



STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 4770
HONOLULU, HAWAII 96814

IN REPLY, PLEASE REFER TO
EPH007008

17 June 1990

Mr. Harry Kim, Chairman
Hawaii Local Emergency Planning Committee
34-A Rainbow Drive
Hilo, Hawaii 96720

Subject: Review of the Revised Puna Geothermal Venture 25 Power
Project Emergency Response Plan-Version No. 3

Dear Mr. Kim:

Thank you for the opportunity to review the Revised Puna Geothermal Venture (PGV) 25 MW Power Project Emergency Response Plan-Version No. 3. The plan now includes a reasonable review of the potential hazards that may be posed by the project. Comments and recommendations provided by the Department of Health to PGV to improve and enhance the document have been addressed by PGV. If the revised plan is fully implemented on a continuing basis while the facility is constructed and operated, public and private interests should be prepared for the emergencies that may arise from the PGV facility. The plan also provides an excellent reference for state and county agencies to use for emergency planning purposes as they relate to the PGV facility.

We look forward to your continued cooperation to improve Hawaii's capability to respond to chemical emergencies. If you have any questions regarding this review, please contact Bruce Anderson, Ph.D. at 548-4189.

Sincerely,

A handwritten signature in black ink, appearing to read "John C. Lewin".

JOHN C. LEWIN, M.D., Chairman,
Hawaii State Emergency Response
Commission and Director of Health

Attachment 4
to
Element II Report

PUNA GEOTHERMAL VENTURE

REVIEW AND RESPONSE TO THE
ELEMENT III, PART II REPORT

MICROMETEOROLOGICAL AEROMETRIC AND HEALTH EFFECTS
ANALYSIS CONTRIBUTION TO THE
INDEPENDENT AIR AND NOISE MONITORING PROGRAM REVIEW
CONCERNING THE JUNE 12, 13 AND 14, 1991
UNCONTROLLED VENTING OF THE
PUNA GEOTHERMAL VENTURES KS8 GEOTHERMAL WELL

PUNA GEOTHERMAL VENTURE
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PGV Response to the Element III-II Executive Summary.

Puna Geothermal Venture (PGV) cannot accept the basic premise of the entire Element III-II Report, as expressed in the second sentence of the Executive Summary: "The purpose of this study is to provide independent verification of monitoring and spot measurements of ambient concentrations of hydrogen sulfide (H₂S) as well as provide estimates of plume concentration and plume transport paths in areas where documented health effects occurred." PGV finds that the author of the Element III-II Report does not provide verification of the hydrogen sulfide monitoring data. Instead, the measured field data is manipulated to fit the author's own model of the uncontrolled flow event. The estimates of plume concentration and plume transport presented in the Element III-II Report are principally based on the undocumented, randomly sampled, unsubstantiated health complaints collected by members of the community, and no attempt is made to determine the statistical relevance of the "sampling" or any linkage to the KS-8 uncontrolled flow event.

PGV strongly disagrees that the "independent estimates of hydrogen sulfide (H₂S) ambient concentrations" prepared as a part of this Element III-II Report were "in substantial agreement with local monitoring station and mobile spot measurements throughout the venting period." In fact, PGV believes that the Element III-II Report Figures 3-1 through 3-16 show exactly the opposite (see PGV Responses F and G). The Element III-II Report provides absolutely no statistically-based cause-and-effect relationship between health complaints and ambient hydrogen sulfide concentrations to justify the extremely subjective "finding" that "Local H₂S concentration were elevated above health significance levels and correlated with health complaints" (see PGV Response K).

The regional wind flow analysis presented in the Element III-II Report does not employ a technically sound approach for estimating plume transport over the two-day period in question, and the author of the Element III-II Report has developed no statistically-based cause-and-effect relationship between the health complaints and the presumed ambient hydrogen sulfide concentrations (see PGV Response H).

PGV believes the Element III-II Report "finding" that the emission of "other" air toxics were of significant health concern is extremely subjective and without any

reasonable basis for establishing a cause-and-effect relationship (see PGV Response K). PGV also does not agree with the "finding" that it did not utilize Best Available Control Technologies and did not utilize equipment described in the Authority to Construct (see PGV Response O). This finding also appears to be beyond the scope of the Element III-II Report's stated purpose.

Finally, the recommendations presented in the Element III-II Report are simply a restated presentation of the recommendations presented in the Element III-I Report, and have very little, if anything, to do with the KS-8 well uncontrolled flow event or its aftermath. See PGV Responses A through C to the Element III-I Report.

