NEIC

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PUNA GEOTHERMAL VENTURE COMPLIANCE INVESTIGATION

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cc: K Kersch

Pahoa, Hawaii

National Enforcement Investigations Center, Denver

U.S. Environmental Protection Agency

Office of Enforcement

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT AND COMPLIANCE ASSURANCE

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Pahoa, Hawaii

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CONTENTS

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

TABLES

INTRODUCTION

At the request of EPA Region 9, the National Enforcement Investigations Center (NEIC) conducted a multimedia compliance investigation of Puna Geothermal Venture (PGV) - Pahoa, Hawaii. PGV produces approximately 25 megawatts (MW)* net of electricity using geothermal fluids (principally steam). The PGV facility occupies approximately 25 acres within a 500-acre leased property and employs 40 people. PGV is located approximately 20 miles south of Hilo, Hawaii.

Approximately 800,000 pounds per hour of geothermal fluid are used to produce the 25 MW net of electrical power sold by PGV. An additional 2.5 MW of power are produced and consumed in the electrical production process. The geothermal fluids, including any separated brine and noncondensible gases, are reinjected back into the ground. Two production wells and three injection wells are currently in use.

The produced geothermal fluid is separated into a steam phase and brine phase. A portion of the steam phase is routed directly to a steam turbine to produce electricity. The steam turbine discharge is combined with the remaining portion and routed to Ormat Energy Converters (OEC). In the OECs, geothermal steam is used to vaporize pentane which in turn is used to drive an organic turbine for additional electrical production. The pentane is condensed and routed to the OEC to repeat the process. The geothermal steam exiting the OEC is combined with the noncondensible gases and geothermal brine before reinjection.

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* *Power production has increased to 30 MW subsequent to the NEIC inspection.*

OBJECTIVE

The specific objectives of the investigation were to determine compliance with:

- Air pollution control regulations, including state permits No. P-833-1524 and No. P-834-1582
- Underground Injection Control (UIC) regulations, including state permit UH-1529
- Emergency Planning and Community Right-to-Know Act (EPCRA), 42 U.S.C. §11001 et seq., EPCRA § 301; and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. § 9603 CERCLA § 103.

In addition, NEIC personnel identified facility activities/conditions that, although not specifically regulated, could impact the environment.

INVESTIGATION METHODS

The investigation of PGV included:

- A review of federal and state files
- An on-site inspection of the facility conducted February 13 through 17, 1995, which included:
    - Discussions with facility personnel
    - Observations and evaluation of facility operations
    - Review/copy facility records
- Sampling of the two groundwater monitoring wells and geothermal reinjection fluid
- Monitoring of 50 potential fugitive emissions points (valves) in pentane service

Personnel from the regional UIC program and NEIC worked as a team to determine compliance with UIC requirements.

The technical report has been divided into four main sections: Process Description - which provides an overview of the geothermal process; and the Air, Underground Injection Control, and EPCRA sections which discuss compliance with applicable regulations and permits. These reports form the basis for the summary of findings presented in the following section.

SUMMARY OF FINDINGS

The areas of noncompliance and areas of concern* identified during the investigation are summarized below. These findings are detailed in the technical report sections.

CLEAN AIR ACT

Areas of Noncompliance

Permit P-833-1524 Attachment II, Condition 20	Semiannual sampling and reporting of the geothermal resource has not been performed for all required parameters. No annual or semiannual resource testing, while operating under normal conditions, was provided to HDOH, prior to 1995. After the NEIC inspection, PGV reported 1994 results compiled from various test locations. NEIC determined that 15 of the required 78 parameters were validly reported for well KS-9, and 37 of 78 for well KS-10. This did not include the three parameters that PGV reported were impossible to monitor, or were redundant with other parameters.
Permit P-834-1582 Attachment II, Condition 5	PGV does not have an installed spare condensate pump. A spare pump is kept in an adjacent warehouse which does not allow it to be utilized immediately upon identification of a malfunction of one of the three operating pumps.

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* *Areas of concern are inspection observations of potential problems/activities that could impact the environment, result in future noncompliance with permit or regulatory requirements, and/or are areas associated with pollution prevention issues.*

Permit P-834-1582 Attachment II, Condition 10	Air quality and meteorological data from the ambient monitoring stations are not summarized in the monthly reports provided to HDOH.
Permit P-834-1582 Attachment II, Condition 2	Some fugitive emission points are not monitored on a weekly basis. Potential fugitive emission points on the fan coolers and OECs have not been monitored since startup of the plant.
Permit P-834-1582 Attachment II, Condition 5	Pentane transfer records were not included with the third and fourth 1994 quarterly reports.

Areas of Concern

- Not all National Emission Standards for Hazardous Air Pollutants (NESHAP) pollutants required to be monitored by the permit are present in the geothermal fluids. Hawaii Department of Health (HDOH) should require sampling of only those NESHAP pollutants which are specifically of interest [PTO P-833-1524, Attachment II, Condition 20].

- HDOH requires that Best Available Control Technology (BACT) be used during periods of well equipment failure or malfunction (Permit P-833-1524 and Permit P-834-1592), but does not define BACT in the permits. HDOH should also clarify whether or not BACT requirements apply to well drilling operations. If HDOH intends for those practices described in the drill plans [which are to be approved by the Hawaii Department of Land and Natural Resources (HDLNR)] to constitute BACT then this fact should be made clear in the permit [PTO P-833-1524, Attachment II, Condition 13].

- Drilling plans prepared after the 1991 KS-8 well incident do not address all recommendations made in independent investigations, or investigations by PGV, subsequent to that incident. These include provisions for adequate kill fluid temperatures and quantities, maximum-sized mud pump liners, and weight criteria. Also there is no apparent written requirement in the drill plan for the addition of lime to the recirculating wellbore fluids. HDOH should review recommendations made in the 1991 investigation, and PGV's response to those recommendations, as well as drill mud lime requirements to ensure that all necessary precautions are being taken.

- There are limited means to verify compliance with the plant-wide 200 pounds per day pentane emission limit. Pentane inventory levels are reconciled only on a quarterly basis and, therefore, daily exceedances can only be confirmed if the total emissions for the quarter exceed 18,000 pounds (90 days per quarter x 200 pounds per day), or if there is a report of a catastrophic release [PTO P-834-1524, Attachment II, Condition 3].

- The permit limitation of fugitive hydrogen sulfide emissions to less than 1 lb/hr is unmeasurable and, therefore, unenforceable. An option to addressing fugitive hydrogen sulfide emissions is to impose additional requirements on PGV's existing in-plant hydrogen sulfide monitoring system. These requirements could address minimum allowable monitor downtime, monitor calibration and identification of plant areas or equipment where repetitive leaks occur [PTO P-834-1524, Attachment II, Condition 20].

- The Emergency Steam Relief Facility (ESRF) design, modifications, and consultant recommendations, and PGV's response to these recommendations and the related NEIC evaluation, should be reviewed to ensure that the 1992 ESRF problems have been adequately addressed. NEIC's evaluation indicates that there are still potential problems.

- Explanations for large pentane transfers should be included on the quarterly air reports. This information would provide operational history of the individual OECs and could be useful in scheduling preventative maintenance activities, such as increased frequency monitoring for OEC requiring frequent pentane transfers [PTO P-834-1524, Attachment II, Condition 5].

- The noncondensible gas vent from the Vapor Recovery Unit (VRU) should be included in the volatile organic compounds (VOC) monitoring program. Monitoring readings may demonstrate that this vent stack is a significant source for pentane losses.

- Fugitive pentane monitoring at a distance of 2 inches, as required by the permit, is not appropriate. The facility has not identified any leaking components since the program was initiated. NEIC identified four components leaking at greater than 1,000 ppm when measured at the interface; however, when the monitoring distance was increased to 2 inches, the readings dropped below the 1,000 ppm limit specified in the permit. The EPA approved fugitive monitoring method, Method 21 Appendix A of CFR 40 Part 60, requires that fugitive monitoring be conducted at the component interface [PTO P-834-1524, Attachment II, Condition 2].

- The number of components identified by NEIC to be leaking, at levels above background, is greater than that identified by PGV monitoring.

NEIC identified seven components leaking at greater than 100 ppm of which four were leaking at greater than 1,000 ppm when monitoring at the component interface. Previous monitoring at the component interface, in the same area, by PGV personnel identified only one leaking component at a concentration of 100 ppm. Due to the slower response time of the PGV monitoring equipment, PGV operators will need to be more deliberate while monitoring potential fugitive emission sources.

or HDOH

- The fugitive monitoring calibration gas used by PGV did not display a manufacture or expiration date. The approved fugitive monitoring method, Method 21 Appendix A of CFR 40 Part 60, requires that calibration gases display a manufacture date.

- Hydrogen sulfide and meteorological monitoring data should be reviewed, evaluated, and summarized on the required reports. Currently, all the monitoring data is supplied without summary or reporting of upset conditions. Combining HDOH and PGV monitoring data into a single program would allow for a comprehensive evaluation of all available data.

- The online time for the three PGV-operated ambient air monitors is only 86% for the last 6 months. The west air monitor was the least reliable and was only operational for 64% of the time. The PGV should purchase a spare H_2S analyzer to eliminate equipment downtime gaps which have occurred in the past monitoring periods.

- PGV should stagger the calibration period for the H_2S analyzers so that at least two analyzers are in operation at all times.

Suggested Permit Changes*

- The permit should clearly specify the chemicals analyses to be conducted on the geothermal resource. The permit requires analyses for the NESHAP pollutants. However, it is unclear as to whether this reference refers to a specific NESHAP chemical, all NESHAP chemicals (40 CFR Part 61), or all Hazardous Air Pollutants (40 CFR Part 63) [PTO P-833-1524, Attachment II, Condition 20].

- The specific controls and/or equipment needed to comply with Best Available Control Technology (BACT) should be specified. The current permit does not define BACT; is unclear as to whether BACT applies only to well drilling malfunctions or during all well drilling activities; and does not specify who is responsible for approving BACT provisions [PTO P-833-1524, Attachment II, Condition 13].

- The permit limitation of 1 lb/hr of H_2S emissions is unmeasurable and therefore unenforceable. There is no requirement for PGV to monitor or otherwise calculate the actual release of H_2S during normal operating conditions. This permit condition should be removed, modified, or perhaps replaced by imposing additional monitoring requirements using PGV's existing in-plant H_2S monitoring system [PTO P-834-1524, Attachment II, Condition 20].

- Allowing the measurement of fugitive emissions points at a 2-inch distance is inconsistent with procedures required in the Method 21 Appendix A of CFR 40 Part 60. Monitoring should be conducted at the component interface as required in Method 21. If monitoring of all VOC

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* *These issues are also discussed under "Areas of Concern."*

components is conducted according to Method 21 Appendix A of CFR 40 Part 60, then less frequent monitoring could be considered. Monthly sampling rather weekly sampling should be considered if monitoring is conducted at the interface. Monthly or quarterly monitoring frequencies are required in the New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations [PTO P-834-1524, Attachment II, Condition 2].

- The 200 lb/day pentane emission limit cannot be verified with existing permit recordkeeping requirements. Either the daily inventory in the pentane storage tanks or the daily quantity of pentane transferred from the VRU to the pentane storage tanks must be recorded into order to calculate the daily emissions [PTO P-834-1524, Attachment II, Conditions 3 and 5].

- The noncondensible gas vent from the VRU should be included in the pentane monitoring system. Based on the low PGV reported leak rates and lack of any reported pentane upset/releases, the VRU vent is a likely source of pentane emissions [PTO P-834-1524, Attachment II, Condition 2] .

- An explanation for pentane transfers should be required in the quarterly reports. This information would provide operational history of the individual OECs and be useful in scheduling preventive maintenance activities [PTO P-834-1524, Attachment II, Condition 5].

- Several data reporting changes should be considered to improve the usefulness of the ambient air monitoring summary.

- Historical data summaries should be included for each hydrogen sulfide analyzer to show dates, durations, and likely causes of past hydrogen sulfide readings.

- Historical data should be included for each hydrogen sulfide analyzer to show availability and online time percentages. Additionally, information regarding daily exceedances should be included with the summary.

- PGV ambient air monitoring data should be submitted more frequently. Availability of the PGV data should be consistent with that of the HDOH data.

- Ambient air and meteorological data from the HDOH monitoring stations should be included.

