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IMPERIAL VALLEY ENVIRONMENTAL PROJECT: PROGRESS REPORT

MASTER

Editors: Paul L. Phelps and Lynn R. Anspaugh

October 19, 1976

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Imperial Valley Environmental Project

Abstract

IMPERIAL VALLEY ENVIRONMENTAL PROJECT: PROGRESS REPORT

Abstract

The Imperial Valley Environmental Project (IVEP) was initiated by the Assistant Administrator for Environment and Safety, Energy Research and Development Administration (ERDA), to establish an environmental data baseline for the Imperial Valley and to assess the potential environment impact of future geothermal installations in the Valley. The Lawrence Livermore Laboratory (LLL) was requested by the Assistant Administrator for Environment and Safety to be the Lead Laboratory to set up and manage the environmental baseline program.

An integrated project (IVEP) was organized and consists of seven main elements:

- Air Quality
- Water Quality
- Ecosystem Quality
- Subsidence and Seismicity
- Socioeconomic Effects
- Health Effects
- Integrated Assessment

A summary of the progress in these areas during the first year of this project is presented.

**Imperial Valley Environmental Project
Summary**

Summary

AIR QUALITY

One of the potentially important impacts of large-scale development of geothermal resources within the Imperial Valley is degradation of air quality. Nearly all geothermal development schemes will release noncondensable gases to the atmosphere. These gases may contain H_2S and NH_3 .

A network consisting of six fixed-location air-quality and meteorological monitoring stations is currently being installed in the Imperial Valley. They will be used to measure current levels of selected air pollutants and to characterize the atmospheric transport properties on a Valley-wide basis.

A major goal of the air quality element has been to evaluate the rate of emission of H_2S , CO_2 , H_2 , N_2 , CH_4 , and C_2H_6 from the operation of the San Diego Gas and Electric (SDGE)/Energy Research and Development Administration (ERDA) geothermal loop experimental facility at Niland. Source-term measurements have been made on a routine basis. Concentrations of H_2S have been found to vary between 1500 to 4900 ppm by volume at the Niland facility.

Ambient baseline data and source-term information are being gathered

and will be eventually used in atmospheric transport models to predict the annual average change in air quality throughout the entire Valley resulting from the operation of postulated geothermal power plants situated anywhere within the Valley.

WATER QUALITY

Development of geothermal resources in the Imperial Valley carries with it the possibility of contaminating surface and subsurface waters by geothermal brines. This could happen from injection into the ground of spent geothermal brines or by accidental releases. Because these brines are moderately to highly saline, the major effect would be an increase in salinity. A problem exists in differentiating any such contamination, because the surface water used in the Imperial Valley is rather highly mineralized from the Colorado River, and the agricultural practices used result in leaching of salts from the soils. It is conceivable that transient increases of salinity in drainage water resulting from agricultural practices could be confused with geothermal contamination.

To distinguish between geothermal fluids and other waters, extensive

sampling networks have been established. Samples are being routinely collected and chemical analysis performed. The sampling program is both Valley-wide and site-specific. A complete sampling network has been established at the Niland test facility. Recently sampling has also begun in the three other major geothermal areas in the Imperial Valley: North Brawley, Heber, and East Mesa.

A significant achievement has been the discovery of an apparent "fingerprint" for water contaminated by geothermal brine. Work to-date at the Niland site has compared irrigation water, irrigation drain water, and Salton Sea water. These have somewhat similar characteristics, though the drain water and Salton Sea water are progressively enriched in sodium chloride relative to the irrigation source water. The analysis of geothermal brine shows a strikingly different compositional profile, being high in K relative to Na, and very low in SO_4 relative to surface waters. The brine also contains significant quantities of Li, an element so unusual in ordinary water that it is used as a tracer in groundwater studies. The brines are also high in Mn and Zn.

