100%
32.0 ft. tot	3	4,071.0	4,081.0	10.0	10.0	100%
32.0 ft. recov	4	4,081.0	4,090.0	9.0	9.0	100%
100%	Vibration, condition hole					
104 BC (D)	1	4,090.0	4,100.0	10.0	10.0	100%
40.0 ft. tot	2	4,100.0	4,110.0	10.0	10.0	100%
40.0 ft. recov	3	4,110.0	4,120.0	10.0	10.0	100%
100%	4	4,120.0	4,130.0	10.0	10.0	100%
104 ML (N)	1	4,130.0	4,140.0	10.0	10.0	100%
40.0 ft. tot	2	4,140.0	4,150.0	10.0	10.0	100%
40.0 ft. recov	3	4,150.0	4,160.0	10.0	10.0	100%
100%	4	4,160.0	4,170.0	10.0	10.0	100%
105 BC (D)	1	4,170.0	4,179.0	9.0	9.0	100%
39.0 ft. tot	2	4,179.0	4,189.0	10.0	10.0	100%
39.0 ft. recov	3	4,189.0	4,199.0	10.0	10.0	100%
100%	4	4,199.0	4,209.0	10.0	10.0	100%
105 ML (N)	1	4,209.0	4,219.0	10.0	10.0	100%
49.0 ft. tot	2	4,219.0	4,229.0	10.0	10.0	100%
49.0 ft. recov	3	4,229.0	4,238.0	9.0	9.0	100%
100%	4	4,238.0	4,248.0	10.0	10.0	100%
	5	4,248.0	4,258.0	10.0	10.0	100%
106 BC (D)	1	4,258.0	4,268.0	10.0	10.0	100%
39.0 ft. tot	2	4,268.0	4,278.0	10.0	10.0	100%
39.0 ft. recov	3	4,278.0	4,288.0	10.0	10.0	100%
100%	4	4,288.0	4,297.0	9.0	9.0	100%
106 ML (N)	1	4,297.0	4,307.0	10.0	10.0	100%
50.0 ft. tot	2	4,307.0	4,317.0	10.0	10.0	100%
50.0 ft. recov	3	4,317.0	4,327.0	10.0	10.0	100%
100%	4	4,327.0	4,337.0	10.0	10.0	100%
	5	4,337.0	4,347.0	10.0	10.0	100%
107 BC (D)	1	4,347.0	4,357.0	10.0	10.0	100%
39.0 ft. tot	2	4,357.0	4,367.0	10.0	10.0	100%
39.0 ft. recov	3	4,367.0	4,377.0	10.0	10.0	100%
100%	4	4,377.0	4,386.0	9.0	9.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
107 ML (N)	1	4,386.0	4,396.0	10.0	10.0	100%
49.0 ft. tot	2	4,396.0	4,406.0	10.0	10.0	100%
49.0 ft. recov	3	4,406.0	4,416.0	10.0	10.0	100%
100%	4	4,416.0	4,425.0	9.0	9.0	100%
	5	4,425.0	4,435.0	10.0	10.0	100%
108 BC (D)	1	4,435.0	4,445.0	10.0	10.0	100%
40.0 ft. tot	2	4,445.0	4,455.0	10.0	10.0	100%
40.0 ft. recov	3	4,455.0	4,465.0	10.0	10.0	100%
100%	4	4,465.0	4,475.0	10.0	10.0	100%
108 ML (N)	1	4,475.0	4,485.0	10.0	10.0	100%
49.0 ft. tot	2	4,485.0	4,494.0	9.0	9.0	100%
49.0 ft. recov	3	4,494.0	4,504.0	10.0	10.0	100%
100%	4	4,504.0	4,514.0	10.0	10.0	100%
	5	4,514.0	4,524.0	10.0	10.0	100%
109 BC (D)	1	4,524.0	4,534.0	10.0	10.0	100%
46.0 ft. tot	2	4,534.0	4,543.0	9.0	9.0	100%
46.0 ft. recov	3	4,543.0	4,553.0	10.0	10.0	100%
100%	4	4,553.0	4,563.0	10.0	10.0	100%
	5	4,563.0	4,570.0	7.0	7.0	100%
109 ML (N)	1	4,570.0	4,575.0	5.0	5.0	100%
43.0 ft. tot	2	4,575.0	4,583.0	8.0	8.0	100%
43.0 ft. recov	3	4,583.0	4,593.0	10.0	10.0	100%
100%	4	4,593.0	4,603.0	10.0	10.0	100%
	5	4,603.0	4,613.0	10.0	10.0	100%
110 BC (D)	1	4,613.0	4,622.0	9.0	9.0	100%
49.0 ft. tot	2	4,622.0	4,632.0	10.0	10.0	100%
49.0 ft. recov	3	4,632.0	4,642.0	10.0	10.0	100%
100%	4	4,642.0	4,652.0	10.0	10.0	100%
	5	4,652.0	4,662.0	10.0	10.0	100%
110 ML (N)						
39.0 ft. tot	1	4,662.0	4,671.0	9.0	9.0	100%
39.0 ft. recov	2	4,671.0	4,681.0	10.0	10.0	100%
100%	3	4,681.0	4,691.0	10.0	10.0	100%
	4	4,691.0	4,701.0	10.0	10.0	100%
111 BC (D)						
30.0 ft. tot	1	4,701.0	4,711.0	10.0	10.0	100%
30.0 ft. recov	2	4,711.0	4,721.0	10.0	10.0	100%
100%	3	4,721.0	4,731.0	10.0	10.0	100%
	Trip rods, survey, bit change.					
111 ML (N)						
12.0 ft. tot	1	4,731.0	4,733.0	2.0	2.0	100%
12.0 ft. recov	2	4,733.0	4,743.0	10.0	10.0	100%
100%						

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
	1	4,743.0	4,753.0	10.0	10.0	100%
112 BC (D)	2	4,753.0	4,763.0	10.0	10.0	100%
29.0 ft. tot	3	4,763.0	4,772.0	9.0	9.0	100%
29.0 ft. recov	Vibration, high torque.					
100%						
	1	4,772.0	4,782.0	10.0	10.0	100%
112 ML (N)	2	4,782.0	4,792.0	10.0	10.0	100%
39.0 ft. tot	3	4,792.0	4,802.0	10.0	10.0	100%
39.0 ft. recov	4	4,802.0	4,811.0	9.0	9.0	100%
100%						
	1	4,811.0	4,821.0	10.0	10.0	100%
113 BC (D)	2	4,821.0	4,831.0	10.0	10.0	100%
50.0 ft. tot	3	4,831.0	4,841.0	10.0	10.0	100%
50.0 ft. recov	4	4,841.0	4,851.0	10.0	10.0	100%
100%	5	4,851.0	4,861.0	10.0	10.0	100%
113 ML (N)	1	4,861.0	4,871.0	10.0	10.0	100%
29.0 ft. tot	2	4,871.0	4,880.0	9.0	9.0	100%
29.0 ft. recov	3	4,880.0	4,890.0	10.0	10.0	100%
100%	Trip for broken wireline					
114 BC (D)	Trip rods, repair cable.					
5.0 ft. tot	1	4,890.0	4,895.0	5.0	5.0	100%
5.0 ft. recov						
100%						
	1	4,895.0	4,905.0	10.0	10.0	100%
114 ML (N)	2	4,905.0	4,915.0	10.0	10.0	100%
40.0 ft. tot	3	4,915.0	4,925.0	10.0	10.0	100%
40.0 ft. recov	4	4,925.0	4,935.0	10.0	10.0	100%
100%						
115 BC (D)	1	4,935.0	4,945.0	10.0	10.0	100%
49.0 ft. tot	2	4,945.0	4,954.0	9.0	9.0	100%
49.0 ft. recov	3	4,954.0	4,964.0	10.0	10.0	100%
100%	4	4,964.0	4,974.0	10.0	10.0	100%
	5	4,974.0	4,984.0	10.0	10.0	100%
115 ML (N)	1	4,984.0	4,994.0	10.0	10.0	100%
34.0 ft. tot	2	4,994.0	5,004.0	10.0	10.0	100%
34.0 ft. recov	3	5,004.0	5,014.0	10.0	10.0	100%
100%	4	5,014.0	5,018.0	4.0	4.0	100%
116 BC (D)	1	5,018.0	5,021.0	3.0	3.0	100%
28.0 ft. tot	2	5,021.0	5,030.0	9.0	9.0	100%
28.0 ft. recov	3	5,030.0	5,039.0	9.0	9.0	100%
100%	4	5,039.0	5,046.0	7.0	7.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
116 ML (N)	1	5,046.0	5,053.0	7.0	7.0	100%
27.0 ft. tot	2	5,053.0	5,059.0	6.0	6.0	100%
27.0 ft. recov	3	5,059.0	5,063.0	4.0	4.0	100%
100%	4	5,063.0	5,073.0	10.0	10.0	100%
117 BC (D)	1	5,073.0	5,081.0	8.0	8.0	100%
18.0 ft. tot	2	5,081.0	5,091.0	10.0	10.0	100%
18.0 ft. recov	Broke wireline, trip out					
100%						
117 ML (N)	Change bit, trip in, redrill bottom 70 ft.					
7.0 ft. tot	1	5,091.0	5,095.0	4.0	3.0	75%
6.0 ft. recov	2	5,095.0	5,098.0	3.0	3.0	100%
86%						
118 BC (D)	1	5,098.0	5,103.0	5.0	5.0	100%
25.0 ft. tot	2	5,103.0	5,113.0	10.0	10.0	100%
25.0 ft. recov	3	5,113.0	5,123.0	10.0	10.0	100%
100%	Condition hole					
118 ML (N)	1	5,123.0	5,133.0	10.0	10.0	100%
29.0 ft. tot	2	5,133.0	5,142.0	9.0	9.0	100%
29.0 ft. recov	3	5,142.0	5,152.0	10.0	10.0	100%
100%						
119 JG (D)	1	5,152.0	5,162.0	10.0	10.0	100%
39.0 ft. tot	2	5,162.0	5,171.0	9.0	9.0	100%
39.0 ft. recov	3	5,171.0	5,181.0	10.0	10.0	100%
100%	4	5,181.0	5,191.0	10.0	10.0	100%
119 BC (N)	1	5,191.0	5,198.0	7.0	7.0	100%
20.0 ft. tot	2	5,198.0	5,201.0	3.0	3.0	100%
20.0 ft. recov	3	5,201.0	5,205.0	4.0	4.0	100%
100%	4	5,205.0	5,211.0	6.0	6.0	100%
	Vibration slowing progress					
120 JG (D)	1	5,211.0	5,220.0	9.0	9.0	100%
39.0 ft. tot	2	5,220.0	5,230.0	10.0	10.0	100%
39.0 ft. recov	3	5,230.0	5,240.0	10.0	10.0	100%
100%	4	5,240.0	5,250.0	10.0	10.0	100%
120 BC (N)	1	5,250.0	5,260.0	10.0	10.0	100%
40.0 ft. tot	2	5,260.0	5,270.0	10.0	10.0	100%
40.0 ft. recov	3	5,270.0	5,280.0	10.0	10.0	100%
100%	4	5,280.0	5,290.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
123 JG (D)	Stick rods, reduce to NQ, drill out bit.					
11.0 ft. tot						
1.0 ft. recov	1	5,290.0	5,301.0	11.0	1.0	9%
9%						
123 BC (N)	1	5,301.0	5,311.0	10.0	7.5	75%
31.0 ft. tot	2	5,311.0	5,322.0	11.0	8.5	77%
26.0 ft. recov	3	5,322.0	5,332.0	10.0	10.0	100%
84%						
124 JG (D)	1	5,332.0	5,339.0	7.0	7.0	100%
30.0 ft. tot	2	5,339.0	5,344.0	5.0	5.0	100%
30.0 ft. recov	3	5,344.0	5,352.0	8.0	8.0	100%
100%	4	5,352.0	5,362.0	10.0	10.0	100%
124 BC (N)	1	5,362.0	5,372.0	10.0	10.0	100%
40.0 ft. tot	2	5,372.0	5,382.0	10.0	10.0	100%
40.0 ft. recov	3	5,382.0	5,392.0	10.0	10.0	100%
100%	4	5,392.0	5,402.0	10.0	10.0	100%
125 JG (D)	1	5,402.0	5,412.0	10.0	10.0	100%
50.0 ft. tot	2	5,412.0	5,422.0	10.0	10.0	100%
50.0 ft. recov	3	5,422.0	5,432.0	10.0	10.0	100%
100%	4	5,432.0	5,442.0	10.0	10.0	100%
	5	5,442.0	5,452.0	10.0	10.0	100%
125 BC (N)						
30.0 ft. tot	1	5,452.0	5,462.0	10.0	10.0	100%
30.0 ft. recov	2	5,462.0	5,472.0	10.0	10.0	100%
100%	3	5,472.0	5,482.0	10.0	10.0	100%
126 JG (D)	1	5,482.0	5,492.0	10.0	10.0	100%
40.0 ft. tot	2	5,492.0	5,502.0	10.0	10.0	100%
40.0 ft. recov	3	5,502.0	5,512.0	10.0	10.0	100%
100%	4	5,512.0	5,522.0	10.0	10.0	100%
126 BC (N)	1	5,522.0	5,532.0	10.0	10.0	100%
40.0 ft. tot	2	5,532.0	5,542.0	10.0	10.0	100%
40.0 ft. recov	3	5,542.0	5,552.0	10.0	10.0	100%
100%	4	5,552.0	5,562.0	10.0	10.0	100%
127 JG (D)	1	5,562.0	5,572.0	10.0	10.0	100%
40.0 ft. tot	2	5,572.0	5,582.0	10.0	10.0	100%
40.0 ft. recov	3	5,582.0	5,592.0	10.0	10.0	100%
100%	4	5,592.0	5,602.0	10.0	10.0	100%
127 BC (N)	1	5,602.0	5,612.0	10.0	10.0	100%
40.0 ft. tot	2	5,612.0	5,622.0	10.0	10.0	100%
40.0 ft. recov	3	5,622.0	5,632.0	10.0	10.0	100%
100%	4	5,632.0	5,642.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
128 JG (D)						
6.0 ft. tot	1	5,642.0	5,648.0	6.0	1.0	17%
1.0 ft. recov	Trip for mislatch, change bit.					
17%						
128 BC (N)	1	5,648.0	5,655.0	7.0	7.0	100%
24.0 ft. tot	2	5,655.0	5,662.0	7.0	7.0	100%
24.0 ft. recov	3	5,662.0	5,672.0	10.0	10.0	100%
100%	Redrill to bottom several times.					
129 JG (D)	1	5,672.0	5,682.0	10.0	10.0	100%
40.0 ft. tot	2	5,682.0	5,692.0	10.0	10.0	100%
40.0 ft. recov	3	5,692.0	5,702.0	10.0	10.0	100%
100%	4	5,702.0	5,712.0	10.0	10.0	100%
	Vibration slowing progress					
129 BC (N)	1	5,712.0	5,722.0	10.0	10.0	100%
40.0 ft. tot	2	5,722.0	5,732.0	10.0	10.0	100%
40.0 ft. recov	3	5,732.0	5,742.0	10.0	10.0	100%
100%	4	5,742.0	5,752.0	10.0	10.0	100%
	Vibration slowing progress					
130 JG (D)	1	5,752.0	5,762.0	10.0	10.0	100%
40.0 ft. tot	2	5,762.0	5,772.0	10.0	10.0	100%
40.0 ft. recov	3	5,772.0	5,782.0	10.0	10.0	100%
100%	4	5,782.0	5,792.0	10.0	10.0	100%
130 BC (N)	1	5,792.0	5,802.0	10.0	10.0	100%
30.0 ft. tot	2	5,802.0	5,812.0	10.0	10.0	100%
30.0 ft. recov	3	5,812.0	5,822.0	10.0	10.0	100%
100%	Vibration slowing progress					
131 JG (D)	1	5,822.0	5,832.0	10.0	10.0	100%
40.0 ft. tot	2	5,832.0	5,842.0	10.0	10.0	100%
40.0 ft. recov	3	5,842.0	5,852.0	10.0	10.0	100%
100%	4	5,852.0	5,862.0	10.0	10.0	100%
	Some vibration					
131 BC (N)	1	5,862.0	5,872.0	10.0	10.0	100%
50.0 ft. tot	2	5,872.0	5,882.0	10.0	10.0	100%
50.0 ft. recov	3	5,882.0	5,892.0	10.0	10.0	100%
100%	4	5,892.0	5,902.0	10.0	10.0	100%
	5	5,902.0	5,912.0	10.0	10.0	100%
	Some vibration					
132 JG (D)	1	5,912.0	5,922.0	10.0	10.0	100%
37.0 ft. tot	2	5,922.0	5,929.0	7.0	7.0	100%
37.0 ft. recov	3	5,929.0	5,939.0	10.0	10.0	100%
100%	4	5,939.0	5,949.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
132 BC (N)	1	5,949.0	5,959.0	10.0	10.0	100%
30.0 ft. tot	2	5,959.0	5,969.0	10.0	10.0	100%
30.0 ft. recov	3	5,969.0	5,979.0	10.0	10.0	100%
100%	Condition hole (2 hr), vibration					
133 ML (D)	1	5,979.0	5,989.0	10.0	10.0	100%
23.5 ft. tot	2	5,989.0	5,993.0	4.0	4.0	100%
23.5 ft. recov	3	5,993.0	5,997.0	4.0	4.0	100%
100%	4	5,997.0	6,000.0	3.0	3.0	100%
	Condition & redrill (2 hrs)					
	5	6,000.0	6,002.5	2.5	2.5	100%
133 JG (N)	1	6,002.5	6,012.0	9.5	9.5	100%
36.5 ft. tot	2	6,012.0	6,022.0	10.0	10.0	100%
36.5 ft. recov	3	6,022.0	6,032.0	10.0	10.0	100%
100%	4	6,032.0	6,039.0	7.0	7.0	100%
134 ML (D)	1	6,039.0	6,048.0	9.0	9.0	100%
38.0 ft. tot	2	6,048.0	6,057.0	9.0	9.0	100%
38.0 ft. recov	3	6,057.0	6,067.0	10.0	10.0	100%
100%	4	6,067.0	6,077.0	10.0	10.0	100%
134 JG (N)	1	6,077.0	6,087.0	10.0	10.0	100%
36.0 ft. tot	2	6,087.0	6,092.0	5.0	5.0	100%
36.0 ft. recov	3	6,092.0	6,102.0	10.0	10.0	100%
100%	4	6,102.0	6,110.0	8.0	8.0	100%
	5	6,110.0	6,113.0	3.0	3.0	100%
135 ML (D)	1	6,113.0	6,122.0	9.0	9.0	100%
25.0 ft. tot	2	6,122.0	6,132.0	10.0	10.0	100%
23.0 ft. recov	3	6,132.0	6,134.0	2.0	1.0	50%
92%	4	6,134.0	6,138.0	4.0	3.0	75%
135 JG (N)	1	6,138.0	6,147.5	9.5	9.5	100%
20.0 ft. tot	2	6,147.5	6,154.0	6.5	5.5	85%
19.0 ft. recov	3	6,154.0	6,156.0	2.0	2.0	100%
95%	4	6,156.0	6,158.0	2.0	2.0	100%
136 ML (D)	1	6,158.0	6,160.0	2.0	2.0	100%
24.0 ft. tot	2	6,160.0	6,164.0	4.0	4.0	100%
24.0 ft. recov	3	6,164.0	6,166.0	2.0	2.0	100%
100%	4	6,166.0	6,172.0	6.0	6.0	100%
	5	6,172.0	6,182.0	10.0	10.0	100%
136 JG (N)	1	6,182.0	6,192.0	10.0	10.0	100%
40.0 ft. tot	2	6,192.0	6,202.0	10.0	10.0	100%
40.0 ft. recov	3	6,202.0	6,212.0	10.0	10.0	100%
100%	4	6,212.0	6,222.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill (shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
137 ML (D)	1	6,222.0	6,232.0	10.0	10.0	100%
35.0 ft. tot	2	6,232.0	6,242.0	10.0	10.0	100%
35.0 ft. recov	3	6,242.0	6,252.0	10.0	10.0	100%
100%	4	6,252.0	6,257.0	5.0	5.0	100%
137 JG (N)	1	6,257.0	6,262.0	5.0	5.0	100%
39.0 ft. tot	2	6,262.0	6,272.0	10.0	10.0	100%
39.0 ft. recov	3	6,272.0	6,282.0	10.0	10.0	100%
100%	4	6,282.0	6,286.0	4.0	4.0	100%
	5	6,286.0	6,296.0	10.0	10.0	100%
138 ML (D)	1	6,296.0	6,306.0	10.0	10.0	100%
36.0 ft. tot	2	6,306.0	6,312.0	6.0	6.0	100%
36.0 ft. recov	3	6,312.0	6,312.5	0.5	0.5	100%
100%	4	6,312.5	6,322.0	9.5	9.5	100%
	5	6,322.0	6,332.0	10.0	10.0	100%
138 JG (N)	1	6,332.0	6,342.0	10.0	10.0	100%
35.0 ft. tot	2	6,342.0	6,352.0	10.0	10.0	100%
35.0 ft. recov	3	6,352.0	6,362.0	10.0	10.0	100%
100%	4	6,362.0	6,367.0	5.0	5.0	100%
139 ML (D)	1	6,367.0	6,376.0	9.0	9.0	100%
29.0 ft. tot	2	6,376.0	6,382.0	6.0	6.0	100%
29.0 ft. recov	3	6,382.0	6,390.0	8.0	8.0	100%
100%	4	6,390.0	6,396.0	6.0	6.0	100%
139 JG (N)						
6.0 ft. tot	1	6,396.0	6,402.0	6.0	6.0	100%
6.0 ft. recov	Trip rods for bit change					
100%						
140 ML (D)	1	6,402.0	6,409.0	7.0	7.0	100%
27.0 ft. tot	2	6,409.0	6,419.0	10.0	10.0	100%
27.0 ft. recov	3	6,419.0	6,429.0	10.0	10.0	100%
100%						
140 JG (N)	1	6,429.0	6,439.0	10.0	10.0	100%
40.0 ft. tot	2	6,439.0	6,449.0	10.0	10.0	100%
40.0 ft. recov	3	6,449.0	6,459.0	10.0	10.0	100%
100%	4	6,459.0	6,469.0	10.0	10.0	100%
141 ML (D)	1	6,469.0	6,479.0	10.0	10.0	100%
42.0 ft. tot	2	6,479.0	6,481.0	2.0	2.0	100%
42.0 ft. recov	3	6,481.0	6,491.0	10.0	10.0	100%
100%	4	6,491.0	6,501.0	10.0	10.0	100%
	5	6,501.0	6,511.0	10.0	10.0	100%

SOH-4
Core Recovery & Footage

Day-Drill	(shift)	Run	Depth From	Depth To	Footage Cored	Footage Recovered	Percent Recovery
141	JG (N)	1	6,511.0	6,521.0	10.0	10.0	100%
41.0 ft. tot		2	6,521.0	6,531.0	10.0	10.0	100%
41.0 ft. recov		3	6,531.0	6,541.0	10.0	10.0	100%
100%		4	6,541.0	6,552.0	11.0	11.0	100%
142	ML (D)	1	6,552.0	6,562.0	10.0	10.0	100%

Table 5
SOH-4
Core Bits

Bit #	Size	S.N.	Date On	On	Off	Ft. Cut	Remarks
1	134	L-39646	12-13-89	0	112	112	
2	101	L-41373	1-6-90	122	342	220	
3	101	SB11371-1	1-7-90	342	438	96	
4	101	SB17538-5	1-8-90	438	572	134	
5	101	SB17537-3	1-9-90	572	667	95	
6	101	SB17537-6	1-9-90	667	757	90	
7	101	SB17537-2	1-10-90	757	925	168	
8	101	SB17538-1	1-11-90	925	955	30	
9	101	SB17538-4	1-11-90	955	1,007	52	
10	134	L-39647	1-25-90	374	377	3	Ruined fishing
11	101	17700-4	2-17-90	1007	1093	86	
12	101	L-62341	2-18-90	1093	1266	173	
13	101	L-62342	2-20-90	1,266	1,363	97	
14	101	L-62339	2-21-90	1,363	1,519	156	
15	101	L-62338	2-23-90	1,519	1,673	154	
16	101	L-62337	2-25-90	1,673	1,812	139	
17	101	L-62340	2-26-90	1,812	2,000	188	
18	HQ	M6-23575	3-15-90	2,000	2,237	237	
19	HQ	M6-23573	3-18-90	2,237	2,660	423	
20	HQ	OR-157664	3-22-90	2,660	3,150	490	
21	HQ	SB-15648	3-27-90	3,150	3,490	340	
22	HQ	GP-71942	3-31-90	3,490	4,058	568	
23	HQ	M6-35649	4-7-90	4,058	4,731	673	
24	HQ	M6-356419	4-15-90	4,731	5,290	559	Lost w/ stuck rods
25	NQ	L-63175	4-26-90	5,290	5,648	358	
26	NQ	L-63178	5-2-90	5,648	6,402	754	
27	NQ	L-63181	5-13-90	6,402	6,562	160	TD bit, pulled earl

Table 6
SOH-4 Project Costs

Item	Cost	Percent Total
Tonto - daily & footage chgs. & personnel	751,295	51.18%
Rental equipment	138,422	9.43%
Water, water hauling	91,257	6.22%
Muds	94,534	6.44%
Bits	35,775	2.44%
Other down hole consumables	36,297	2.47%
Casing, cement & cement services	132,680	9.04%
Shipping, transportation	22,544	1.54%
Miscellaneous labor & materials	34,584	2.36%
Logging, testing & technical services	130,661	8.90%
Total	1,468,049	100.00%

Activity	Cost	Cost/ft*	% Total
Mob & set-up	42,297	6.45	2.88%
134mm coring 0 - 112 ft.	13,702	122.34	0.93%
Rotary 17-1/2" 0 - 114 ft.	53,847	472.34	3.67%
Case & cmt. w/ 13-3/8"	31,886	279.70	2.17%
101mm coring 114 - 992 ft.	65,930	75.09	4.49%
Rotary 12-1/4" 114 - 992 ft.	284,891	324.48	19.41%
Case & cmt. w/ 9-5/8"	53,617	54.05	3.65%
101mm coring 992 - 2,000 ft.	89,452	88.74	6.09%
Rotary 8-1/2" 992 - 2,000 ft.	78,311	77.69	5.33%
Case & cmt. w/ 7"	82,249	41.12	5.60%
HQ/NQ coring 2,000 - 6,562 ft.	537,556	117.83	36.62%
Completion (log, test, tubing & rig down)	134,311	20.47	9.15%
Total	$1,468,049		100.00%
Overall Cost/Ft @ 6,562 ft.	$223.72		

* Reflects cost/ft only for interval involved.

APPENDIX IV.

SOH-1 SUMMARY DRILLING REPORT AND WELL HISTORY

-by-

John E. Deymonaz
Geothermal Drilling Consultant

Scientific Observation Hole #1

PURPOSE AND SCOPE

The Scientific Observation Hole program ("SOH") was undertaken as both a scientific research project, and to aid in evaluating the geothermal potential of the Kilauea East Rift Zone on the island of Hawaii.

The SOH drilling is providing the first extensive core ever taken in Hawaii. Continuous core yields invaluable information to geologists and other earth scientists concerning the Kilauea East Rift Zone. This information can be utilized as a model to interpret the past geologic history of Hawaii and other islands in the Hawaiian Archipelago. It also offers a unique insight into the current and future volcanic and erosional activity along the rift zone. To geologists, the core is a tangible geologic record spanning a period of time which began when this part of Hawaii was still thousands of feet below sea level. The core provides detailed information of the islands evolution through periods of volcanic aggradation, erosion, sedimentation, mass wasting, intrusive activity and subsidence to its current state.

SOH drilling is also instrumental in evaluating the extent of a commercially viable geothermal resource along the East Rift Zone. Deep core, geophysical logs, temperature profiles and injection testing will assist both the state of Hawaii and private developers in understanding the nature of the resource and aid in establishing realistic resource development goals. The core in particular, offers an opportunity to study alteration, mineralization and fracturing in reservoir rock which is unavailable in conventional rotary drilled holes.

After completion and testing the SOH's will, as their name implies, serve as long term observation holes. They will provide stations to monitor the effects of geothermal production throughout the rift zone. Changes in temperature and pressure will be monitored and deep fluid samples may be collected.

SOH-1 was the second in a series of 4 planned Scientific Observation Holes to be drilled in the Kilauea East Rift Zone. The target depth for the SOH's is 4,000 to 6,500 feet. Actual completion depth of each hole depends on drilling conditions, temperature and a number of other factors which are evaluated on a continuing basis as the holes are drilled. The drilling program was designed to remain as flexable as possible to accommodate a variety of potential situations as they are encountered.

CONTRACTOR AND EQUIPMENT

Tonto Drilling Services Inc. of Salt Lake City, Utah is the drilling contractor chosen for the SOH program. Tonto has provided an experienced crew and the Universal 5000 rotary/core drilling rig to undertake this unique project. The Universal 5000 drilling rig is one of only two such units in existence and is uniquely suited for the requirements of the SOH project. It has been extensively modified for geothermal work and to meet stringent noise limitations mandated by the county of Hawaii.

The drilling rig is mounted on a 3-axle trailer and weighs approximately 94,600 pounds. A self-elevating jack-up system permits raising the rig and placing a 10.5 foot high substructure under the mast. The substructure carries the weight associated with drilling, serves as a working floor and permits the above ground installation of blow out prevention equipment ("BOPE").

Specifications for the Universal 5000 drill rig include:

a. Rotation head hoisting capacity of 100,000 pounds.

b. Main hoist capacity of 88,000 pounds (single line, 1-3/16 inch cable).

c. Rotation head pull down of 30,000 pounds.

d. Rotation head speed variable from 0 to 2,250 RPM.

e. Maximum rotation head output torque of 6,630 foot pounds.

f. Wireline winch with 18,000 feet of 3/8 inch wire rope and a full drum pull of up to 1,500 feet per minute.

g. Hydraulic system consisting of axial and radial piston pumps and motors designed as three independent open loop circuits.

h. 56 foot mast with a 40 foot rod pull and stacking capacity.

i. Hydraulically operated and self energizing casing and rod slips.

Depth rating of the Universal 5000 depends on the size of drill rods used, drilling conditions and other factors. In the case of NQ drill rods, which were used to complete SOH-1, the theoritical maximum depth is over 17,000 feet.

DRILLING OPERATIONS

SOH-1 was spudded-in at 2 PM on May 31 and completed to a total depth of 5,526 feet G.L. (Ground Level) on December 21, 1990. A total of 205 working days was involved in drilling the hole. Following a break for Christmas, completion and testing involved an additional 15 days and the rig was released on January 13, 1991. A brief summary of drilling activities is presented in Table 1 and graphically illustrated in Figure 1.

Surface Casing

SOH-1 was spudded-in with 101mm core (3.98" hole x 2.50" core) and drilled to 202 feet G.L. Total loss of drilling fluids occured at 25 feet and drilling continued without returns. The hole was then opened to 12-1/4 inches with a Hughes ATJ-33C tricone bit and near-bit welded blade stabalizer. Total loss of drilling fluids occured at 31 feet and drilling continued without returns to 202 feet.

9-5/8 inch K-55, 40 lb/ft buttress threaded and coupled casing was run open ended to 202 feet and set on bottom. The hole was dry to TD and the casing was cemented with 135 cubic feet of redimix concrete (5 sack mix w/ 1/2" minus aggregate). After 15 cubic feet of concrete was poured down the annulus, the casing was picked up off bottom several times to allow the cement to flow around the base of the casing and clean out any debris. The casing was then set back on bottom and the annulus filled with concrete to the surface.

Concrete volume was approximately 200% of theoretical, however, the annular space did not fill to surface. Cementing was completed with 3 top jobs using a total of 87 sacks of neat cement and 40 cubic feet of redimix.

Blow out prevention equipment (BOPE) was nippled up and tested to 600 psi. BOP equipment consisted of a 3M slip on wellhead with 2 inch flanged outlets, a 12 inch Type E double gate preventer with pipe and blind rams and 2 inch kill and flow lines attached to 2 inch 3M valves.

Intermediate (Protection) Casing

From 11:00 AM on June 9 until 4:00 PM on June 14 (5.2 days) the contractor was put on standby awaiting a decision by the Hawaii County Planning Commission to permit the next phase of the drilling operation.

When drilling operations resumed, 101mm core drilling proceeded from 202 - 1,996 feet with partial return of drilling fluids. Core drilling began on June 14 and reached 1,996 feet on July 1, a total of 18 days.

After running a deviation survey (Table 8), the hole was opened to 8-1/2 inches from 202 - 1,996 feet using a 8-1/2 inch Hughes ATJ-33C tricone and near bit welded blade stabalizer.

Hole opening began on July 2 and reached 1,996 feet on July 25, a total of 24 days. The drill rods were tripped out of the hole and 7 inch L-80, 35 pound/foot buttress threaded and coupled casing was run. Float equipment consisted of a guide shoe and float collar at the top of the first joint (39.5 feet from bottom). When 1,800 feet of casing (63,000 pounds) had been run, the 1 inch cable on the main winch line snapped behind the socket and the casing string dropped into the hole. A fishing tool was fabricated and the lifting plug retrieved. The remaining 7 inch casing was stabbed into the dropped section and made up. After an 80,000 pound pull failed to pick up the casing, a 5-5/8 inch tricone was run in to the float collar to clean any debris and verify the casing integrity. On July 29 Halliburton Services was used to cement the 7 inch casing.

7 Inch Casing Cementing

Pump 40 bbls water, followed with 6 bbls super flush ahead of lead slurry.

Lead slurry:	49 bbl silica/spherelite cement (11 lb/gal, 88 sk cement, 4,400 lb spherelite, 3,300 lb silica flour, 4% bentonite, 2% CaCl)
Tail slurry:	27 bbl silica cement (15.8 lb/gal, 93 sk cement 3,500 lb silica flour, 2% CFR-3)
Displacement:	68 bbl water. No cement returns to surface.
Top job #1:	27 bbl silica cement (100 sk cement, 3,500 lb silica flour, 2% CFR-3, 2% CaCl)
Top job #2:	18 bbl silica cement (47 sk cement, 1,900 lb silica flour, 50 c.f. perlite, 2% CFR-3, 3% bentonite, 3% CaCl)
Top job #3	18 bbl silica cement (47 sk cement, 1,900 lb silica flour, 50 c.f. perlite, 2% CFR-3, 3% CaCl)

Theoretical cementing volume: 254 cubic feet; cement required: 778 cubic feet.

BOP equipment was nippled up on July 30 and consisted of:

a. 7 inch ESFO slip-on well head with 2 inch flanged outlets.
b. 6 inch WKM 3M gate valve.
c. 7 inch LWS double-gate preventer with gate and blind rams.
d. High speed rotating head.
e. 2 inch flow and kill lines connected to 2 inch 3M gate valves.

The BOP equipment was pressure tested to 600 psi.

4-1/2 Inch Casing

The cement and 7 inch float equipment were drilled out with a 5-7/8 inch tricone and 5 inch flush joint casing with left-hand buttress threads was set below the wellhead to 1,996 feet to provide a "sleeve" for the core drill rods.

Core drilling with 101mm (3.98" hole x 2.50" core) commenced on July 31 and advanced to 2,505 feet on August 7. Drilling progressed reasonably well with average daily footages of 78 feet per day. At 2,505 feet the hole was cemented back to 2,316 feet with 20 cubic feet of neat cement in an attempt to stabalize a poorly consolidated sandy interval below 2,419 feet. After drilling out cement, the 101mm core hole was advanced to 2,671 feet encountering several poorly consolidated sandy intervals. In an attempt to stabalize the hole, it was cemented back with 20 cubic feet of neat cement. While tripping in the hole on August 13 to drill out cement, several bridged-off intervals were encountered, beginning at 2,205 feet, and drilled out. While cleaning the hole the drill rods became stuck tight while making a connection at 2,234 feet.

A mechanical cutter was tripped in on NQ drill rods (2.75" O.D.) and the 101mm drill rods cut 3 feet above the core barrel. The core barrel assembly dropped down the hole after being cut free from the upper rods but the drill rods would not pull free. The rods were cut at 2,140 feet and finally at 1,995 feet before the upper portion could be pulled free and retrieved. After removing the 5 inch casing sleeve, the remaining 101mm drill rods were recovered by reaming over the rods with a 134mm casing shoe (5.28" O.D. x 4.125" I.D.). The reaming and recovery operation began on August 13 and was completed August 31 (18 days).

After retrieving the 101mm rods, the hole was opened to 5-7/8 inches with a tricone bit from 1,996 - 2,671 feet during a 10 day period from August 31 to September 10. Several zones of poorly consolidated sandy material and fractured unstable formation were encountered and reaming was slow and difficult requiring numerous redrills of unstable intervals. After briefly sticking the drill rods at 2,441 feet while tripping out of the hole, the rotary drill assembly was removed and drilling continued with a 134mm coring assembly (5.28" hole x 3.35" core).

The 134mm core hole was advanced from 2,671 - 3,022 feet in difficult conditions. While drilling the 134mm hole, average core runs were only 5.83 feet and core recovery averaged 87 percent. Due to the hard, fractured, abrasive and unstable nature of this interval, seven bits were consumed in coring 351 feet. Average bit life was slightly over 50 feet. These events resulted in an extremely high bit cost of $34.42 per foot for the 134mm cored interval.

After completing the hole to 3,022 feet, a casing string was run to TD and consisted of: 1,017 feet of flush joint 4-1/2 inch, 11.6 pound/foot J-55 casing from 3,022 - 2,005 feet and short threaded and coupled 4-1/2 inch, 10.5 pound/foot J-55 casing from 2,005 feet to the surface. A guide shoe and float collar were run with the casing. The bottom 200 feet of the casing was cemented with neat cement on September 22.

HQ & NQ Core Drilling (3,022 - 5,526 feet)

Core drilling resumed with HQWL (3.83" hole x 2.50" core) in broken, unstable and abrasive hyaloclastics, basalt flows and intrusive rock from 3,022 - 4,325 feet. Drilling this 1,303 foot interval required 49 days, an average of 26.6 feet per day. The entire interval proved to be extremely difficult to core drill. Core runs in this interval averaged only 3.93 feet, core recovery dropped to 80.49 percent and 31 bits were consumed.

The hole was reduced to NQ (2.98" hole x 1.875" core) and cored from 4,325 - 4,880 feet with similar problems to those encountered while coring with HQ. This 555 foot section required an additional 24 days, an average of 23.1 feet per day. Core runs in this interval averaged 3.54 feet, core recovery averaged 88.62 percent and 6 more bits were consumed.

By contrast, HQ and NQ core drilling the 3,562 foot interval below 3,000 feet in SOH-4 averaged 71.2 feet per day during a 50 day period using only 7 bits (487 feet per bit) with mostly 10 foot core runs and nearly 100 percent core recovery. The problems hampering the core drilling efforts in SOH-1 are discussed below:

a. Short bit life: 31 HQ and 7 NQ bits were expended in drilling 1,649 feet. Average bit footage was 43.4 feet. Each bit change necessiated the time consuming and nonproductive process of tripping all drill rods out of the hole, replacing the bit and tripping back in the hole. In this interval the time involved was 5 - 7 hours, exclusive of cleaning and reaming the hole. The primary reason for short bit life was the pervasively fractured, hard and abrasive nature of the formation.

The fractured rock was generally broken into small (less than 3 inches) angular fragments which tended to roll around below, outside and inside the bit cutting surfaces. This action greatly accelerated deterioration of the bits inner and outer guage. When inside bit guage is lost, the core is unable to slide into the inner tube assembly. Loss of outside gauge made it necessary to spend time reaming the next bit through the undersized hole. The reaming process also caused considerable wear on the bit before any new hole was drilled.

b. Short core runs: The equipment used was designed to retrieve 10 foot sections of core. In this interval the average core retrieval was only 3.93 feet with NQ and 3.54 feet with HQ. Retrieval involves lowering an overshot attached to a 3/8 inch wireline until it latches onto the inner tube assembly, then pulling the inner tube to the surface and lowering an empty tube into position. The time involved depends on the hole depth, in this interval the retrieval operation required 20 - 30 minutes. If, for example, 10 short runs take place in a day, approximately 5 hours of time is lost to non-drilling core retrieval operations.

A ratcheting core barrel assembly was employed while coring HQ and produced a slight improvement in core runs. The ratcheting core barrel has a spring loaded ratchet device which engages when core entering the inner tube blocks off. When engaged it transmits a rapid series of sharp blows to the tube, hopefully, loosening the blockage.

c. Redrilling: The fractured, poorly consolidated rock above 4,880 feet proved to be unstable, with frequent caving. In order to clean the cave and material dropped from the inner tube, redrilling was required after most core runs to clean and stabalize the well bore. Since the core bit is not designed to efficiently grind up loose rubble, a small tricone bit was tripped in on five occassions to clean and stabalize the hole between 4,364 and 4,880 feet. Use of the tricone was successful in cleaning the hole but required additional trips in and out of the hole, which together with cleaning and reaming, often consumed over 24 hours of rig time.

d. Dropped core: The small size of the fractured rock often made it difficult to retain all of the rubble in the inner tube upon retrieval. Occasionally, a piece of this rock would wedge in the drill rods and prevent the empty inner tube from dropping into place. This would force the pulling of drill rods to clear the obstruction. Each trip resulted in the loss of up to 7 hours.

Regarding cost/time effectiveness, the only productive time spent during a core drilling operation is when the bit is on bottom, drilling new hole. Although necessary to continue drilling, time involved in core runs, bit changes, tripping drill rods, reaming and washing the hole, etc. is non-productive in terms of deepening the hole. As the above discussion illustrates, the majority of time in the 3,231 - 4,880 foot interval was consumed by non-coring operations.

Conditions for core drilling above 4,880 feet were extremely difficult and although the progress was slow and expensive, it is a tribute to the Tonto drilling crew that they were able to advance the hole in the adverse drilling environment.

Reasons for the hard, fractured and poorly consolidated nature of the formation are open for suggestion. An obvious correlation in SOH-4, SOH-1 and currently in SOH-2 indicate that the subaerial volcanics provide no significant problems to core drilling. Submarine volcanics and associated clastic material, however, create the hostile enviornment for core drilling described above. This environment presists until a depth is reached where substantial thermal alteration has taken place. Thermal alteration appears to decrease the abrasiveness and secondary mineralization and alteration bonds the fractured and poorly consolidated rock to a state of competence where core drilling can be efficiently accomplished. If this can be expected with regularity in the rift zone, core drilling should be avoided in the interval of submarine volcanics above the zone of thermal alteration.

The subaerial/submarine interface becomes deeper at locations inland with higher elevation. At SOH-4, with a surface elevation of 1,195 feet, the contact is at approximately 4,000 feet below sea level (5,554 ft. G.L.). At SOH-1 the surface elevation is 620 feet and the contact is at 1,831 feet below sea level (2,451 ft. G.L.). At the current hole, SOH-2, situated at an elevation of 270 feet, the contact is approximately 1,380 feet below sea level (1,680 ft. G.L.).

A deeper subaerial/submarine contact provides better opprotunity for thermal alteration and mineralization. With this simple model, continuous coring appears to be most feasable at higher elevation sites along the rift zone as at SOH-4 and the planned SOH-3 hole. Regardless of the location, core drilling from the surface to the subaerial/submarine contact has proved to be feasible and provides valuable information for researchers. Rotary drilling is the most effective method for penetrating the interval of submarine volcanics and hyaloclastic material above the zone of thermal alternation. After casing this interval off, core drilling can resume with reasonable efficiency.

Noise Mitigation And Local Resident Complaints

Noise generated by drilling activities has been a major concern to nearby residents. To underscore this concern, Hawaii County restrictions accompanying the drilling permit limit noise levels at the nearest residence (in some instances slightly more than 1/4 mile) to 55 dBA during daylight hours and 45 dBA at night (7 PM - 7 AM). Although these levels have not been exceeded in 14 months of drilling operations, complaints are often filed simply because a resident can hear noise generated by the operation regardless of measured noise levels. During certain meteorological conditions, noise originating at the SOH site are audible at considerable distances from the site. Although it is not possible for the drilling operations to be completely inaudible, one of the SOH project's target goals is to eliminate even this nuisance level of noise.

Forty complaints were received while drilling SOH-1 (Table 3). Of these, thirty-eight were for noise, one for light and one for odor. Thirty of the complaints were from a single individual located over 1/2 mile from the drill site. All but one of the complaints were from individuals publicly opposed to geothermal development.

