U.S. Environmental Protection Agency, Region 9

UNDERGROUND INJECTION CONTROL (UIC)

DRAFT INDIVIDUAL PERMIT

Class V Injection

Permit No. HI596002

Is issued to: Puna Geothermal Venture
14-3860 Kapoho Pahoa Road
Pahoa, Hawaii 96778

and

COSI Puna, Inc. (the operator)
14-3860 Kapoho Pahoa Road
Pahoa, Hawaii 96778

TABLE OF CONTENTS

PART I. JURISDICTION AND AUTHORIZATION TO OPERATE

The U.S. Environmental Protection Agency (EPA) issues its UIC Permit pursuant to its authority under the Safe Drinking Water Act (SDWA), as amended, and implementing regulations at Title 40 of the Code of Federal Regulations, Parts 124, 144, 146, 147, and 148.

Pursuant to its permitting authority, the EPA hereby authorizes

Puna Geothermal Venture
14-3860 Kapoho Pahoa Road
Pahoa, Hawaii 96778

and

COSI Puna, Inc. (the operator)
14-3860 Kapoho Pahoa Road
Pahoa, Hawaii 96778

(for simplicity,both shall be refered to as PGV in this permit), to operate three existing Class V geothermal injection wells, known as geothermal wells Kapoho State 1A (KS-1A), Kapoho State 3 (KS-3), Kapoho State 4 (KS-4):

Injection Well No.	Operational Status	Located on Well Pad	Approximate Wellhead Elevation Above Mean Sea Level
KS-1A	Primary Injector	A	617 feet
KS-3	Primary Injector	E	618 feet
KS-4	Primary Injector	E	618 feet

and having the specifications as listed in Figure No. 1, Figure No. 2, and Figure No. 3, respectively, of Appendix A--Injection Well Schematics; to reinject geothermal fluids consisting of geothermal brine, geothermal steam condensate, and geothermal noncondensible gases that are produced during the operation of the well field and power plant; chemical additions for process system and well casing biofouling, corrosion, and scale control; and the intermittent injection of supplement water; back into the geothermal reservoir at an interval between the approximate depths of 3,900 feet and 7,300 feet; located at the facility's address of 14-3860 Kapoho Pahoa Road, Pahoa, Hawaii, 96778; at Tax Key Number, 3rd Div. 1-4-01:2 and 19; at the approximate well pad coordinates:

Well Pad A: Latitude 19 28' 49" N and
Longitude 154 53' 35" W;

Well Pad E: Latitude 19 28' 41" N and
Longitude 154 53' 40" W;

in accordance with monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

The EPA authorizes the operation of the three (3) existing Class V geothermal injection wells, and the construction and operation of up to seven (7) new Class V geothermal injection wells, contingent on the conditions of this permit being met. As specified in Part II.A.2 of this permit, the location of new injection wells will be included in Appendix B--Existing and Proposed Well Locations, when this information is provided by the permittee, and will be subject to public review and comment.

All conditions set forth herein refer to Title 40 Parts 124, 144, 146, and 148 of the Code of Federal Regulations.

This permit consists of ___ total pages and includes all items listed in the Table of Contents. Further, this permit is based upon representations made by the permittee and on other information contained in the administrative record. It is the responsibility of the permittee to read and understand all provisions of this permit.

This permit is issued by the EPA for a period of ten (10) years unless terminated under the conditions set forth in Part III, Section B of this permit.

This permit is issued on _____ and becomes effective on _____.

_____

Alexis Strauss, Acting Director
Water Division, U.S. EPA Region 9

PART II. SPECIFIC PERMIT CONDITIONS

A. LOCATION OF EXISTING AND PROPOSED INJECTION WELLS

1. Existing Injection Well Locations

The permittee currently operates three (3) Class V injection wells known as geothermal wells, Kapoho State 1A (KS-1A), Kapoho State 3 (KS-3), and Kapoho State 4 (KS-4).

Injection Well No.	Status	Located on Well Pad	Approx. Wellhead Elevation Above Mean Sea Level
KS-1A	Primary Injector	A	618 feet
KS-3	Primary Injector	E	617 feet
KS-4	Primary Injector	E	617 feet

The wells are located at the facility's address of 14-3860 Kapoho Pahoa Road, Pahoa, Hawaii 96778; at Tax Key Number, 3rd Div. 1-4-01:2 and 19; at the approximate well pad coordinates:

Well Pad A: Latitude 19° 28' 49" N and Longitude 154° 53' 35" W;

Well Pad E: Latitude 19° 28' 41" N and Longitude 154° 53' 40" W;

2. Proposed Injection Well Locations

The permittee is authorized by the EPA to operate the three (3) existing geothermal injecton wells, and construct and operate up to seven (7) new geothermal injection wells, contingent upon meeting the conditions of this permit. New injection wells are defined as new wells that are either drilled as injection wells or converted to injection wells. The new injection wells will be located within the property boundary delineated in Appendix B, and will be set back at least six hundred (600) feet from the property boundry.

The permittee must receive written approval from the EPA prior to the construction of an injection well or the conversion to an injection well. To initiate the approval process for a new injection well or wells, at least one hundred twenty (120) days prior to the planned spudding of the injection well or the conversion to an injection well, the permittee shall, through certified mail, provide the EPA with: 1) the latitude

and longitude of the new well; 2) a map similar to the one in Appendix B with the location of the existing and proposed wells; and 3) documentation of the actual need for the new well.

Notwithstanding the conditions of Part II.A.2 of this permit being met, approval of a new well or wells will not be given prior to sixty (60) days following the close of the public comment period on EPA's review report of PGV's Emergency Response Plan and the County of Hawaii's Emergency Operations Plan. Approval of new wells shall be conditioned on the adequacy of the emergency response plans.

B. WELL CONSTRUCTION AND RELATED CONDITIONS

1. Casing and Cementing

The specifications in Figures No. 1, No. 2, and No. 3 in Appendix A, apply to injection wells KS-1A, KS-3, and KS-4, respectively. New injection wells will be drilled according to the plans submitted in Attachment L of the application. Within sixty (60) days of well completion or conversion, the well schematic will be provided to the EPA to be included in Appendix A. All existing and new wells shall be cased and cemented to prevent the movement of fluids behind the casing and the casing shall be maintained until the plugging and abandonment of the well.

2. Tubing

Injection tubing (hangdown liner) will be utilized within the longstring casing and will extend to the depths indicated on the well schematics. For existing wells, injection tubing extends to below 3,700 feet (all depths are referenced to the Kelly Bushing - KB). The casing/tubing annulus of all existing and proposed injection wells will be filled with nitrogen gas down to a depth of at least 2,000 feet.

3. Injection Intervals

For each well, injection into the intended zones will be through the open borehole, with or without a slotted (perforated) liner, below the cemented solid casing. Alteration of the injection perforations and other rework operations must be properly reported using EPA Form 7520-12 in Appendix C--Approved Changes and Workover Plans and Sample Forms. Injection between the outermost casing and the well bore is prohibited. The injection interval of the proposed well will be at a depth so as not to cause the migration of injected fluids into Underground Sources of Drinking Water (USDW).

4. Monitoring Devices

Pursuant to 40 CFR §§144.51(h) and 144.52(a)(9) in order to prevent the migration of injected fluids into a USDW, the

operator shall maintain, in accurate and good operating condition, the following:

(a) A sampling port on the reinjection (injectant) line between the reinjection common header and an active injection well for the purpose of obtaining representative samples of the injection fluids;

(b) A continuously recording injection pressure recorder (gauge and graphical chart) on the injectant line prior to the wellhead of each well, in addition to a remote injection pressure recorder on the combined brine reinjection line that provides information directly to the control room; on the combined brine reinjection line, an injection pressure switch that triggers visual and audible alarms in the control room as well as a computer printout;

(c) A continuously recording pressure recorder (gauge and graphical chart) on the wellhead of each well to measure annular nitrogen pressure that can be read in the control room;

(d) A flow meter at each well that is read locally and a continuously recording ultrasonic flow transmitter on the combined flow reinjection line that can be read in the control room;

(e) A continuously recording temperature recorder (gauge and graphical chart) located on the injectant line prior to the wellhead of each well, in addition to a remote temperature recorder on the combined brine reinjection line that provides information directly to the control room;

(f) A continuously recording flow meter at the production wells;

(g) A continuously recording flow totalizer (flow meter) located on the injectant line prior to the wellhead of each well, in addition to a remote flow totalizer on the combined brine reinjection line that provides information directly to the control room;

5. Proposed Changes and Workovers

The permittee shall give advance notice, of at least seven (7) days, to the EPA of any planned physical alterations or additions to the permitted injection wells, or any planned conversions. Any changes in the well construction will require prior approval of the EPA and either a major or minor permit modification under the requirements of 40 CFR §§144.39 and 144.41. In addition, the permittee shall provide all records of well workovers, well conversions, logging, or other subsequent test data, to the EPA within sixty (60) days of completion of the activity. Appendix C contains a sample of the appropriate reporting form. Demonstration of mechanical integrity shall be performed within thirty (30) days of

completion of workovers, alterations or conversions. Mechanical integrity shall be demonstrated prior to resuming or commencing injection activities, following in accordance with Part II.D.1 of this permit.

C. CORRECTIVE ACTION

1. Area of Review

(a) The area of review (AOR) shall consist of a radius of one-fourth (1/4) mile beyond the property boundry as identified in Appendix B.

(b) Prior to the construction of a new injection well or the conversion to an injection well, all wells that are located within the AOR and penetrate the injection zone shall be properly plugged and abandoned if they are improperly sealed, improperly completed, or improperly or temporarily abandoned.

(c) Prior to constructing any new developmental well, exploration well, production well, monitoring well, or any other well that penetrates the injection zone within the AOR, the permittee shall submit to the EPA a plan of the steps that are necessary to prevent the movement of fluid into the USDW. Upon receiving written approval of the plans from the EPA, the permittee may commence construction.

2. Corrective Action

(a) The permittee shall conduct both internal and external mechanical integrity tests on the abandoned scientific observation well known as SOH-1 within a year of the effective date of this permit. If mechanical integrity cannot be demonstrated for SOH-1, then the permittee is responsible for the proper plugged and abandoned of SOH-1 within one (1) year from the date that this determination is made. If SOH-1 has mechanical integrity, then internal and external mechanical integrity tests are required annually.

(b) The permittee is responsible for the proper plugging and abandonment of the temporarily abandoned production well known as HGP-A. The permittee has two years from the issuance of this permit in which to properly plug and abandon HGP-A. In the meantime, the drilling of injection wells or the conversion wells to injecttion wells is prohibited within one-fourth (1/4) mile of HGP-A.

D. WELL OPERATION

1. Mechanical Integrity

(a) All injection wells must have and maintain mechanical integrity consistent with 40 CFR §146.8. The permittee must show that there are no significant leaks in the casing and tubing and that there is no significant fluid movement into a

USDW through vertical channels adjacent to the injection wellbore.

(b) The permittee shall implement the Program for Mechanical Integrity Testing and Monitoring of Injection Wells, dated July 29, 1996, in Appendix D--Casing Monitoring Program, or as modified with the written approval of the EPA.

(c) In addition, an annulus pressure decrease of more than ten (10) percent in five (5) hours constitutes a significant leak. If this occurs at times other than the annual casing pressure test, or at any time the gas/fluid interface cannot be maintained at a depth of at least 2,000 ft. KB (1,975 ft. below ground level), then the permittee is required to inspect the wellhead for leaks, repair any wellhead leaks found, and resume monitoring. If either one of the aforementioned conditions persists, then the permittee is required to shut in and secure the well, submit an action plan for locating and repairing the leak, repair the leak, and satisfactorily demonstrate mechanical integrity before returning to operations. The tests and monitoring data that show that the well has had its mechanical integrity restored shall be sent to the EPA.

(d) If leaks are detected and confirmed in two injection wells at the same time, flow into the two injection wells will be stopped, and if necessary, the control operator will reduce the incoming flow from the production well(s). If all injection wells incur leaks or mechanical integrity failures at the same time, all injection wells shall be shut. Mechanical integrity shall be demonstrated before an injection well is returned to operations.

2. Injection Pressure Limitation

(a) Injection pressure should not exceed: 1) the fracture pressure of the receiving formation; or 2) the injection pressures for the individual wells as listed below.

Well	Maximum Injection Wellhead Pressure (psig)
KS-1A	500
KS-3	500
KS-4	500

The injection pressure limitations for new wells shall be included in Appendix E--Injection Pressure Limitations for New Wells.

(b) The injection system will be maintained so that the injection pumps shut off automatically if the injection pressure exceeds 500 psig at the relief valves at the individual wellheads, or 470 psig in the combined brine reinjection line.

(c) All piping, valves and facilities associated with injection operations shall meet or exceed ANSI standards for the injection pressure and shall be maintained in a safe and leak-free condition.

3. Injection Rate Limitation

The injection rate shall not cause an exceedance of the injection pressure limitation in Part II.D.2.a. Should the maximum injection rate increase to a point where it appears that the maximum injection pressure limitation will be exceeded, then the EPA will reconsider setting maximum injection rate limitations.

4. Injection Fluid Limitation

(a) Injectant in this permit is limited to geothermal fluids, supplement water, and chemical additions for process system and well casing biofouling, corrosion, and scale control.

(b) Geothermal fluids consist of geothermal brine, geothermal steam condensate, and geothermal noncondensible gases.

(c) Supplement water may consist of steam turbine seal water, rinsate from the water softener system, sulfatreat heat exchanger cooling water, raw/quench water, production well bleed system, abatement fluids, sulfatreat system vacuum pump seal water, condensate from the sulfatreat system, periodic produced drilling fluids, and fluids from the plant water storage tank and the emergency steam release facility (ESRF). Some of these fluids may contain the additives listed in Appendix F--Chemical Additives.

(d) Use of chemical additives for process system and well casing biofouling, corrosion, and scale control must be in accordance with the Chemical Additives Management Plan prepared by Puna Geothermal Venture or as modified with written approval of the EPA. These additives are listed in Appendix F.

(e) Fluids to be injected other than those described in paragraphs (a) through (d), above, shall be reported to the EPA thirty (30) days prior to the injection. Injection shall only commence after written approval from EPA is issued.

5. Upset Conditions

In the event of an upset of facility operations where the injection wells can not be used, brine will not be disposed of on the ground. The permittee shall contact the EPA and other appropriate federal, state, and local agencies as specified in this permit (Parts III.11 and 13) and in the permits of the other agencies.

E. MONITORING, RECORDKEEPING, AND REPORTING OF RESULTS

1. Hydrologic Monitoring Program

The permittee shall implement the Hydrologic Monitoring Program dated April 1990, in Appendix G, with the modifications specified in Appendix G, or as modified with the written approval of the EPA.

2. Program for Mechanical Integrity Testing and Monitoring of Injection Wells

(a) The permittee shall implement the Program for Mechanical Integrity Testing and Monitoring of Injection Wells, dated July 29, 1996, in Appendix D or as modified with the written approval of the EPA. This program shall be implemented for all injection wells, including active, temporarily abandoned (idle), and injection wells converted to monitoring wells.

(b) The permittee shall notify the EPA no later than forty-five (45) days before performing the annual mechanical integrity tests. For mechanical integrity tests resulting from well repair, the permittee will notify the EPA as soon as possible.

(c) In addition, a continuous recording of the injection wellhead pressure, injection rate, and annulus pressure shall be maintained. Pressure recordings shall be documented on a graphical chart, such as a strip chart or circular chart, that shows the relationship between pressure and elapsed time. The pressure recordings shall be maintained whether or not the injection well is in use. The pressure recordings shall distinguish between the time periods of use and nonuse, if any. A summary report that contains the maximum daily injection pressure shall be submitted to the EPA monthly. Any decrease in the annulus pressure of ten (10) percent or greater over a continuous five (5) hour period or any rise in the gas/brine interface above 2,000 ft. KB (1975 ft. below ground level) in the tubing/casing annulus shall be reported within twenty-four (24) hours to the EPA, and in the monthly report with an explanation.

3. Injection Well Performance

A periodic status report shall be generated at least once every three (3) months regarding the performance of the injection wells. The status report shall be made by a professional consultant, engineer, or geologist proficient in injection well performance. The status report shall document the performance of the injection wells and shall follow the same format that has been supplied under the DOH's UIC permit and shall include daily maximum and average injection pressures, daily injection rate, total daily injection rate, daily minimum annulus pressure and calculated minimum annulus pressure required to depress the nitrogen/brine interface below 2,000 ft.

4. Injection Well Monitoring Program

Samples and measurements shall be representative of the monitored activity. The permittee shall utilize the applicable analytical methods described in Table I of 40 CFR §136.3, or in Appendix III of 40 CFR §261, or in certain circumstances, other methods that have been approved by the EPA. Reporting shall consist of a daily record of the injectant quantity being disposed of into each injection well and the daily average injection rate. The injection pressure shall be measured in the injectant line immediately before the wellhead or at the wellhead.

5. Injection Fluid Monitoring Program

(a) Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity. Injectant samples shall be taken at the reinjection line sampling port between the reinjection common header and injection well KS-1A or any active injection well.

(b) A monthly report shall be prepared for each well following the same format that has been supplied under the DOH's UIC permit. Records shall be kept for and this report shall include the following:

(i) The daily average injection rate;

(ii) The quantity of geofluids injected. These measurements shall be continuously made through a direct measurement of the injectant stream. A summary report shall be submitted to the EPA monthly for each injection well;

(iii) The quantity of supplement water injected. The recordings shall be continuously made with the use of instruments that directly measure the flow of the supplement water.

(iv) Chemical additions shall conform to the Chemical Additives Management Plan and use of such additives shall be recorded daily;

(v) The daily average temperature of the injectant;

(vi) The daily average annulus nitrogen pressure.

6. Injection Fluid Analysis

(a) The permittee shall comply with the analytical and reporting conditions of the facility's Chemical and Physical Analysis Plan For Injectant Testing in Appendix H, or as amended with written approval the EPA.

(b) Under applicable conditions, the EPA shall have the right to order and direct the permittee to collect and analyze special or unscheduled samples of the injectant. Applicable conditions consist of, but are not limited to, accidental discharges, malicious discharges, and undefined discharges

into the injection well. The permittee is required to maintain records of the sample collection and analysis in conformance with Part II.E.10 of this permit.