UNDERGROUND INJECTION CONTROL

Areas of Noncompliance

Permit UH-1529 Part I.A.3(a)	Injection rate exceeded 675,000 pounds for 10 days during September 1994. Notification was provided within 1 week to HDOH for five of the daily exceedances.
Permit UH-1529 Part I B. 1. (f)	PGV does not monitor for all parameters identified in the permit. Instead of reporting m- and p-cresol as individual compounds as required under type II sampling in the permit, the company reported combined m- and p-cresol. Additionally, for Type III sampling, the following chemicals were not reported. • 2-Chloroethylvinyl ether • Dibromochloromethane • 1,1-Dichloroethane • 1,2-Dichloropropane • 1,1,2,2-Tetrachloroethane • 1,1,1-Trichloroethane • 1,1,2-Trichloroethane
Permit UH-1529 Part III A. 1 (a)	PGV did not follow the Standard Operating Procedures for Monitoring Well Sampling as referenced in the "Hydrologic Monitoring Program." There was no purging of MW-1. The procedures call for sampled wells to be purged of 3 to 10 times its borehole volume of standing water.
Permit UH-1529 Part III A. 1. (b)	PGV did not follow the procedures specified in the "Production and Reinjection Well Casing Monitoring Program." ***Redacted due to Confidential Business Information.***

Areas of Concern

- The calculation procedures used to report the hourly injectate rates may not accurately reflect the true hourly injectate rates. PGV calculates, and subsequently reports, the average hourly flow rate by dividing the daily total mass quantity by 24 hours. This calculation procedure results in the reporting of the average hourly flow rate as opposed to the actual hourly flow rate.

- PGV should consider including a narrative description for "large" annulus pressure changes in the Quarterly Injection Well Status Reports. Additionally, the company should develop estimates as to the acceptable pressure drops or pressure drop rates. Specifically the company should specify what pressure drop would indicate a loss of mechanical integrity during normal operations.

- The existing injectate cooling equipment does not provide sufficient cooling to maximize retention of volatile components in the sample. Injectate samples should be further cooled prior to collection. The collection sample temperature should also be recorded.

- PGV has not analyzed for all parameters specified in the permit and the state has apparently not requested this missing information. Several required chemical constituents (e.g., helium) could likely be dropped from the permit, or reduced in sampling frequency, without impacting the effectiveness of the permit. Additionally, the permit should be modified to reflect analyses for constituents in the aqueous form rather than the gaseous form (e.g., chloride rather than chlorine). PGV and the state should consider modifying the UIC permit to include appropriate chemicals for analyses.

- PGV should document the basis for their assumptions of flows entering the ESRF collection pond. This information could then be used to determine if the ESRF collection pond is sized appropriately.

- The costs for plugging more than one relatively deep geothermal well could be high. There is the need to assess if the current bond for plugging and abandoning is insufficient. If additional wells are drilled, the bond for plugging and abandoning should be increased.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT

Areas of Concern

- The assumptions and calculations used to estimate the quantity of H_2S released (or other reportable materials) should be included with the incident reports. Retention of this documentation at a central location within the plant will facilitate emergency prevention, preparedness, and planning as well as easier review for future incidents (if any).

- A preliminary review of the draft Emergency Response Plan (version 6.2) identified several deficiencies which should be addressed. Some of these deficiencies were also pointed out in the review of the previous version by Region 9. Generally, the plan does not provide specific information. Several terms or phrases should be defined or clarified to avoid confusion or misunderstandings if an incident occurred. The deficiencies in the draft version are identified in the ERP section of this report.

PROCESS DESCRIPTION

The PGV geothermal plant produces 25 megawatts* net of electricity using geothermal fluids. The geothermal fluid is separated into liquid (brine) and vapor (steam) phases. The brine is routed directly to the reinjection wells and a portion of the steam is routed to a steam turbine to produce electricity. The unused steam portion is combined with the spent steam exiting the turbine, and is routed to 1 of 10 Ormat Energy Conversion (OEC) units.

Paragraph redacted due to Confidential Business Information.

The following process discussion has been divided into three sections: Geothermal Production Wells, Power Plant, and Reinjection Wells. A plot plan of the facility is provided in Figure 1, and a simplified process flow diagram is provided in Figure 2.

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* *Power production has increased to 30 MW subsequent to the NEIC inspection.*

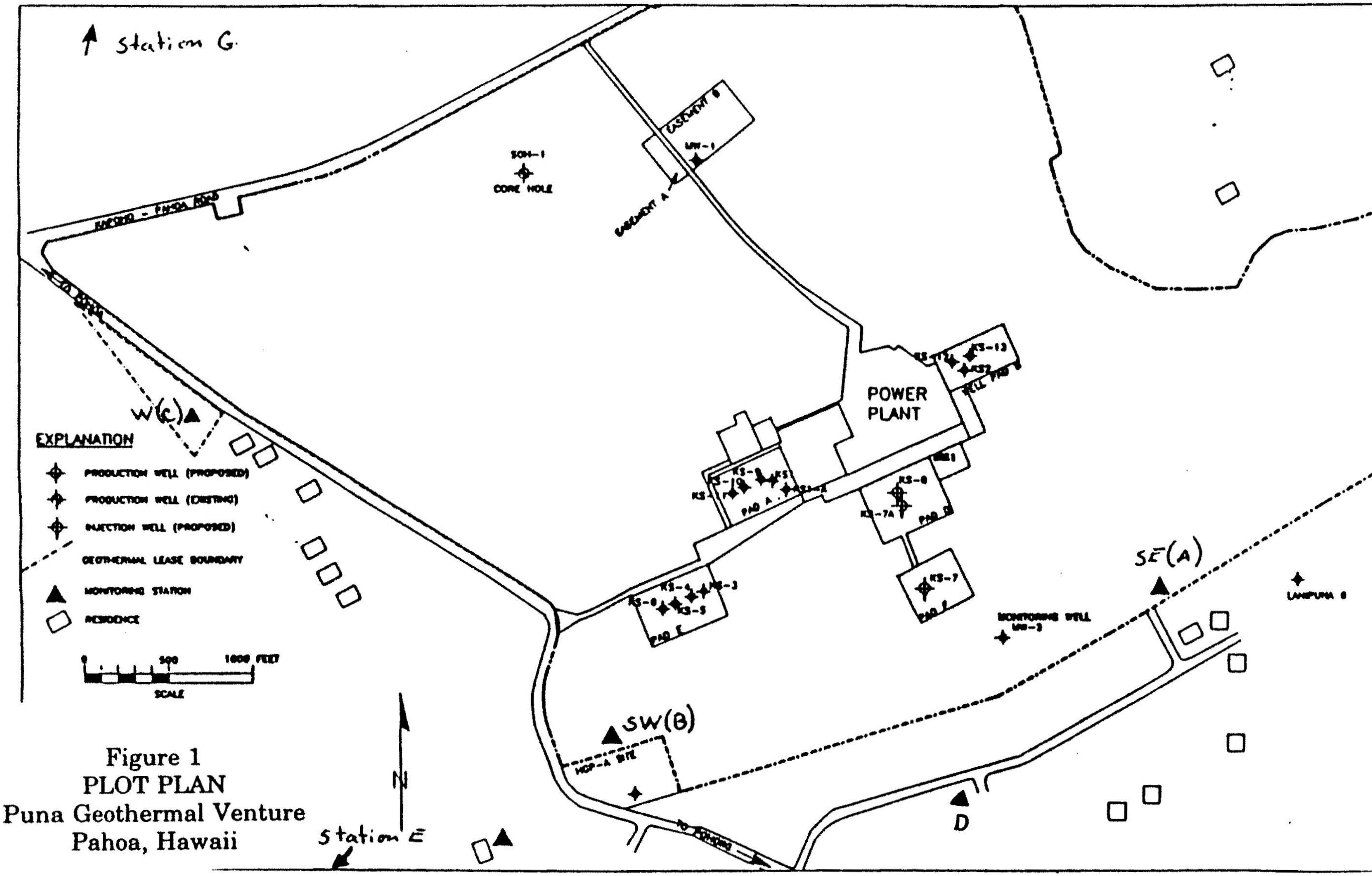

Figure 1
PLOT PLAN
Puna Geothermal Venture
Pahoa, Hawaii

Figure 2 - Process Flow Diagram - Redacted due to Confidential Business Information

GEOTHERMAL PRODUCTION WELLS

Two production wells, KS-9 and KS-10, provide all the geothermal fluid needed to operate the plant. Each well produces a two-phase flow consisting of steam and brine. Only the steam phase is used for electrical production. Operating characteristics of the production wells, as provided during the February 1995 inspection, are summarized below.

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Paragraph redacted due to Confidential Business Information.

From the control loops, the geothermal fluid flows through a flash separator [photograph 1]* where the steam and brine are separated. During normal operation, the combined steam flow from KS-9 and KS-10 flash separators are routed through a common header to the power plant. Brine is

* All photographs are found in Appendix A.

routed to the reinjection wells. ***Redacted due to Confidential Business Information.***

Paragraph redacted due to Confidential Business Information.

The caustic system consists of two caustic (sodium hydroxide) storage tanks and three caustic delivery pumps. The first tank stores strong caustic (50%) used to make the dilute caustic (15%) stored in the second tank. The concentrated caustic pump is used to transfer 50% caustic to the dilute caustic tank. The two dilute caustic pumps inject the dilute caustic solution into the pipeline leading to the rock mufflers.

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Paragraph redacted due to Confidential Business Information.

A history for wells drilled at PGV is summarized in Appendix B. Wells are used either for steam production, as described above, or for reinjection discussed later in this section. The actual well usage might not be determined until well drilling and developing steps are completed. Some wells (e.g., KS-7 and KS-8) could not be used for their intended purpose due to geothermal controllability problems.

POWER PLANT

Power is produced through 10 equally-sized electrical power generators. Each generator is connected through reducing gears to two turbines, the steam turbine and the organic turbine. Geothermal steam is used directly to power the steam turbine and pressurized pentane vapor is used to power the organic turbine.

Steam flow from the common header is divided into separate lines leading to the 10 generators. A portion of the steam is directed through the steam turbine. The steam exiting the turbine is recombined with the bypassed portion and is routed to the OEC unit [Figure 2].

The OEC unit is a closed loop system using pressurized pentane vapors to power the organic turbine. ***6 lines redacted due to Confidential Business Information.***

Paragraph redacted due to Confidential Business Information.

Noncondensible gases (primarily H_2S and CO_2) removed from the 10 pentane vaporizers are collected and cooled before entering the first compressor. The ***CBI*** compressors are operated in parallel, with each having the capacity to compress the total noncondensible gas flow. Condensate removed prior to the first stage and between the first and second stages is combined with the geothermal steam condensate from the OECs.

Paragraph redacted due to Confidential Business Information.

A small quantity of inert gas accumulates in the OEC recirculating pentane system and must be periodically vented. The vapor, containing mostly pentane and nitrogen, is vented from the pentane accumulators to the Vapor Recovery Unit (VRU). The VRU uses refrigeration to condense the pentane and water form the vapor. The nitrogen and any other inert gas is released to the atmosphere. The hydrocarbon is returned to one of two pentane storage tanks. Pentane is periodically withdrawn from these tanks for makeup to the OECs.

GEOTHERMAL REINJECTION WELLS

The geothermal brine separated at the production wells, geothermal steam condensate collected from the 10 OECs and compressor knockout pots, and noncondensible gases are all recombined prior to reinjection. A corrosion inhibitor is added into this stream prior to underground injection in order to minimize corrosion in the injection wells.

The OEC steam condensate and the compressors condensate are combined, mixed with a corrosion inhibitor, and routed to one of three condensate reinjection pumps. Typically all three pumps are in operation. These pumps boost the pressure of the combined stream to avoid flashing when combined with the brine separated at the production wellheads.

The condensate reinjection pump flow passes through a pressure control valve and a mixing spool where the compressor discharge gases are added. A pipeline carries the recombined geothermal fluid to the reinjection area. At the reinjection area the flow is split with a portion routed to each reinjection well: KS-1A, KS-3, and KS-4. Each well is equipped with flow and pressure measurement for balancing well operations. The quality and quantity of fluids injected through the reinjection wells is regulated by UIC permit UH-1529 and is discussed in the UIC portion of this report.

