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FINAL

THE GEOTHERMAL ENVIRONMENTAL ADVISORY PANEL

DRAFT

GUIDELINES FOR ACQUIRING ENVIRONMENTAL BASELINE DATA

ON FEDERAL GEOTHERMAL LEASES

U. S. GEOLOGICAL SURVEY
DISTRICT GEOTHERMAL OFFICE
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AREA GEOTHERMAL SUPERVISOR'S OFFICE
CONSERVATION DIVISION
U.S. GEOLOGICAL SURVEY
MENLO PARK, CALIFORNIA

UNITED STATES DEPARTMENT OF THE INTERIOR

MENLO PARK, CALIFORNIA

UNITED STATES GOVERNMENT

Memorandum

O : Interested Parties

DATE: December 14, 1976

FROM : Geothermal Environmental Advisory Panel

SUBJECT: Guidelines for acquisition of Environmental Baseline Data on Federal Geothermal Leases

The attached document was prepared as a consequence of regulations implementing the Geothermal Steam Act of 1970, specifically Title 30 CFR 270.34, which includes in subsection (k) "A requirement for the collection of data concerning the existing air and water quality, noise, seismic and land subsidence activities, and ecological system of the leased lands covering a period of at least one year prior to the submission of a plan for production".

The purpose of these guidelines is to aid lessees in the development of plans to meet this requirement in an orderly and timely manner. Whenever possible the Panel recommends that plans for baseline data acquisition be started as soon as it becomes apparent that a commercially developable resource has been identified. In addition to assuring that lessees are adequately forewarned of the need for advance planning to meet the requirement, the guidelines are designed to provide as much consistency as possible in the data acquired and to provide a framework that will aid the Supervisor in evaluating plans received.

It is emphasized that these guidelines in no sense modify the responsibility of the Area Geothermal Supervisor, Conservation Division, USGS, who, in cooperation with the surface management agencies, (typically BLM or USFS) retains the sole responsibility for approving plans to meet these requirements. The guidelines therefore comprise a set of recommendations prepared for the assistance of both the lessee and the Supervisor. Furthermore, it must be noted that these guidelines are not regarded as a rigid or absolute set of standards. In general, they are presumed to represent the typical range of baseline data appropriate for large-scale geothermal development, generally for electric power. But even for such applications they provide only "guides" in the true sense, because each "Plan" should be prepared on a site-specific basis, so as to be adapted to the nature and scope of the operation proposed and to the particular terrane and ecologic setting involved. In order to accommodate the development of small, localized, or low temperature heat sources, particularly for non-power uses, plans of vastly smaller scope may suffice; in many cases the necessary data may be available from existing sources. This flexibility in scope is accommodated by the exercise of the Supervisor's discretion to accept plans appropriate to the specific situation.



Initial drafts of the guidelines were prepared by a Working Group chaired by Robert Scott. Subgroups dealing specifically with water, air, and biological data were under the chairmanship of J. H. Feth, Dave Jesson, and W. M. Spaulding. Membership of the Working Group was as follows:

Robert Scott, Environmental Protection Agency,
Chairman

Robert Conover, Solicitors Office
Edward Horton, U.S. Forest Service
Joel Robinson, Union Oil Company
Warren Smith, Union Oil Company
John Feth, U.S. Geological Survey
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David Jesson, Environmental Protection Agency
Hamilton Hess, Sierra Club
Ralph Longaker, Pacific Gas and Electric Company
Willard M. Spaulding, U.S. Fish and Wildlife Service

Final revisions were made by the Panel as a whole, and responsibility for the content rests with the Panel rather than with the Working Group. It is a pleasure to acknowledge the importance of the diverse points of view represented on the working group, and to thank each member personally for his generous contribution of time and thought. Final revision by the Panel required extensive study and effort, and this too is gratefully acknowledged.



Max D. Crittenden, Jr.
Chairman

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1.0 INTRODUCTION

1.1 Purpose

These guidelines are developed to assist geothermal lessees and operators in complying with Federal Regulation 30 CFR 270.34 (k) which states that a plan of operation shall include "A requirement for the collection of data concerning the existing air and water quality, noise, seismic, and land subsidence activities, and ecological system of the leased lands covering a period of at least one year prior to the submission of a plan for production."

The purpose of collecting environmental data is to provide a baseline representing selected physical, chemical and biological conditions prior to significant disturbance by lease operations against which later environmental data can be compared. This comparison will provide a basis for determining the net environmental change attributable to the operations on the leasehold at any subsequent time.

The purpose of these guidelines is to aid those involved in the exploration for geothermal resources in meeting the requirements for baseline data in a timely manner. Where unit operations are involved these guidelines should apply to the entire unit in the same way as to an individual leasehold. Their timing is designed to coordinate with the generalized scheme of phased operations outlined in orders issued or to be issued by the Supervisor, Conservation Division, USGS.