7. Injection Fluid Monitoring Data

Parameter	Monitoring Frequency	Instrument
injection pressure	continous	graphical chart, digital recording
	4X/day	visual observation
annulus pressure	continous	graphical chart digital recording
	4X/day	visual observation
injection rate	daily	graphical chart digital recording
injectant temperature	continuous	graphical chart

8. Calibration of Monitoring Equipment

All monitoring and recording equipment shall be calibrated on a regular basis. The permittee shall submit, to the EPA, a one-time report describing the calibration procedures and the frequency at which the equipment will be calibrated.

9. Automatic Alarms and Shut-Off Devices

(a) Visual checks shall be made daily of the injection pressure and annulus pressure gauges and their recording devices. Injection pressure shall also be monitored in the control room and an automatic computer printout system shall be maintained so as to notify operators when the injection pressure activates of the relief value in the combined brine reinjection line.

(b) The following shall be maintained in good working order: the pressure switch on the combined brine reinjection line; and the relief valves on the individual injection wells. The pressure switch and relief valves shall be set so as to not cause an exceedance of the injection pressures for the individual wells in Part II.D.2(a), or the fracture pressure of the formation, whichever is less.

(c) The two manual block values on each injection and production well shall be maintained in good working order.

10. Monitoring Information

Records of any monitoring activity required under this permit shall include:

(a) The date, exact place, and time of sampling or field measurements;

(b) The name of the individual(s) who performed the sampling or measurements;

(c) The exact sampling method(s) used to take samples;

(d) The date(s) laboratory analyses were performed;

(e) The name of the individual(s) who performed the analyses;

(f) The analytical techniques or methods used by laboratory personnel;

(g) The results of such analyses; and

(h) Chain of custody records.

11. Recordkeeping

(a) The permittee shall retain records concerning:

(i) The origin, physical properties, and chemical composition of all injected fluids until three (3) years after the well has been plugged and abandoned in accordance with the Plugging and Abandonment Plan shown in Appendix I; and

(ii) All monitoring information, including all calibration and maintenance records and recordings used for continuous monitoring and copies of all reports required by this permit, shall be maintained by the permittee for a period of at least five (5) years from the date of the sample, measurement, or report until the well had been plugged and abandoned.

(b) The permittee shall continue to retain such records after the retention periods specified in paragraph (a) unless it delivers the records to the EPA or obtains written approval from the EPA to discard the records.

(c) The permittee shall maintain copies (or originals) of all pertinent observation records available for inspection at the facility, unless the permittee has archieved the records with the EPA or has obtained permission from the EPA to discard the records.

12. Accurate, Current, and Representative Information

The submission of records, analytical results, recorded inspections, status reports, and any other reporting as specified and required by this permit shall be accurate, current, and representative of the activity being monitored within the specified time frame for monitoring. The submission of inaccurate, out-dated, and/or unrepresentative records, results, inspections, reports, and any other required information, or the nonsubmission of the required materials,

is a violation of this permit.

13. Reporting of Results

The permittee shall submit the following information to the EPA:

(a) Semiannual groundwater monitoring data as required by the Hydrologic Monitoring Program;

(b) Annual mechanical integrity test results and monitoring data as required by the Program for Mechanical Integrity Testing and Monitoring and Part II.E.2 of this permit, plus the forty-five (45) day notification prior to commensing tests;

(c) All records of mechanical integrity test results, monitoring data, workovers, well conversions, logging or other subsequent test data generated by the workover, alteration, or repair of a well as required by Parts II.B.5 and II.D.1.

(d) The one-time calibration report describing the calibration proceduces and frequency for monitoring equipment as required by Part II.E.8, in addition to calibrations required for the other reports;

(e) Quarterly injection well performance status reports as required by Part II.E.4 of this permit, which includes narrative descriptions and explanations of any incidence of noncompliance that has occurred;

(f) Twenty-four (24) hour oral and five (5) working day written narrative descriptions and explanations of all noncompliance that occurred;

(g) Well schematics, well pad location, latitude and longitude, area of review, need, and the maximum injection pressure for all new injection well proposals;

(h) Monthly reports shall be submitted for the reporting periods by the respective due dates as listed below:

Reporting Period	Report Due
Jan, Feb, Mar	May 1
Apr, May, June	Aug 1
July, Aug, Sept	Nov 1
Oct, Nov, Dec	Feb 1

Copies of the monitoring results and all other reports required by this permit shall be submitted to the following addresses:

U.S. Environmental Protection Agency
Ground Water Office (WTR-9)
75 Hawthorne St.
San Francisco, CA 94105

14. Modifications to Monitoring and Reporting

This permit herein acknowledges that environmental and facility operating conditions affecting the monitoring and reporting conditions of this permit could warrant the EPA's reevaluation of those conditions in order to address changing concerns and to establish relevant analyses. Modifications to the monitoring and reporting conditions, resulting from reevaluations, shall be approved by the EPA.

15. Modifications to Monitoring Programs

This permit herein acknowledges that conditions affecting the Hydrologic Monitoring Program and the Production and Casing Monitoring Program could warrant the reevaluation and modification of the monitoring programs to address changing concerns.

16. Additional Monitoring and Reporting

If the operation of the injection wells is additionally regulated by other pollution control programs, e.g., National Pollution Discharge Elimination System (NPDES), the adherence to the monitoring and reporting conditions of such other pollution control programs shall not be circumvented by the terms and conditions of this permit.

17. Twenty-Four Hour Reporting

Under any of the following conditions, an oral report to the EPA is required within 24 hours from the time the permittee becomes aware of the circumstances:

(a) Any monitoring, or other information, which indicates that the injection activity is causing or could cause an endangerment to a USDW.

(b) Any noncompliance with a permit condition, or malfunction of the injection well system, which may cause fluid migration into or between a USDW.

(c) Any overflows of the injection well or the emergency steam release facility (ESRF) pond.

A written report shall also be submitted within five (5) days of the time the permittee becomes aware of the circumstances. The written report shall contain a description of the incident and its cause, including exact dates and times, and if the incident has not been mitigated, the anticipated length of time that it is expected to continue; also, planned or accomplished measures to reduce, eliminate and prevent the reoccurrence of the incident.

Oral reports to EPA shall be made to (415)744-1835. Messages can be left at this number for oral reporting that occurs during evenings, weekends, and holidays.

18. Reporting of Noncompliance of Permit Limitations

The permittee shall notify the EPA of any exceedances of or noncompliance with limitations (i.e. conditions) contained in this permit. Permit limitations in this permit refer to, and are not limited to, injectant pressure, annulus pressure, injectant chemical concentrations, and physical parameters, chemical additives, and scheduled events such as analyses, evaluations, and reports. The notification shall consist of a report that shall include the parameter and/or event in question and an explanation for the exceedance or noncompliance. The report shall be submitted to the EPA within five (5) days of knowledge of the exceedance or noncompliance.

F. PLUGGING AND ABANDONMENT

1. Notice of Plugging and Abandonment

The permittee shall notify the EPA no later than forty-five (45) days before further conversion, workover, or abandonment of a well. The EPA may require that the plugging and abandonment be witnessed by a EPA representative.

2. Plugging and Abandonment Plan

The permittee shall abandon the well according to the Plugging and Abandonment Plan in Appendix I, and must also comply with the abandonment conditions required by the State of Hawaii and the County of Hawaii. The EPA reserves the right to change the manner in which a well will be plugged if the well is modified during its permitted life or if the well is not consistent with EPA requirements for construction or mechanical integrity. The EPA may ask the permittee to estimate and to update the estimated plugging cost periodically. Such estimates shall be based upon costs which a third party would incur to plug the well according to the plan. Prior to the construction of a new injection well, the financial assurance instrument shall be modified to reflect the cost of plugging and abandoning any additional well.

3. Plugging and Abandonment Report

Within sixty (60) days after plugging the well, the permittee shall submit a report on 7520-14 in Appendix I to the EPA. The report shall be certified as accurate by the person who performed the plugging operation, and the report shall consist of either: (1) a statement that the well was plugged in accordance with the plan, or (2) a statement specifying the different procedures followed where actual plugging differed from the plan.

4. Cessation of Injection Activities

The permittee shall properly plug and abandon, in accordance with the conditions in Part II.F.1-3, any injection well that is not performing its intended purpose or is determined to be a threat to a USDW, either voluntarily or thereupon notification by the EPA.

G. FINANCIAL RESPONSIBILITY

1. Demonstration of Financial Responsibility

The permittee is required to maintain financial responsibility and resources to close, plug, and abandon all underground injection wells, including active, temporarily abandoned (idle), and injection wells converted to monitoring wells, as provided in the Plugging and Abandonment Plan.

(a) The permittee has provided an irrevocable standby letter of credit, No. 306S230525, date May 5, 1997, and trust agreement for the estimated cost of plugging the three existing injection wells which is $417,200.

(b) Demonstration of financial responsibility must be provided to the EPA every year by June 1.

(c) The EPA can periodically require the permittee to update the Plugging and Abandonment Plan and the cost associated with it. If the updated estimate indicates that the cost of the plugging and abandonment is ten (10) percent greater or less than the most recent estimate, the financial assurance instrument shall be increased or decreased accordingly.

(d) Prior to the construction of any new injection well, the financial assurance mechanism shall be modified to reflect the cost of plugging the additional well. Should the cost of plugging the well, once it is constructed, vary by more or less than ten (10) percent of the original estimate, then the financial assurance mechanism shall be modified accordingly.

2. Insolvency of Financial Institution

The permittee must submit an instrument of financial responsibility acceptable to the EPA within sixty (60) days after either of the following events occur:

(a) The institution issuing the irrevocable standby letter of credit or financial instrument files for bankruptcy; or

(b) The authority of the trustee institution to act as trustee, or the authority of the institution issuing the financial instrument is suspended or revoked.

PART III. GENERAL CONDITIONS

A. EFFECT OF PERMIT

The permittee is allowed to engage in underground injection well operation in accordance with the conditions of this permit. The permittee shall not construct, operate, modify, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR Part 141 or may otherwise adversely affect the health of persons. Furthermore, any underground injection activity not specifically authorized in this permit is prohibited. Compliance with this permit during its term constitutes compliance for purposes of enforcement with Part C of the Safe Drinking Water Act (SDWA). Such compliance does not constitute a defense to any action brought under Section 1431 of the SDWA, or any other common or statutory law other than Part C of the SDWA. Issuance of this permit does not convey property rights of any sort or any exclusive privilege, nor does it authorize any injury to persons or property, any invasion of other private rights, or any infringement of State or local law or regulations. Nothing in this permit shall be construed to relieve the permittee of any duties under applicable regulations.

If at any time the EPA learns that an injection well may cause a violation of primary drinking water regulations, the EPA shall order the permittee to take such actions as may be necessary to prevent the violation, including, where required, cessation of operation of the injection well. The EPA will issue an order to immediately cease and desist injection upon receipt of factual information that the injection has caused or is likely to cause imminent and substantial danger to the health of a person or persons due to contamination of a public water supply or underground source of drinking water.

B. PERMIT ACTIONS

1. Modification, Revocation, Reissuance, and Termination

The EPA may, for cause or upon request from the permittee or any interested person or upon the EPA's initiative, modify, revoke and reissue, or terminate this permit in accordance with applicable jurisdictions under 40 CFR §§ 124.5, 144.12, 144.39, and 144.40. Also, the permit is subject to minor modifications for cause as specified in 40 CFR § 144.41. The filing of a request for a permit modification, revocation and reissuance, or termination, or the notification of planned changes, or anticipated noncompliance on the part of the permittee does not stay the applicability or enforceability of any permit condition. The EPA may also modify, revoke and reissue, or terminate this permit in accordance with any amendments to the SDWA if the amendments have applicability to this permit.

2. Transfer of Permits

This permit is not transferable to any person except after: 1) written notice and an application are submitted to the EPA thirty (30) days in advance of the proposed transfer date and in compliance with the requirements of 40 CFR § 144.38. The EPA may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary.

C. SEVERABILITY

The provisions of this permit are severable, and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected thereby.

D. CONFIDENTIALITY

In accordance with 40 CFR §§ 2 and 144.5, any information submitted to the EPA pursuant to this permit may be claimed as confidential by the submitter. Any such claim must be asserted at the time of submission by stamping the words "confidential business information" on each page containing such information. If no claim is made at the time of submission, the EPA may make the information available to the public without further notice.

E. GENERAL DUTIES AND REQUIREMENTS

1. Duty to Comply

The permittee shall comply with all applicable UIC Program regulations and conditions of this permit, except to the extent and for the duration such noncompliance is authorized by an emergency permit issued in accordance with 40 CFR § 144.34. Any permit noncompliance constitutes a violation of the SDWA and is grounds for enforcement action, permit termination, revocation and reissuance, modification, or for denial of a permit renewal application.

2. Penalties for Violations of Permit Conditions

Any person who violates a permit condition is subject to civil penalties, fines, and other enforcement action under the SDWA. Any person who willfully violates permit conditions may be subject to criminal prosecution.

3. Need to Halt or Reduce Activity not a Defense

It shall not be a defense, for the permittee in an enforcement action, that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

4. Duty to Mitigate

The permittee shall take all reasonable steps to minimize and correct any adverse impact on the environment resulting from noncompliance with this permit.

5. Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of this permit.

6. Duty to Provide Information

The permittee shall furnish to the EPA, within the time specified herein, any information which the EPA may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the EPA, upon request, copies of records required to be kept by this permit.

7. Inspection and Entry

The permittee shall allow the EPA or authorized representatives, upon the presentation of credentials and other documents as may be required by law, to:

(a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records are kept under the conditions of this permit;

(b) Have access to and copy any records that are kept under the conditions of this permit;

(c) Inspect and photograph any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

(d) Sample or monitor for the purposes of assuring permit compliance or as otherwise authorized by the SDWA, any substances or parameters at any location.

8. Records of the Permit Application

The permittee shall maintain records of all data required to complete the permit application and any supplemental information submitted with the permit application for a period of five (5) years for EPA from the effective date of this permit.

9. Availability of Reports

All reports prepared in accordance with the conditions of this permit shall be available for public inspection at appropriate offices of the EPA. Permit applications, permits, and well operation data shall not be considered confidential.

10. Signatory Requirements

All reports or other information requested by the DOH and/or EPA shall be signed and certified by a responsible corporate officer or duly authorized representative according to 40 CFR § 144.32.

11. Reporting of Changes and Noncompliance

(a) Anticipated Changes and Noncompliance

The permittee shall give advance notice, of at least seven (7) days, to the EPA of any planned changes in the permitted facility or activity which may significantly change any injection well operating characteristics or injection well specifications; or which may result in noncompliance with permit requirements. Changes, modifications or revisions in the operation characteristics or specifications of the injection wells shall not be implemented unless otherwise approved by the EPA.

(b) Twenty-four Hour Reporting

(i) The permittee shall report to the EPA any noncompliance which may adversely affect the health of persons or may endanger an USDW. Information shall be provided orally, within twenty-four (24) hours from the time the permittee becomes aware of the circumstance. Oral reporting shall conform to the conditions as specified in Part II.E.17 of this permit.

(ii) A written submission shall also be provided within five (5) days of the time the permittee becomes aware of the circumstances pursuant to Part II.E.17 of this permit.

(c) Other Noncompliance

The permittee shall report all other instances of noncompliance not otherwise reported at the time monitoring reports are submitted. The reports shall contain the information listed in Part II. E. of this permit.

(d) Other Information

Where the permittee becomes aware that it failed to submit all relevant facts in permit application, or submitted incorrect information in a permit application or in any report to the EPA, the permittee shall submit such facts or information within two (2) weeks of the time such information becomes

known.

12. Continuation of Expiring Permits

(a) Duty to Reapply

If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must submit a complete application for a new permit to the EPA at least one hundred eighty (180) days before this permit expires.

(b) Permit Extensions

The conditions of an expired permit may continue in force in accordance with 5 United States Code (U.S.C.) §558(c) until the effective date of a new permit, if:

(i) The permittee has submitted a timely application which is a complete application for a new permit;

(ii) The EPA, through no fault of the permittee, does not issue a new permit with an effective date on or before the expiration date of the previous permit; and

(iii) The new permit has not been denied, and if a denial has been appealed, the denial has not been upheld on appeal. (The appeal is still pending or has resulted in a reversal of the denial of the new permit application.)