CLEAN AIR ACT

Discussions of air compliance issues have been divided into three sections: Wellfield, which includes productions wells, reinjection wells, and drilling activities; Power Plant, which includes those fugitive and point sources associated with power production; and Ambient Air Monitoring, which includes air quality and meteorological off-site monitoring.

WELLFIELD EMISSIONS

Wellfield emissions primarily occur during nonroutine conditions such as well drilling, flow testing, and abated well cleanout. Wellfield emissions can also occur from leaks in flanges, connections, valves, or fittings. When completed wells are not experiencing any equipment failure or malfunction, there are no wellfield emissions. At the time of the NEIC investigation, all five active wells were in normal operation.

Table 1 summarizes well blowout and geothermal release incidents which have occurred at PGV [Appendix C].* The table shows ambient H_2S concentrations resulting from those incidents (when such data were available from PGV incident reports). Three incidents have resulted in exceedances of permit limits for ambient hydrogen sulfide concentrations. These were a result of a well blowout at KS-8 and flange leaks at KS-3 and KS-8.

Permit No. P-833-1524 [Appendix D], issued by the HDOH on July 26, 1993, regulates the wellfield operations for the five geothermal wells currently

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* *Many of the readings in the PGV incident reports [Appendix C] were difficult to understand, and should be made more legible in future incident reports.*

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Table 1

HYDROGEN SULFIDE RELEASE INCIDENTS
Puna Geothermal Venture
Pahoa, Hawaii

Date	Source	Incident	Mobile H_2S Concentration	Fixed Station H_2S Concen
02/21/91	KS-7	Blowout occurs during drilling due to unexpected high geothermal fluid pressures experienced at 1700 feet.		
06/11/91	KS-8	Blowout occurs during drilling due to unexpected high geothermal well pressures. Well shutin after 30-hour release.		
09/10/91	KS-3	During temperature logging, a leak occurred at the lubricator and flange. Master valve closed but leak continued until well cemented in subsequently allowing access by pump truck to kill well.		SW station - 60 ppb max, 8 ppb hr avg HGP-A 29 ppb
08/13/92	KS-8	Initiated KS-8 flow test with 4-hr well cleanout, steam diverted to ESRF. H_2S emissions = 3.81 lb/hr		
08/13/92	KS-8	KS-8 flow test continued. Steam rate to ESRF lowered to test efficiency. Wide fluctuation in low steam flow caused large fluctuation in caustic flow. H_2S emission 5.16 lb/hr. Steam flow put in manual control.		SW station - 1 ppb hr avg. W station - 1 ppb hr avg.
08/14/92	KS-8	KS-8 flow test continued. Started OEC which reduced steam flow to ESRF from 120,000 lb/hr to 50,000 lb/hr. H_2S emission 5.75 lb/hr. Increased ESRF steam flow to maintain a minimum flow for better control.		SW station - 1-2 ppb hr avg W station - 1 ppb hr avg.
08/14/92	KS-8	Flow test continued. More OEC units brought online causing steam flow to the ESRF to go to 20,000 lb/hr. H_2S emission 7.18 lb/hr.		SE sta.- 0-2 ppb hr avg SW sta. - 0-1 ppb hr avg W sta. - 1 ppb hr avg
08/15/92	KS-8	Flow test continued. Cycling between OEC units causes low flow to ESRF. H_2S emissions 5.9 lb/hr. Caustic flow manually increased.		SE sta.- 1-3 ppb hr avg SW sta.- 1 ppb hr avg. W sta.- 0-1 ppb hr avg
08/17/92	KS-8	Flow test continued. ESRF steam shut off but leak occurred through valve without caustic sytem in operation.	48 ppb	HGPA sta-8-16 ppb hr avg
10/09/92	KS-8	Leak in general area in and around KS-8 cellar.	10 ppb to 1 ppm near cellar.	Not provided
10/13/92	KS-8	Leak on gauge line for valve near wellhead.	10 ppb at perimeter. 40 to 120 in cellar	Not provided
10/28/92	Power plant	OEC # 23 steam turbine seal maintenance resulted in leakage at seal.	20 ppb at perimeter	SW sta.- 5-6 ppb hr avg
10/28/92	Power plant	NCG compressor A leakage.	21 ppb at Gate 4.	DOH sta.- 25-39 ppb max. SW sta - 9 ppb hr avg
11/03/92	KS-8	During initial phase of KS-8 kill operation leak occurred on 3 in. flange at wellhead.	None provided	DOH Hinalo Rd sta- 672 ppb for 9 min, 150 ppb hr avg
02/08/93	KS-9	Thirty-min cleanout caused excessive emissions from the cyclonic muffler over 2- to 4-minute period. Inadequate mixing with NaOH in the flow line.	250 ppm spike	SE sta- 23 ppb hr avg
02/28/93	KS-9	Hole in lubricator caused by wire coming out of hole when a caliper tool broke off.	24 ppb spike	C sta - 7 ppb hr avg
03/01/93	KS-9	Leaking fittings above 3 in. valve on wellhead.	4-22 ppb on-site	A sta - 25 ppb alarm
05/11/93	Power plant	Power plant tripped offline causing flow to ESRF for 10- and 20-second periods.	None detected	None detected
05/14/93	KS-1	Release of H_2S from circulation wellbore fluid during plugging, abandonment operation.	None detected	SW sta- 3.4 ppb 1 hr avg, 62 pp[illegible]

in service. It is effective until July 1, 1995,* and specifies emission control, monitoring, and reporting requirements. Permit No. NSP 0008-01-N [Appendix E] provides similar limits for the construction of up to 14 exploratory/developmental wells which could be installed in the future. This permit was issued on June 22, 1994 and is effective until June 1, 1999. Mr. Lynn White, PGV General Manager, stated during the inspection that there is no current intent by PGV to drill additional wells, but circumstances, such as failure of an existing well, might necessitate installing additional wells.

During the NEIC investigation, the following wellfield air pollution issues were identified.

- BACT requirements for geothermal well emissions
- Required periodic geothermal resource sampling
- Special geothermal resource sample requirements

<u>BACT for Geothermal Well Emissions</u>

HDOH requires that Best Available Control Technology (BACT) be applied to H_2S emissions during geothermal well flow testing operations and periods of well equipment failure (special condition 13, Attachment II of permit PTO P-833-1524). However, the permit does not define BACT.

Hawaii regulation 11-60.1-1 defines BACT to be an emission limitation, which the director of HDOH determines is achievable based upon a number of factors including economics and environmental impact [Appendix F]. The regulation allows for use of technology requirements, or work practice

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* PGV has applied for renewal of the permit. HDOH has not reissued the permit, however in accordance with Hawaii air regulations, the existing permit remains valid.

standards if an emissions standard is infeasible. The permit does not include an emission limitation, or any of the prescribed alternatives to an emission limitation, when it refers to BACT*.

It is also not clear if the BACT requirement applies to drilling activities (General requirement B.8 of Attachment II, NCF No. 0008-01-N states that during well blowouts, the permittee shall "immediately proceed with measures to kill or gain control of the well"). Bob Verity, PGV consultant, stated that BACT is defined prior to each well operation in the plan provided to HDLNR pursuant to HDLNR notification requirements. The HDOH permit does not state that HDLNR is responsible for approving BACT provisions. The HDOH permit should be revised to include specific BACT provisions based on Hawaii regulation 11-60.1-1.

Subsequent to the blowout of well KS-8 in June 1991, a third-party team consisting of four investigators experienced in geothermal drilling and resource issues, evaluated the adequacy of PGV's drilling and blowout prevention equipment (BOPE) and procedures. In their report [Appendix G], they determined that the blowout and subsequent release of hydrogen sulfide occurred because of shortcomings in the PGV program and not as the result of unusual or unmanageable subsurface geologic or hydrologic conditions. Their recommendations included a number of equipment and procedural changes which could be used to provide a basis for defining BACT for drilling activities at PGV (their recommendations, however, are not currently required by HDOH as BACT). On the other hand, the investigation report cautioned against agencies being too specific in specifying BOPE and casing requirements, and recommended that the operator be permitted to make judgement calls to modify the drilling operation.

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* *This is not the same definition of BACT as under the Federal regulations.*

PGV has drilled two wells, KS-9 and KS-10, subsequent to the KS-8 incident. Neither well activity resulted in emissions that exceeded the ambient permit limits of 10 ppb daily or 25 ppb hourly (see discussion below regarding ambient monitoring). There was a release of hydrogen sulfide resulting in a 23-ppb ambient hourly H_2S concentration during the abated cleanout of well KS-9 due to inadequate caustic scrubbing of noncondensible gas prior to its release from the cyclonic muffler. PGV has since modified caustic introduction to prevent future occurrences of this nature.

Paragraph redacted due to Confidential Business Information.

Table 2

KS-9 DRILLING PLAN REVIEW
Puna Geothermal Venture
Pahoa, Hawaii

1991 Investigation Recommendations	**PGV 1992 Drilling Plan for KS-9**
Control of Geothermal Kicks • Provide large supply of cold or cool water (<75 °F). • Provide a pump system with adequate capacity to kill a kick in a large well.	***Redacted due to Confidential Business Information.***
Blow Out Prevention Equipment • Allow for adequate mud cooler capability; larger than used on KS-8. • Ensure that pit level indicators and other monitoring readouts are located for ready observation by well driller. • Provide a low pressure burst plate on relief line. • Provide an adequate diameter choke line (4"). • Ensure that mud pumps have maximum sized pump liners. • Ensure that silencer/muffler is installed on end of choke manifold line.	***Redacted due to Confidential Business Information.***
Drilling Below 500' without BOPE • Take maximum bottom hole temperatures at every connection. • Collect and quickly conduct conductivity/ salinity analyses of water samples. • Collect cutting samples every 10' and analyze for geothermal minerals.	***Redacted due to Confidential Business Information.***
Driller Supervision/Training • Supervisory personnel should be present on rig floor during all drilling. • Tool pushers, drillers, and derrick men should be trained in use of monitoring equipment.	***Redacted due to Confidential Business Information.***

PGV responded to the recommendations made by the investigation team in a September 5, 1991 report [Appendix I]. In general, they did not agree that any of the suggestions provided by the team would have prevented the release that occurred at KS-8. They instead outlined subsequent PGV drilling program changes, which included only some of the recommendations of the investigation team. Their changes addressed actions for each of the following areas: drill casing, mud weight, supervision, training, monitoring equipment, water supply, mud system, BOPE system and wellhead design. It is not clear how drilling of wells KS-9 and KS-10 incorporated these changes. Some of the guidelines were vague and not clearly defined (e.g., the casing setting criteria, how mineralization of drill cuttings would be used in conjunction with other "criteria," and how mud weight requirements would change with depth). Other guidelines were less vague but were not specified or referenced in subsequent drilling plans (e.g., the 425 °F temperature readings for determining the top of the formation, the chain of responsibility for determining actions, and drilling monitoring alarm levels). In summary, although PGV stated that the actions they provided for in their September 5, 1991 report would more satisfactorily prevent incidents similar to KS-8 from occurring, there is a lack of documentation to show to what degree these actions were implemented in subsequent drilling at the site.

There is no reconciliation between the KS-8 1991 drill program changes, or subsequent drilling plans for KS-9. Consequently, NEIC was unable to evaluate PGV's modifications to drilling practices. The 1991 recommendation that the state of Hawaii work toward establishing drilling equipment and procedures standards has not been completed. These standards would have been helpful in this evaluation. Although the development of such standards would be likely hindered by state budget limitations, it is appropriate that HDOH and PGV develop a cost estimate and schedule for doing this work, and solicit assistance from appropriate industry groups to aid in this effort.

Paragraph redacted due to Confidential Business Information.

Required Periodic Geothermal Resource Sampling

Geothermal resource sampling is required by special condition 20 in PTO P-833-1524. Geothermal condensate, steam, particulates, and gases from each production well must be tested annually for the chemical constituents specified in special condition 20. If there is more than a +/- 10% change in the hydrogen sulfide concentration of the fluid from a well, then the well must be tested semi-annually and results submitted to HDOH.

PGV stated that much of the analytical data required for the geothermal fluid is collected monthly, but has not been submitted to the HDOH in a semiannual or annual format. NEIC reviewed PGV monthly sampling [Appendix J] results. Table 3 shows reported brine and vapor hydrogen sulfide concentrations. There has been more than a +/- 10% change in the hydrogen sulfide concentration. For example, hydrogen sulfide vapor concentration at KS-10 has increased from approximately 300 ppm to greater than 500 ppm.