In the process of sampling, a sump was encountered containing water with very high electrical conductance. The sump (Sump 116) was located near

the Sinclair #4 pond on Boyle Road. It was determined that the sump accumulates water from a tile system draining a nearby field. Analysis of the water indicated the pattern of elements to be anomalous relative to the normal surface water. A substantial amount of Li in the surface water strongly suggests an admixture of geothermal brine. In addition, the sample showed a low Na/K ratio, high Mn and Zn, and low SO_4 , a pattern fitting almost exactly that of geothermal brines. Evidence suggests that the old geothermal holding pond is leaking into the drainage system of Sump 116. Although these data strongly suggest a definite relationship between geothermal brines and brine-contaminated surface water, it should be noted that this is a limited observation and awaits further verification.

SUBSIDENCE AND SEISMICITY

Any significant subsidence or seismic activity that might be induced by geothermal activity, primarily the production and injection of geothermal brines into the formation, would engender serious environmental concern in the Imperial Valley community. The detection of such earth movements in the presence of a high level of naturally occurring ground-surface subsidence and a degree of earthquake activity among the highest in the

United States requires careful documentation of the present levels of activity and monitoring of any incremental surface movements.

A major accomplishment has been the installation of a high-resolution subsidence-detection network in the Salton Sea geothermal field area, centered on the SDGE/ERDA geothermal test facility at Niland. This network will detect any local movement and has been tied in with the Valley-wide network.

The Imperial Valley Environmental Project (IVEP) has contracted with the California Division of Oil and Gas to take part in a resurvey of the Imperial Valley Subsidence Detection Network. Previous data from this network have indicated a 13-cm drop over a recent 2-year interval in the northern part of the Valley as compared to the mountains on either side of the Valley.

To obtain detailed seismic coverage in the Salton Sea area, the IVEP has contracted with the U.S. Geothermal Survey to install six seismometer stations. These units will be tied to the USGS regional network.

ECOSYSTEM QUALITY

Extensive baseline data are being collected on vegetation, soil, and animals. Site-specific collections have taken place on agricultural lands surrounding the Niland test facility.

A large number of soil and vegetation samples were collected by LLL and Environmental Protection Agency (EPA) teams. Currently, samples are being analyzed for trace metals.

In cooperation with the U.S. Fish and Wildlife Service and the California Department of Fish and Game, vital organs from about 100 ducks and 20 geese were sampled at the Wildlife Refuges. A smaller number of 10 other species of birds were collected. These collections were from birds shot legally by hunters and from poached birds confiscated by law enforcement officers. Elemental analyses were performed on the various tissues.

Samples in the Salton Sea area were collected. The polychete worm Neanthes, commonly called the pile-worm, is a sediment dweller and detritus converter and serves as food for every major fish in the Salton Sea. Other samples collected were the three major species of fish. All samples have been prepared for analysis of trace elements.

A network for routinely sampling agricultural products in the various Known Geothermal Resource Areas (KGRA) was established. The first samples of milk and vegetables have been collected. Trace analyses will be performed.

In the East Mesa KGRA, a team from UCLA has set up a program to sample

desert vegetation, animals, and soil. All samples are being prepared for trace elemental analysis.

Air-pollution-effects studies have been conducted in the Imperial Valley. These involved setting up a series of experiments using exposure chambers over various agricultural crops. A mixture of gases (15 CO₂: 1 H₂S: 1 CH₄: 2 N₂ parts by volume added to air) prepared to simulate postulated releases from geothermal operations was used in the exposure chambers. Initial studies were conducted with lettuce plants.

SOCIOECONOMIC EFFECTS

A major effort has gone into establishing a background of data needed to do subsequent impact assessments related to socioeconomic issues raised by geothermal developments. Three baseline-characterization reports are in press and another report has been published. These reports deal with Imperial County economic characterization, Imperial County fiscal characterization, social characterization of Imperial County, and the 1972 flow of electrical energy in California and its relationship to selected county-level-characteristic parameters.

Work on preliminary assessments is now underway based upon selected

development scenarios, system characterizations, and various models. The goal of this part of the program is to identify areas of primary concern for further study.