13. Required Immediate and Followup Notifications of Non-permitted Releases

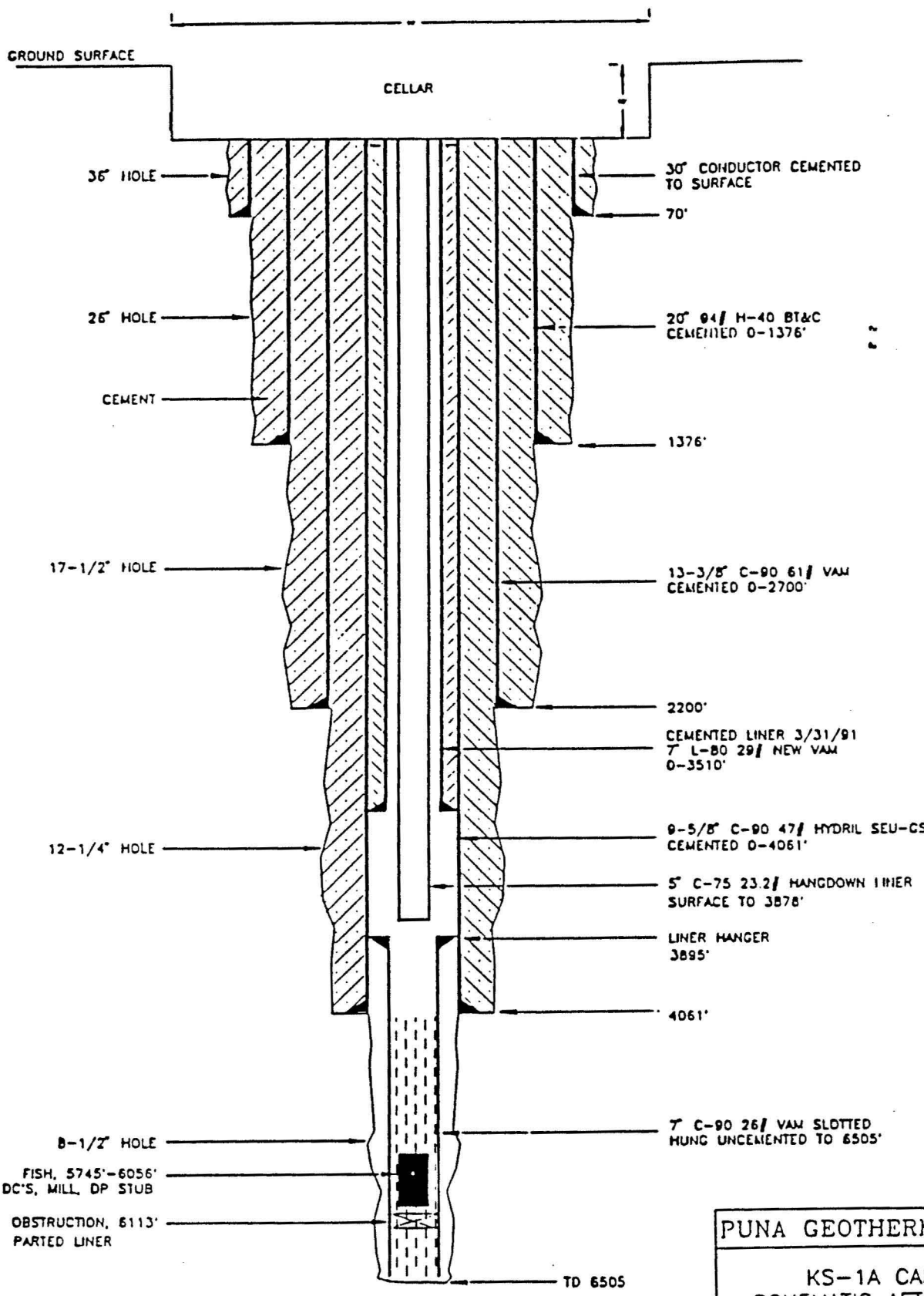
(a) Pursuant to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Section 103 and/or the Emergency Planning and Community Right To Know Act (EPCRA) Section 304, the permittee will immediately notify the National Response Center (NRC) at (800)424-8802, the Hawaii State Emergency Response Commission (SERC) and the Hawaii County Local Emergency Planning Committee (LEPC) as soon as it has knowledge that there has been a release into the environment of a reportable quantity of a hazardous or extremely hazardous substance.

(b) As soon as practicable following a reportable release under EPCRA Section 304, the permittee will submit a written followup report to the SERC and LEPC which conforms to the requirements of that section.

PART IV. APPENDICES

APPENDIX A

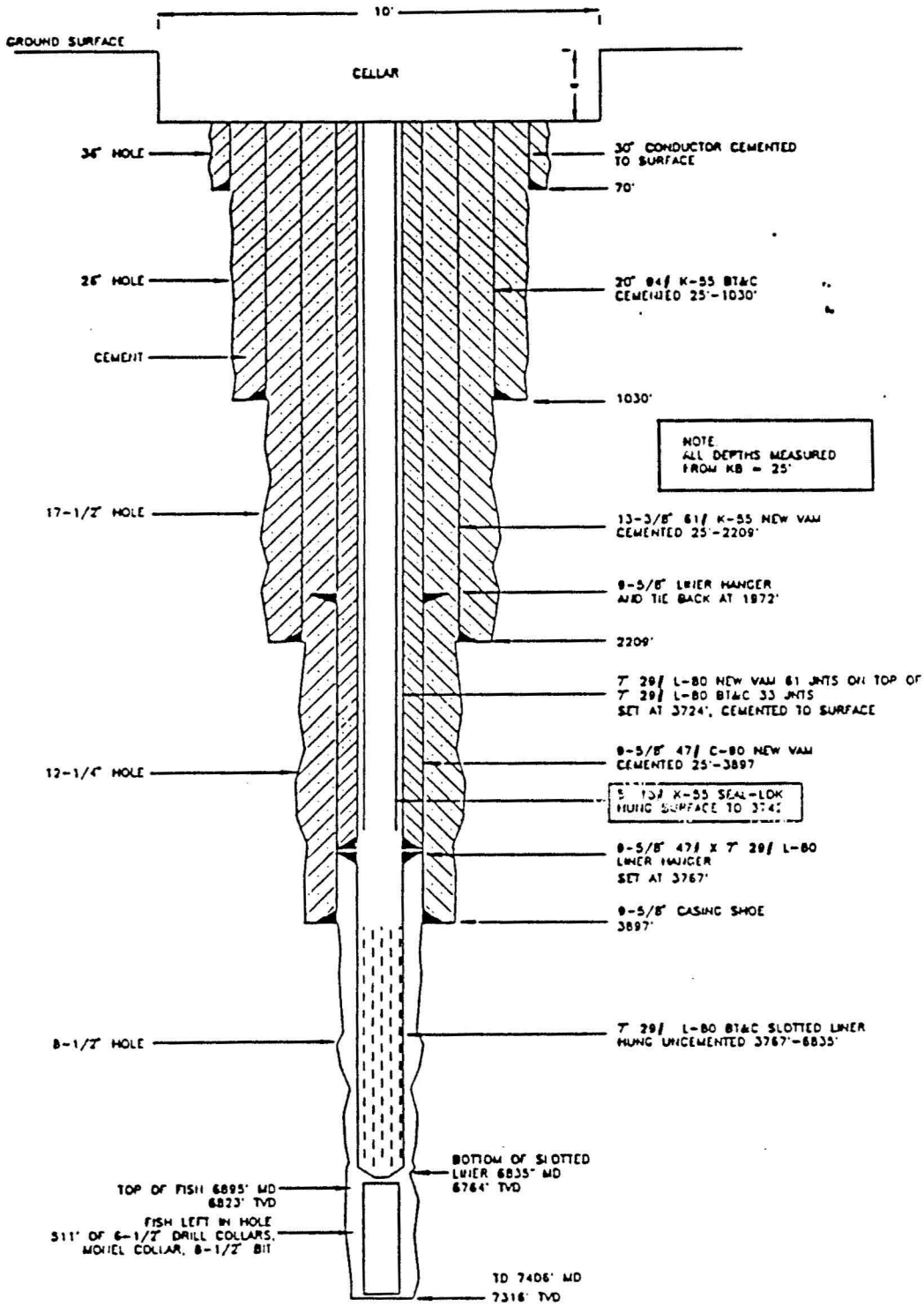
INJECTION WELL SCHEMATICS



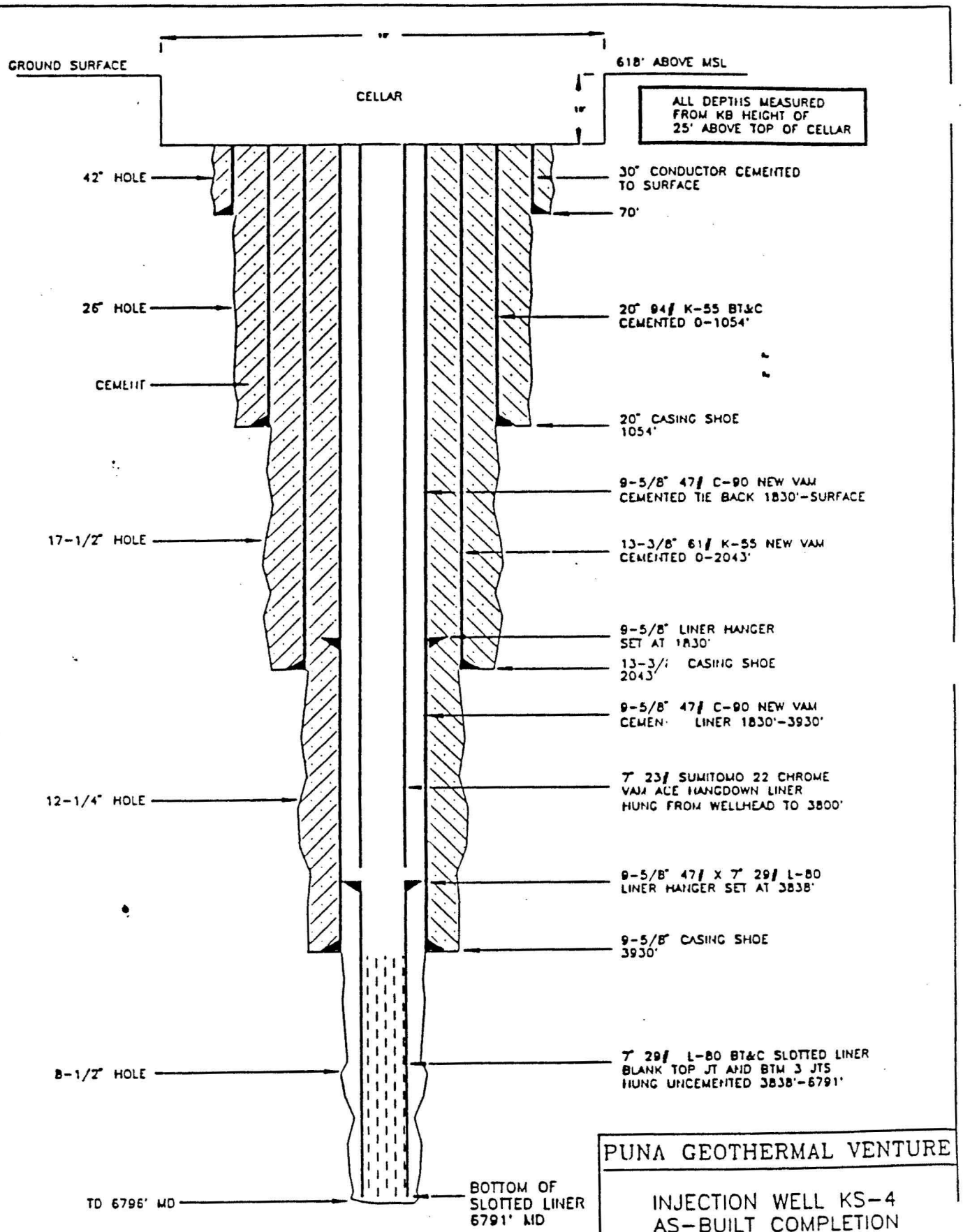
PUNA GEOTHERMAL VENTURE

KS-1A CASING
SCHEMATIC AFTER REWORK
AS OF 10/14/92

DATE 12/22/92		REV. 1



PUNA GEOTHERMAL VENTURE	
KS-3 COMPLETION SCHEMATIC AS OF 10/29/92	
DATE 10/30/92	REV. 2



PUNA GEOTHERMAL VENTURE

INJECTION WELL KS-4
AS-BUILT COMPLETION
SCHEMATIC

DATE 11/30/92		REV. 2
BY TEPLOW	FILE:PGV\KS4ASBLT.DWG	FIGURE NO. 3

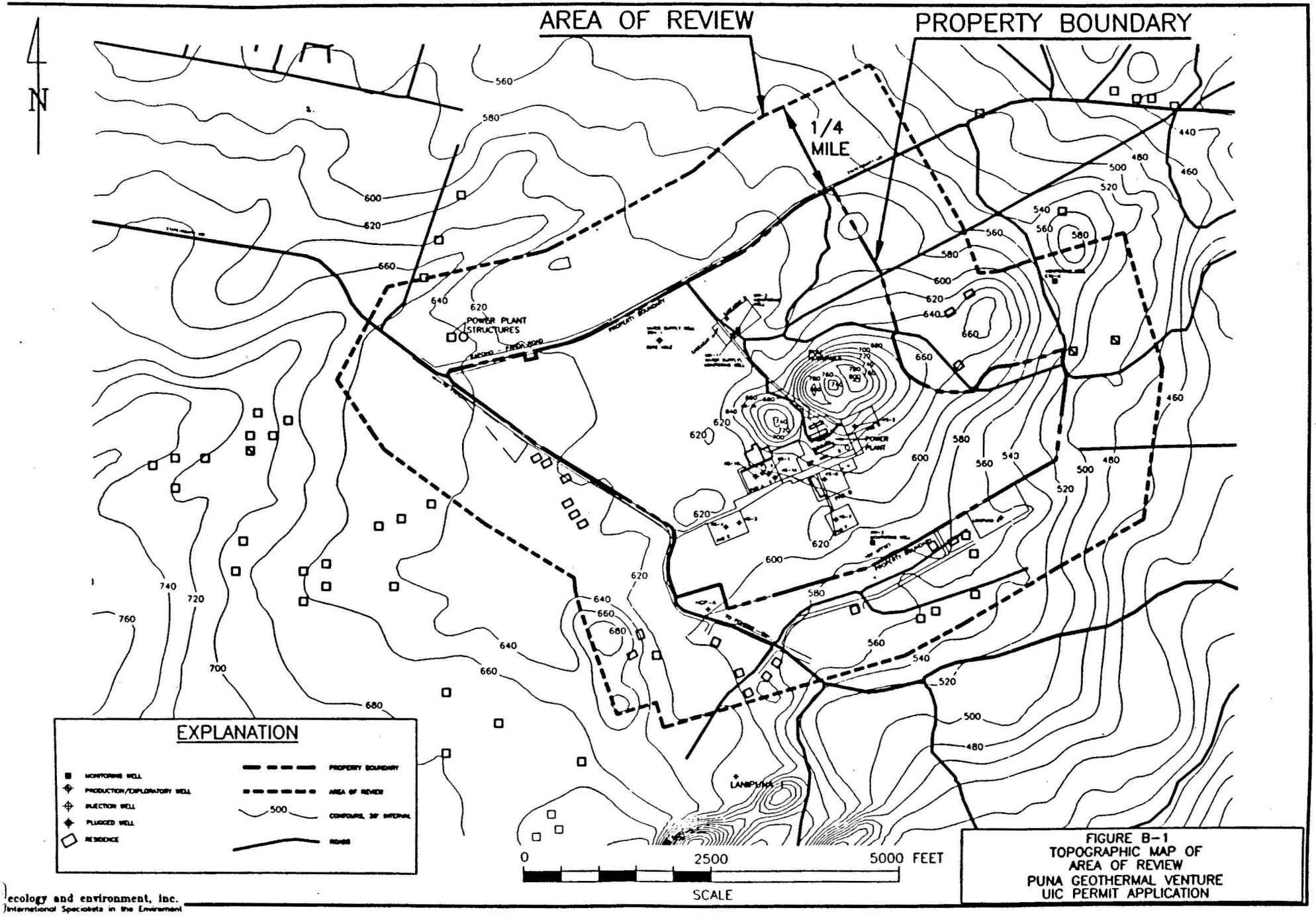


FIGURE B-1
TOPOGRAPHIC MAP OF
AREA OF REVIEW
PUNA GEOTHERMAL VENTURE
UIC PERMIT APPLICATION

ecology and environment, inc.
International Specialists in the Environment

APPENDIX B

EXISTING AND PROPOSED WELL LOCATIONS

APPENDIX C

APPROVED CHANGES AND WORKOVER PLANS

Form Approved. OMB No. 2040-0042. Expires 6-30-98

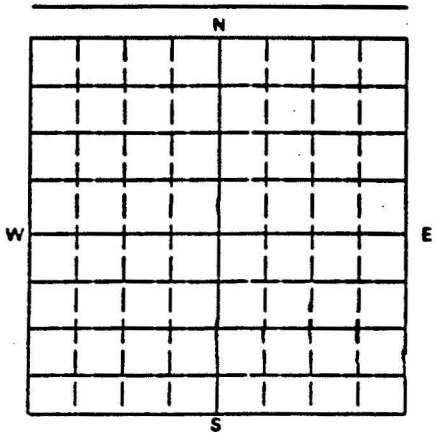
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

EPA

WELL REWORK RECORD

NAME AND ADDRESS OF PERMITTEE	NAME AND ADDRESS OF CONTRACTOR

LOCATE WELL AND OUTLINE UNIT ON SECTION PLAT — 640 ACRES



STATE	COUNTY	PERMIT NUMBER

SURFACE LOCATION DESCRIPTION
___ 1/4 of ___ 1/4 of ___ 1/4 of ___ 1/4 of Section ___ Township ___ Range ___

LOCATE WELL IN TWO DIRECTIONS FROM NEAREST LINES OF QUARTER SECTION AND DRILLING UNIT

Surface Location ____ ft. from (N/S) ____ Line of quarter section

and ____ ft. from (E/W) ____ Line of quarter section

WELL ACTIVITY	Total Depth Before Rework	TYPE OF PERMIT
☐ Brine Disposal ☐ Enhanced Recovery ☐ Hydrocarbon Storage	Total Depth After Rework	☐ Individual ☐ Area Number of Wells ____
Lease Name	Date Rework Commenced	Well Number
	Date Rework Completed	

WELL CASING RECORD — BEFORE REWORK

Casing		Cement		Perforations		Acid or Fracture
Size	Depth	Sacks	Type	From	To	Treatment Record

WELL CASING RECORD — AFTER REWORK *(Indicate Additions and Changes Only)*

Casing		Cement		Perforations		Acid or Fracture
Size	Depth	Sacks	Type	From	To	Treatment Record

DESCRIBE REWORK OPERATIONS IN DETAIL USE ADDITIONAL SHEETS IF NECESSARY	WIRE LINE LOGS, LIST EACH TYPE	
	Log Types	Logged Intervals

CERTIFICATION

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32).

NAME AND OFFICIAL TITLE *(Please type or print)*	SIGNATURE	DATE SIGNED

APPENDIX D

CASING MONITORING PROGRAM

PUNA GEOTHERMAL VENTURE

PROGRAM FOR MECHANICAL INTEGRITY TESTING AND
MONITORING OF INJECTION WELLS
July 29, 1996

1. INTRODUCTION

1.1 Background

Pursuant to Underground Injection Control (UIC) Permit No. HI5960002, the U.S. Environmental Protection Agency requires that Puna Geothermal Venture (PGV) comply with this Testing and Monitoring Program (TMP) for injection wells. Monitoring and testing provisions in this TMP are similar in most respects to those in the "Casing Monitoring Program," April 26, 1993 version, which is referenced by title in PGV's current UIC Permit No. UH-1529. It is anticipated that this same TMP will be approved and adopted by the Hawaii Department of Health as a replacement for the 1993 "Casing Monitoring Program." Revisions to testing and monitoring provisions in the 1993 "Casing Monitoring Program" have been made as a result of a joint review of PGV's injection well monitoring and testing involving EPA, BLM (as advisor to EPA), HDOH and PGV. The purpose of these revisions is to better accomplish the goal of protecting the groundwater aquifer under the PGV project site, which is considered to be a USDW. The principle changes in the monitoring and testing procedures are as follows:

- As described in Section 3.1 of this TMP for wells in injection service, the annulus nitrogen pressure will be maintained to keep the nitrogen/water interface at a depth of at least 2000 ft.