1.2 Timing

It is presumed that development of a typical large-scale geothermal resource will pass through a succession of phases. Except where not required by regulations, activities will be carried out under a series of Plans of Operations of the types outlined below:

Plan of Exploration:	Geologic and geophysical surveys Shallow temperature gradient holes Deep exploration drilling
Plan of Development:	Development drilling Permanent roads and pipelines Other facilities
Plan of Production:	Operation of wells and facilities for production and use of geothermal energy

Environmental baseline data must be collected over a period of at least a year prior to the submission of a plan of production. Therefore approval of a program of data collection should be obtained with sufficient lead time to allow the actual collection of data to be carried out within the required one year time frame. To allow for purchase,

installation and testing of equipment, this implies a lead time of at least 18 months prior to the filing of a plan of production. Consequently, the design of a data collection program should begin as soon as it is evident that a potentially producible resource has been identified. (See Figure 1).

Ideally, it is recommended both in the interests of the lessee and for the protection of the environment, that collection of data on air, water, and biological conditions commence and occur during the exploration drilling phase following the approval of a plan of exploration. It is also recommended, particularly in areas sensitive to subsidence, that levelling surveys should commence as soon as commercial development appears probable, if possible during the geologic and geophysical testing periods which may pre-date the approval of a plan of exploration. Programs for data collection submitted on this schedule should include relevant information from these prior collections of environmental data. If it is not practical to begin data collection at these early stages, lessees should at the very latest, submit a program for the collection of environmental baseline data at the same time as they file the initial plan for development.

1.3 Scope

The wide differences in geothermal resources require that the Supervisor retain a corresponding degree of latitude as to the scope of activities appropriate to satisfy the requirements for acquisition of baseline data. In the exercise of such latitude it is assumed that the Supervisor will seek the review and recommendation of the Geothermal Environmental Advisory Panel, and will consult with other Federal, State and local agencies having expertise and/or regulatory responsibility.

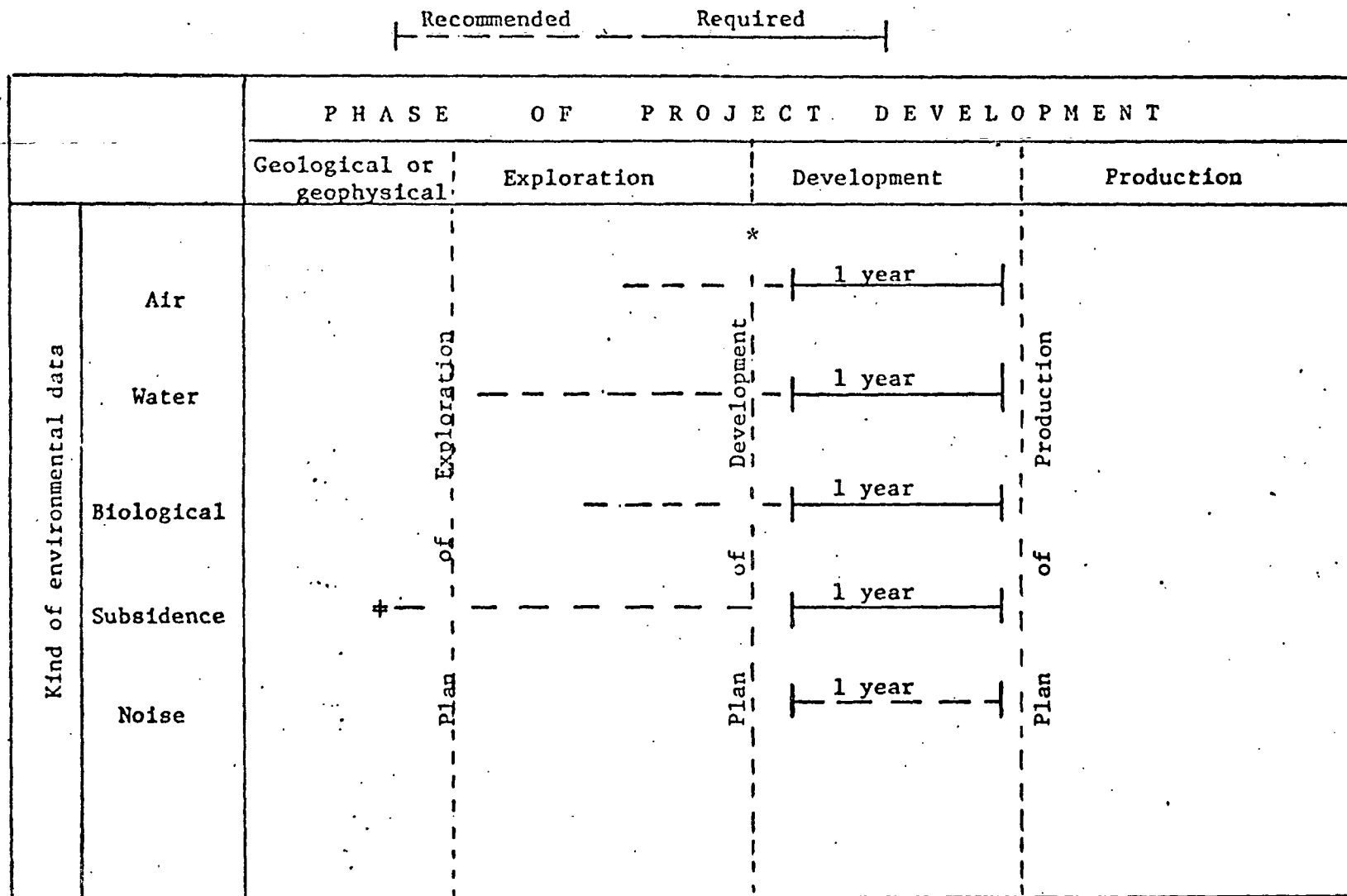
Most of the material that follows is applicable to large scale geothermal development, typically for generation of electrical power. In all areas of extensive development, designs for baseline data acquisition should be site-specific, so as to be adapted to the particular environment involved.