To minimize the potential nuisance impact of noises generated by round-the-clock drilling operations, the contractor made extensive modifications and additions to the equipment. Additional sound mitigation measures have been undertaken by Tonto and SOH personnel since the project began. Some of the measures include:

a. Completely enclosing the main power plant, a 410 HP General Motors diesel unit, with sound dampening panels.

b. Constructing sound absorbing duct work over air intake and discharge areas around the engine compartment.

c. Modification of ancillary equipment normally powered by small gas or disel engines. These are now driven by hydraulic motors, powered by the drilling rigs hydraulic system.

d. Enclosing the main hydraulic winch at the top of the mast with sound dampening panels.

e. Erecting sound dampening panels around the front of the drill rig and adjacent to other sources of excessive noise as they are isolated.

d. Lining pipe rack slides with plywood to dampen noise as pipe and casing is lifted to the rig floor.

e. Enclosing the rig floor with heavy wind walls and doors.

f. Installation of large "hospital type" mufflers on the rig engine.

g. Running equipment at lower speeds during night time operations, when practical, to lower noise levels.

h. Suspension of night time operations when work involves excessive noise such as cementing operations.

As one source of noise is quieted, another is often exposed and each drill site poses a new variety of challenges due to differing topography, proximity to neighbors, etc. Evaluation and improving the sound mitigation measures is an ongoing task which will continue throughout the SOH project.

Ground Water Sampling

The surface elevation at SOH-1 is 620 feet and the static water level was measured at between 615 and 620 feet. On June 18, the 101mm core hole reached a depth of 669 feet. A bottom hole temperature of 79 F was measured and the hole was bailed with a 30 foot long bailer constructed of 2 inch galvanized pipe. Samples were collected after 2 hours, 3 hours and 4.5 hours respectively. Temperature increased slightly as the hole was bailed. Sample #3 had a temperature of 88 F. The samples were submitted for a standard water analysis.

Bottom Hole Temperatures

Core drilling presents an excellent opprotunity to monitor formation temperatures on a real time basis as the hole is drilled. This results from several factors:

a. The low rate at which drilling fluids are pumped during core drilling as opposed to rotary drilling larger holes. Pumping rates for core drilling are 10 - 20 gallons per minute while pump rates for rotary drilling larger holes are several hundred gallons per minute. Thus, even when all fluids flow into the formation surrounding the bore hole, the cooling effect is much less when core drilling then rotary drilling and temperature increases are more likely to be noted.

b. Annular space between the well bore and drill rods is less than 0.15 inch in a core hole as opposed to several inches in rotary holes.

c. The relatively thin walled core drill rods rapidly equillibrate to surrounding fluid temperatures, whereas, massive drill collars run behind rotary drill bits require a considerable period of time to reach thermal equillibration.

In order to anticipate potential safety problems related to formation tempertures, bottom hole temperature measurements are taken at intervals of approximately 50 feet. Since the SOH holes are not hampered by requirements of production casing design, additional casing strings can be set as required by changing down hole conditions. Measured bottom hole temperatures will deviate from actural formation temperatures depending on drilling fluid loss into the formation, pump rates, hole size and time of measurement after cessation of pumping.

Tables & Figures

Table 1.
SOH-1 Drilling Summary

Dates	Day #	Activity
5/26 - 5/30		Move equipment to site, rig up install water line.
5/31 - 6/2	1 - 2	Core 101mm 0 - 202 ft
6/2 - 6/4	3 - 5	Open hole to 12-1/4" 0 - 202 ft.
6/4 - 6/8	5 - 9	Run 9-5/8" casing, cement and nipple up BOP equipment.
6/9 - 6/14	10 - 15	Stand by for decision from Hawaii County for approval to continue.
6/14 - 7/1	15 - 32	Core 101mm from 202 - 1,996 ft & run deviation survey.
7/2 - 7/25	33 - 56	Open hole to 8-1/2" 202 - 1,996 ft.
7/25 - 7/30	56 - 61	Run 7" casing, drop casing and fish out, cement and nipple up BOP equipment.
7/31 - 8/13	62 - 75	Core 101mm from 1,996 - 2,671 ft. Stick drill rods.
8/13 - 8/31	75 - 93	Fish and ream over 101 rods with 134mm bit and retrieve equipment.
8/31 - 9/10	93 - 103	Open hole to 5-7/8" from 1,996 - 2,671 ft.
9/10 - 9/20	103 - 113	Core 134mm from 2,671 - 3,022 ft.
9/21 - 9/22	114 - 115	Run 4-1/2" casing to 3,022 ft. and cement.
9/22 - 11/10	115 - 164	Core HQ from 3,022 - 4,325 ft.
11/11 - 12/21	165 - 205	Reduce to NQ, core 4,325 - 5,526 ft.
12/22 - 1/2	N/A N/A	Christmas break.
1/3 - 1/13	206 - 217	Condition hole, run tubing, log, test and rig down.

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
31-May	101mm	0.0	11.0	11.0	6.0	55%
31-May	101mm	11.0	21.0	10.0	10.0	100%
31-May	101mm	21.0	31.0	10.0	10.0	100%
31-May	101mm	31.0	41.0	10.0	10.0	100%
31-May	101mm	41.0	52.0	11.0	10.0	91%
31-May	101mm	52.0	62.0	10.0	6.0	60%
31-May	101mm	62.0	72.0	10.0	9.0	90%
31-May	101mm	62.0	72.0	10.0	9.0	90%
31-May	101mm	72.0	82.0	10.0	10.0	100%
31-May	101mm	82.0	92.0	10.0	8.0	80%
31-May	101mm	92.0	102.0	10.0	10.0	100%
31-May	101mm	102.0	112.0	10.0	10.0	100%
31-May	101mm	112.0	122.0	10.0	10.0	100%
01-Jun	101mm	122.0	132.0	10.0	10.0	100%
01-Jun	101mm	132.0	142.0	10.0	10.0	100%
01-Jun	101mm	142.0	152.0	10.0	9.5	95%
01-Jun	101mm	152.0	162.0	10.0	10.0	100%
01-Jun	101mm	162.0	170.0	8.0	6.0	75%
01-Jun	101mm	170.0	176.0	6.0	6.0	100%
01-Jun	101mm	176.0	182.0	6.0	6.0	100%
01-Jun	101mm	182.0	192.0	10.0	10.0	100%
01-Jun	101mm	192.0	202.0	10.0	10.0	100%
14-Jun	101mm	202.0	208.0	6.0	6.0	100%
14-Jun	101mm	208.0	218.0	10.0	10.0	100%
14-Jun	101mm	218.0	228.0	10.0	10.0	100%
14-Jun	101mm	228.0	238.0	10.0	9.5	95%
14-Jun	101mm	238.0	248.0	10.0	10.0	100%
14-Jun	101mm	248.0	252.0	4.0	4.0	100%
14-Jun	101mm	252.0	258.0	6.0	6.0	100%
14-Jun	101mm	258.0	265.0	7.0	6.5	93%
14-Jun	101mm	265.0	276.0	11.0	10.0	91%
14-Jun	101mm	276.0	287.0	11.0	10.0	91%
14-Jun	101mm	287.0	290.0	3.0	3.0	100%
15-Jun	101mm	290.0	300.0	10.0	10.0	100%
15-Jun	101mm	300.0	307.0	7.0	7.0	100%
15-Jun	101mm	307.0	311.5	4.5	2.5	56%
15-Jun	101mm	311.5	314.0	2.5	2.5	100%
15-Jun	101mm	314.0	320.0	6.0	6.0	100%
15-Jun	101mm	320.0	326.0	6.0	5.5	92%
15-Jun	101mm	326.0	334.0	8.0	7.5	94%
15-Jun	101mm	334.0	339.0	5.0	3.0	60%
15-Jun	101mm	339.0	346.0	7.0	7.0	100%
15-Jun	101mm	346.0	353.0	7.0	7.0	100%
15-Jun	101mm	353.0	359.0	6.0	4.5	75%
15-Jun	101mm	359.0	366.0	7.0	7.0	100%
15-Jun	101mm	366.0	371.0	5.0	2.5	50%
15-Jun	101mm	371.0	381.0	10.0	8.0	80%
15-Jun	101mm	381.0	387.0	6.0	6.0	100%
15-Jun	101mm	387.0	395.0	8.0	8.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
15-Jun	101mm	395.0	405.0	10.0	10.0	100%
15-Jun	101mm	405.0	414.0	9.0	7.5	83%
15-Jun	101mm	414.0	425.0	11.0	9.0	82%
15-Jun	101mm	425.0	433.0	8.0	6.5	81%
16-Jun	101mm	433.0	441.0	8.0	7.5	94%
16-Jun	101mm	441.0	448.0	7.0	6.5	93%
16-Jun	101mm	448.0	451.0	3.0	3.0	100%
16-Jun	101mm	451.0	460.0	9.0	9.0	100%
16-Jun	101mm	460.0	470.0	10.0	10.0	100%
16-Jun	101mm	470.0	475.0	5.0	4.5	90%
16-Jun	101mm	475.0	484.0	9.0	9.0	100%
16-Jun	101mm	484.0	487.5	3.5	3.0	86%
16-Jun	101mm	487.5	490.5	3.0	1.5	50%
16-Jun	101mm	490.5	493.5	3.0	3.0	100%
16-Jun	101mm	493.5	498.0	4.5	3.0	67%
16-Jun	101mm	498.0	503.0	5.0	3.0	60%
16-Jun	101mm	503.0	513.0	10.0	10.0	100%
16-Jun	101mm	513.0	518.0	5.0	3.0	60%
16-Jun	101mm	518.0	528.0	10.0	8.5	85%
16-Jun	101mm	528.0	534.5	6.5	4.5	69%
16-Jun	101mm	534.5	539.0	4.5	3.5	78%
16-Jun	101mm	539.0	549.0	10.0	9.0	90%
16-Jun	101mm	549.0	556.0	7.0	7.0	100%
16-Jun	101mm	556.0	563.0	7.0	10.0	143%
17-Jun	101mm	563.0	573.0	10.0	8.0	80%
17-Jun	101mm	573.0	576.0	3.0	2.5	83%
17-Jun	101mm	576.0	583.0	7.0	7.0	100%
17-Jun	101mm	583.0	589.0	6.0	6.0	100%
17-Jun	101mm	589.0	592.0	3.0	3.0	100%
17-Jun	101mm	592.0	594.5	2.5	2.5	100%
17-Jun	101mm	594.5	602.0	7.5	6.5	87%
17-Jun	101mm	602.0	610.0	8.0	7.5	94%
17-Jun	101mm	610.0	616.0	6.0	6.0	100%
17-Jun	101mm	616.0	622.0	6.0	6.0	100%
17-Jun	101mm	622.0	631.0	9.0	8.0	89%
17-Jun	101mm	631.0	639.0	8.0	8.0	100%
17-Jun	101mm	639.0	647.0	8.0	8.0	100%
17-Jun	101mm	647.0	657.0	10.0	6.0	60%
17-Jun	101mm	657.0	665.0	8.0	4.5	56%
17-Jun	101mm	665.0	669.0	4.0	4.0	100%
18-Jun	101mm	669.0	675.0	6.0	5.0	83%
18-Jun	101mm	675.0	681.0	6.0	5.0	83%
18-Jun	101mm	681.0	691.0	10.0	10.0	100%
18-Jun	101mm	691.0	701.0	10.0	8.5	85%
18-Jun	101mm	701.0	710.5	9.5	9.0	95%
18-Jun	101mm	710.5	714.5	4.0	3.0	75%
18-Jun	101mm	714.5	717.0	2.5	0.0	0%
18-Jun	101mm	717.0	719.5	2.5	2.5	100%
18-Jun	101mm	719.5	720.5	1.0	1.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
18-Jun	101mm	720.5	723.0	2.5	1.0	40%
18-Jun	101mm	723.0	730.0	7.0	4.5	64%
18-Jun	101mm	730.0	732.0	2.0	1.0	50%
18-Jun	101mm	732.0	739.0	7.0	3.5	50%
18-Jun	101mm	739.0	749.0	10.0	10.0	100%
18-Jun	101mm	749.0	755.0	6.0	6.0	100%
19-Jun	101mm	755.0	761.0	6.0	4.0	67%
19-Jun	101mm	761.0	766.0	5.0	2.0	40%
19-Jun	101mm	766.0	772.5	6.5	6.5	100%
19-Jun	101mm	772.5	779.0	6.5	4.5	69%
19-Jun	101mm	779.0	780.5	1.5	0.5	33%
19-Jun	101mm	780.5	788.5	8.0	7.0	88%
19-Jun	101mm	788.5	792.5	4.0	3.5	88%
19-Jun	101mm	792.5	803.0	10.5	7.0	67%
19-Jun	101mm	803.0	813.0	10.0	9.0	90%
19-Jun	101mm	813.0	817.5	4.5	4.5	100%
19-Jun	101mm	817.5	820.0	2.5	2.5	100%
19-Jun	101mm	820.0	829.0	9.0	8.0	89%
19-Jun	101mm	829.0	839.0	10.0	10.0	100%
19-Jun	101mm	839.0	843.0	4.0	2.5	63%
19-Jun	101mm	843.0	853.0	10.0	6.5	65%
19-Jun	101mm	853.0	857.5	4.5	4.0	89%
19-Jun	101mm	857.5	866.0	8.5	7.0	82%
19-Jun	101mm	866.0	870.0	4.0	2.5	63%
19-Jun	101mm	870.0	874.0	4.0	3.5	88%
20-Jun	101mm	874.0	885.0	11.0	10.0	91%
20-Jun	101mm	885.0	894.0	9.0	9.0	100%
20-Jun	101mm	894.0	899.0	5.0	3.0	60%
20-Jun	101mm	899.0	904.0	5.0	5.0	100%
20-Jun	101mm	904.0	911.0	7.0	5.0	71%
20-Jun	101mm	911.0	921.0	10.0	10.0	100%
20-Jun	101mm	921.0	931.0	10.0	9.0	90%
20-Jun	101mm	931.0	934.0	3.0	3.0	100%
20-Jun	101mm	934.0	936.0	2.0	2.0	100%
20-Jun	101mm	936.0	944.0	8.0	6.0	75%
20-Jun	101mm	944.0	950.5	6.5	6.0	92%
20-Jun	101mm	950.5	956.5	6.0	4.0	67%
20-Jun	101mm	956.5	962.0	5.5	5.5	100%
20-Jun	101mm	962.0	971.0	9.0	7.5	83%
20-Jun	101mm	971.0	976.0	5.0	4.0	80%
20-Jun	101mm	976.0	984.0	8.0	7.0	88%
21-Jun	101mm	984.0	989.0	5.0	5.0	100%
21-Jun	101mm	989.0	994.0	5.0	5.0	100%
21-Jun	101mm	994.0	1,000.0	6.0	6.0	100%
21-Jun	101mm	1,000.0	1,006.0	6.0	6.0	100%
21-Jun	101mm	1,006.0	1,009.5	3.5	3.5	100%
21-Jun	101mm	1,009.5	1,010.0	0.5	0.5	100%
21-Jun	101mm	1,010.0	1,015.0	5.0	5.0	100%
21-Jun	101mm	1,015.0	1,025.0	10.0	10.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
21-Jun	101mm	1,025.0	1,029.0	4.0	3.5	88%
21-Jun	101mm	1,029.0	1,034.0	5.0	5.0	100%
21-Jun	101mm	1,034.0	1,036.0	2.0	2.0	100%
21-Jun	101mm	1,036.0	1,040.0	4.0	4.0	100%
22-Jun	101mm	1,040.0	1,048.0	8.0	5.0	63%
22-Jun	101mm	1,048.0	1,051.0	3.0	3.0	100%
22-Jun	101mm	1,051.0	1,055.0	4.0	4.0	100%
22-Jun	101mm	1,055.0	1,059.0	4.0	2.0	50%
22-Jun	101mm	1,059.0	1,065.0	6.0	6.0	100%
22-Jun	101mm	1,065.0	1,071.0	6.0	6.0	100%
22-Jun	101mm	1,071.0	1,072.5	1.5	1.5	100%
22-Jun	101mm	1,072.5	1,077.5	5.0	5.0	100%
22-Jun	101mm	1,077.5	1,087.0	9.5	9.5	100%
22-Jun	101mm	1,087.0	1,094.0	7.0	3.0	43%
22-Jun	101mm	1,094.0	1,100.0	6.0	6.0	100%
22-Jun	101mm	1,100.0	1,107.0	7.0	6.0	86%
22-Jun	101mm	1,107.0	1,112.0	5.0	3.0	60%
22-Jun	101mm	1,112.0	1,115.0	3.0	2.0	67%
22-Jun	101mm	1,115.0	1,123.0	8.0	7.5	94%
22-Jun	101mm	1,123.0	1,128.0	5.0	3.5	70%
22-Jun	101mm	1,128.0	1,136.5	8.5	8.0	94%
22-Jun	101mm	1,136.5	1,142.0	5.5	2.5	45%
23-Jun	101mm	1,142.0	1,148.0	6.0	4.0	67%
23-Jun	101mm	1,148.0	1,156.0	8.0	4.0	50%
23-Jun	101mm	1,156.0	1,163.0	7.0	5.0	71%
23-Jun	101mm	1,163.0	1,165.0	2.0	1.5	75%
23-Jun	101mm	1,165.0	1,169.5	4.5	3.0	67%
23-Jun	101mm	1,169.5	1,176.5	7.0	6.0	86%
23-Jun	101mm	1,176.5	1,180.0	3.5	3.0	86%
23-Jun	101mm	1,180.0	1,184.5	4.5	4.5	100%
23-Jun	101mm	1,184.5	1,188.5	4.0	3.0	75%
23-Jun	101mm	1,188.5	1,193.0	4.5	3.5	78%
23-Jun	101mm	1,193.0	1,198.0	5.0	4.5	90%
23-Jun	101mm	1,198.0	1,206.0	8.0	7.0	88%
23-Jun	101mm	1,206.0	1,213.0	7.0	7.0	100%
23-Jun	101mm	1,213.0	1,215.0	2.0	1.5	75%
23-Jun	101mm	1,215.0	1,220.5	5.5	5.0	91%
23-Jun	101mm	1,220.5	1,222.0	1.5	1.0	67%
23-Jun	101mm	1,222.0	1,227.5	5.5	5.0	91%
23-Jun	101mm	1,227.5	1,233.0	5.5	5.0	91%
23-Jun	101mm	1,233.0	1,241.0	8.0	7.0	88%
23-Jun	101mm	1,241.0	1,245.0	4.0	4.0	100%
24-Jun	101mm	1,245.0	1,256.0	11.0	10.0	91%
24-Jun	101mm	1,256.0	1,266.0	10.0	10.0	100%
24-Jun	101mm	1,266.0	1,268.0	2.0	1.0	50%
24-Jun	101mm	1,268.0	1,271.0	3.0	3.0	100%
24-Jun	101mm	1,271.0	1,274.0	3.0	1.5	50%
24-Jun	101mm	1,274.0	1,278.0	4.0	4.0	100%
24-Jun	101mm	1,278.0	1,281.5	3.5	3.5	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
24-Jun	101mm	1,281.5	1,285.0	3.5	3.0	86%
24-Jun	101mm	1,285.0	1,290.0	5.0	5.0	100%
24-Jun	101mm	1,290.0	1,295.0	5.0	4.5	90%
24-Jun	101mm	1,295.0	1,301.0	6.0	5.0	83%
24-Jun	101mm	1,301.0	1,306.5	5.5	5.0	91%
24-Jun	101mm	1,306.5	1,317.0	10.5	10.0	95%
24-Jun	101mm	1,317.0	1,322.0	5.0	4.0	80%
24-Jun	101mm	1,322.0	1,330.0	8.0	8.0	100%
24-Jun	101mm	1,330.0	1,334.0	4.0	2.5	63%
25-Jun	101mm	1,334.0	1,337.0	3.0	3.0	100%
25-Jun	101mm	1,337.0	1,346.0	9.0	9.0	100%
25-Jun	101mm	1,346.0	1,348.0	2.0	0.0	0%
25-Jun	101mm	1,348.0	1,357.0	9.0	9.0	100%
25-Jun	101mm	1,357.0	1,360.0	3.0	3.0	100%
25-Jun	101mm	1,360.0	1,370.0	10.0	10.0	100%
25-Jun	101mm	1,370.0	1,380.0	10.0	10.0	100%
25-Jun	101mm	1,380.0	1,384.0	4.0	2.5	63%
25-Jun	101mm	1,384.0	1,390.0	6.0	6.0	100%
25-Jun	101mm	1,390.0	1,394.0	4.0	2.5	63%
25-Jun	101mm	1,394.0	1,398.5	4.5	4.0	89%
25-Jun	101mm	1,398.5	1,402.0	3.5	2.0	57%
25-Jun	101mm	1,402.0	1,411.0	9.0	9.0	100%
25-Jun	101mm	1,411.0	1,414.0	3.0	3.0	100%
25-Jun	101mm	1,414.0	1,418.0	4.0	3.0	75%
26-Jun	101mm	1,418.0	1,419.5	1.5	0.5	33%
26-Jun	101mm	1,419.5	1,423.5	4.0	3.0	75%
26-Jun	101mm	1,423.5	1,434.0	10.5	8.0	76%
26-Jun	101mm	1,434.0	1,439.0	5.0	5.0	100%
26-Jun	101mm	1,439.0	1,446.0	7.0	6.5	93%
26-Jun	101mm	1,446.0	1,452.5	6.5	6.5	100%
26-Jun	101mm	1,452.5	1,459.0	6.5	6.5	100%
26-Jun	101mm	1,459.0	1,465.0	6.0	6.0	100%
26-Jun	101mm	1,465.0	1,475.0	10.0	10.0	100%
26-Jun	101mm	1,475.0	1,485.0	10.0	10.0	100%
26-Jun	101mm	1,485.0	1,495.0	10.0	8.5	85%
26-Jun	101mm	1,495.0	1,501.0	6.0	4.0	67%
26-Jun	101mm	1,501.0	1,508.0	7.0	6.0	86%
27-Jun	101mm	1,508.0	1,515.0	7.0	7.0	100%
27-Jun	101mm	1,515.0	1,521.0	6.0	3.5	58%
27-Jun	101mm	1,521.0	1,526.0	5.0	3.0	60%
27-Jun	101mm	1,526.0	1,533.0	7.0	6.0	86%
27-Jun	101mm	1,533.0	1,539.0	6.0	5.0	83%
27-Jun	101mm	1,539.0	1,548.0	9.0	7.5	83%
27-Jun	101mm	1,548.0	1,557.0	9.0	8.0	89%
27-Jun	101mm	1,557.0	1,564.0	7.0	7.0	100%
27-Jun	101mm	1,564.0	1,573.0	9.0	7.0	78%
27-Jun	101mm	1,573.0	1,578.0	5.0	4.0	80%
27-Jun	101mm	1,578.0	1,585.0	7.0	6.0	86%
27-Jun	101mm	1,585.0	1,589.0	4.0	2.5	63%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
27-Jun	101mm	1,589.0	1,596.0	7.0	6.0	86%
27-Jun	101mm	1,596.0	1,604.5	8.5	7.5	88%
27-Jun	101mm	1,604.5	1,615.0	10.5	10.0	95%
28-Jun	101mm	1,615.0	1,618.0	3.0	1.0	33%
28-Jun	101mm	1,618.0	1,623.0	5.0	0.5	10%
28-Jun	101mm	1,623.0	1,633.0	10.0	10.0	100%
28-Jun	101mm	1,633.0	1,643.0	10.0	6.0	60%
28-Jun	101mm	1,643.0	1,653.0	10.0	10.0	100%
28-Jun	101mm	1,653.0	1,655.0	2.0	1.0	50%
28-Jun	101mm	1,655.0	1,660.0	5.0	4.5	90%
28-Jun	101mm	1,660.0	1,671.0	11.0	10.0	91%
28-Jun	101mm	1,671.0	1,681.0	10.0	8.5	85%
28-Jun	101mm	1,681.0	1,687.5	6.5	4.5	69%
28-Jun	101mm	1,687.5	1,695.0	7.5	7.5	100%
28-Jun	101mm	1,695.0	1,702.0	7.0	6.0	86%
28-Jun	101mm	1,702.0	1,709.0	7.0	5.0	71%
29-Jun	101mm	1,709.0	1,719.0	10.0	9.0	90%
29-Jun	101mm	1,719.0	1,729.0	10.0	9.0	90%
29-Jun	101mm	1,729.0	1,737.0	8.0	8.0	100%
29-Jun	101mm	1,737.0	1,745.0	8.0	6.5	81%
29-Jun	101mm	1,745.0	1,750.0	5.0	2.5	50%
29-Jun	101mm	1,750.0	1,752.0	2.0	0.0	0%
29-Jun	101mm	1,752.0	1,756.0	4.0	3.0	75%
29-Jun	101mm	1,756.0	1,764.0	8.0	8.0	100%
29-Jun	101mm	1,764.0	1,774.0	10.0	10.0	100%
29-Jun	101mm	1,774.0	1,782.0	8.0	8.0	100%
29-Jun	101mm	1,782.0	1,792.0	10.0	10.0	100%
29-Jun	101mm	1,792.0	1,802.0	10.0	10.0	100%
30-Jun	101mm	1,802.0	1,813.0	11.0	10.0	91%
30-Jun	101mm	1,813.0	1,823.0	10.0	10.0	100%
30-Jun	101mm	1,823.0	1,832.0	9.0	8.5	94%
30-Jun	101mm	1,832.0	1,841.0	9.0	9.0	100%
30-Jun	101mm	1,841.0	1,851.0	10.0	10.0	100%
30-Jun	101mm	1,851.0	1,857.0	6.0	6.0	100%
30-Jun	101mm	1,857.0	1,862.0	5.0	5.0	100%
30-Jun	101mm	1,862.0	1,872.0	10.0	10.0	100%
30-Jun	101mm	1,872.0	1,882.0	10.0	10.0	100%
30-Jun	101mm	1,882.0	1,892.0	10.0	10.0	100%
30-Jun	101mm	1,892.0	1,902.0	10.0	10.0	100%
30-Jun	101mm	1,902.0	1,911.0	9.0	9.0	100%
01-Jul	101mm	1,911.0	1,918.0	7.0	5.0	71%
01-Jul	101mm	1,918.0	1,921.0	3.0	3.0	100%
01-Jul	101mm	1,921.0	1,931.0	10.0	10.0	100%
01-Jul	101mm	1,931.0	1,940.0	9.0	8.0	89%
01-Jul	101mm	1,940.0	1,946.0	6.0	6.0	100%
01-Jul	101mm	1,946.0	1,953.0	7.0	6.0	86%
01-Jul	101mm	1,953.0	1,957.0	4.0	4.0	100%
01-Jul	101mm	1,957.0	1,960.0	3.0	3.0	100%
01-Jul	101mm	1,960.0	1,964.0	4.0	4.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
01-Jul	101mm	1,964.0	1,967.0	3.0	2.5	83%
01-Jul	101mm	1,967.0	1,974.0	7.0	5.0	71%
01-Jul	101mm	1,974.0	1,981.0	7.0	6.5	93%
01-Jul	101mm	1,981.0	1,990.0	9.0	7.0	78%
01-Jul	101mm	1,990.0	1,996.0	6.0	6.0	100%
31-Jul	101mm	1,996.0	1,999.0	3.0	1.0	33%
31-Jul	101mm	1,999.0	2,003.0	4.0	4.0	100%
31-Jul	101mm	2,003.0	2,009.0	6.0	6.0	100%
31-Jul	101mm	2,009.0	2,012.0	3.0	3.0	100%
31-Jul	101mm	2,012.0	2,014.0	2.0	1.0	50%
01-Aug	101mm	2,014.0	2,018.0	4.0	4.0	100%
01-Aug	101mm	2,018.0	2,025.5	7.5	7.5	100%
01-Aug	101mm	2,025.5	2,030.5	5.0	5.0	100%
01-Aug	101mm	2,030.5	2,036.5	6.0	2.5	42%
01-Aug	101mm	2,036.5	2,040.0	3.5	3.5	100%
01-Aug	101mm	2,040.0	2,048.0	8.0	8.0	100%
01-Aug	101mm	2,048.0	2,056.0	8.0	8.0	100%
01-Aug	101mm	2,056.0	2,059.0	3.0	3.0	100%
01-Aug	101mm	2,059.0	2,060.0	1.0	0.5	50%
01-Aug	101mm	2,060.0	2,061.5	1.5	1.0	67%
01-Aug	101mm	2,061.5	2,074.5	13.0	2.0	15%
02-Aug	101mm	2,074.5	2,080.0	5.5	5.5	100%
02-Aug	101mm	2,080.0	2,086.5	6.5	6.5	100%
02-Aug	101mm	2,086.5	2,087.0	0.5	0.5	100%
02-Aug	101mm	2,087.0	2,097.0	10.0	10.0	100%
02-Aug	101mm	2,097.0	2,107.0	10.0	10.0	100%
02-Aug	101mm	2,107.0	2,117.0	10.0	10.0	100%
02-Aug	101mm	2,117.0	2,127.0	10.0	10.0	100%
02-Aug	101mm	2,127.0	2,137.0	10.0	10.0	100%
03-Aug	101mm	2,137.0	2,147.0	10.0	10.0	100%
03-Aug	101mm	2,147.0	2,157.5	10.5	10.5	100%
03-Aug	101mm	2,157.5	2,160.0	2.5	2.5	100%
03-Aug	101mm	2,160.0	2,166.5	6.5	6.5	100%
03-Aug	101mm	2,166.5	2,176.5	10.0	10.0	100%
03-Aug	101mm	2,176.5	2,184.0	7.5	7.5	100%
03-Aug	101mm	2,184.0	2,191.0	7.0	7.0	100%
03-Aug	101mm	2,191.0	2,201.0	10.0	10.0	100%
03-Aug	101mm	2,201.0	2,211.0	10.0	10.0	100%
04-Aug	101mm	2,211.0	2,219.0	8.0	8.0	100%
04-Aug	101mm	2,219.0	2,224.0	5.0	5.0	100%
04-Aug	101mm	2,224.0	2,231.0	7.0	7.0	100%
04-Aug	101mm	2,231.0	2,241.0	10.0	10.0	100%
04-Aug	101mm	2,241.0	2,251.0	10.0	10.0	100%
04-Aug	101mm	2,251.0	2,261.0	10.0	10.0	100%
04-Aug	101mm	2,261.0	2,266.0	5.0	4.5	90%
05-Aug	101mm	2,266.0	2,273.5	7.5	7.5	100%
05-Aug	101mm	2,273.5	2,283.5	10.0	10.0	100%
05-Aug	101mm	2,283.5	2,293.5	10.0	10.0	100%
05-Aug	101mm	2,293.5	2,304.0	10.5	10.5	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
05-Aug	101mm	2,304.0	2,314.0	10.0	10.0	100%
05-Aug	101mm	2,314.0	2,324.5	10.5	10.0	95%
05-Aug	101mm	2,324.5	2,331.0	6.5	6.5	100%
05-Aug	101mm	2,331.0	2,338.0	7.0	7.0	100%
05-Aug	101mm	2,338.0	2,348.0	10.0	10.0	100%
05-Aug	101mm	2,348.0	2,358.0	10.0	10.0	100%
05-Aug	101mm	2,358.0	2,368.0	10.0	10.0	100%
06-Aug	101mm	2,368.0	2,378.5	10.5	7.5	71%
06-Aug	101mm	2,378.5	2,388.5	10.0	10.0	100%
06-Aug	101mm	2,388.5	2,399.0	10.5	10.5	100%
06-Aug	101mm	2,399.0	2,409.0	10.0	10.0	100%
06-Aug	101mm	2,409.0	2,419.5	10.5	10.5	100%
06-Aug	101mm	2,419.5	2,429.5	10.0	10.0	100%
06-Aug	101mm	2,429.5	2,437.5	8.0	6.0	75%
06-Aug	101mm	2,437.5	2,448.0	10.5	0.5	5%
06-Aug	101mm	2,448.0	2,450.0	2.0	2.0	100%
06-Aug	101mm	2,450.0	2,455.0	5.0	5.0	100%
06-Aug	101mm	2,455.0	2,465.0	10.0	10.0	100%
06-Aug	101mm	2,465.0	2,475.0	10.0	10.0	100%
06-Aug	101mm	2,475.0	2,481.0	6.0	6.0	100%
07-Aug	101mm	2,481.0	2,491.0	10.0	10.0	100%
07-Aug	101mm	2,491.0	2,501.0	10.0	10.0	100%
07-Aug	101mm	2,501.0	2,505.5	4.5	4.5	100%
09-Aug	101mm	2,505.5	2,510.0	4.5	4.5	100%
09-Aug	101mm	2,510.0	2,520.0	10.0	10.0	100%
09-Aug	101mm	2,520.0	2,530.0	10.0	10.0	100%
09-Aug	101mm	2,530.0	2,540.0	10.0	10.0	100%
10-Aug	101mm	2,540.0	2,550.0	10.0	10.0	100%
10-Aug	101mm	2,550.0	2,560.0	10.0	10.0	100%
10-Aug	101mm	2,560.0	2,569.5	9.5	9.5	100%
10-Aug	101mm	2,569.5	2,580.0	10.5	10.5	100%
10-Aug	101mm	2,580.0	2,590.0	10.0	4.5	45%
10-Aug	101mm	2,590.0	2,600.0	10.0	10.0	100%
10-Aug	101mm	2,600.0	2,610.0	10.0	5.0	50%
10-Aug	101mm	2,610.0	2,620.0	10.0	10.0	100%
10-Aug	101mm	2,620.0	2,629.0	9.0	9.0	100%
10-Aug	101mm	2,629.0	2,639.0	10.0	10.0	100%
10-Aug	101mm	2,639.0	2,645.0	6.0	5.0	83%
11-Aug	101mm	2,645.0	2,655.0	10.0	10.0	100%
11-Aug	101mm	2,655.0	2,661.0	6.0	6.0	100%
11-Aug	101mm	2,661.0	2,671.0	10.0	3.5	35%
10-Sep	134mm	2,671.0	2,679.0	8.0	8.0	100%
10-Sep	134mm	2,679.0	2,691.0	12.0	12.0	100%
10-Sep	134mm	2,691.0	2,702.0	11.0	11.0	100%
10-Sep	134mm	2,702.0	2,708.0	6.0	6.0	100%
10-Sep	134mm	2,708.0	2,714.0	6.0	6.0	100%
10-Sep	134mm	2,714.0	2,717.0	3.0	0.0	0%
11-Sep	134mm	2,717.0	2,721.0	4.0	4.0	100%
11-Sep	134mm	2,721.0	2,726.0	5.0	5.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
11-Sep	134mm	2,726.0	2,730.0	4.0	4.0	100%
11-Sep	134mm	2,730.0	2,732.0	2.0	2.0	100%
11-Sep	134mm	2,732.0	2,733.0	1.0	1.0	100%
11-Sep	134mm	2,733.0	2,738.0	5.0	5.0	100%
12-Sep	134mm	2,738.0	2,752.0	14.0	5.0	36%
12-Sep	134mm	2,752.0	2,755.0	3.0	3.0	100%
12-Sep	134mm	2,755.0	2,758.0	3.0	0.0	0%
12-Sep	134mm	2,758.0	2,763.0	5.0	1.0	20%
12-Sep	134mm	2,763.0	2,768.0	5.0	0.0	0%
12-Sep	134mm	2,768.0	2,770.0	2.0	2.0	100%
13-Sep	134mm	2,770.0	2,782.0	12.0	12.0	100%
13-Sep	134mm	2,782.0	2,793.0	11.0	11.0	100%
13-Sep	134mm	2,793.0	2,805.0	12.0	12.0	100%
13-Sep	134mm	2,805.0	2,816.0	11.0	11.0	100%
13-Sep	134mm	2,816.0	2,827.0	11.0	11.0	100%
13-Sep	134mm	2,827.0	2,836.0	9.0	9.0	100%
14-Sep	134mm	2,836.0	2,846.0	10.0	6.0	60%
14-Sep	134mm	2,846.0	2,851.0	5.0	1.0	20%
14-Sep	134mm	2,851.0	2,852.0	1.0	0.0	0%
14-Sep	134mm	2,852.0	2,855.0	3.0	3.0	100%
14-Sep	134mm	2,855.0	2,861.0	6.0	6.0	100%
14-Sep	134mm	2,861.0	2,865.0	4.0	1.5	38%
15-Sep	134mm	2,865.0	2,866.0	1.0	0.0	0%
15-Sep	134mm	2,866.0	2,868.0	2.0	0.0	0%
16-Sep	134mm	2,868.0	2,871.0	3.0	0.0	0%
16-Sep	134mm	2,871.0	2,874.0	3.0	0.0	0%
16-Sep	134mm	2,874.0	2,877.0	3.0	0.0	0%
16-Sep	134mm	2,877.0	2,889.0	12.0	5.0	42%
16-Sep	134mm	2,889.0	2,892.0	3.0	2.5	83%
16-Sep	134mm	2,892.0	2,894.0	2.0	2.0	100%
16-Sep	134mm	2,894.0	2,896.0	2.0	1.0	50%
17-Sep	134mm	2,896.0	2,901.0	5.0	5.0	100%
17-Sep	134mm	2,901.0	2,910.0	9.0	9.0	100%
17-Sep	134mm	2,910.0	2,914.0	4.0	4.0	100%
17-Sep	134mm	2,914.0	2,918.0	4.0	4.0	100%
17-Sep	134mm	2,918.0	2,922.0	4.0	4.0	100%
17-Sep	134mm	2,922.0	2,926.0	4.0	3.0	75%
17-Sep	134mm	2,926.0	2,927.0	1.0	0.0	0%
17-Sep	134mm	2,927.0	2,928.5	1.5	0.5	33%
17-Sep	134mm	2,928.5	2,930.0	1.5	0.5	33%
17-Sep	134mm	2,930.0	2,933.0	3.0	3.0	100%
17-Sep	134mm	2,933.0	2,935.5	2.5	0.0	0%
18-Sep	134mm	2,935.5	2,938.0	2.5	0.5	20%
18-Sep	134mm	2,938.0	2,944.0	6.0	6.0	100%
18-Sep	134mm	2,944.0	2,946.0	2.0	0.0	0%
18-Sep	134mm	2,946.0	2,947.0	1.0	1.0	100%
18-Sep	134mm	2,947.0	2,949.0	2.0	0.0	0%
18-Sep	134mm	2,949.0	2,950.0	1.0	0.5	50%
18-Sep	134mm	2,950.0	2,951.5	1.5	1.5	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
18-Sep	134mm	2,951.5	2,952.0	0.5	0.0	0%
18-Sep	134mm	2,952.0	2,954.5	2.5	0.5	20%
18-Sep	134mm	2,954.5	2,957.0	2.5	2.5	100%
19-Sep	134mm	2,957.0	2,961.0	4.0	4.0	100%
19-Sep	134mm	2,961.0	2,967.0	6.0	6.0	100%
19-Sep	134mm	2,967.0	2,973.0	6.0	6.0	100%
19-Sep	134mm	2,973.0	2,977.0	4.0	4.0	100%
19-Sep	134mm	2,977.0	2,983.0	6.0	6.0	100%
19-Sep	134mm	2,983.0	2,986.0	3.0	3.0	100%
19-Sep	134mm	2,986.0	2,989.0	3.0	3.0	100%
19-Sep	134mm	2,989.0	2,993.0	4.0	4.0	100%
20-Sep	134mm	2,993.0	2,997.0	4.0	4.0	100%
20-Sep	134mm	2,997.0	3,003.0	6.0	6.0	100%
20-Sep	134mm	3,003.0	3,008.0	5.0	5.0	100%
20-Sep	134mm	3,008.0	3,020.0	12.0	12.0	100%
20-Sep	134mm	3,020.0	3,021.0	1.0	0.0	0%
22-Sep	134mm	3,021.0	3,027.0	6.0	6.0	100%
22-Sep	134mm	3,027.0	3,037.0	10.0	10.0	100%
23-Sep	134mm	3,037.0	3,047.5	10.5	10.5	100%
23-Sep	134mm	3,047.5	3,058.0	10.5	10.5	100%
23-Sep	134mm	3,058.0	3,068.0	10.0	10.0	100%
23-Sep	134mm	3,068.0	3,078.0	10.0	10.0	100%
23-Sep	134mm	3,078.0	3,088.0	10.0	10.0	100%
23-Sep	134mm	3,088.0	3,098.0	10.0	10.0	100%
23-Sep	134mm	3,098.0	3,104.0	6.0	6.0	100%
24-Sep	134mm	3,104.0	3,113.0	9.0	9.0	100%
24-Sep	134mm	3,113.0	3,121.0	8.0	10.0	125%
24-Sep	134mm	3,121.0	3,133.0	12.0	10.0	83%
24-Sep	134mm	3,133.0	3,143.0	10.0	10.0	100%
24-Sep	134mm	3,143.0	3,152.0	9.0	9.0	100%
24-Sep	134mm	3,152.0	3,162.0	10.0	10.0	100%
24-Sep	134mm	3,162.0	3,172.0	10.0	10.0	100%
25-Sep	134mm	3,172.0	3,182.0	10.0	10.0	100%
25-Sep	134mm	3,182.0	3,192.0	10.0	10.0	100%
25-Sep	134mm	3,192.0	3,202.0	10.0	10.0	100%
25-Sep	134mm	3,202.0	3,207.0	5.0	5.0	100%
25-Sep	134mm	3,207.0	3,211.0	4.0	4.0	100%
25-Sep	134mm	3,211.0	3,221.0	10.0	10.0	100%
25-Sep	134mm	3,221.0	3,231.0	10.0	10.0	100%
26-Sep	HQ	3,231.0	3,237.0	6.0	6.0	100%
26-Sep	HQ	3,237.0	3,241.0	4.0	4.0	100%
26-Sep	HQ	3,241.0	3,246.0	5.0	5.0	100%
26-Sep	HQ	3,246.0	3,251.0	5.0	5.0	100%
26-Sep	HQ	3,251.0	3,257.0	6.0	6.0	100%
26-Sep	HQ	3,257.0	3,261.0	4.0	4.0	100%
26-Sep	HQ	3,261.0	3,266.0	5.0	5.0	100%
27-Sep	HQ	3,266.0	3,275.0	9.0	9.0	100%
27-Sep	HQ	3,275.0	3,285.0	10.0	10.0	100%
27-Sep	HQ	3,285.0	3,295.0	10.0	10.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
27-Sep	HQ	3,295.0	3,298.0	3.0	1.0	33%
27-Sep	HQ	3,298.0	3,303.0	5.0	3.0	60%
27-Sep	HQ	3,303.0	3,305.0	2.0	0.0	0%
27-Sep	HQ	3,305.0	3,305.5	0.5	0.0	0%
27-Sep	HQ	3,305.5	3,308.0	2.5	0.0	0%
28-Sep	HQ	3,308.0	3,314.0	6.0	1.0	17%
28-Sep	HQ	3,314.0	3,318.0	4.0	0.0	0%
28-Sep	HQ	3,318.0	3,320.0	2.0	0.5	25%
28-Sep	HQ	3,320.0	3,323.5	3.5	0.0	0%
28-Sep	HQ	3,323.5	3,325.0	1.5	0.5	33%
28-Sep	HQ	3,325.0	3,327.0	2.0	2.0	100%
28-Sep	HQ	3,327.0	3,329.0	2.0	2.0	100%
29-Sep	HQ	3,329.0	3,332.0	3.0	0.0	0%
29-Sep	HQ	3,332.0	3,336.0	4.0	0.5	13%
29-Sep	HQ	3,336.0	3,337.0	1.0	0.5	50%
29-Sep	HQ	3,337.0	3,339.0	2.0	2.0	100%
29-Sep	HQ	3,339.0	3,343.0	4.0	4.0	100%
29-Sep	HQ	3,343.0	3,346.0	3.0	3.0	100%
30-Sep	HQ	3,346.0	3,352.0	6.0	6.0	100%
30-Sep	HQ	3,352.0	3,356.0	4.0	4.0	100%
30-Sep	HQ	3,356.0	3,364.0	8.0	8.0	100%
30-Sep	HQ	3,364.0	3,368.0	4.0	3.0	75%
30-Sep	HQ	3,368.0	3,372.0	4.0	4.0	100%
30-Sep	HQ	3,372.0	3,377.0	5.0	5.0	100%
01-Oct	HQ	3,377.0	3,385.0	8.0	8.0	100%
01-Oct	HQ	3,385.0	3,389.0	4.0	1.5	38%
01-Oct	HQ	3,389.0	3,393.0	4.0	2.0	50%
01-Oct	HQ	3,393.0	3,396.0	3.0	1.0	33%
01-Oct	HQ	3,396.0	3,397.5	1.5	1.0	67%
01-Oct	HQ	3,397.5	3,399.0	1.5	1.5	100%
01-Oct	HQ	3,399.0	3,402.0	3.0	3.0	100%
02-Oct	HQ	3,402.0	3,405.0	3.0	2.0	67%
02-Oct	HQ	3,405.0	3,408.0	3.0	3.0	100%
02-Oct	HQ	3,408.0	3,411.0	3.0	1.0	33%
02-Oct	HQ	3,411.0	3,414.0	3.0	0.2	7%
02-Oct	HQ	3,414.0	3,415.5	1.5	1.0	67%
02-Oct	HQ	3,415.5	3,417.0	1.5	1.5	100%
02-Oct	HQ	3,417.0	3,422.0	5.0	5.0	100%
03-Oct	HQ	3,422.0	3,429.0	7.0	7.0	100%
03-Oct	HQ	3,429.0	3,438.0	9.0	9.0	100%
03-Oct	HQ	3,438.0	3,447.0	9.0	9.0	100%
03-Oct	HQ	3,447.0	3,453.0	6.0	6.0	100%
03-Oct	HQ	3,453.0	3,462.0	9.0	9.0	100%
04-Oct	HQ	3,462.0	3,472.0	10.0	10.0	100%
04-Oct	HQ	3,472.0	3,482.0	10.0	6.0	60%
04-Oct	HQ	3,482.0	3,491.0	9.0	9.0	100%
04-Oct	HQ	3,491.0	3,498.0	7.0	7.0	100%
05-Oct	HQ	3,498.0	3,508.0	10.0	10.0	100%
05-Oct	HQ	3,508.0	3,510.0	2.0	0.0	0%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
05-Oct	HQ	3,510.0	3,512.0	2.0	1.0	50%
05-Oct	HQ	3,512.0	3,512.5	0.5	0.0	0%
06-Oct	HQ	3,512.5	3,513.0	0.5	0.1	20%
06-Oct	HQ	3,513.0	3,523.0	10.0	7.0	70%
06-Oct	HQ	3,523.0	3,527.0	4.0	0.0	0%
06-Oct	HQ	3,529.0	3,532.0	3.0	0.0	0%
06-Oct	HQ	3,532.0	3,538.0	6.0	0.0	0%
07-Oct	HQ	3,538.0	3,540.5	2.5	0.3	12%
07-Oct	HQ	3,540.5	3,541.0	0.5	0.0	0%
07-Oct	HQ	3,541.0	3,545.0	4.0	0.0	0%
07-Oct	HQ	3,545.0	3,548.0	3.0	0.0	0%
07-Oct	HQ	3,548.0	3,549.0	1.0	0.0	0%
07-Oct	HQ	3,549.0	3,550.0	1.0	0.0	0%
08-Oct	HQ	3,550.0	3,550.5	0.5	0.0	0%
08-Oct	HQ	3,550.5	3,559.0	8.5	1.0	12%
08-Oct	HQ	3,559.0	3,564.0	5.0	3.0	60%
08-Oct	HQ	3,564.0	3,564.5	0.5	0.0	0%
09-Oct	HQ	3,564.0	3,570.0	6.0	6.0	100%
09-Oct	HQ	3,570.0	3,574.0	4.0	4.0	100%
09-Oct	HQ	3,574.0	3,576.0	2.0	2.0	100%
09-Oct	HQ	3,576.0	3,580.0	4.0	4.0	100%
09-Oct	HQ	3,580.0	3,590.0	10.0	4.0	40%
10-Oct	HQ	3,590.0	3,600.0	10.0	10.0	100%
10-Oct	HQ	3,600.0	3,608.0	8.0	8.0	100%
10-Oct	HQ	3,608.0	3,610.0	2.0	1.0	50%
10-Oct	HQ	3,610.0	3,618.0	8.0	8.0	100%
10-Oct	HQ	3,618.0	3,621.0	3.0	3.0	100%
10-Oct	HQ	3,621.0	3,625.0	4.0	2.0	50%
11-Oct	HQ	3,625.0	3,630.0	5.0	2.0	40%
11-Oct	HQ	3,630.0	3,633.0	3.0	3.0	100%
11-Oct	HQ	3,633.0	3,637.0	4.0	4.0	100%
11-Oct	HQ	3,637.0	3,646.0	9.0	9.0	100%
11-Oct	HQ	3,646.0	3,650.0	4.0	2.0	50%
11-Oct	HQ	3,650.0	3,660.0	10.0	10.0	100%
12-Oct	HQ	3,660.0	3,670.0	10.0	10.0	100%
12-Oct	HQ	3,670.0	3,680.0	10.0	10.0	100%
12-Oct	HQ	3,680.0	3,690.0	10.0	10.0	100%
12-Oct	HQ	3,690.0	3,700.0	10.0	10.0	100%
12-Oct	HQ	3,700.0	3,706.0	6.0	6.0	100%
12-Oct	HQ	3,706.0	3,716.0	10.0	10.0	100%
13-Oct	HQ	3,716.0	3,726.0	10.0	10.0	100%
13-Oct	HQ	3,726.0	3,732.0	6.0	6.0	100%
13-Oct	HQ	3,732.0	3,740.0	8.0	8.0	100%
13-Oct	HQ	3,740.0	3,749.0	9.0	4.5	50%
13-Oct	HQ	3,749.0	3,755.0	6.0	6.0	100%
13-Oct	HQ	3,755.0	3,765.0	10.0	10.0	100%
13-Oct	HQ	3,765.0	3,775.0	10.0	10.0	100%
14-Oct	HQ	3,775.0	3,785.0	10.0	10.0	100%
14-Oct	HQ	3,785.0	3,795.0	10.0	10.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
14-Oct	HQ	3,795.0	3,805.0	10.0	10.0	100%
14-Oct	HQ	3,805.0	3,814.0	9.0	9.0	100%
14-Oct	HQ	3,814.0	3,824.0	10.0	10.0	100%
14-Oct	HQ	3,824.0	3,834.0	10.0	10.0	100%
14-Oct	HQ	3,834.0	3,844.0	10.0	10.0	100%
15-Oct	HQ	3,844.0	3,849.0	5.0	5.0	100%
15-Oct	HQ	3,849.0	3,853.0	4.0	4.0	100%
15-Oct	HQ	3,853.0	3,855.0	2.0	1.0	50%
15-Oct	HQ	3,855.0	3,858.0	3.0	3.0	100%
15-Oct	HQ	3,858.0	3,862.0	4.0	4.0	100%
15-Oct	HQ	3,862.0	3,863.0	1.0	1.0	100%
15-Oct	HQ	3,863.0	3,865.5	2.5	0.5	20%
15-Oct	HQ	3,865.5	3,867.0	1.5	1.5	100%
15-Oct	HQ	3,867.0	3,870.0	3.0	2.0	67%
16-Oct	HQ	3,870.0	3,872.0	2.0	0.0	0%
16-Oct	HQ	3,872.0	3,874.0	2.0	2.0	100%
16-Oct	HQ	3,874.0	3,876.0	2.0	2.0	100%
16-Oct	HQ	3,876.0	3,884.0	8.0	7.5	94%
16-Oct	HQ	3,884.0	3,885.0	1.0	0.0	0%
16-Oct	HQ	3,885.0	3,887.5	2.5	2.5	100%
16-Oct	HQ	3,887.5	3,892.0	4.5	4.0	89%
17-Oct	HQ	3,892.0	3,895.0	3.0	3.0	100%
17-Oct	HQ	3,895.0	3,897.0	2.0	2.0	100%
17-Oct	HQ	3,897.0	3,904.0	7.0	7.0	100%
17-Oct	HQ	3,904.0	3,906.0	2.0	2.0	100%
17-Oct	HQ	3,906.0	3,908.0	2.0	2.0	100%
17-Oct	HQ	3,908.0	3,911.0	3.0	3.0	100%
17-Oct	HQ	3,911.0	3,918.5	7.5	7.5	100%
17-Oct	HQ	3,918.5	3,920.0	1.5	1.5	100%
18-Oct	HQ	3,920.0	3,920.5	0.5	0.5	100%
18-Oct	HQ	3,920.5	3,922.0	1.5	0.0	0%
18-Oct	HQ	3,922.0	3,924.0	2.0	2.0	100%
18-Oct	HQ	3,924.0	3,926.0	2.0	2.0	100%
18-Oct	HQ	3,926.0	3,934.0	8.0	8.0	100%
19-Oct	HQ	3,934.0	3,939.0	5.0	4.5	90%
19-Oct	HQ	3,939.0	3,944.0	5.0	5.0	100%
19-Oct	HQ	3,944.0	3,949.0	5.0	5.0	100%
19-Oct	HQ	3,949.0	3,951.0	2.0	2.0	100%
19-Oct	HQ	3,951.0	3,956.0	5.0	5.0	100%
19-Oct	HQ	3,956.0	3,966.0	10.0	10.0	100%
19-Oct	HQ	3,966.0	3,968.0	2.0	2.0	100%
19-Oct	HQ	3,968.0	3,971.0	3.0	3.0	100%
19-Oct	HQ	3,971.0	3,976.0	5.0	5.0	100%
20-Oct	HQ	3,976.0	3,981.0	5.0	5.0	100%
20-Oct	HQ	3,981.0	3,986.0	5.0	5.0	100%
20-Oct	HQ	3,986.0	3,991.0	5.0	5.0	100%
21-Oct	HQ	3,991.0	3,996.0	5.0	4.0	80%
21-Oct	HQ	3,996.0	4,003.0	7.0	7.0	100%
21-Oct	HQ	4,003.0	4,005.0	2.0	2.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
21-Oct	HQ	4,005.0	4,010.0	5.0	5.0	100%
21-Oct	HQ	4,010.0	4,012.0	2.0	2.0	100%
21-Oct	HQ	4,012.0	4,015.0	3.0	3.0	100%
21-Oct	HQ	4,015.0	4,020.0	5.0	4.0	80%
21-Oct	HQ	4,020.0	4,023.0	3.0	0.0	0%
21-Oct	HQ	4,023.0	4,025.0	2.0	1.0	50%
21-Oct	HQ	4,025.0	4,026.0	1.0	0.0	0%
22-Oct	HQ	4,026.0	4,028.0	2.0	2.0	100%
22-Oct	HQ	4,028.0	4,028.5	0.5	0.5	100%
22-Oct	HQ	4,028.5	4,030.0	1.5	1.0	67%
22-Oct	HQ	4,030.0	4,033.0	3.0	3.0	100%
22-Oct	HQ	4,033.0	4,034.0	1.0	1.0	100%
22-Oct	HQ	4,034.0	4,037.0	3.0	2.0	67%
23-Oct	HQ	4,037.0	4,043.0	6.0	6.0	100%
23-Oct	HQ	4,043.0	4,046.0	3.0	3.0	100%
23-Oct	HQ	4,046.0	4,050.0	4.0	3.0	75%
23-Oct	HQ	4,050.0	4,052.0	2.0	2.0	100%
23-Oct	HQ	4,052.0	4,053.0	1.0	1.0	100%
23-Oct	HQ	4,053.0	4,056.5	3.5	3.5	100%
23-Oct	HQ	4,056.5	4,061.0	4.5	3.0	67%
23-Oct	HQ	4,061.0	4,062.5	1.5	0.5	33%
23-Oct	HQ	4,062.5	4,063.5	1.0	1.0	100%
23-Oct	HQ	4,063.5	4,064.0	0.5	0.0	0%
24-Oct	HQ	4,064.0	4,064.5	0.5	0.5	100%
24-Oct	HQ	4,064.5	4,065.5	1.0	1.0	100%
24-Oct	HQ	4,065.5	4,069.0	3.5	2.0	57%
24-Oct	HQ	4,069.0	4,071.0	2.0	1.0	50%
24-Oct	HQ	4,071.0	4,072.5	1.5	0.0	0%
24-Oct	HQ	4,072.5	4,074.0	1.5	1.5	100%
24-Oct	HQ	4,074.0	4,074.5	0.5	0.5	100%
24-Oct	HQ	4,074.5	4,078.5	4.0	4.0	100%
24-Oct	HQ	4,078.5	4,081.5	3.0	3.0	100%
25-Oct	HQ	4,081.5	4,085.0	3.5	3.5	100%
25-Oct	HQ	4,085.0	4,087.0	2.0	2.0	100%
25-Oct	HQ	4,087.0	4,088.5	1.5	1.0	67%
25-Oct	HQ	4,088.5	4,091.0	2.5	2.5	100%
25-Oct	HQ	4,091.0	4,093.0	2.0	2.0	100%
25-Oct	HQ	4,093.0	4,094.0	1.0	0.5	50%
25-Oct	HQ	4,094.0	4,097.0	3.0	3.0	100%
25-Oct	HQ	4,097.0	4,098.0	1.0	0.5	50%
26-Oct	HQ	4,098.0	4,100.0	2.0	2.0	100%
26-Oct	HQ	4,100.0	4,105.0	5.0	4.0	80%
26-Oct	HQ	4,105.0	4,106.0	1.0	0.5	50%
26-Oct	HQ	4,106.0	4,106.1	0.1	0.1	100%
26-Oct	HQ	4,106.1	4,108.5	2.4	2.0	83%
26-Oct	HQ	4,108.5	4,110.0	1.5	0.5	33%
26-Oct	HQ	4,110.0	4,111.5	1.5	1.0	67%
26-Oct	HQ	4,111.5	4,113.0	1.5	1.5	100%
27-Oct	HQ	4,113.0	4,115.0	2.0	0.5	25%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
27-Oct	HQ	4,115.0	4,116.0	1.0	0.5	50%
27-Oct	HQ	4,116.0	4,119.0	3.0	3.0	100%
27-Oct	HQ	4,119.0	4,119.5	0.5	0.5	100%
27-Oct	HQ	4,119.5	4,120.5	1.0	0.2	20%
28-Oct	HQ	4,120.5	4,130.0	9.5	9.5	100%
28-Oct	HQ	4,130.0	4,132.5	2.5	2.5	100%
28-Oct	HQ	4,132.5	4,134.5	2.0	1.5	75%
28-Oct	HQ	4,134.5	4,135.0	0.5	0.5	100%
29-Oct	HQ	4,135.0	4,140.5	5.5	5.5	100%
29-Oct	HQ	4,140.5	4,145.0	4.5	3.5	78%
29-Oct	HQ	4,145.0	4,151.0	6.0	5.5	92%
29-Oct	HQ	4,151.0	4,156.0	5.0	5.0	100%
29-Oct	HQ	4,156.0	4,162.0	6.0	3.5	58%
29-Oct	HQ	4,162.0	4,166.0	4.0	3.0	75%
29-Oct	HQ	4,166.0	4,167.0	1.0	0.0	0%
30-Oct	HQ	4,167.0	4,168.5	1.5	0.5	33%
30-Oct	HQ	4,168.5	4,173.0	4.5	3.0	67%
30-Oct	HQ	4,173.0	4,176.0	3.0	1.0	33%
30-Oct	HQ	4,176.0	4,180.0	4.0	1.0	25%
30-Oct	HQ	4,180.0	4,181.0	1.0	1.0	100%
30-Oct	HQ	4,181.0	4,181.5	0.5	0.5	100%
31-Oct	HQ	4,181.5	4,182.0	0.5	0.5	100%
31-Oct	HQ	4,182.0	4,184.0	2.0	2.0	100%
31-Oct	HQ	4,184.0	4,186.0	2.0	1.0	50%
31-Oct	HQ	4,186.0	4,188.0	2.0	1.5	75%
01-Nov	HQ	4,188.0	4,196.5	8.5	2.5	29%
01-Nov	HQ	4,196.5	4,198.5	2.0	2.0	100%
01-Nov	HQ	4,198.5	4,200.5	2.0	1.5	75%
01-Nov	HQ	4,200.5	4,202.0	1.5	1.5	100%
01-Nov	HQ	4,202.0	4,205.0	3.0	3.0	100%
01-Nov	HQ	4,205.0	4,209.0	4.0	2.5	63%
01-Nov	HQ	4,209.0	4,211.0	2.0	1.5	75%
01-Nov	HQ	4,211.0	4,214.0	3.0	1.5	50%
02-Nov	HQ	4,214.0	4,218.5	4.5	2.0	44%
02-Nov	HQ	4,218.5	4,222.5	4.0	1.0	25%
02-Nov	HQ	4,222.5	4,223.5	1.0	1.0	100%
02-Nov	HQ	4,223.5	4,226.0	2.5	1.0	40%
03-Nov	HQ	4,226.0	4,231.0	5.0	4.0	80%
03-Nov	HQ	4,231.0	4,234.0	3.0	3.0	100%
03-Nov	HQ	4,234.0	4,236.0	2.0	1.5	75%
03-Nov	HQ	4,236.0	4,236.5	0.5	0.0	0%
04-Nov	HQ	4,236.5	4,239.5	3.0	2.5	83%
04-Nov	HQ	4,239.5	4,242.0	2.5	2.0	80%
04-Nov	HQ	4,242.0	4,244.0	2.0	1.0	50%
04-Nov	HQ	4,244.0	4,248.0	4.0	2.0	50%
05-Nov	HQ	4,248.0	4,253.0	5.0	0.5	10%
05-Nov	HQ	4,253.0	4,255.0	2.0	2.0	100%
05-Nov	HQ	4,255.0	4,258.0	3.0	0.5	17%
05-Nov	HQ	4,258.0	4,259.5	1.5	1.5	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
05-Nov	HQ	4,259.5	4,260.5	1.0	0.0	0%
06-Nov	HQ	4,260.5	4,261.0	0.5	0.0	0%
06-Nov	HQ	4,261.0	4,262.0	1.0	0.5	50%
06-Nov	HQ	4,262.0	4,270.0	8.0	5.0	63%
06-Nov	HQ	4,270.0	4,273.0	3.0	1.0	33%
06-Nov	HQ	4,273.0	4,274.0	1.0	1.0	100%
06-Nov	HQ	4,274.0	4,277.0	3.0	1.0	33%
06-Nov	HQ	4,277.0	4,280.0	3.0	2.0	67%
06-Nov	HQ	4,280.0	4,284.0	4.0	4.0	100%
06-Nov	HQ	4,284.0	4,287.0	3.0	1.5	50%
07-Nov	HQ	4,287.0	4,289.5	2.5	2.5	100%
07-Nov	HQ	4,289.5	4,299.0	9.5	9.5	100%
07-Nov	HQ	4,299.0	4,300.0	1.0	1.0	100%
07-Nov	HQ	4,300.0	4,302.0	2.0	0.5	25%
08-Nov	HQ	4,302.0	4,305.5	3.5	1.0	29%
08-Nov	HQ	4,305.5	4,306.5	1.0	0.5	50%
08-Nov	HQ	4,306.5	4,307.0	0.5	0.5	100%
09-Nov	HQ	4,307.0	4,311.0	4.0	3.0	75%
09-Nov	HQ	4,311.0	4,315.0	4.0	4.0	100%
09-Nov	HQ	4,315.0	4,318.0	3.0	0.0	0%
09-Nov	HQ	4,318.0	4,320.0	2.0	2.0	100%
09-Nov	HQ	4,320.0	4,323.0	3.0	1.0	33%
09-Nov	HQ	4,323.0	4,324.5	1.5	0.0	0%
11-Nov	NQ	4,324.5	4,326.5	2.0	1.0	50%
11-Nov	NQ	4,326.5	4,327.5	1.0	1.0	100%
11-Nov	NQ	4,327.5	4,331.5	4.0	2.0	50%
11-Nov	NQ	4,331.5	4,333.5	2.0	1.0	50%
11-Nov	NQ	4,333.5	4,335.0	1.5	0.0	0%
12-Nov	NQ	4,335.0	4,345.0	10.0	7.0	70%
12-Nov	NQ	4,345.0	4,349.0	4.0	1.0	25%
12-Nov	NQ	4,349.0	4,351.5	2.5	2.0	80%
12-Nov	NQ	4,351.5	4,355.0	3.5	2.0	57%
12-Nov	NQ	4,355.0	4,358.0	3.0	1.5	50%
12-Nov	NQ	4,358.0	4,360.0	2.0	0.5	25%
13-Nov	NQ	4,360.0	4,362.0	2.0	2.0	100%
13-Nov	NQ	4,362.0	4,363.5	1.5	0.0	0%
13-Nov	NQ	4,363.5	4,364.0	0.5	0.0	0%
15-Nov	NQ	4,364.0	4,369.0	5.0	1.0	20%
15-Nov	NQ	4,369.0	4,377.0	8.0	8.0	100%
15-Nov	NQ	4,377.0	4,387.0	10.0	10.0	100%
16-Nov	NQ	4,387.0	4,393.5	6.5	6.5	100%
16-Nov	NQ	4,393.5	4,404.0	10.5	10.5	100%
16-Nov	NQ	4,404.0	4,407.5	3.5	3.5	100%
16-Nov	NQ	4,407.5	4,410.5	3.0	2.0	67%
16-Nov	NQ	4,410.5	4,414.0	3.5	3.5	100%
16-Nov	NQ	4,414.0	4,417.0	3.0	3.0	100%
16-Nov	NQ	4,417.0	4,420.5	3.5	3.5	100%
16-Nov	NQ	4,420.5	4,422.0	1.5	1.0	67%
16-Nov	NQ	4,422.0	4,423.0	1.0	0.5	50%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
16-Nov	NQ	4,423.0	4,425.0	2.0	1.5	75%
16-Nov	NQ	4,425.0	4,429.0	4.0	4.0	100%
17-Nov	NQ	4,429.0	4,433.0	4.0	4.0	100%
17-Nov	NQ	4,433.0	4,437.5	4.5	4.5	100%
17-Nov	NQ	4,437.5	4,442.5	5.0	5.0	100%
17-Nov	NQ	4,442.5	4,444.5	2.0	2.0	100%
17-Nov	NQ	4,444.5	4,446.0	1.5	0.5	33%
17-Nov	NQ	4,446.0	4,447.5	1.5	1.5	100%
17-Nov	NQ	4,447.5	4,450.0	2.5	2.5	100%
17-Nov	NQ	4,450.0	4,451.5	1.5	1.0	67%
17-Nov	NQ	4,451.5	4,455.5	4.0	4.0	100%
17-Nov	NQ	4,455.5	4,460.0	4.5	4.0	89%
18-Nov	NQ	4,460.0	4,464.5	4.5	4.5	100%
18-Nov	NQ	4,464.5	4,466.5	2.0	2.0	100%
18-Nov	NQ	4,466.5	4,470.0	3.5	3.5	100%
18-Nov	NQ	4,470.0	4,472.0	2.0	2.0	100%
18-Nov	NQ	4,472.0	4,473.0	1.0	0.0	0%
18-Nov	NQ	4,473.0	4,474.5	1.5	1.0	67%
18-Nov	NQ	4,474.5	4,479.5	5.0	5.0	100%
18-Nov	NQ	4,479.5	4,487.0	7.5	7.5	100%
18-Nov	NQ	4,487.0	4,490.0	3.0	3.0	100%
19-Nov	NQ	4,490.0	4,500.0	10.0	10.0	100%
19-Nov	NQ	4,500.0	4,510.0	10.0	10.0	100%
19-Nov	NQ	4,510.0	4,520.0	10.0	10.0	100%
19-Nov	NQ	4,520.0	4,523.0	3.0	3.0	100%
19-Nov	NQ	4,523.0	4,524.5	1.5	1.0	67%
19-Nov	NQ	4,524.5	4,530.0	5.5	5.5	100%
20-Nov	NQ	4,530.0	4,534.0	4.0	4.0	100%
20-Nov	NQ	4,534.0	4,542.0	8.0	8.0	100%
20-Nov	NQ	4,542.0	4,545.0	3.0	3.0	100%
20-Nov	NQ	4,545.0	4,549.5	4.5	4.5	100%
20-Nov	NQ	4,549.5	4,557.0	7.5	7.5	100%
21-Nov	NQ	4,557.0	4,565.0	8.0	8.0	100%
21-Nov	NQ	4,565.0	4,572.0	7.0	7.0	100%
21-Nov	NQ	4,572.0	4,575.5	3.5	3.5	100%
21-Nov	NQ	4,575.5	4,578.0	2.5	0.5	20%
21-Nov	NQ	4,578.0	4,580.0	2.0	0.5	25%
21-Nov	NQ	4,580.0	4,581.5	1.5	0.5	33%
21-Nov	NQ	4,581.5	4,583.0	1.5	1.5	100%
21-Nov	NQ	4,583.0	4,585.0	2.0	0.5	25%
21-Nov	NQ	4,585.0	4,587.0	2.0	2.0	100%
21-Nov	NQ	4,587.0	4,589.0	2.0	0.5	25%
21-Nov	NQ	4,589.0	4,595.0	6.0	6.0	100%
22-Nov	NQ	4,595.0	4,597.0	2.0	2.0	100%
23-Nov	NQ	4,597.0	4,597.5	0.5	0.0	0%
23-Nov	NQ	4,597.5	4,599.0	1.5	1.0	67%
23-Nov	NQ	4,599.0	4,600.5	1.5	0.5	33%
23-Nov	NQ	4,600.5	4,602.0	1.5	0.0	0%
24-Nov	NQ	4,602.0	4,603.0	1.0	0.5	50%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
24-Nov	NQ	4,603.0	4,604.5	1.5	1.5	100%
24-Nov	NQ	4,604.5	4,605.0	0.5	0.0	0%
24-Nov	NQ	4,605.0	4,607.0	2.0	2.0	100%
24-Nov	NQ	4,607.0	4,609.0	2.0	2.0	100%
24-Nov	NQ	4,609.0	4,610.0	1.0	1.0	100%
24-Nov	NQ	4,610.0	4,612.0	2.0	2.0	100%
24-Nov	NQ	4,612.0	4,614.5	2.5	2.0	80%
24-Nov	NQ	4,614.5	4,621.0	6.5	6.5	100%
25-Nov	NQ	4,621.0	4,624.0	3.0	3.0	100%
25-Nov	NQ	4,624.0	4,632.0	8.0	8.0	100%
25-Nov	NQ	4,632.0	4,635.0	3.0	3.0	100%
25-Nov	NQ	4,635.0	4,639.5	4.5	4.5	100%
25-Nov	NQ	4,639.5	4,643.0	3.5	3.5	100%
25-Nov	NQ	4,643.0	4,644.0	1.0	1.0	100%
25-Nov	NQ	4,644.0	4,646.0	2.0	2.0	100%
25-Nov	NQ	4,646.0	4,647.5	1.5	1.5	100%
25-Nov	NQ	4,647.5	4,648.0	0.5	0.0	0%
25-Nov	NQ	4,648.0	4,649.0	1.0	0.3	30%
25-Nov	NQ	4,649.0	4,650.0	1.0	0.5	50%
26-Nov	NQ	4,650.0	4,651.0	1.0	0.5	50%
26-Nov	NQ	4,651.0	4,660.0	9.0	9.0	100%
26-Nov	NQ	4,660.0	4,661.5	1.5	0.5	33%
26-Nov	NQ	4,661.5	4,666.5	5.0	5.0	100%
26-Nov	NQ	4,666.5	4,667.5	1.0	0.0	0%
26-Nov	NQ	4,667.5	4,669.0	1.5	1.5	100%
26-Nov	NQ	4,669.0	4,675.0	6.0	6.0	100%
26-Nov	NQ	4,675.0	4,677.5	2.5	2.5	100%
26-Nov	NQ	4,677.5	4,680.5	3.0	3.0	100%
26-Nov	NQ	4,680.5	4,684.5	4.0	4.0	100%
27-Nov	NQ	4,684.5	4,689.0	4.5	4.5	100%
27-Nov	NQ	4,689.0	4,695.0	6.0	6.0	100%
27-Nov	NQ	4,695.0	4,698.5	3.5	3.5	100%
29-Nov	NQ	4,699.0	4,701.0	2.0	2.0	100%
29-Nov	NQ	4,701.0	4,704.0	3.0	2.5	83%
29-Nov	NQ	4,704.0	4,705.5	1.5	0.5	33%
29-Nov	NQ	4,705.5	4,707.5	2.0	2.0	100%
29-Nov	NQ	4,707.5	4,709.0	1.5	1.0	67%
29-Nov	NQ	4,709.0	4,710.5	1.5	1.0	67%
29-Nov	NQ	4,710.5	4,714.0	3.5	3.5	100%
29-Nov	NQ	4,714.0	4,719.0	5.0	5.0	100%
29-Nov	NQ	4,719.0	4,721.0	2.0	1.5	75%
29-Nov	NQ	4,721.0	4,723.5	2.5	2.5	100%
30-Nov	NQ	4,723.5	4,724.5	1.0	0.5	50%
30-Nov	NQ	4,724.5	4,727.5	3.0	3.0	100%
30-Nov	NQ	4,727.5	4,730.0	2.5	2.5	100%
30-Nov	NQ	4,730.0	4,733.5	3.5	2.0	57%
30-Nov	NQ	4,733.5	4,735.0	1.5	1.0	67%
30-Nov	NQ	4,735.0	4,736.0	1.0	0.5	50%
30-Nov	NQ	4,736.0	4,739.0	3.0	3.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
30-Nov	NQ	4,739.0	4,744.0	5.0	5.0	100%
30-Nov	NQ	4,744.0	4,748.0	4.0	4.0	100%
30-Nov	NQ	4,748.0	4,753.0	5.0	5.0	100%
01-Dec	NQ	4,753.0	4,754.0	1.0	0.5	50%
01-Dec	NQ	4,754.0	4,755.5	1.5	0.5	33%
01-Dec	NQ	4,755.5	4,757.5	2.0	1.0	50%
01-Dec	NQ	4,757.5	4,760.0	2.5	2.5	100%
01-Dec	NQ	4,760.0	4,761.0	1.0	1.0	100%
01-Dec	NQ	4,761.0	4,762.0	1.0	0.0	0%
01-Dec	NQ	4,762.0	4,766.0	4.0	3.5	88%
01-Dec	NQ	4,766.0	4,771.0	5.0	5.0	100%
01-Dec	NQ	4,771.0	4,773.5	2.5	2.5	100%
01-Dec	NQ	4,773.5	4,777.5	4.0	4.0	100%
02-Dec	NQ	4,777.5	4,782.0	4.5	4.5	100%
02-Dec	NQ	4,782.0	4,786.0	4.0	4.0	100%
02-Dec	NQ	4,786.0	4,788.0	2.0	2.0	100%
02-Dec	NQ	4,788.0	4,790.5	2.5	2.5	100%
02-Dec	NQ	4,790.5	4,793.0	2.5	2.5	100%
02-Dec	NQ	4,793.0	4,797.0	4.0	4.0	100%
02-Dec	NQ	4,797.0	4,803.0	6.0	6.0	100%
02-Dec	NQ	4,803.0	4,812.0	9.0	9.0	100%
04-Dec	NQ	4,812.0	4,819.5	7.5	7.5	100%
04-Dec	NQ	4,819.5	4,829.5	10.0	10.0	100%
04-Dec	NQ	4,829.5	4,838.5	9.0	9.0	100%
04-Dec	NQ	4,838.5	4,848.5	10.0	10.0	100%
04-Dec	NQ	4,848.5	4,855.5	7.0	7.0	100%
05-Dec	NQ	4,855.5	4,865.5	10.0	10.0	100%
05-Dec	NQ	4,865.5	4,871.5	6.0	6.0	100%
05-Dec	NQ	4,871.5	4,872.5	1.0	1.0	100%
05-Dec	NQ	4,872.5	4,875.5	3.0	0.0	0%
05-Dec	NQ	4,875.5	4,879.0	3.5	0.0	0%
05-Dec	NQ	4,879.0	4,880.0	1.0	0.0	0%
06-Dec	NQ	4,880.0	4,880.5	0.5	0.5	100%
06-Dec	NQ	4,880.5	4,888.5	8.0	8.0	100%
07-Dec	NQ	4,888.5	4,904.0	15.5	10.0	65%
07-Dec	NQ	4,904.0	4,913.5	9.5	9.5	100%
07-Dec	NQ	4,913.5	4,920.5	7.0	7.0	100%
07-Dec	NQ	4,920.5	4,930.5	10.0	10.0	100%
07-Dec	NQ	4,930.5	4,941.0	10.5	10.0	95%
08-Dec	NQ	4,941.0	4,951.0	10.0	10.0	100%
08-Dec	NQ	4,951.0	4,961.0	10.0	10.0	100%
08-Dec	NQ	4,961.0	4,971.0	10.0	10.0	100%
08-Dec	NQ	4,971.0	4,981.0	10.0	10.0	100%
08-Dec	NQ	4,981.0	4,991.0	10.0	10.0	100%
09-Dec	NQ	4,991.0	5,001.0	10.0	10.0	100%
09-Dec	NQ	5,001.0	5,011.0	10.0	10.0	100%
09-Dec	NQ	5,011.0	5,021.0	10.0	10.0	100%
09-Dec	NQ	5,021.0	5,030.5	9.5	7.5	79%
09-Dec	NQ	5,030.5	5,034.5	4.0	4.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
09-Dec	NQ	5,034.5	5,040.5	6.0	6.0	100%
09-Dec	NQ	5,040.5	5,043.5	3.0	2.0	67%
10-Dec	NQ	5,043.5	5,052.0	8.5	8.5	100%
10-Dec	NQ	5,052.0	5,055.5	3.5	3.5	100%
10-Dec	NQ	5,055.5	5,057.5	2.0	2.0	100%
10-Dec	NQ	5,057.5	5,061.0	3.5	3.5	100%
10-Dec	NQ	5,061.0	5,066.5	5.5	4.0	73%
10-Dec	NQ	5,066.5	5,067.5	1.0	1.0	100%
10-Dec	NQ	5,067.5	5,069.5	2.0	2.0	100%
10-Dec	NQ	5,069.5	5,072.5	3.0	2.5	83%
10-Dec	NQ	5,072.5	5,078.0	5.5	5.5	100%
11-Dec	NQ	5,078.0	5,083.0	5.0	5.0	100%
11-Dec	NQ	5,083.0	5,091.0	8.0	8.0	100%
11-Dec	NQ	5,091.0	5,095.0	4.0	4.0	100%
11-Dec	NQ	5,095.0	5,098.5	3.5	3.5	100%
11-Dec	NQ	5,098.5	5,108.5	10.0	9.0	90%
11-Dec	NQ	5,108.5	5,111.5	3.0	2.0	67%
11-Dec	NQ	5,111.5	5,114.5	3.0	0.5	17%
11-Dec	NQ	5,114.5	5,116.0	1.5	1.5	100%
11-Dec	NQ	5,116.0	5,116.5	0.5	0.5	100%
12-Dec	NQ	5,116.5	5,119.5	3.0	3.0	100%
12-Dec	NQ	5,119.5	5,123.0	3.5	3.5	100%
12-Dec	NQ	5,123.0	5,126.5	3.5	3.5	100%
12-Dec	NQ	5,126.5	5,135.0	8.5	8.5	100%
12-Dec	NQ	5,135.0	5,145.0	10.0	9.0	90%
12-Dec	NQ	5,145.0	5,155.0	10.0	10.0	100%
12-Dec	NQ	5,155.0	5,159.0	4.0	3.5	88%
13-Dec	NQ	5,159.0	5,163.0	4.0	4.0	100%
13-Dec	NQ	5,163.0	5,167.0	4.0	4.0	100%
13-Dec	NQ	5,167.0	5,173.0	6.0	3.0	50%
13-Dec	NQ	5,173.0	5,177.0	4.0	4.0	100%
13-Dec	NQ	5,177.0	5,180.5	3.5	3.0	86%
13-Dec	NQ	5,180.5	5,182.5	2.0	1.5	75%
13-Dec	NQ	5,182.5	5,190.5	8.0	8.0	100%
13-Dec	NQ	5,190.5	5,198.5	8.0	8.0	100%
14-Dec	NQ	5,198.5	5,203.5	5.0	5.0	100%
14-Dec	NQ	5,203.5	5,208.5	5.0	5.0	100%
14-Dec	NQ	5,208.5	5,218.5	10.0	10.0	100%
14-Dec	NQ	5,218.5	5,227.0	8.5	8.5	100%
14-Dec	NQ	5,227.0	5,237.0	10.0	10.0	100%
14-Dec	NQ	5,237.0	5,247.0	10.0	10.0	100%
15-Dec	NQ	5,247.0	5,267.0	20.0	10.0	50%
15-Dec	NQ	5,267.0	5,277.0	10.0	10.0	100%
15-Dec	NQ	5,277.0	5,287.0	10.0	10.0	100%
15-Dec	NQ	5,287.0	5,295.5	8.5	8.5	100%
16-Dec	NQ	5,295.5	5,305.5	10.0	10.0	100%
16-Dec	NQ	5,305.5	5,313.0	7.5	7.5	100%
16-Dec	NQ	5,313.0	5,322.0	9.0	9.0	100%
16-Dec	NQ	5,322.0	5,332.0	10.0	10.0	100%