  The 1993 CMP requires that the nitrogen/water interface be maintained "more than half way down the annulus." Based on a nominal casing depth of 4000 ft, the two criteria are effectively the same.

- In accordance with Section 3.2.1, the annual casing pressure test of each well will be done by depressing the water level to 3000 ft with nitrogen while the well is on injection. Annulus pressure drop exceeding 10% in five hours will be considered indicative of a leak requiring diagnosis and repair.

  The 1993 CMP specifies that the pressure test be done by depressing the water level to the shoe of the 9⅝-inch casing with nitrogen (while, by practical necessity, the well is shut in.). An

annulus pressure drop exceeding 8% in 30 minutes was considered indicative of a leak requiring diagnosis and repair. The principle difference is the increase in length of the test period from 30 minutes to five hours, which makes the nitrogen pressure test equivalent to a 30-minute test with water.

1.2 Purpose

The purpose of this TMP is to specify the observations, tests, drilling operations and, if necessary, remedial actions required to insure that the mechanical integrity of injection well casing and cement is maintained throughout the drilling, testing and operation of PGV wells. The cemented and hung casing strings that are used in the PGV wells are designed to prevent contamination of any underground source of drinking water (USDW) by injected fluids. Contamination of the USDW's might occur if the casing strings are breached due to corrosion or mechanical failure or if there is a failure of the cement to seal the casing/borehole annulus between the casing shoe and the lowermost USDW. The testing and monitoring program described below is designed to detect and diagnose a loss of mechanical integrity in the casing or cement. Remedial actions required to restore mechanical integrity are also described.

1.3 Scope

This TMP covers all injection wells on the 500-acre PGV site.

2. TESTING DURING DRILLING AND COMPLETION

2.1 Pressure Testing During Drilling

Each injection well is completed with three casing strings (not including the 30-inch conductor pipe) cemented to the surface (Figure 1). Upon completion of cementing each casing string and prior to drilling out the cement shoe, the casing will be pressure tested. The DLNR will be notified at least 24 hours before each test for the opportunity to witness it. The test will consist of pressurizing the casing with water or drilling mud to a specified test pressure and monitoring the pressure for 30 minutes with the well shut-in. The minimum casing test pressure shall be approximately one-third of

the internal yield pressure rating, provided that the test pressure shall not be less than 600 psig nor greater than 2500 psig. In cases where combination strings or liners are involved, the above test pressures shall apply to the lowest pressure-rated casing. The pressure drop during the 30-minute period shall not exceed 10% of the test pressure.

In the event of a pressure loss exceeding the above criterion, one or more of the following diagnostic methods will be used to locate the leak:

- Temperature log while injecting
- Shut-in temperature survey
- Casing inspection logs with multi-arm caliper and/or magnetic inspection tools
- Pressure testing with a packer(s) on drillpipe
- Other applicable methods

After identification of the point of leakage, a cement squeeze job will be performed and the casing retested.

After a successful pressure test of each casing string, drilling will proceed to a point at least one foot below the casing shoe, and a pressure leak-off test will be performed to test the integrity of the annular cement. Each test will be performed at a pressure approaching the fracturing pressure of the exposed formation. If there is excessive leak-off, a squeeze cement job will be performed, the cement will be drilled out and the test will be repeated. Drilling will not proceed until an effective cement seal is established in the casing/borehole annulus above the casing shoe. In some situations, such as the case where there is natural formation permeability immediately below the casing shoe, it may not be practical to prove cement integrity with the pressure test described above. As an alternative, a standard water shutoff test (WSO) may be done above the shoe, or shut-in temperature surveys may be run.

2.2 Logs and Surveys During Injection Testing

Upon completion of drilling and prior to installation of the hangdown liner, a water injection test may be performed, if needed, to obtain a preliminary evaluation of the well. During such a test, one or more of the following logs or surveys may be run:

- TPS or T/P logs through the open hole and cased intervals with the well on injection; or

- Shut-in temperature survey(s) before and/or after injection.

If any of these logs or surveys indicates a loss of mechanical integrity, the problem will be diagnosed, and repair procedures will be performed in accordance with Section 2.3.

2.3 Casing Repair

Once a loss of mechanical integrity is identified and approximately located, casing repair procedures will be initiated. These procedures may include any or all of the following activities:

2.3.1 Shut in well and run magnetic and multi-arm casing inspection logging tools to locate the leak and to evaluate the casing condition.

2.3.2 Rig up workover rig on well. Run packer(s) on drillpipe and pressure test to confirm suspected leaking interval.

2.3.3 Execute cement squeeze job to seal casing leak or stop interzonal flows behind casing.

2.3.4 Perform casing pressure test and other diagnostic tests as necessary to confirm success of the remedial work. If good, move rig off well and return well to injection service.

2.3.5 In the event of major casing failure, a cemented liner may be installed through the damaged interval.

2.3.6 Prior to drilling out the liner shoe, the liner will be pressure tested as described in Section 2.1.

2.3.7 If mechanical integrity cannot be restored satisfactorily, the well will be plugged and abandoned.

3. MONITORING AND TESTING AFTER WELL IS PLACED IN SERVICE

3.1 Continuous Monitoring During Routine Injection Operations

During routine injection well operations, including brief periods when well(s) may be temporarily out of service, the following conditions will be maintained:

3.1.1 A continuous recording of the following parameters will be maintained for each well:

- Injection wellhead pressure,
- Annulus (nitrogen) pressure, and
- Injection flow rate.

These parameters shall be recorded on a graphical chart which shows their relationship to elapsed time. Plant operators will take daily readings at each well.

3.1.2 The annular space between the hangdown liner and cemented casing will be pressurized with nitrogen, and the pressure will be monitored and recorded in accordance with Section 3.1.1 above. The annulus will be repressurized with nitrogen as necessary to maintain the nitrogen/water interface at a depth of 2000 ft KB (1975 ft below ground level) or deeper. Some loss of nitrogen pressure is normal, and occasional repressurization will be required. If the rate of nitrogen pressure decline is such that it is impractical to maintain the required minimum pressure, it will be considered indicative of a leak requiring diagnosis and repair.

3.2 Annual Testing

Once annually, tests and surveys will be conducted to verify mechanical integrity of the hangdown liner. The casing and hangdown liner will be tested for leaks by one of the following procedures, or a combination thereof:

3.2.1 Perform a pump-down test on the annulus between the hangdown liner and the cemented casing. The test will be done with the well on injection at normal operating flow rate and wellhead pressure, or higher. Nitrogen will be injected into the annulus to a pressure sufficient to displace the water level to a depth of at least 3000 ft and shut in. Surface pressure on the annulus and hangdown liner will be monitored and recorded. Annulus pressure leak-off exceeding 10% in five hours will be considered indicative of a leak requiring diagnosis and repair. Analysis to quantify the rate of nitrogen pressure leak-off will include a correction for changes in wellhead pressure and injection rate during the 5-hour test period, if applicable.

or

3.2.2 If the hangdown liner is pulled, the casing may be pressure tested above a bridge plug or packer set near the shoe following the basic procedure outlined in Section 2.1. Integrity of the hangdown liner may be verified by inspection on the surface, by a pressure test (with nitrogen) after it is run in the hole, or by a TPS log with the well on injection.

Integrity of the cement (external mechanical integrity) will be checked during each workover by one or more of the following procedures:

3.2.3 One or more shut-in static temperature surveys will be run. Shut-in time will be at least 12 hours, or longer if necessary to obtain meaningful results.

or

3.2.4 Other logs or surveys may be run, at the discretion of PGV, if static temperature surveys are not definitive.

3.3 Restoration of Mechanical Integrity or Abandonment

In the event that the diagnostic procedures indicate a loss of mechanical integrity, remedial or abandonment procedures will be carried out as specified in Section 2.3.

CSGMON96.INJ

APPENDIX E

INJECTION PRESSURE LIMITATIONS FOR NEW WELLS

APPENDIX F

CHEMICAL ADDITIVES

Product Name	Chemical Ingredient
Catalyzed Sulfite	Sodium Sulfite Benzoic Acid
Amersite 11	Sodium Sulfite Sodium Hydroxide Sodium Gluconate
WPD 11-306 (Tm)	Dimethyldioctylammonium Chloride Soya Amine Polyethoxylate Cyclohexylamine
West R-322	Polyamidoamino Acetate POE (15) Tallow Amine
Midland 203	Sodium Metabisulfite Cobalt Compounds
Drew 11-575	Sodium Chloride Phosphonic Acid Derivative Trade Secret per MSDS
Sodium Hydroxide	Sodium Hydroxide (NaOH)
Biosperse 250	Magnesium Nitrate 5-Chloro-2-Methyl-4-Isothiazolin-3-one Magnesium Chloride 2-Methyl-4-Isothiazolin-3-one Cupric Nitrate
Midland 676	Disodium Ethylenebis-Dithiocarbamate Dimethylamine Ethylene Diamine Ethylene Thiourea
Drew 11-480	Soya Amine Polyethoxylate
Sulfuric Acid	Sulfuric Acid (H_2SO_4)

APPENDIX G

HYDROLOGIC MONITORING PROGRAM

Ground water monitoring shall be conducted in accordance with the Hawaii Department of Health's UIC permit #UH-1529 to PGV and the "Puna Geothermal Venture Hydrologic Monitoring Program", dated April 1990, with the following exceptions. Ground water samples shall be taken from MW-1, MW-2, GTW-III, and Malama Ki. Ground water sampling and reporting shall occur once every six months and can be scheduled to also meet the requirements of the Hawaii Department of Health's UIC permit #UH-1529 to PGV. Detection limits shall be below the Maximum Contaminant Level (MCL) for those analytes that have an MCL. Any analyte concentration detected above the detection limit shall be reported.

PUNA GEOTHERMAL VENTURE

HYDROLOGIC MONITORING PROGRAM

PREPARED BY:

Science Applications International Corporation

April, 1990

TRANSMITTAL LETTER

F11-2

PUNA GEOTHERMAL VENTURE
HYDROLOGIC MONITORING PROGRAM

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ATC	Authority to Construct
dB	Decibel Level - relative
dBA	Decibel Level - absolute
dd	Distance doubled
DOH	State of Hawaii Department of Health
EPA	United States Environmental Protection Agency
GRP	Geothermal Resources Permit
GTW	Geothermal Test Well
H_2S	Hydrogen Sulfide
HMP	Hydrologic Monitoring Plan
LERZ	Lower East Rift Zone
m	Meters
mm	Millimeters
MAQMP	Meteorologic and Air Quality Monitoring Plan
MMMD	Mean Maximum Mixing Depth
MW	Megawatt
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NBS	National Bureau of Standards
NMP	Noise Monitoring Plan
NWS	National Weather Service
PGV	Puna Geothermal Venture
PM	Particulate Matter
ppb	Parts per billion
ppm	Parts per million
ppmv	Parts per million volume
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QC	Quality Control
RH	Relative Humidity
SAAQS	State Ambient Air Quality Standards
SLM	Sound Level Meter
TSP	Total Suspended Particulates
YSI	Yellow Springs Instrument
ZAM	Zero Air Module

PUNA GEOTHERMAL VENTURE
HYDROLOGIC MONITORING PROGRAM

EXECUTIVE SUMMARY

This Hydrologic Monitoring Program is being submitted as part of the requirements of the Geothermal Resource Permit Condition 10. The Program as submitted is in full compliance with this condition. It will document the hydrologic conditions in the shallow aquifer in existing wells that occur in the vicinity of the site and at a water supply well on the site prior to and over the duration of the project activities.

Scope

The scope of the plan provides for quarterly monitoring of water levels and appropriate chemical species from existing wells completed in the shallow aquifer in those areas downgradient of the project area, at the Green Lake water supply, and from two monitoring wells located within the project boundary completed within the shallow aquifer.

The proposed scope of the monitoring program will be to:

- Review and update the well data files for existing non-geothermal wells in the site vicinity,
- Identify the location of the two on-site monitoring wells,
- Determine the flow gradient in the site vicinity by completing two on-site and rehabilitating a third, nearby, monitoring well (GTW III).
- Document background conditions for selected wells by conducting the initial round of complete water level measurements and water sampling at all monitoring wells and water supply locations prior to beginning injection activities at the site, and,

- Implement the proposed monitoring program by conducting measurements on a quarterly basis thereafter.

Permit Conditions 11 and 13 are, in part, related to ground water, but, since they relate to potential upset conditions for the project, any necessary response actions go beyond monitoring routine activities at the site. They require, in the event of shallow ground water contamination being caused by the project construction or operation (Condition #11) or the Green Lake Water Supply becoming contaminated as a result of the project (Condition #13), that the source of the contamination be eliminated and that an alternative water supply for Green Lake be provided.

PGV will immediately notify the County Planning Department and State Department of Health in situations when a change in geothermal well conditions indicates there is a leak or failure in the production or injection well casing. PGV will take the appropriate steps to test the production/injection system and evaluate the related well and casing downhole conditions. If leakage of geothermal waters to the shallow aquifer is demonstrated, any wells leaking would be shut in accordance with GRP Condition 11, and an assessment of the potential impact would be made by the monitoring contractor. In addition, steps would be identified to evaluate the impact as it relates to downgradient water users.

Equipment, Data Collection and Reporting

Water level meters will be used to measure the depth to water at all monitoring locations. Samples will be taken using pumps in wells equipped with these devices or using bailers. Field analyses will be supplemented by laboratory analyses for components that have been developed by PGV in concert with the State Department of Health, Safe Drinking Water Branch. All samples will be taken and field analyses conducted in accordance with standard protocols approved by the EPA. An EPA or State of Hawaii-certified laboratory will be used to conduct the analyses for samples submitted.

The final locations established for monitoring will be sampled and measured quarterly. Data from each site will be processed and checked. Quality Control/Quality Assurance procedures will be in compliance with standards of practice for similar programs relative to the acquisition, reduction, verification, and validation of the site data.

In compliance with permit conditions, semi-annual reports of the data will be submitted along with the project status reports on February 15 and August 15 of each calendar year.

PUNA GEOTHERMAL VENTURE
HYDROLOGIC MONITORING PROGRAM

H1. INTRODUCTION

This document provides the basis for the Hydrologic Monitoring Program (HMP) for the Puna Geothermal Venture. The HMP is complementary to two additional environmental compliance monitoring programs also being submitted by PGV for their proposed activities at the site. The other two programs are the Meteorology and Air Quality Monitoring Program (MAQMP) and the Noise Monitoring Program (NMP), being submitted concurrently.

The HMP is organized into the following eight chapters, which make up the entire program:

Chapter H1, INTRODUCTION, presents the background, purpose, and scope of the monitoring program. Chapter H2, HYDROLOGIC ENVIRONMENT DESCRIPTION, presents background about the geology, hydrogeology and hydrochemistry of the site vicinity based on previous studies. Chapter H3, PROGRAM DESCRIPTION, describes the activities associated with the proposed program. Chapter H4, SITE DESCRIPTIONS, identifies characteristics associated with the expected monitoring locations. Chapter H5, MONITORING EQUIPMENT AND OPERATION, describes the type of equipment to be used in the measurement, sampling, and analyses of the ground water. Chapter H6, DATA REPORTING, presents the manner in which the monitoring program data will be reported. Chapter H7, QUALITY ASSURANCE PROGRAM, identifies the quality control and quality

assurance procedures that will be incorporated as part of the program. Chapter H8, REFERENCES, lists the references cited throughout the text, and in the Figures, Tables, and Appendices. Appendices H1 through H3 contain support documentation for the proposed program.

H1.1 BACKGROUND SUMMARY

On October 3, 1989, the County of Hawaii Planning Commission approved a Geothermal Resource Permit (GRP) GRP 87-2 allowing PGV to proceed with development of a geothermal energy source in the State of Hawaii. PGV will build and operate this 25 MW geothermal energy plant on the Big Island of Hawaii, about 25 miles south of Hilo (Figure H1-1). The project is expected to be producing power in late 1990 from a central production facility situated in an agricultural and rural setting about 3 miles southeast of the town of Pahoa (Figure H1-2). The area is in the Lower East Rift Zone (LERZ) of the Kilauea Volcanic Area, about 20 miles east of the current eruptive center.

The site area is about 500 acres. Approximately 25 of these acres will be disturbed by up to six drill pads, the plant site, and associated piping. Drilling will take place for up to about two years with an anticipated 10 to 14 wells being required to produce adequate steam and hot geothermal liquid to meet the required production capacity. Well depths are expected to be between 4000 and 7000 feet. Steam and liquid coming to the surface will be injected back into the geothermal reservoir using dedicated wells.

There will not be any emissions, other than fugitive, to air or water under normal operational conditions. Well venting and pipe clean out are intermittent but necessary parts of the development of the project. These actions will be scheduled to minimize impacts.

H1.2 OBJECTIVES AND SCOPE

A Hydrologic Monitoring Program is a requirement of the GRP. The text of GRP Condition #10 associated with the HMP is provided in Appendix H1. The general objective of the HMP as stated, is to:

> "...monitor the shallow ground water immediately prior to, and during, all periods of well drilling, testing, production, and injection activity approved under the Geothermal Resource Permit."

This objective will be met by implementing the proposed monitoring program which is described in detail in the following sections.

The required scope of the HMP, as outlined in Condition #10 of the GRP, requires that the following actions be conducted as a minimum:

- Provide quarterly monitoring of water levels and appropriate chemical species:
  - from existing wells completed in the shallow aquifer in those areas downgradient of the project area,
  - from the Green Lake water supply, and
  - from a well located within the project boundary and completed within the shallow aquifer.

- Submit the data obtained from this program on a regular basis as outlined in the GRP.