The analytical parameters required by condition 20 of PTO P-833-1524, and those parameters analyzed monthly by PGV in data made available at the

Table 3

HYDROGEN SULFIDE CONCENTRATION (PPM)
Puna Geothermal Venture
Pahoa, Hawaii

Month/Year	Well KS-9		Well KS-10	
	Brine	Vapor	Brine	Vapor
12/93	8.15		4.84	
01/94	11.7		6.89	
02/94		834	5.75	322
03/94	7.81	816	2.96	298
04/94	7.94	831	5.17	589
05/94	7.38	817	4.82	515
06/94	6.80	845	4.14	560
07/94	8.62			
08/94				539
09/94	7.84	821	3.24	
10/94	7.39	701	2.95	
11/94		742		

time of the NEIC inspection, are shown in Table 4. Concentration limits are not set for any of the identified parameters; however, a monitoring schedule is established. Based on the data made available during the inspection, PGV analyzed 11 of the 20 required brine parameters, and 5 of the 11 required gas phase parameters for each well. Of the parameters required for monitoring in special condition 20, there is a requir ment to monitor "NESHAP pollutants," some of which are also specified individually (e.g., mercury, benzene, etc.) in the permit. It is not clear whether the NESHAP list includes only original NESHAP predating the 1990 Clean Air Act amendments (40 CFR 61.01), or the hazardous air pollutant list promulgated pursuant as 42 USC 7412; Clean Air Act, Title I, Part A, Section 112 (as amended, 1990). It is recommended that HDOH re-examine the NESHAP requirement and specify individual NESHAP parameters likely to occur in geothermal resources, which should be monitored. At the time of the inspection, PGV had not reported results of any routine annual or semiannual resource sample analysis.

After the NEIC inspection, PGV summarized monitoring results and submitted them on June 29, 1995 to the HDOH [Appendix K]. The submittal included data which had not been reviewed or copied by NEIC during the inspection. These data were reported by PGV to be from "mixed" sources (i.e., some directly from the wells, and other from the "process" after the steam from each well was combined). Data from downstream "process" monitoring points do not meet the requirement of special condition 20. Although there were some apparent discrepancies in the summary sheets, NEIC was not able to review the supporting data in order to evaluate those discrepancies. Based on PGV's summary information for 1994, PGV analyzed 15 of the required 78 parameters at KS-9, and 37 of the required 78 parameters at KS-10. (This assumes, as stated by PGV, that total sulfur, HCl, and sulfur dioxide are either impossible to measure, or are redundant and, therefore, unnecessary.) No resource data for operations during 1993, or before, were provided.

Table 4

ANALYSES OF GEOTHERMAL FLUID PARAMETERS
REVEIWED DURING NEIC INSPECTION
Puna Geothermal Venture
Pahoa, Hawaii

Analyses Required by Permit PTO P-833-1524 Semiannual/Annual and Abated Well Cleanout	Monthly Analyses by PGV for 1993/94	Abated Well Cleanout* Analyses by PGV in 1993
<u>Steam Condensate/Total Steam/Total Brine</u>	<u>Brine</u>	<u>Brine</u>
Benzene		Benzene
Ammonia (total)		
Arsenic		
Lead		
Cadmium		
Bicarbonate and carbonate	Total alkalinity	Total alkalinity
Sulfates	Sulfates	Sulfates
Chlorides	Chlorides	Chlorides
Nitrates		
Boron (total)	Boron	Boron
Hydrogen Sulfide (total)	Hydrogen sulfide	Hydrogen sulfide
Fluorides (total)	Fluorides	Fluoride
Total sulfur		
Mercury (total)		
pH	pH	pH
Total dissolved solids	Total dissolved solids	Total dissolved solids
Total suspended solids	Total suspended solids	Total suspended solids
Percent noncondensibiles	Percent noncondensibiles	Percent noncondensibiles
Hydrogen Chloride		
Other NESHAPs pollutants		
<u>Gas Phase</u>	<u>Vapor</u>	<u>Vapor</u>
Benzene	Benzene	Benzene
Hydrogen sulfide	Hydrogen sulfide	Hydrogen sulfide
Ammonia	Ammonia	Ammonia
Radon 222 and daughters		
Mercury vapor		
Methane	Methane	Methane
Nonmethane hydrocarbons		Nonmethane hydrocarbons
Carbon dioxide		
Sulfur dioxide		
Hydrogen chloride		
Other NESHAPs		GC/MS scan provided

* *Flow testing and abated well cleanout were conducted for wells KS-9 and KS-10 in 1993.*

Special Geothermal Resource Sample Requirements

During well drilling, abated well cleanout, and flow testing, PGV is required by special condition 20 of the permit to test for the same chemical constituents discussed in the section above.

NEIC reviewed test results provided for the abated well cleanout of wells KS-9 and KS-10 performed in 1993. Table 4 shows analyses required in special condition 20 of the permit and the analyses conducted by PGV. PGV analyzed 11 of the 20 required condensate parameters and 5 of the 11 vapor parameters. Mr. Paul Hirtz, PGV consultant, stated that although other specified constituents are not individually indicated in the reports, the HDOH was provided a copy of the GC/MS strip charts along with the report. Also, in accordance with special condition 29 of Attachment II, PTO P-833-1524 effective in 1993, the HDOH required, and was provided with, a test plan for all tests that were conducted in conjunction with those activities. Consequently, HDOH had the opportunity to disapprove the proposed analysis if the Agency did not feel the plan met the permit requirements. In their June 1995 submittal to HDOH after the NEIC inspection, PGV reported values for 37 of the 39 required parameters for KS-9, and 37 of 39 parameters for KS-10. (Again, this assumes HCl, SO_2, and total sulfur are either impossible to measure, or can be calculated from other data.)

POWER PLANT EMISSIONS

The primary emissions from the power plant are hydrogen sulfide and pentane, both of which can result from various emission sources. Fugitive geothermal gas emissions containing hydrogen sulfide can occur from leaks in power plant components such as compressors, pumps, pipe fittings, valves, etc. Treated geothermal gas emissions containing hydrogen sulfide are released

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from the ESRF when there is overpressurization in the main geothermal steam supply line to the power plant. Treated geothermal gas emissions containing hydrogen sulfide are released from the Sulfa-Treat system which receives vent gas from the turbine seals. Fugitive pentane emissions can occur from leaks in the Ormat units due to leaks in flanges, fittings, valves, and pumps. Treated pentane emissions occur from the vapor recovery unit which treats gases vented from the pentane condenser.

Power plant emissions are regulated under HDOH permit PTO No. P-834-1582. The permit, dated September 23, 1993, is effective until July 1, 1995* and specifies emission control, monitoring, and reporting requirements.

Air pollution issues identified by NEIC for power plant operations are associated with:

- Fugitive emissions containing hydrogen sulfide
- ESRF system design
- Spare geothermal condensate return pump
- Pentane emissions
- Fugitive pentane emission monitoring

Fugitive Emissions Containing Hydrogen Sulfide

Hydrogen sulfide emissions are limited by special condition 20 of Attachment II, PTO No. P-834-1582. Condition 20 limits the hydrogen sulfide emissions to less than 1 lb/day. PGV is not required by the permit to monitor or otherwise calculate the actual release rate of hydrogen sulfide. PGV stated

* *PGV has applied for renewal of the permit. HDOH has not reissued the permit; however, in accordance with Hawaii air regulations, the existing permit remains valid.*

that although they do not calculate a daily release rate they have an extensive in-plant and plant peripheral hydrogen sulfide sensing system. They reported that when any of these monitors sense a concentration of hydrogen sulfide greater than 10 ppm at internal monitor locations, or 5 ppm at peripheral process locations, an alarm is sounded which is immediately responded to by plant operators. Using hand-held hydrogen sulfide detectors, operating personnel reportedly then locate the source of the leak which is repaired immediately.

NEIC conducted an inspection of plant areas that are expected to be more prone to leakage, such as equipment with moving parts with vibrations that could result in line or fitting separations. Where hydrogen sulfide odors were detected, a hand-held Omni 4000 hydrogen sulfide analyzer was used to "sniff" the area to determine the magnitude of the leak. Only very slight, nonpersistent odors were detected in areas near the noncondensible compressors, production wellheads, and Sulfa-Treat discharge. No measurable hydrogen sulfide was detected (lower detection level 1 ppm). What came out pm 10?

NEIC reviewed the PGV system for recording in-plant hydrogen sulfide analyzer information. Figure 3 shows the location of the monitors. Concentrations are sensed at the monitor location and transmitted to the alarm system, strip charts, and plant computer located in the control room. The computer does not maintain alarm or hydrogen sulfide concentration history for any of the monitor locations beyond 90 days, maximum. There are also no data available for tracking online operating times of each individual monitor. PGV operating personnel stated that in-plant hydrogen sulfide alarms occur approximately six times per year and are of variable duration. They are not reported to HDOH. Dave Berube, former plant manager, stated that there are no particular plant areas that have been found to be more prone to hydrogen sulfide leakage than other areas.

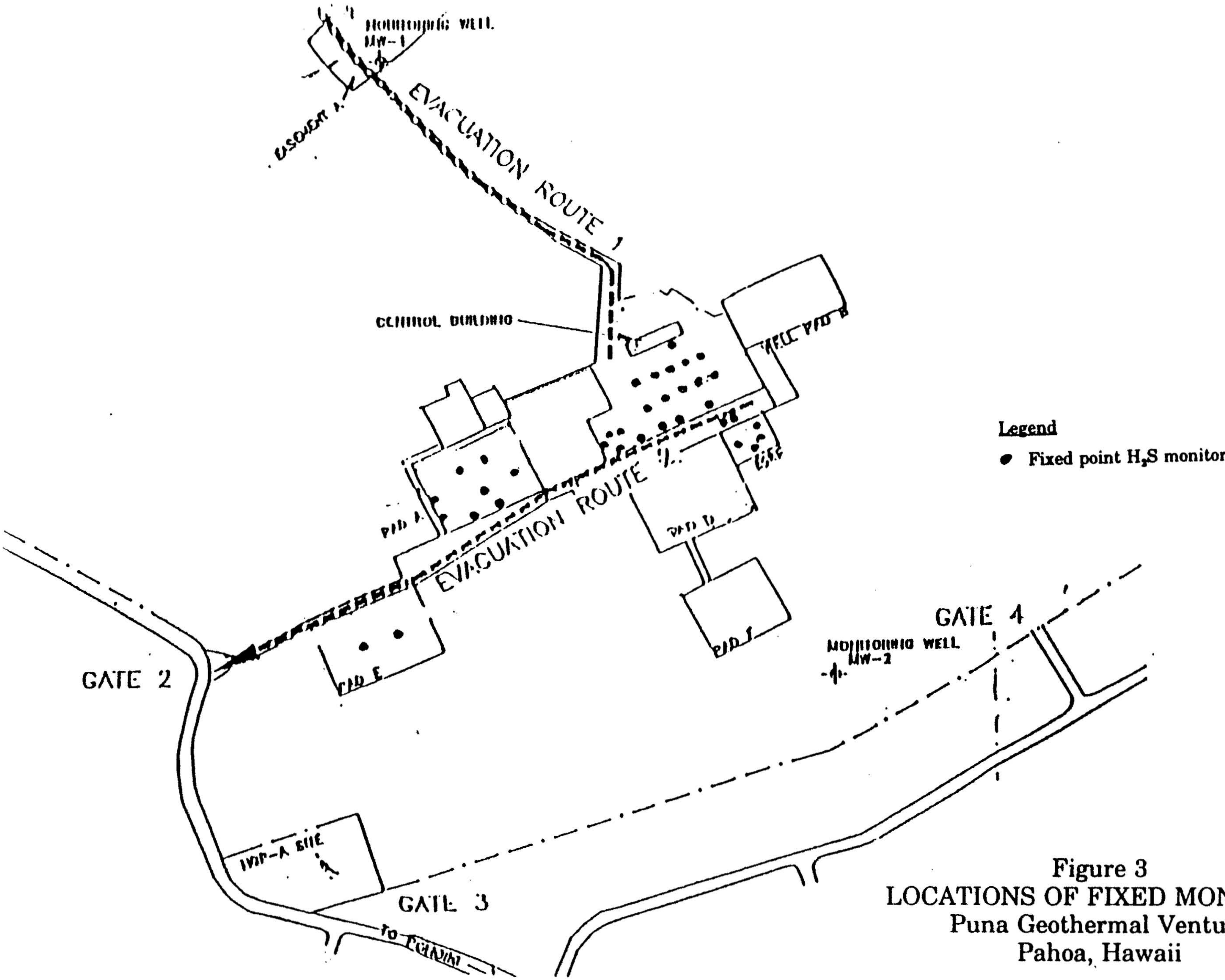

Figure 3
LOCATIONS OF FIXED MONITORS
Puna Geothermal Venture
Pahoa, Hawaii

ESRF System Design

NEIC examined the incident reports for the ESRF since 1992. Emission data from those reports are summarized in Table 1. The incident reports stated that excess emissions occurred in 1992 at low steam flow conditions (less than about 120,000 lbs/hr) due to poor controllability. ***6 line redacted due to Confidential Business Information.***

Paragraph redacted due to Confidential Business Information.