Table 2

SOH-1
Coring Performance

Date	Core Size	Run Start	Run End	Footage Cored	Footage Recovered	Percent Recovery
16-Dec	NQ	5,332.0	5,342.0	10.0	10.0	100%
17-Dec	NQ	5,342.0	5,352.0	10.0	10.0	100%
17-Dec	NQ	5,352.0	5,362.0	10.0	10.0	100%
17-Dec	NQ	5,362.0	5,372.0	10.0	10.0	100%
17-Dec	NQ	5,372.0	5,382.0	10.0	10.0	100%
18-Dec	NQ	5,382.0	5,392.0	10.0	10.0	100%
18-Dec	NQ	5,392.0	5,402.0	10.0	10.0	100%
18-Dec	NQ	5,402.0	5,412.0	10.0	10.0	100%
18-Dec	NQ	5,412.0	5,422.0	10.0	10.0	100%
19-Dec	NQ	5,422.0	5,432.0	10.0	10.0	100%
19-Dec	NQ	5,432.0	5,442.0	10.0	10.0	100%
19-Dec	NQ	5,442.0	5,452.0	10.0	5.0	50%
19-Dec	NQ	5,452.0	5,456.5	4.5	4.0	89%
20-Dec	NQ	5,456.5	5,466.5	10.0	10.0	100%
20-Dec	NQ	5,466.5	5,476.5	10.0	10.0	100%
20-Dec	NQ	5,476.5	5,486.0	9.5	9.5	100%
20-Dec	NQ	5,486.0	5,496.0	10.0	10.0	100%
20-Dec	NQ	5,496.0	5,506.0	10.0	10.0	100%
21-Dec	NQ	5,506.0	5,516.0	10.0	10.0	100%
21-Dec	NQ	5,516.0	5,526.0	10.0	10.0	100%
		Overall Totals		5,534.0	4,862.7	88%

Table 3
SOH-1 Complaints

#	Date	Resident	Complaint
1	JUN 1	D. Pommerenk	Rig light shines in her window & sound gives her a headache.
2	JUN 4	P. Majeska	Machine noise woke him up last night and was curious about source.
3	JUN 4	D. Pommerenk	Noise complaint and is worried about permanent hearing damage. Also claims "hum in her head" caused by HGP-A has come back.
4	JUN 4	B. Petricci	Noise complaint, "doesn't like it" and is "keeping notes."
5	JUN 4	R. Jones	Noise wakes him up some nights, interested in measurements at Loughlins home.
6	JUN 13	B. Gold	Light and noise complaint.
7	JUN 28	D. Pommerenk	Noise complaint and wants combination to access road gate lock.
8	JUL 17	D. Pommerenk	Noise complaint.
9	JUL 25	B. Petricci	Noise complaint.
10	JUL 25	D. Pommerenk	Noise complaint.
11	JUL 26	D. Pommerenk	Noise complaint.
12	JUL 31	D. Pommerenk	Noise complaint.
13	AUG 2	G. Pommerenk	"Wants to know if its his imagination or is rig operation getting louder".
14	AUG 10	D. Pommerenk	Noise complaint.
15	AUG 11	D. Pommerenk	Claims 46db at her house, and "doesn't know how much more she can take".
16	AUG 28	D. Pommerenk	Noise complaint.
17	AUG 28	S. Phillips	Noise complaint.
18	SEP 3	S. Phillips	Noise complaint.

#	Date	Resident	Complaint
19	SEP 3	S. Phillips	Noise complaint
20	SEP 7	D. Pommerenk	Noise complaint and complained because she couldn't reach crew on rig mobile phone.
21	SEP 24	D. Pommerenk	Claims "SOH noise wakes children 3 times per week".
22	SEP 26	D. Pommerenk	Noise complaint.
23	SEP 28	S. Philips	Noise complaint.
24	OCT 9	A. Sarhanis	Claims SOH noise wakes him up.
25	OCT 16	D. Muller	Heard machinery noise one night, wanted to know what was going on.
26	OCT 21	D. Pommerenk	SOH lights are shining in her window.
27	OCT 22	D. Pommerenk	Noise complaint.
28	OCT 27	D. Pommerenk	Noise complaint.
29	OCT 28	D. Pommerenk	Noise complaint.
30	NOV 1	D. Pommerenk	Noise complaint.
31	NOV 4	D. Pommerenk	Noise complaint.
32	NOV 5	D. Pommerenk	Noise complaint.
33	NOV 21	D. Pommerenk	"Strange smell" around her house all day yesterday and "worse right now".
34	NOV 26	D. Pommerenk	Noise complaint.
35	DEC 4	G. Pommerenk	Noise complaint.
36	DEC 17	D. Pommerenk	Noise complaint.
37	JAN 5	D. Pommerenk	Noise complaint.
38	JAN 6	D. Pommerenk	Noise complaint and claimed she read 50db on the noise meter she received for Christmas.
39	JAN 7	D. Pommerenk	Noise complaint and claimed she read 52db on her noise meter.
40	JAN 7	D. Pommerenk	Noise complaint.