- A. Page 3, Introduction, Paragraph 2, discussion regarding emissions of hydrogen sulfide during the KS-8 uncontrolled flow event.

In PGV Responses AB through AD to the Element III-I Report, PGV stated that, during the period prior to 06:00 on June 13, 1991, the KS-8 well had a total flow of geothermal steam and fluid of between 150,000 and 200,000 lbs/hr, which contained an average hydrogen sulfide concentration of 440 ppmv. Thus, PGV estimates that from 66 to 88 lbs/hr of hydrogen sulfide were emitted during this period of the uncontrolled flow. Subsequent to 06:00, PGV estimates that the total flow of geothermal steam and fluid increased to approximately 246,000 lbs/hr, producing a total emission of approximately 108 lbs/hr or less of hydrogen sulfide. Although the flow of geothermal steam and fluid estimated by PGV are in general agreement with the quantity of geothermal steam only estimated by the Element III-I Report, PGV's estimates of hydrogen sulfide emissions are substantially lower because the Element III-I Report uses an incorrectly high assumption regarding the concentration of hydrogen sulfide in the geothermal steam and fluid (see PGV Response AB to the Element III-I Report).

- B. Page 3, Introduction, Paragraph 2, discussion regarding emissions of "air toxics" during the KS-8 uncontrolled flow event.

In regard to the "air toxics" stated in the Element III-II Report to be emitted during the uncontrolled flow event, PGV does not understand the origins of, nor can it substantiate, the emission rates presented in Table 1-1 of the Element III-II Report. Based upon statements made in the Element III-I Report (page 27, paragraph 2), and statements made in the Element III-II Report, PGV was led to understand that the numbers presented Table 1-1 were based on Table 4-4 of the PGV wellfield application for the ATC permit. However, PGV finds that fully one-half of the elements or chemical compounds listed on Table 1-1 (lead, nickel, chromium, copper, and zinc) are not even listed on Table 4-4. For the other elements and compounds

which are presented in Table 4-4 of the ATC permit application, PGV does not understand how this information was used to calculate the numbers presented in Table 1-1 of the Element III-II Report. Lacking sufficient information to verify the conclusions expressed in this paragraph in the Element III-II Report, PGV does not accept the validity of these conclusions; PGV simply has no idea where they came from.

PGV would also point out that "copper", "zinc", "silicon oxide" and "total dissolved solids" listed in Table 1-1 are not listed as hazardous air pollutants under the 1990 Clean Air Act Amendments.

- C. Page 5, Study Methodology, paragraph 1, regarding the mathematical model used in the micrometeorological analysis.

Mathematical models are used by atmospheric scientists and engineers to predict, or estimate, the concentration of an atmospheric pollutant in the ambient air once it is emitted from a source. These models require that certain characteristics of the emission source (flow rate, velocity, pollutant concentration, etc.), and certain characteristics regarding the meteorology (wind speed, wind direction, temperature, etc.) be known or assumed, then the computer will calculate the anticipated pollutant concentrations in the air at any specified point. Without these models, there is no reasonable method available to determine what happens when a pollutant is emitted into the air. However, all models are subject to errors which can invalidate the results. First, the model may be given incorrect emission or meteorological information to work with; incorrect emission rates or wind speeds will produce invalid results. Second, the model itself may not correctly reproduce actual measured pollutant concentrations even if given the correct source and meteorology information. In this case, the model may have certain limitations which prevent it from giving correct information in certain circumstances, or may simply be programmed incorrectly. The more widely used a model, the more likely its limitations are known and the less likely there are any undetected programming errors.

The Micrometeorological Air Dispersion Assessment Methodology (MADAM) model used to estimate ambient air concentrations during the KS-8 uncontrolled flow event was developed by the author of the Element III-II Report. This model has not been accepted by the EPA as a "guideline" model for use in regulatory applications, which raises questions as to the confidence of the modeling results presented in the Element III-II Report. The model's performance characteristics have not been well documented for evaluation by the scientists and engineers who are trained and experienced in the use of such models. Appendix A of the Element III-II Report does not present sufficient information for verification of any of the questions arising

regarding the use of the MADAM model. It is unknown whether the MADAM model has unique limitations which may make its use in this instance inappropriate, nor is it known under what conditions it will fail to accurately estimate ambient concentrations.

- D. Page 6, Study Methodology, paragraph 2, suggested health safety limit for the general public.