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Table 5 - Two Phase Engineering and Research ESRF Recommendations

Redacted due to Confidential Business Information

Spare Geothermal Condensate Return Pump

An installed spare geothermal fluid pump is required by special condition 6 of Attachment II, PTO No. P-834-1582. Mr. Bruce Davis, PGV (Constellation Energy) attorney, stated that PGV interpreted this condition in the permit to apply to only the brine return pumps, which are no longer necessary because PGV relies on the pressure in the geothermal fluid for reinjection of the brine. PGV does not believe that the condensate pumps that transfer geothermal condensate from the power plant are regulated by this condition of the permit. Mr. Peter Arthur, PGV, stated that a spare condensate pump is kept, however, in the maintenance shop located adjacent to the pump installation.

NEIC inspected the condensate reinjection pumps 40-P-47A, B, and C, which were all operating at the time of the inspection. Geothermal condensate represents a significant part of the liquid fluid which must be reinjected. It contains hydrogen sulfide concentrations comparable to those found in the brine removed at the wellhead. The installed spare geothermal fluid return capacity requirements should apply to any pumps used for reinjection of geothermal fluids, and whose malfunction may necessitate that geothermal steam be released directly to the atmosphere.

Total Pentane Emissions

Pentane emissions are limited by special conditions 2 and 3 of Attachment II of PTO No. P-834-1582. Total pentane emissions from all 10 Ormat Energy Converters (OECs), including fugitive leaks, are limited to less than 200 pounds per day. PGV is required to report the amount of pentane released each quarter. PGV calculates quarterly pentane losses by taking the difference between the beginning and ending inventories of the two pentane storage tanks (tanks 40-V-42-A and B) plus any purchases. This calculation method is the most appropriate procedure in determining the actual pentane losses.

NEIC reviewed PGV's total reported pentane emissions for 1994. PGV inventory records of 1994 quarterly pentane losses, as reported to the Department of Health, are summarized below:

Quarter	Pentane Emission in Pounds
1st	9,472
2nd	11,680
3rd	11,449
4th	9,125

Because inventory records are reconciled only on a quarterly basis, it is not possible to determine if the 200-pound-per-day limit has been exceeded, unless greater than 18,000 pounds (200 pounds/day x 90 days) are reported for a quarterly loss.

Based on the lack of any reported pentane spills and the extremely low fugitive leak rate (discussed below), reported quarterly pentane losses cannot be accounted for through fugitive losses.* A combination of factors likely contribute to the reported quarterly losses, as identified below:

- PGV has reported incorrect or incomplete monitoring results based on sampling procedures outlined in the permit. These issues are discussed later in this section.

* *Fugitive losses are the combined pentane emissions which occur from any seal, flange valve, or other fugitive emission point.*

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- Not all fugitive emission points are included in the PGV monitoring program. This issue is discussed later.

- Other sources, such as the noncondensible gas vent for the vapor recovery unit, have not been included in the monitoring program.

The vapor recovery unit (VRU) treats gases vented from the pentane accumulator. Using a refrigeration system, the VRU condenses pentane, which is returned to the pentane storage tanks, and discharges noncondensible gases. Records are not maintained or required to be maintained as to the quantity of pentane condensed and returned to storage. Additionally, there are no requirements to quantify the amount of pentane released through the noncondensible gas vent stack. Records are, however, maintained for the quantity of pentane transferred from the pentane tanks to the OECs. These pentane transfer records are required by condition 5 Attachment II of Permit P-834-1582. Pentane transfer records were provided for the first and second quarters of 1994, but not included in the third and fourth quarterly reports submitted to HDOH.

Review of the quarterly pentane transfer records show large variations in the amount of pentane transferred to the various OECs. The amount of pentane transferred to the individual OECs for the first and second quarters is summarized in Table 6. The quarterly transfers range from about 250 to 2,800 gallons. Typically, transfer quantities are several hundred gallons; however, a single daily transfer of 2,774 pounds was reported on May 18, 1994 to OEC 23. Large single transfers, or large cumulative quarterly transfers, may be indicative of problems within particular OECs, or may correspond to maintenance activities. Information is not recorded as to why the transfers were necessary.

Table 6

FIRST AND SECOND QUARTER 1994 PENTANE TRANSFERS TO OECS
Puna Geothermal Venture
Pahoa, Hawaii

OEC Number	1st Quarter Transfers (gallons)	2nd Quarter Transfers (gallons)
11	3,902	617
12	266	252
13	530	505
14	1,176	930
15	786	199
21	1,505	1,348
22	2,648	478
23	767	2,774
24	2,820	1,670
25	2,146	267

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Explanations for large pentane transfers should be included on the quarterly reports. This information would provide operational history of the individual OECs and may be useful in scheduling preventative maintenance activities, such as increased frequency monitoring for an OEC requiring frequent pentane transfers.

Pentane Fugitive Emission Monitoring

Fugitive pentane emissions are limited by special condition 2 of Attachment II of PTO No. P-834-1582. Fugitive emissions shall not exceed 0.4 lbs/hr or 1,000 ppm from any seal, flange, valve, or other fugitive point when measured from a distance of 2 inches. All fugitive emission points are to be measured on a weekly basis. Quarterly reports submitted to the Department of Health are required to:

- Identify the number of fugitive emission points exceeding the 1,000 ppm limit

- Quantify the amount of pentane released for the quarter

- Provide information on the date and amount of pentane transferred to and from each OEC module

As part of the PGV fugitive pentane monitoring, NEIC reviewed the 1994 quarterly reports submitted to the Department of Health [Appendix M], evaluated the PGV fugitive emission monitoring plan, and monitored approximately 50 fugitive emission points.

PGV has established a fugitive emission monitoring program requiring the operators to monitor on a weekly basis each of the components listed on

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the fugitive emissions monitoring records. Separate monitoring records [Appendix N] have been prepared for the OECs and pentane storage tanks. Fifty-one components are listed on the OEC monitoring record. (Because each of the OECs are identical in construction, a single list can be duplicated for each of the 10 OECs.) Twenty-seven components are listed on the "storage tank and header" monitoring record.

The PGV monitoring and reporting procedures require that components be monitored in accordance with the permit requirements: specifically, that monitoring be conducted at 2 inches from the component. The PGV procedures state, "Sniff at the listed source point (sample as close as possible). If a reading of 1,000 ppm is indicated, move the probe back to 2 inches from the source point and do a second reading." The reading taken at the 2-inch distance is recorded on the log. PGV uses a Bacharach TLV instrument to conduct all fugitive monitoring, and facility personnel are responsible for monitoring process units assigned to their shift.

The 1994 monitoring records indicate that no leaking components (1,000 ppm at 2 inches) were detected. However, numerous leaks have been recorded when the initial monitoring is conducted "as close as possible" (at the component interface). Component monitoring at a point other than the component interface dramatically reduces the effectiveness and purpose of fugitive emission monitoring. The EPA-accepted fugitive monitoring procedures* require monitoring at the component interface.

NEIC conducted fugitive monitoring at OEC 24 and at the pentane storage tanks. NEIC monitoring was performed using a Foxboro OVA-108. The instrument was calibrated prior to use with zero air, 1,000 ppm, and

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* Method 21, as referenced in Appendix A 40 CFR part 60.

10,000 ppm gas standards. OEC 24 and the pentane storage tanks were selected for monitoring because these areas had been monitored earlier in the day by PGV personnel. (The time difference between the NEIC and PGV monitoring should have little impact on monitoring results.) NEIC monitoring was conducted at both the component interface and at a distance of approximately 2 inches.

Different fugitive monitoring results were obtained from the PGV and NEIC sampling. PGV fugitive sampling [Appendix N] reported no monitoring reading above background levels for any components when monitoring at the interface. NEIC monitoring at the interface identified seven components [Table 7] with emissions greater than background levels, of which four were leaking at greater than 1,000 ppm. Monitoring readings for these four valves were reduced to less than 1,000 ppm when the monitoring distance was increased to 2 inches. NEIC sampling confirmed that no reading above background levels were detected at the pentane storage tanks.

The difference in monitoring results may be explained by either of, or a combination of, the two factors identified below:

- The response time of monitoring equipment varied. The OVA instrument responds very quickly to changes in pentane concentrations. The Bacharach instrument required a minute or longer before leveling out at constant readings.

- The NEIC monitoring procedures were perhaps more diligently performed than those used by PGV personnel.

Table 7

NEIC FUGITIVE MONITORING RESULTS OEC NO. 24
Puna Geothermal Venture
Pahoa, Hawaii

PGV Location Number	Description	NEIC Interface Reading (ppm)	NEIC 2-Inch Reading* (ppm)	PGV 2-Inch Reading* (ppm)
2	Feed pump isolation valve	10,000	0	0
4**	Plug in pump filter cover	2,000	300	0
7**	Pump discharge pump valve	300	30	0
26	Bypass valve flange	200	0	0
30	Preheated discharge flange	100	0	0
35	Control panel vaporizer isolation valve	7,000	75	0
50	Turbine drain valve	4,000	10	0

* *2-inch distance specified in permit*
** *Component not identified on listing. Number corresponds to nearest available component.*

After NEIC personnel pointed out the specific location of the emission source, PGV personnel were able to verify magnitude and location of the leak. The NEIC OVA instrument reading would stabilize at the maximum reading within 5 seconds. At leak concentrations greater than 1,000 ppm, the PGV Bacharach instrument would require up to 1 minute before stabilizing at the maximum concentration.

NEIC fugitive monitoring of OEC 24 required approximately 1 hour. NEIC did not monitor 12 components in OEC 24, which required special safety or hoisting equipment to reach inaccessible components. PGV personnel were reportedly able to complete monitoring within 20 minutes including the inaccessible components.

After observing NEIC monitoring procedures, PGV operators had the opportunity to use the NEIC monitoring equipment. PGV personnel indicated that after seeing the difference in the two instruments, that future monitoring would be conducted more deliberately to allow for the slower response of their instrument.

All potential fugitive emission components are not currently monitored by PGV. At least two components in OEC 24 (plug-in pump filter cover and the check valve on the pump discharge), and none of the components on the air coolers (neither the valves nor the fin fan plugs) are monitored on a regular basis. In a letter dated March 10, 1995 [Appendix O], PGV stated that these components had been monitored during the initial startup in 1993, and no leaks had been found and, therefore, PGV determined that these points were not "fugitive pentane points." The PGV interpretation is inconsistent with other fugitive monitoring programs inspected by NEIC.

The PGV calibration gas standards do not meet the requirements specified in Method 21 of 40 CFR Part 60 Appendix A. The PGV calibration gas standards do not have a specified shelf life, as required in Appendix A Method 21 of 40 CFR Part 60. The current PGV calibration gas standards were purchased with the Bacharach instrument in 1993. Typical gas standards have a shelf life of 1 year.

AMBIENT AIR MONITORING SYSTEM

The ambient air monitoring system for the PGV facility consists of three stations operated by PGV and four* stations operated by HDOH. The three

* *Subsequent to the NEIC inspection, one monitoring station (station F) has been shutdown pending relocation.*

PGV stations [photographs 4 and 5]* have been an ongoing requirement of the wellfield and power plant air permits. The HDOH stations [photographs 6 and 7] were installed by the state in order to supplement and provide an independent check of the PGV monitoring system. Figure 1 shows the location of the six stations.