Table 4
SOH-1 Core Bits

Bit #	Bit Size	S/N	Depth In	Depth Out	Footage Cut	Cost	Cost/ Foot	Cum. Bit Cost/ Foot	
1	101mm	17700-3	0	381	381	1,016.00	2.67	2.67	
2	101mm	17700-1	381	592	211	1,016.00	4.82	3.43	
3	101mm	17700-5	592	730	138	1,016.00	7.36	4.18	
4	101mm	17700-6	730	1,010	280	1,016.00	3.63	4.02	
5	101mm	19925-6	1,010	1,034	24	858.00	35.75	4.76	
6	101mm	L-68514	1,034	1,115	81	858.00	10.59	5.18	
7	101mm	17700-2	1,115	1,278	163	1,015.00	6.23	5.32	
8	101mm	19999-3	1,278	1,459	181	949.00	5.24	5.31	
9	101mm	19999-5	1,459	1,655	196	949.00	4.84	5.25	
10	101mm	19999-4	1,655	1,996	341	949.00	2.78	4.83	
11	101mm	19999-1	1,996	2,014	18	949.00	52.72	5.26	
12	101mm	19999-2	2,014	2,074	60	1,016.00	16.93	5.60	
13	101mm	L-68517	2,074	2,201	127	1,016.00	8.00	5.74	
14	101mm	L-68515	2,201	2,331	130	1,016.00	7.82	5.85	
15	101mm	L-68516	2,331	2,481	150	1,016.00	6.77	5.91	101mm bit cost/ft.
16	101mm	19999-6	2,481	2,671	190	1,016.00	5.35	5.87	$5.87
17	134mm	L-71870	2,671	2,717	46	1,759.00	38.24	6.42	
18	134mm	L-71871	2,717	2,768	51	1,759.00	34.49	6.93	
19	134mm	L-72641	2,768	2,851	83	1,643.00	19.80	7.31	
20	134mm	L-72642	2,851	2,868	17	1,643.00	96.65	7.84	
21	134mm	L-73246	2,868	2,884	16	1,759.00	109.94	8.40	
22	134mm	73246	2,884	2,949	65	1,759.00	27.06	8.81	134mm bit cost/ft.
23	134mm	73370	2,949	3,022	73	1,759.00	24.10	9.18	$34.42
24	HQ	3567419	3,022	3,231	209	785.66	3.76	8.83	
25	HQ	M62357-1	3,231	3,305	74	555.26	7.50	8.80	
26	HQ	L-63216	3,305	3,318	13	789.00	60.69	9.01	
27	HQ	M63564-6	3,318	3,332	14	786.00	56.14	9.20	
28	HQ	L-63213	3,332	3,368	36	789.00	21.92	9.34	
29	HQ	M63564-10	3,368	3,399	31	786.00	25.35	9.49	
30	HQ	L-3208	3,399	3,414	15	788.70	52.58	9.68	
31	HQ	15648-10	3,414	3,510	96	792.00	8.25	9.64	
32	HQ	L-68480	3,510	3,512	2	801.90	400.95	9.86	
33	HQ	M63564-24	3,512	3,529	17	785.66	46.22	10.03	
34	HQ	L-68515	3,529	3,541	12	1,051.60	87.63	10.30	
35	HQ	M63564-11	3,541	3,550	9	785.66	87.30	10.49	
36	HQ	71942-2	3,550	3,564	14	842.85	60.20	10.69	
37	HQ	X9-956	3,564	3,625	61	918.50	15.06	10.76	
38	HQ	68474	3,625	3,726	101	843.70	8.35	10.70	
39	HQ	19993-8	3,726	3,870	144	800.20	5.56	10.50	
40	HQ	20180-3	3,870	3,922	52	816.64	15.70	10.57	
41	HQ	20180-6	3,922	3,980	58	816.64	14.08	10.62	
42	HQ	M6-0309-3	3,980	4,025	45	785.66	17.46	10.70	
43	HQ	M4-0308-2	4,025	4,064	39	785.66	20.15	10.79	
44	HQ	M4-0308-3	4,064	4,098	34	785.66	23.11	10.89	

Table 4
SOH-1 Core Bits

Bit #	Bit Size	S/N	Depth In	Depth Out	Footage Cut	Cost	Cost/ Foot	Cum. Bit Cost/ Foot	
45	HQ	M4-0308-1	4,098	4,120	22	785.66	35.71	11.03	
46	HQ	20180-2	4,120	4,135	15	816.64	54.44	11.18	
47	HQ	M4-0308-4	4,135	4,167	32	785.66	24.55	11.29	
48	HQ	BL-20180-1	4,167	4,182	15	816.64	54.44	11.44	
49	HQ	OS-8387	4,182	4,214	32	673.20	21.04	11.51	
50	HQ	OS-8396	4,214	4,236	22	673.24	30.60	11.61	
51	HQ	L-77550	4,236	4,260	24	843.70	35.15	11.75	
52	HQ	OS-8399	4,260	4,302	42	673.20	16.03	11.79	
53	HQ	OS-8397	4,302	4,324	22	673.20	30.60	11.88	HQ bit cost/ft.
54	HQ	L-77689	4,324	4,324	0	843.70	N/A	12.08	$18.80
55	NQ	L-33201	4,324	4,334	10	627.00	62.70	12.20	
56	NQ	9809-5	4,334	4,364	30	482.69	16.09	12.22	
57	NQ	MX5-6583-4	4,364	4,364	0	481.60	N/A	12.33	
58	NQ	L-74607	4,364	4,597	233	627.00	2.69	11.84	
59	NQ	OS-10589	4,597	4,699	102	559.75	5.49	11.71	
60	NQ	L-74606	4,699	4,812	113	627.00	5.55	11.56	
61	NQ	L-67694	4,812	4,880	68	576.40	8.48	11.52	NQ bit cost/ft
62	NQ	L-67701	4,880	5,526	646	576.40	0.89	10.28	$3.79
			Total Bit Cost			$56,786.63			

Bits used for reaming over stuck drill rods

1	134mm	L-71770	1,996	2,016	20	1,609.00	80.45
2	134mm	L-71794	2,016	2,029	13	2,385.00	183.46
3	134mm	L-71795	2,029	2,063	34	2,385.00	70.15
4	134mm	L-71923	2,063	2,072	9	1,342.00	149.11
5	134mm	L-71924	2,072	2,123	51	1,324.00	25.96
6	134mm	L-71925	2,123	2,218	95	1,342.00	14.13
7	134mm	L-71926	2,218	2,230	12	1,342.00	111.83
		Total Reaming Bit Cost				$11,729.00	

Coring stabalizers, reamers
& other down hole consumable items. $30,988.94

Total bits & other down hole consumables. $99,504.57

Table 5
SOH DRILLING EXPENDITURES

ACTIVITY	SOH-1 COST	SOH-1 % TOTAL	SOH-4 COST	SOH-4 % TOTAL
SITE & ROAD CONSTRUCTION	5,589	0.34%	4,500	0.31%
MOB, PREP. & SET-UP	17,621	1.07%	23,099	1.57%
RIG, LABOR, FOOTAGE CHG. & TAX	961,614	58.51%	735,347	50.13%
RENTAL EUIPMENT	138,732	8.44%	105,468	7.19%
BITS (core and rotary)	73,569	4.48%	35,775	2.44%
MISC. DOWN HOLE EQUIP.	30,989	1.89%	36,297	2.47%
MUDS	91,810	5.59%	94,534	6.44%
WATER (trucking & county charges)	16,401	1.00%	91,972	6.27%
CMT. & CMT SERVICES	33,525	2.04%	36,029	2.46%
WELLHEAD, CASING & FLOAT EQUIP.	87,890	5.35%	96,651	6.59%
BOP EQUIP. (Rental equipment)	52,921	3.22%	29,693	2.02%
TRANSPORTATION	10,254	0.62%	18,524	1.26%
MISC MATERIALS	8,770	0.53%	8,577	0.58%
MISC LABOR & SERVICES	11,461	0.70%	10,266	0.70%
SUPERVISION	82,200	5.00%	58,800	4.01%
GEOPHYSICAL LOGGING	0	0.00%	58,445	3.98%
OTHER	20,198	1.23%	22,836	1.56%
TOTAL EXPENDITURES	1,643,544		1,466,813	

Table 6
SOH-1
DRILLING COSTS AND ACTIVITIES

Activity	Date	Day Number	Footage Start	Footage End	Daily Footage	Daily Cost	Cost-to Date	
Mob & set-up	May 1 - 31	0		0		42,916	42,916	SITE CONSTRUCTION,
Core 101mm	01-Jun	1	0	122	122	10,057	52,973	MOB & SET-UP
Core 101 & open 12.5"	02-Jun	2	122	202	80	8,079	61,052	Total Cost $42,916
Open 12-1/2"	03-Jun	3	30	100	0	7,090	68,142	
Open 12-1/2"	04-Jun	4	100	188	0	7,725	75,867	
Open 12-1/2" case & cmt	05-Jun	5	188	202	0	10,163	86,030	
Cmt	06-Jun	6	202	202	0	5,539	91,569	CORE, OPEN TO 12-1/4"
Cmt	07-Jun	7	202	202	0	7,591	99,160	CASE & CEMENT (0 - 212 ft)
Cmt	08-Jun	8	202	202	0	5,316	104,476	202 ft. @ $66,972
Cmt, test BOP	09-Jun	9	202	202	0	5,412	109,888	Cost/foot $331.54
Wait on county	10-Jun	10	202	202	0	5,142	115,030	
Wait on county	11-Jun	11	202	202	0	5,057	120,087	
Wait on county	12-Jun	12	202	202	0	5,066	125,153	
Wait on county	13-Jun	13	202	202	0	5,057	130,210	DELAY - COUNTY OF HAWAII
Wait on county	14-Jun	14	202	202	0	5,093	135,303	Total Cost $29,061
Wait & core 101mm	15-Jun	15	202	290	88	7,292	142,595	
Core 101mm	16-Jun	16	290	433	143	8,473	151,068	
Core 101mm	17-Jun	17	433	563	130	7,849	158,917	
Core 101mm	18-Jun	18	563	669	106	7,986	166,903	
Core 101mm	19-Jun	19	669	755	86	8,449	175,352	
Core 101mm	20-Jun	20	755	874	119	7,101	182,453	
Core 101mm	21-Jun	21	874	984	110	7,554	190,007	
Core 101mm	22-Jun	22	984	1,040	56	8,673	198,680	
Core 101mm	23-Jun	23	1,040	1,142	102	8,003	206,683	
Core 101mm	24-Jun	24	1,142	1,245	103	7,322	214,005	
Core 101mm	25-Jun	25	1,245	1,334	89	8,212	222,217	
Core 101mm	26-Jun	26	1,334	1,418	84	6,890	229,107	
Core 101mm	27-Jun	27	1,418	1,508	90	8,256	237,363	
Core 101mm	28-Jun	28	1,508	1,615	107	7,865	245,228	
Core 101mm	29-Jun	29	1,615	1,709	94	8,215	253,443	CORE 101mm (202 - 1995 ft)
Core 101mm	30-Jun	30	1,709	1,802	93	7,685	261,128	1,793 ft. @ $136,457
Core 101mm	01-Jul	31	1,802	1,911	109	7,327	268,455	Cost/foot $76.11
Core 101mm dev sur.	02-Jul	32	1,911	1,996	85	6,951	275,406	
Open 8.5"	03-Jul	33	202	271	69	11,479	286,885	
Open 8.5"	04-Jul	34	271	432	161	7,002	293,887	
Open 8.5"	05-Jul	35	432	549	117	6,441	300,328	
Open 8.5" & cmt back	06-Jul	36	549	555	6	8,344	308,672	
Drl cmt 253 - 430 ft.	07-Jul	37	555	555	0	8,072	316,744	
Drl cmt & open 8.5"	08-Jul	38	555	573	18	7,830	324,574	
Open 8.5"	09-Jul	39	573	590	17	8,393	332,967	
Down for repairs.	10-Jul	40	590	590	0	5,363	338,330	
Repairs & open 8.5"	11-Jul	41	590	621	31	5,917	344,247	
Open 8.5" cmt & drl cmt	12-Jul	42	621	629	8	7,645	351,892	
Drl cmt 290 - 583 ft.	13-Jul	43	629	629	0	6,206	358,098	
Drl cmt & open 8.5"	14-Jul	44	629	770	141	6,770	364,868	
Open 8.5" & cmt back	15-Jul	45	770	796	26	7,670	372,538	

Table 6
SOH-1
DRILLING COSTS AND ACTIVITIES

Activity	Date	Day Number	Footage Start	Footage End	Daily Footage	Daily Cost	Cost-to Date	
Drl cmt & open 8.5"	16-Jul	46	796	870	74	6,684	379,222	
Open 8.5"	17-Jul	47	870	1,023	153	7,817	387,039	
Open 8.5"	18-Jul	48	1,023	1,180	157	7,943	394,982	
Open 8.5" cmt & drl cmt	19-Jul	49	1,180	1,200	20	7,815	402,797	
Drl cmt & open 8.5"	20-Jul	50	1,200	1,298	98	6,950	409,747	
Open 8.5"	21-Jul	51	1,298	1,412	114	6,690	416,437	
Open 8.5"	22-Jul	52	1,412	1,574	162	7,548	423,985	
Open 8.5"	23-Jul	53	1,574	1,731	157	6,808	430,793	
Open 8.5"	24-Jul	54	1,731	1,820	89	6,401	437,194	
Open 8.5"	25-Jul	55	1,820	1,958	138	7,171	444,365	
Open 8.5" lay dn rods	26-Jul	56	1,958	1,996	38	6,634	450,999	
Run csg, drop, fish.	27-Jul	57	1,996	1,996	0	6,260	457,259	
Fishing	28-Jul	58	1,996	1,996	0	6,045	463,304	OPEN HOLE, FISH, CASE &
Fish, rig for cmt	29-Jul	59	1,996	1,996	0	40,677	503,981	CEMENT (202 - 1,996 ft)
Cmt	30-Jul	60	1,996	1,996	0	33,333	537,314	1,794 ft. @ $268,742
Rig BOP, test, drl cmt	31-Jul	61	1,996	1,996	0	6,834	544,148	Cost/foot $149.80
Drl cmt, core 101mm	01-Aug	62	1,996	2,014	18	7,345	551,493	
Core 101mm	02-Aug	63	2,014	2,074	60	5,889	557,382	
Core 101mm	03-Aug	64	2,074	2,137	63	6,166	563,548	
Core 101mm	04-Aug	65	2,137	2,201	64	6,215	569,763	
Core 101mm	05-Aug	66	2,201	2,266	65	5,985	575,748	
Core 101mm	06-Aug	67	2,266	2,368	102	7,644	583,392	
Core 101mm	07-Aug	68	2,368	2,481	113	7,891	591,283	
Core 101mm & cmt back	08-Aug	69	2,481	2,505	24	5,891	597,174	
Drl out cmt.	09-Aug	70	2,505	2,505	0	6,394	603,568	
Drl out cmt.	10-Aug	71	2,505	2,505	0	4,853	608,421	CORE 101mm (1,996 - 2,671 ft)
Core 101mm	11-Aug	72	2,505	2,645	140	8,438	616,859	675 ft. @ $84,463
Core 101mm & cmt back	12-Aug	73	2,645	2,671	26	5,878	622,737	Cost/foot $125.13
RIH, stick rods	13-Aug	74	2,671	2,671	0	5,874	628,611	
RIH, cut rods	14-Aug	75	2,671	2,671	0	5,494	634,105	
Cut & jar rods	15-Aug	76	2,671	2,671	0	6,833	640,938	
make up 134mm rods	16-Aug	77	2,671	2,671	0	6,540	647,478	
Ream over w/ 134mm	17-Aug	78	1,996	2,009	13	8,010	655,488	
Ream over w/ 134mm	18-Aug	79	2,009	2,024	15	9,222	664,710	
Ream over w/ 134mm	19-Aug	80	2,024	2,039	15	9,485	674,195	
Ream over w/ 134mm	20-Aug	81	2,039	2,060	21	6,980	681,175	
Ream over w/ 134mm	21-Aug	82	2,060	2,063	3	5,799	686,974	
Ream over w/ 134mm	22-Aug	83	2,063	2,072	9	9,338	696,312	
Ream over w/ 134mm	23-Aug	84	2,072	2,086	14	7,704	704,016	
Ream over w/ 134mm	24-Aug	85	2,086	2,118	32	6,670	710,686	
Ream over w/ 134mm	25-Aug	86	2,118	2,138	20	7,607	718,293	
Ream over w/ 134mm	26-Aug	87	2,138	2,170	32	6,669	724,962	
Ream over w/ 134mm	27-Aug	88	2,170	2,213	43	6,424	731,386	
Ream over w/ 134mm	28-Aug	89	2,213	2,218	5	7,784	739,170	
Ream over w/ 134mm	29-Aug	90	2,218	2,230	12	6,402	745,572	
Fish out 101mm rods	30-Aug	91	2,230	2,230	0	5,925	751,497	

Table 6
SOH-1
DRILLING COSTS AND ACTIVITIES

Activity	Date	Day Number	Footage Start	Footage End	Daily Footage	Daily Cost	Cost-to Date	
Fish & open 5-7/8" hole	31-Aug	92	1,996	2,010	14	13,053	764,550	
Open 5-7/8" hole	01-Sep	93	2,010	2,082	72	5,835	770,385	
Open 5-7/8" hole	02-Sep	94	2,082	2,152	70	6,041	776,426	
Open 5-7/8" hole	03-Sep	95	2,152	2,183	31	6,897	783,323	
Open 5-7/8" hole	04-Sep	96	2,183	2,277	94	6,223	789,546	
Open 5-7/8" hole	05-Sep	97	2,277	2,369	92	6,484	796,030	
Open 5-7/8" hole	06-Sep	98	2,369	2,451	82	6,655	802,685	FISH, REAM OVER STUCK RODS
Open 5-7/8" hole & wash	07-Sep	99	2,451	2,506	55	7,834	810,519	& OPEN HOLE TO 5-5/8"
Wash hole	08-Sep	100	2,506	2,506	0	6,328	816,847	(1,996 - 2,671 ft)
Open 5-7/8" hole	09-Sep	101	2,506	2,600	94	6,916	823,763	Total Cost $201,709
Open hole, stick rods	10-Sep	102	2,600	2,671	71	6,557	830,320	
POH, core 134mm	11-Sep	103	2,671	2,717	46	10,316	840,636	
Core 134mm	12-Sep	104	2,717	2,738	21	8,191	848,827	
Core 134mm	13-Sep	105	2,738	2,770	32	8,172	856,999	
Core 134mm	14-Sep	106	2,770	2,836	66	6,691	863,690	
Core 134mm	15-Sep	107	2,836	2,865	29	8,394	872,084	
Core 134mm	16-Sep	108	2,865	2,868	3	7,919	880,003	
Core 134mm	17-Sep	109	2,868	2,896	28	9,167	889,170	CORE 134mm 2,671 - 3,022 ft
Core 134mm	18-Sep	110	2,896	2,935	39	6,960	896,130	& SET 4-1/2" CSG.
Core 134mm	19-Sep	111	2,935	2,957	22	8,648	904,778	351 ft. @ $73,047
Core 134mm	20-Sep	112	2,957	2,993	36	6,802	911,580	Cost/foot $208.11
Core 134mm	21-Sep	113	2,993	3,022	29	7,717	919,297	
Run & cmt 4.5" csg	22-Sep	114	3,022	3,022	0	7,096	926,393	
WOC, core HQ	23-Sep	115	3,022	3,037	15	23,329	949,722	CASING OPERATIONS
Core HQ	24-Sep	116	3,037	3,104	67	6,551	956,273	4-1/2" CASING 0 - 3,022 ft
Core HQ	25-Sep	117	3,104	3,172	68	6,221	962,494	& CEMENT
Core HQ	26-Sep	118	3,172	3,231	59	6,784	969,278	Total cost $23,026
Core HQ	27-Sep	119	3,231	3,266	35	7,478	976,756	
Core HQ	28-Sep	120	3,266	3,308	42	6,732	983,488	
Core HQ	29-Sep	121	3,308	3,329	21	7,172	990,660	
Core HQ	30-Sep	122	3,329	3,346	17	7,295	997,955	
Core HQ	01-Oct	123	3,346	3,377	31	6,999	1,004,954	
Core HQ	02-Oct	124	3,377	3,402	25	7,682	1,012,636	
Core HQ	03-Oct	125	3,402	3,422	20	6,067	1,018,703	
Core HQ	04-Oct	126	3,422	3,462	40	6,193	1,024,896	
Core HQ	05-Oct	127	3,462	3,498	36	6,054	1,030,950	
Core HQ	06-Oct	128	3,498	3,512	14	9,532	1,040,482	
Core HQ	07-Oct	129	3,512	3,538	26	7,639	1,048,121	
Core HQ	08-Oct	130	3,538	3,550	12	6,896	1,055,017	
Core HQ	09-Oct	131	3,550	3,565	15	6,532	1,061,549	
Core HQ	10-Oct	132	3,565	3,590	25	6,790	1,068,339	
Core HQ	11-Oct	133	3,590	3,625	35	6,138	1,074,477	
Core HQ	12-Oct	134	3,625	3,660	35	6,902	1,081,379	
Core HQ	13-Oct	135	3,660	3,716	56	6,176	1,087,555	
Core HQ	14-Oct	136	3,716	3,775	59	7,405	1,094,960	
Core HQ	15-Oct	137	3,775	3,844	69	6,265	1,101,225	

Table 6
SOH-1
DRILLING COSTS AND ACTIVITIES

Activity	Date	Day Number	Footage Start	Footage End	Daily Footage	Daily Cost	Cost-to Date	
Core HQ	16-Oct	138	3,844	3,870	26	6,095	1,107,320	
Core HQ	17-Oct	139	3,870	3,892	22	7,423	1,114,743	
Core HQ	18-Oct	140	3,892	3,920	28	6,308	1,121,051	
Core HQ	19-Oct	141	3,920	3,934	14	7,024	1,128,075	
Core HQ	20-Oct	142	3,934	3,976	42	6,348	1,134,423	
Core HQ	21-Oct	143	3,976	3,992	16	7,033	1,141,456	
Core HQ	22-Oct	144	3,992	4,025	33	6,186	1,147,642	
Core HQ	23-Oct	145	4,025	4,037	12	7,661	1,155,303	
Core HQ	24-Oct	146	4,037	4,064	27	7,145	1,162,448	
Core HQ	25-Oct	147	4,064	4,081	17	7,908	1,170,356	
Core HQ	26-Oct	148	4,081	4,098	17	7,389	1,177,745	
Core HQ	27-Oct	149	4,098	4,113	15	6,492	1,184,237	
Core HQ	28-Oct	150	4,113	4,120	7	7,156	1,191,393	
Core HQ	29-Oct	151	4,120	4,135	15	7,423	1,198,816	
Core HQ	30-Oct	152	4,135	4,167	32	6,546	1,205,362	
Core HQ	31-Oct	153	4,167	4,181	14	7,602	1,212,964	
Core HQ	01-Nov	154	4,181	4,188	7	7,187	1,220,151	
Core HQ	02-Nov	155	4,188	4,214	26	6,121	1,226,272	
Core HQ	03-Nov	156	4,214	4,226	12	6,771	1,233,043	
Core HQ	04-Nov	157	4,226	4,236	10	8,342	1,241,385	
Core HQ	05-Nov	158	4,236	4,248	12	5,940	1,247,325	
Core HQ	06-Nov	159	4,248	4,260	12	6,538	1,253,863	
Core HQ	07-Nov	160	4,260	4,287	27	6,037	1,259,900	
Core HQ	08-Nov	161	4,287	4,302	15	6,817	1,266,717	CORE HQ (3,022 - 4,325 FT)
Core HQ	09-Nov	162	4,302	4,307	5	6,025	1,272,742	1,303 ft. @ $360,154
Core HQ	10-Nov	163	4,307	4,324	17	6,884	1,279,626	Cost/foot $276.40
Reduce to NQ	11-Nov	164	4,324	4,324	0	6,921	1,286,547	
Core NQ	12-Nov	165	4,324	4,334	10	6,124	1,292,671	
Core NQ	13-Nov	166	4,334	4,360	26	6,436	1,299,107	
Core NQ	14-Nov	167	4,360	4,364	4	6,748	1,305,855	
Core NQ	15-Nov	168	4,364	4,364	0	6,872	1,312,727	
Core NQ	16-Nov	169	4,364	4,387	23	7,078	1,319,805	
Core NQ	17-Nov	170	4,387	4,429	42	6,851	1,326,656	
Core NQ	18-Nov	171	4,429	4,460	31	7,162	1,333,818	
Core NQ	19-Nov	172	4,460	4,490	30	6,178	1,339,996	
Core NQ	20-Nov	173	4,490	4,530	40	6,415	1,346,411	
Core NQ	21-Nov	174	4,530	4,565	35	6,200	1,352,611	
Core NQ	22-Nov	175	4,565	4,595	30	6,398	1,359,009	
Core NQ	23-Nov	176	4,595	4,597	2	6,488	1,365,497	
Core NQ	24-Nov	177	4,597	4,602	5	7,950	1,373,447	
Core NQ	25-Nov	178	4,602	4,621	19	6,142	1,379,589	
Core NQ	26-Nov	179	4,621	4,650	29	6,348	1,385,937	
Core NQ	27-Nov	180	4,650	4,684	34	6,283	1,392,220	
Core NQ	28-Nov	181	4,684	4,699	15	6,834	1,399,054	
Core NQ	29-Nov	182	4,699	4,699	0	7,126	1,406,180	
Core NQ	30-Nov	183	4,699	4,723	24	6,753	1,412,933	

Table 6
SOH-1
DRILLING COSTS AND ACTIVITIES

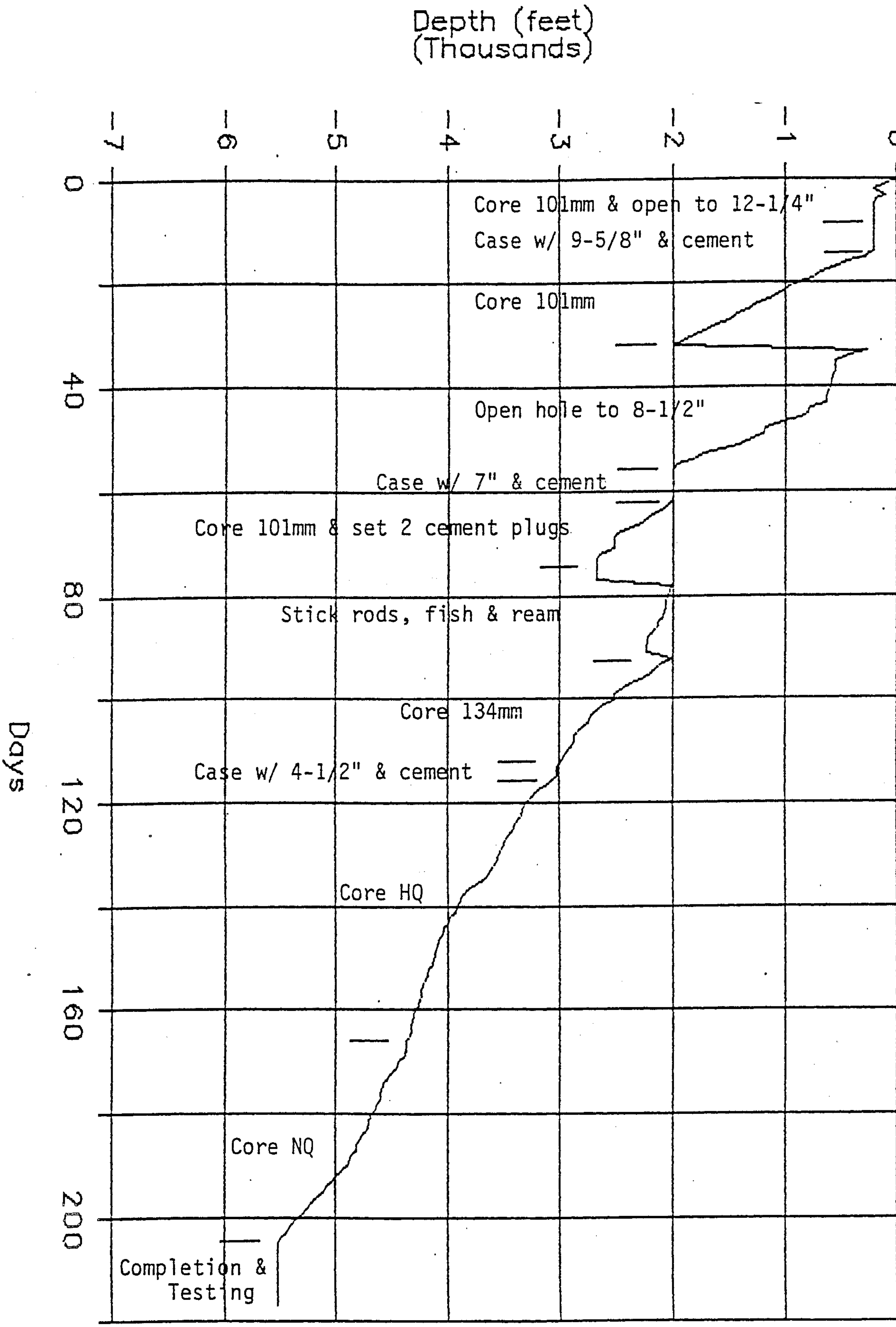
Activity	Date	Day Number	Footage Start	Footage End	Daily Footage	Daily Cost	Cost-to Date	
Core NQ	01-Dec	184	4,723	4,753	30	6,462	1,419,395	
Core NQ	02-Dec	185	4,753	4,777	24	6,365	1,425,760	
Core NQ	03-Dec	186	4,777	4,812	35	6,262	1,432,022	
Core NQ	04-Dec	187	4,812	4,812	0	6,483	1,438,505	
Core NQ	05-Dec	188	4,812	4,855	43	6,815	1,445,320	
Core NQ	06-Dec	189	4,855	4,880	25	6,667	1,451,987	
Core NQ	07-Dec	190	4,880	4,888	8	6,557	1,458,544	
Core NQ	08-Dec	191	4,888	4,941	53	6,164	1,464,708	
Core NQ	09-Dec	192	4,941	4,991	50	6,128	1,470,836	
Core NQ	10-Dec	193	4,991	5,043	52	6,191	1,477,027	
Core NQ	11-Dec	194	5,043	5,078	35	5,852	1,482,879	
Core NQ	12-Dec	195	5,078	5,116	38	5,901	1,488,780	
Core NQ	13-Dec	196	5,116	5,159	43	6,044	1,494,824	
Core NQ	14-Dec	197	5,159	5,198	39	6,349	1,501,173	
Core NQ	15-Dec	198	5,198	5,247	49	6,032	1,507,205	
Core NQ	16-Dec	199	5,247	5,295	48	5,842	1,513,047	
Core NQ	17-Dec	200	5,295	5,342	47	5,951	1,518,998	
Core NQ	18-Dec	201	5,342	5,382	40	5,875	1,524,873	
Core NQ	19-Dec	202	5,382	5,422	40	5,799	1,530,672	CORE NQ (4,325 - 5,526 FT)
Core NQ	20-Dec	203	5,422	5,456	34	5,641	1,536,313	1,201 ft. @ $258,989
Core NQ	21-Dec	204	5,456	5,506	50	5,730	1,542,043	Cost/foot $215.64
TD hole, survey	22-Dec	205	5,506	5,526	20	3,493	1,545,536	
Condition hole, shut in	23-Dec	206	5,526	5,526	0	2,986	1,548,522	
Condition hole	04-Jan	207	5,526	5,526	0	10,518	1,559,040	
Condition, standby	05-Jan	208	5,526	5,526	0	5,454	1,564,494	
Run temp & press. logs	06-Jan	209	5,526	5,526	0	6,236	1,570,730	
Run gam. & cal. logs	07-Jan	210	5,526	5,526	0	5,662	1,576,392	
Lay dn rods, run tubing	08-Jan	211	5,526	5,526	0	30,657	1,607,049	
Hang tubing, install w/h	09-Jan	212	5,526	5,526	0	13,357	1,620,406	
Test, log & rig down	10-Jan	213	5,526	5,526	0	5,427	1,625,833	
Loggine & rig down	11-Jan	214	5,526	5,526	0	5,115	1,630,948	
Rig down & repairs	12-Jan	215	5,526	5,526	0	5,271	1,636,219	COMPLETION, TESTING &
Rigging down	13-Jan	216	5,526	5,526	0	4,271	1,640,490	RIG DOWN
Rig down & move	14-Jan	217	5,526	5,526	0	3,054	1,643,544	Total Cost $98,008

TOTAL DRILLING COSTS: $1,643,544

Table 7

SOH-1
Hole Deviation Measurements

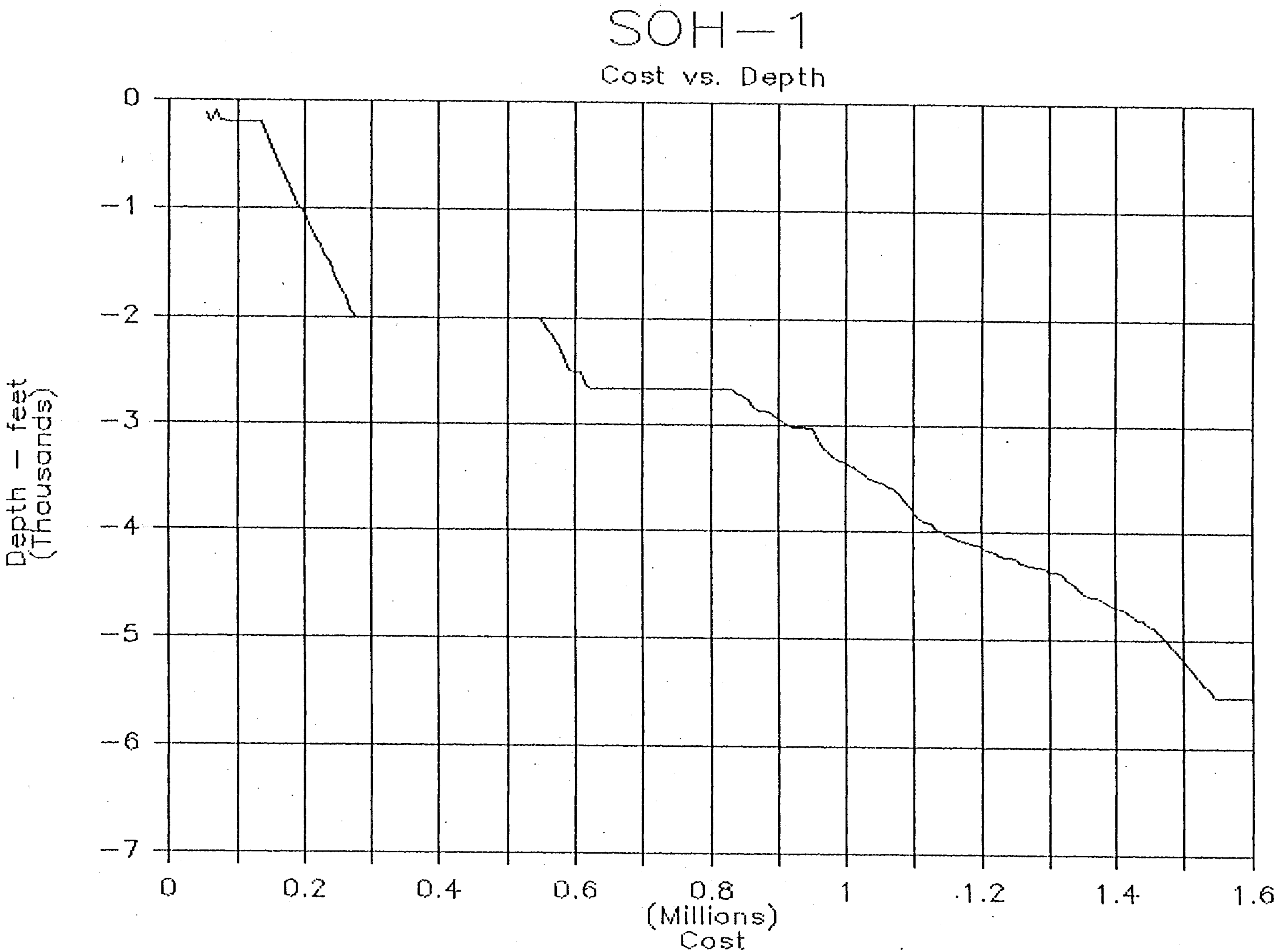
Depth (feet)	Angle (degrees)	Bearing
1,130	0.50	S
1,250	0.50	S
1,370	0.75	S
1,490	1.00	S-5-E
1,610	1.00	S-5-E
1,730	1.00	S-10-E
1,850	1.00	S-10-E
1,990	0.75	S-10-W
3,400	2.50	S-40-W



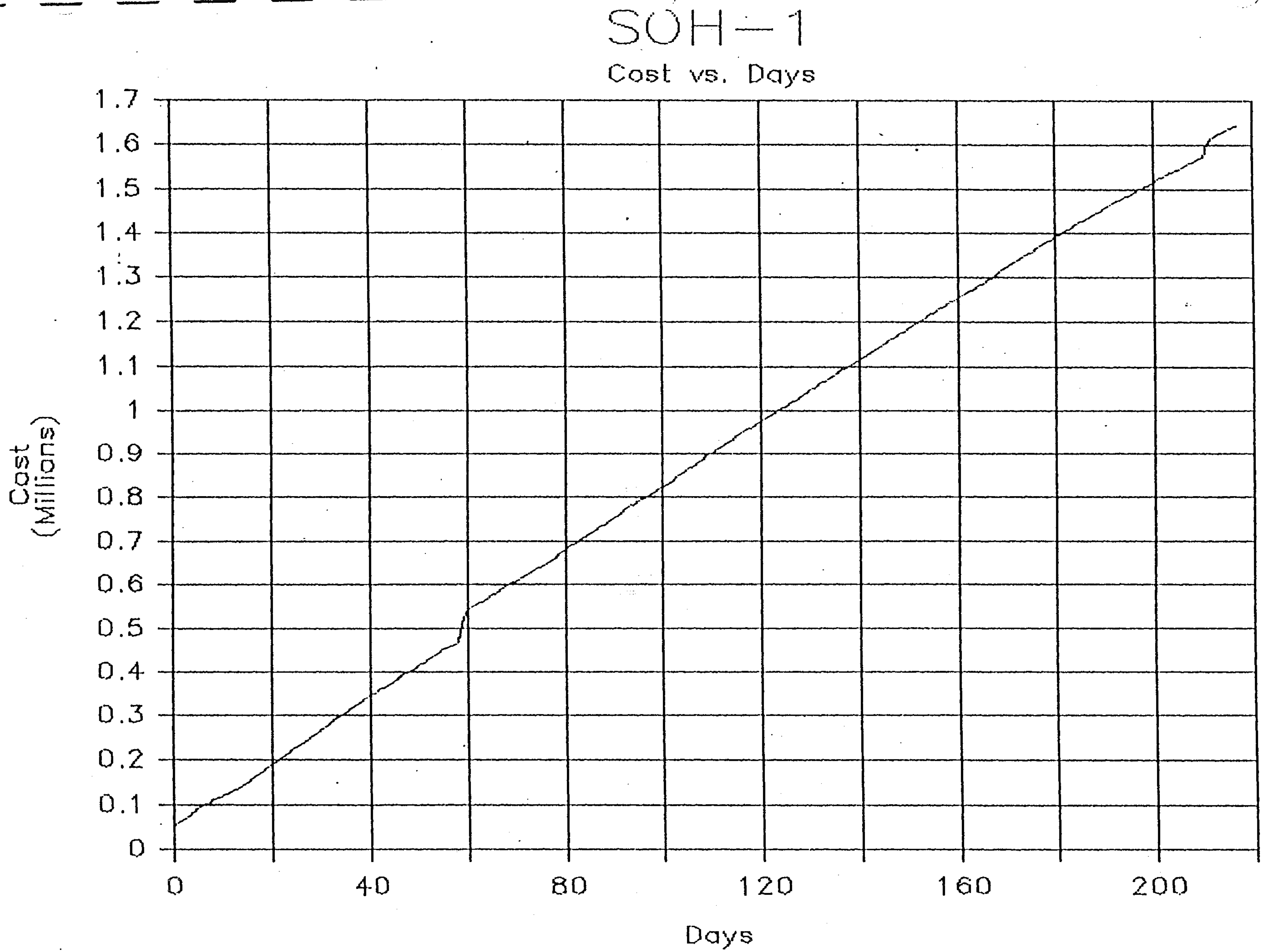
SOH—1
Time vs. Depth

Figure 1

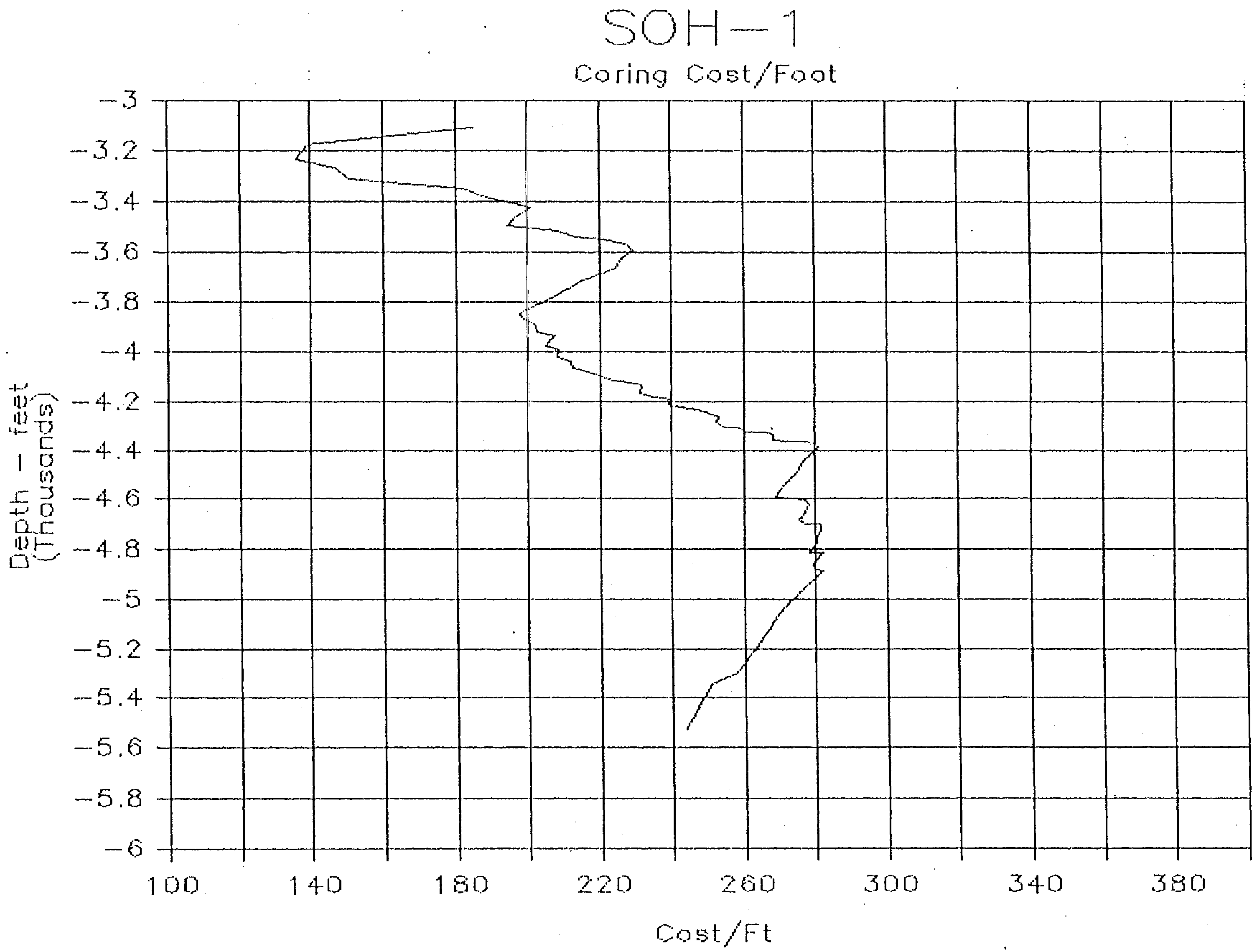
Figure 2

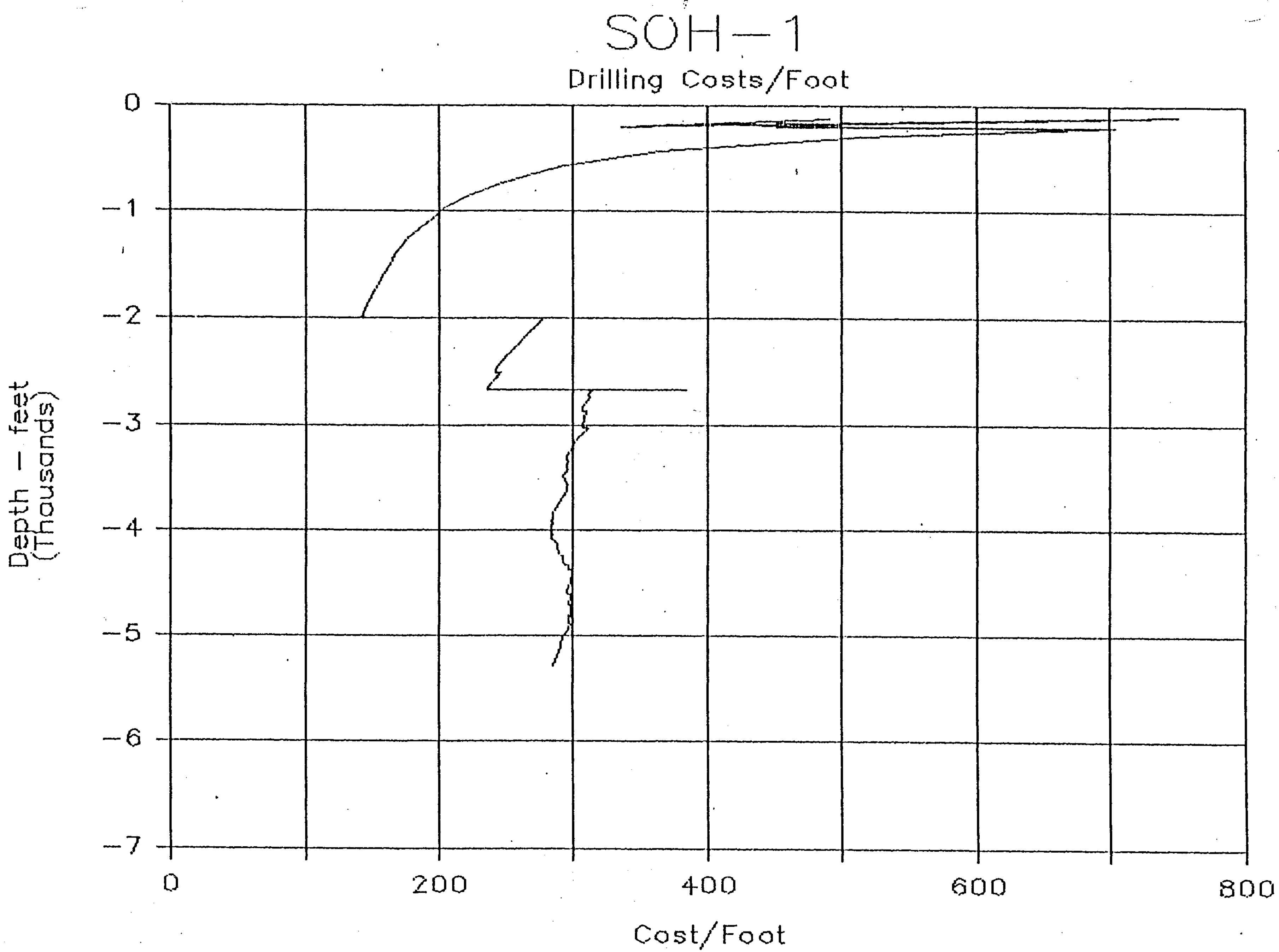


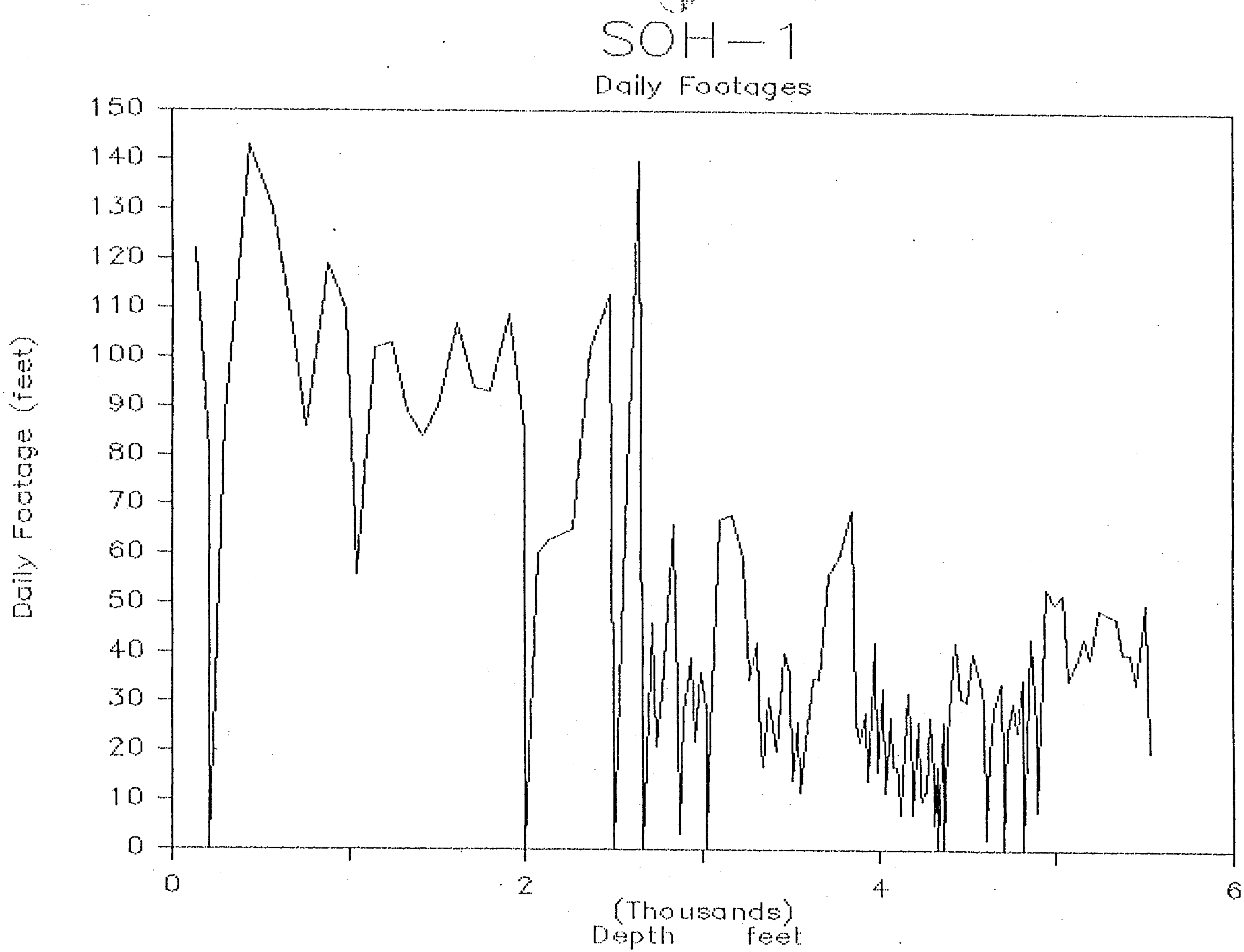
SOH-1
Cost vs. Depth
Depth - feet
(Thousands)
0
-1
-2
-3
-4
-5
-6
-7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
(Millions)
Cost


