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INTERIM REPORT: GEOTHERMAL AQUATIC ECOSYSTEM PROGRAM: GEYSER-CALISTOGA KGRA

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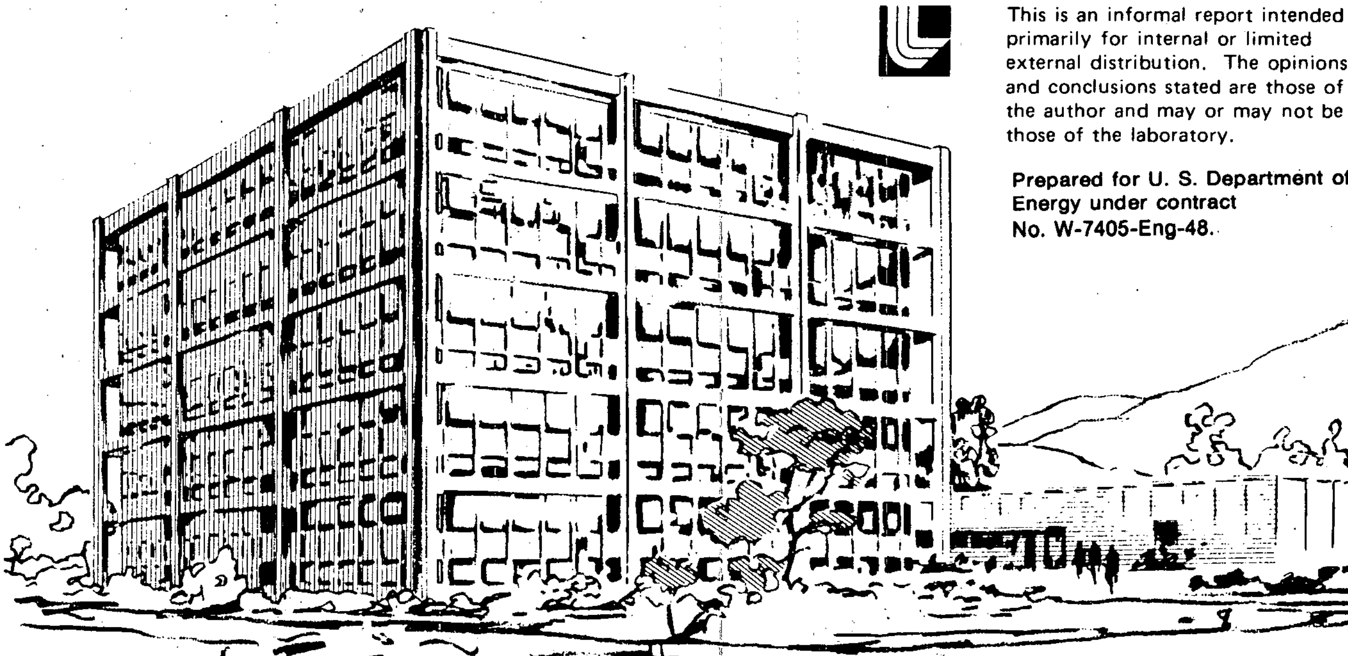
October 12, 1979



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INTERIM REPORT:

GEOTHERMAL AQUATIC ECOSYSTEM PROGRAM: GEYSER-CALISTOGA KGRA

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The formulation of a study plan for assessing the impact of geothermal development in the Geysers-Calistoga KGRA upon the local aquatic ecosystem was based largely upon the need to be consistant with the issues and recommendations set forth by the LLL Geothermal Environmental Overview Project, sponsored by ASEV. Of the eight volumes of UCRL-52496, the following four were taken into consideration in making our decisions.

Volume 1: Issues and Recommendations

Volume 4: Environmental Geology

Volume 5: Ecosystem Quality

Volume 6: Water Quality

A second major consideration was avoiding duplication of previous efforts. We sought to fill the data gaps which would be most meaningful in light of the recommended studies by implementing a program which could not only stand on its own but also add to and complement the myriad of previous and ongoing studies within the KGRA.

From the overview project, three key issues were apparent: erosion, cooling tower drift, and long-term ecosystem effects. The problem due to erosion with regard to the aquatic environment is siltation and sedimentation within the streambed. Both physical and chemical impacts may be effected. Physically, siltation may impede the development and reproduction of the aquatic invertebrates essential to a healthy stream. Secondly, siltation has a proven effect upon the fish spawning capacity of a streambed by filling in the interstices of gravel beds needed for egg development. Chemically, erosion activities adds organic matter thereby decreasing available oxygen in the water. This in turn may lead to changes in redox potentials and resolubilization of bound elements within the sediment, particularly in regard to certain potentially toxic elements such as mercury and arsenic.