The three PGV stations are referred to in the PGV monthly reports as Southeast, Southwest, and West stations (designations for these stations are more currently referred to in other documents as stations A, B, and C, respectively). The location of the W (C) station is proximate to residential areas, although it is not in a prevailing downwind direction from PGV facilities. The SW (B) and SE (A) stations are located in the prevailing downwind and topographically downgradient directions from the PGV property boundary, respectively. All three monitoring sites are instrumented with similar systems for monitoring ambient levels of H_2S and local meteorology (wind speed, wind direction, sigma theta, ambient temperature, ambient relative humidity, and precipitation). Two high-volume PM_{10} samplers are also located at the SW (B) station.

The three HDOH stations (D, E, and G) also have continuous H_2S analyzers and meteorological monitors. They are operated and maintained by the HDOH's Clean Air Branch. Station D is approximately 500 feet south of the PGV facility, in the prevailing downwind direction. Station E is almost 6,000 feet southwest. Station G is located about 6,000 feet northwest of PGV facilities.

Ambient air monitoring data for the PGV and HDOH stations are recorded in a number of computer and direct readout systems. The primary

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* *Photographs have been included for only two of the monitoring stations.*

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method of data acquisition for the PGV data is by telephone to a computer located in the PGV control room. Enviro/Loggers are also located at each station along with a complementary system of strip chart recorders. Similar provisions for readout at the HDOH stations are made. Contemporaneous HDOH data also can be accessed from the PGV control room, but it is not summarized in a computer data base.

Ambient air monitoring requirements have been specified in previous and current air permits for the power plant and wellfield. Requirements for the three PGV monitoring stations are currently stated in special condition 10 of Attachment II, PTO No. P-834-1582, and special condition 5 of Attachment II, PTO No. P-833-1524. Air quality and meteorological data must be summarized and submitted monthly in writing to the HDOH. The combined emissions of hydrogen sulfide from the power plant and the associated wellfield, including periods of equipment failure or malfunctions are not allowed to cause or contribute to an exceedance of the H_2S ambient level of 10 ppb on a 24-hour rolling average or 25 ppb on a 1-hour average at or beyond the project boundary (special condition 23, Attachment II, PTO No. P-833-1524). During the 31-hour KS-8 blowdown, there were exceedances of both the 1-hour and the rolling 24-hour limitations. In addition, there have been two other incidents of exceedances of the 1-hour standard, both associated with leaks from wellhead flanges, as shown in Table 1.

NEIC reviewed monthly hydrogen sulfide reports maintained by PGV. The monthly reports provide hour-by-hour readings for required ambient air parameters [Appendix P]. They do not summarize analyzer online times/ reliability or provide analyses of H_2S and meteorological monitoring results. Data on trends and overall project impacts are difficult to extract. A summary of data for the last 6 months of 1994, prepared by NEIC, is provided in Table 8. The average daily hydrogen sulfide concentration at each station was

Table 8

PGV H_2S AMBIENT MONITOR SUMMARY DATA
Puna Geothermal Venture
Pahoa, Hawaii

	07/94	08/94	09/94	10/94	11/94	12/94	Total 6-month Period
W (C) Station							
Average daily H_2S concentration (ppb)	0.6	0.9	1.6	1.4	NA*	1.2	1.1
Maximum daily H_2S concentration (ppb)	5.0	3.1	3.8	3.1	NA	3.6	5.0
Percent H_2S analyzer online time	98.2	99.2	89.4	87.6	0	7.4	63.6
Number days with negative average concentrations	3	0	0	0	NA	NA	3
SE (A) Station							
Average daily H_2S concentration (ppb)	0.7	1.2	1.0	1.0	1.7	1.2	1.1
Maximum daily H_2S concentration (ppb)	2.0	3.4	4.3	5.1	4.4	3.8	5.1
Percent H_2S analyzer online time	99.0	99.4	93.5	98.3	97.8	99.3	97.9
Number days with negative average H_2S concentrations	4	0	4	4	0	2	16
SW (B) Station							
Average daily H_2S concentration (ppb)	1.2	1.0	0.8	1.2	1.3	0.9	1.1
Maximum daily H_2S concentration (ppb)	2.9	3.8	3.1	3.0	12.2**	6.4	12.2
Percent H_2S analyzer online time	98.9	98.6	95.1	98.7	92.8	99.6	97.5
Number days with negative average H_2S readings	0	0	0	0	0	1	1

* *Not analyzed - analyzer down for repair*

** *Three hourly readings following calibration exceeded 10 ppb on November 30, 1994.*

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1.1 ppb. The highest maximum concentration was 12.2 ppb recorded at the SW (B) station in November. The overall reliability (online time) of the hydrogen sulfide analyzers was 86%, due primarily to the W (C) station analyzer being out of service for 2 months. The analyzer at the SE (A) station had an abnormally large amount of days with negative hydrogen sulfide concentrations (16), almost 10% of the 6-month period. Negative values were not explained by PGV. There were no exceedances of the ambient concentration limits, and PGV reported no H_2S release incidents for the period.

Air monitoring issues identified by NEIC during the site investigation involved:

- Unresolved items from the 1991 KS-8 incident investigation
- Calibration time periods for hydrogen sulfide monitors
- Spare hydrogen sulfide analyzer
- Hydrogen sulfide/meteorological data summaries

Unresolved Items from the 1991 KS-8 Incident Investigation

An investigation of air monitoring issues was conducted after the unplanned venting incident involving KS-8. The investigation was conducted as part of element III of the Geothermal Action Plan by the state of Hawaii. It was conducted by an independent investigative team consisting of Robert L. Reynolds, Lake County Air Quality Management District, California; and Dr. Wilson B. Goddard, Goddard and Goddard Engineering, also of California. The team reviewed a number of air issues and made several recommendations regarding the ambient air program [Appendix Q]. Although a number of the recommendations made were adopted, there are some unresolved issues from that work which merit further consideration.

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The investigators recommended that the air monitoring systems should be unified into a single, comprehensive program, managed and audited by the state with input from PGV and the community. This recommendation still has merit and would ensure uniformity in meeting quality assurance requirements between the existing PGV and HDOH monitoring systems. It would also promote the integration of data from all monitoring systems into a common data management and summary report system. HDOH and PGV should evaluate costs and time frames for accomplishing this objective.

Calibration Time Periods for Hydrogen Sulfide Monitors

PGV calibrates all three hydrogen sulfide monitors during the 12 midnight to 1 a.m. time period. No PGV monitoring of ambient air hydrogen sulfide concentrations occurs during that 1-hour time period. It would be advisable to stagger the calibration period for these monitors so that at least two monitors will be in operation at all times.

Spare Hydrogen Sulfide Analyzer

PGV maintains some spare parts on-site for hydrogen sulfide analyzers; however, there is no spare analyzer. During the NEIC investigation, PGV air monitoring consultant, Kim Borne, was questioned about the H_2S analyzer reading fluctuations that were occurring at the SE (A) station analyzer. He replied that the analyzer was probably in need of some repair but, due to lead times, was not to be taken out of service in the near future. In addition, the W (C) station analyzer underwent a 2-month outage for repairs, substantially exceeding the 4- to 5-day repair period that was initially anticipated. The purchase of a spare hydrogen analyzer would significantly improve instrument availability.

Hydrogen Sulfide Data Summaries

Monthly ambient air monitoring data summaries are required by the air permits for the wellfield and power plant. The requirement for the data summaries are not further defined in the permit. PGV includes hour-by-hour data summaries in their monthly reports. No summary information on past instrument readings is provided. No information is included on analyzer online time in the monthly report.

Data collected from the HDOH monitor locations are not summarized by PGV. The permit does not require HDOH data to be included in the PGV monthly reports. HDOH is reportedly working on recording analyzer data in a data logger to better integrate all ambient monitoring data, but it is not clear when this task will be completed.

Several reporting changes can be made to improve ambient air summary data and data usefulness for the PGV facility.

- Ambient air and meteorological data from the HDOH monitoring stations should be included in the PGV monthly reports to make the reports more comprehensive.

- Data summaries should be included for each hydrogen sulfide analyzer location to show dates, durations, and likely causes of past hydrogen sulfide readings from the start of the project. Trends and correlations with meteorological conditions can then be conducted. Wind roses can also be prepared.

- Data should be included for each hydrogen sulfide analyzer to show availability and online time percentages of the start of the project. Additionally, information regarding daily average, daily maximum, and list of permit limit exceedances should be included with the summary.

SUMMARY OF FINDINGS

Areas of Noncompliance

Permit P-833-1524 Attachment II, Condition 20	Semiannual sampling and reporting of the geothermal resource has not been performed for all required parameters. No annual or semiannual resource testing, while operating under normal conditions, was provided to HDOH, prior to 1995. After the NEIC inspection, PGV reported 1994 results compiled from various test locations. NEIC determined that 15 of the required 78 parameters were validly reported for well KS-9, and 37 of 78 for well KS-10. This did not include the three parameters that PGV reported were impossible to monitor, or were redundant with other parameters.
Permit P-834-1582 Attachment II, Condition 5	PGV does not have an installed spare condensate pump. A spare pump is kept in an adjacent warehouse which does not allow it to be utilized immediately upon identification of a malfunction of one of the three operating pumps.
Permit P-834-1582 Attachment II, Condition 10	Air quality and meteorological data from the ambient monitoring stations are not summarized in the monthly reports provided to HDOH.
Permit P-834-1582 Attachment II, Condition 2	Some fugitive emission points are not monitored on a weekly basis. Potential fugitive emission points on the fan coolers and OECs have not been monitored since startup of the plant.

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Permit P-834-1582 Attachment II, Condition 5	Pentane transfer records were not included with the third and fourth 1994 quarterly reports.

Areas of Concern

- Not all National Emission Standards for Hazardous Air Pollutants (NESHAP) pollutants required to be monitored by the permit are present in the geothermal fluids. Hawaii Department of Health (HDOH) should require sampling of only those NESHAP pollutants which are specifically of interest [PTO P-833-1524, Attachment II, Condition 20].

- HDOH requires that Best Available Control Technology (BACT) be used during periods of well equipment failure or malfunction (Permit P-833-1524 and Permit P-834-1592), but does not define BACT in the permits. HDOH should also clarify whether or not BACT requirements apply to well drilling operations. If HDOH intends for those practices described in the drill plans [which are to be approved by the Hawaii Department of Land and Natural Resources (HDLNR)] to constitute BACT then this fact should be made clear in the permit [PTO P-833-1524, Attachment II, Condition 13].

- Drilling plans prepared after the 1991 KS-8 well incident do not address all recommendations made in independent investigations, or investigations by PGV, subsequent to that incident. These include provisions for adequate kill fluid temperatures and quantities, maximum-sized mud pump liners, and weight criteria. Also there is no apparent written requirement in the drill plan for the addition of lime to the recirculating wellbore fluids. HDOH should review recommendations made in the 1991 investigation, and PGV's response to those recommendations, as well as drill mud lime requirements to ensure that all necessary precautions are being taken.

- There are limited means to verify compliance with the plant-wide 200 pounds per day pentane emission limit. Pentane inventory levels are reconciled only on a quarterly basis and, therefore, daily exceedances can only be confirmed if the total emissions for the quarter exceed 18,000 pounds (90 days per quarter x 200 pounds per day), or if there is a report of a catastrophic release [PTO P-834-1524, Attachment II, Condition 3].

- The permit limitation of fugitive hydrogen sulfide emissions to less than 1 lb/hr is unmeasurable and, therefore, unenforceable. An option to addressing fugitive hydrogen sulfide emissions is to impose additional requirements on PGV's existing in-plant hydrogen sulfide monitoring system. These requirements could address minimum allowable monitor downtime, monitor calibration and identification of plant areas or equipment where repetitive leaks occur [PTO P-834-1524, Attachment II, Condition 20].

- The Emergency Steam Relief Facility (ESRF) design, modifications, and consultant recommendations, and PGV's response to these recommendations and the related NEIC evaluation, should be reviewed to ensure that the 1992 ESRF problems have been adequately addressed. NEIC's evaluation indicates that there are still potential problems.

- Explanations for large pentane transfers should be included on the quarterly air reports. This information would provide operational

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history of the individual OECs and could be useful in scheduling preventative maintenance activities, such as increased frequency monitoring for OEC requiring frequent pentane transfers [PTO P-834-1524, Attachment II, Condition 5].