PGV's proposed scope for the HMP consists of the following seven tasks:

Task 1: Review and update, with selected field measurements, the well data files for existing, non-geothermal wells in the site vicinity,

Task 2: Identify where the two site monitoring locations will be within the project boundary,

Task 3: Rehabilitate the GTW III well east of the project area,

Task 4: Drill and complete two on-site monitoring wells,

Task 5: Document background conditions for the selected wells by conducting the initial round of water level measurements and water sampling at all monitoring wells and water supply locations prior to beginning of injection of geothermal fluids,

Task 6: Continue the proposed monitoring program by conducting measurements and selected sample analyses on a quarterly basis thereafter, and,

Task 7: Provide data reports as required.

Two other Permit conditions are, in part, related to ground water, but, since they relate to potential upset conditions for the project, any necessary response actions go beyond the scope of the routine HMP. They require, in the event of shallow ground water contamination being caused by the project construction or operation (Condition #11) or the Green Lake Water Supply becoming contaminated as a result of the project (Condition #13), that the source of the contamination be eliminated and that an alternative water supply for Green Lake be provided.

PGV will immediately notify the County Planning Department and the DOH in situations when a change in geothermal well conditions indicates there is a leak or

failure in the production or injection well casing. PGV will take the appropriate steps to test the production/injection system in question and evaluate the related well and casing downhole conditions. If leakage of geothermal waters to the shallow aquifer is demonstrated, the well would be shut in accordance with GRP Condition #11, and an assessment of the potential impact on the shallow aquifer would be made by the monitoring contractor. In addition, appropriate steps would be identified to evaluate the impact as it relates to downgradient water users.

H2. HYDROLOGIC ENVIRONMENT DESCRIPTION

The purpose of this chapter is to present an overview and summary of what is known about the geologic, hydrogeologic, and hydrochemical setting of the near surface, shallow ground waters at the site and surrounding vicinity. Local conditions, wells, and related features relative to the site hydrologic system are shown on Figure H2-1.

Investigations related to the geothermal development of the area have been ongoing in the site vicinity for about 20 years. Much of the work has evaluated the geologic setting and hydrothermal characteristics associated with the deeper reservoirs below the shallow ground water. Details of the background studies conducted in the 1970s and early 1980s are included in several reports developed by Thermal Power Company (TPC), the previous operators of the PGV project. Three specific studies done which include much of the pertinent data and information related to the hydrogeology and hydrochemistry of the shallow aquifer system at the site include Kroopnick (1978), Weiss Associates (1983), and Thermal Power Company (1986).

H2.1 GEOLOGIC SETTING

The purpose of this section is to present a summary of the geology that has been described by other investigators for the site area.

The project site is in the southeastern part of the Island of Hawaii within the Lower East Rift Zone (LERZ) of Kilauea Volcano. The area is characterized by vesicular, young, sub-aerial basalt lava flows and high annual rainfall.

Weiss (1983, p. 4) reports the following related to the rift zone and the dike systems that influence the areas vulcanism and geology:

"(The rift zone)...is a zone of linear fissures, faults, cones, dikes and other volcanic features that extend from the Kilauea crater east...(to the ocean).

The basalts that originate along the rift form gently sloping layers of several inches to more than one hundred feet thick. Along the rift, the dikes feeding the flows form vertical walls of dense basalt, and a structure of many closely-spaced vertical dikes results in the near horizontal, less dense flows."

The general geologic setting is, therefore, progressively younger overlying lava flows at depths extending from thousands of feet up to the surface, cut vertically along the rift zone by an east-west trending dike system. In the immediate site area, a north-south trending transverse fault and potentially associated dikes cross-cut the easterly rift zone trend and are thought to be directly linked to the upward migration path for geothermal waters in the area (Figure H2-1).

H2.2 HYDROGEOLOGIC SETTING

The purpose of this section is to present a summary of the understanding of the ground water flow systems active in the site and surrounding area.

The occurrence of ground water in Hawaii was summarized in general by Weiss (1983, p. 13) based on the results of many earlier investigations by the U.S. Geological Survey, Hawaii DOH, University of Hawaii researchers, and other local experts. They identified four main types of ground water in Hawaii, all of which are potentially occurring in the site and surrounding vicinity. They are basal, perched, dike-confined, and geothermal. Figure H2-2 is a cross-section conceptually illustrating how these four types of ground waters occur in 'shallow-aquifer' type zones.

H2.2.1 Recharge Mechanisms

The site is characterized as being in an area of relatively high recharge, with ground water flow occurring in interlayered low to high permeability sub-horizontal lava flows. Ground water flow in the site area has two primary and one potential secondary recharge mechanisms. The primary mechanisms are from precipitation and from local upwelling of geothermal fluids. Downgradient flow from Mauna Loa may also occur, but it is unlikely that this secondary mechanism, if present, is as important to the site area. Perched waters may occur in the area, but their existence has not been documented.

Precipitation

Precipitation is one of the three recharge sources to the area. Average rainfall in the area is reported to be from about 110 to 125 inches per year (Weiss, 1983, p. 5; Kroopnick, 1978, p. 11). An estimated 73 percent of the rainfall percolates downward to the shallow ground water table (Eyre, 1977). Recharge to the shallow ground water system underlying the 500 acre site area would be on the order of about 3400 to 3800 acre-feet per year based on the estimated range of rainfall and the percolation percentage provided by Eyre.

Upwelling Geothermal Fluids

The second primary mechanism for ground water recharge at the site area is from upwelling geothermal fluids. The vertical pathways for the geothermal fluids are believed to be first, in fractures and fault planes adjacent to and associated with the dikes and, second, in areas such as the transverse fault that cuts across the site area between KS-1 and the HGP-A geothermal research well (Figure H2-1). The upwelling is further suggested by the characteristics of the shallow geothermal-influenced ground water (Section H2.3) that has been detected at the site to date.

Downgradient Flow

A secondary mechanism for ground water recharge to the area is believed to be from ground water flowing laterally towards the site area from the north and northwest, down slope from Mauna Loa. The dike systems act as local barriers preventing this underground flow from continuing to move downgradient towards the ocean. Instead, the majority of the ground water is believed to change direction moving to both the east and west along the rift.

H2.2.2 Discharge Mechanisms

Discharge from the shallow aquifer systems occurs from three primary mechanisms, evaporation and evapotranspiration, subsurface migration or lateral underflow, and extractions for drinking water and irrigation use. There are no surface streams in the immediate area.

Evaporation and Evapotranspiration

Evaporation and evapotranspiration represent the principal consumptive use in the area. About 25 to 30 percent of the water falling as precipitation is believe to be consumed in this manner (Eyre, 1977).

Subsurface Migration or Underflow

Flow occurs from the site area and discharges down slope towards the ocean. Spring and sub-sea discharge of warm water along the coast south of the project area has been investigated by researchers working in the area. Local precipitation that reaches the shallow aquifer in the dike-controlled or basal flow areas will also move downgradient away from the site, although the rate and direction of flow are not documented.

Consumptive Use

There are a few shallow aquifer sources that provide ground water for drinking and irrigation purposes in the area in or south of the rift zone. The amount extracted at Green Lake is on the order of 50,000 gallons per day (County of Hawaii, Water Supply Department, 1989, written communication). Volumes for the other wells, if they are being used, are not known.

Discharges from private lands from springs and shallow wells directly along the coast also occur, but the quantities are not known and are not going to affect, nor be affected by, the project activity since they are so near to the ocean and will have local recharge from precipitation to these areas.

H2.2.3 Flow System Description

Based on the work and site data analysis done to date, the following flow dynamics are apparently associated with the site ground water movement:

- The net rainfall (precipitation minus evaporation and evapotranspiration) flows downward into a dike-confined flow system underneath the site, recharging both the shallow ground water systems in the dike-confined areas and into any adjacent shallow basal ground water areas.
- Geothermal waters occur at depth beneath the site and are upwelling in the site area mixing with the precipitation recharge.
- Most ground water moving laterally down slope from Mauna Loa does not reach the site area as it is blocked by the rift zone and dikes. Instead, most is diverted and flows along the rift zone, possibly to both the east and west.

Only a few wells exist in the site and surrounding vicinity which are completed in the shallow ground water aquifer and believed to be potentially downgradient from the project area. Table H2-1 lists the wells currently identified as being completed in this zone. No recent water level measurements are available for many of the wells. Their locations are shown on Figure H2-1.

Table H2-1. Wells in the Shallow-Aquifer[1]

Well Name/Number	Elevation	Depth	Last Reported Use
Allison [A]	132	140	Irrigation
GTW-III	563	690	Abandoned
GTW-IV	259	290	Abandoned
Malama Ki [9-9]	274	316	Abandoned
Kapoho [9-6]	287	337	Abandoned
Kapoho Shaft [9]	38	41	Municipal

Footnotes:
1. Data reported in Weiss, 1983, Table 4, p. 26.

H2.3 HYDROCHEMICAL SETTING

The purpose of this section is to summarize what is understood about the hydrochemistry of the shallow ground water aquifer at and in the immediate potential downgradient directions from the site vicinity.

The LERZ is believed to act as a hydraulic barrier as well as a divide for ground water quality. Chloride concentrations north of the rift are generally low, and concentrations south of the rift have been reported to be greater than 1000 mg/l.

Potable water supplies are obtained from the shallow aquifer at three locations: Pahoa, Green Lake (Kapoho), and Keauohana [9-7]. All are more than 3 miles from the site. Pahoa is north of the rift and has good drinking water quality. Green Lake

is in the rift zone and has marginal water quality. The Keauohana [9-7] well is south of the rift zone about 6 miles southwest of the site and has good water quality.

Geothermal waters have been believed to be influencing and mixing with the shallow ground water in the site vicinity for some time. In 1986, TPC compiled much of the background geochemical data for wells in the site area. This was done as part of their request to the DOH to have the Underground Injection Control line moved so as to exclude the site and surrounding area from continuing to be designated as a potential underground supply source of drinking water. Results of their study suggested that there was no potential for a potable water supply to be developed in the site area due to the abundance of geothermal-influenced shallow-aquifer waters occurring over a relatively widespread area near and downgradient from the site.

The University of Hawaii (UH) Agricultural Station at Malama Ki and the Allison wells are located south and east southeast of the site. They have elevated temperatures and levels of chloride in excess of 7000 and 750 mg/l, respectively (Weiss, 1983, p. 26). Both wells may be influenced either directly or as a result of mixing with the upwelling geothermal waters from near the site. The Malama-Ki well is not in use. It is located just south of the transverse fault, about one mile south of the project area. The Allison well, previously used for agriculture as an irrigation water source, is topographically downgradient, about two miles east, southeast from the project area.

The GTW III well just east of the project area was drilled in 1961. The initial sampling of shallow aquifer indicated a temperature of about 200°F and chloride levels over 500 mg/l (Weiss, 1983).

Water samples were taken from the shallow ground water during drilling at KS-1, KS-1A, and KS-2 exploration boreholes on the property. Samples were taken in uncased boreholes at depths of about 700 feet, well above the level of the target geothermal horizons. Table H2-2 summarizes the ranges of constituents for these samples. The

samples clearly indicate the geothermal nature of the shallow ground water in the immediate site area.

Results of the sampling done to date indicate that the site vicinity has geothermal-influenced waters in the immediate area. Potable water lies to the north of the rift zone and, based on the existing data, will not be affected by the upwelling of geothermal fluids in the area. The relationship of the waters at Green Lake to the upwelling in the site vicinity is not established, although some investigators have suggested they are not connected or affected by the PGV site area. The area near the Keauohana well is too distant and hydraulically lateral from the site and therefore will not likely be affected by site-related upwelling. Potentially downgradient locations at the Allison and Malama Ki wells have non-potable waters that may be mixed with, or be the direct result of, geothermal waters upwelling locally.

Table H2-2. Shallow-Aquifer Water Quality Data from KS-1, KS-1A, and KS-2 Wells[1]

CONSTITUENT	RANGE OF VALUES[2]
Temperature	115°F
pH	8.5 to 9.5 pH units
Na	600 to 1000
K	26 to 94
Ca	53 to 65
Mg	1 to 30
Cl	1100 to 1600
SO_4	74 to 210
SiO_2	80 to 105
Total Fe	15 to 70
TDS	2200 to 3100

FOOTNOTES:
1 - Source of data from internal files from TPC Project.
2 - Constituents values other than pH reported in mg/l unless otherwise shown.

H3. PROGRAM DESCRIPTION

The purpose of this section is to outline the scope associated with the seven tasks associated with PGV's Hydrologic Monitoring Program.

There are no anticipated project effluent discharges to the shallow basal or dike-confined ground water. These waters are believed to occur at depths between about 500 and 650 feet below the plant site and surrounding area. There may be a few wells in the area that provide irrigation-type water supplies. One area near the Kapoho Crater, referred to as Green Lake, will be part of the monitoring program.

The proposed monitoring program has been revised to reflect follow-up discussions that have occurred with both the County of Hawaii Planning Department and the State Department of Health, Safe Drinking Water Branch. The revisions have been to:

1. Add an additional on-site monitoring location to the program so that two monitoring locations within the project area are in place prior to beginning of injection at the site,
2. Attempt to rehabilitate the GTW III monitoring well location just east of the site, thereby providing a third data point upon which to evaluate ground water flow direction in the site vicinity, and,
3. Increase the number of parameter analyses at selected locations for the initial year of monitoring.

The revised program now consists of seven tasks as follows:

Task 1 - Date Base Update
Task 2 - Locating On-Site Monitoring Wells
Task 3 - GTW III Rehabilitation
Task 4 - Completing On-Site Monitoring Wells
Task 5 - Background Sampling Measurements
Task 6 - Continuing Sampling and Measurements
Task 7 - Reporting

Details regarding each of these tasks follow. Locations, measurement and sampling techniques, and data reporting associated with the monitoring program are described in Chapters 4, 5 and 6, respectively.

H3.1 TASK 1 - DATA BASE UPDATE

This task will involve:

* getting permission to access the sites
* review and update the well data for existing non-geothermal wells in the site vicinity (with assistance from DOH and County staff as available).
* make selected field measurements at selected locations.

H3.2 TASK 2 - LOCATING ON-SITE MONITORING WELLS

This task will:

* evaluate the feasibility of using existing geothermal wells on the site to be completed as a monitoring well in the shallow aquifer,
* Finalize the location of the monitoring wells to be located within the project boundary and,
* Obtain permits from DLNR for drilling these wells.

H3.3 TASK 3 - GTW III REHABILITATION

This task will include:

* Getting permission to access the site,
* Sounding the well for depth,

* Mobilizing a drill rig and cleaning out the well, and,
* Sampling the well.

An alternative location for this third hydrologic monitoring point will be developed in conjunction with the County and DOH if rehabilitation efforts are not successful.

H3.4 TASK 4 - COMPLETING ON-SITE MONITORING WELLS

This task will include completing two on-site monitoring wells. If one of the locations involves use of an existing well, then the scope of this task will include those related actions.

H3.5 TASK 5 - BACKGROUND SAMPLING MEASUREMENTS

This task will include documenting background conditions for all selected wells by conducting an initial round of complete water level measurements and water sampling at all monitoring locations prior to beginning of injection of geothermal fluids.

H3.6 TASK 6 - CONTINUING SAMPLING AND MEASUREMENTS

This task will include implementation of the proposed monitoring program by continuing measurements and sampling on a quarterly basis after start of injection.

H3.7 TASK 7 - REPORTING

This task will involve providing reports on a semi-annual basis as required by the GRP.

H4. SITE DESCRIPTIONS

The purpose of this section is to describe the setting of locations associated with the proposed monitoring program.

The locations for the monitoring of ground water conditions are to be finalized based on the results of the initial task activities. At this time, however, there are five known off-site locations, at a minimum, that would be measured and sample analyses obtained, at least for the first year of monitoring. In addition, two on-site monitoring wells will be sampled prior to start of injection. Other locations may be included as a result of the update of the data base for the area.

H4.1 EXISTING OFF-SITE LOCATIONS

There are five of-site locations that will be part of the initial annual monitoring program. These, shown on Figure H2-1, are at the:

- Municipal supply in Pahoa [9-5A,B; 9-11],
- Municipal supply for Green Lake (Kapoho area),
- 'Allison' [A] well on the Pohoiki Road, and
- Unused Malama Ki [9-9] well on the University of Hawaii Agricultural Station, and
- GTW III Monitoring Well

PAHOA [9-5A,B; 9-11]

The town of Pahoa is served by three wells which tap the basal ground water at depths of up to about 800 feet below the surface. The supply is low-temperature, low-conductivity fresh water in a location about 3 to 4 miles upgradient from the site, north of the rift zone.

One of the wells at Pahoa is a proposed monitoring location since it will serve as a source for documenting levels of constituents in non-geothermal ground waters. Coordination with the Hawaii County Department of Water Supply will be maintained so as to supplement, where required, their ongoing monitoring of this public drinking water supply.

GREEN LAKE [9]

This is a municipal water supply that County Officials report comes from a thin layer of fresh ground water overlying brackish or salty water. The supply was developed by excavation to the water level with a bulldozer, installation of piping and refilling the hole, leaving a piping conduit for the water to flow from the source.

The location is included since quarterly monitoring of the Green Lake water supply is a condition of Condition 10 of the GRP. Coordination with the Hawaii County Department of Water Supply will be maintained so as to supplement, where required, their ongoing monitoring of this public drinking water supply.

ALLISON WELL [A]

The 'Allison' well is a private well that has been used in the past for irrigation. Its current use has not been checked yet. It is located just off the Pohoiki Road about three miles east southeast of the site. Weiss (1983, p.26) reports the well is about 140 feet deep and has a reported temperature of about 110°F, chloride level of about 750 mg/l, and conductivity of about 2000 micromhos/cm.

The location was selected as a proposed monitoring location since it may be hydrogeologically downgradient from the site and in an area that is already influenced by geothermal waters. Permission to access the site has been requested. To date, no approval has been granted. When obtained, coordination with the current owner will be maintained so as to supplement, where required, any ongoing monitoring that the owner may be doing for this well.

MALAMA KI [9-9]

The University of Hawaii maintains an Agricultural Research Station in the Malama Ki Research Forest Area just south of the site. A well, located at a ground elevation of about 274 feet, was drilled to a depth of about 316 feet on this property in the early 1960s (Weiss, 1983, p.26). It was not used, perhaps because of its elevated temperature of about 140°F and its chloride levels over about 6000 mg/l. Sampling was done monthly at this location from January 1980 until June, 1981 as part of background studies of ground water in the area (W. Burkhard, personal communication, December, 1989).