The issue of cooling tower drift is not unrelated. Emissions of H_2S, NH_3, B, Hg, and As have been proven to be at times far above recommended standards. The natural washing of rainfall, as well as infrequent accidental spills, leads one to ponder the fate of the constituents as they enter the aquatic environment.

Thirdly, long-term ecosystem effects have not been adequately characterized, although a number of studies have been conducted or are in progress to add data bits to the overall picture.

In order to simultaneously address the key issues and fill a much needed data gap, we have designed a program for chemically characterizing the various partitions of the streambed sediment. This is currently being done on a quaterly basis in the Big Sulphur Creek drainage. The goal is to provide information about transfer, cycling, and the accumulation of potentially toxic trace elements such as Hg, As, B, and NH_3.

Sediments are separated into different size classes in the field using nylon sieves. These sizes are 849μ - 590 μ, 590 μ- 250 μ, 250 μ - 149 μ and less than 149 μ(see Figure 1). The last fraction is recovered quantitatively by certrifugation in the laboratory. All of these fractions are leached with 0.5 N HCl for trace metal extraction which provides us values we can compare to the literature.

The less than 149 μ fraction is further characterized by a sequential extraction procedure. Unfortunately, most of the numbers in the literature are generated by acid leach methods as mentioned in the previous paragraph. However, these numbers consider the total concentration of any given element to be indicative of equal availability and reactivity, which is not the case. A sequential extraction scheme yields much more information about the biogeochemistry of the sediment sample, the biological and physicochemical availablility of the trace elements, as well as their origin, mobilization potential, and probable transport.

Table I lists the chemicals used to peel away the elements from the sediments. The exchangeable phase refers to that held by sorption - desorption phenomena which could likely be affected by salinity and thermal changes. The carbonate bound fraction would be susceptible to changes in pH. The iron and manganese oxide bound fractions are held by these precipitating scavengers which are thermodynamically unstable under low oxygen or reducing conditions. A dynamic equilibria always exists with regard to trace elements and organic matter such that complexation or release depends upon type. quantity, and a host of environmental variables. The residual phase tells us about the lattice structure of the minerals and generally is reflective of the geology of the area rather than as a source of available elements.

Table 2 is our field data sheet which we compiled and utilize at each sampling location (Figure 3). One can see that while our thrust is at the characterization of the sediments, we have not ignored any facet of transport phenomena: soluble, particulate bound, or sediment bound.

We are employing a wide range of analytical tools to chemically define these facets. Most of the analyses are done in a liquid acidified medium so atomic absorption spectroscopy (AA) and ion coupled plasma optical emission spectroscopy (ICPOES) are most commonly utilized. For difficult elements like Hg and As, a state-of-the-art cold vapor hydride reduction AA system is used. Other tools used include X-ray diffraction for determining the crystal content of the sediment and particulate minerals, selective ion meters for analyses such as ammonia, the ion chromatograph for anions, an organic carbon analyzer for dissolved and particulate organic matter, and a host of common water quality instruments for conductivity, flow pH, etc.

The goal of this program is to maximize the yield without compromising the quality or duplicating the efforts of others. Toward this end, we have established a complementary and coordinated effort with the aquatic biology arm of Pacific Gas and Electric. P.G.&E. has been conducting a variety of studies in past and present years. These include sedimentation studies to physically characterize the size percentages of the streambed sediment above and below the power plants from pre-operational through post-operational time periods to determine the extent of siltation caused by erosion. They have also conducted fisheries resource inventories to determine any effect upon population dynamics due to alteration of spawning areas as well as general water quality surveys.

We have selectively modified our program so that it harmonizes well with P.G.&E.'s. Our chemical characterization studies of the different sediment partitions will provide a enhancement of their physical size classing of the total streambed load. We overlap in the area between 839 μ to 590 μ for commonality. Naturally, their data will provide us with a more total picture of the load movement within the aquatic environment. A data blend like this will be of mutual benefit in that it will provide a synergistic picture of the origin and extent of imposed additions to the ecosystem. We are in the process of establishing a common computerized data base here at LLL for ourselves and P.G.&E. for this program in order to manipulate the physical and chemical data.