In order to accommodate development of small scale or low-grade heat sources (for example a single well or spring supplying water below 100° C), for small scale use in space or agricultural heating, for development in areas where interaction with the environment will be limited, or for small-scale temporary or experimental facilities, the Supervisor may approve data collection programs of much more limited scope. In some areas these programs may be based largely on existing data.

1.4 Cooperative Studies

In areas with more than one lessee, or in areas of mixed Federal and private land ownership, lessees should be encouraged to cooperate in planning for and acquiring baseline data on a regional basis, and these data may be accepted in lieu of measurements otherwise presumed to be acquired on lease. For certain parameters (eg. air), such regional data may be more significant than those of a more local scale.

Figure 1.-- Idealized scheme for collection of environmental baseline data
on Federal leased lands



* Lessee submits plan for collection of baseline data.

Recommended particularly in areas sensitive to subsidence (eg. irrigated lands)

Published data and records of other information collected more than one year before the submission of the plan of production, if they adequately disclose the conditions, may be used to supplement data collected specifically to meet these requirements. If the lessee should determine that data applicable to the lease area are being collected by credible agencies or individuals during the required one-year period, he may request that the Supervisor approve inclusion of those data in his data collection plan. The lessee then may not be required to collect duplicate data.

1.5 General Methodology

The basic element in any system for collecting environmental baseline data is a network of sampling stations at which repeated measurements of biological, chemical, or physical parameters can be made. Most stations are fixed and provide a record of changes through time at one specific site. Temporary or mobile stations may also be used to locate points of maximum or minimum impact for a particular parameter, and may be particularly useful as a reconnaissance tool in designing a more permanent net. To be effective, stations not occupied continuously must be identified on the ground so that repeated measurements will be comparable. Parameters that vary on a daily or seasonal cycle should be measured so as to encompass the range of expected variation.

The network design should identify sampling sites that are representative of major parts of the ecologic system to be sampled. If the scope of the program justifies, sites may also be selected to characterize extreme conditions, or those believed to involve unusually severe impact for some specific parameter.

The proposed station network should be shown on a map or maps. Background information and rationale for the proposed network should be included in the program of collection of environmental data that will accompany each plan of development.

The network of fixed stations should be operated in a consistent and uniform manner. Parameter coverage should be as uniform as possible throughout, and should be sufficiently precise to permit detailed and quantitative comparisons from one station to another. Parameter coverage should be extensive enough to characterize the part of the environment being measured in scientifically accepted terms, and to describe problems that may be known to exist. One of the purposes of broad parameter coverage is to identify problems and conditions not previously known in order to separate those environmental impacts that are, in fact, attributable to activities of the lessee from those that result from other causes.

The Supervisor may increase or decrease requirements for baseline data collection at any time if clearly warranted by naturally occurring environmental changes on the leasehold or by significant environmental factors recognized during early phases of measurement. Data collected in accordance with an approved program shall be deemed to be presumptively adequate;

the Supervisor is obligated to demonstrate the inadequacy of the data collection program before imposing additional requirements. Techniques used for collection, measurement, and analysis should be in accordance with the methods prescribed specifically or by reference in the following sections, unless alternatives are specifically approved by the Supervisor.

1.6 Data Reporting

Data should be compiled, analyzed and interpreted in an orderly manner by the lessee. The Supervisor may impose a format for data compilation that is compatible with similar formats for data being compiled on a regional or national basis. The Supervisor may inspect the compiled data at any reasonable time. Of primary importance is the maintenance of uniformity in the data collected from fixed stations or in other measurements or observations. Data analysis and interpretation by the lessee should proceed to the extent warranted by sound scientific judgment. To the extent possible, interrelations within the ecosystem should be determined by the lessee by integration of the various kinds of baseline data collected.

Environmental baseline data and the available interpretation should be reported to the office of the Supervisor on a quarterly basis, in addition to any other report requirements prescribed in 30 CFR 270 and 271. The Supervisor may require additional reporting in cases where usual reporting and interpretation is not adequate.

2.0 DEFINITIONS

2.1 General Definitions

Operations - Any activity on the lease other than casual use by the lessee or others for the exploration, testing, development, production and utilization of geothermal resources.

Plan of Operations - A statement of procedures, materials and equipment used in operations. During the lifetime of a geothermal field, a sequence of such plans will normally be involved unless excepted by subsequent regulations or orders.

1. Plan of exploration may include:

- a. geologic or geophysical surveys
- b. shallow temperature gradient holes
- c. deep exploration drill holes
- d. disposal of fluids and wastes

2. Plan of development may include:

- a. development drilling
- b. construction of permanent roads, pipelines and facilities
- c. construction (but not operation) of plants for utilization of water or steam

A program for acquisition of environmental baseline data should be submitted at this stage, or at least 18 months before plan of production is submitted.

3. Plan of Production

A detailed plan outlining means of utilizing and disposing of geothermal fluids and controlling the related environmental impacts. Baseline data must be acquired for at least a one-year period before this plan is submitted.