SOH-1
Cost vs. Days
Cost (Millions)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
40
80
120
160
200
Days

Figur F


SOH-1
Coring Cost/Foot
-3
-3.2
-3.4
-3.6
-3.8
-4
-4.2
-4.4
-4.6
-4.8
-5
-5.2
-5.4
-5.6
-5.8
-6
Depth - feet (Thousands)
100
140
180
220
260
300
340
380
Cost/Ft


SOH-1
Drilling Costs/Foot
Depth - feet
(Thousands)
0
-1
-2
-3
-4
-5
-6
-7
0
200
400
600
800
Cost/Foot


SOH-1
Daily Footages
Daily Footage (feet)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
(Thousands)
Depth feet

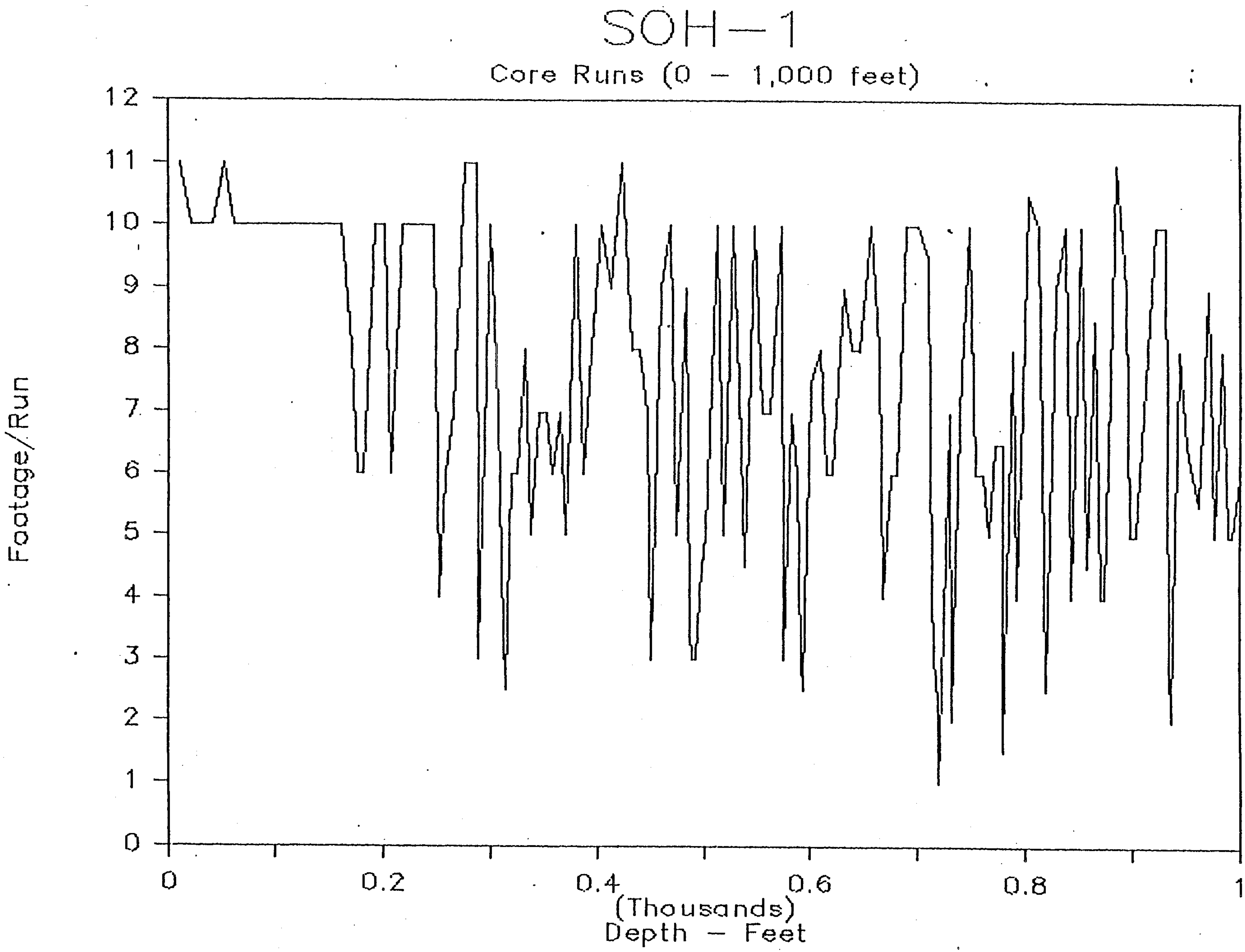

SOH-1
Core Runs (0 - 1,000 feet)
Footage/Run
0
1
2
3
4
5
6
7
8
9
10
11
12
0
0.2
0.4
0.6
0.8
1
(Thousands)
Depth - Feet

Figure 7a

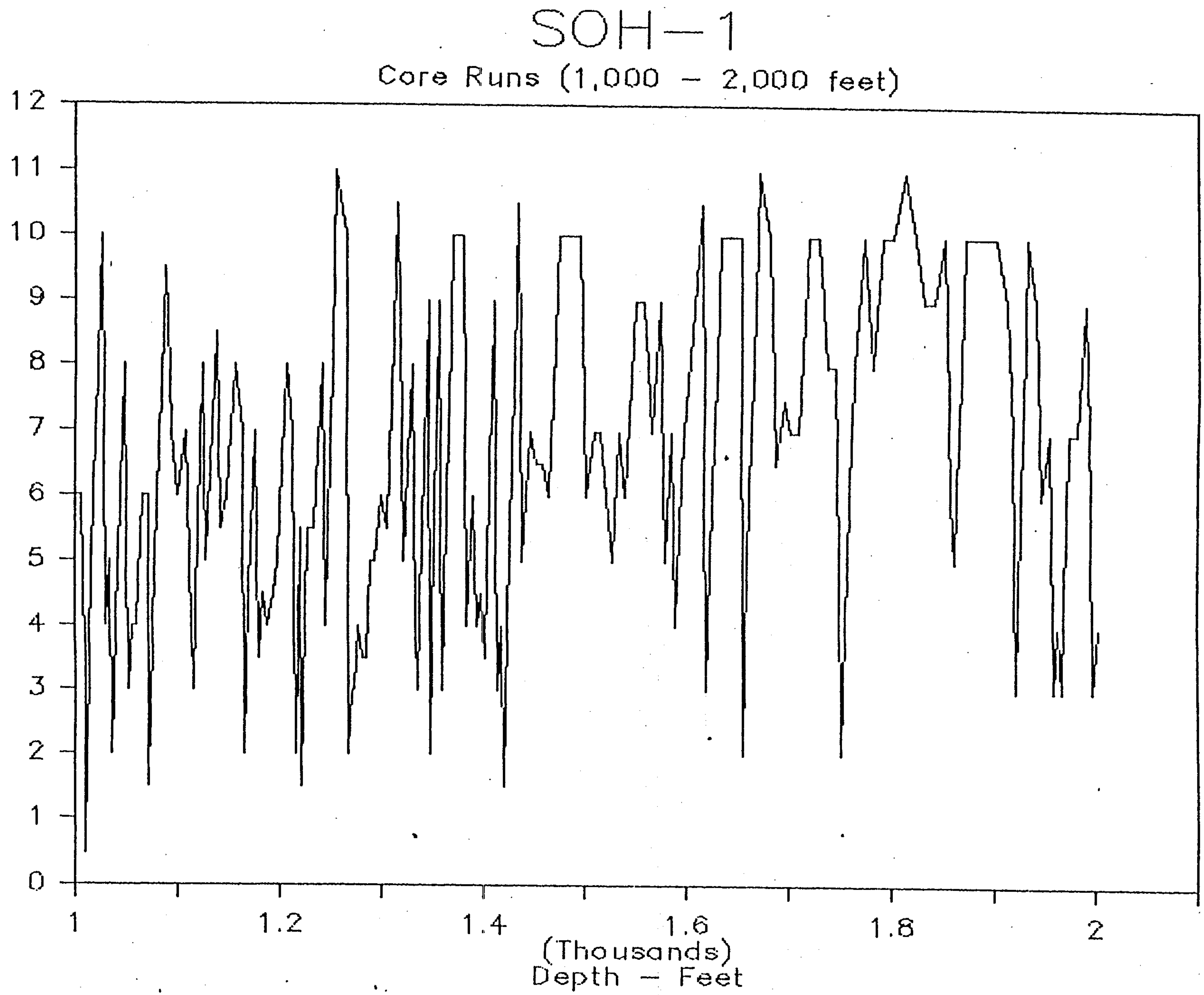

SOH-1
Core Runs (1,000 - 2,000 feet)
12
11
10
9
8
7
6
5
4
3
2
1
0
1
1.2
1.4
1.6
1.8
2
(Thousands)
Depth - Feet

Figure 7b

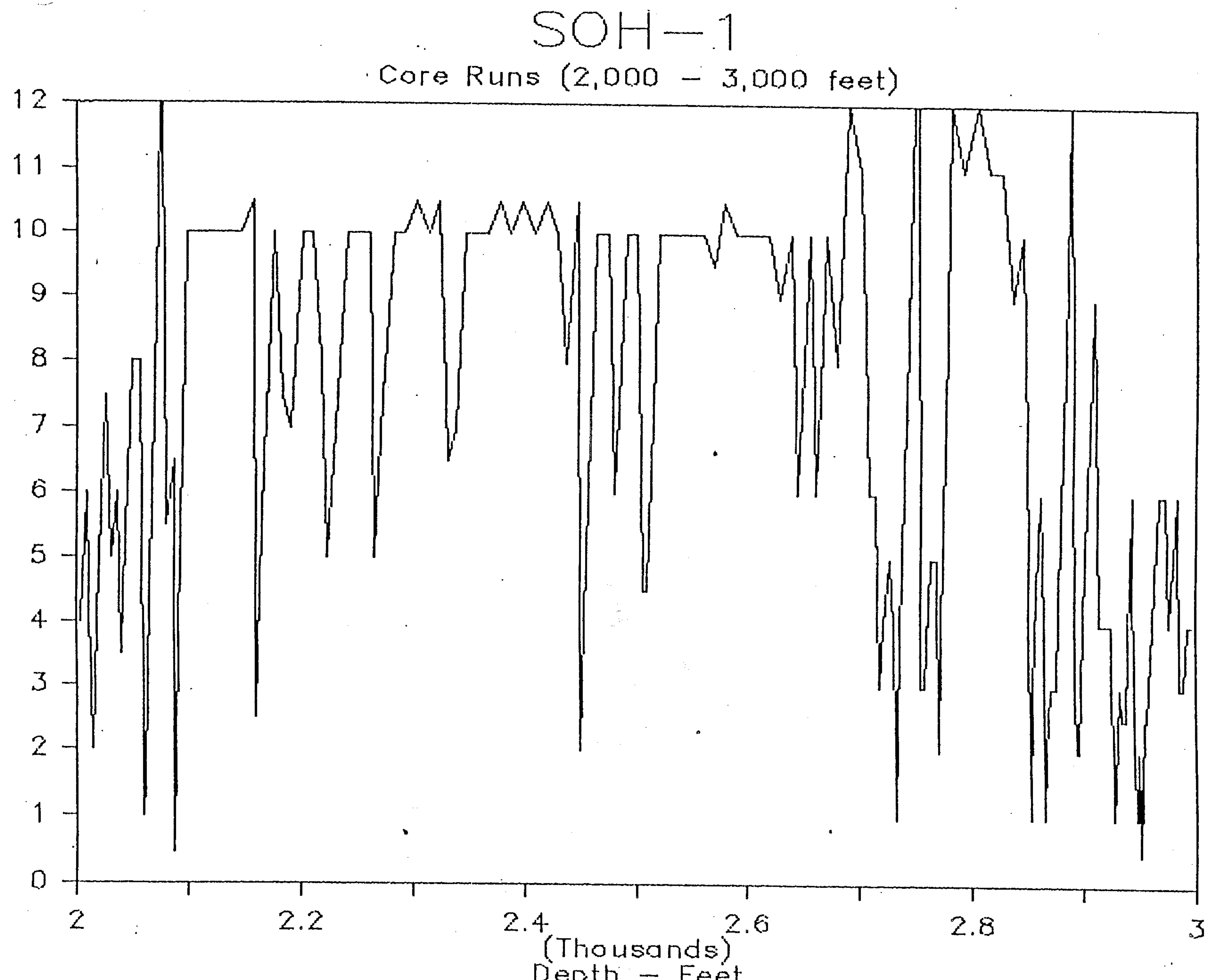

SOH-1
Core Runs (2,000 - 3,000 feet)
12
11
10
9
8
7
6
5
4
3
2
1
0
2
2.2
2.4
2.6
2.8
3
(Thousands)
Depth - Feet

Figure 7c

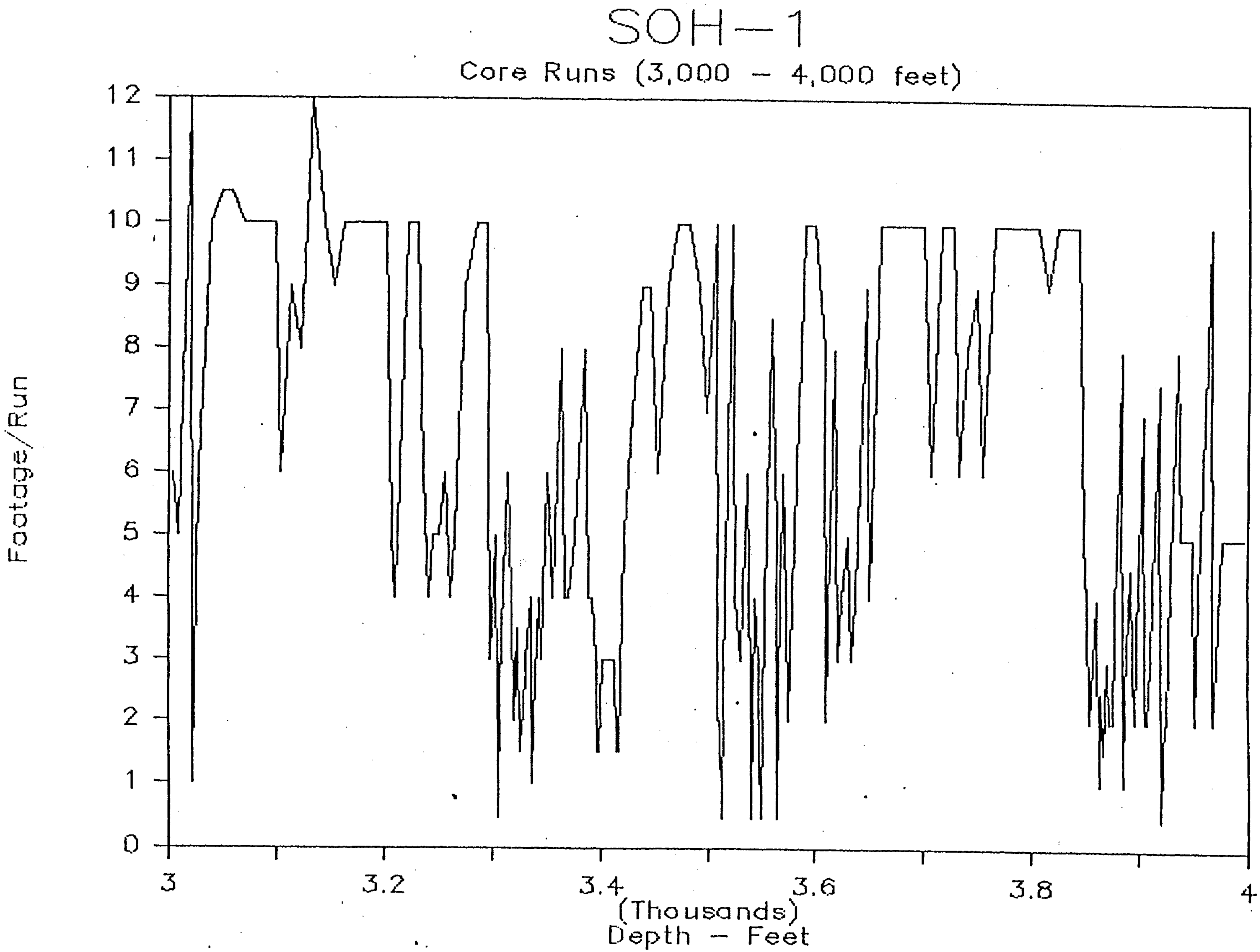
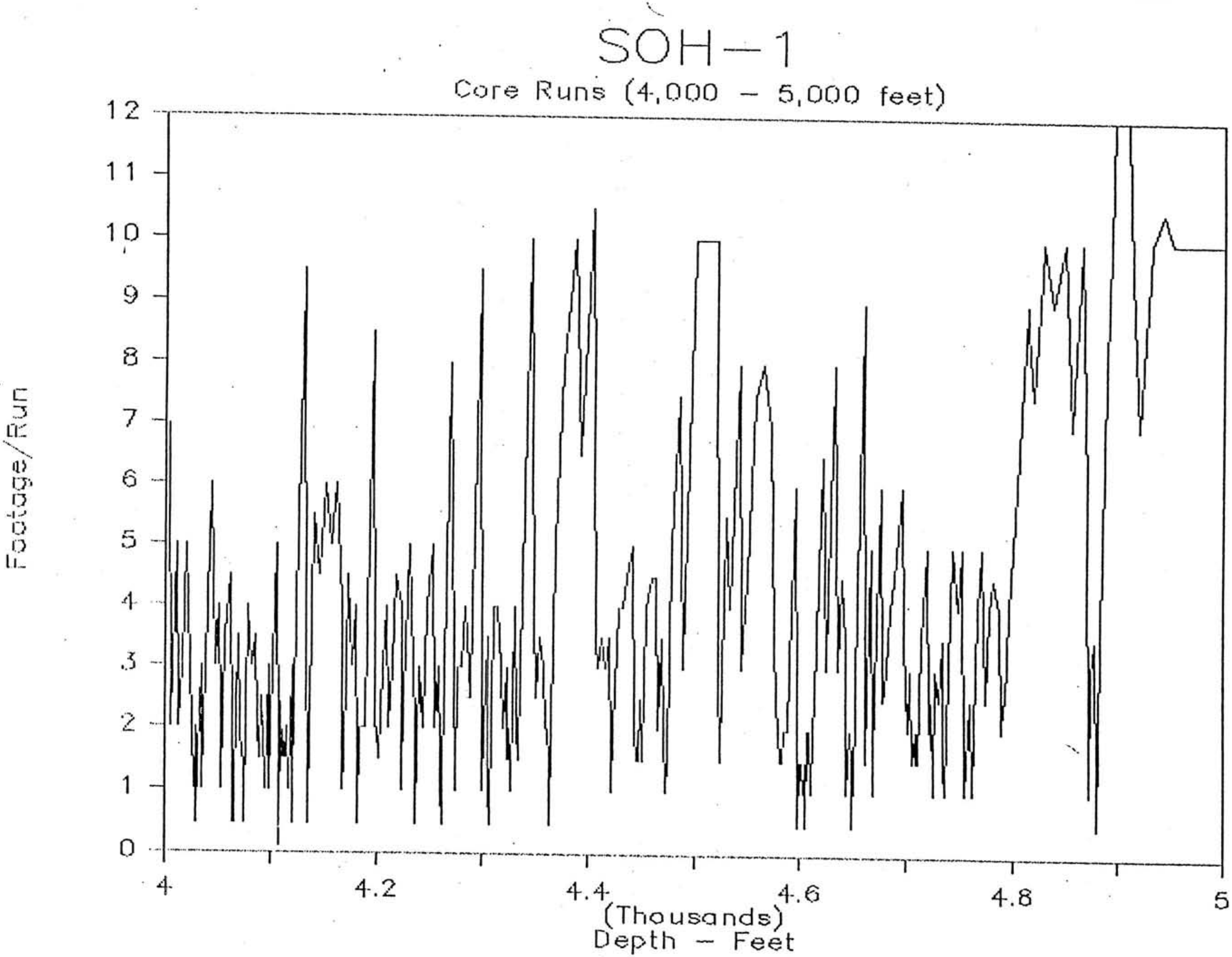

SOH-1
Core Runs (3,000 - 4,000 feet)
12
11
10
9
8
7
6
5
4
3
2
1
0
Footage/Run
3
3.2
3.4
3.6
3.8
4
(Thousands)
Depth - Feet

Figure 7d



SOH-1
Core Runs (4,000 - 5,000 feet)
Footage/Run
12
11
10
9
8
7
6
5
4
3
2
1
0
4
4.2
4.4
4.6
4.8
5
(Thousands)
Depth - Feet

Figure 7e

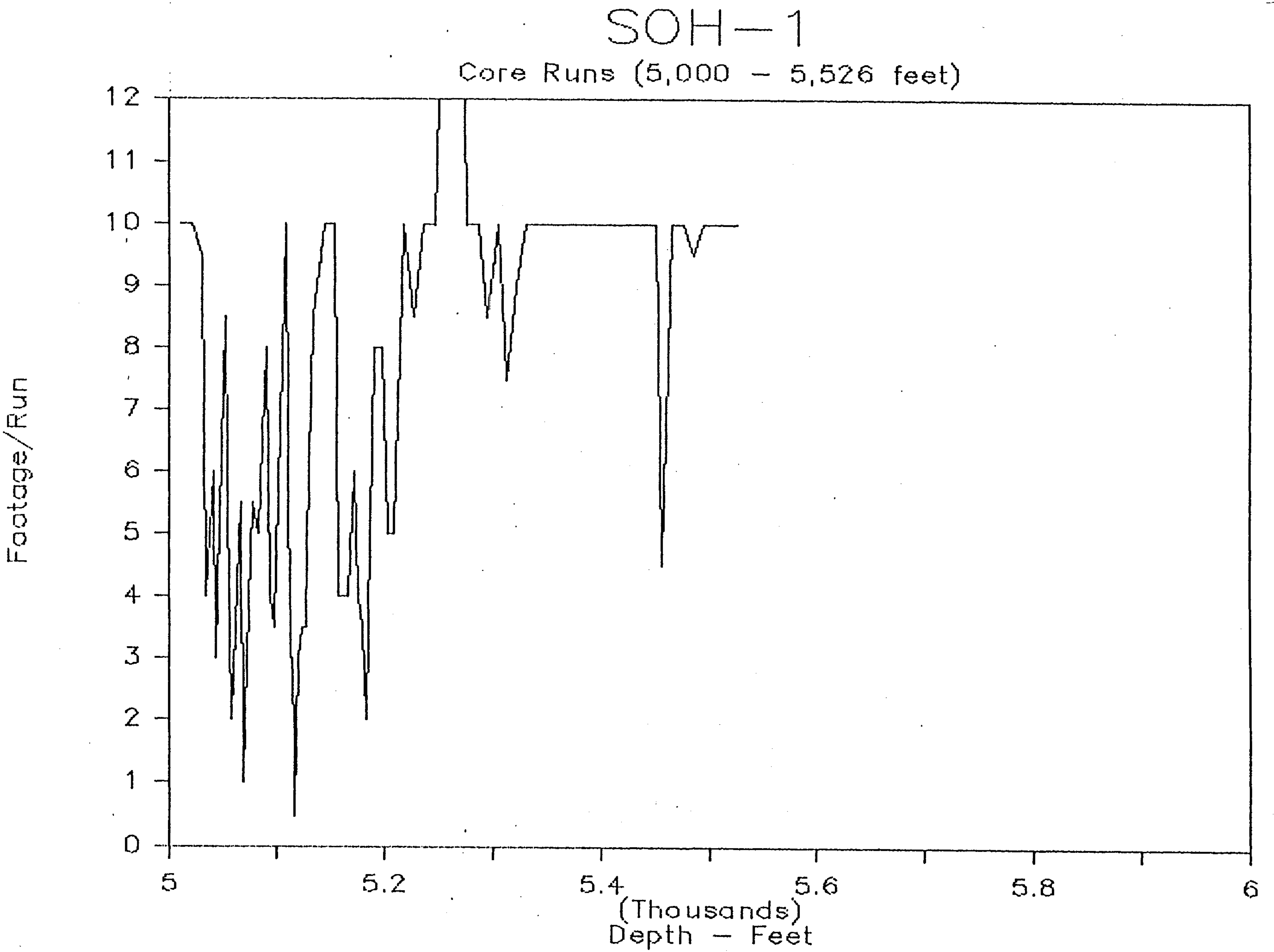
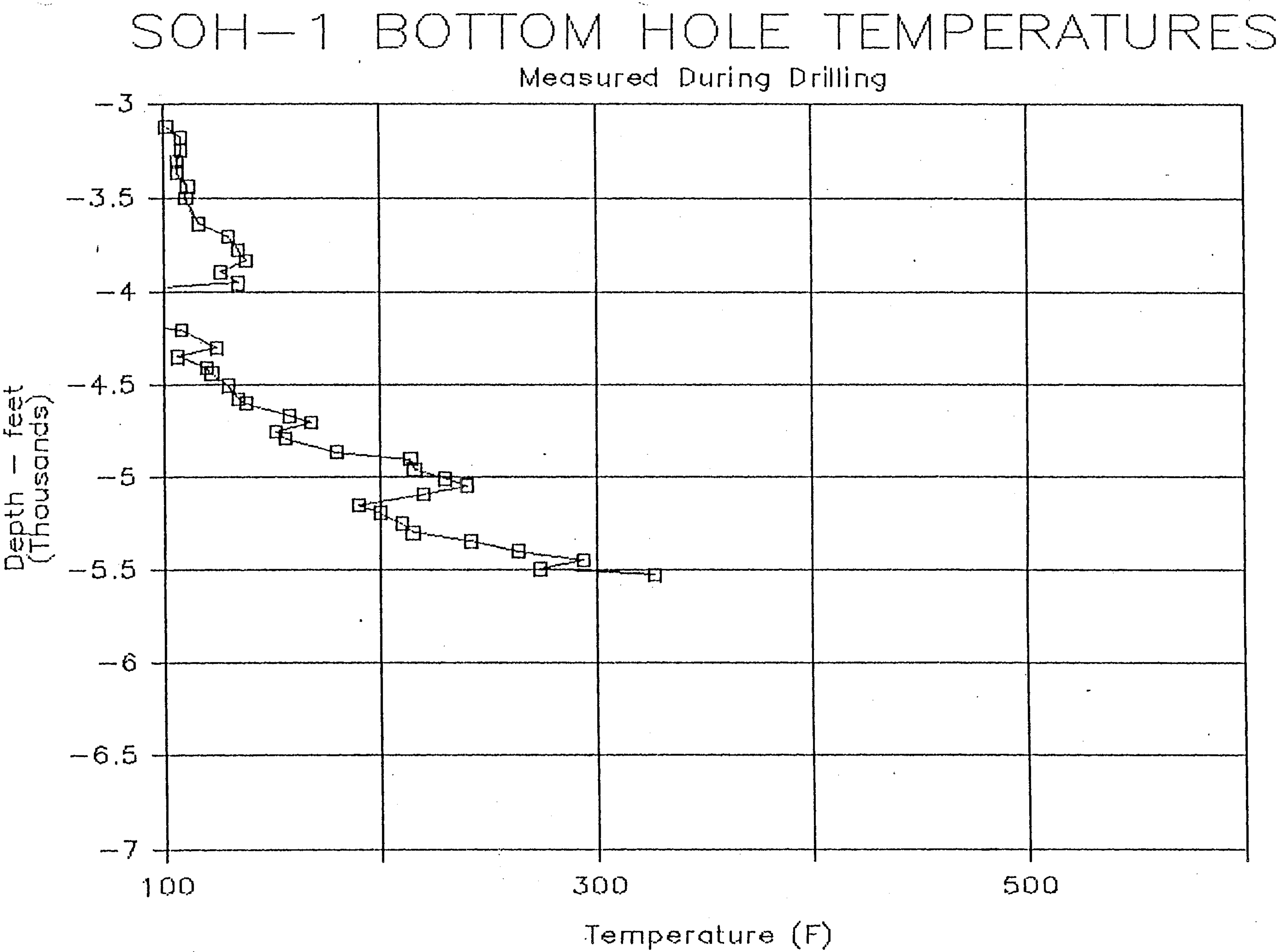

SOH-1
Core Runs (5,000 - 5,526 feet)
Footage/Run
12
11
10
9
8
7
6
5
4
3
2
1
0
5
5.2
5.4
5.6
5.8
6
(Thousands)
Depth - Feet

Figure 7f

Figure 8


SOH-1 BOTTOM HOLE TEMPERATURES
Measured During Drilling
-3
-3.5
-4
-4.5
-5
-5.5
-6
-6.5
-7
Depth - feet
(Thousands)
100
300
500
Temperature (F)

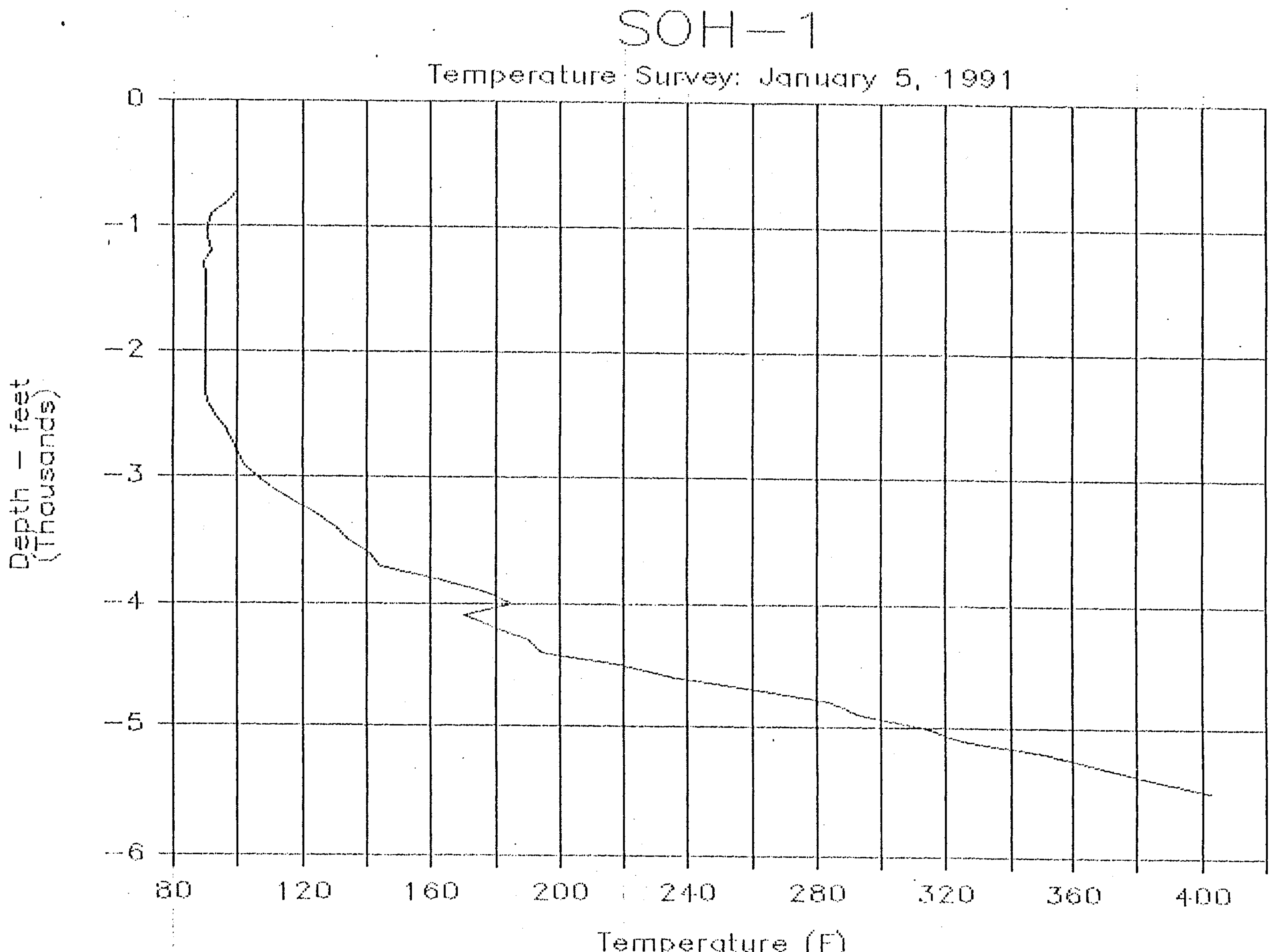

SOH-1
Temperature Survey: January 5, 1991
0
-1
-2
-3
-4
-5
-6
Depth - feet
(Thousands)
80
120
160
200
240
280
320
360
400
Temperature (F)

Figure 9

Figure 10

Completed SOH-1 Schematic

0 - 202 ft. - 12-1/4" hole
9-5/8" K-55, 40#/ft. casing
Cemented w/ redimix concrete

202 - 1,996 ft. - 8-1/2" hole
7" L-80, K-55, 35#/ft. casing
Cemented w/ silica/spherelite cement

1,996 - 2,671 ft. - 5-7/8" hole

2,671 - 3,022 ft. - CHD-134 hole (5.27")
4-1/2" casing 0-3,022 ft.
0-2,005 ft. J-55, 10.5 #/ft., ST&C
2,005 - 3,022 ft. J-55, 11.6#/ft., flush joint
Bottom 200 ft. cemented w/ neat cement

3,022 - 4,325 ft. - HQWL hole (3.83" hole x 2.50" core)

4,325 - 5,526 ft. - NQ hole (2.98" hole x 1.875" core)

Completion tubing - NQ (2.75" O.D. x 2.375" I.D.)
5.2#/ft., perforated w/ 1/2" holes on 6" centers

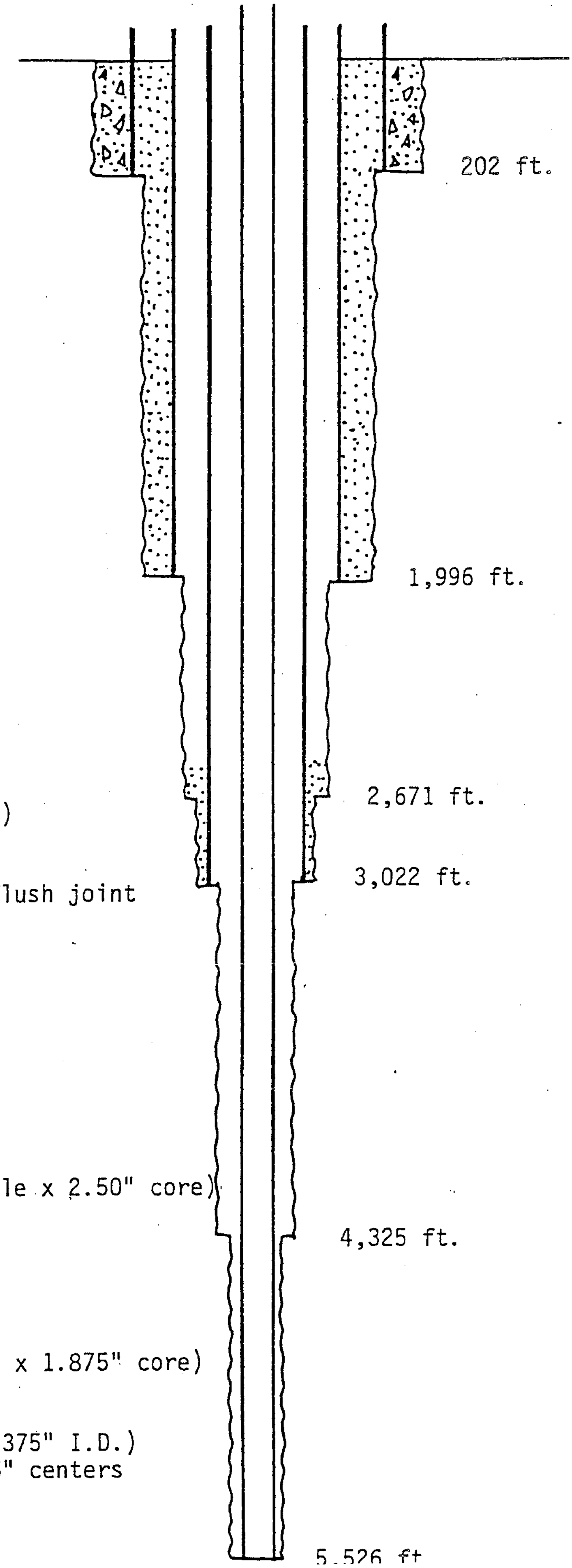
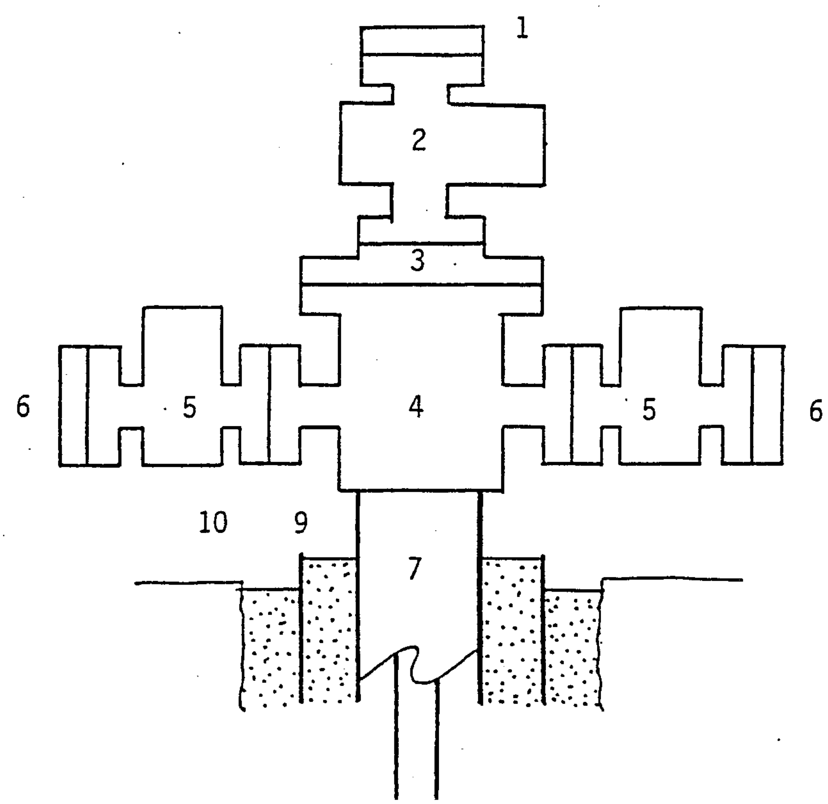


Figure 11

SOH-1 Completion Wellhead

1. Companion Flange - 2-9/16" 3M x 3" L.P.
2. Gate Valve - 2-9/16" Foster Flow-Seal w/ T-24 trim
3. Tubing Head Adapter - 7-1/16" 3M x 2-9/16" 3M
4. 7" EFSO Slip On Wellhead
5. Gate Valves - 2-1/16" 3M Foster Flow-Seal w/ T-24 trim
6. Companion Flanges - 2-1/16" 3M x 2" L.P.
7. 7" L-80, 35#/ft. casing
8. NQ Completion Tubing (2.75" O.D., 5.5#/ft.)
9. 9-5/8" K-55, 40#/ft. casing



APPENDIX V.

SOH-2 SUMMARY DRILLING REPORT AND WELL HISTORY

-by-

John E. Deymonaz
Geothermal Drilling Consultant

SCIENTIFIC OBSERVATION HOLE #2
KILAUEA EAST RIFT ZONE, HAWAII
SUMMARY REPORT OF DRILLING OPERATIONS

Prepared By

John E. Deymonaz
SOH Drilling Manager

March 1992

Scientific Observation Hole #2

PURPOSE AND SCOPE

The Scientific Observation Hole program ("SOH") is a multifaceted project designed to provide data for scientific research, aid in evaluating the commercial geothermal potential along the Kilauea East Rift Zone, and serve as long term monitoring sites.

A primary concern in engineering the project was to minimize the environmental and sociological impact. This was achieved by choosing equipment and drilling techniques so that operations required only a limited work area (less than 1/3 acre), surpassed county noise guidelines, had low water consumption and did not require a high volume of heavy truck traffic. Drill sites were carefully selected to eliminate the need for new road construction, maintain as much distance as possible from residences and use the natural terrain to negate the visual and audible impact on the community.

SOH-2 was the third and final hole in the first phase of the Scientific Observation Hole program. The three holes involved the drilling of 18,890 feet of hole (6,562 feet, 5,526 feet and 6,802 feet) and the recovery of nearly 15,000 feet of core.

The SOH drilling has provided the first extensive core ever taken in Hawaii. Continuous core yields invaluable, tangible information to geologists and other earth scientists concerning the evolution of the Hawaiian volcanoes in general and the Kilauea East Rift Zone in particular. Analysis of the SOH core will provide unique information concerning the evolution of the East Rift Zone through periods of volcanic aggradation, erosion, sedimentation, mass wasting, intrusive activity and subsidence to its current state.

A primary goal of the SOH program has been to evaluate the extent of a commercially viable geothermal resource along the East Rift Zone. The SOH holes compliment geothermal exploration and production drilling underway in the East Rift Zone. Study of core samples aids in understanding the interrelationship of permeability, secondary mineralization and alteration in a geothermal system. Temperature surveys and geophysical logs provide information on the extent and nature of the system. Detailed descriptive logs, data bases and the archiving of core for future study provides a powerful long term reference tool for geologists involved in current and future geothermal production drilling operations.

Following their completion, the SOHs will serve as long term observation sites. From these sites changes in temperature, water level and water chemistry will be monitored to determine the effects of long term commercial geothermal production.

CONTRACTOR AND EQUIPMENT

Tonto Drilling Services Inc. of Salt Lake City, Utah was the drilling contractor chosen for the first phase of the SOH program. Tonto provided an experienced crew and a Universal 5000 rotary/core drilling rig to undertake this project. The Universal 5000 drilling rig is one of only two such units in existence and is uniquely suited for the requirements of the SOH project. It has been extensively modified for geothermal work and to meet stringent noise level limitations mandated by the county of Hawaii.

The drilling rig is mounted on a 3-axle trailer and weighs approximately 94,600 pounds. A self-elevating jack-up system permits raising the rig and placing a 10.5 foot high substructure under the mast. The substructure carries the weight associated with drilling, serves as a working floor and permits the above ground installation of blow out prevention equipment ("BOPE").