We have also established working relationships with other researchers and agencies for a more complete picture. One group at the University of California, Berkeley has been studying the benthic invertebrates at selected sites within the watershed for the past several years. We invited them to our coordination meeting when we were intially determining our sampling locations. Another group is at U.C. Davis who are studying the migrational dynamics of selected fish species for several watersheds in the area. Yet another group is the California Department of Fish and Game who have also conducted siltation and fisheries inventory studies.

All of the above groups are very much interested in the type of chemical characterization data we are making available. We hope to integrate our data with each of theirs to provide a better insight and understanding of not only physicochemical processes and dynamics, but also what role all of this has upon bioavailability and bioaccumulation.

As evidence of the workability of our plan, we recently were invited to a meeting of the California Energy Commission. The CEC is attempting to organize researchers in the Geysers KGRA to avoid duplication of effort and to guide those willing toward filling uncertain data gaps. After presentation of our plan as put forth here, detailing our already integrated program with P.G.&E., and outlining the existing working relationships with other organizations, the CEC was pleased to note that we seemed to be well on our way toward fulfilling what they perceived to be their function. It was generally conceded that this plan would be of benefit to most all of the participants. These benefits would come from the blending of physical, chemical, and biological inputs and could be of considerable value to decision makers in the areas of control technology and mitigation.

We had originally intended to implement this program in the Putah Creek watershed, where new Units 13, 16, and 19 are in varying stages of development. However, as yet, none of these have come on-line due to various delays. Instead, we chose to test our detailed scheme in the Big Sulphur watershed, where development has been ongoing since Unit 1 was placed in operation in 1960. We aim, even in the absence of baseline data, to address ourselves to providing information about the transfer, cycling, and accumulation of potentially toxic trace elements of goethermal concern such as Hg, As, B, and NH_3. Our goal is to provide data to show the relative contributions from different sources, i.e., geothermal units, natural geothermal input such as hot springs, and fumaroles, and the many abandoned mercury mines in the area. We want to answer the following questions. What is the extent of the additions? How are the constituents mobilized and transported? To what extent are they accumulated? What is their bioavailability? What effect are they having on the aquatic ecosystem?

We then feel this program can be applied to Putah Creek watershed with its new development. It would also be an especially viable program in the third watershed in the Geysers KGRA, the Kelsey Creek drainage, where mounting evidence indicates a large liquid-dominated geothermal reservoir remains to be tapped.

We are currently preparing for a third field trip to the area. Trip #1 in the spring was a preliminary effort to iron out the bugs and provide samples for analytical experience. Trip #2 was the summer quarter and the first one to be considered real from A to Z. Trip #3 will be in October just after the first rains wash the hillsides and mobilize to a great extent the trace elemental burden of the cooling tower drift. Trip #4 will be in the winter to determine the extent of natural flushing in the drainage due to high flow. Trip #5 will be in the spring, 1980 and will overlap Trip #1 from 1979.

We also anticipate moving into the Putah Creek drainage in the spring to implement this program there prior to any significant contributions from new power units.

Figure 1. Sediment Chemical Characterization

I. 849 μ - 590 μ, 590 μ - 250 μ, 250 μ - 149 μ: 0.5 N HCl

149 μ

II. <149 μ

1. Exchangeable

   1 M $MgCl_2$

2. Bound to carbonate

   NaOAc

3. Bound to iron and manganese oxides

   $NH_2OH \cdot HCl + HOAc$

4. Bound to organic matter

   HNO_3, H_2O_2

   NH_4OAc

5. Residual

   HF - $HClO_4$

FIELD DATA SHEET

Date	Initial Time	Final Time	Station	Elevation	Weather	Bottom Type

Photographs	Film	Air Temp.	Sfc Temp.	Mid Temp.	Bot. Temp.	pH

Conductivity	DO	Turbidity	H_2S	Alkalinity	Flow #

Water Velocity	Width	Mid depth	Qt. depth	Qt. depth

Comments: ______

Total Suspended Solids:

Filter #	Vol.(mls)

IONS: T.E., Anions, NH_3

UNFILTERED

	Bottle #	Fix
Reference		
Total TE		
Hg		
DW Blank		
DW Spike 1		
DW Spike 2		

FILTERED

	Filter #	Vol.(mls)	Bottle#	Fix
Reference				
Partic. TE				
Dissolv. TE				
Hg				
NH_3				
Anions				