The location was selected as a proposed monitoring location since it appears to be potentially downgradient from the site and in an area that is already influenced by geothermal waters. PGV has contacted the University of Hawaii and obtained permission to sample this well. Coordination with the University of Hawaii Agriculture Department will be maintained so as to supplement any ongoing monitoring that they may be conducting.

GTW III MONITORING WELL

This well is currently abandoned and a blockage exists in the well at a depth of about 270 feet below ground surface. The well was drilled as one of four geothermal test wells along the LERZ in 1960 and 1961. It was originally completed to a depth of about 690 feet, about 130 feet below sea level. As noted in Section H2.3, initial sampling done encountered high temperatures of about 200°F and chloride levels over 500 mg/l (Weiss, 1983).

PGV has obtained permission to access the property and clean out the well. A driller has been contracted and should begin work in mid-April. Cleanout is expected to take about one week. PGV will maintain access and sample and measure the well as part of the ongoing Hydrologic Monitoring Program.

H4.2 ON-SITE LOCATIONS

Two monitoring locations will be situated in the south and north half of the project area. This will complement the GTW III location and allow a ground water flow direction to be calculated in the immediate site vicinity. The location in the south part will be as close to the injection site (Wellpad F) as possible. The location in the north part will be near Wellpad A if an existing well is used, or towards the Kapoho-Pahoa Road if a new monitoring well is drilled.

Once the locations are finalized, applications will be submitted, the required permits obtained, and the wells will be drilled, completed, and sampled. The wells will serve as dedicated monitoring wells for the hydrologic monitoring program.

H4.3 ADDITIONAL LOCATIONS

Any other locations identified beyond those described above in Section H4.1 will be added to the monitoring plan and described, along with the rationale for their being included.

H5. MONITORING EQUIPMENT AND OPERATION

The purpose of this section is to summarize the types of equipment and techniques used to perform the field-related measurements and sampling activities of the monitoring program.

H5.1 WATER LEVEL MEASUREMENTS

Water level measurements will be recorded for those wells identified as an integral part of the monitoring program.

Water level measurements will be obtained utilizing an electronic direct contact detection probe with a calibrated cable/tape for direct measurement at the top of the well casing. Calibrated cable/tape length shall be sufficient to measure water levels in the deepest wells identified. The metering device shall be equipped with an audible signal and light to indicate water level contact. Specifications for equipment similar to what will be used for this type of activity are in Appendix H2.

Water level measurements shall be conducted at each individual well prior to any additional testing or sampling of that particular well. All measurements will be obtained utilizing standard protocols for the equipment described in a separate 'Operating Procedures' document to be finalized as the program is implemented in the field.

H5.2 WATER QUALITY SAMPLING AND ANALYSIS

Water samples will be obtained from each of the wells identified for determination of selected physical and chemical characteristics of the waters from those wells to which access can be readily obtained.

Samples will be obtained from each well according to the characteristics of that well. Wells equipped with pumps will be sampled from the most suitable ported connection. Those wells not in use or not equipped with pumping devices shall be sampled with a stainless steel bailer lowered into the well by winch line to retrieve the volume of water required for each sample.

At each sampling location, standardized equipment cleaning will be carried out prior to obtaining each sample. Protocols to be used for sampling will be provided in the supplemental 'Operating Procedures' document to be finalized when the program is implemented.

Selected parameters values will be determined at each site upon retrieval of the water samples from the well. The field analysis will include measurement of:

- pH,
- temperature,
- conductivity,
- salinity, and
- chloride.

These measurements will be obtained by using calibrated instruments specifically designed to directly measure these physical and chemical parameters within the operational constraints dictated by site conditions. Specifications for equipment similar to what will be used for this type of activity are in Appendix H2.

Water samples will be submitted for the remainder of the analyses to an EPA or a State-certified laboratory. Samples will be transferred from the bailer/sample port directly to appropriately prepared containers supplied by the laboratory. Samples will be labeled, and stored and transported in a chilled state in insulated containers to the laboratory.

Parameters for analysis by the laboratory will, at least for the first year, include selected parameters that are related to underground waters that provide a public drinking water supply. These parameters are listed in Table H5-1.

In addition, the initial year of sampling at all monitoring locations will include, as requested by the DOH, analyses for other organics and other parameters recommended by DOH. These are listed in Appendix H3. After the first year, sampling will not include all of these parameters since there are no sources for many of these constituents associated with the project.

In addition, analysis will be done for the following five constituents which can be associated with geothermal reservoirs:

* Lithium
* Vanadium
* Boron
* Silica
* Bromine
* Nickel

The results of the quarterly sampling will be reviewed at the end of the first year to determine if there is a need to supplement the analysis or if the number of parameters can be reduced. Any recommendations for modification to the sampling program would be included with the semiannual report and submitted to the county for approval.

Table H5-1. List of Water Sample Parameters for Routine Analyses

	Drinking Water Maximum Contaminant Levels
Inorganic Constituents	
Arsenic	0.05
Selenium	0.01
Mercury	0.002
Cadmium	0.010
Lead	0.05
Chromium	0.05
Barium	1.0
Silver	0.05
Secondary Constituents	
Total Dissolved Solids	500.0
Color	15. color unit
Copper	1.00
Foaming Agent	0.50
Iron	0.30
Manganese	0.05
Odor	3.00 ton
Sulfate	250.00
Zinc	5.00
pH	6.50 - 8.5 scale
Corrosivity	Non-corrosive
Other Constituents	
Lithium	
Vanadium	
Boron	
Silica	
Bromine	
Nickel	

H6. DATA REPORTING

The purpose of this section is to summarize the frequency, content, and format for the hydrologic monitoring program data.

H6.1 FREQUENCY AND CONTENT

In compliance with permit conditions, semi-annual reports of the data will be submitted thereafter, along with the project status reports on February 15 and August 15 of each calendar year. The initial submittal will include information regarding all well locations, and as-built diagrams relative to GTW III and the on-site monitoring locations.

Subsequent reports will be in letter format and will include activities conducted during that period, laboratory results of sampling conducted, and recommendations as required.

H6.2 FORMAT

Reporting format will incorporate standard forms and reporting protocols established for similar environmental compliance monitoring programs. The forms and protocols may be modified to reflect the project specific conditions.

H7. QUALITY ASSURANCE PROGRAM

In any program that requires a substantial data base, the credibility of the data must be assured before any derivations from it can be reasonably made. In monitoring programs, the two types of activities necessary to assure the validity of the collected data are Quality Control (QC) and Quality Assurance (QA). Quality Control activities are the primary avenue by which the data are kept within prescribed control conditions. The field QC activities are carried out by the site technician while in-house QC activities are performed by experienced personnel involved with the data reduction and analyses. Quality Assurance activities ensure that each QC activity is performed and documented completely and accurately. A control loop is thereby formed such that if a QA check indicates that an out-of-control condition has been allowed to occur, then the related QC activity will be modified or strengthened to eliminate future occurrences.

All activities of the PGV hydrologic monitoring program will be conducted in compliance with a strong and effective quality assurance program. This program will be managed in accordance with other similar environmental compliance monitoring projects to a standard similar to that expected by the EPA. Details of the QC/QA plan established for this project's hydrologic monitoring program will be submitted as a supplement after details of proposed sampling and measurement activities have been finalized.

Quality assurance also plays a key role in data reduction and analysis and will be performed on a regular basis by a trained professional hydrogeologist. Activities of the Quality Assurance program are designed to ensure overall accountability, traceability, and repeatability.

H7.1 QUALITY CONTROL ACTIVITIES

All equipment will be calibrated prior to use at the site in accordance with manufacturers' specifications. Program technicians will be fully trained in the use of field equipment and performance of field measurement and sampling actions.

Quality Control activities shall incorporate the use of the Standard Operating Procedures (SOPs) for well measurement, sampling, and equipment cleaning developed from U.S. EPA Sampling Protocols. These will be included in the supplemental 'Operating Procedures' document.

Calibration and use of equipment shall be conducted in accordance with Standard Operating Procedures developed for each type of equipment and the manufacturer's recommendation for operation and calibration of each unit.

H7.2 DATA QUALITY ASSURANCE ACTIVITIES

Quality Assurance related to all project measuring and sampling activities will include documenting that field activities were conducted in accordance with the required procedures and recording all field data on forms in accordance with the monitoring contractors standard internal Quality Assurance program.

Quality Assurance related to water sampling shall also include the use of blind duplicates, field blanks, and trip blanks as required to assure environmental control and external laboratory quality assurance.

Data will be reported by the hydrologic consultant, and interpretations and calculations will be checked independently.

H7.3 LABORATORY QUALITY ASSURANCE ACTIVITIES

The laboratory selected for analysis of the samples generated during this monitoring program shall be certified by the EPA or the State of Hawaii Department of Health to conduct those analyses required in this investigation.

Laboratory Quality Assurance is the responsibility of the laboratory. However, the laboratory may be requested to provide documentation of its QA procedures for any of the required analyses at any time.

In addition, blind duplicates and field blanks shall be included in each quarterly sampling for a to determine if the test results are reproducible. If required, duplicate samples may be analyzed by a second independent laboratory for reproducibility of results.

Duplicate samples will be provided to DOH for their independent analysis, upon request.

H8. REFERENCES

Eyre, P.E., 1977. A hydrogeologic study of an area around the Hawaii geothermal project well HGP-A, unpublished.

Kroopnick, P.M., R.W. Buddemeier, and D. Thomas, 1978. Hydrology and Geochemistry of a Hawaii Geothermal System: HGP-A, prepared for National Science Foundation Grant GI-38319, Hawaii Institute of Geophysics, Honolulu, Hawaii, 64 p.

Thermal Power Company, 1986. Petition to Modify the UIC Line in the Lower East Rift Zone, Puna, Hawaii, Internal report submitted to Hawaii State Department of Health.

Weiss Associates, 1983. Hydrology of the Puna Area, Hawaii, Unpublished Report for Thermal Power Company, San Francisco, CA.