Specifications for the Universal 5000 drill rig include:

a. Rotation head hoisting capacity of 100,000 pounds.

b. Main hoist capacity of 88,000 pounds (single line, 1-3/16 inch cable).

c. Rotation head pull down of 30,000 pounds.

d. Rotation head speed variable from 0 to 2,250 RPM.

e. Maximum rotation head output torque of 6,630 foot pounds.

f. Wireline winch with 18,000 feet of 3/8 inch wire rope and a full drum pull of up to 1,500 feet per minute.

g. Hydraulic system consisting of axial and radial piston pumps and motors designed as three independent open loop circuits.

h. 56 foot mast with a 40 foot rod pull and stacking capacity.

i. Hydraulically operated and self energizing casing and rod slips.

Depth rating of the Universal 5000 depends on the size of drill rods used, drilling conditions and other factors. For NQ drill rods, which were used to complete SOH-2, the theoretical maximum depth is over 17,000 feet.

MODIFIED CORE DRILLING PROGRAM

The original SOH drilling program specified core drilling from the surface to total depth in each hole. To permit the installation of 7 inch and 9-5/8 inch casing strings in the upper 2,000 feet of SOH-1 and SOH-4, the holes were first core drilled, then opened with rotary bits or hole openers. After casing was cemented, core drilling resumed and continued to total depth.

In order to reduce drilling costs, coring in the cased portion of SOH-2 was omitted and the upper 1,909 feet was rotary drilled in a single pass. Rotary drilling was then scheduled to continue until conditions favorable to efficient core drilling were encountered. Attempts at core drilling involved the installation of a retrievable casing sleeve, which permited the resumption of rotary drilling.

A casing sleeve is necessary to prevent excessive lateral movement of the drill rods. Unlike heavy rotary drill pipe, rods used in core drilling are relatively light with thin walls (0.18 - 0.3 inches). Rod failure will occur rapidly if the rods are subjected to high speed rotation without proper lateral support.

Based on information gained in drilling SOH-1 and SOH-4, it was determined that core drilling was efficient and cost effective in most subaerial volcanic sections and in submarine volcanics and intrusives which have undergone extensive thermal alteration and secondary mineralization. The subaerial/submarine volcanic boundary is variable and dependent upon the amount of subsidence and/or normal faulting and sea level at the time of deposition. The occurrence of hyaloclastics and/or carbonate reef material were the primary determining factors used to identify the top of the submarine volcanic section. At higher elevations the volcanic pile is thicker and hence more subsidence was anticipated. However, the thickness of subaerial volcanics at the SOH-4 site was surprising. Table 1 summarizes surface elevations and relative depths below mean sea level to the first occurrence of submarine volcanics.

Table 1
SOH Subaerial/Submarine Contact Depths
(Depths in feet)

Hole	Surface Elevation	Subaerial Volcanic Thickness	Contact Depth M.S.L.
SOH-4	1,195	5,554	-4,359
SOH-1	620	2,551	-1,931
SOH-2	270	1,680	-1,410

Submarine volcanics which have not undergone extensive thermal alteration are extremely difficult to core drill in the East Rift Zone. The pervasive fracturing and abrasive nature dramatically shortens bit life due to rapid deterioration of the bit face and inner and outer gauge, reduces core recovery, results in hole stability problems and requires excessive trip time. Thermal alteration serves to both reduce the abrasiveness and bonds the rock into a cohesive mass which is easily cored with excellent recovery. The most obvious example of the change in rock character is the increase in bit life from generally less than 30 feet in unaltered submarine volcanics to 600 - 1,000 feet in altered intervals.

Bottom hole temperature ("BHT") measurements were made on a regular basis while drilling each of the SOHs. In each of the holes bit life increase occurred when measured BHT's exceeded 175 - 200 F and a high positive thermal gradient was established. The increase in temperature and change in lithologic character suggests the presence of a definitive boundary between permeable sections containing cool shallow aquifers and the geothermal system with thermally altered volcanics, elevated temperatures and low permeability.

In order to obtain core for study, two small intervals of submarine volcanics were core drilled in SOH-2 prior to encountering elevated temperatures. The first cored interval was a 135 foot section from 1,909 to 2,044 feet and the second was a 46 foot section from 2,784 to 2,830 feet. Coring in both sections was slow and difficult, with core runs averaging only about 3 feet in hard, abrasive and pervasively fractured flows and intrusives. While the first attempt resulted in a core recovery of only 60 percent, a 99 percent recovery rate was attained in the deeper section. Core drilling in both sections was very similar to conditions encountered in the section between 1,996 to 4,880 feet in SOH-1 which consisted of submarine volcanics lacking extensive thermal alteration.

Shallow groundwater in the area is approximately 68 to 75 F, however, a water well located 300 feet east of SOH-2 produces 98 F water from a depth of 300 feet. BHT's in excess of 100 F did not occur until a depth of 3,848 feet where a temperature of 104 F was recorded. A second measurement at a depth of 3,907 feet also yielded a 104 F temperature. The measured BHT rapidly increased to 120 F at a depth of 4,045 feet, a temperature gradient of nearly 12 F/100 feet. Other signs of thermal alteration included a noticeable decrease in the rock hardness below 3,735 feet and a change in the color of the drilling mud returns from medium gray to pale green.

Rotary drilling was suspended at 4,103 feet and casing was run in preparation of core drilling. The first BHT measurement taken after core drilling began was 206 F recorded at a depth of 4,152 feet.

DRILLING OPERATIONS

SOH-2 was spudded-in at 11:30 AM on February 3, 1991 and completed to a total depth of 6,802 feet G.L. (Ground Level) at 1:00 AM on May 29. A total of 115 days was involved in drilling the hole. Completion, testing and demobilization of equipment required an additional 11 days. A brief summary of drilling activities is presented in Table 2 and graphically illustrated in Figure 1.

Surface Casing

The hole was spudded-in with 134 mm core (5.28" hole x 3.35" core) and drilled to 10 feet. The hole was then opened to 8-1/2 inches to a depth of 9 feet. A 12-1/4 inch drilling assembly consisting of a ATJ-33 bit, near bit stabalizer and 6-1/2 inch collars was then made up and the hole deepened to 202 feet. Circulation was lost near the surface and never regained in this interval.

Drilling the top 202 feet required nearly 5 days. Progress was slowed by dense basalt flows and numerous voids and fractures. Standby time resulting from a shortage of water totaled nearly 30 hours. A nearby water well was utilized to supply drilling water, however, the output of 50 GPM was not sufficient while drilling the 12-1/4 inch hole. Water trucks were used as a backup supply, but Hawaii county regulations prohibited truck traffic to the drill site between 7 PM and 7 AM.

On February 8, 202 feet of 9-5/8 inch K-55, 40 lb/ft buttress threaded and coupled casing was run open ended and set on bottom. The hole was dry to TD and the casing was cemented in two stages using redimix concrete (5 sack mix w/ 1/2" minus aggregate). First, 15 cubic feet of concrete was poured down the annulus, the casing was picked up off bottom several times to allow concrete to wash around the base of the casing. The casing was then set back on bottom and 200 cubic feet of concrete poured down the annulus with no returns to the surface. Twelve hours later 110 cubic feet of concrete were required to bring the concrete back to the surface. Total concrete required was approximately 300% of theoretical.

The BOP equipment was nippled up and tested to 600 psi for 20 minutes. Equipment consisted of a 3M slip-on wellhead with 2 inch flanged outlets, a 9 inch 5M Type E double gate BOP with pipe and blind rams and 2 inch kill and flow lines with 2 inch 3M gate valves (Figure 2).

Intermediate (Protection) Casing

Drilling resumed at 10:00 AM on February 10, with a 8-1/2 inch ATJ-33 bit, near bit stabalizer and 120 feet of 6 inch drill collars.

The drilling plan for the rotary portion of SOH-2 was similar to that used successfully in SOH-1. Rather than attempt to maintain fluid returns throughout the drilling process, the hole was drilled in intervals without returns. Intervals varied from 300 - 800 feet and were dependent on hole stability. Water was used as the drilling fluid and when additional cleaning was required, 100 bbl sweeps of high viscosity bentonite mud was circulated in the hole. Cementing was accomplished using neat cement mixed with loss circulation material ("LCM" generally cotton seed hulls, wood fiber, crushed nut hulls and shreaded paper and plastic) which was pumped into the hole thru open ended drill rods positioned near the bottom of the hole. The cement was staged in batches of approximately 100 cubic feet each and the drill rods raised 120 feet prior to pumping additional cement.

Table 3
SOH-2 Open Hole Cementing

Depth (ft)	Cement Volume	Top Of Cement
390	172 sx	168
704	150 sx	368
1,017	175 sx	500
1,871	1,100 sx	N/A

Drilling progressed from 202 - 1,871 feet in subaerial basalt flows, interflow zones and intrusives to 1,680 feet and submarine flows and intrusives from 1,680 to 1,871 feet. The rock was generally hard, abrasive and fractured with some minor open cavities. No fluid returns occurred above 1,000 feet and the static fluid level in the hole remained at or above sea level (270 feet G.L.).

At a depth of 331 feet, the drilling assembly was tripped out and drill rods were run in the hole with a 134 mm core bit. A 1.5 inch x 40 foot bailer attached to a 3/8 inch wireline was used to bail the hole for 3.5 hours to obtain water samples for analysis. Design of the bailer prohibited it from dropping below a landing ring on the bit, eliminating the risk of a fishing job in the event of a wireline failure. Fluid level in the hole remained at approximately 270 feet during the bailing operation. Fluid sample turbidity decreased rapidly during the bailing operation indicating active fluid movement across the bore hole.

The program of drilling ahead blind and cementing back was successful until an unstable fractured zone at 1,688 to

1,733 feet was encountered on February 25. A total loss of drilling fluids occurred at 1,688 feet. Static fluid level in the hole, however, remained at 270 feet. Penetrating this interval required several redrills but the formation was solid and stable below 1,733 feet. At a depth of 1,871 feet cave from the previous fractured interval briefly stuck the drilling rods. Several unsuccessful attempts were made to stabilize the hole with high viscosity mud sweeps prior to tripping out of the hole.

The drilling assembly was removed and open ended drill rods tripped in the hole to 1,810 feet. A 175 sack cement plug mixed with 10 sacks of LCM was set and the top tagged at 1,650 feet. The rotary drilling assembly was tripped in but encountered only a five foot thick cement bridge. Eight additional cement plugs were set in attempts to seal off this zone. In addition to 1,100 sacks of cement, 53 sacks of LCM (Multiseal, cotton seed hulls and walnut hulls), 70 bags of 1 inch bentonite gravel and 268 paper bags (empty bentonite sacks) were pumped into this zone with little effect. However, the cementing did stabilize the zone so drilling could continue.

The drilling fluid system was changed over from water to bentonite/polymer mud and the hole was advanced to 1,901 feet without returns. At 1,901 feet the pin on the #2 drill collar sheared. The remaining drilling assembly was fished out and drilling was suspended so geophysical logs could be run in the open hole.

On March 6, U.S. Geological Survey personnel assisted by University of Hawaii personnel ran temperature, spinner, gamma, caliper and televiewer surveys in the hole. A maximum temperature of 85 F was recorded at TD and the caliper log revealed that cementing and redrilling had left the hole in excellent condition.

Drilling resumed on the evening of March 6 and the pin on the #3 collar sheared after advancing the hole 3 feet to a depth of 1,904 feet. The drilling assembly was fished out and a magnetic flux inspection was run on all remaining collars. Drilling resumed and a third collar separation occurred after advancing the hole from 1,904 to 1,907 feet. The drilling assembly was successfully fished out and it was determined that a dogleg (sudden change in hole angle and/or direction) had developed in the hole and was causing collar failures. On each fishing job, the drilling assembly was sitting free on bottom and picked up with very little drag, indicating a stable hole with only minor fill.

Open ended drill rods were run to TD and a 100 sack cement plug with 3% CaCl was set. No cement was located when the wireline was run to TD. A second 100 sack cement plug with 6 bags of LCM and 3% CaCl was set and cement was tagged at 1,870 feet. The cement was drilled out to 1,900 feet and a deviation survey was run using a Sperry-Sun single shot camera.

The deviation survey (Table 4) confirmed a minimum 4 degree dogleg within the 27 foot interval between 1,860 to 1,887 feet. A later survey (Table 8 and Figure 5) conducted with a Eastman Christensen gyroscopic tool confirmed the single-shot survey results. There are several possible causes for the dogleg, but it most likely results from either a high angle dike or fault with a dense foot wall. Either occurrence, with fractured, easily penetrated rock forming the hanging wall and dense competent rock in the foot wall could tend to deflect the rotary drilling assembly.

Seven inch J-55, 23#/foot casing was run to 1,896 feet with a guide shoe, float collar, 2 cement baskets at 1,596 feet and DV (multiple stage cementing) tool at 1,580 feet. Centralizers were positioned at intervals of approximately 120 feet. Cementing was performed by Halliburton Services in two stages followed by 4 top jobs as follows:

First Stage. Pump 10 bbls Super Flush solution, 5 bbl water spacer and 84 cubic feet of cement w/ 40% SiO_2 and 3% CFR. Release plug, displace with water and bump float collar. Release opening plug, open DV tool with 1,200 psi and circulate 30 bbl water.

Second Stage. Pump 10 bbl Super Flush, 3 bbl water spacer and 264 cubic feet of spherulite cement with 40% SiO_2 and 3% CFR (15.4#/gal). Release closing plug and set with 1,000 psi. No returns to surface, but pump pressure increased to 600 psi indicating cement moving up annulus above DV tool. Wait on cement 4 hours.

Top Job #1. Pump 70 cubic feet of spherulite cement with 40% SiO_2 and 3% CFR. Wait on cement 8 hours.

Top Job #2. Pump 97 cubic feet of spherulite cement with 40% SiO_2, 3% CFR and 3% CaCl. Wait on cement 6 hours.

Top Job #3. Pump 97 cubic feet of spherulite cement with 40% SiO_2, 3% CFR and 3% CaCl. Wait on cement 4 hours.

Top Job #4. Pump 78 cubic feet of spherulite cement with 40% SiO_2, 3% CFR and 3% CaCl and bring cement to surface.

BOP equipment (Figure 2) was nippled up and consisted of a 7 inch EFSO wellhead with two 2 inch flanged outlets, a 6 inch 3M drilling valve, 9 inch Type B double gate preventor with pipe and blind rams and a high speed rotating head. Two inch 3M gate valves were attached to flanged outlets on the wellhead, one served as a flow line and the other was connected to a mud pump as a kill line. The equipment was pressure tested to 600 psi for 30 minutes.

Core Drilling 1,909 - 2,044 Feet

Although no increase in bottom hole temperatures had been encountered at this point, an attempt was made to obtain core samples below the 7 inch casing. A 5-5/8 inch rotary bit was used to drill out the DV tool, float collar, guide shoe and cement. Drilling fluids were lost at the bottom of the cemented hole (1,907 feet). The hole was advanced to 1,909 feet and the rotary drilling assembly removed. A temporary casing sleeve of 134 mm core drilling rods was run in the hole and a HQ core drilling assembly made up.

Using a bentonite/polymer drilling fluid the hole was advanced from 1,909 to 2,044 feet over a period of 4 days with no drilling fluid returns. Coring was accomplished using a HQWL bit which drilled a 3.83 inch hole and produced 2.5 inch core. Drilling was slow, core runs averaged 3 feet, core recovery averaged only 60 percent and bit footage was as low as 13 feet (Table 5). Rock type consisted of dense, abrasive and pervasively fractured intrusives and submarine volcanics. Conditions were similar to those encountered in the submarine volcanic section above 5,000 feet in SOH-1.

On March 21, the temporary casing sleeve was removed from the hole and a 5-7/8 inch rotary drilling assembly was run in the hole.

Rotary Drilling 2,044 - 2,784 Feet

The HQ core hole was opened to 5-7/8 inches from 1,909 - 2,044 feet and the hole advanced to a depth of 2,047 feet without drilling fluid returns. To stabilize this section of the hole a 65 sack neat cement plug with 2% CaCl was set from 1,888 - 2,047 feet. Fluid returns were lost at 1,919 feet, while drilling out cement, and were intermittent to 2,045 feet. Below 2,045 feet there was a total loss of drilling fluids with static fluid level in the hole remaining at 270 feet. Rotary drilling continued to a depth of 2,785 feet with no increase in measured bottom hole temperatures.

Core Drilling 2,784 - 2,830 Feet

At 2,784 feet the rotary drilling assembly was removed and a temporary casing sleeve of 134 mm drill rods was run in the hole. The hole was core drilled from 2,784 to 2,830 feet with HQWL and nearly full drilling fluid returns using a bentonite/polymer drilling fluid. The formation consisted of fractured submarine volcanics, intrusives and sandy clay. As in the previous coring attempt, runs were short (2.8 feet average) but core recovery was nearly 99% due to the clay and clay filled fractures (Table 5). After recovering 45 feet of core the casing sleeve was removed and rotary drilling resumed.

Rotary Drilling 2,830 - 4,108 Feet

Rotary drilling resumed at 2,830 feet using a 5-7/8 inch bit. There were no return drilling fluids, however, the fluid level remained near the surface while pumping and the static fluid level remained constant at 270 feet. A low viscosity (37 - 40 seconds) bentonite/polymer drilling fluid was used and higher viscosity (55 - 60 seconds) sweeps of the hole were made when torque or sticking became a problem. Drilling continued without returns from 2,830 to 3,700 feet. Below 3,700 feet fluid returns gradually increased to 70 percent. The first noticeable increase in bottom hole temperature occurred at 3,848 feet where a temperature of 104 F was recorded (Table 6 and Figure 3).

While cleaning the hole at 4,103 feet the 134 mm drill rods separated with the rotary bit 10 feet off bottom. Separation occurred at the dog leg which had been identified at approximately 1,880 feet. The remaining drilling rods and drilling assembly were recovered and the undamaged bit was rerun.

On reentering the hole, fill was encountered at 4,063 feet. The interval from 4,063 to 4,073 feet was washed thru several times with considerable volumes of fine sand being washed from the hole. Each time the bit would pass below 4,073 feet the formation would squeeze in around the drill rods.

The drill rods were tripped out and a mixed casing string (Table 7) was run to TD. Below 4,073 feet an attempt was made to circulate and wash in the casing. Each time the casing dropped below this depth, pump pressure increased to 900 psi and circulation could not be maintained. With the pumps off, however, the casing string was lowered thru this zone to TD without difficulty. The casing string consisted of:

0 - 1,794 ft: CHD-134mm drill rod (5"), 14.34#/ft
1,794 - 3,722 ft: 4-1/2" 10.5#/ft, J-55 BT&C
3,722 - 4,104 ft: 5" 15#/ft, K-55 left hand flush joint

HQ Core Drilling 4,108 - 4,988 Feet

The casing was cleaned out with a 3-15/16 inch tricone bit and core drilling resumed with a HQWL bit (3.83" hole x 2.50" core). Drilling progressed with near total drilling fluid returns, runs in excess of 9 feet and nearly 100 percent core recovery in submarine volcanics and intrusives (Table 5 & Figure 11). The bottom hole temperature at 4,152 feet was 206 F. From 4,152 to 5,000 feet measured bottom hole temperatures increased at a rate of over 24 F/100 ft.

Although the HQ core drill rods are smaller, thinner walled and much more flexible than the 134 mm drill rods the dog leg at 1,880 feet continued to be a source of problems. Due to the severity of the bend it was necessary to pump down the 10 foot long inner tube after retrieving core. Under normal conditions the tube is allowed to free fall into position thru the fluid filled drill rods.

A more serious problem resulted from drill rod separation which occurred when threaded pins sheared while being rotated past the dogleg. The first separation occurred while drilling at a depth of 4,262 feet. Three more occurred between 4,622 and 4,739 feet. A mixed string of stronger CHD-101 mm drill rods was run at the dog leg and bit weight was increased to minimize rod tension, but only temporary improvement was achieved. Three more rod separations occurred while advancing the hole from 4,888 to 4,988 feet. All seven rod separations occurred in the immediate area of the dogleg. The hole was maintained in good condition and all drilling equipment was recovered from the hole without incident.

On April 28, an HQ coring sleeve was run to 4,988 feet in preparation to core drill with smaller, lighter and more flexible NQ equipment. The upper 2,200 feet of the HQ casing was hung in tension to minimize the curvature around the dog leg.

NQ Core Drilling 4,988 - 6,802 Feet

NQ core drilling commenced on April 29, with full drilling fluid returns and nearly 100 percent core recovery (Table 5). Fluid returns gradually declined below 5,200 feet and dropped to 70 percent by 5,300 feet. From 5,300 to 6,300 feet the drilling fluid returns remained at 60 - 70 percent and then increased to approximately 80 percent from 6,300 to 6,550 feet.

Although the permitted depth of SOH-2 was 6,500 feet, a request to deepen the hole to a maximum depth of 7,000 feet was made to the Department of Land and Natural Resources. The decision to deepen SOH-2 was based on the occurence of commercially viable temperatures and steady drilling progress. At 4:30 PM on May 24, with the hole at a depth of 6,491 feet, verbal approval was received and drilling continued.

At a depth of 6,583 feet a mislatch of the inner tube required tripping out of the hole to retrieve a 9 foot section of core. Although the bit had cored 821 feet, it was in excellent condition and was rerun to complete the hole. Less than six inches of fill was encountered in the hole while tripping back in.

At approximately 6,700 feet, a decrease in drilling fluid returns was noted. By 6,750 feet, fluid returns stabilized at about 50 percent. At 1 AM on May 28 the hole was completed at a depth of 6,802 feet (G.L.). The final bottom hole temperature recorded was 634 F at 6,752 feet. The NQ bit used to complete the hole had cored 1,040 feet and was still in excellent condition when removed.

Completion

The NQ drill rods were tripped out and stood back in 40 foot lengths. Next the HQ drill rods used as a temporary casing sleeve were removed and laid down in doubles (20 foot lengths). The HQ rods had separated at 4,182 feet and the bottom section moved 10 feet further down the hole. A mechanical cutter was run in on NQ drill rods and the HQ rods were cut at 4,762 feet. The upper HQ rods were retrieved with a Bowen spear and laid down in doubles. The HQ rods from 4,762 to 4,998 feet were left in the hole to case off sandy, unstable sections in this interval.

NQ tubing (5.2 lb/ft, 2-3/4" O.D. x 2-3/8" I.D.) was run and set on bottom. The tubing was slotted from 4,127 to 6,800 feet (Figure 12). After running the NQ tubing, water was injected into the hole at a rate of 10 gpm thru the kill line. Next the wellhead equipment was removed and the 134 mm casing sleeve removed and laid down in singles. A 2-7/8" EUE by NQ crossover was made up to the tubing hanger and the tubing tensioned in the wellhead. The double gate BOP was reinstalled and preparations were made for logging. At all times while BOP equipment was removed from the wellhead, cold water was injected into the hole thru the kill line at the rate of 10 gpm.

After running temperature and directional surveys in the hole on June 2, BQ drill rods (2-3/16" O.D.) were tripped inside the tubing to bottom and the hole was flushed out in 500 foot stages with fresh water. At a pump rate of 50 gpm, all fluid was lost to the formation. After tripping the BQ drill rods out, an injection rate of 10 gpm was maintained in the hole thru the kill line and the BOP equipment removed. The completion wellhead was installed (Figure 4) with a 2-9/16 inch 3M top valve and two 2-1/16 inch 3M wing valves. All valves have T-24 trim.

Rigging down began on June 3, and continued to June 6. Equipment was moved to the HGP-A site for a workover project and the remainder stored at the SOH-1 site. A series of downhole temperature/pressure surveys and injection tests were conducted from June 7 - 9. Temperature and pressure surveys were conducted by Pruett Industries, Halliburton Services provided a pump unit for injection testing and the testing procedures were designed and supervised by Geothermex Inc. University of Hawaii and SOH personnel provided assistance.

Directional Survey

On June 2, a U.S. Geological Survey logging truck was used to run a directional survey with a Eastman-Christensen "Seeker" gyroscopic instrument. Although the assembly was enclosed in a heat shield, internal heat in the gyroscopic unit began increasing below 4,500 feet. At a depth of 5,400 feet the Eastman-Christensen engineer elected to terminate the survey before thermal damage to the instrument occured.

Results of the survey (Table 8, and Figure 5) agree closely with an earlier survey of the upper 1,900 feet which was run with a Sperry-Sun single shot instrument. The March 3 single shot survey (Table 4) defined a dogleg between a depth of 1,860 to 1,887 feet. The hole is near vertical to 1,000 feet, with drift angle slowly building to about 5 degrees by 1,800 feet. With the 100 foot station spacing on the gyroscopic survey the dogleg at about 1,870 feet is not precisely located but is defined by an increase in angle from 5 degrees at 1,800 feet to 10 degrees at 1,900 feet. This is accompanied by a 30 degree change in drift direction with the hole tracking almost due south. As expected, drift angle decreased steadily below the dogleg to less than 2 degrees by 4,500 feet and only 1 degree at 5,400 feet.

Bottom hole location of the hole at 6,802 feet was projected from the last reading at 5,400 feet to be approximately 270 feet south and 41 feet east of the well head. The extrapolation of the bottom hole location of SOH-2 is most likely very accurate. A core drilled hole will not deviate radically unless extreme formation conditions force the bit from its course. Throughout this interval drilling progress was smooth and consistent, with no evidence of conditions which might tend to deflect the bit.

The process of core drilling tends to produce a bore hole free of severe changes in angle or direction for two basic reasons:

a. Low bit weight - Drill rods being in a state of tension rather than compression result in the natural tendency of the bit to cut in the vertical direction.

b.Rod diameter vs. hole size - Core drilling rod diameters are only a fraction of an inch smaller than the hole being cut. This results in an annular space of 0.10 to 0.15 inches which prevents the drill rods from flexing and driving the bit from its established course except in extreme drilling conditions.

Should any rapid change in hole drift occur, it becomes readily apparent to the driller due to increased rod torque while rotating, drag when pulling rods and in extreme cases, problems lowering the empty inner tube. These conditions all occured while working around the dogleg at 1,870 feet. No indications were evident to suggest a similar situation occurred during the core drilling operations. It is likely that if the upper 2,000 feet of SOH-2 had been core drilled and the pilot hole then opened, as was done at SOH-1 and SOH-4, the dogleg at 1,870 feet would been prevented.

NOISE MITIGATION

Noise generated by round-the-clock drilling operations was a primary concern expressed by County of Hawaii officials. County restrictions accompanying the drilling permit limit noise levels at the nearest residence to a maximum of 55 dBA during daylight hours and 45 dBA at night (7 PM - 7 AM). These noise levels were not exceeded at any of the three SOH sites during 18 months of drilling. Complaints, however, were often filed simply because a resident could hear sounds generated at the drill site regardless of measured noise levels.

A program of noise level monitoring was continued throughout the SOH project. At SOH-2, monitoring stations were maintained at the drill site and at the two nearest residences. The monitoring stations were designed by Ron Darby and Associates of Honolulu and serviced by an independent contractor from Hilo. Strip chart recorders provided a continuous and permanent record of noise levels.

The drilling rig and ancillary equipment are extremely quiet, noise levels were generally less than 60 - 65 dBA at the drill site. With certain meteorological conditions, noise originating at the SOH site is audible at considerable distances from the source. On some occasions, even voices of crew members could be heard over the machinery noise at distances of over 1,500 feet. Although it is not possible for drilling operations to be completely inaudible, one of the SOH project's target goals was to eliminate as much "nuisance level" noise as possible even though county guidelines were already being met.

Prior to beginning the project the drilling contractor, working with an acoustical consultant (Ron Darby and Associates), made extensive modifications and additions to the equipment. These equipment alterations reduced noise levels to within Hawaii County specified limits during most operations. From the initiation of the SOH project in December 1989, an ongoing effort was made to further minimize sources of noise as they were identified. This effort was undertaken by Tonto and SOH personnel. Technical advice was provided by the acoustical consultant. Some of the measures taken included:

a. Completely surrounding the main power plant, a 410 HP General Motors diesel unit, with a sound dampening enclosure.

b. Constructing sound absorbing duct work over air intake and discharge areas around the engine compartment. The ducts were designed to both absorb sound and direct it upward away from residences.

c. Modification of ancillary equipment normally powered by small gas or diesel engines. These are now driven by hydraulic motors, powered by the drilling rigs hydraulic system.

d. Installing a 5 x 7 duplex mud pump and diesel power unit in a 20 foot sound insulated shipping container.

e. Enclosing the main hydraulic hoist assembly at the top of the mast with sound dampening panels.

f. Erecting sound dampening panels around the front of the drill rig and adjacent to other sources of noise. Panels were moveable so each site could be custom fitted.

g. Installation of large "hospital type" mufflers on the rig engine.

h. Enclosing the substructure with sound dampening panels.

i. Lining pipe rack slides with plywood to dampen noise as rods and casing are lifted to the rig floor.

j. Enclosing the rig floor with heavy wind walls and doors.

k. Locating each drill site as distant from existing residences as practical within selected target areas, and positioning equipment to minimize noise directed at residences.

l. Running equipment at lower speeds during night time operations to reduce noise levels.

m. Suspension of night time operations when work involves excessive noise such as cementing operations.

n. An acoustical survey was conducted at each location and adjustments were made to address the unique conditions encountered at each site.

BOTTOM HOLE TEMPERATURE MEASUREMENTS

Bottom hole temperatures ("BHT's") were obtained on a regular basis by lowering a maximum reading thermometer ("MRT") in a pressure tight container attached to the inner tube overshot. When recovering core, the overshot was lowered on a wireline until it latched onto a ten foot long innertube containing the core. On BHT runs, the overshot was left in position for 5 minutes before retrieving the innertube. This procedure provided temperature measurements 10 - 15 feet off bottom and 20 - 40 minutes after pumping was halted. The precise time and distance from bottom varied depending on hole depth and distance the bit was lifted off bottom prior to making a recovery run.

Core drilling presents a unique set of circumstances when drilling in a geothermal environment. The low pump rates (10 - 20 gpm), and small annular space (less than 0.15 inch) and thousands of feet of thin walled drill rods creat an excellent heat exchanger. Even when formation temperatures, and possibly downhole circulating mud temperatures, exceed 600 degrees F, drilling mud discharge temperatures remained nearly unchanged.

While surface mud discharge temperatures do not reflect elevated formation temperatures, bottom hole temperatures which occur minutes after circulating pumps are shut down are usually near equilibrated formation temperatures. The exception to this occurs when drilling fluids migrate outward from the bore hole in the vicinity of the measurement. When this occurs, BHT measurements may be depressed depending on the volume of fluids lost and geometry of the fluid migration.

Drilling in the three SOH holes indicates that within areas of elevated formation temperature along the East Rift Zone, permeability is limited and restricted to isolated fracture zones. Most of the fractured intervals encountered in the higher temperature sections of the SOH's appear to have low permeability. This situation prohibits the movement of drilling fluids outward from the bore hole and results in reasonably accurate measurements of formation temperatures.

Fluid migration is apparently the cause of the discrepency between the BHTs and the June 6 temperature survey above 5,0 5,000 feet (Table 6 and Figure 3), and possibly the difference noted near TD. Drilling fluid losses were noted in both intervals. Although injection testing did identify a permeable zone from 4,200 - 4,900 feet, no permeability was evident deeper in the hole. The fluid loss noted while drilling and the depressed BHT's may have resulted from either the limited nature of the permeable zone or the plugging of fractures by cuttings from drilling and hole completion activities.

SOH PROJECT REVIEW

The SOH project broke new ground by drilling deep core holes into an active basaltic rift zone in a region where no core drilling had previousely been attempted. The 6,802 foot SOH-2 is the deepest and hottest geothermal core hole ever drilled, with a maximum temperature of 661 F recorded at 6,782 feet.

The SOH project was undertaken to provide an additional dimension to the exploration and understanding of Hawaii's geothermal resource and the geologic history of the Hawaiian volcanoes. The holes were not designed to be used for production purposes, or flow testing. Fluid or gas discharges from the holes were specifically prohibited in project permits. The holes do, however, provide information on the geology, temperature, permeability and drilling conditions above and within the geothermal reservoir. The collection of 15,000 feet of core for current and future study is a unique and valuable contribution to the process of understanding and properly developing Hawaii's geothermal resource. The holes will also provide long term service as monitoring sites to help determine the regional effect of commercial geothermal development on the resource.

Evolution of the Drilling Program

The original drilling program for SOH was intended to be as flexable as possible due to the lack of any previous core drilling in this environment. Since the holes were to be drilled to a maximum depth of 4,000 feet and were not to be flowed, casing was kept to a minimum and designed for blow out control only. A short conductor would be cemented to 100 feet and light weight 4 to 7 inch casing set to a maximum depth of 2,000 feet. The entire hole would be core drilled and intervals to be cased opened to a maximum diameter of 8-1/2 inches.

This is similar in design to many geothermal core holes drilled on the mainland, although mainland regulations generally require casing to be set to only ten percent of the holes planned depth. If any indication of abnormal temperatures was encountered above 2,000 feet, drilling would be halted and 7 inch casing would be cemented in place. Drilling would then continue and 4-1/2 inch casing could be cemented to approximately 2,000 feet if necessary.

As the permitting process for the first hole, SOH-4, progressed local and state regulators, citizens, geothermal developer representatives and other parties became involved in the specifics of designing the casing plan. The end result was a plan calling for multiple strings of heavy, large diameter casing in the upper 2,000 feet of SOH-4 (Figure 6). Although never intended to produce fluids, the upper portion of SOH-4 was designed along the lines of a production well.

To state that SOH-4 was hampered by unreasonable requirements for large, multiple strings of casing in the upper 2,000 feet is an understatement. The drill crew, while very experienced in core drilling and small diameter rotary drilling, had never seen, let alone drilled with 17-1/2 inch equipment. A large diameter hole on a core drilling operation is typically 6 - 7 inches. The final requirements for SOH-4 specified 200 feet of 17-1/2 inch hole with 13-3/8 inch 61 lb/ft casing, 1,000 feet of 9-5/8 inch 40 lb/ft casing and 2,000 feet of 7 inch 35 lb/ft casing. While these may not present a problem for a production rotary drill rig, the Universal 5000 core rig, which is one of the largest core drilling rigs ever built, has only 10 - 15 percent of the horsepower, torque and lifting capacity of a production drill rig. The 7 inch casing string, for example, had a hanging weight of 70,000 pounds, which left a very small operating margin considering the 88,000 pound rating on the rigs main hoist. It's a credit to the Tonto drilling crew that they were able to safely and successfully complete that portion of SOH-4.

SOH-4 was drilled to a total depth of 6,562 feet in 151 days at a direct drilling and testing cost of $1,466,813 (Table 10 & Figure 7). As a result of the over engineered casing plan, approximately $250,000 in additional costs were incurred. The upper 2,000 feet of SOH-4 cost $794,900 while the lower 4,562 feet of core drilled hole cost $532,267.

The second hole was SOH-1 which was drilled to a total depth of 5,526 feet in 217 days at a direct drilling and testing cost of $1,643,544 (Table 10 & Figure 8). For SOH-1, the casing plan was modified, with the casing requirements reduced to 200 feet of 9-5/8 inch and 2,000 feet of 7 inch casing. Again, the hole was core drilled from surface to TD. The upper 2,000 feet of SOH-1 was completed at a cost of $537,000. While performance in the upper portion of the hole showed substantial improvement, the core drilling from 2,000 to 5,526 feet required 156 days at a cost of over $1,000,000.

Unlike SOH-4, which had a 5,554 foot thick section of subaerial volcanics, the subaerial section at SOH-1 was only 2,551 feet thick (Table 1). As discussed previously, the subaerial volcanics in SOH-1 and SOH-4 presented no exceptional problems in core drilling. Submarine volcanics, sediments and intrusives, however, which have not undergone extensive thermal alteration proved to be extremely difficult to core drill. The broken and abrassive nature of the formation resulted in short bit life, poor recovery and short core runs which slowed progress to a few feet per day. Bottom hole temperatures began increasing below a depth of 4,500 feet and by 4,900 feet conditions for core drilling were similar to those encountered in SOH-4.

With the experience gained in SOH-1 and SOH-4 the drilling plan was modified for the third hole, SOH-2. Core drilling in the upper 2,000 feet was omitted to reduce drilling costs by approximately $100,000. The casing program resembled SOH-1 except a lighter 7 inch casing was used (23 lb/ft vs. 35 lb/ft). Additionally, extra drill collars and a larger mud pump were used while rotary drilling. Core drilling below 2,000 feet was only undertaken to obtain sample core, or when conditions permitted efficient core drilling. A removeable casing sleeve was used while coring. Cementing sections of casing below 2,000 feet, as was done in SOH-1, was avoided. This permited the removal of the casing sleeve and resumption of rotary drilling as required.

With the exception of the dogleg at 1,880 feet and problems related to it, SOH-2 progressed quite well, being completed to 6,802 feet in 126 days at a direct drilling and testing cost of $1,108,935 (Figures 9 & 10, Tables 10 & 11). Since coring the upper 2,000 feet would have likely eliminated the dogleg and prevented approximately $200,000 in delays, reduced drilling performance, fishing costs and material losses, the elimination of coring from this section resulted in an estimated net additional cost of $100,000. On future SOH type holes, consideration should be given to core drilling and opening the upper cased intervals. This will insure a straight hole and, in addition, provide valuable core for the geoscientists.

Expenditures directly related to drilling activities totaled $997,000. Testing, logging and completion brought the total to slightly over 1.1 million dollars on SOH-2. This amounts to $147/foot for the drilling and $163/foot completed. SOH-1 and SOH-4 by contrast had costs of $297 and $223 per completed foot respectively. Based on experience gained in the drilling of the first three SOHs a realistic goal for future holes of this type, completed to 6,500 feet, should be in the range of $145 - $150/foot.

As discussed previousely, the primary considerations relate to the thickness of the subaerial volcanic section and depth to the top of the zone of thermal alteration and secondary mineralization in the submarine volcanic section. Although conditions for core drilling vary from site to site, there are a number of generalities which seem to remain constant within the three environments.

1. Subaerial volcanics can be efficiently core drilled and opened to larger diameters by rotary drilling methods or rotary drilled in a single pass. Maintaining circulation in this section is neither necessary nor cost effective and conventional LCM has little effect. Setting cement plugs and redrilling problem intervals will maintain hole stability and help insure a proper casing cement job.

2. Submarine volcanics above the zone of thermal alteration are extremely difficult to core drill. Core drilling in this environment is neither time nor cost effective. Rotary drilling in this section, however, does not pose any significant difficulties except for loss of drilling fluids and some hole stability problems. Again, cement is the most effective remedy.

3. Submarine volcanics which exhibit extensive thermal alteration can be core or rotary drilled efficiently. Experience to date indicates that thermal alteration greatly reduces permeability and prevents the cooling effect of the shallow ground water system. This in turn provides a system of conductive heat flow within which may occur isolated fractures or fracture zones.

With minor changes in equipment, future SOH drilling could be modified in a manner which would permit limited flow testing. Although there is no substitution for large diameter production wells for long term flow testing in a proven geothermal field, they are not always practical during the initial exploratory phases of geothermal development. Production size wells are major undertakings which require significant parcels of land, improved roads, consume large volumes of water, generate considerable noise, are high profile and may cause considerable community disruption.

The SOH project by contrast has proven that deep, high temperature drilling in adverse conditions can be successfully accomplished using relatively small equipment, at a reasonable cost and with a minimal impact on the environment and local community.

Tables & Figures

Table 1

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Table 2
SOH-2 Drilling Summary

Dates	Day #	Activity
1/25 - 1/31	N/A	Grub & grade site, pour concrete pads, top coat site w/ cinder & install sump liner.
1/29 - 2/3	N/A	Mob equipment to site and rig up.
2/3 - 2/8	1 - 6	Drill 12-1/4" hole 0 - 202 feet.
2/8 - 2/10	6 - 9	Run & cement 9-5/8" casing. Nipple up and test BOP equipment.
2/10 - 3/11	9 - 37	Rotary drill 8-1/2" hole 202 - 1,907 feet.
3/11 - 3/14	37 - 40	Run and cement 7" casing. Nipple up and test BOP equipment.
3/14 - 3/17	40 - 43	Drill out cement, set temp. casing sleeve, rig up for core drilling.
3/17 - 3/20	43 - 46	Core HQ 1,907 - 2,044 feet, rig down core drilling equipment.
3/20 - 3/27	46 - 53	Rotary drill 5-7/8" hole 2,044 - 2,785 feet, POH, run temp. casing sleeve.
3/27 - 3/29	53 - 55	Core HQ 2,785 - 2,830 feet, rig down core drilling equipment.
3/29 - 4/10	55 - 67	Rotary drill 5-7/8" hole 2,830 - 4,103 feet.
4/10 - 4/12	67 - 69	Run 4-1/2" casing, clean out csg w/ rotary bit, rig up for core drilling.
4/12 - 4/27	69 - 84	Core HQ 4,103 - 4,988 feet.
4/27 - 5/28	84 - 115	Set HQ casing to 4,988 feet, core NQ 4,988 - 6,802 feet, TD hole.
5/28 - 6/2	115 - 120	Lay down drill rods, run temp & dev survey, remove temporary casing, run tubing, flush hole & install completion well head.
6/2 - 6/8	120 - 126	Rig down and move equipment, run injection test and temperature and pressure surveys.