Figure 2

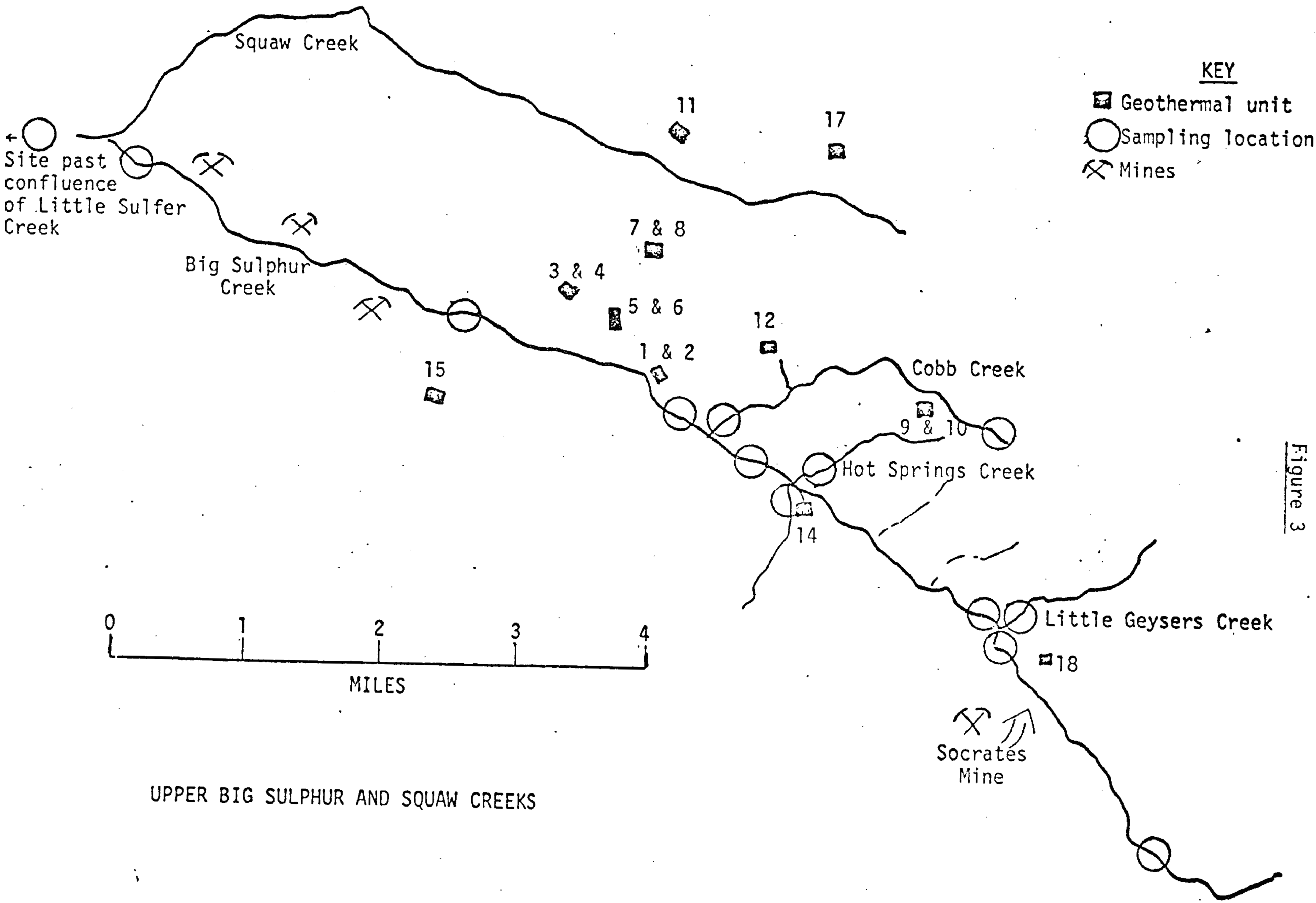
Water OC:

	Ampule #	
Total OC		
Dissol. OC		
		Vol (mls)
Part. OC		

SEDIMENT:

	Weight	Weight	Weight
>849 μ			
	Bottle #	Bottle #	Bottle #
590-849μ			
297-590μ			
149-297 μ			
<149μ			
Composite			

AQUATIC ECOLOGY SAMPLING LOCATIONS



UPPER BIG SULPHUR AND SQUAW CREEKS

Figure 3

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