- The noncondensible gas vent from the Vapor Recovery Unit (VRU) should be included in the volatile organic compounds (VOC) monitoring program. Monitoring readings may demonstrate that this vent stack is a significant source for pentane losses.

- Fugitive pentane monitoring at a distance of 2 inches, as required by the permit, is not appropriate. The facility has not identified any leaking components since the program was initiated. NEIC identified four components leaking at greater than 1,000 ppm when measured at the interface; however, when the monitoring distance was increased to 2 inches, the readings dropped below the 1,000 ppm limit specified in the permit. The EPA approved fugitive monitoring method, Method 21 Appendix A of CFR 40 Part 60, requires that fugitive monitoring be conducted at the component interface [PTO P-834-1524, Attachment II, Condition 2].

- The number of components identified by NEIC to be leaking, at levels above background, is greater than that identified by PGV monitoring. NEIC identified seven components leaking at greater than 100 ppm of which four were leaking at greater than 1,000 ppm when monitoring at the component interface. Previous monitoring at the component interface, in the same area, by PGV personnel identified only one leaking component at a concentration of 100 ppm. Due to the slower response time of the PGV monitoring equipment, PGV operators will need to be more deliberate while monitoring potential fugitive emission sources.

- The fugitive monitoring calibration gas used by PGV did not display a manufacture or expiration date. The approved fugitive monitoring method, Method 21 Appendix A of CFR 40 Part 60, requires that calibration gases display a manufacture date.

- Hydrogen sulfide and meteorological monitoring data should be reviewed, evaluated, and summarized on the required reports. Currently, all the monitoring data is supplied without summary or reporting of upset conditions. Combining HDOH and PGV monitoring data into a single program would allow for a comprehensive evaluation of all available data.

- The online time for the three PGV-operated ambient air monitors is only 86% for the last 6 months. The west air monitor was the least reliable and was only operational for 64% of the time. The PGV should purchase a spare H_2S analyzer to eliminate equipment downtime gaps which have occurred in the past monitoring periods.

- PGV should stagger the calibration period for the H_2S analyzers so that at least two analyzers are in operation at all times.

UNDERGROUND INJECTION CONTROL

The underground reinjection of the used geothermal fluid is regulated by the conditions specified in the UIC permit Number UH-1529 [Appendix R]. The permit limits the reinjection quantity and also establishes operating conditions and identifies monitoring/reporting requirements. The permit regulates reinjection activities for three wells, KS-1A, KS-3, and KS-4.

As part of the inspection, Regional and NEIC inspectors examined the injection and production wells, three groundwater monitoring wells, the emergency steam release system, and the mud pits. Samples were collected from the recombined geothermal injectate flow and groundwater monitoring wells, MW-1 and MW-2. Sampling analytical results are presented in Appendix S.

This portion of the report is divided into four sections: the injection wells, monitoring wells, emergency steam relief system, and the mud pits.

INJECTION WELLS

Quantity

The permit limits the quantity of geothermal injectate to approximately 675,000 lbs/hour. The injectate is made of four primary streams: steam condensate, brine, supplemental water, and total noncondensible gases. Stormwater collected in the ESRF pit is also reinjected and included on the monthly UIC reports. The permit estimates the injectate composition as follows:

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Source	Approximate Flow (lbs/hr)
Steam condensate	505,816
Brine	128,250
Supplemental water	39,751
Total noncondensible gases	1,183

PGV submitted a letter [Appendix T] on September 15, 1994 to the HDOH indicating that the facility had exceeded the 675,000 lbs/hr limitation. The reported dates and rates for the exceedances are listed below.

Date	Reported Flow (lbs/hr)
090/8/94	707,000
09/09/94	752,000
09/10/94	753,000
09/11/94	731,000
09/12/94	752,000

A review of the records indicate that on at least five other dates,* after September 12, 1994, the 675,000-lbs/hr limit was exceeded. These exceedances were not reported to HDOH until December 22, 1994 with the submittal of the Quarterly Injection Well Status Report. PGV personnel reported that the HDOH had granted permission for injectate rates greater than 675,000 lbs/hr during the telephone notification of the first five exceedances. Documentation of this could not be provided by PGV. [May be additional violations, have not been provided with the fourth quarter 1994 report or reports.]

PGV submitted a UIC permit revision request to the HDOH on May 9, 1994 requesting a higher injection rate allowance. The HDOH is currently reviewing the permit revision. On November 7, 1994 HDOH issued a letter

* *Subsequent to the NEIC inspection, the HDOH UIC program provided information that the 675,000 lbs/hr limit had been exceeded on 13 other dates after September 12, 1994.*

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which granted an "interim increase" in the injection quantity and rate from 675,000 lbs/hr to 1,111,800 lbs/hr. This "interim increase" authorized increased reinjection until February 28, 1995. This "interim increase" has subsequently been extended to May 31, 1995, then to August 31, 1995, then to December 31, 1995, and is currently authorized until April 20, 1996.

The calculation procedures used to report the hourly injectate rates may not accurately reflect the true hourly injectate rates. The monthly and quarterly UIC data reports list daily injection rate totals, as required by the permit. However, the permit limits the injection rate based on an hourly limit, specifically 675,000 lbs/hr. PGV calculates, and subsequently reports, the average hourly flow rate by dividing the daily total mass quantity by 24 hours. This calculation procedure results in the reporting of the average hourly flow rate, as opposed to the actual hourly flow rate. Based on the fluctuations in the daily average flow rates, it is likely that the hourly flow rates are also variable which may have resulted in unreported hourly periods when the injection rate exceeded the permitted limits.

Sampling

The UIC permit requires that sampling for certain parameters be conducted on the injectate. Sampling parameters and frequencies are specified in the permit as either Type I, Type II, or Type III. Type I samples are generally metals or conventional parameters (different parameters for liquid or gas phases), Type II samples are hazardous waste constituents (TCLP), and Type III are generally volatile compounds. Concentration limits have not been set for these constituents; however, a sampling schedule and reporting requirements have been incorporated into the permit.

One sample of the injectate was collected during the NEIC inspection in order to assess its characteristics using selected parameters. The sample was collected from well pad A at a point where the brine, steam condensate, and noncondensible gases had combined [photograph 10]. Calculations based on the flow and pressure readings, during sampling, indicated that the injectate was in single phase (liquid). Type I NEIC sampling results are compared to the most recent PGV results (December 1994/January 1995) in Table 9. There is little difference between the NEIC and PGV analytical results for Type I parameters.

The permit includes fluorine, chlorine, bromine, and iodine in the Type I parameters, but instead of reporting these, PGV reported results for fluorides, chlorides, and bromides. NEIC included chloride results for comparison.

PGV reported analytical results for all required noncondensible gas parameters except for helium. Helium is an inert gas and has no impact on the surrounding environment.

For the Type II parameters, the NEIC and PGV analytical results were similar. NEIC and PGV analyses both show all parameters below the level of detection, except for benzene, arsenic, and barium. PGV analyses showed the benzene concentration to be 12 parts per billion (ppb) and NEIC results were below the level of detection (LOD) or 25 ppm. The higher LOD for the NEIC samples resulted from sample dilutions necessary to avoid damage to analytical equipment from high sulfide concentrations in the sample. The concentrations for arsenic and barium were also comparable as shown below.

Table 9

TYPE I INJECTATE SAMPLING RESULTS
Puna Geothermal Venture
Pahoa, Hawaii

Constituent	NEIC Sample Results (mg/kg)	July 1994 Puna Sample (mg/kg)
Lithium	0.997	1.10
Sodium		2,410
Potassium		566
Magnesium		0.103
Calcium	55	59.1
Barium	2.82	3.95
Vanadium	0.007	<0.02
Chromium	<0.008	0.017
Manganese	0.236	0.302
Iron	0.70	0.488
Nickel	0.01	<0.005
Copper	<0.005	<0.02
Silver	0.004	<0.02
Zinc	0.010	<0.01
Cadmium	0.005	<0.0013
Mercury	<0.0002	<0.003
Boron	2.8	2.81
Lead	0.002	<0.001
Arsenic	0.052	0.145
Selenium	0.004	<0.25
Fluorine (Fluoride ?)*		0.091
Chlorine (Chloride?)*	3,000	4,270
Bromine (Bromide ?)*		13.7
Iodine		Not reported
Ammonia		<0.2
Sulfate		4.09
Thiosulfate		<0.13
Nitrate	7.3	<1.4
Alkalinity, as HCO_3		<2.0
Silica		339
TDS		8,100
TSS		12.0
Conductivity		11,500
pH	5.7	4.92

* *Assumes fluoride, chloride, and bromide compounds were reported rather than fluorine, chlorine, and bromine gases. NEIC value represents chloride concentration.*

	NEIC results	PGV results
Arsenic	2.82 ppm	3.95 ppm
Barium	0.052 ppm	0.145 ppm

PGV reported analytical results for m- and p-cresol as a combined value rather than individual parameters, as required in the permit. It should be noted however, that the concentration for the combined isomers is below the LOD.

Type III analytical results from both NEIC and PGV were below the LOD for all reported parameters, except for toluene. PGV reported 0.004 ppm, whereas NEIC results were below the LOD, 0.025 mg/L. PGV failed to report values for seven of the required parameters [Appendix U].

- 2-Chloroethylvinyl ether
- Dibromochloromethane
- 1,1-Dichloroethane
- 1,2-Dichloropropane
- 1,1,2,2-Tetrachloroethane
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane

PGV injectate sampling procedures may have resulted in underreporting of volatile constituents because of the elevated sampling temperatures. According to PGV personnel, previous samples were reportedly partially cooled in a double pipe heat exchanger using plant water; however, temperatures were not recorded. During the NEIC sampling, the double pipe heat exchanger was used and an additional cooling coil immersed in ice was required to cool the sample to an appropriate temperature. Using the ice cooled coil, the samples were collected at about 23 °C (73 °F). PGV personnel reportedly had not previously used the iced coil to collect samples.

PGV and the state should consider modifying the UIC permit to include appropriate chemicals for analyses. PGV has not analyzed for all parameters specified in the permit (e.g., helium) and the state has apparently not requested this missing information. Several required chemical constituents could likely be dropped from the permit, or reduce sampling frequency without impacting the effectiveness of the permit. Additionally, the permit should be modified to reflect analyses for constituents in the aqueous form rather than the gaseous form (e.g. chloride rather than chlorine).

Mechanical Integrity Tests

As a requirement of the UIC permit, PGV was required to develop and implement a "Production and Reinjection Well Casing Monitoring Program." The program calls for annual mechanical integrity tests for each of the wells consisting of a shut-in temperature survey and a casing pressure test. Procedures to be used for these tests are included in the well casing program.

Paragraph redacted due to Confidential Business Information.

Well Annulus Pressure

The UIC permit requires that the annulus nitrogen pressure be continuously monitored and recorded. This information is recorded in the PGV data system and is displayed at the well building. During the NEIC visit the KS-3 annulus nitrogen pressure was approximately 975 psi and KS-4 showed a pressure of about 1,200 psi. The observed pressures are similar to those documented during normal operation.

Annulus nitrogen pressure typically remains fairly constant over the reporting period. There are occasions, however, when the pressure drops by 100 to 200 psi. (These were the largest pressure drops and were reported in September 1994.) When asked what pressure drop constituents a problem, PGV personnel could not provide an answer. PGV should consider including a narrative description for "large" annulus pressure changes in the quarterly reports. Additionally, the company should develop estimates as to the acceptable pressure drops or pressure drop rates. Specifically the company should specify what pressure drop would indicate a loss of mechanical integrity during normal operations.

MONITORING WELLS

Provision in the Geothermal Resource Permit, Condition 10, require PGV to monitor for potential impacts on the surrounding groundwater. As part of the inspection, NEIC collected samples and observed the PGV sampling procedures of monitoring wells MW-1 and MW-2.

Observed sampling procedures for MW-2 did not follow the procedures in the "SAIC Standard Operating Procedures No. 365 - Monitoring Well Purging." The procedures call for sampled wells to be purged of 3 to 10 times their borehole volume of standing water. There was no purging of the well, which may have resulted in nonrepresentative samples being collected. Water level in the well was at a surface depth of about 574 feet. A bottom-filling bailer attached to a hand-operated winch was used to obtain the sample [photographs 11 and 12]. Based on the depth of this well it is not practical to hand bail this well 3 to 10 well volumes. The called for procedure should be altered or a pump should be installed in the well.