Aquifer - A body of consolidated or unconsolidated material in the earth that is saturated with water and capable of yielding water in significant quantities to wells or springs.

Environmental baseline data - Information and measurements adequate to describe the physical, chemical, and biological components of the environment in the lease (or unit) area during at least a one-year period prior to submission of a plan for production.

Geothermal lease - A lease issued under the act of December 24, 1970 (84 Stat. 1566) pursuant to the leasing regulations contained in 43 CFR Group 3200.

GRO - A Geothermal Resources Operational Order issued by the Supervisor as defined in 30 CFR 270.2 (e).

Ground water - Water in an underground aquifer below the top of the zone of saturation.

Hazardous substance - An element or compound which, when discharged into the environment presents an imminent and substantial danger to the public health or welfare, including, but not limited to fish, shellfish, and wildlife.

Lessee - The individual, corporation, association, or municipality to which a geothermal lease has been issued, its successor in interest or assignee, any agent or operator holding authority by or through the lessee.

Operator - The individual, corporation, association having control or management of operations on the leased lands or a portion thereof. The operator, or agent of the lessee, or holder of rights under an approved operating agreement.

Parameter - A quantity or characteristic which describes physical, chemical, or biological conditions such as: temperature, dissolved oxygen, color, count, species composition, or condition of terrestrial or aquatic organisms, stream flow, velocity, or area of channel cross section.

Pollution - The man-made or man-induced adverse alteration of the chemical, physical, biological, and radiological integrity of the environment.

Supervisor - The Area Geothermal Supervisor, Conservation Division, U.S. Geological Survey, or his designee.

Surface water - Any water resource on the land surface, such as rivers, streams, ponds, lakes.

Toxic pollutant - Those pollutants, or combinations of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring.

Unit - A unit area as defined in 30 CFR 271.2 (e).

2.2 Glossary of terms related to biological data

Aquatic macrophyte - Any aquatic plant that can be seen with the unaided eye, e.g., aquatic mosses, ferns, liverworts, rooted plants, etc.

Critical habitat - Any air, land, or water area including any elements thereof which the Secretary of the Interior, through the Director, U.S. Fish and Wildlife Service or National Marine Fishery Service, has determined is essential to the survival of wild populations of a listed species or to its recovery to a point at which the measures provided pursuant to the Endangered Species Act of 1973 are no longer necessary. Determinations will be published in the Federal Register.

Ecosystem - A biological community including all the component organisms, together with their environment, forming an interacting system.

Endangered species - Any species that is in danger of extinction throughout all or a significant portion of its range. (See Endangered Species Act of 1973, PL 93-205, 87 Stat. 884).

Important organisms - Organisms having significant commercial, recreational, or ecological value, including organisms that may occupy critical trophic levels.

Indicator organism - A species whose presence or absence may be characteristic of environmental conditions in a particular habitat.

Macroinvertebrates - Those organisms visible with the unaided eye and which are retained in a U.S. Standard sieve No. 30 (openings of 1.589 mm).

Periphyton - Aquatic micro-organisms growing on the bottom, or on other submerged substrates.

Plankton - Suspended micro-organisms that have relatively low power of locomotion, or that drift in the water subject to the action of waves and currents.

Priority station - A location in the ecosystem (aquatic, terrestrial, atmospheric) that has the greatest potential for deterioration as a result of its relation to geothermal lease activity.

Proportion of vegetative cover - The proportion of the ground surface under aerial parts of the plants.

Representative station - A location in the ecosystem selected in such a manner that the conditions or parameters measured characterize or approximate those existing over a larger area.

Sensitive habitats - Those portions of an organism's range that are indispensable to the population's survival, welfare, and reproduction.

Threatened species - Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. (See Endangered Species Act of 1973, PL 93-205)

Transect - Refers to a line or linear band along or within which various parameters of the ecosystem may be measured.

Vegetation type - A plant community which dominates or appears to dominate a geographical region, i.e., grassland, coniferous forest, or tundra.

3.0 AIR QUALITY

3.1 Introduction

3.11 The purpose of the air quality baseline plan should be:

1. to characterize the ambient air quality prior to significant changes associated with geothermal development;
2. to identify substances that may have an adverse effect on the environment and to establish baseline concentrations for these substances;
3. to identify and quantify existing natural and man-made point sources;
4. to collect meteorological data necessary for understanding dispersion and conversion patterns;
5. to provide baseline data compatible with later measurements needed to assure compliance with state or regional air quality standards.

3.12 Individual characteristics of each proposed development will largely influence the lessee's air sampling requirements. The plan for data acquisition must be adapted to the specific geothermal resource, terrain, meteorological complexity, proximity to human population and vulnerable natural and economic resources, probable scale of operation, and nature of the development process.

The Supervisor must consequently retain discretion to fix air baseline data requirements appropriate to the particular circumstances, and to judge the adequacy of the lessee's program in close consultation with local, state, and federal air quality agencies.

3.13 Measurement standards and equipment specifications should conform to published EPA Quality Assurance procedures or their equivalent as prescribed by the Supervisor.

3.14 In areas of mixed federal and private land ownership, or one with two or more lessees, lessees should be encouraged to cooperate in the development of programs for acquiring baseline data on a regional basis, if appropriate, in cooperation with local public agencies.