The Element III-II Report presents here a calculation for a "suggested health safety limit" for hydrogen sulfide for the general public which is insufficiently supported and inappropriate. The "health safety limit" which is "suggested" by the author of the Element III-II Report is based on the U.S. Occupational Safety and Health Administration (OSHA) worker Permissible Exposure Limit (PEL) of 10 ppm for hydrogen sulfide. OSHA PELs are time-weighted average concentrations of airborne contaminants to which most workers can have a daily exposure during a 40 hour work week for a working lifetime without suffering ill effects. As such, PELs developed for protecting the long-term (chronic) exposure of workers were not developed for the purpose of protecting the health of the general public from short-term (acute) exposures, and should not be used as the sole toxicological basis for risk assessment. See PGV Response H.

It is also interesting to note that the acute (short-term) "health safety limit for the general public" of 24 ppb one hour average "suggested" by the Element III-II Report is below the long-term California Ambient Air Quality Standard (AAQS) of 0.03 ppm one hour average set by the State of California to prevent nuisance effects.

- E. Page 7, paragraphs 2 through 7, and page 8, paragraphs 1 through 3, discussion regarding meteorological conditions during the event.

All of the MADAM model runs were conducted with actual hourly-averaged wind speed and direction data from the PGV SW site, but with an assumed worse-case stability (Class E) and an extremely limited mixing height of 100 meters. Actual on-site measurements of sigma theta and wind speed do not support the assumption of stability Class E (slightly stable conditions) for all but two hours used in the MADAM assessments. Instead, monitoring data for the time period involved indicate that the prevailing stability class was Class D (neutral, well-mixed conditions). Also, the 100-meter mixing height assumed by the author of the Element III-II report is very unlikely to occur with these well-mixed conditions. The regional meteorological data from the Hilo Airport also does not support the limited mixing height assumed by the author of the Element III-II Report. Insufficient information is available

regarding the MADAM model to understand how use of the correct assumptions would change the concentration estimated by the model.

PGV believes that the statement made in the final paragraph of this section, that the "meteorological conditions during the event were not 'worst case' for air dispersion," is very misleading. Although the paragraph goes on to state that "wind speeds could have been very low or calm which would have increased proportionately the severity of the impacts," the frequency of occurrence of these low or calm windspeeds, and the "degree of proportionality," is left unstated. In fact, a quick review of the diagrams presented in Figure 3-1 and Figure 3-2 of the Element III-II Report show that the periods of calm are very infrequent, and that the low wind speeds measured during the early morning hours of June 14, 1991 (1.79 meters per second, or 3.88 miles per hour) were, in fact, in the lowest of the "non-calm" windspeeds. The Element III-II Report presents no data to support the statement that the impacts measured during this uncontrolled flow event would have been significantly higher under different wind regimes.

- F. Page 8, local air quality impact assessment, paragraphs 1, 2, and 3, discussion regarding modeled air quality impact and its agreement with the measured ambient hydrogen sulfide concentrations.

PGV does not agree with the statement made in the third paragraph of this section, that "the relationship of estimated plume position and estimated plume ground level H₂S concentration are in agreement with the monitoring stations and the spot measurements."

Figures 3-3 through 3-15 of the Report present plots of the MADAM-predicted plume centerline hydrogen sulfide concentrations for 13 selected hourly or multi-hour periods. The ambient hydrogen sulfide concentrations monitored ("observed") during these same time periods, consisting of a mixture of instantaneous readings from portable samplers and Drager tubes, as well as hourly-average readings from fixed monitoring stations, have been plotted based on these same figures by the author of the Element III-II Report in an effort to validate the model predictions.

Comparing the MADAM model predictions of hourly averages to instantaneous field readings is inappropriate. Spot readings of up to a few minutes duration can be several times greater than an hourly average measured and recorded at the same location. For example, the PGV SW site measured and recorded instantaneous hydrogen sulfide concentrations on the order of 500 ppb during mid-day on June 14, 1991, yet the hourly averages measured and recorded during the same time period were only 100 to 200 ppb. Unfortunately, none of the MADAM model plots were

prepared for those time periods when the SW site was downwind of the steam plume, an oversight which would have provided a much better opportunity for "validation" of the MADAM modeling results than the graphical representations and broad statements presented in the Element III-II Report.

See also PGV Response G.