PGV sampling of MW-2, in May and July 1994, identified low concentrations of chlorinated compounds. The presence of 1,1-Dichloroethane was detected in the NEIC sample [Table 10]. The company has attributed the presence of these compounds to contamination introduced during the installation of downhole monitoring equipment. Phenol and 4-methylphenol, at low concentrations, were also detected in the NEIC sample.

Table 10

SAMPLING RESULTS OF MW-2
Puna Geothermal Venture
Pahoa, Hawaii

Parameter	May 1994 Sampling* (ppm)	July 1994 Sampling* (ppm)	February 1995 NEIC (ppm)
Tetrachloroethylene	0.005	0.0025	<0.005
1,1-Dichloroethane	0.010	0.023	0.011
1,2-Dichlorethylene	0.007	0.010	<0.005
Trichloroethylene	0.005	NR**	<0.005
Phenol	NR	NR	0.0031
4-methylphenol	NR	NR	0.0011

* *PGV reported sampling results.*
** *Not reported*

An installed submersible pump was used to purge MW-1 prior to sampling. No semivolatile compounds (SW846-8260) were detected in MW-1 samples. Additionally, no volatile compounds (SW846-8270) were detected in MW-1 samples.

EMERGENCY STEAM RELIEF SYSTEM

The purpose of the emergency steam relief system is to remove H_2S and minimize noise associated with emergency release of steam or during well testing. (Operation of the Emergency Steam Relief System is discussed in the air portion of this report.) Water which accumulates in the ESRF collection pond [photograph 9] is intermittently pumped to the reinjection well. The quantity of water removed and pumped to the reinjection wells is reported on the monthly UIC reports.

The lower 6 feet of the ESRF pond is lined and has a capacity of about 135,000 gallons. The upper portion of the pond has not been lined [photographs 8 and 9]. According to PGV personnel, approximately 1 to 2 feet of water are maintained within the pond which reduces the effective storage volume to about 94,000 gallons.

PGV estimated the holding time for the collection pond to be 7.8 hours. This estimate was based on the 94,000-gallon capacity and an entering flow rate of 200 gpm. The 7.8 hour estimate also assumed no withdrawals via pumping. Holding times would be increased to 10.4 or 31.4 hours with pump out rates of 50 or 150 gpm, respectively. PGV could not provide a basis for the 200 gpm entering flow rate. Additionally, the pumpout rates could not be provided during the NEIC inspection.

PGV should document the basis for their assumptions and calculate retention times for the ESRF collection pond.

MUD PITS

The mud pits associated with the drilling activities have been closed. The removed mud pit material was sampled and according to Lynn White, General Manager, was suitable for disposal in the local landfill.* PGV elected

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* The HDOH UIC program directed the chemical analyses of the mud pit material. The TCLP analyses demonstrated that the mud pit material qualified as a solid waste which did not require hazardous material management.

to landfill the material at a central location within the operating portion of the facility. The landfilled material has been covered with a liner.

Lynn White reported that duplicate samples for landfilled material had been collected by a state agency. Reportedly, these duplicate samples also showed the material was suitable for disposal in the local landfill. The RCRA division of HDOD was unaware of any duplicate sampling or analytical results from the mud pits. (Other state agencies have not been contacted for copies of these results.)

SUMMARY OF FINDINGS

Areas of Noncompliance

Permit UH-1529 Part I.A.3(a)	Injection rate exceeded 675,000 pounds for 10 days during September 1994. Notification was provided within 1 week to HDOH for five of the daily exceedances.
Permit UH-1529 Part I B. 1(f)	PGV does not monitor for all parameters identified in the permit. Analytical results for m- and p-cresol isomers were combined rather than reported separately, as specified for the Type II sampling. Additionally, for Type III sampling, the following chemicals were not reported.

- 2-Chloroethylvinyl ether
- Dibromochloromethane
- 1,1-Dichloroethane
- 1,2-Dichloropropane
- 1,1,2,2-Tetrachloroethane
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane

Permit UH-1529 Part III A. 1(a)	PGV did not follow the Standard Operating Procedures for Monitoring Well Sampling as referenced in the "Hydrologic Monitoring Program." There was no purging of the MW-2. The procedures call for sampled wells to be purged of 3 to 10 times their borehole volume of standing water.
Permit UH-1529 Part III A. 1(b)	PGV did not follow the procedures specified in the "Production and Reinjection Well Casing Monitoring Program." ***Redacted due to Confidential Business Information.***

Areas of Concern

- The calculation procedures used to report the hourly injectate rates may not accurately reflect the true hourly injectate rates. PGV calculates, and subsequently reports, the average hourly flow rate by dividing the daily total mass quantity by 24 hours. This calculation procedure results in the reporting of the average hourly flow rate, as opposed to the actual hourly flow rate.

- PGV should consider including a narrative description for "large" annulus pressure changes in the Quarterly Injection Well Status Reports. Additionally, the company should develop estimates as to the acceptable pressure drops or pressure drop rates. Specifically the company should specify what pressure drop would indicate a loss of mechanical integrity during normal operations.

- Injectate samples should be further cooled prior to collection. The existing cooling equipment does not provide sufficient cooling to ensure that volatile components remain in the sample. The temperature of the collected samples should be recorded.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO KNOW ACT

PGV is subject to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Provisions in CERCLA require facilities to report releases of hazardous substances in excess of reportable quantities to the National Response Center (NRC). PGV is subject to the Designation, Reportable Quantities, and Notification requirements of 40 CFR Part 302 (CERCLA § 103, 42 U.S.C. § 9603).

The Emergency Planning and Community Right to Know Act (EPCRA) was enacted as Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986. EPCRA (also known as SARA Title III) requires regulated facilities to provide information to EPA, state, and community groups concerning chemicals handled by the facility and chemical releases. PGV is subject to the Emergency Planning and Notification requirements of 40 CFR Part 355 [EPCRA § 304 (42 U.S.C. § 11004)], the Hazardous Chemical Reporting: Community Right-to-Know requirements of 40 CFR Part 370 [EPCRA § 311 (42 U.S.C. § 11021) and 312 (42 U.S.C. § 11022)].

The facility released H_2S, in excess of the EPCRA/CERCLA reportable quantity, into the air in June 1991 and February 1993. Approximately 2,247 pounds of H_2S were released during the first incident which occurred June 12 through 14, 1991. The second incident occurred on February 8, 1993 and resulted in the release of approximately 162 pounds of H_2S. EPA issued an administrative complaint to PGV on May 4, 1994 for failure to immediately notify the National Response Center and failure to provide timely written follow-up reports to state and local authorities for these releases. Additionally, PGV failed to provide state and local authorities with complete inventories of chemicals stored on-site in 1991 and 1992.

This section of the report is divided into three main sections: Release Notifications, Chemical Inventory, and the PGV Emergency Response Plan.

RELEASE NOTIFICATIONS

Based on information provided in the PGV incident reports, there have been no unreported spill releases exceeding the reportable quantity since February 1993. An incident report is prepared when the ambient air monitors detect H_2S at greater than 25 ppb for a 6-minute average. There have been four incident reports since February 8, 1993 [Table 1]. Neither the 25-ppb hourly average or 10-ppb daily average permit limits were exceeded for these four incidents. The quantity of H_2S released from these incidents was calculated, by PGV, to be less than the reportable quantity. There have been no reported incidents since May 14, 1993.

The assumptions and calculations used to estimate the quantity of H_2S (or other reportable materials) released should be included with the incident reports. Information used to calculate the release estimates for the four 1993 incident reports was not readily available. Calculation estimates were recreated while on-site.

CHEMICAL INVENTORY

The 1993 Chemical Inventory Form (Tier II) was reviewed. Copies of the inventory were provided to the State Emergency Response Commission, the Local Emergency Planning Committee, and the Hawaii County Fire Department. All chemicals present at the facility, at greater than the threshold levels, appear to be included on the Tier II submittal. The inventory and purchase records for chemicals used on-site were compared to those provided on the Tier II submittals. The inventory quantities substantiate the values submitted on the Tier II reports.

PGV maintains copies of all MSDS sheets and provides a list of these materials to the State Emergency Response Commission, the Local Emergency Planning Committee, and the Hawaii County Fire Department.

PGV EMERGENCY RESPONSE PLAN

PGV is required to prepare an Emergency Response Plan (ERP) as required by condition 26 of the Geothermal Resource Permit GRP 87-2. The specific material to be included in the ERP is also outlined in condition 26.

The PGV Facility Emergency Response Plan (version 6.0) dated December 1991, was reviewed by Region 9 personnel. Deficiencies potentially impacting local residents were identified within the plan and comments were provided to HDOH. The identified deficiencies have not been forwarded to PGV. A revised draft copy of the PGV Facility ERP (version 6.2) was forwarded to NEIC in early July 1995. A preliminary review of the current draft version identified the following deficiencies:

- Acronyms are used extensively throughout the ERP. A list of acronyms would be helpful for readers not familiar with certain terms.

- Conflicting information regarding well flows and H_2S concentrations is provided in Table 8.1 and Table 3 presented in Appendix 3. Table 8.1 (Site Releases Under Routine and Upset Conditions) assumptions include well flows of 400,000 pounds per hour and a 650-ppm H_2S concentration. In Appendix H, Table 2

(Emitted Geothermal Resource Characteristics) assumptions include well flows of 500,000 lbs/hr and 896 ppm H_2S concentrations. Based on the variance granted in the UIC permit, the well flows may be higher than either of the above listed values.

- The use of off-site ambient air monitoring data should be more fully discussed in the ERP. Although PGV has included vague language which implies that this data is part of the emergency response program, it is not clear how the information will be specifically used. For example, in the Chapter 3 discussion of staff responsibilities the only person who may have responsibility for maintaining an up-to-date understanding of wind speed, direction, and ground level H_2S concentrations is the incident commander. The ERP states that the incident commander: "will assess danger....," and "will assure all non-essential personnel are out of the danger zone."

  The ERP does not state how wind speed direction and ambient H_2S analyzer information is incorporated in the assessment. In the training section (Chapter 6), there are no specific training requirements, for the incident commander, stating how the ambient air data will be used. Additionally, there are no discussions as to how wind speed direction and general atmospheric stability conditions are considered prior to beginning venting or drilling operations.

- Many of the figures are outdated or illegible. The location of Off Site Emergency Facilities on Figure 4-1 cannot be discerned.

- Reference is made to Table 8-8 on page 44. There is no Table 8-8. This reference may be a typographical error.

- On page 56, a reference is made to ***CBI*** which is supposed to be a list of well control specialists from the mainland. The information presented in ***CBI*** is a list of crane and truck operators, caustic removal specialists, propane removal specialists, gasoline/diesel fuel removal specialists, and welders/ cutters. All listed contractors are from Hawaii and it is not clear if 24-hour access phone numbers are provided. Additionally, there is no list of well control specialists. At minimum the well drilling consultant should be referenced.

- The ERP references all permits except the UIC permit. Impacts of the UIC permit should be included.

- The plan does not define "incidents." The ERP outlines what actions will occur when an incident happens. Because there is no definition of "incident," expectations of nearby residents, regulatory, and what constitutes an "incident" should be defined prior to its occurrence to avoid differences in expectations between PGV personnel, regulatory personal, and nearby residences.

  Additionally, the term "timely" communications, as referenced on page 13, should be clarified.

- The PGV Emergency Drill discussed briefly in Chapter 7 indicates that operations and maintenance personnel will participate. No mention is made as to whether local agencies or emergency response crews will be involved.

- The phrase "Assess the conditions" referenced on page 43 is vague. This phrase should be clarified or perhaps deleted.

- Step 7 of the PGV General Response on page 49 states "Take whatever follow-up appropriate actions are necessary to deal with the facility emergency situation." This step seems somewhat general and broad.

SUMMARY OF FINDINGS

The following areas of concern were identified.

- The assumptions and calculations used to estimate the quantity of H_2S released (or other reportable materials) should be included with the incident reports. Retention of this documentation at a central location will facilitate easier review for future incidents (if any).

- A preliminary review of the draft Emergency Response Plan (version 6.2) identified several deficiencies which should be addressed. Some of these deficiencies were also pointed out in the review of the previous version by Region 9. Generally, t[illegible] plan does not provide specific information. Several t[illegible] phrases should be defined or clarifie[illegible] misunderstandings if an incident v[illegible]