3.2 Identification of components to be measured

- 3.21 The baseline data plan should include a program for ambient air analysis of hazardous substances anticipated from geothermal operations or pollutants for which there are local, state, or federal standards. At a minimum these should include: particulates, SO_x , NH_3 , NO_x , CO , H_2S , and hydrocarbons/photochemical oxidants. In addition, air analyses should be undertaken for other pollutants whose concentrations are known or reasonably expected to warrant establishment of baseline data. These pollutants may be identified by a program which includes:
- standard analysis of geothermal fluids, (see 4.31A)
 - analysis of gasses where geothermal fluids escape substantially into the atmosphere as a gas or gas-liquid mixture; separate analyses of the gaseous phase at representative wells,
 - analysis of representative naturally occurring gas seeps,
 - examination of existing air quality data.
- 3.22 The Supervisor, in consultation with the surface management agency, and with federal, state and local air quality agencies, must retain latitude to prescribe, curtail, or suspend measurements for individual pollutants as appropriate in each case, based on data from progressive sampling and on the particular circumstances of projected development in and around the lease area.
- 3.23 In selecting hazardous substances to be measured and in establishing the number and location of sites and the frequency of measurement, the lessee should consider:
- downwind, offsite consequences of project emissions,
 - the degree of population exposure and ecosystem sensitivity,
 - topographical and meteorological complexities; seasonal variations,
 - the impact of synergistic effects that may occur,
 - anticipated air quality during ultimate development, including the cumulative impact of both long-term, low-level stack emissions, and secondary or indirect source emissions (for example, traffic to geothermally heated homes or worker traffic; industrial emissions from geothermally heated crop drying; evaporative emissions from ponded brines).
- 3.24 The Supervisor may require special measurement of ozone and sulfur dioxide levels in agricultural areas where sulfur compound emissions from geothermal activities might raise existing oxidant levels above the damage threshold for vegetation.
- 3.25 In areas susceptible to fog or dust conditions visibility should be measured.

3.3 Meteorological measurements

- 3.31 Since meteorological data are necessary as a prerequisite to an adequate program to understand the distribution of pollutants in ambient air, the lessee should gather existing seasonal meteorological information, including temperature, barometric pressure, relative humidity, wind speed and direction, and precipitation. Such data alone may be adequate for small, non-power projects.
- 3.32 Most extensive geothermal developments will require a network of surface meteorological recording stations in topographically representative positions. If appropriate one station may be placed 50-200 feet above ground at a proposed plant site or area of maximum projected emissions. Each station should be capable of meeting the following requirements: 1) relative humidity or dew point shall have an accuracy of $\pm 2^{\circ}$ F, 2) temperature range: -20° F to 130° F, 3) wind speed starting threshold of 1 mph and an accuracy of 0.5 mph, or 1 percent of the wind speed, whichever is greater, 4) precipitation accurate of ± 0.01 inch, 5) for parameters normally recorded continuously, data should be acquired over at least 75% of the base period.
- 3.33 For a period of at least one week in each season, temperature inversions should be ascertained by pibals, acoustic radar, radiosondes, wiresondes, or aircraft flights.
- 3.34 Lessee should locate meteorological stations so that data obtained are adequate to apply to dispersion models if appropriate.

3.4 Data acquisition

- 3.41 The lessee should assemble existing air quality data, which may be substituted for portions of the lessee's data gathering program if specifically approved by the Supervisor.
- 3.42 Ambient air quality at fixed stations should be measured continuously for the baseline period (1 year) with 75% recovery of data.
- 3.43 Temporary or mobile units may be required to measure high local concentrations of air pollutants as well as releases resulting from incidents such as upsets, breakdowns, or blowouts. Spot sampling locations downwind from a well blowout or other hazardous occurrence should also be undertaken for as long a period as circumstances warrant.
- 3.44 If hydrogen sulfide is found to be present in ambient air in concentrations exceeding 10 ppb, the plan should provide for the installation and servicing of an array of lead acetate tabs (or similar devices) to measure H_2S at wells, natural seeps, and in areas where risk to people or to the ecosystem may be especially acute. Lessee should map these areas of crucial exposure by census. If well testing

occurs within the base period the operator should gather data both during well testing and when wells are not being tested. One or more continuously recording stations may be required. The following equipment specifications and reporting requirements are recommended if H₂S measurements are required:

HYDROGEN SULFIDE - MICRO-METEOROLOGICAL STATION

1. H₂S analytical equipment should be capable of a precision of 0.01 ppm (v/v), and accuracy of 5 percent of full scale (v/v), with minimal detectable sensitivity of 0.005 - 0.01 ppm (v/v).
 2. Sulfur analyzers should possess dynamic calibration to assure consistency in tolerances.
 3. At least one secondary calibrating sulfur analyzer should be used to obtain a breakdown of the various species of sulfur making up the analysis.
 4. Data should be processed to yield:
 - a. highest hourly average hydrogen sulfide concentration daily
 - b. 24-hour average hydrogen sulfide concentration
 - c. monthly average hydrogen sulfide concentrations
 - d. seasonal average hydrogen sulfide concentrations.
 5. Where terrain and climatic factors make them significant, the following additional relations should be determined:
 - a. the relation between hydrogen sulfide concentration and wind direction
 - b. diurnal variations in hydrogen sulfide relative to micro-meteorological parameters
 - c. hydrogen sulfide concentrations related to rain, snow, temperature and dew point or relative humidity
- 3.45 Lessee shall comply with applicable federal, state, and local standards affecting measuring equipment and techniques for individual pollutants, and lessee should attempt to follow other established design criteria, network strategy, and analytical methodology.