G. Page 25, Local Impact Assessments, paragraphs 1 through 4.

PGV does not understand how the Element III-II Report can claim that the results of the MADAM modelling are validated by comparisons with the spot and monitoring station data results. Spot measurements are frequently presented in the figures which are as much as an order of magnitude or more lower than the values predicted by the MADAM model (such as "48 ppb" on Figure 3-5 and "92 ppb" on Figure 3-13). On the other hand, none of the predicted ambient concentrations come close to validating the high values (22 and 29 ppm) originally reported early on during the venting by PGV which have now been called into question (see PGV Response E to the Element II Report). There are no measurements, either spot or from the monitoring stations, which validate the high hourly average hydrogen sulfide concentrations (in excess of 500 ppb hourly average) consistently predicted by the MADAM model in the plume centerline during most of the hours evaluated. Given all of the spot monitoring conducted by PGV and the various agencies, and all the periods during which the plume could have impacted one or both of the monitoring stations during the 31-hour uncontrolled flow event, it is inconceivable to PGV that at no time would there be any measurements taken of these maximum concentrations in the plume centerlines. Thus, PGV questions the validity of the MADAM-modeled results.

In addition, it is impossible to determine or validate, on the basis of the information presented in the Element III-II Report, what modelling was undertaken to predict the ambient hydrogen sulfide concentrations shown on Figures 3-6 through 3-13 for those periods when geothermal resource was flowing through the choke line. It would appear from the way in which the lines on the figures are drawn (straight lines with no dispersion shown) that the lines do not represent any mathematical modeling, but instead were simply sketched in by the author of the Element III-II Report.

H. Page 25, paragraphs 5 through 7, and page 26, paragraphs 1 through 4, Regional Impact Assessment.

The regional wind flow analysis presented in the Element III-II Report does not employ a technically sound approach for estimating plume transport over the two day period in question.

Although it is impossible to understand with certainty the approach taken by the author of the Element III-II Report in estimating "plume transport" over the two day period in question, it is certain that this "regional wind flow analysis" does not employ an approach which is technically sound. It would appear that the author of the Element III-II Report has based his analysis of the regional plume movements principally on trying to match "plume movement" with the randomly sampled, unverified health complaints collected by members of the community. Figure 3-16 appears to be a simple, general diagram of typical regional air flow that has ostensibly been "fine-tuned" by use of the frequency of health complaints. This approach is an entirely inappropriate use of data of limited technical basis to justify the analysis. (See PGV Response K.)

Although the Element III-II Report does not specifically state, PGV assumes that the concentrations presented in Table 3-1 are hydrogen sulfide levels calculated by the MADAM model. As such, PGV believes them to be subject to the same significant overestimation problems discussed in PGV Responses A, B, C, E and G.

I. Page 28, paragraphs 1 through 10, and page 29, paragraph 1, Public Health Effects.

This section of the Element III-II Report is an inappropriate "hodge-podge" of complex health and toxicology data that are presented out of context and are incorrectly summarized. The author of the Element III-II Report continually shifts from statements regarding acute exposure to chronic exposure to nuisance exposure and back again, such that the reader is left with the impression that there are insignificant differences between and among them (which is completely invalid). For example, the author of the Element III-II Report creates a 24 ppb ($34 \mu\text{g}/\text{m}^3$) "health safety limit for the general public," and implies that the State of California agrees with this number. The referenced document referenced by the Element III-II Report utilizes the methodology described in the Element III-II Report (dividing the OSHA TLV values by 420) as a method of calculating chronic acceptable exposure levels to which, to quote the referenced report, "exposure below the acceptable exposure level (for a lifetime of 70 years, 24 hours a day) is not expected to result in adverse health effects." It is incorrect and inappropriate to imply that this level is to be used when evaluating acute exposures. What is even more inappropriate is that even the State of California has not used this suggested method to calculate the acceptable chronic exposure level for hydrogen sulfide.

In the final two paragraphs of this section, the author of Element III-II Report purportedly quotes a definition of "public nuisance" from what he states are "various Civil Codes". This is an example of a statement which is both unsupported and completely irrelevant to an analysis of the public health effects related to the uncontrolled flow event.

J. Pages 30 through 37, Tables 4-1 through 4-3.

Tables 4-1 through 4-3 present a simplistic summary of extremely complex health information in a manner which is neither helpful nor relevant to the discussion of the KS-8 uncontrolled flow event. The information presented here is not useful in assessing the specific health effects of the KS-8 uncontrolled flow event. For example, Table 4-1 is presented as purportedly listing the "health effects of air pollutants often found in geothermal resources and developments." However, the author of the Element III-II Report makes no attempt to demonstrate that any of these "air pollutants" were emitted in amounts which could actually result in the levels identified. Moreover, many of the listed health effects are a mixture of acute and/or chronic health effects, which creates a further confusion in attempting to undertake any health assessment effort.