HEALTH EFFECTS

The Health Effects studies have not yet been implemented. Plans are currently being developed with the California Department of Health, and it is anticipated that the program will commence in FY 1977. Four major tasks are planned for the health effects studies:

- Publish a review of known source-term data and expected health effects with recommendations for needed basic research, if appropriate;
- Establish and maintain an exemplary program for reporting health statistics in Imperial County;
- Conduct studies of community response to odor pollution and perceived health effects; and
- Review occupational health programs at geothermal facilities, and examine if special health monitoring tests would be desirable.

INTEGRATED ASSESSMENT

A comprehensive report is in press; it covers the physical and biological environments of the

Imperial Valley. This report presents relevant background information on the Valley that will be required in making impact assessments of geothermal developments.

Underway are a set of geothermal energy scenarios that include power-development schedules, technology characterizations, and considerations of power-plant-siting criteria. Also a Gaussian air-pollution model has been modified for use in preliminary air-quality assessments. A crop-growth model has been developed to evaluate impacts of gases released from geothermal operations on various agricultural crops. Work has also progressed on the legal analysis of geothermal legislation and the legal aspects of water-supply utilization.

Data acquired by the measurement groups (i.e., air quality, water quality, ecosystem quality, etc.) have been entered into a data base for future retrieval and analyses. An important aspect of the Integrated Assessment element is to transfer information to government agencies, legislative bodies, and planning groups. Information on air quality is now being routinely transferred to the Air Resources Board of California. These data will be used by developers

of geothermal resources in the Imperial Valley.

REMOTE SENSING

The IVEP is currently receiving remote sensing support from EG&G, Las Vegas, Nevada. This effort has been directed for the most part at the Salton Sea, Heber, Brawley, and East Mesa KGRAs. However, large-format photography of the entire Salton Trough has been completed. Thermal and multispectral imaging has been done for several selected sites in the Salton Sea KGRA. This information will serve as background data for thermal distributions and crop conditions.

RESEARCH SUPPORT CONTRACTS

Contracts to government agencies and universities totaling over \$450,000 were let in FY 1976. Although the contracts are supported by FY 1976 funds, most of the work will actually be done in FY 1977. The contracts are distributed by IVEP elements as follows:

• Air Quality	4
• Subsidence/Seismicity	3
• Socioeconomic Effects	3
• Ecosystem Quality	<u>15</u>
Total	25

Imperial Valley Environmental Project

Introduction

Introduction

Paul L. Phelps

A geothermal loop experimental facility in the Imperial Valley, jointly sponsored by the San Diego Gas and Electric Company (SDGE) and the Energy Research and Development Administration (ERDA) resulted in ERDA sponsoring a program to establish an environmental data baseline for the Imperial Valley and to assess the potential environmental impact of future geothermal installations in the Valley. The Lawrence Livermore Laboratory (LLL) at the request of the Assistant Administrator for Environment and Safety of ERDA was appointed the Lead Laboratory to set up and manage an environmental baseline program. Subsequently, the Imperial Valley Environmental Project (IVEP) was established.

This progress report represents a summary of the goals and accomplishments of the IVEP. This report covers approximately the first year of field work in the Valley and should prove useful to developers and planners engaged in activities related to the development of geothermal resources in the Imperial Valley and elsewhere. While the progress report does contain a good deal of technical detail, it is not intended as a substitute for complete in-depth reports that are

forthcoming from the various IVEP elements.

Efforts in the first year centered on development of a comprehensive plan and its initial implementation. This resulted in the following accomplishments:

- Completed detailed plans for all IVEP elements, except for Health Effects;
- Identified IVEP participants and established functional relationships;
- Negotiated over 30 contracts with various government agencies, universities, and private concerns;
- Specified and purchased complex instrumentation for field systems;
- Established protocols for conducting environmental baseline measurements and sample collections;
- Began installation of field stations for long-term environmental sampling;
- Began conducting source-term measurements, field-baseline measurements, and sample collections;
- Planned and initiated high priority environmental effects studies;
- Wrote a comprehensive report to describe the existing physical and biological environment of Imperial Valley;

- Developed preliminary geothermal scenarios for Imperial Valley; and
- Established an Advisory Panel to review the IVEP plans and results.