4.0 WATER QUALITY

4.1 Introduction

Procedures recommended for establishing a water-quality baseline on geothermal leases and units are divided into two categories, 1) general, and 2) site specific. These recommendations stem from the principle that detailed knowledge of water quality in the environment and of the geothermal fluid(s) is needed early in any operation, to establish baseline concentrations and to determine which potentially harmful constituents are present. Later, measurements may be limited to those constituents that may adversely affect the environment.

4.2 General sampling requirements

To provide an adequate body of baseline data on water quality, the following procedures and principles are generally recommended for all leases or units:

4.21 Standards

Collection and analysis of water samples should be done according to current methods published by EPA, USGS, "Standard Methods" as summarized in "Recommended Methods for Water-Data Acquisition" (3). Analyses by State-certified laboratories are preferred.

4.22 Sources to be sampled

A. Surface water

Where present, perennial streams and significant intermittent streams should be sampled at or near the upstream and downstream boundaries of the lease or unit. Ponds, lakes, canals and drains, if present, should also be sampled. In areas of complex ownership or development lessees should be encouraged to develop sampling programs on a cooperative basis (1.4 above) taking into consideration differences in topography, geology, land use and access.

B. Ground water

Where present, ground-water sources (springs, seeps, and water wells) on the leasehold should be sampled for analysis as prescribed by the Supervisor. If the leasehold overlies and is upgradient from parts of an aquifer from which water is used for domestic, irrigation, stock, or wildlife supply, the Supervisor may require the lessee to obtain water samples for analysis from that aquifer during the drilling of geothermal

wells, even though no wells on the lease hold produce from that aquifer.

C. Geothermal fluids

Geothermal fluids produced under the lease should be sampled for analysis according to provisions of GRO Order No. 4, and as specified below. (see 4.31).

4.23 Frequency and duration of sampling

- A. The Supervisor should have wide latitude in determining frequency and duration of sampling during the baseline period.
- B. The size, nature, intensity of development, and use of the geothermal resources should be important determining factors.
- C. Frequency of sampling of streams should be selected with regard to the regimen and environment of the stream. Quarterly samples may define basic conditions in areas where streamflow is fairly uniform. In areas of significant seasonal variation, times of sampling should be adjusted to determine quality of typical high and low flows and/or of extreme events.
- D. Ground-water sources upgradient of lessee's structures should be sampled at least once. Downgradient sources should be sampled at frequencies determined by the Supervisor in light of the chemical quality of geothermal fluids and other conditions and events peculiar to the lease.
- E. Natural discharges of geothermal fluids (as from hot springs) should be sampled at least once prior to commencement of exploration drilling, and at least once more during the baseline data period.
- F. Artificially produced geothermal fluids should be sampled for analysis when encountered and after there has been enough discharge to assure that the sample is representative of fluid(s) in the producing zone. Thereafter, samples may be required by the Supervisor after any major modification to the well or change in flow characteristics.

4.24 Parameters to be measured

A. Physical

1. Discharge of streams, wells, and springs should be measured each time a sample is taken.
2. Temperature should be determined each time a water source is sampled. Precision should be:

 0.2°C in the range 0° to 30°C
 1.0°C in the range 31° to 100°C
 5.0° above 100°C
3. pH should be determined each time a water source is sampled. For the range 6.0 to 9.0 a precision of about 0.5 pH unit will be accepted. Outside of this range more precise measurements should be obtained.
4. Specific conductance should be determined each time a water source is sampled.
5. Turbidity should be measured on surface-water samples where eutrophication exists or is threatened.

B. Chemical

1. Surface waters

The first surface water sample from each site should receive a standard analysis. Standard analyses include DO, SiO₂, Ca, Mg, Na, K, alkalinity, SO₄, Cl, NO₃, F, dissolved solids, total P. Thereafter, where specific conductance does not increase by more than 10 percent, repeat analyses may not be required.

2. Ground water

Ground-water samples from each sampling site should be given standard analysis as required for surface water at least once. Analysis of the first sample from each ground-water source shall include an assay for gross radioactivity.

4.3 Site Specific sampling requirements

The following requirements are to be within the province of the Supervisor and should become part of the required environmental

baseline for surface and ground waters when toxic substances have been determined to exist in natural discharges of geothermal fluids or in fluids from geothermal wells, or if the Supervisor has reason to expect that toxic substances exist owing to geologic or other conditions. If the lessee in his plan of operation indicates he intends to use toxic substances, a baseline for such substances should be established prior to their introduction on the lease.

4.31 Geothermal fluids

A. All pre-lease thermal wells and hot springs should be sampled in accordance with 4.23 E above. In addition to the standard analysis the following components are to be quantified by accepted laboratory methods (reference 4)

1. Gases: CO_2 , H_2S , SO_2 , NH_3 , and Rn-222

2. Water: As, Ag, B, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Mo, NH_4 , Pb, Se, Sr, and Zn.

B. Analysis of produced geothermal fluids is required under provisions of GRO Order No. 4, section 10, within 30 days of completion of any geothermal well.