FIGURES

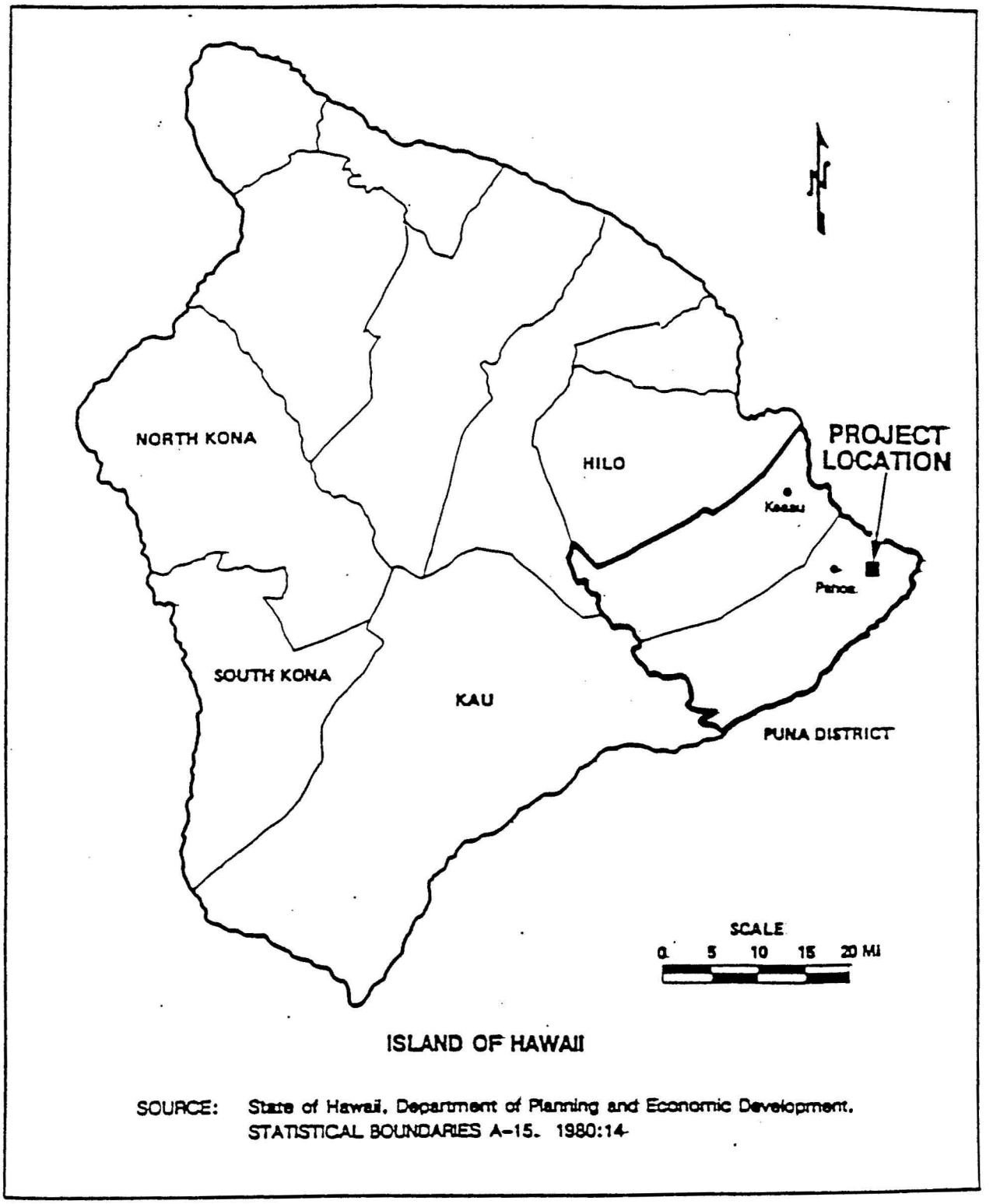


Figure H1-1. Key Location Map

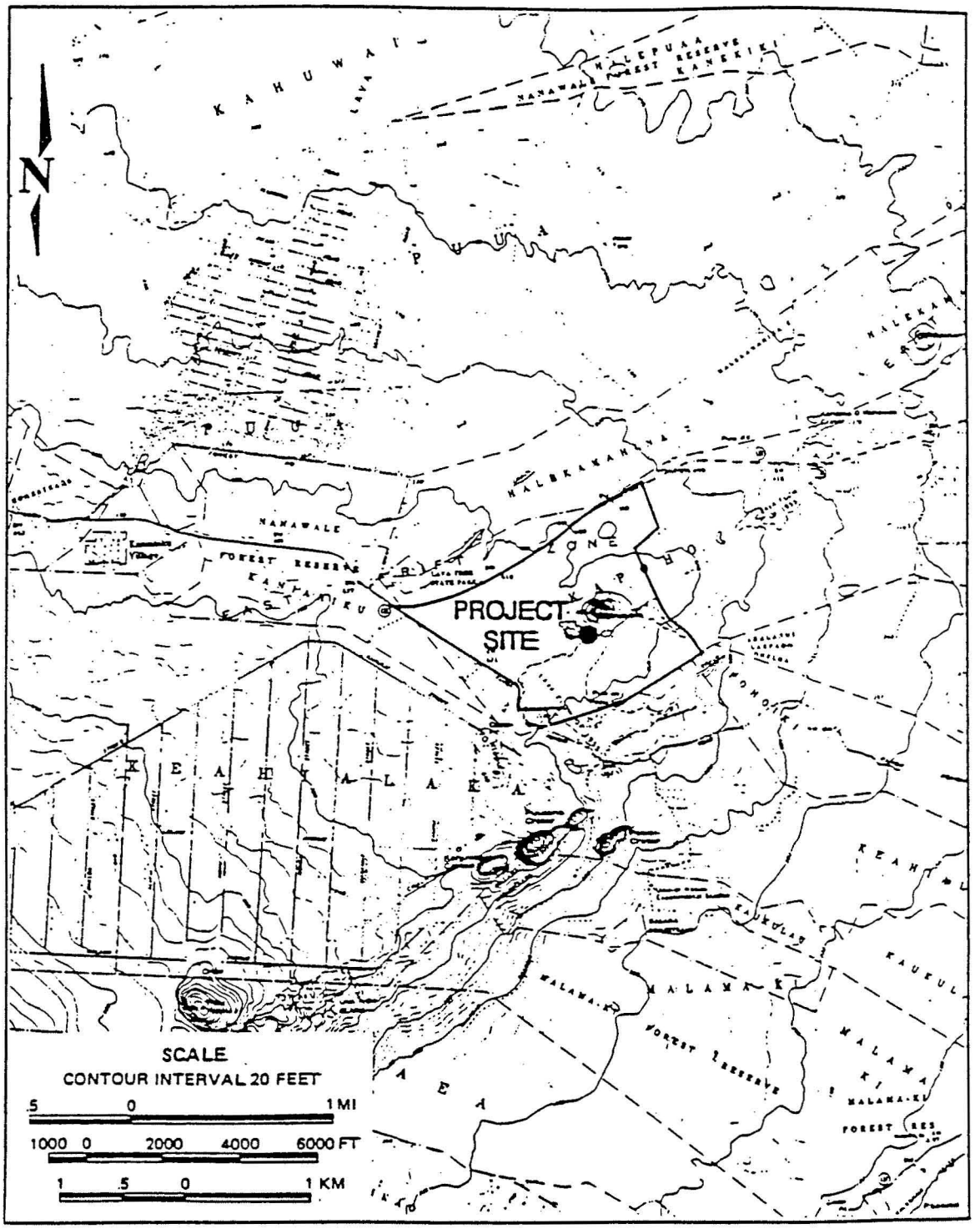


Figure H1-2. Site Vicinity Map

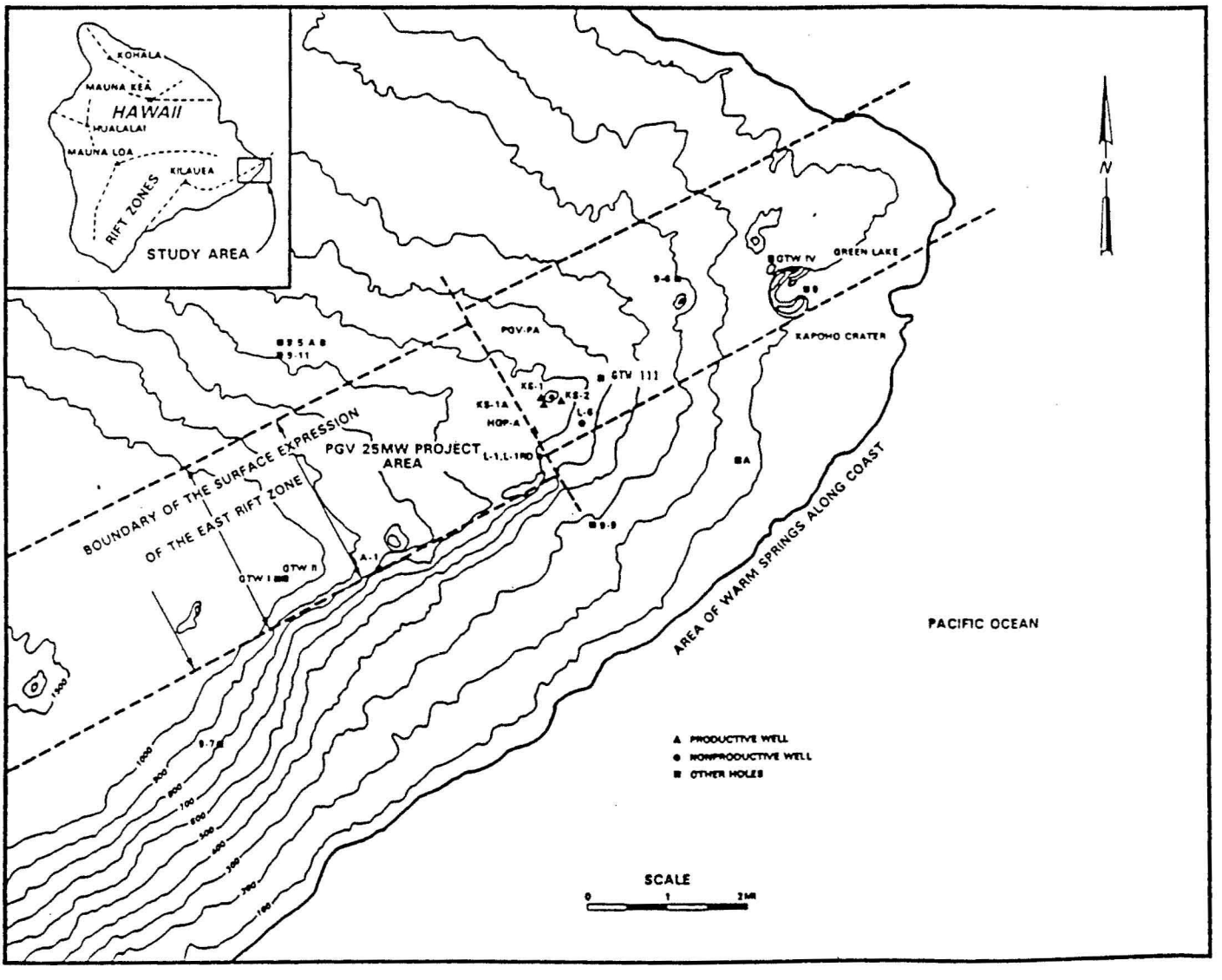


Figure H2-1. Site Hydrologic Data Sources and Related Features

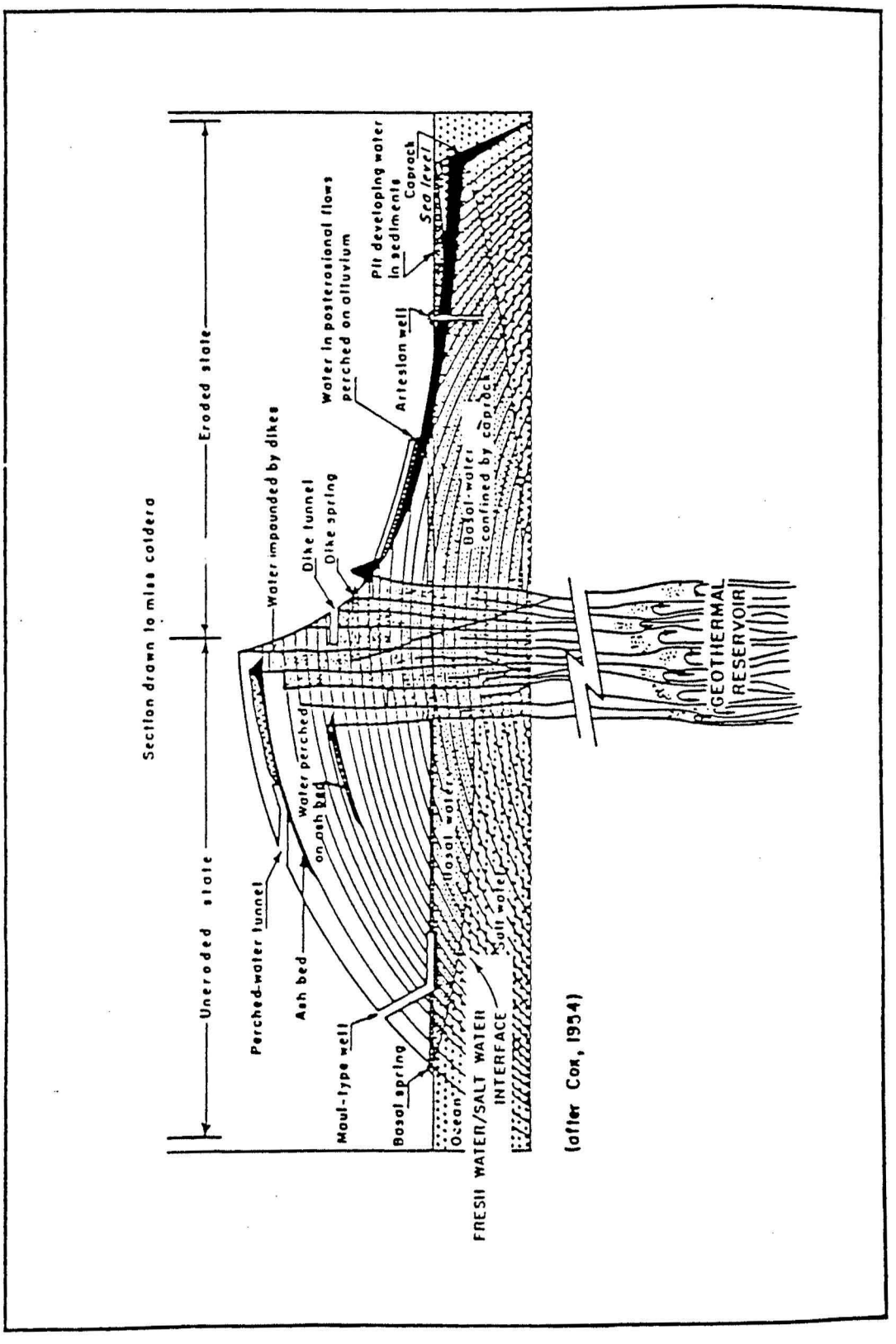


Figure H2-2. Types of Ground Water Occurrence and Development in Hawaii

PUNA GEOTHERMAL VENTURE
HYDROLOGIC MONITORING PROGRAM

APPENDIX H1

GRP CONDITIONS RELATIVE TO THE HYDROLOGIC MONITORING PROGRAM

PUNA GEOTHERMAL VENTURE
HYDROLOGIC MONITORING PROGRAM
APPENDIX H1

GRP CONDITIONS RELATIVE TO THE
HYDROLOGIC MONITORING PROGRAM

"10. Prior to commencing any geothermal well drilling, testing, production, or injection activity approved under this Geothermal Resource Permit, the permittee shall submit to, and secure the approval of, the Planning Director of a hydrologic monitoring program. The program shall, at a minimum, provide for the quarterly monitoring of water levels and appropriate chemical species from existing wells completed within the shallow aquifer in those areas downgradient of the project area, including the Green Lake water supply, as well as from a well located within the project boundary and completed within the shallow aquifer. The monitoring, sampling, and analysis protocols shall be clearly defined in the program submitted to and approved by the Planning Director. The monitoring and sampling shall be conducted by a qualified contractor, and the samples analyzed by a qualified laboratory, selected by the permittee but subject to the approval of the Planning Director. The selected contractor and laboratory shall operate under contract to, and shall be funded by the permittee. The program shall monitor the shallow groundwater immediately prior to, and during, all periods of well drilling, testing, production, and injection activity approved under this Geothermal Resource Permit. The data obtained shall be submitted to the Planning Director in accordance with the requirements contained in this Geothermal Resource Permit for submittal of all collected environmental monitoring data. The County shall make random checks of the ground water supply no less than every two months."

PUNA GEOTHERMAL VENTURE
HYDROLOGIC MONITORING PROGRAM

APPENDIX H2

EXAMPLE EQUIPMENT SPECIFICATIONS

EI

Solinst
Water Level Meter

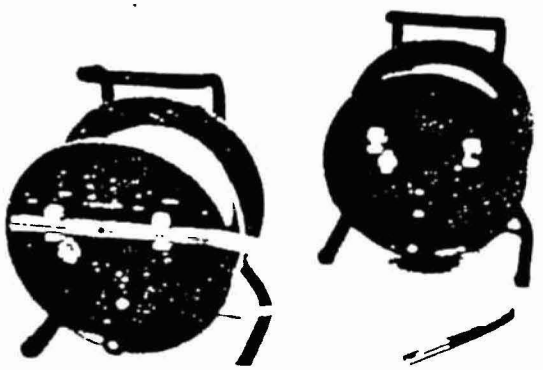
MODEL 101

Flat Tape Water Level Meter

For measuring the depth of water in boreholes, standpipes and wells, the Flat Tape Water Level Meter (dipmeter) is the most reliable and accurate of the Solinst Water Level Meters and is easy to operate and read.
Also available is the Model #102 Coaxial Cable Water Level Meter for use in applications with small size tubes.

Operating Principle

The standard Flat Tape Water Level Meter (dipmeter) uses a 0.59" (15mm) diameter probe constructed of nickel plated brass. This is fitted to a permanently marked, medium density, polyethylene flat tape which contains two stranded stainless steel conductors. The probe itself incorporates an insulating gap around a central stainless steel electrode. When contact is made with water, the circuit is completed, sending a signal back to the cable drum where a clearly audible buzzer is activated.
The water level can then be determined by taking a reading off the cable, at the top of the borehole, pipe or tube. The cable is housed on a high quality storage and winding reel equipped with a brake. The reel has a convenient carrying handle and a sturdy stand-alone design. Standard controls include a battery test button, on/off switch and sensitivity adjustment.



Features

Accurate
markings at cm, 1/2" or 1/20" intervals.
sensitivity control which adjusts to suit water conductivity.

Reliable
permanent, hot stamped markings.

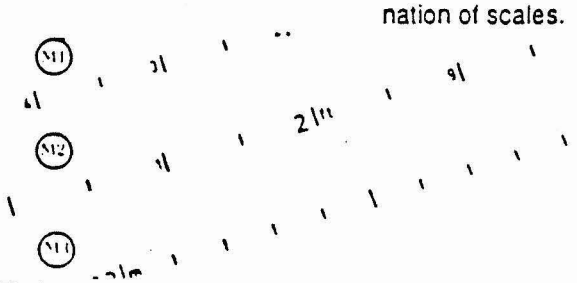
Long Life
rugged, free standing reel.
corrosion proof components.
standard 9v battery.
replacement probes and cables available.

Flexible
lengths up to 1650 ft. (500m).
stainless steel probe and other options available

Measurement Options

The flexible, polyethylene flat tape gives very accurate readings because the permanent markings are at close intervals. The high strength stainless steel conductors provide strength and the design prevents it from adhering to wet surfaces in boreholes and tubes.
Markings are permanently embossed onto one side of the tape and are available in your choice of three scales or, if preferred, any combination of scales, one on each side.

M1 Feet and Inches : with markings every 1/2"
M2 Feet and 10ths of feet : with markings every 1/20ft.
M3 Meters and centimeters : with markings every cm.
M4 Markings both sides : any combination of scales.



EI

Conductivity Meters

S-C-T Meter
YSI Model 33

- Measures Salinity, Conductivity, Temperature
- Direct Reading Water Quality Meter
- Portable, Battery-Powered
- Designed For Field Measurements

INSTRUMENT SPECIFICATIONS

Conductivity Ranges:
0 to 50,000 µmhos/cm in three ranges. Readability 3% of scale. Error less than ± 3% of reading (plus probe).

Salinity Range:
0-40 PPT from + 2 to + 45°C, readability of 2 PPT. Error above 4°C less than ± 1.1 PPT at 40 PPT, ± 0.7 PPT at 20 PPT, plus probe.

Temperature Range:
− 2 to + 50°C, readability 0.15°C from − 2 to + 37°C. Error ± 0.1°C at − 2°C, ± 0.6°C at 45°C, plus probe.

100 or 600 Hz Operation:
100 Hz for 500 µmho range, optional 600 Hz for higher conductivity and salinity ranges.

Ambient Temperature:
Operates from − 5 to + 45°C. Max. drift 0.1% of reading per °C change in ambient. Negligible drift if red line is adjusted.

Probe:
Integral conductivity/temperature probe of durable plastic 1¼" dia. x 2" long (3 x 5 cm), constant of K = 5 ± 0.1 cm^{-1}. Error less than ± 2% of readings for salinity and conductivity, ± 0.1°C for temperature measurement at 0°C, ± 0.3°C at 40°C. Probe electrodes can be replatinized by using the instrument plus platinizing solution.

Power Supply:
Two Eveready E95 batteries or equivalent provide 200 hours operation.

Instrument Size:
9 x 16 x 25 cm, 2 kg (3½ x 6½ x 10 in., 4 lbs.).

Ordering Part Numbers:
YSI Model 33 S-C-T Meter
YSI 3310 S-C-T Probe, 10' lead (3m)
YSI 3311 S-C-T Probe, 50' lead (15m). For longer leads to 100', place an "X" after probe number and specify length. Probes 50' or longer supplied with storage reel. For leads over 100', contact factory.
YSI 3140 Platinizing Solution, 2 oz.
YSI 5890 Carrying Case.

T-L-C Meter
YSI Model 3000

- Portable, Self-Contained Water Quality Meter
- Measure Temperature, Level, Conductivity
- Groundwater or Surface Water

INSTRUMENT SPECIFICATIONS

Temperature:
Range: − 5.0 to + 50.0°C. *Accuracy:* ± 0.3°C including probe. *Resolution:* 0.1°C.

Level:
Range: 0 to 150 ft. *Accuracy:* ± 1" per 50' of cable.

Conductivity:
Nominal Range: 0 to 2,000 millimhos/cm (0 to 2,000 µmhos/cm). 0 to 20,000 millimhos/cm (0 to 20,000 µmhos/cm). *Accuracy:* ± 3% of full scale including probe. *Resolution:* 1 part in 2,000.

Temperature-Compensated Conductivity:
Nominal Range: 0 to 2,000 millimhos/cm (0 to 2,000 µmhos/cm). 0 to 20,000 millimhos/cm (0 to 20,000 µmhos/cm). *Accuracy:* ± 4% of full scale including probe. *Resolution:* 1 part in 2,000.
Note: Range actually ends at 1,999 or 19.99.

Probe and Cable:
Probe has CPVC body and removable stainless steel weight attached to durable polyurethane-jacketed cable. Probe has 1" nominal diameter, 4¾" length. Cable is 150' long with depth markings every 12"; a water-tight MS connector attaches cable to instrument. Cell constant is K = 5.0/cm ± 0.1. Error less than ± 2% of readings for conductivity, ± 0.1°C for temperature.

Ambient Temperature:
0 to 50°C.

Humidity:
Operates under any humidity condition if seals are intact and desiccant is in place.

Case:
Water-tight to MIL-T-28800C; weighs 7.5 pounds.

Power Supply:
Six "C" size heavy-duty carbon-zinc batteries provide better than 1200 hours operation based on 4 hours use per day. Alkaline cells provide better than 1700 hours. Low-battery indicator warns when to replace batteries.

Ordering Part Numbers:
YSI Model 3000 T-L-C Meter
YSI 3040 Test Probe (tests calibration)
YSI 3050 Replacement Probe, Cable and Reel Assembly
YSI 3140 Platinizing Solution, 2 oz. (for probe maintenance)

EI

pH Meters

ORION SA 250 Portable pH/mV/temperature Meter For Hand-held And Bench-top Use.

The SA 250 meter is supplied with a best-performing ROSS combination epoxy-body pH electrode and ATC probe for fast, accurate pH, no matter what the sample temperature

ADVANCED FEATURES

pH Autocal, or manual buffer entry
Choice of display resolution
Adjustable isopotential point
Automatic temperature compensation
"No slip" grip fits comfortably in one hand
Durable, dust and splash resistant
Line or battery operated

SIMPLE TO USE

Prompting, by advancing to next step
Assistance (error) codes

THE SA 250 METER IS FOR THE CUSTOMER WHO WANTS:

An accurate and portable pH system
A pH meter that is supplied complete and ready to use, with all the accessories you need to make pH measurements in the field or lab

025000 SA 250 Portable pH/mV/temperature Meter for hand-held/bench-top use. Digital, LCD meter comes with carrying case, Model 81-56 ROSS pH electrode, ATC probe, attached shorting plug, one 3M KCl 2 oz. bottle of filling solution, three 60 ml solution bottles, one plastic beaker, electrode holder, support rod, rod guide, one packet pH 7 buffer, one 9V battery, instruction manual, and training guide

OPTIONAL ACCESSORIES FOR SA 250, SA 230, AND SA 210 METERS

020041 Shoulder strap and meter holder for hands-free operation. Great for plant or field work

020045 Stable electrode stand with heavy base, rod, and holder

ORION SA 230 Portable pH/mV/temperature Meter For Hand-held And Bench-top Use.

The SA 230 Meter is shown with a convenient holder that is a sturdy stand for flat surfaces and has a neck strap for hands-free operation.

ADVANCED FEATURES

Automatic temperature compensation
"No slip" grip fits comfortably in one hand
Durable, dust and splash resistant
Recessed control knobs prevent settings from being changed unintentionally
Line or battery operated

THE SA 230 METER IS FOR THE CUSTOMER WHO WANTS:

An economical meter with the added accuracy and convenience of temperature compensated pH measurements

023000 SA 230 Portable pH/mV/temperature Meter for hand-held/bench-top use. Digital, LCD meter comes in carrying case with combination pH electrode, ATC probe, attached shorting plug, three 60 ml solution bottles, one 150 ml beaker, electrode holder, support rod, rod guide, one packet pH 7 buffer, one 9V battery, instruction manual, and training guide

ORION SA 210 Portable pH/mV Meter For Hand-held And Bench-top Use.