The IVEP is a long-term effort to acquire complete understanding of the environmental quality in the Imperial Valley of California prior to any major geothermal developments. The purpose of this project is to ensure that the development of geothermal resources proceeds on an environmentally sound basis. Consequently, the Imperial Valley Environmental Project is committed to an intensive and comprehensive study for the establishment of an environmental baseline for the Imperial Valley as well as an understanding of the possible effects upon the environment that may be associated with the development of geothermal resources.

The IVEP is an integrated project bringing together under a single management (see Fig. 1) all areas of expertise needed to cover the significant issues and concerns. The areas of expertise are represented by the following sections:

- Air Quality,
- Water Quality,
- Ecosystem Quality (soil, plants, animals, etc.),
- Subsidence and Seismicity,
- Health Effects,
- Socioeconomics, and
- Integrated Assessment.

A strong thrust of the project is to integrate the output of the various studies into a single overall assessment. This includes not only the data obtained from the Lawrence Livermore Laboratory studies but input from all other identifiable programs as well. To this end, the Imperial Valley Environmental Project has developed a data base from information available through a number of studies relating to the long-term environmental assessment of the Imperial Valley. The Lawrence Livermore Laboratory is working closely with a number of universities and various federal, state, and county agencies and other groups to obtain the needed information. These efforts are in part funded by the Imperial Valley Environmental Project. Also, a great deal of cooperation with various other public groups has been achieved, and their programs in some cases have been reoriented to assist on problems specific to the development of geothermal resources in Imperial Valley. A summary of the participants is given in Table 1.

Several measures are being taken to assure quality of performance and accuracy of data from the IVEP. Among these are:

- Establishment of an Advisory Panel made up of members from many significant sectors concerned with geothermal development. The

Project Organization
Imperial Valley Environmental Project
LLL Lead Laboratory

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Fig. 1. Project organization of the Imperial Valley Environmental Project.

- membership is listed under "Advisory Panel" of this report.
- Interchanging of environmental samples and standards with other laboratories and comparing results obtained by various analytical methods.
- Use of approved laboratories for elemental analysis, i.e., water samples are done by state certified laboratories.
- Calibration of instruments and standards by the California Air and Industrial Hygiene Laboratory.

Table 1. IVEP Participants. Participants in the IVEP have been drawn from various county, state, and federal government agencies, universities and ERDA contract laboratories, geothermal developers, and utility companies. Involvement in the IVEP by individuals from these groups started in the early planning phases of the project. The level of participation has ranged from that of an advisor to taking a lead part in field and laboratory studies.

Imperial County	Department of Public Works Air Pollution Control District Planning Department Department of Health
State of California	Energy Resources Conservation and Development Commission Air Resources Board Water Resources Control Board Department of Health Department of Fish and Game
Federal	Environmental Protection Agency Fish and Wildlife Service Geological Survey Department of Agriculture National Science Foundation Bureau of Reclamation Bureau of Land Management
Universities, ERDA labs, others	California Institute of Technology St. Mary's College, Moraga University of California Battelle Pacific Northwest Laboratory Brookhaven National Laboratory E.G. & G. Electric Power Research Institute Jet Propulsion Laboratory Pomona College Arizona State University California State University, Hayward North Carolina Central University
Developers	Chevron, USA, Inc. Imperial Magma Corporation Union Oil Company of California Republic Geothermal, Inc.
Utilities	San Diego Gas & Electric Company Southern California Edison Company Imperial Irrigation District

- Calibration checks of field air quality systems by the Environmental Protection Agency.
- Periodic peer review by ERDA staff and technical consultants.

A few changes have taken place in the IVEP management structure. The Socioeconomics Effects element was previously under the direction of K. F. Haven, who since has left LLL. C. H. Hall is now responsible for this element. T. D. Palmer has also resigned his position at LLL. Currently his vacancy in the Contracts Administration and Remote Sensing element has not been filled.

