Date: February 16, 1997
To: Julie Hart MS 3805 6-9087
From: Paul Grahovac MS 3805 6-3488
Subject: CRADA 96-CR-01 PUBLIC RELEASE ABSTRACT - PG-15-97

I am submitting the abstract below to you as CRADA Administrator to fulfill the requirement of CRADA Article XI: Reports and Abstracts subsection A(1).

The purpose of this Cooperative Research and Development Agreement (CRADA) was to assess and develop control practices for nuisance algae growth in power canal that deliver water to hydro-generation facilities. This growth results in expenditures related not only to lost generation but also labor and materials costs associated with implementing remediation procedures. On an industry-wide basis these costs associated with nuisance algal growth are estimated to be several million dollars per year.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.
I am submitting the abstract below to you as CRADA Administrator to fulfill the requirement of CRADA Article XI: Reports and Abstracts subsection A(2).

The purpose of this Cooperative Research and Development Agreement (CRADA) was to assess and develop control practices for nuisance algae growth in power canal that deliver water to hydro-generation facilities. This growth results in expenditures related not only to lost generation but also labor and materials costs associated with implementing remediation procedures. On an industry-wide basis these costs associated with nuisance algal growth are estimated to be several million dollars per year.

The benefits resulting from this CRADA are that we are positioned to do follow-on work in this field with PG&E or other partners.
I am submitting the abstract below to you as CRADA Administrator to fulfill the requirement of CRADA Article XI: Reports and Abstracts subsection A(3).

Purpose

The purpose of this Cooperative Research and Development Agreement (CRADA) was to assess and develop control practices for nuisance algae growth in power canal that deliver water to hydro-generation facilities. This growth results in expenditures related not only to lost generation but also labor and materials costs associated with implementing remediation procedures. On an industry-wide basis these costs associated with nuisance algal growth are estimated to be several million dollars per year.

Background

Participant: Tiger Creek Canal system has been selected for initial investigations in developing algae control strategies. This canal system is located in the Sierra Nevada Mountains, west of Sacramento, California. The canal is approximately 14 feet across and 7 feet in depth and extends for approximately 17 miles. Design flow is 550 cfs but transfer rate is usually maintained at approximately 500 cfs, which translates to about 8 feet per second in distance/time flow (6 mph).

The algae grows on the sides and bottom of the canal. The growth of algae in these canals displaces a certain cross sectional area in the canal. As the algae continue to grow, the transfer capacity of the canal is reduced, therefore less water is shunted to the canals to prevent over-topping of the canal walls. Algal growth in the canal is not a new problem, however, the extent and frequency of algae related problems are increasing.

Algae grows in the canals around the year, but the summer months are the most likely time for the development of nuisance algae growth. Peak algal growth typically occurs between May and October. During the remainder of the year the algae does not interfere with flow. Excessive growth results in the need to interrupt flow in the canal in order to remove the algae. This watershed is a multiple use watershed, therefore there are certain restrictions on what materials can be added to the water to treat the algae. Currently water blasting, a mechanical method, is used to remove the algae. During the 1994 generation year the system was taken out of service
four times for removal of excess algae growth. During 1995, there were over six outages to remove excess algae.

Within the last several years the Participant has conducted tests to identify possible algae control methods suitable for their needs. They have developed baseline information that has provided a comparison of control strategies. Different control techniques were evaluated based on their environmental acceptability, potential effectiveness and estimated cost. A few of the methods have been tested in the Tiger Creek Canal system while other control methods were tested in different PG&E canals that have similar algae problems.

**Contractor:** Algal studies have been conducted at the INEL to examine the interaction of algae with their environment. The following represent a selection of these studies.

Algae were cultured and grown in the geothermal effluent at Raft River, Idaho. The purpose of these growth studies was to investigate the potential production of biomass (alternative feedstocks) and mineral removal from the geothermal discharge.

A research program between the INEL and the United States Bureau of Mines investigated conditions characteristic of mining environments and the relationships micro-organisms play in the movement and sequestering of metal ions and other materials associated with mine sites. Algae were isolated, cultured, and subsequently used as adsorbents to recover metal ions from typical liquid mine waste.

A discharge pond at the Idaho Chemical Processing Plant (ICPP) developed nuisance algae growth. Based on the type of algae present, a treatment plan and methodology was developed to control the algae problem.

Research at the INEL has focused on the control of algae for the provision of nutrients for plant growth. Algae, capable of fixing atmospheric nitrogen into a form suitable for the support of field plants, have been cultured and incorporated into an immobilized matrix for application to field plots.

During 1994 and 1995 both the Participant and the Contractor worked together to develop an initial characterization of the algal problem in the Tiger Creek Canal system. Water and algal samples have been collected and analyzed to establish a base-line of information. This information was essential for the continuation of the scope of work in this CRADA.
Scope of Work

The purpose of this CRADA was to combine the efforts, experience, and expertise of personnel representing LMITCO and PG&E in developing algae control techniques. The Participant was looking for a suitable, effective, and environmentally safe method of controlling excessive growth of algae in their hydro-generation canals in order to provide a more stable and reliable source of water for electrical power generation. The objective of the Contractor was to assist the Participant in their endeavor and also to produce an algal control agent that is of biological origin, environmentally acceptable, and able to compete with existing products on the market for use in controlling algae.