C. Analyses of geothermal fluids should include determination of gross radioactivity. If radioactivity exceeds the following values (gross $\alpha > 10 \text{ pCi/l}$, gross $\beta > 50 \text{ pCi/l}$) the Supervisor may require specific radionuclide assays of these and other water sources on the lease.

4.32 If water pollution is threatened from sources on the lease other than geothermal fluids the Supervisor should require sampling and analysis of those sources and of the water bodies (surface or subsurface) threatened. Potential sources of pollution include, but are not restricted to, effluent or drainage streams including road culverts, mud pits or other sumps, sanitary facilities, and waste-disposal leachates.

4.33 Biochemical, bacteriological, and organic quality of streams, canals and drains should be determined at the discretion of the Supervisor. In general, stations upstream and downstream from construction sites will be of principal interest. Parameters that may be called for include: BOD_5 , TOC, COD, fecal coliform bacteria, and fecal streptococcus bacteria. Pesticide analysis should be required if pesticides have been used extensively on the leasehold.

Leachates of any origin originating on the leasehold should be analyzed for deleterious organic constituents and characteristics.

The Supervisor may require biochemical, bacteriological, and organic quality determinations on runoff from construction sites such as roads and drilling pads if that runoff reaches a body of surface water.

4.34 Samples for determination of suspended sediment may be taken from surface sources at discretion of the Supervisor. The load of any component absorbed on suspended sediment may require quantification.

4.35 Standing surface-water bodies (such as ponds, lakes, or reservoirs) on the leasehold or within the realm of influence from operations on the leasehold should be sampled for analysis to determine water quality prior to operations by the lessee. Dissolved oxygen, BOD₅, pH, specific conductance, temperature, and fecal bacteria may be determined monthly or seasonally.

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5. "Standard methods for the examination of water and waste water" (latest edition) prepared and published jointly by American Public Health Association, American Water Works Association, and Water Pollution Control Federation.
6. Environmental Protection Agency, 1973, Water quality criteria 1972: EPA-R3-033, March 1973, 594 p.

5.0 BIOLOGICAL DATA

5.1 Review of program design

The adequacy of the design and conduct of the biological baseline data program should be determined by the Supervisor in consultation with surface management agencies, State fish and game agencies, and the U.S. Fish and Wildlife Service.

5.2 Aquatic

The following instructions refer to all surface waters. Although specific sampling techniques will vary, the types of information needed to establish an effective baseline for any aquatic resource are the same. The design of the sampling scheme, specific methods of sample collection and analysis and, in some cases, the frequency of sampling will usually be site specific.

5.21 Station Selection Criteria

- A. Priority stations should be established at all points of potential impact and at any location where initial inventories (see below) identify endangered or threatened species or a fishery resource of recognized high value. Points of potential impacts are recognized as, but not limited to, perennial aquatic resources upstream and downstream from areas of intensive environmental manipulation, such as road development, pad preparation, well drilling, retaining ponds and temporary or permanent facilities.
- B. Representative stations should be established at a sufficient number of points to document the structure of the aquatic ecosystem.

5.22 Prior to, or concurrently with, selection of the sampling stations, an initial inventory of the floral and faunal components of the aquatic ecosystem should be accomplished in sufficient detail and intensity to identify: 1) the presence of any endangered or threatened species listed in accordance with the Endangered Species Act of 1973, and 2) other species and the relative abundance of those species present in the ecosystem. After compilation of the inventory data, sensitive and/or important organisms will be identified and selected for more detailed study. Selection of these species and the degree to which their population dynamics are quantified will determine the level of resolution in identifying and separating natural population changes from those resulting from geothermal development. In addition to the investigations dealing

with individual species, attention should be directed to determining community structure and function in terms of abundance, diversity and biomass of the organisms present. General parameters to be investigated will be determined by the particular species present in the ecosystem and their required habitat. The following biotic groups will generally be represented: periphyton, plankton, aquatic macrophytes, macroinvertebrates, and fish and/or other vertebrates. Specific parameters for the identified sensitive and/or important species will include estimates of such things as abundance, standing crop of biomass, diversity, and intrinsic growth rate (as related to biomass). The required habitat should be inventoried for any listed sensitive and/or important species for which critical life stages have been identified (eg salmonid spawning grounds). Baseline levels of heavy metals should be determined in fish. If determined levels exceed levels indicated in State or Federal water quality criteria, measurements of heavy metal content may be required for baseline purposes in other components of the ecosystem.

5.23 Frequency

The sampling frequencies for the various general parameters (Table 1) are to be used as initial sampling schedules and may be adjusted by the Supervisor on the basis of demonstrated population dynamics.

5.24 Data Interpretation and Reporting

Analysis and interpretation of data should be in accordance with methodologies acceptable within the scientific community. Degree of precision and, where available, accuracy will be reported for the estimates of all parameters. Reports will describe the structure and functional nature of the aquatic ecosystem.