D. W. Layton is now in charge of the

Integrated Assessment element, replacing R. L. Ritschard, former leader for the Integrated Assessment element, and L. R. Anspaugh, former acting element leader.

Financial support for the IVEP is from the Assistant Administrator for Environment and Safety of the Energy Research and Development Administration. A major focal point for the IVEP is the Division of Technology Overview, Office of Environment and Safety. Field liaison to ERDA is maintained through the ERDA San Francisco Operations Office. These relationships are shown in Fig. 2.

Fig. 2. Relationship of the Imperial Valley Environmental Project (IVEP) to the U.S. Energy Research and Development Administration. The IVEP is under the auspices of the Assistant Administrator for Environment and Safety of ERDA. Close coordination exists between the Geothermal Technology and Environmental groups. Names indicated are principal contacts.

Imperial Valley Environmental Project (IVEP) Elements

IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Air Quality

AIR QUALITY

Paul H. Gudiksen

Introduction

One of the potentially important impacts of large-scale development of geothermal resources within the Imperial Valley is the degradation of air quality. Nearly all geothermal development schemes will release non-condensable gases to the atmosphere. The principal constituent of the non-condensable fraction is CO_2 , but lesser amounts of H_2S , H_2 , CH_4 , NH_3 , and N_2 are generally present as well. To assess this impact, the objectives of the Air Quality Program are to:

- Measure the current levels of selected air pollutants at various locations within the Imperial Valley;
- Characterize the atmospheric transport properties on a Valley-wide basis by measuring specific meteorological parameters at several locations;
- Characterize the concentrations of specific pollutants in the vicinity of specialized sources connected with geothermal operations and agricultural activities;
- Evaluate the rate of emissions of selected pollutants from geothermal operations;
- Measure the transport of pollutants across the northern and southern boundaries of the Valley; and
- Utilize the above data in our atmospheric transport models to predict the annual average change in air quality throughout the entire valley resulting from the operation of postulated geothermal power plants situated anywhere within the Valley.

To accomplish these objectives we have established a multidisciplinary program that requires the combined efforts of many investigators from several laboratories. The first three objectives are being addressed by the installation of six fixed-location air-quality and meteorological-monitoring stations in the Imperial Valley and the utilization of a mobile air-quality laboratory for site-specific measurements. The monitoring systems are being assembled and fielded by LLL personnel with support from the State of California Air and Industrial Hygiene Laboratory and Air Resources Board. The Imperial Valley Air Pollution Control District will supply additional manpower to assist in the normal operation of the stations. Particulate sampling and analyses will be performed by investigators from the University of California at Davis, Rockwell International, Brookhaven National Laboratory, and Lawrence Livermore Laboratory (LLL). The U.S. Environmental Protection

Agency (EPA) (Las Vegas) will be responsible for the conduct of the quality assurance program for the ambient-air gas analyses. The EPA will also supplement our program by making additional air-quality measurements in specific areas. In addition, airborne measurements made by EG&G, Inc. will provide vertical profiles of pollutant concentrations. The evaluation of the emissions of pollutants also draws upon the talents of investigators from several laboratories. Measurements of specific chemical species in the noncondensable gases emitted by geothermal operations will be performed by personnel from the Battelle Pacific Northwest Laboratories, LFE Environmental Analysis Laboratories, U.S. EPA (Las Vegas), and LLL. The final objective will be to utilize these data as input to atmospheric transport models for the prediction of the impact of geothermal operations on the Valley's air quality. This will be performed at LLL using advanced three-dimensional transport models.

Fixed Air-Quality and Meteorological Monitoring Stations

We are currently in the process of installing the six stations within the Valley. Each station will provide measurements of wind speed, wind direction, temperature, relative humidity, and the concentration of

H_2S , SO_2 , O_3 , CO_2 , and particles. In addition, three of the stations will be equipped with the capability to measure the concentrations of NO , NO_2 , and NO_x .