K. Page 38, paragraphs 1 through 8, an page 39, paragraph 1, community Health Assessment.

The conclusions presented in the Element III-II Report are unsubstantiated and appear highly subjective. The author of the Element III-II Report has not established any statistically-based cause-and-effect relationship between public health complaints and measured or predicted ambient hydrogen sulfide concentrations. Instead, it would appear that the author of the Element III-II Report has simply accepted at face value the randomly sampled, unsubstantiated health complaints collected by members of the community, without regard to the statistical relevance of the "sampling" or any linkage to the KS-8 uncontrolled flow event. No true "estimates" of adverse effects have been derived by the author of the Element III-II Report. These "health complaints" were then summarily compared to the values presented in Tables 4-1 through 4-3 to obtain health complaint "guesstimates" of the ambient concentrations, which were then used as a "verification" of the MADAM-modeled ambient concentrations. Since the MADAM-modeled ambient air concentrations for hydrogen sulfide have previously been shown to be extremely questionable (see PGV Responses A, B, C, E and G), PGV believes this underscores the questionable nature of the entire analysis presented in Section 4.1 of the Element III-II Report.

- L. Page 41, Summary and Conclusions, paragraphs 1 and 2.

PGV does not agree that the author of the Element III-II Report has successfully demonstrated that "individuals and families near and surrounding the site for several miles experiences periods where health complaints resulted from exposures to the released air toxics in the form of gases, aerosols and particulates (emphasis added)." In addition, PGV does not agree that either the Element III-I Report or the Element III-II Report documented that the KS-8 uncontrolled flow event "resulted in high emission levels of H₂S and other air toxics (emphasis added)." Instead of attempting to develop any well-reasoned, scientific analysis of the uncontrolled flow event, it appears that the author of the Element III-II Report simply started with the assumption that these two statements were correct, then attempted to present data which was selected to support these assumptions.

- M. Page 41, Summary and Conclusions, Paragraphs 3 and 4, correspondence between measured and estimated local and regional ambient hydrogen sulfide concentrations.

PGV disagrees that the measured and estimated (predicted by the modeling conducted by the author of the Element III-II Report) ambient hydrogen sulfide concentrations are in substantial agreement, and believes that the figures presented in the Element III-II Report, when interpreted without bias, verify this. PGV believes that the discrepancy may be, in part, a result of an over-estimation of the emission rate for the hydrogen sulfide (see PGV Response A, B), but may also result from the model used by the author of the Element III-II Report and the other inappropriate assumptions used in the MADAM modelling (see PGV Response C).

- N. Page 41, Summary and Conclusions, Paragraph 5, discussion of estimated impacts under "worst case" conditions.

This paragraph contains statements which are totally conclusionary and completely unsupported by any information presented within either of the Element III Reports. There is no evidence whatsoever presented in the Element III-II Report, or any of the other Reports, which supports the statement that if the KS-8 uncontrolled venting would have occurred when winds were near calm or at 1.0 mph, impacts would have increased "an estimated 4 to 10 times." Nor is there any support whatsoever for the statement that under these conditions, "the distance to where health complaints were reported would have extended several fold."

- O. Page 41, Summary of Conclusions, Paragraphs 6, 7, and 8, conclusions regarding PGV operations.

These three paragraphs are conclusionary and unsubstantiated.

The author of the Element III-II Report presents no evidence whatsoever to support the conclusion that the uncontrolled flow event was due to "lack of preparedness and mismanagement of techniques which could have prevented unabated H₂S releases," or that PGV violated "ambient air quality standards for other air toxics."

PGV has discussed the use of Best Available Control Technology for air and noise emissions during this uncontrolled flow event in Response AI to the Element III-I Report. PGV further disagrees with the statement that "the permittee has used equipment not described in the Authority to Construct which may have added to the air emissions and noise levels during the event" for which the author has provided no substantiation.

This type of uncontrolled flow event was clearly discussed as a possibility in both the Authority to Construct permit issued by the Department of Health (Conditions 13, 17, and 26, for example) and in the Emergency Response Plan (ERP) approved by the Hawaii Civil Defense Agency (in PGV ERP Section 8.2.1 and others).

P. Page 42, Recommendations.

The recommendations presented in the Element III-II are simply a restated presentation of the recommendations presented in the Element III-I Report, and have very little, if anything, to do with the KS-8 well uncontrolled flow event or its aftermath. See PGV Responses A through C to the Element III-I Report.