Table 3

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Table 4
SOH-2 Directional Survey - March 12, 1991

Depth	Bearing	Deviation	Depth	Bearing	Deviation
243	N/A	0.0	1,494	S-60-W	3.5
442	N/A	0.0	1,623	S-60-W	4.5
639	N/A	0.0	1,742	S-57-W	5.0
836	S-60-W	0.5	1,781	S-52-W	4.5
1,015	N/A	0.0	1,820	S-48-W	4.0
1,135	S-20-W	1.0	1,840	S-47-W	4.5
1,255	S-45-W	1.5	1,860	S-26-W	4.5
1,375	S-57-W	3.0	1,887	S-02-E	8.5

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
16-Mar	HQ	1,909.0	1,913.0	4.0	1.0	25%	Fractured
16-Mar	HQ	1,913.0	1,916.5	3.5	3.5	100%	
16-Mar	HQ	1,916.5	1,924.0	7.5	7.5	100%	Stuck tube
16-Mar	HQ	1,924.0	1,929.0	5.0	5.0	100%	
17-Mar	HQ	1,929.0	1,937.5	8.5	6.5	76%	
17-Mar	HQ	1,937.5	1,943.0	5.5	5.0	91%	
17-Mar	HQ	1,943.0	1,952.0	9.0	9.0	100%	
17-Mar	HQ	1,952.0	1,962.0	10.0	6.5	65%	
17-Mar	HQ	1,962.0	1,971.0	9.0	2.0	22%	Soft, broken
17-Mar	HQ	1,971.0	1,978.0	7.0	2.5	36%	Soft, broken
17-Mar	HQ	1,978.0	1,984.0	6.0	2.0	33%	Fractured
17-Mar	HQ	1,984.0	1,990.0	6.0	4.0	67%	Fractured
17-Mar	HQ	1,990.0	1,994.0	4.0	4.0	100%	
17-Mar	HQ	1,994.0	1,996.5	2.5	2.0	80%	
17-Mar	HQ	1,996.5	1,998.0	1.5	1.0	67%	Fractured
17-Mar	HQ	1,998.0	1,999.0	1.0	1.0	100%	Vibration
17-Mar	HQ	1,999.0	2,001.0	2.0	1.0	50%	Fractured
18-Mar	HQ	2,001.0	2,003.0	2.0	2.0	100%	Fractured
18-Mar	HQ	2,003.0	2,004.0	1.0	1.0	100%	Fractured
18-Mar	HQ	2,004.0	2,008.5	4.5	1.5	33%	Fractured
18-Mar	HQ	2,008.5	2,017.0	8.5	1.0	12%	Fractured
18-Mar	HQ	2,017.0	2,018.5	1.5	1.0	67%	Fractured
18-Mar	HQ	2,018.5	2,020.0	1.5	1.0	67%	Fractured
18-Mar	HQ	2,020.0	2,021.0	1.0	1.0	100%	Fractured
18-Mar	HQ	2,021.0	2,023.0	2.0	1.0	50%	Fractured, redrill
18-Mar	HQ	2,023.0	2,024.0	1.0	1.0	100%	Fractured, redrill
18-Mar	HQ	2,024.0	2,025.0	1.0	0.0	0%	Fractured, redrill
18-Mar	HQ	2,025.0	2,026.0	1.0	0.0	0%	Fractured, redrill
18-Mar	HQ	2,026.0	2,027.0	1.0	0.0	0%	Fractured, redrill
18-Mar	HQ	2,027.0	2,027.5	0.5	0.0	0%	Fractured, redrill
19-Mar	HQ	2,027.5	2,028.0	0.5	0.0	0%	Frac, sandy, redril
19-Mar	HQ	2,028.0	2,029.5	1.5	0.0	0%	Frac, sandy, redril
19-Mar	HQ	2,029.5	2,030.0	0.5	0.5	100%	Frac, sandy, redril
19-Mar	HQ	2,030.0	2,030.0	0.0	0.0	ERR	Frac, sandy, redril
19-Mar	HQ	2,030.0	2,031.0	1.0	1.0	100%	Frac, sandy, redril
19-Mar	HQ	2,031.0	2,034.0	3.0	1.5	50%	Frac, sandy, redril
19-Mar	HQ	2,034.0	2,036.5	2.5	0.0	0%	Frac, sandy, redril
19-Mar	HQ	2,036.5	2,037.0	0.5	0.0	0%	Frac, sandy, redril
19-Mar	HQ	2,037.0	2,037.5	0.5	0.0	0%	Frac, sandy, redril
19-Mar	HQ	2,037.5	2,038.0	0.5	0.0	0%	Frac, sandy, redril
19-Mar	HQ	2,038.0	2,040.0	2.0	2.0	100%	Frac, sandy, redril
20-Mar	HQ	2,040.0	2,041.5	1.5	0.0	0%	Frac, sandy, redril
20-Mar	HQ	2,041.5	2,042.5	1.0	2.0	200%	Frac, sandy, redril
20-Mar	HQ	2,042.5	2,043.5	1.0	1.0	100%	Frac, sandy, redril

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
20-Mar	HQ	2,043.5	2,044.0	0.5	0.0	0%	Suspend coring
27-Mar	HQ	2,784.5	2,785.0	0.5	0.5	100%	
28-Mar	HQ	2,785.0	2,788.0	3.0	3.0	100%	
28-Mar	HQ	2,788.0	2,790.5	2.5	2.5	100%	
28-Mar	HQ	2,790.5	2,793.5	3.0	2.5	83%	
28-Mar	HQ	2,793.5	2,795.5	2.0	2.0	100%	Hard w/ clay seams
28-Mar	HQ	2,795.5	2,799.0	3.5	3.5	100%	
28-Mar	HQ	2,799.0	2,801.0	2.0	2.0	100%	
28-Mar	HQ	2,801.0	2,805.5	4.5	4.5	100%	Frac. w/ clay seams
28-Mar	HQ	2,805.5	2,811.0	5.5	5.5	100%	
28-Mar	HQ	2,811.0	2,813.0	2.0	2.0	100%	
28-Mar	HQ	2,813.0	2,816.5	3.5	3.5	100%	Frac. w/ clay seams
28-Mar	HQ	2,816.5	2,818.0	1.5	1.5	100%	Frac. w/ clay seams
28-Mar	HQ	2,818.0	2,818.0	0.0	0.0	N/A	Ream, squeezing in
28-Mar	HQ	2,818.0	2,819.5	1.5	1.5	100%	High torque
28-Mar	HQ	2,819.5	2,822.5	3.0	3.0	100%	
28-Mar	HQ	2,822.5	2,825.0	2.5	2.5	100%	Frac. w/ clay seams
29-Mar	HQ	2,825.0	2,830.0	5.0	5.0	100%	Unable to maintain open hole, clay squeezing in. Suspend coring.
12-Apr	HQ	4,108.0	4,118.0	10.0	10.0	100%	
12-Apr	HQ	4,118.0	4,127.0	9.0	9.0	100%	
12-Apr	HQ	4,127.0	4,137.0	10.0	7.0	70%	Drop core
12-Apr	HQ	4,137.0	4,144.0	7.0	10.0	143%	Recover core
12-Apr	HQ	4,144.0	4,152.0	8.0	8.0	100%	206 F BHT
13-Apr	HQ	4,152.0	4,157.0	5.0	5.0	100%	
13-Apr	HQ	4,157.0	4,167.0	10.0	10.0	100%	
13-Apr	HQ	4,167.0	4,177.0	10.0	10.0	100%	Minor vib.
13-Apr	HQ	4,177.0	4,187.0	10.0	4.0	40%	Drop core
13-Apr	HQ	4,187.0	4,192.0	5.0	7.0	140%	Recover core
13-Apr	HQ	4,192.0	4,200.0	8.0	10.0	125%	Recover core
13-Apr	HQ	4,200.0	4,205.0	5.0	5.0	100%	206 F BHT
13-Apr	HQ	4,205.0	4,212.0	7.0	3.0	43%	Drop core
14-Apr	HQ	4,212.0	4,218.0	6.0	10.0	167%	Recover core
14-Apr	HQ	4,218.0	4,228.0	10.0	10.0	100%	
14-Apr	HQ	4,228.0	4,238.0	10.0	2.5	25%	Drop core
14-Apr	HQ	4,238.0	4,240.5	2.5	10.0	400%	Recover core
14-Apr	HQ	4,240.5	4,251.5	11.0	10.0	91%	
14-Apr	HQ	4,251.5	4,262.0	10.5	10.0	95%	226 F BHT
14-Apr	HQ	4,262.0	4,264.0	2.0	2.0	100%	Rod break @ 1,880
14-Apr	HQ	4,264.0	4,272.0	8.0	8.0	100%	
15-Apr	HQ	4,272.0	4,282.0	10.0	10.0	100%	

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
15-Apr	HQ	4,282.0	4,291.0	9.0	9.0	100%	
15-Apr	HQ	4,291.0	4,301.0	10.0	10.0	100%	
15-Apr	HQ	4,301.0	4,311.0	10.0	10.0	100%	239 F BHT
15-Apr	HQ	4,311.0	4,322.0	11.0	10.0	91%	
15-Apr	HQ	4,322.0	4,332.0	10.0	10.0	100%	
15-Apr	HQ	4,332.0	4,342.0	10.0	10.0	100%	
15-Apr	HQ	4,342.0	4,352.0	10.0	10.0	100%	232 F BHT
15-Apr	HQ	4,352.0	4,362.0	10.0	10.0	100%	
16-Apr	HQ	4,362.0	4,372.0	10.0	10.0	100%	
16-Apr	HQ	4,372.0	4,382.0	10.0	10.0	100%	
16-Apr	HQ	4,382.0	4,392.0	10.0	10.0	100%	Minor vib.
16-Apr	HQ	4,392.0	4,402.0	10.0	10.0	100%	248 F BHT
16-Apr	HQ	4,402.0	4,412.0	10.0	10.0	100%	
16-Apr	HQ	4,412.0	4,422.0	10.0	10.0	100%	
16-Apr	HQ	4,422.0	4,432.0	10.0	10.0	100%	
16-Apr	HQ	4,432.0	4,442.0	10.0	10.0	100%	
16-Apr	HQ	4,442.0	4,452.0	10.0	10.0	100%	240 F BHT
17-Apr	HQ	4,452.0	4,462.0	10.0	10.0	100%	
17-Apr	HQ	4,462.0	4,472.0	10.0	10.0	100%	
17-Apr	HQ	4,472.0	4,482.0	10.0	10.0	100%	
17-Apr	HQ	4,482.0	4,492.0	10.0	10.0	100%	
17-Apr	HQ	4,492.0	4,502.0	10.0	10.0	100%	270 F BHT
17-Apr	HQ	4,502.0	4,512.0	10.0	10.0	100%	
18-Apr	HQ	4,512.0	4,522.0	10.0	10.0	100%	
18-Apr	HQ	4,522.0	4,532.0	10.0	10.0	100%	
18-Apr	HQ	4,532.0	4,542.0	10.0	10.0	100%	
18-Apr	HQ	4,542.0	4,552.0	10.0	10.0	100%	284 F BHT
18-Apr	HQ	4,552.0	4,562.0	10.0	10.0	100%	
18-Apr	HQ	4,562.0	4,572.0	10.0	10.0	100%	LC zone
19-Apr	HQ	4,572.0	4,582.0	10.0	10.0	100%	
19-Apr	HQ	4,582.0	4,592.0	10.0	10.0	100%	
19-Apr	HQ	4,592.0	4,602.0	10.0	10.0	100%	276 F BHT
19-Apr	HQ	4,602.0	4,612.0	10.0	10.0	100%	
19-Apr	HQ	4,612.0	4,622.0	10.0	10.0	100%	Broke rods @ 1,890
20-Apr	HQ	4,622.0	4,632.0	10.0	10.0	100%	
20-Apr	HQ	4,632.0	4,642.0	10.0	10.0	100%	
20-Apr	HQ	4,642.0	4,652.0	10.0	10.0	100%	
20-Apr	HQ	4,652.0	4,672.0	20.0	10.0	50%	
20-Apr	HQ	4,672.0	4,682.0	10.0	10.0	100%	Broke rods @ 1,870
21-Apr	HQ	4,682.0	4,692.0	10.0	10.0	100%	
21-Apr	HQ	4,692.0	4,702.0	10.0	10.0	100%	
21-Apr	HQ	4,702.0	4,712.0	10.0	10.0	100%	306 F BHT
21-Apr	HQ	4,712.0	4,722.0	10.0	10.0	100%	
21-Apr	HQ	4,722.0	4,729.0	7.0	7.0	100%	

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
21-Apr	HQ	4,729.0	4,739.5	10.5	10.5	100%	Broke rods @ 1,900
22-Apr	HQ	4,739.5	4,749.5	10.0	10.0	100%	Clean hole
22-Apr	HQ	4,749.5	4,759.5	10.0	10.0	100%	332 F BHT
22-Apr	HQ	4,759.5	4,769.5	10.0	10.0	100%	Begin using SB-111
22-Apr	HQ	4,769.5	4,780.0	10.5	10.5	100%	
22-Apr	HQ	4,780.0	4,785.0	5.0	5.0	100%	
22-Apr	HQ	4,785.0	4,795.0	10.0	10.0	100%	
22-Apr	HQ	4,795.0	4,798.0	3.0	3.0	100%	Broken, LC
22-Apr	HQ	4,798.0	4,805.0	7.0	7.0	100%	298 F BHT
22-Apr	HQ	4,805.0	4,815.0	10.0	10.0	100%	
23-Apr	HQ	4,815.0	4,825.0	10.0	10.0	100%	
23-Apr	HQ	4,825.0	4,835.0	10.0	10.0	100%	
23-Apr	HQ	4,835.0	4,845.0	10.0	10.0	100%	
23-Apr	HQ	4,845.0	4,855.0	10.0	10.0	100%	
23-Apr	HQ	4,855.0	4,865.0	10.0	10.0	100%	
23-Apr	HQ	4,865.0	4,875.0	10.0	10.0	100%	
23-Apr	HQ	4,875.0	4,883.0	8.0	8.0	100%	Fractured
23-Apr	HQ	4,883.0	4,888.0	5.0	5.0	100%	Broke rods @ 1,880
24-Apr	HQ	4,888.0	4,891.0	3.0	3.0	100%	
24-Apr	HQ	4,891.0	4,898.0	7.0	7.0	100%	Clean hole, redrill
24-Apr	HQ	4,898.0	4,902.0	4.0	4.0	100%	Clean hole, redrill
24-Apr	HQ	4,902.0	4,909.0	7.0	7.0	100%	
24-Apr	HQ	4,909.0	4,912.0	3.0	3.0	100%	
25-Apr	HQ	4,912.0	4,917.0	5.0	5.0	100%	Fractured
25-Apr	HQ	4,917.0	4,925.0	8.0	8.0	100%	
25-Apr	HQ	4,925.0	4,933.0	8.0	8.0	100%	
25-Apr	HQ	4,933.0	4,940.0	7.0	7.0	100%	320 F MRT
25-Apr	HQ	4,940.0	4,950.0	10.0	10.0	100%	Broke rods @ 1,800
26-Apr	HQ	4,950.0	4,959.0	9.0	9.0	100%	Clean btm 100 ft.
27-Apr	HQ	4,959.0	4,969.0	10.0	10.0	100%	
27-Apr	HQ	4,969.0	4,979.0	10.0	10.0	100%	
27-Apr	HQ	4,979.0	4,988.0	9.0	9.0	100%	Broke rods @ 1,800
27-Apr	NQ	4,988.0	4,991.0	3.0	3.0	100%	Set HQ, reduce
28-Apr	NQ	4,991.0	5,001.0	10.0	10.0	100%	411 F BHT
28-Apr	NQ	5,001.0	5,011.0	10.0	10.0	100%	
28-Apr	NQ	5,011.0	5,021.0	10.0	10.0	100%	
29-Apr	NQ	5,021.0	5,031.0	10.0	10.0	100%	
29-Apr	NQ	5,031.0	5,041.5	10.5	10.5	100%	
29-Apr	NQ	5,041.5	5,051.5	10.0	10.0	100%	400 F BHT
29-Apr	NQ	5,051.5	5,062.0	10.5	10.5	100%	
29-Apr	NQ	5,062.0	5,072.0	10.0	10.0	100%	
29-Apr	NQ	5,072.0	5,082.0	10.0	10.0	100%	
29-Apr	NQ	5,082.0	5,092.0	10.0	10.0	100%	
29-Apr	NQ	5,092.0	5,102.0	10.0	10.0	100%	400 F BHT

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
30-Apr	NQ	5,102.0	5,112.0	10.0	10.0	100%	
30-Apr	NQ	5,112.0	5,122.0	10.0	10.0	100%	
30-Apr	NQ	5,122.0	5,132.0	10.0	10.0	100%	
30-Apr	NQ	5,132.0	5,142.0	10.0	10.0	100%	
30-Apr	NQ	5,142.0	5,150.8	8.8	8.8	100%	414 F BHT
30-Apr	NQ	5,150.8	5,161.0	10.2	10.2	100%	Fractured
30-Apr	NQ	5,161.0	5,171.0	10.0	10.0	100%	
30-Apr	NQ	5,171.0	5,181.0	10.0	10.0	100%	
30-Apr	NQ	5,181.0	5,191.0	10.0	10.0	100%	Vibration
30-Apr	NQ	5,191.0	5,201.5	10.5	10.5	100%	409 F BHT
01-May	NQ	5,201.5	5,211.5	10.0	10.0	100%	
01-May	NQ	5,211.5	5,222.0	10.5	10.5	100%	Fractured
01-May	NQ	5,222.0	5,231.5	9.5	9.5	100%	
01-May	NQ	5,231.5	5,241.5	10.0	10.0	100%	Fractured
01-May	NQ	5,241.5	5,252.0	10.5	10.5	100%	422 F BHT
01-May	NQ	5,252.0	5,262.0	10.0	10.0	100%	
01-May	NQ	5,262.0	5,272.0	10.0	10.0	100%	
02-May	NQ	5,272.0	5,282.0	10.0	10.0	100%	
02-May	NQ	5,282.0	5,292.0	10.0	10.0	100%	
02-May	NQ	5,292.0	5,302.0	10.0	10.0	100%	438 F BHT
02-May	NQ	5,302.0	5,312.0	10.0	10.0	100%	
02-May	NQ	5,312.0	5,322.0	10.0	10.0	100%	
02-May	NQ	5,322.0	5,332.0	10.0	10.0	100%	
02-May	NQ	5,332.0	5,342.0	10.0	10.0	100%	
03-May	NQ	5,342.0	5,352.0	10.0	10.0	100%	434 F BHT
03-May	NQ	5,352.0	5,362.0	10.0	10.0	100%	
03-May	NQ	5,362.0	5,372.0	10.0	10.0	100%	
03-May	NQ	5,372.0	5,382.0	10.0	10.0	100%	
03-May	NQ	5,382.0	5,392.0	10.0	10.0	100%	
03-May	NQ	5,392.0	5,402.0	10.0	10.0	100%	434 F BHT
04-May	NQ	5,402.0	5,407.0	5.0	4.0	80%	Soft & broken
04-May	NQ	5,407.0	5,413.0	6.0	6.0	100%	Soft & broken
04-May	NQ	5,413.0	5,422.0	9.0	9.0	100%	
04-May	NQ	5,422.0	5,432.0	10.0	10.0	100%	
04-May	NQ	5,432.0	5,436.0	4.0	4.0	100%	
04-May	NQ	5,436.0	5,445.0	9.0	9.0	100%	
04-May	NQ	5,445.0	5,455.0	10.0	10.0	100%	442 F BHT
04-May	NQ	5,455.0	5,462.0	7.0	7.0	100%	
05-May	NQ	5,462.0	5,472.0	10.0	10.0	100%	Fractured
05-May	NQ	5,472.0	5,479.0	7.0	7.0	100%	Fractured
05-May	NQ	5,479.0	5,484.0	5.0	5.0	100%	Fractured
05-May	NQ	5,484.0	5,488.5	4.5	4.0	89%	Fractured
05-May	NQ	5,488.5	5,498.5	10.0	10.0	100%	445 F BHT
05-May	NQ	5,498.5	5,509.0	10.5	10.5	100%	

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
05-May	NQ	5,509.0	5,512.0	3.0	3.0	100%	
06-May	NQ	5,512.0	5,522.0	10.0	10.0	100%	
06-May	NQ	5,522.0	5,525.0	3.0	1.5	50%	
06-May	NQ	5,525.0	5,535.0	10.0	10.0	100%	
06-May	NQ	5,535.0	5,545.0	10.0	10.0	100%	
06-May	NQ	5,545.0	5,555.0	10.0	10.0	100%	
06-May	NQ	5,555.0	5,565.0	10.0	10.0	100%	471 F BHT
06-May	NQ	5,565.0	5,575.0	10.0	10.0	100%	
07-May	NQ	5,575.0	5,585.0	10.0	10.0	100%	
07-May	NQ	5,585.0	5,592.0	7.0	7.0	100%	
07-May	NQ	5,592.0	5,602.0	10.0	10.0	100%	468 F BHT
07-May	NQ	5,602.0	5,612.0	10.0	10.0	100%	
07-May	NQ	5,612.0	5,618.0	6.0	6.0	100%	Fractured
07-May	NQ	5,618.0	5,628.0	10.0	10.0	100%	
07-May	NQ	5,628.0	5,638.0	10.0	10.0	100%	
08-May	NQ	5,638.0	5,648.0	10.0	10.0	100%	
08-May	NQ	5,648.0	5,658.0	10.0	4.0	40%	496 F BHT
08-May	NQ	5,658.0	5,662.0	4.0	10.0	250%	
08-May	NQ	5,662.0	5,672.0	10.0	10.0	100%	
08-May	NQ	5,672.0	5,682.0	10.0	10.0	100%	
08-May	NQ	5,682.0	5,692.0	10.0	10.0	100%	
08-May	NQ	5,692.0	5,702.0	10.0	10.0	100%	488 F BHT
09-May	NQ	5,702.0	5,712.0	10.0	10.0	100%	
09-May	NQ	5,712.0	5,722.0	10.0	10.0	100%	Vibration
09-May	NQ	5,722.0	5,732.0	10.0	10.0	100%	
09-May	NQ	5,732.0	5,742.0	10.0	10.0	100%	
09-May	NQ	5,742.0	5,752.0	10.0	10.0	100%	501 F BHT
09-May	NQ	5,752.0	5,752.0	0.0	0.0	N/A	Stuck tube, POH
10-May	NQ	5,752.0	5,762.0	10.0	10.0	100%	39 hrs repairs
12-May	NQ	5,762.0	5,772.0	10.0	10.0	100%	
12-May	NQ	5,772.0	5,782.0	10.0	10.0	100%	
12-May	NQ	5,782.0	5,792.0	10.0	10.0	100%	
12-May	NQ	5,792.0	5,802.0	10.0	10.0	100%	506 F BHT
12-May	NQ	5,802.0	5,812.0	10.0	10.0	100%	
12-May	NQ	5,812.0	5,822.0	10.0	10.0	100%	
12-May	NQ	5,822.0	5,832.0	10.0	10.0	100%	
13-May	NQ	5,832.0	5,842.0	10.0	10.0	100%	
13-May	NQ	5,842.0	5,852.0	10.0	10.0	100%	506 F BHT
13-May	NQ	5,852.0	5,862.0	10.0	10.0	100%	
13-May	NQ	5,862.0	5,872.0	10.0	10.0	100%	
13-May	NQ	5,872.0	5,882.0	10.0	10.0	100%	
13-May	NQ	5,882.0	5,892.0	10.0	10.0	100%	
13-May	NQ	5,892.0	5,902.0	10.0	10.0	100%	510 F BHT
13-May	NQ	5,902.0	5,912.0	10.0	10.0	100%	

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
14-May	NQ	5,912.0	5,922.0	10.0	10.0	100%	
14-May	NQ	5,922.0	5,927.0	5.0	5.0	100%	
14-May	NQ	5,927.0	5,937.0	10.0	10.0	100%	
14-May	NQ	5,937.0	5,944.0	7.0	7.0	100%	
14-May	NQ	5,944.0	5,952.0	8.0	8.0	100%	515 F BHT
14-May	NQ	5,952.0	5,962.0	10.0	10.0	100%	
14-May	NQ	5,962.0	5,972.0	10.0	10.0	100%	
14-May	NQ	5,972.0	5,980.0	8.0	8.0	100%	
15-May	NQ	5,980.0	5,990.0	10.0	10.0	100%	
15-May	NQ	5,990.0	6,000.0	10.0	10.0	100%	527 F BHT
15-May	NQ	6,000.0	6,010.5	10.5	10.5	100%	
15-May	NQ	6,010.5	6,021.0	10.5	10.5	100%	
15-May	NQ	6,021.0	6,031.0	10.0	10.0	100%	
15-May	NQ	6,031.0	6,041.0	10.0	10.0	100%	
16-May	NQ	6,041.0	6,051.0	10.0	10.0	100%	531 F BHT
16-May	NQ	6,051.0	6,061.0	10.0	10.0	100%	
16-May	NQ	6,061.0	6,070.0	9.0	9.0	100%	
16-May	NQ	6,070.0	6,080.0	10.0	10.0	100%	
16-May	NQ	6,080.0	6,090.0	10.0	10.0	100%	
16-May	NQ	6,090.0	6,100.0	10.0	10.0	100%	545 F BHT
16-May	NQ	6,100.0	6,110.0	10.0	10.0	100%	
17-May	NQ	6,110.0	6,120.5	10.5	10.5	100%	
17-May	NQ	6,120.5	6,130.0	9.5	9.5	100%	
17-May	NQ	6,130.0	6,141.0	11.0	10.5	95%	
17-May	NQ	6,141.0	6,151.0	10.0	10.0	100%	558 F BHT
17-May	NQ	6,151.0	6,161.0	10.0	10.0	100%	
17-May	NQ	6,161.0	6,171.0	10.0	10.0	100%	
18-May	NQ	6,171.0	6,181.5	10.5	10.5	100%	
18-May	NQ	6,181.5	6,191.5	10.0	10.0	100%	
18-May	NQ	6,191.5	6,201.5	10.0	10.0	100%	564 F BHT
18-May	NQ	6,201.5	6,212.0	10.5	10.5	100%	
18-May	NQ	6,212.0	6,222.0	10.0	10.0	100%	
18-May	NQ	6,222.0	6,232.0	10.0	10.0	100%	
19-May	NQ	6,232.0	6,242.0	10.0	10.0	100%	
19-May	NQ	6,242.0	6,252.0	10.0	10.0	100%	569 F BHT
19-May	NQ	6,252.0	6,262.0	10.0	10.0	100%	
19-May	NQ	6,262.0	6,272.0	10.0	10.0	100%	
19-May	NQ	6,272.0	6,282.0	10.0	10.0	100%	
19-May	NQ	6,282.0	6,292.0	10.0	10.0	100%	
20-May	NQ	6,292.0	6,302.0	10.0	10.0	100%	578 F BHT
20-May	NQ	6,302.0	6,312.0	10.0	10.0	100%	
20-May	NQ	6,312.0	6,319.5	7.5	7.5	100%	
20-May	NQ	6,319.5	6,329.5	10.0	10.0	100%	
20-May	NQ	6,329.5	6,339.5	10.0	10.0	100%	

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
20-May	NQ	6,339.5	6,349.5	10.0	10.0	100%	585 F BHT
21-May	NQ	6,349.5	6,360.0	10.5	10.5	100%	
21-May	NQ	6,360.0	6,370.0	10.0	10.0	100%	
21-May	NQ	6,370.0	6,380.0	10.0	10.0	100%	
21-May	NQ	6,380.0	6,388.0	8.0	8.0	100%	Broke rods @ 1,880
22-May	NQ	6,388.0	6,398.5	10.5	10.5	100%	
22-May	NQ	6,398.5	6,408.5	10.0	10.0	100%	
22-May	NQ	6,408.5	6,418.5	10.0	10.0	100%	602 F BHT
22-May	NQ	6,418.5	6,428.5	10.0	8.5	85%	Drop core
22-May	NQ	6,428.5	6,436.0	7.5	9.5	127%	Recover core
22-May	NQ	6,436.0	6,446.5	10.5	8.5	81%	Drop core
22-May	NQ	6,446.5	6,455.0	8.5	10.0	118%	Recover core
23-May	NQ	6,455.0	6,462.0	7.0	7.0	100%	608 F BHT
23-May	NQ	6,462.0	6,472.0	10.0	9.5	95%	
23-May	NQ	6,472.0	6,481.0	9.0	9.0	100%	
23-May	NQ	6,481.0	6,491.0	10.0	10.0	100%	
23-May	NQ	6,491.0	6,501.0	10.0	10.0	100%	
23-May	NQ	6,501.0	6,511.0	10.0	10.0	100%	
23-May	NQ	6,511.0	6,521.5	10.5	10.0	95%	610 F BHT
24-May	NQ	6,521.5	6,531.5	10.0	9.5	95%	
24-May	NQ	6,531.5	6,540.0	8.5	9.0	106%	
24-May	NQ	6,540.0	6,545.0	5.0	5.0	100%	
24-May	NQ	6,545.0	6,555.0	10.0	10.0	100%	
24-May	NQ	6,555.0	6,565.0	10.0	10.0	100%	
24-May	NQ	6,565.0	6,574.0	9.0	9.0	100%	
24-May	NQ	6,574.0	6,582.0	8.0	7.0	88%	Mislatch, POH
25-May	NQ	6,582.0	6,592.0	10.0	10.0	100%	
25-May	NQ	6,592.0	6,602.0	10.0	10.0	100%	
25-May	NQ	6,602.0	6,612.0	10.0	10.0	100%	
25-May	NQ	6,612.0	6,622.0	10.0	10.0	100%	
26-May	NQ	6,622.0	6,632.0	10.0	10.0	100%	
26-May	NQ	6,632.0	6,642.0	10.0	10.0	100%	
26-May	NQ	6,642.0	6,652.0	10.0	10.0	100%	
26-May	NQ	6,652.0	6,662.0	10.0	10.0	100%	
26-May	NQ	6,662.0	6,672.0	10.0	10.0	100%	626 F BHT
26-May	NQ	6,672.0	6,682.0	10.0	10.0	100%	
26-May	NQ	6,682.0	6,692.0	10.0	10.0	100%	
26-May	NQ	6,692.0	6,702.0	10.0	10.0	100%	
27-May	NQ	6,702.0	6,712.0	10.0	10.0	100%	
27-May	NQ	6,712.0	6,719.0	7.0	7.0	100%	
27-May	NQ	6,719.0	6,723.0	4.0	4.0	100%	
27-May	NQ	6,723.0	6,725.5	2.5	2.5	100%	
27-May	NQ	6,725.5	6,732.0	6.5	6.5	100%	
27-May	NQ	6,732.0	6,742.0	10.0	10.0	100%	

Table 5

SOH-2
Coring Performance

Date	Core Size	Run Start	Run End	Cored	Recover	Percent Recovery	Comments
27-May	NQ	6,742.0	6,752.0	10.0	10.0	100%	634 F BHT
28-May	NQ	6,752.0	6,762.0	10.0	10.0	100%	
28-May	NQ	6,762.0	6,772.0	10.0	10.0	100%	
28-May	NQ	6,772.0	6,782.0	10.0	10.0	100%	
28-May	NQ	6,782.0	6,792.0	10.0	10.0	100%	
28-May	NQ	6,792.0	6,802.0	10.0	8.0	80%	634 F BHT

Depth Interval	Av Run	Av Recovery
1,909 - 2,044 ft	3.07	60.74%
2,784 - 2,830 ft	2.84	98.90%
4,108 - 4,502 ft	9.16	98.86%
4,502 - 5,001 ft	8.18	98.00%
5,001 - 5,498 ft	9.39	99.70%
5,498 - 6,000 ft	9.29	99.70%
6,000 - 6,501 ft	9.82	99.80%
6,501 - 6,802 ft	9.41	98.84%

2,694 ft cored
2,672 ft recovered
99.18% core overall recovery below 4,108 ft

Table 6

SOH-2
Bottom Hole Temperatures

Activity	Depth Ft.	Temp F.	Activity	Depth Ft.	Temp F.
Rotary 5-7/8"	3,632	100	Core NQ	5,302	438
Rotary 5-7/8"	3,711	100	Core NQ	5,352	434
Rotary 5-7/8"	3,770	100	Core NQ	5,402	434
Rotary 5-7/8"	3,848	104	Core NQ	5,455	442
Rotary 5-7/8"	3,907	104	Core NQ	5,498	445
Rotary 5-7/8"	3,987	112	Core NQ	5,555	471
Rotary 5-7/8"	4,045	120	Core NQ	5,602	468
Core HQ	4,152	206	Core NQ	5,652	496
Core HQ	4,200	206	Core NQ	5,702	488
Core HQ	4,262	226	Core NQ	5,752	501
Core HQ	4,311	239	Core NQ	5,802	506
Core HQ	4,352	232	Core NQ	5,852	506
Core HQ	4,402	248	Core NQ	5,902	510
Core HQ	4,452	240	Core NQ	5,952	515
Core HQ	4,502	270	Core NQ	6,000	527
Core HQ	4,552	284	Core NQ	6,051	537
Core HQ	4,602	276	Core NQ	6,100	545
Core HQ	4,662	294	Core NQ	6,151	558
Core HQ	4,712	306	Core NQ	6,201	564
Core HQ	4,762	332	Core NQ	6,252	569
Core HQ	4,805	296	Core NQ	6,302	578
Core HQ	4,855	320	Core NQ	6,350	585
Core HQ	4,902	348	Core NQ	6,418	602
Core HQ	4,950	320	Core NQ	6,462	608
Core NQ	5,001	411	Core NQ	6,521	610
Core NQ	5,051	400	Core NQ	6,602	626
Core NQ	5,102	400	Core NQ	6,672	626
Core NQ	5,150	414	Core NQ	6,752	634
Core NQ	5,201	409	Core NQ	6,802	634
Core NQ	5,252	422			

Table 7

SOH-2 Casing
5" & 4-1/2" Mixed String
Date run: April 11, 1991

#	Item	Length	Total	#	Item	Length	Total
1	5" L/H	38.25	38.25	33	4.5" BT&C	39.17	1,217.96
2	5" L/H	35.00	73.25	34	4.5" BT&C	39.17	1,257.12
3	5" L/H	39.50	112.75	35	4.5" BT&C	39.17	1,296.29
4	5" L/H	33.75	146.50	36	4.5" BT&C	39.17	1,335.46
5	5" L/H	38.00	184.50	37	4.5" BT&C	39.17	1,374.62
6	5" L/H	39.50	224.00	38	4.5" BT&C	39.17	1,413.79
7	5" L/H	39.50	263.50	39	4.5" BT&C	38.75	1,452.54
8	5" L/H	39.50	303.00	40	4.5" BT&C	39.17	1,491.71
9	5" L/H	39.50	342.50	41	4.5" BT&C	39.17	1,530.87
10	5" L/H	39.50	382.00	42	4.5" BT&C	39.17	1,570.04
11	LH x BT&C	1.29	383.29	43	4.5" BT&C	38.83	1,608.87
12	4.5" BT&C	39.08	422.37	44	4.5" BT&C	39.17	1,648.04
13	4.5" BT&C	39.17	461.54	45	4.5" BT&C	39.17	1,687.21
14	4.5" BT&C	39.08	500.62	46	4.5" BT&C	39.17	1,726.37
15	4.5" BT&C	39.08	539.71	47	4.5" BT&C	38.83	1,765.21
16	4.5" BT&C	39.17	578.87	48	4.5" BT&C	39.17	1,804.37
17	4.5" BT&C	39.08	617.96	49	4.5" BT&C	39.17	1,843.54
18	4.5" BT&C	38.83	656.79	50	4.5" BT&C	39.17	1,882.71
19	4.5" BT&C	39.17	695.96	51	4.5" BT&C	39.17	1,921.87
20	4.5" BT&C	39.17	735.12	52	4.5" BT&C	39.17	1,961.04
21	4.5" BT&C	38.92	774.04	53	4.5" BT&C	38.83	1,999.87
22	4.5" BT&C	38.50	812.54	54	4.5" BT&C	39.17	2,039.04
23	4.5" BT&C	39.17	851.71	55	4.5" BT&C	35.67	2,074.71
24	4.5" BT&C	30.17	881.87	56	4.5" BT&C	39.17	2,113.87
25	4.5" BT&C	39.17	921.04	57	4.5" BT&C	39.17	2,153.04
26	4.5" BT&C	23.83	944.87	58	4.5" BT&C	39.17	2,192.21
27	4.5" BT&C	38.83	983.71	59	4.5" BT&C	39.17	2,231.37
28	4.5" BT&C	39.17	1,022.87	60	4.5" BT&C	39.17	2,270.54
29	4.5" BT&C	38.92	1,061.79	61	4.5" BT&C	39.17	2,309.71
30	4.5" BT&C	38.92	1,100.71	62	BT&C x LH	0.75	2,310.46
31	4.5" BT&C	39.17	1,139.87	63	LH x 134mm	0.67	2,311.12
32	4.5" BT&C	38.92	1,178.79	64-154	134mm rods	1,791.00	4,102.12

Casing used:
5" K-55, 11.5#/ft w/ flush joint left-hand mod. buttress thread
4.5" J-55, 10.5#/ft BT&C
134mm drill rods, 14.34#/ft, 19.68 ft/joint (removed at completion)

Table 8
SOH-2 DIRECTIONAL SURVEY
June 2, 1991

Measured Depth	Drift Angle		Drift Direction				Vertical Depth-FT.	Rectangular Coordinates			
0	0	0	N	0	0	E	0.00	0.00	N	0.00	E
100	0	17	N	8	15	W	100.00	0.24	N	0.04	W
200	0	32	N	52	19	W	200.00	0.77	N	0.44	W
300	0	38	N	60	42	W	299.99	1.33	N	1.29	W
400	0	31	N	65	13	W	399.99	1.79	N	2.18	W
500	0	26	N	67	0	W	499.98	2.13	N	2.94	W
600	0	23	N	80	37	W	599.98	2.33	N	3.62	W
700	0	28	S	60	14	W	699.98	2.18	N	4.30	W
800	0	32	S	63	49	W	799.97	1.77	N	5.07	W
900	0	37	S	58	40	W	899.97	1.29	N	5.95	W
1,000	0	45	S	47	36	W	999.96	0.57	N	6.89	W
1,100	0	57	S	49	23	W	1,099.95	0.42	S	8.00	W
1,200	1	16	S	59	22	W	1,199.93	1.52	S	9.58	W
1,300	2	18	S	65	30	W	1,299.88	2.91	S	12.36	W
1,400	3	2	S	69	32	W	1,399.76	4.76	S	16.91	W
1,500	3	49	S	67	15	W	1,499.57	7.07	S	22.70	W
1,600	4	50	S	65	44	W	1,599.28	10.08	S	29.61	W
1,700	5	2	S	64	12	W	1,698.91	13.72	S	37.40	W
1,800	4	50	S	62	9	W	1,798.54	17.60	S	45.08	W
1,900	9	58	S	3	2	W	1,897.79	28.23	S	49.27	W
2,000	10	19	S	1	49	W	1,996.23	45.82	S	50.01	W
2,100	10	31	S	0	27	W	2,094.58	63.90	S	50.37	W
2,200	9	29	S	0	36	E	3,193.06	81.26	S	50.35	W
2,300	9	23	S	1	49	W	2,291.71	97.65	S	50.51	W
2,400	8	4	S	1	0	E	2,390.55	112.81	S	50.65	W
2,500	6	39	S	6	16	E	2,489.72	125.58	S	49.90	W
2,600	6	38	S	6	32	E	2,589.05	137.08	S	48.61	W
2,700	6	1	S	6	0	E	2,688.44	148.03	S	47.40	W
2,800	5	27	S	3	58	E	2,787.94	157.98	S	46.53	W
2,900	4	58	S	13	18	E	2,887.53	166.93	S	45.20	W
3,000	4	48	S	14	5	E	2,987.17	175.20	S	43.19	W
3,100	4	20	S	15	51	E	3,086.85	182.89	S	41.14	W
3,200	4	2	S	21	33	E	3,186.58	189.80	S	38.81	W
3,300	3	39	S	23	48	E	3,286.36	195.98	S	36.24	W
3,400	3	38	S	23	2	E	3,386.16	201.81	S	33.71	W
3,500	2	34	S	34	54	E	3,486.01	206.56	S	31.19	W
3,600	2	48	S	46	33	E	3,585.90	210.08	S	28.14	W
3,700	3	19	S	48	41	E	3,685.76	213.67	S	24.19	W
3,800	2	56	S	50	50	E	3,785.61	217.19	S	20.04	W
3,900	2	42	S	48	14	E	3,885.49	220.38	S	16.30	W
4,000	2	36	S	50	29	E	3,985.38	223.39	S	12.79	W
4,100	2	25	S	51	11	E	4,085.29	226.15	S	9.40	W
4,200	2	37	S	47	42	E	4,185.19	229.01	S	6.07	W

Table 8
SOH-2 DIRECTIONAL SURVEY
June 2, 1991

Measured Depth	Drift Angle		Drift Direction	Vertical Depth-FT.	Rectangular Coordinates	
4,300	2	22	S 47 39 E	4,285.10	231.94 S	2.85 W
4,400	2	23	S 43 33 E	4,385.01	234.84 S	0.11 E
4,500	1	53	S 50 10 E	4,484.94	237.40 S	2.80 E
4,600	1	50	S 40 27 E	4,584.89	239.67 S	5.10 E
4,700	1	36	S 40 10 E	4,684.84	241.95 S	7.04 E
4,800	1	42	S 38 49 E	4,784.80	244.17 S	8.87 E
4,900	1	36	S 45 5 E	4,884.76	246.32 S	10.79 E
5,000	1	25	S 50 40 E	4,984.73	248.08 S	12.73 E
5,100	1	11	S 59 58 E	5,084.70	249.38 S	14.58 E
5,200	1	22	S 50 7 E	5,184.67	250.67 S	16.39 E
5,300	1	2	S 48 49 E	5,284.65	252.02 S	17.99 E
5,400	1	6	S 52 5 E	5,384.64	253.21 S	19.42 E
6,802	1	6	S 52 5 E	6,786.38	269.75 S	40.66 E

Contractor: Eastman Christensen
Operator: Tom Ray
Survey Type: Seeker Gyroscopic Survey
Ref. Elevation: Ground Level
Final position at 6,802 ft. is a projected station

Table 9

SOH-2 Temperature Survey
June 6, 1991

Depth (feet)	Temp (F)	Depth (feet)	Temp (F)	Depth (feet)	Temp (F)
200	77.51	2,450	110.38	4,700	352.26
250	83.88	2,500	117.71	4,750	357.06
300	91.18	2,550	121.38	4,800	403.33
350	94.83	2,600	124.13	4,850	411.08
400	92.09	2,650	131.49	4,900	419.81
450	83.88	2,700	140.69	4,950	429.53
500	80.24	2,750	145.30	5,000	437.31
550	78.42	2,800	149.92	5,050	442.18
600	76.60	2,850	154.54	5,100	447.06
650	76.60	2,900	158.23	5,150	454.87
700	75.69	2,950	160.08	5,200	464.65
750	74.78	3,000	161.01	5,250	474.44
800	73.87	3,050	164.71	5,300	480.32
850	72.96	3,100	167.49	5,350	488.18
900	72.05	3,150	171.19	5,400	495.06
950	72.05	3,200	176.76	5,450	501.95
1,000	72.05	3,250	186.98	5,500	508.85
1,050	72.05	3,300	210.28	5,550	516.74
1,100	71.15	3,350	213.08	5,600	522.67
1,150	72.05	3,400	215.88	5,650	529.10
1,200	72.05	3,450	218.69	5,700	535.53
1,250	72.05	3,500	221.50	5,750	542.47
1,300	72.05	3,550	226.18	5,800	548.43
1,350	73.87	3,600	229.93	5,850	553.90
1,400	72.96	3,650	235.56	5,900	559.36
1,450	73.87	3,700	241.19	5,950	565.33
1,500	73.87	3,750	244.95	6,000	572.60
1,550	75.69	3,800	257.19	6,050	580.60
1,600	74.78	3,850	260.96	6,100	587.40
1,650	75.69	3,900	257.19	6,150	595.00
1,700	77.51	3,950	260.96	6,200	601.80
1,750	78.42	4,000	264.73	6,250	607.20
1,800	80.24	4,050	269.45	6,300	612.00
1,850	83.88	4,100	274.18	6,350	617.10
1,900	88.44	4,150	280.80	6,400	621.90
1,950	96.66	4,200	283.64	6,450	626.70
2,000	99.40	4,250	288.38	6,500	630.60
2,050	100.31	4,300	318.80	6,550	634.40
2,100	100.31	4,350	323.57	6,650	637.60
2,150	101.23	4,400	328.34	6,700	653.60
2,200	101.23	4,450	333.11	6,750	656.80
2,250	102.14	4,500	336.94	6,781	660.40
2,300	103.05	4,550	341.72		
2,350	103.97	4,600	344.59		
2,400	105.80	4,650	349.39		

USGS temperature survey 6/6/91 (200 - 5,950 feet)
Pruett temperature survey 6/6/91 (6,000 - 6,781 feet)

Table 10
SOH DRILLING EXPENDITURES

ACTIVITY	SOH-1 COST	SOH-1 % TOTAL	SOH-4 COST	SOH-4 % TOTAL	SOH-2 COST	SOH-2 % TOTAL
SITE & ROAD CONSTRUCTION	5,589	0.34%	4,500	0.31%	10,161	0.92%
MOB, PREP. & SET-UP	17,621	1.07%	23,099	1.57%	18,939	1.71%
RIG, LABOR, FOOTAGE CHG. & TAX	961,614	58.51%	735,347	50.13%	575,905	51.93%
RENTAL EUIPMENT	138,732	8.44%	105,468	7.19%	60,799	5.48%
BITS (core and rotary)	73,569	4.48%	35,775	2.44%	20,039	1.81%
MISC. DOWN HOLE EQUIP.	30,989	1.89%	36,297	2.47%	18,798	1.70%
MUDS	91,810	5.59%	94,534	6.44%	69,154	6.24%
WATER (trucking & county charges pumps, equipment & repairs)	16,401	1.00%	91,972	6.27%	34,658	3.13%
CMT. & CMT SERVICES	33,525	2.04%	36,029	2.46%	64,849	5.85%
WELLHEAD, CASING & FLOAT EQUIP.	87,890	5.35%	96,651	6.59%	89,594	8.08%
BOP EQUIP. (Rental equipment)	52,921	3.22%	29,693	2.02%	23,958	2.16%
TRANSPORTATION	10,254	0.62%	18,524	1.26%	23,416	2.11%
MISC MATERIALS	8,770	0.53%	8,577	0.58%	7,636	0.69%
MISC LABOR & SERVICES	11,461	0.70%	10,266	0.70%	9,914	0.89%
SUPERVISION	82,200	5.00%	58,800	4.01%	45,850	4.13%
GEOPHYSICAL LOGGING	0	0.00%	58,445	3.98%	17,332	1.56%
OTHER	20,198	1.23%	22,836	1.56%	17,933	1.62%
TOTAL EXPENDITURES	1,643,544		1,466,813		1,108,935	