The scope of work contained the following:

1) Continued collection of water quality measurements. During 1995 water samples were collected and a baseline of information was established. The reasons for continuing this operation are to compare the seasonality of the water quality and look at long term trends that extend over several years. This past year was a good water year since there was an ample snow pack in the mountains feeding melt to the watershed. This last year represents one set of data. By collection in 1996 and 1997 it will be possible to obtain a better understanding of possible annual variations and use that information in developing a long term algae control strategy.

From the work conducted this past year, five (5) stations have been selected to represent spatial differences over the 17 mile length of the canal. These stations will be sampled twice a month throughout the algae growing season (May to October) and once a month during the remainder of the year. This work was initiated during the summer of 1995 and will continue through 1996 and 1997. These samples will be analyzed for basic nutrient content.

The break out of responsibilities fell along the following lines

- The Participant will provide personnel for the collection and distribution of samples for water quality analysis.
- The Participant will be involved in the summarization and evaluation of the water quality data.
- The Contractor will assist in developing the water sampling protocol.

- The Contractor will participate in the summarization and evaluation of water quality data.

2) **Collection of algae samples for community structure analysis.** Similar to other green plants, different types of algae have different nutrient and growth requirements. Also, individual species of algae respond differently to applied control measure whether it be chemical, biological, or mechanical methods. Algal samples have been collected from the Tiger Creek Canal system during 1994 and 1995 and this effort will continue through 1996 and 1997. The purpose for this effort was to determine seasonal and spatial distribution of algal species in the canal. The frequency of the unscheduled outages associated with nuisance algae growth has increased over the last couple of years. There was an interest in whether the increase in problem growth may be related to a change in the dominant forms of algae in the canals, therefore this objective will be aimed at resolving such questions. And, similar to the water quality data, it was important to collect algae over several years and seasons to develop a broader understanding of the variability in algal growth patterns. This information will benefit the development of a control plan for the nuisance algae.

Typical flow conditions (550 cfs/7 mph) in the canal do not permit the collection of algae while under full operation. Therefore algae can only be collected during scheduled and unscheduled outages. Algal samples will be collected at the same water quality stations during any outage on the canal throughout the year in 1996 and 1997.

The break out of responsibilities fell along the following lines

- The Participant will collect and distribute algae samples.

- The Contractor will examine the algae samples collected by the Participant

- The Contractor will identify the algae to genus and species level (if possible) to develop an understanding of the community structure.
The Contractor will also collect algae from other points in the Tiger Creek Canal basin to determine possible relationships between the algae in the canal and the algae in the surrounding watershed.

- The Contractor will investigate methods that will permit the collection of algal samples from the canal under full flow conditions

3) **Determine the chemical characteristics of the algal filaments associated with water flow problems in the Tiger Creek Canal system.** There was some interest in knowing the relative chemical composition of the algae as it may relate to spatial distribution of algae in the Tiger Creek Canal. Similar forms of algae exist throughout the 17 mile length of the canal. Observations made with light microscopy on algae collected during 1994 and 1995 have indicated that there are "apparent" differences in the filament structure among the same algal species collected at different locations along the canal. One of the objectives of the Contractor was to develop a biological control agent for the algae. The determination of the differences in composition of these algal specimens may provide insight into the development of this product. Several analytical techniques were to be be used as more information was obtained. Initially a procedure will be applied to determine the carbon, nitrogen, sulfur, and hydrogen content in prepared samples.

The break out of responsibilities fell along the following lines

- The Participant will collect and distribute algae samples

- The Contractor will analyze the samples to determine their relative composition.

- The Contractor will evaluate the results of the analyses to determine their importance in developing an algicide.

4) **Collection of algae samples from locations other than the Tiger Creek Canal system.** Algae growth problems have been reported in many areas other than the Tiger Creek Canal and hydro-generation systems. Recent searches conducted on different data-bases have indicated that similar problems are associated with public drinking water supplies, recreational areas, and industrial water systems. Both the
Participant and Contractor have previous experience in dealing with algal control problems at other locations at other times. The Participant has reported on algal growth problems in several of their power generation locations, beside the Tiger Creek Canal. Therefore one aspect of the scope of work will contain the further investigation of areas where nuisance algal growth are reported. This information will benefit both parties by providing some insight into the "successes" and "failures" of other algae control programs. This information will be helpful in developing the long term strategy for algae control in the Tiger Creek basin, and will be helpful in assessing the market potential for any product developed by the Contractor. This work will continue through 1996 and 1997.

The breakout of responsibilities fell along the following lines.

- The Participant will investigate and assess the extent of algal growth problems in their canals, in addition to the Tiger Creek system.

- The Contractor will investigate the assess the extent of algal growth problems in other areas such as mining, agriculture, and industry.

- The Contractor will assess the information and report on the relative importance of this data to product/market potential.

Funding for the project was cut, and so the CRADA was terminated before the scope of work was completed.

The benefits resulting from this CRADA are that we are positioned to do follow-on work in this field with PG&E or other partners.

Subject Inventions: none.