TABLE 1. RECOMMENDED SAMPLING FREQUENCY FOR GENERAL
PARAMETERS AND ASPECTS OF THOSE PARAMETERS. a/

COMPONENT	STANDING CROP (in numbers and biomass)	DIVERSITY	INTRINSIC GROWTH RATE (as related to biomass)	REMARKS
Phyton	Seasonally	Seasonally	Seasonally	Estimates of net production will be made.
ston	Monthly	Monthly	Monthly	In standing waters only
ic Macrophytes	Semi-annually	Annually	Semi-annually	Estimates of net production will be made.
invertebrates	Seasonally	Seasonally	Annually	
<u>b/</u>	Annually	Annually	Annually	

a/ Sampling frequencies will vary from these basic guidelines depending on the sensitive and/or important species under investigation and the seasonal characteristics of activity.

b/ Natality, and mortality by age class will be estimated annually for fish populations. See chemical sections for sampling frequencies for heavy metals.

5.3 Terrestrial

5.31 Introduction

Baseline studies of terrestrial biology should consist essentially of inventories necessary to establish the identity of flora and fauna within the lease area and in areas likely to be affected by lessee activity. These studies are necessary to identify significant processes and relationships within the ecosystem. The importance of review by people and organizations having acknowledged familiarity with and information on the flora and fauna of the lease site is emphasized. Duplication of efforts should be avoided by making use of existing information whenever possible. For example, universities or agencies having information should be consulted. Such pre-existing data may be included in the data collection program with the approval of the Supervisor.

5.32 Flora

The first step in baseline studies of flora and fauna should be to obtain copies of recent aerial photographs and prepare a vegetative type map of the lease area and adjacent areas of concern. Color aerial infrared photographs are preferred and can be used to delineate and document major vegetative types. The photos should be of a scale satisfactory to reveal individual types within the lease area. Ground verification should be carried out as needed to characterize floral components of each type. Examples of vegetative types identified at this stage include riparian, grassland, desert shrub, woodland, or forest.

A. Station Selection Criteria

The number and location of representative stations or transects should be selected so as to characterize each vegetative type within the lease area. Priority stations shall be selected in areas of special interest based on knowledge of anticipated geothermal development, concern for critical habitat, or for other reasons.

B. Parameters and Methods

Parameters to be identified or measured include the following:

1. Vegetative-types
2. Identification of plant communities within

- vegetative types (e.g. pinyon-juniper, creosote bush, oak-mixed shrub, saltbush-greasewood)
3. Measurements of cover density and species composition within plant communities
 4. Measurements such as the volumes of seed or forage production as may be related to use by animal species in the area
 5. Identify and locate endangered or threatened plant species
 6. Identify species and/or communities with special scientific values

Exact sampling methodology and additional parameters will be those relevant to the specific lease area as determined through consultation with knowledgeable individuals and agencies and approved by the Supervisor.

Methods of data analysis will be those generally accepted by the scientific community concerned with the particular parameters. This will be primarily the land administering agency, the U.S. Fish and Wildlife Service and the State Fish and Game Department.

5.33 Fauna

The baseline inventory of the animal community found on or associated with the lease area should include: identification of species present and their relative abundance and habitat association or preference; the presence of threatened or endangered species; seasonal use patterns and movements of both resident and migratory species; and, if data are available, the identification of "key" indicator species. This initial inventory should include a review and compilation of existing data from sources such as universities, fish and wildlife agencies, check lists, etc. This inventory should be expanded as required to accomplish the objectives.

A. Station Selection Criteria

The number and extent of stations or transects should be sufficient to provide reliable data on particularly sensitive areas, coverage of representative habitats on the lease area, and as the basis for comparability with data collected during the subsequent monitoring phase. Should critical or particularly sensitive species or habitats occur within the lease area the Supervisor may require a more rigorous and extensive sampling program.

B. Frequency

Each station or transect should be sampled quarterly so as to determine seasonal variations in use, nesting/breeding seasons, and relative abundance of species using the lease area.

6.0 NOISE

Ambient noise levels prior to the operations of the lessee constitute the baseline against which later measurements can be compared. In many natural settings remote from the activities of man, sound level measurements available from management agencies or other sources may be acceptable. In areas affected by noise from highways, frequent planes, or other industrial or manmade sources, sound measurements to establish a baseline should be carried out by the lessee. These measurements should be conducted in accordance with the provisions of GRO-4, section 11.

7.0 SEISMICITY AND SUBSIDENCE

7.1 Seismicity

Measurements of seismic activity, on a regional basis, are the responsibility of public agencies. The lessee should cooperate with the appropriate agencies in installation of seismographs and in the acquisition of seismic and related data. Measurements of seismic activity within the lease area may be required by the Supervisor.

7.2 Subsidence

Periodic surveys within a lease or area of subsequent unitization to detect possible land subsidence resulting from fluid withdrawals are the responsibility of the lessee. A network of permanent bench marks should be established, maintained, and protected by the lessee or his agents in each production area as required by GRO Order No. 4. In areas sensitive to elevation changes, the Supervisor may require that surveys of these bench marks be scheduled to obtain background data on rates of uplift or subsidence prior to production. At the discretion of the Supervisor, the survey net specified in USGS GRO Order No. 4 may be accepted as the minimum net to fulfill this requirement. In many areas, however, particularly those where changes in elevation (subsidence) may have a deleterious effect on associated or pre-existing land uses, a more closely spaced net to better define the nature and areal extent of possible subsidence around each well may be required.