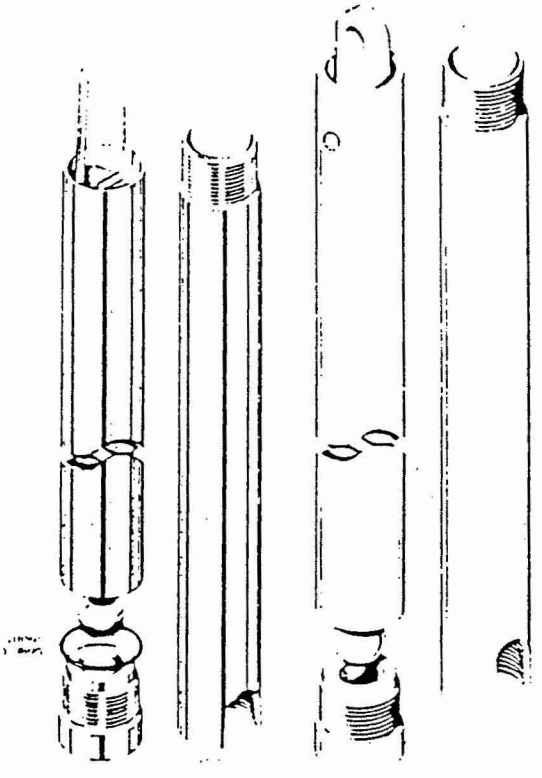
Both the SA 230 and SA 210 Meters have a wide ±1 999 mV

Same features as the SA 230, but without automatic temperature compensation or temperature readout, with manual temperature compensation

021000 SA 210 Portable pH/mV Meter for hand-held/bench-top use. Digital, LCD meter comes in carrying case with combination pH electrode, attached shorting plug, three 60 ml solution bottles, one 150 ml beaker, electrode holder, support rod, rod guide, one packet pH 7 buffer, one 9V battery, instruction manual, and training guide

EI

Regular Bailers PVC Teflon® Stainless Steel



Regular Bailers for Well Purging and Sample Retrieval

TIMCO™ bailers are available in Teflon®, stainless steel, PVC and acrylic in sizes from 0.84" to 4.5" (21.4mm—114.3mm) diameter and 1' to 6' (31cm—183cm) lengths.

All are solvent free, and have a flush "V" threaded ball check for ease of decontamination. This design permits the addition of a body extension piece to increase capacity.

The ball check design allows for the inclusion of a Viton® "O" ring in all but the Teflon® opaque model. The Viton® "O" ring provides a leak free joint. It is inert and will not compromise the collected sample.

The bail, an integral part of the bailer body, permits easy attachment of a suspension cord. Stainless steel models have a fixed bail.

PUNA GEOTHERMAL VENTURE
HYDROLOGIC MONITORING PROGRAM

APPENDIX H3

LIST OF ANALYSES FOR FIRST YEAR SAMPLING PROGRAM

Department of Health Laboratories

Form Number _____

SAFE DRINKING WATER BRANCH
CHAIN OF CUSTODY & EDB/DBCP CONTAMINANT REPORT

Water System Name_____Number_____

Sample Location_____

Well Log #_____-____ Sample Point # _____-___

Type of sample: Routine__ Special_____

Collection remarks_____

Sample Chlorinated Y___, N___, ?____

Sampler(s) _____,_____

Date: _____ Time:_____

Sample Location

Relinquished by: Date/Time	Received by: Date/Time
Dispatched by: Date/Time	Rec'vd for Laboratory by: Date/Time

Method of Shipment: _____ Seal Intact: Yes_____

Sample Lab # Relinquished by: Date/Time	Received by: Date/Time
Sample Lab # Locked in Refrig Date/Time	Rem'vd from Refrig Date/Time

Regulated Compound	ND	NQ	RESULT*	Method	Date	Analyst	Lab #
Ethylene Dibromide	< .	< .		A B C D			
1,2-Dibromo-3-Chloropropane	< .	< .		A B C D			

1/90

* Measured in micrograms per liter (ug/l) unless otherwise specified.

Methods:
A=Purge Trap
B=GC
C=GCMS
D=Other_____

Sample Preservation:
HCL (Circle) Y N

Dechlorination:
appx 3 mg $Na_2S_2O_3$

Reported by:_____ Date:_____QA Check:_____ Date:_____

TEST	contaminants	maximum contaminant levels*	lab results*	analytical method	date analyzed	analyst	lab number
	Arsenic	0.05					
	Selenium	0.01					
	Mercury	0.002					
	Cadmium	0.010					
	Lead	0.05					
	Chromium	0.05					
	Barium	1.					
	Silver	0.05					
	Nitrate (as N)	10.					
	Fluoride						
	Chloride	250.					
	Total Dissolved Solids	500.					
	Sodium						

*Measured in milligrams per liter (mg/l) unless otherwise specified.

Analytical Method:

A - Atomic Absorption
B - Atomic Absorption; Chelation-extraction
C - Atomic Absorption; Flameless
D - Atomic Absorption; Flameless Graphite Furnace
E - Atomic Absorption; Gaseous
F - Cadmium Reduction
G - Colorimetric with preliminary distillation
H - Electrode
I - Gas Chromatography
J - Gravimetric Analysis
K - Silver Diethyl-dithiocarbonate
L - Titrimetric Analysis
M - _____
N - _____

No. of Containers: _____ Preservative Added (ml) Signature Date Lab. No.

Container: No. 1 Metals _____ _____ _____ _____

No. 2 Hg _____ _____ _____ _____

No. 3 NO_3 _____ _____ _____ _____

No. 4 TDS/CL/F _____ _____ _____ _____

Reported by: _____ Date: _____ QA Check: _____ Date: _____

Forwarded by: _____ Date: _____

CONTAMINANT	MCL*	lab results*	analytical method	date analyzed	analyst	lab number
Trihalomethanes	0.10		A B C D			
CHLOROFORM			A B C D			
BROMOFORM			A B C D			
CHLORODIBROMOMETHANE			A B C D			
DICHLOROBROMOMETHANE			A B C D			
			A B C D			
			A B C D			
			A B C D			
			A B C D			
			A B C D			
			A B C D			
			A B C D			
			A B C D			
			A B C D			
			A B C D			

*Measured in miligrams per liter (mg/l) unless otherwise specified.

Methods:
A=Purge Trap
B=GC
C=GCMS
D=Other _____

Sample Preservation:
HCL (circle) Y N

Dechlorination:
appx 3mg $Na_2S_2O_3$ added to sample
Y N

Reported by:_____ Date:_____ QA Check:_____ Date:_____

Forwarded by:_____Date:_____

TEST	contaminants	maximum contaminant levels*	lab results*	analytical method	date analyzed	analyst	lab number
	Endrin	0.0002					
	Lindane	0.004					
	Methoxychlor	0.1					
	Toxaphene	0.005					
	2, 4 - D	0.1					
	2, 4, 5 -TP Silvex	0.01					
	Total Trihalomethanes	.10					

*Measured in milligrams per liter (mg/l) unless otherwise specified.

Analytical Method:

G - Colorimetric with preliminary distillation
H - Electrode
I - Gas Chromatography
J - Gravimetric Analysis
K - Silver Diethyl-dithiocarbonate
L - Titrimetric Analysis
M - Purge and Trap
N - _____

Reported by: _____ Date: _____ QA Check: _____ Date: _____

Forwarded by: _____ Date: _____

Regulated Compound	MCL*	ND	NQ	RESULT*	Method	Date	Analyst	Lab #
Vinyl Chloride	2	<0.3	<1.0		A B C D			
1,1-Dichloroethylene	7	<0.3	<1.0		A B C D			
1,1,1-Trichloroethane	200	<0.3	<1.0		A B C D			
Carbon Tetrachloride	5	<0.3	<0.5		A B C D			
Benzene	5	<0.3	<1.0		A B C D			
1,2-Dichloroethane	5	<0.3	<1.0		A B C D			
Trichloroethylene	5	<0.3	<0.5		A B C D			
p-Dichlorobenzene	75	<0.3	<1.0		A B C D			

Unregulated Compound							
1. Chloromethane	<0.3	<1.0		A B C D			
2. Bromomethane	<0.3	<1.0		A B C D			
3. Chloroethane	<0.3	<1.0		A B C D			
4. Methylene Chloride	<0.2	<0.6		A B C D			
5. trans-1,2-Dichloroethene	<0.3	<1.0		A B C D			
6. 1,1-Dichloroethane	<0.3	<1.0		A B C D			
7. 2,2-Dichloropropane	<0.5	<2.0		A B C D			
8. cis-1,2-Dichloroethene	<0.3	<1.0		A B C D			
9. Chloroform	<0.2	<0.6		A B C D			
10. 1,1-Dichloropropene	<0.3	<1.0		A B C D			
11. 1,2-Dichloropropane	<0.3	<1.0		A B C D			
12. Bromodichloromethane	<0.3	<1.0		A B C D			
13. Dibromomethane	<0.5	<1.0		A B C D			
14. trans-1,3-Dichloropropene	<0.3	<1.0		A B C D			
15. Toluene	<0.3	<1.0		A B C D			
16. cis-Dichloropropene	<0.3	<1.0		A B C D			
17. 1,1,2-Trichloroethane	<0.3	<1.0		A B C D			
18. Tetrachloroethene	<0.2	<0.3		A B C D			
19. 1,3-Dichloropropane	<0.3	<1.0		A B C D			
20. Dibromochloromethane	<0.3	<1.0		A B C D			
21. Chlorobenzene	<0.3	<1.0		A B C D			
22. Ethyl benzene	<0.3	<1.0		A B C D			
23. 1,1,1,2-Tetrachloroethane	<0.3	<1.0		A B C D			
24. m-Xylene } coelute	<0.3	<1.0		A B C D			
25. p-Xylene	<0.3	<1.0		A B C D			
26. o-Xylene	<0.3	<1.0		A B C D			
27. Styrene	<0.3	<1.0		A B C D			
28. Bromoform	<0.5	<2.0		A B C D			
29. 1,1,2,2-Tetrachloroethane	<0.3	<1.0		A B C D			
30. 1,2,3-Trichloropropane	<0.3	<1.0		A B C D			
31. Bromobenzene	<0.3	<1.0		A B C D			
32. 2-Chlorotoluene	<0.3	<1.0		A B C D			
33. 4-Chlorotoluene	<0.3	<1.0		A B C D			
34. 1,3-Dichlorobenzene	<0.3	<1.0		A B C D			
35. 1,2-Dichlorobenzene	<0.3	<1.0		A B C D			

Unreg Compounds on List 3							
36. Bromochloromethane	<0.3	<1.0		A B C D			
37. 1,2,4-Trichlorobenzene	<0.3	<1.0		A B C D			
38. Hexachlorobutadiene	<0.3	<1.0		A B C D			
39. Naphthalene	<0.3	<1.0		A B C D			
40. 1,2,3-Trichlorobenzene	<0.3	<1.0		A B C D			

APPENDIX H

CHEMICAL AND PHYSICAL ANALYSIS PLAN FOR INJECTANT TESTING

Type I samples will be collected once every two month and Type III and IV samples will be collected twice a year in accordance with the monitoring and reporting schedule in the Hawaii Department of Health's UIC permit #UH-1529 to PGV. A cooling coil shall be used to properly cool the samples during collection.

TEST PARAMETERS FOR TYPE I SAMPLE

Parameter	Parameter	Gas Parameter
Lithium (Li)	Sulfur (S)	Carbon Dioxide (CO_2)
Sodium (Na)	Selenium (Se)	Hydrogen Sulfide (H_2S)
Potassium (K)	Fluoride (F)	Argon (Ar)
Magnesium (Mg)	Chloride (Cl)	Nitrogen (N_2)
Calcium (Ca)	Bromide (Br)	Methane (CH_4)
Barium (Ba)	Iodide (I)	Hydrogen (H_2)
Vanadium (V)	Ammonia (NH_3)	Oxygen (O_2)
Chromium (Cr)	Sulfate (SO_4)	Radon
Manganese (Mn)	Nitrate (NO_3)	
Iron (Fe)	Bicarbonate (HCO_3)	
Nickel (Ni)	Carbonate (CO_3)	
Copper (Cu)	Silica (SiO_2)	
Silver (Ag)	Total Dissolved Solids (TDS)	
Zinc (Zn)	Total Suspended Solids (TSS)	
Cadmium (Cd)	Total Alkalinity	
Mercury (Hg)	Conductivity	
Boron (B)	pH	
Lead (Pb)	Oil & Grease	
Arsenic (As)	Isopentane	

TEST PARAMETERS FOR TYPE III SAMPLE

Parameter	Regulatory Level (mg/l)	Method
		As described in 40 CFR (1992):
Ignitability		Part 261.21
Corrosivity		Part 261.22
Reactivity		Part 261.23
Inorganics:		Method 1311 (TCLP), with appropriate methods of analyses contained in SW-846
arsenic	5.0	
barium	100.0	
cadmium	1.0	
chromium	5.0	
lead	5.0	
mercury	0.2	
selenium	1.0	
silver	5.0	
Organics:		1311
benzene	0.5	
carbon tetrachloride	0.5	
chlorobenzene	100.0	
chloroform	6.0	
o-cresol	200.0	
m-cresol	200.0	
p-cresol	200.0	
1,4-dichlorobenzene	7.5	
1,2-dichloroethane	0.5	
1,1-dichloroethylene	0.7	
2,4-dinitrotoluene	0.13	
hexachlorobenzene	0.13	
hexachloro-1,3-butadiene	0.5	
hexachloroethane	3.0	
methyl ethyl ketone	200.0	
nitrobenzene	2.0	
pyridine	5.0	
tetrachloroethylene	0.7	
trichloroethylene	0.5	
2,4,5-trichlorophenol	400.0	
2,4,6-trichlorophenol	2.0	
vinyl chloride	0.2	

TEST PARAMETERS FOR TYPE IV SAMPLE

Parameter	Method
Volatile Organics	624 (8240)
Benzene	
Bromodichloromethane	
Bromoform	
Bromomethane	
Carbon Tetrachloride	
Chlorobenzene	
Chloroethane	
2-Chloroethylvinyl ether	
Chloroform	
Chloromethane	
Dibromochloromethane	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene	
1,4-Dichlorobenzene	
1,1-Dichloroethane	
1,2-Dichloroethane	
1,1 Dichloroethylene	
trans-1,2-Dichloroethene	
1,2-Dichloropropane	
cis-1,3-Dichloropropene	
trans-1,3-Dichloropropene	
Ethyl benzene	
Methylene chloride	
1,1,2,2-Tetrachloroethane	
Tetrachloroethene	
Toluene	
1,1,1-Trichloroethane	
1,1,2-Trichloroethane	
Trichloroethene	
Trichlorofluoromethane	
Vinyl Chloride	

APPENDIX I

PLUGGING AND ABANDONMENT PLAN

Upon completion of injection activities, the well will be abandoned according to federal and state regulations to ensure protection of underground sources of drinking water. The permittee will be required to re-submit a customized plugging and abandonment (P&A) plan, which will include EPA Form 7520-14, for each new injection well within 60 days of well completion.

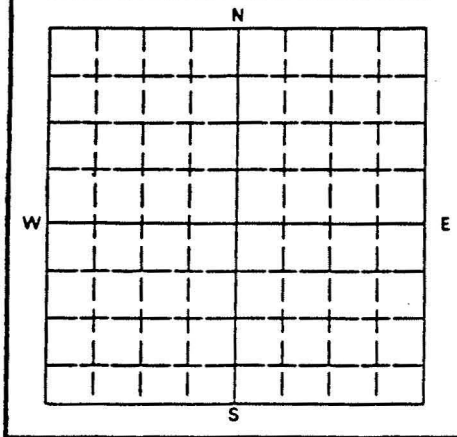
Form Approved. OMB No. 2040-0042. Approval Expires 6-30-98

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

EPA PLUGGING AND ABANDONMENT PLAN

NAME AND ADDRESS OF FACILITY	NAME AND ADDRESS OF OWNER/OPERATOR

LOCATE WELL AND OUTLINE UNIT ON SECTION PLAT — 640 ACRES



STATE	COUNTY	PERMIT NUMBER

SURFACE LOCATION DESCRIPTION
___ 1/4 of ___ 1/4 of ___ 1/4 of ___ 1/4 of Section___ Township___ Range___

LOCATE WELL IN TWO DIRECTIONS FROM NEAREST LINES OF QUARTER SECTION AND DRILLING UNIT

Surface Location _____ ft. from (N/S) _____ Line of quarter section

and _____ ft. from (E/W) _____ Line of quarter section

TYPE OF AUTHORIZATION

- ☐ Individual Permit
- ☐ Area Permit
- ☐ Rule

Number of Wells _____

Lease Name

WELL ACTIVITY

- ☐ CLASS I
- ☐ CLASS II
  - ☐ Brine Disposal
  - ☐ Enhanced Recovery
  - ☐ Hydrocarbon Storage
- ☐ CLASS III

Well Number

CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT(LB/FT)	TO BE PUT IN WELL (FT)	TO BE LEFT IN WELL (FT)	HOLE SIZE

METHOD OF EMPLACEMENT OF CEMENT PLUGS

- ☐ The Balance Method
- ☐ The Dump Bailer Method
- ☐ The Two-Plug Method
- ☐ Other

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7
Size of Hole or Pipe in which Plug Will Be Placed (inches)							
Depth to Bottom of Tubing or Drill Pipe (ft.)							
Sacks of Cement To Be Used (each plug)							
Slurry Volume To Be Pumped (cu. ft.)							
Calculated Top of Plug (ft.)							
Measured Top of Plug (if tagged ft.)							
Slurry Wt. (Lb./Gal.)							
Type Cement or Other Material (Class III)							

LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS AND INTERVALS WHERE CASING WILL BE VARIED *(If any)*

From	To	From	To

Estimated Cost to Plug Wells

CERTIFICATION

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

NAME AND OFFICIAL TITLE *(Please type or print)*	SIGNATURE	DATE SIGNED