SOH DRILLING PROGRESS

Figure 1

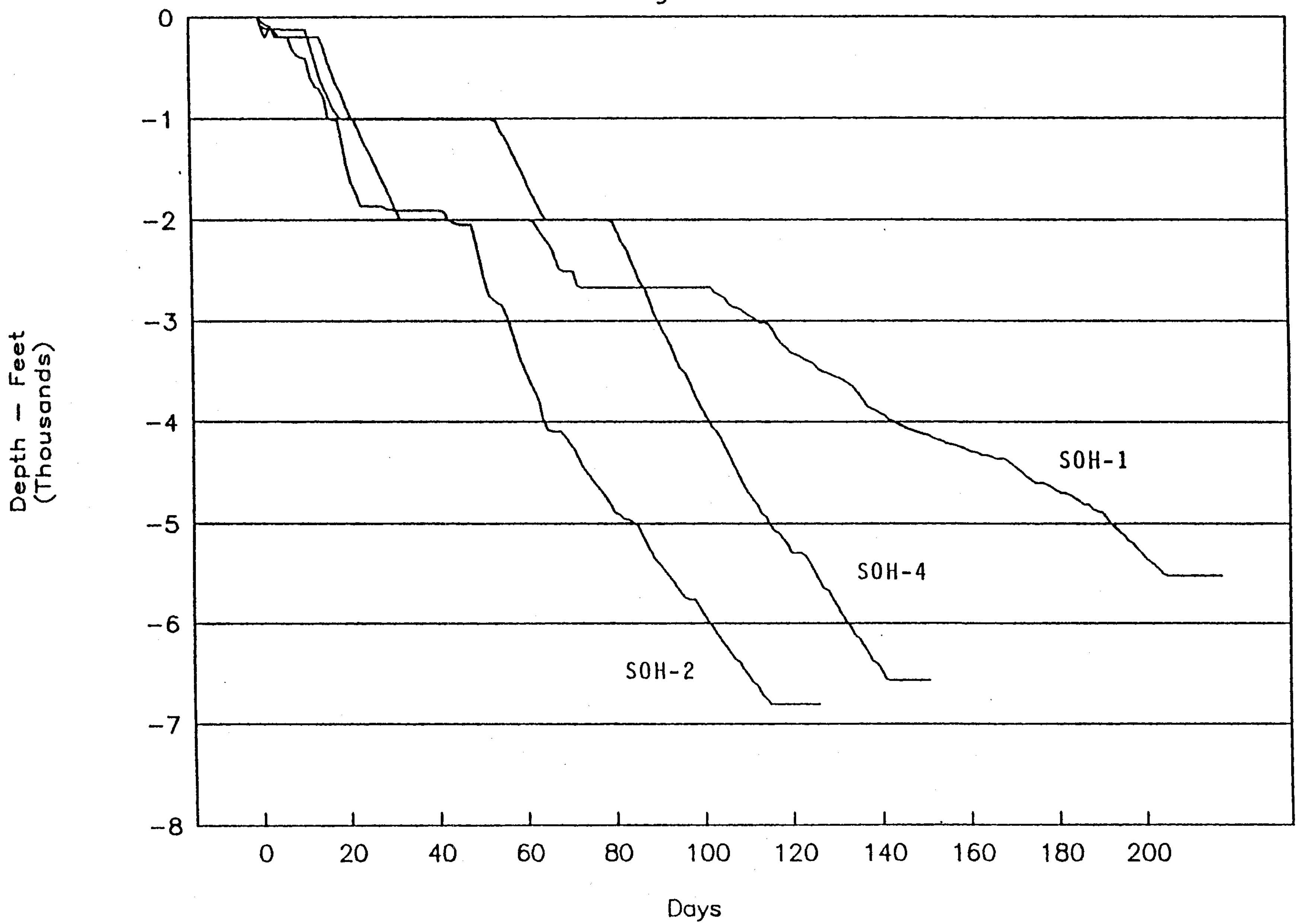
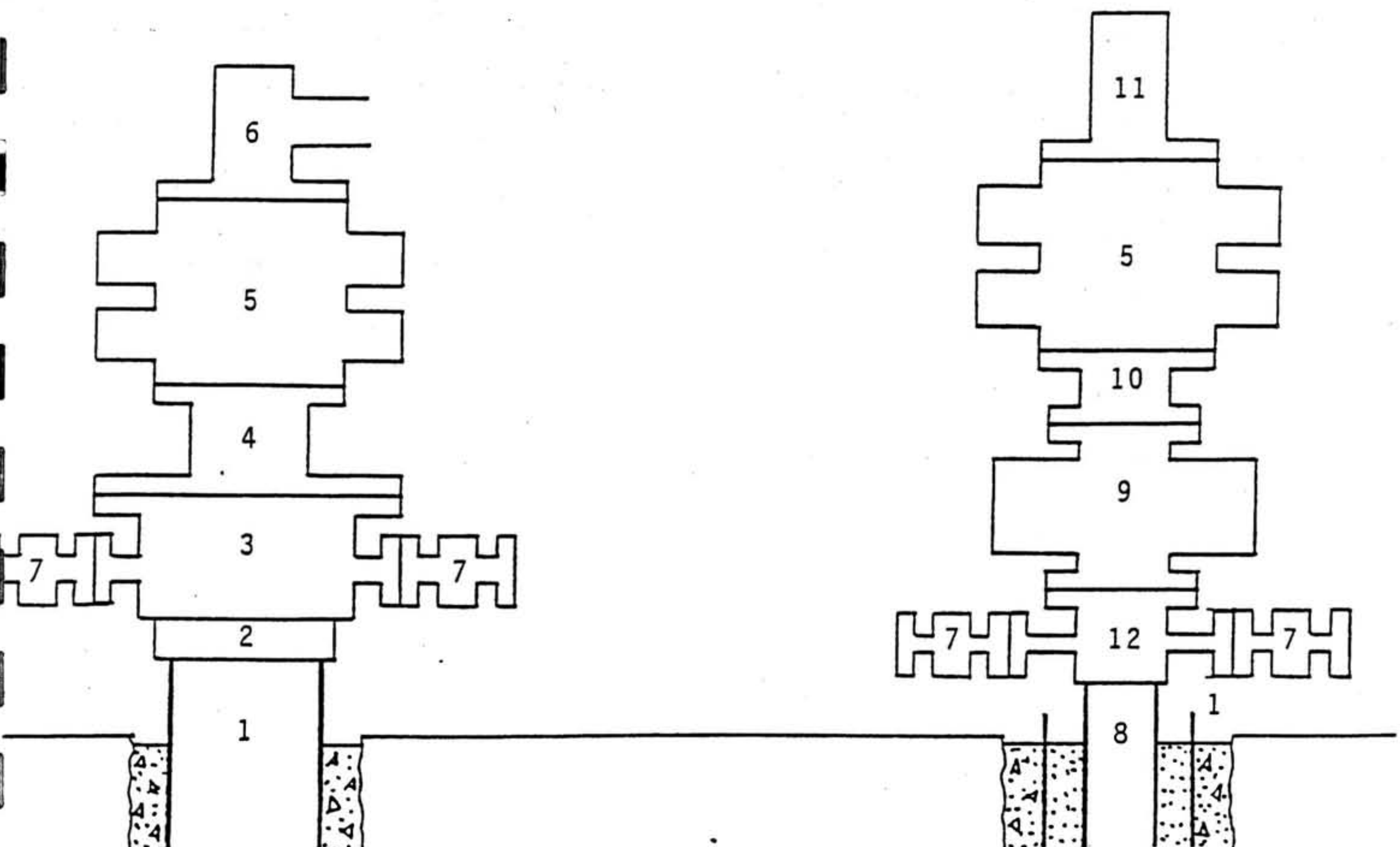


Figure 2

SOH-2 BOP Equipment
7" & 9-5/8" Wellhead

1. 9-5/8" casing
2. 9-5/8" x 13-3/8" bushing
3. 13-3/8" 3M wellhead
4. 13-3/8" x 9" 3M spool
5. 9" 5M Type E double gate BOP
6. Picture nipple
7. 2-1/16" 3M gate valves
8. 7" casing
9. 6" 3,000 WKM drilling valve
10. 7" x 9" 3M spool
11. Rotating head
12. 7" 3M wellhead



SOH-2 BHT's & 6/6/91 TEMPERATURE SURVEY

Figure 3

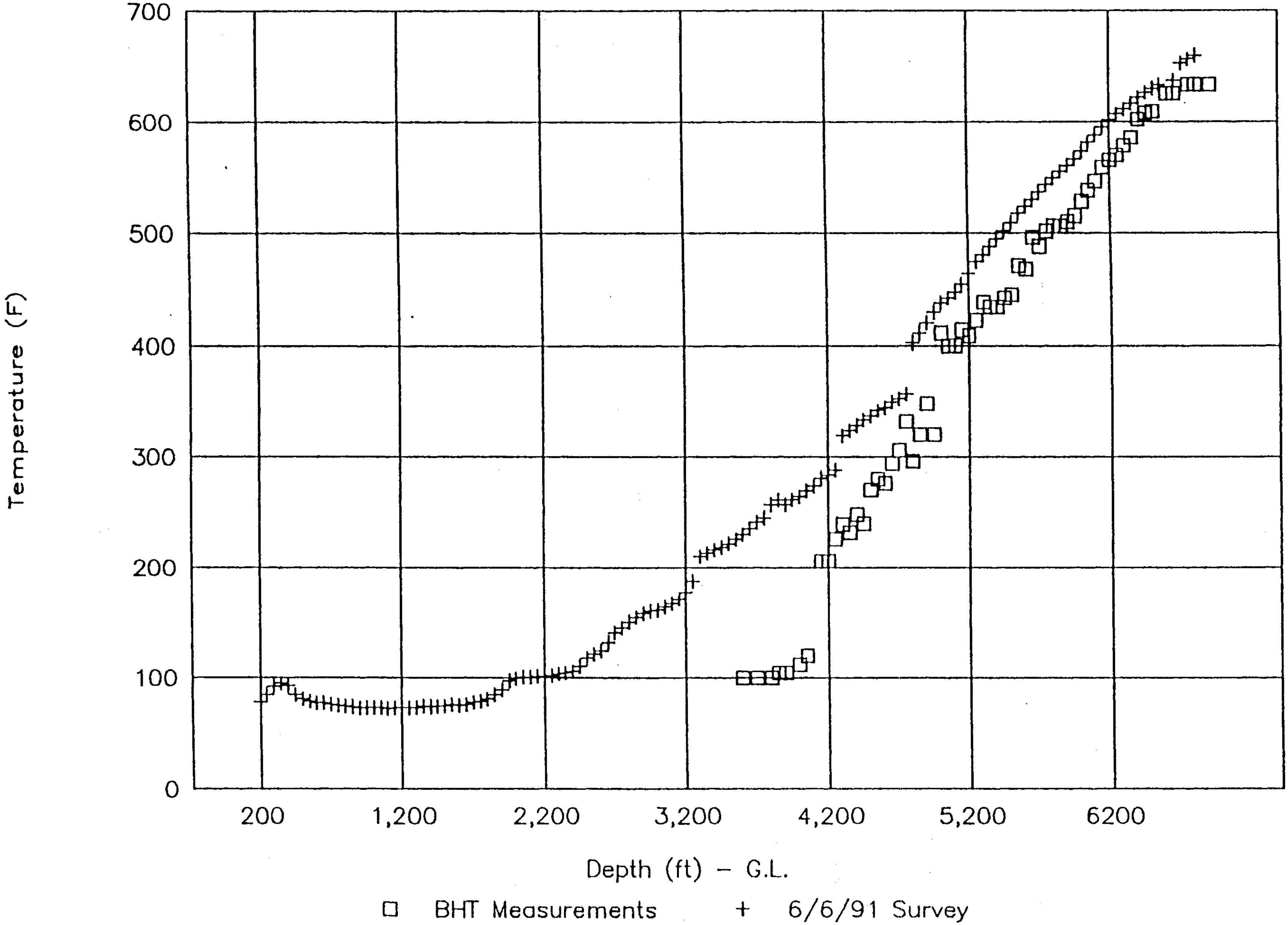
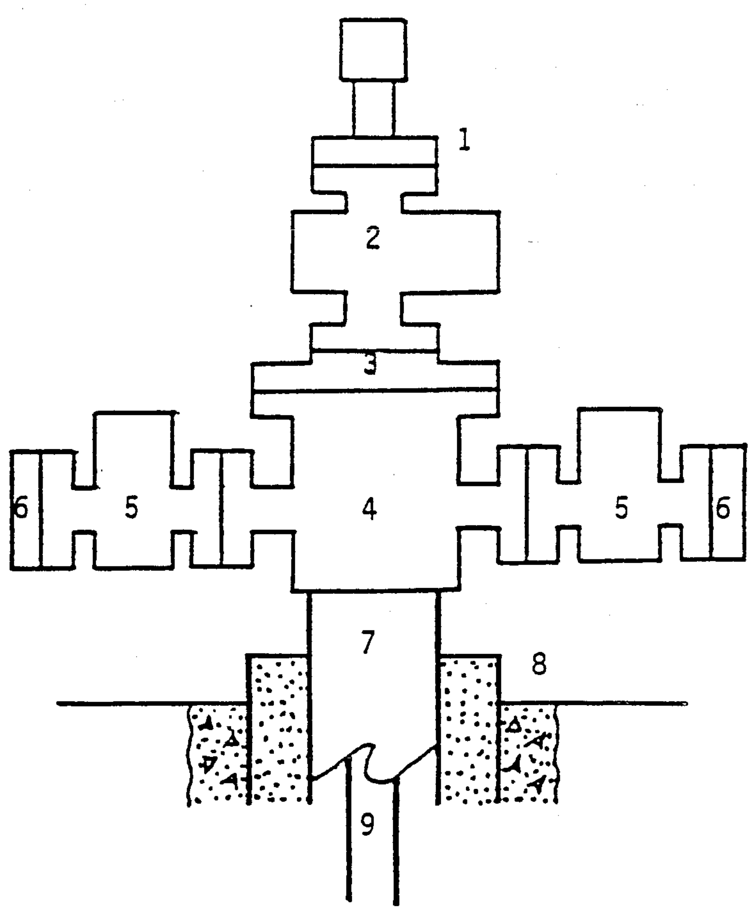


Figure 4
SOH-2 Completion Wellhead

1. Companion flange: 3M, 2-9/16" x 3" L.P.
2. Gate valve: 2-9/16" 3M w/ T-24 trim
3. Tubing head adapter: 7-1/16" x 2-9/16" 3M
4. Casing head: 7-1/16" EFSO 3M w/ 2-1/16" flanged outlets
5. Gate valves: 2-1/16" 3M w/ T-24 trim
6. Companion flanges: 3M, 2-1/16" x 2" L.P.
7. Casing: 7" J-55, 23 lb/ft (0 - 1,896 ft)
8. Casing: 9-5/8" K-55, 40 lb/ft (0 - 202 ft)
9. Completion tubing: NQ (2-3/4" x 2-3/8") 5.2 lb/ft
   0 - 6,802 ft. slotted 4,127 - 6,800 ft.



SOH-2 DIRECTIONAL SURVEY 6-2-91

Figure 5

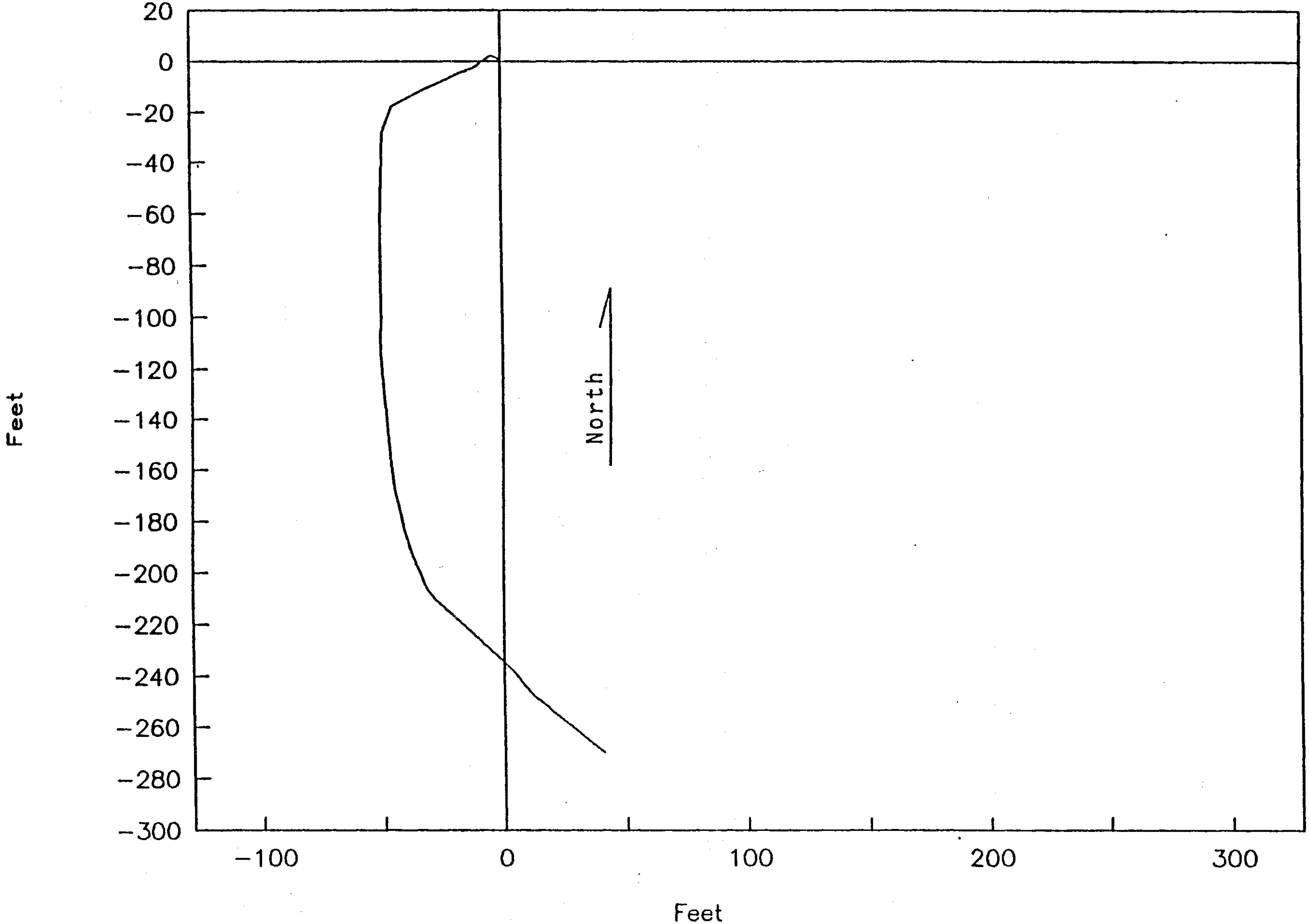
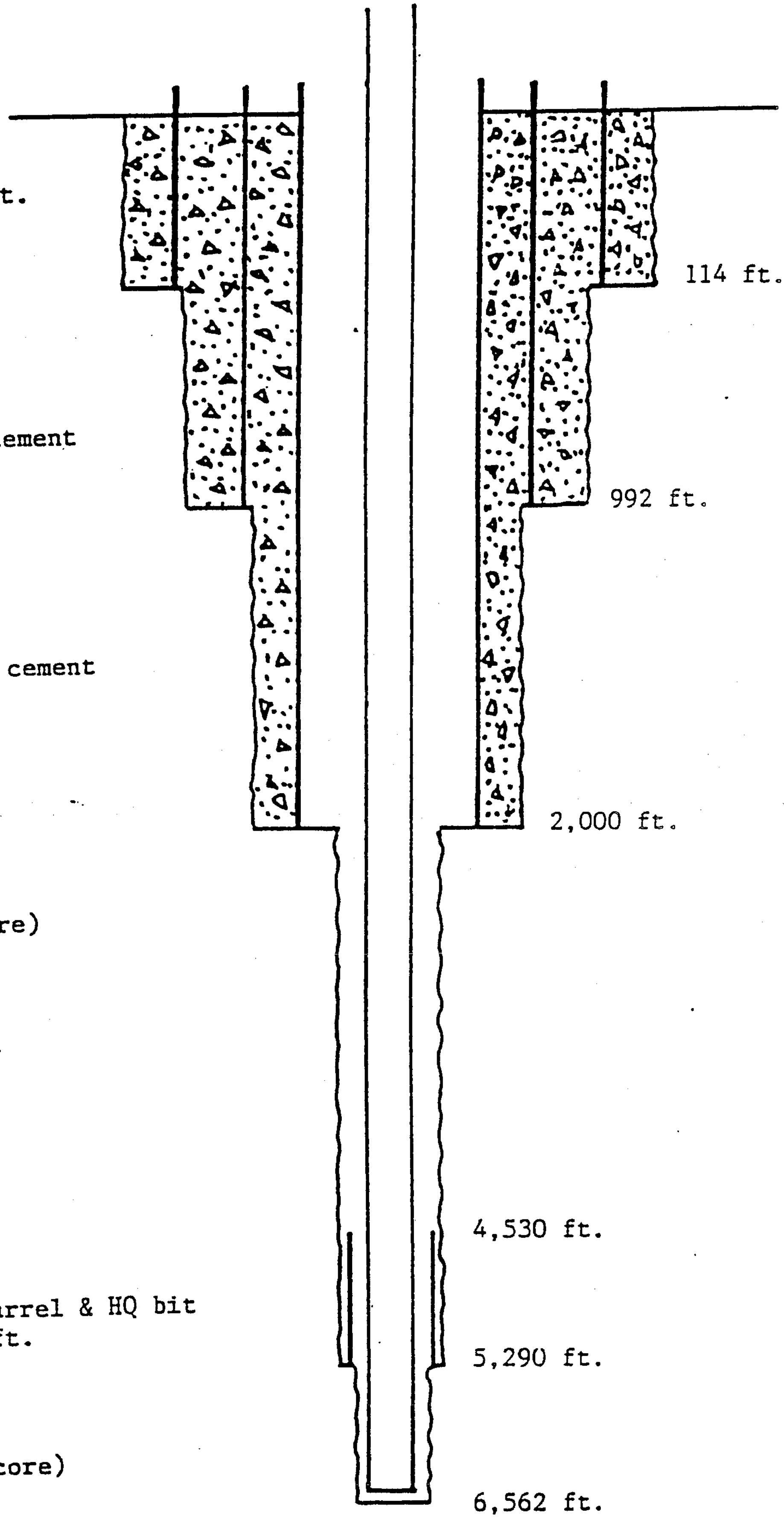


Figure 6
SOH-4
Completed Well Schematic



17.5" hole from surface - 114 ft.
3.375" K-55, 61#/ft casing
emented w/ redimix

12.25" hole from 114 - 992 ft.
.625" K-55, 40#/ft casing
emented w/Class G high temp. cement

.5" hole from 992 - 2,000 ft.
" L-80, 35#/ft casing
Cemented w/ Class G high temp. cement

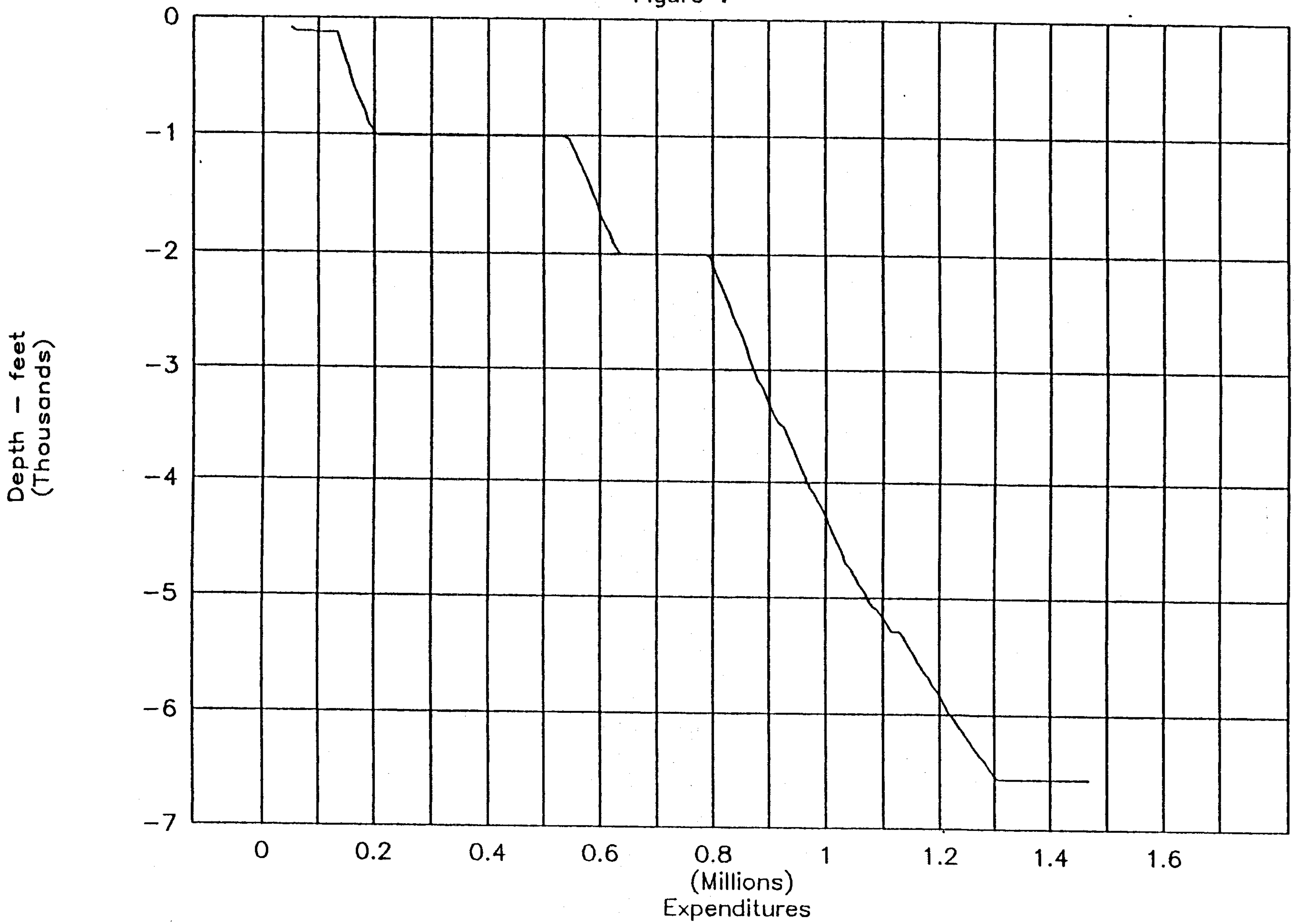
HQ hole (3.78" hole x 2.50" core)
2,000 - 5,290 ft.

750 ft. HQ core rods, outer barrel & HQ bit
left in hole. 4,530 - 5,290 ft.

NQ hole (2.98" hole x 1.875" core)
5,290 - 6,562 ft.

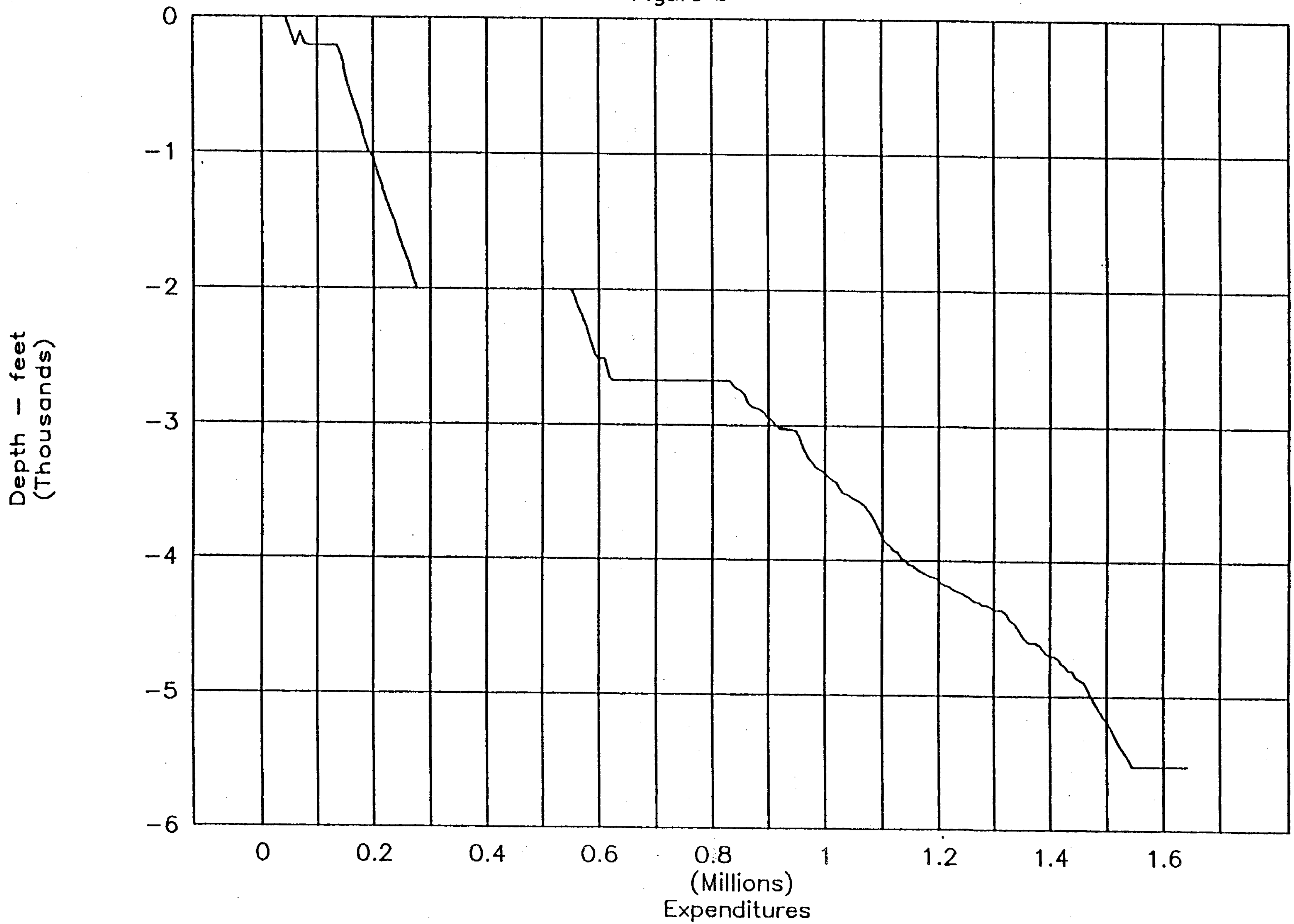
SOH-4 DRILLING EXPENDITURES

Figure 7



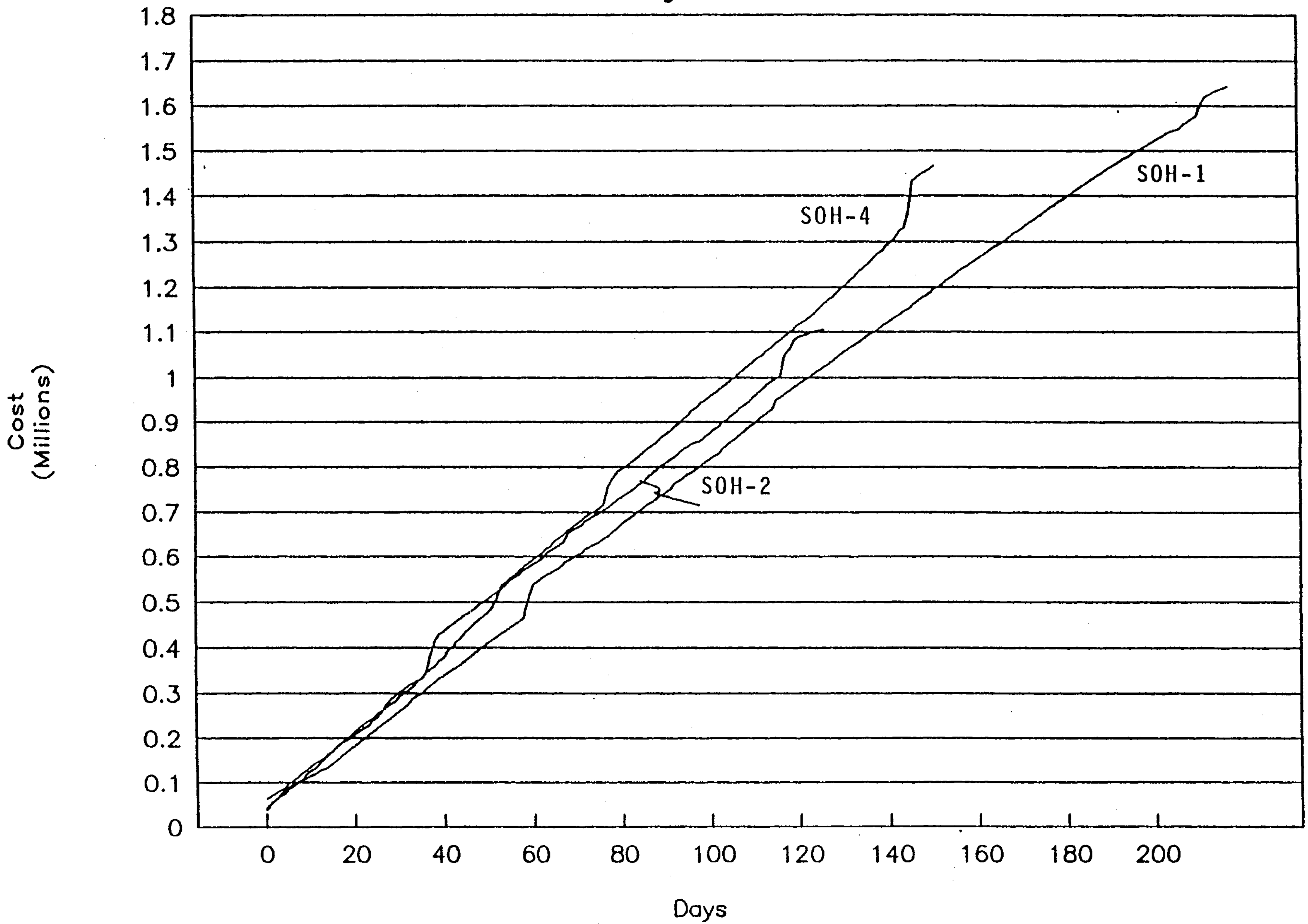
SOH-1 DRILLING EXPENDITURES

Figure 8



SOH DRILLING COSTS

Figure 9



SOH-2 DRILLING EXPENDITURES

Figure 10

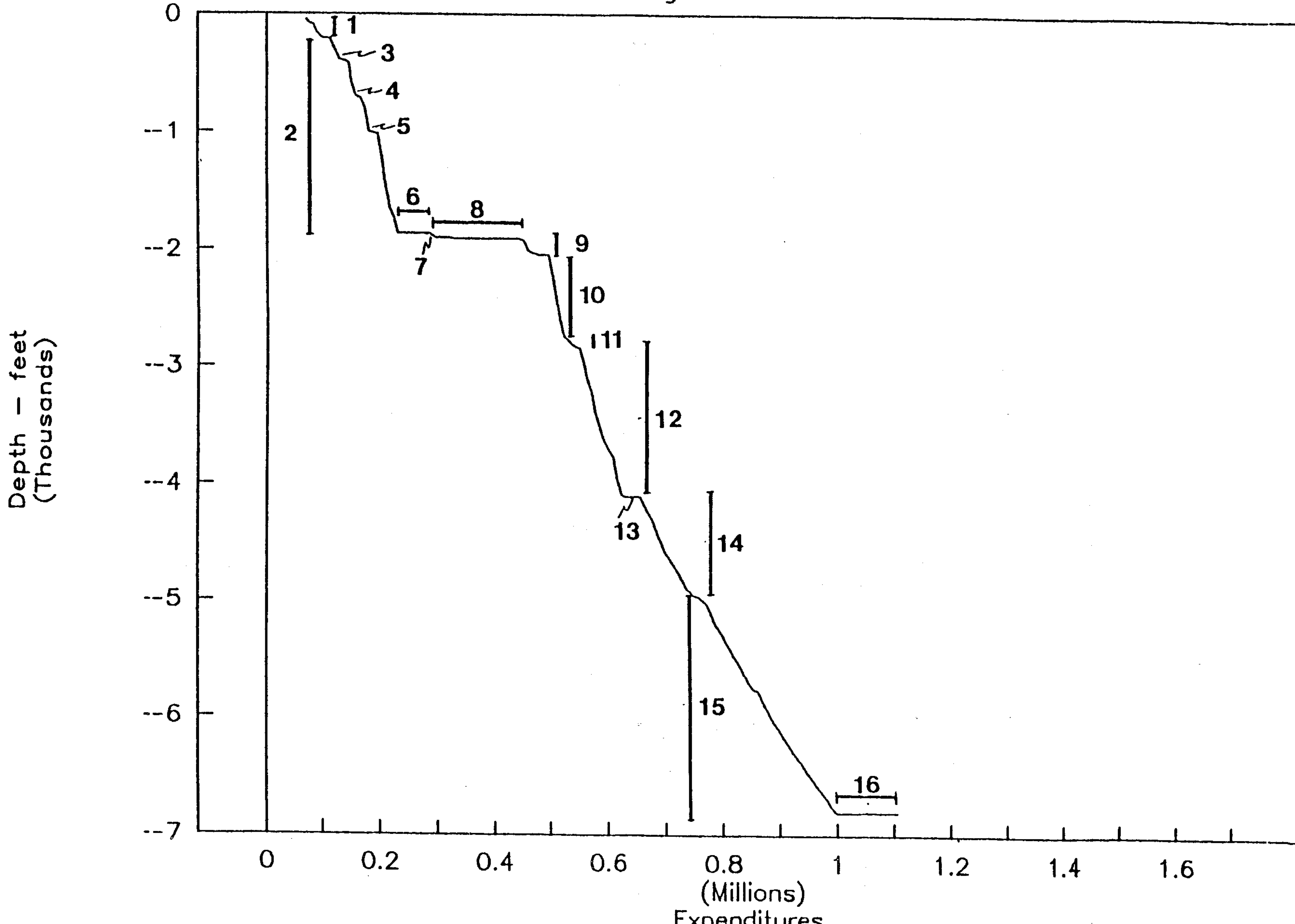


Figure 10 Summary

1. Rotary drill 12-1/4" hole 0 - 202 ft. Run and cement 9-5/8" casing.

2. Rotary drill 8-1/2" hole 202 - 1,907 ft.

3. Cement back from 390 ft. & redrill.

4. Cement back from 704 ft. & redrill.

5. Cement back from 1,017 ft. & redrill.

6. Cement back from 1,901 ft. & redrill.

7. Rotary drill 8-1/2" hole 1,901 - 1,907 ft. & run logs.

8. Run & cement 7" casing.

9. Core drill HQ 1,907 - 2,044 ft.

10. Rotary drill 5-7/8" hole 2,044 - 2,785 ft.

11. Core drill HQ 2,785 - 2,830 ft.

12. Rotary drill 5-7/8" hole 2,830 - 4,103 ft.

13. Run mixed 4.5/5" casing string.

14. Core drill HQ 4,103 - 4,988. Delays due to 7 rod separations.

15. Core drill NQ 4,988 - 6,802 ft.

16. Completion and testing.

SOH-2 DAILY DRILLING FOOTAGE

Figure 11

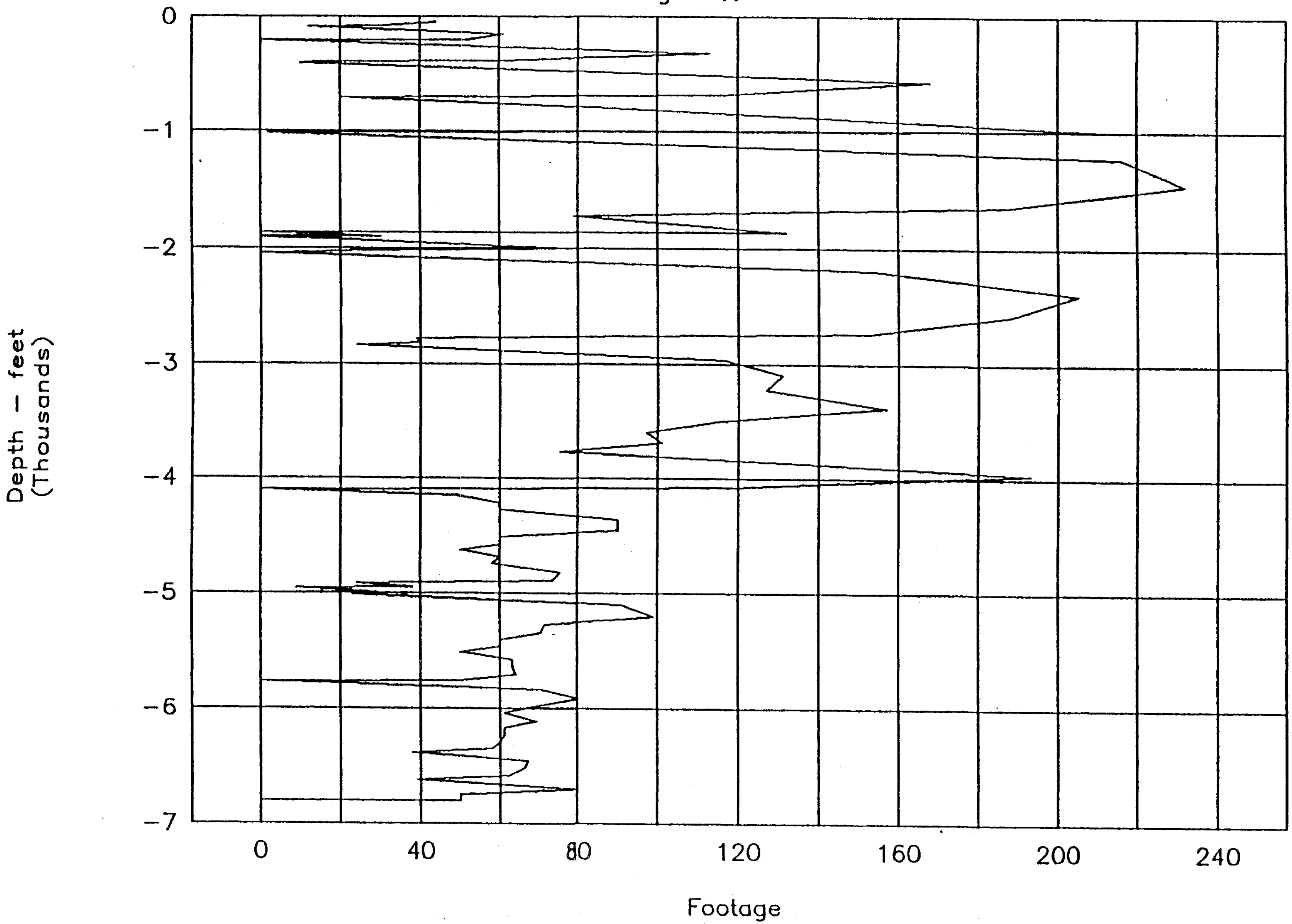
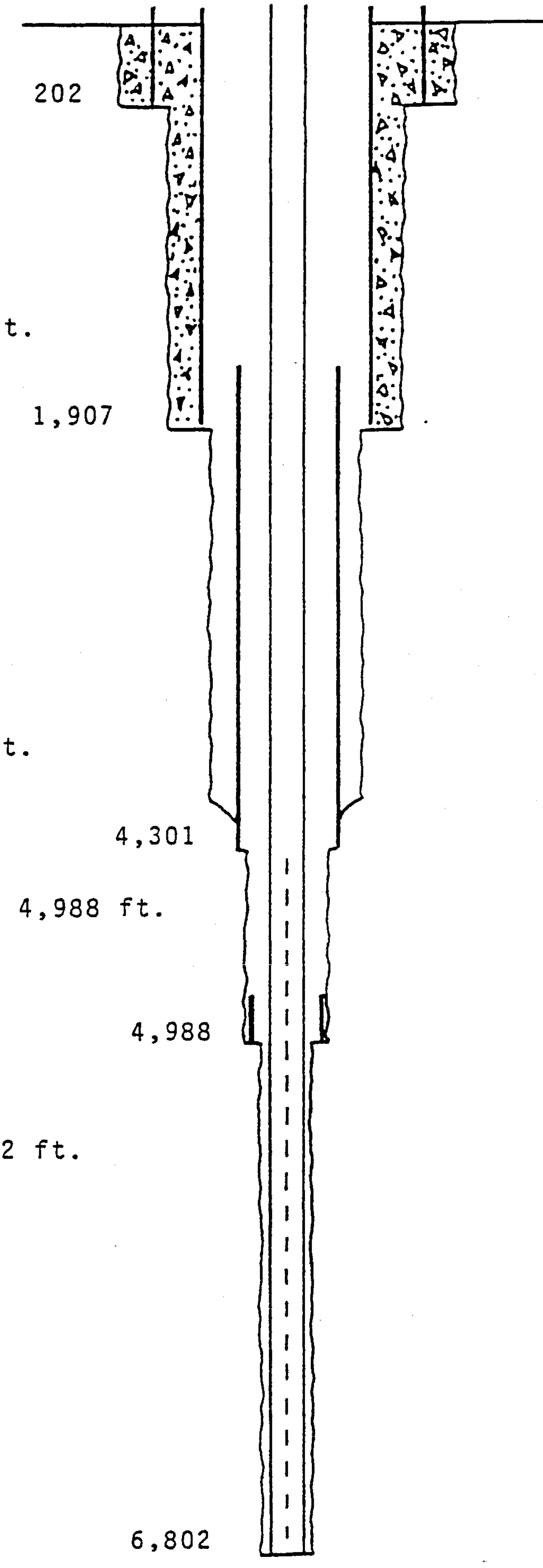


Figure 12

SOH-2 Completion Hole Schematic



0 - 202 Ft. 12-1/4" hole w/
9-5/8" K-55, 40 lb/ft casing

202 - 1,907 Ft. 8-1/2" hole w/
7" J-55, 23 lb/ft casing set to 1,896 ft.
DV tool @ 1,580 ft.
Two cement baskets @ 1,596 ft.
Float collar @ 1,855 ft.

1,907 - 4,103 Ft. 5-7/8" hole w/
noncemented mixed casing string.
5" K-55, 23 lb/ft 3,721 - 4,103 ft.
4-1/2" J-55, 10.5 lb/ft 1,794 - 3,721 ft.

4,103 - 4,988 Ft. HQ (3.83") hole w/
noncemented HMQ (3-1/2") casing 4,762 - 4,988 ft.

4,988 - 6,802 Ft. NQ (2.98") hole

Completion Tubing: NQ (2-3/4") 0 - 6,802 ft.
Perforated w/ 3/16" x 2-3/4" slots from
4,127 - 6,800 ft.