The sites where the six air-quality stations will be situated are shown in Fig. 1. The selection of these sites was based on the most likely geothermal source points, the expected current ambient-air-pollutant levels, the distribution of population centers, and meteorological considerations. Two sites (Nos. 1 and 5) were chosen near the south end of the Salton Sea to define the flow entering into or exiting out of the north end of the Valley. Site No. 1 is situated about 1 km northwest of the San Diego Gas and Electric Company's (SDG&E) Geothermal Loop Experimental Facility near Niland. Similarly two sites are located near the southern border at the Heber and East Mesa KGRAs (Known Geothermal Resource Area) to evaluate the flow of pollutants across the southern boundary. Another site is situated slightly north of Brawley on a Union Oil Company lease where future geothermal development is expected. The latter represents a recent change in location that was requested by the Union Oil Company. The remaining site was selected within the city of Imperial to provide coverage for the central section of the Valley.

Fig. 1. Map of Imperial Valley showing the location of the air-quality stations.

The air-quality station at Site No. 1 has been operating since June 1976. It has provided data on the ambient-air concentrations of H_2S , SO_2 , and O_3 as well as wind speed, wind direction, temperature, and relative humidity. An additional four stations have been shipped to the Imperial Valley. Two of these have been installed at the East Mesa and Heber sites (Nos. 4 and 3, respectively). At the Brawley Site (No. 6) we are waiting for the installation of commercial power by the Union Oil Company so that we can install our monitoring system. We are also setting up Station No. 5 at the southwest corner of the Salton Sea, but unfortunately that unit was severely damaged during commercial shipping from LLL to the Imperial Valley and requires major repair work. The remaining Station No. 2 is waiting at LLL for delivery of additional parts.

We expect to have Stations 1, 3, and 4 operating during November 1976 and the remaining stations on line by the end of CY 1976. This does represent a departure from our earlier estimates because of unexpected delays in parts and equipment deliveries as well as the severe damage incurred by Station No. 5 during transit. In addition, the installation of commercial power at various sites has taken

longer than expected because of increased workloads for the linemen caused by the occurrence of unusual rain storms. This inclement weather has also slowed our field activities.

Each station consists of an air-conditioned trailer, housing the air-quality instruments and the data-processing and recording systems. Five of the stations are also equipped with 10-m instrumented meteorological towers. The Heber Site No. 3 contains a 60-m tower, instrumented at 2 levels and erected by the San Diego Gas and Electric Company (SDG&E) under Electric Power Research Institute (EPRI) funding. Each station has the capability of measuring O_3 , SO_2 , H_2S , and CO_2 , while three stations will also be capable of measuring NO , NO_2 , and NO_x . A Hi-Vol sampler is mounted on the roof of each trailer for mass-loading measurements. In addition, a three-stage impactor is included in each station to collect samples for elemental analysis of particles. Meteorological measurements at each station include wind velocity, temperature, and relative humidity. Solar radiation and visibility measurements will be made at one station. An acoustic sounder will also be employed for inversion-height determinations.

A photograph of a typical station with a trailer and a 10-m tower in

the background is shown in Fig. 2. Table 1 provides a listing of the air-quality and meteorological sensors utilized in the program. Figure 3 is a schematic diagram of a typical station. Air is drawn in at a height of 5 m through a glass and Teflon sample train leading to the air-quality instruments. The outputs from these instruments are fed into a digital cassette-tape-recording system that was designed and built

Fig. 2. Exterior view of an air-quality station showing the trailer and the 10-m meteorological tower.

at LLL. This unit contains 32 channels and features dual recorders. When recording the data in all channels at 15-min intervals, the system can accumulate data for 1 month without changing cassettes. This data-logging system also includes signal conditioning for the meteorological sensors. All signals are normally averaged over 15-min periods. Peak values of all air-quality measurements are also recorded. Data in selected channels are recorded by two 6-channel strip-chart recorders. This serves as a back-up to the tape systems and provides a means for evaluating instrument performance in the field. The instruments are mounted on a dual rack as shown in Fig. 4.

The tape cassettes are being collected on a weekly basis for transport to LLL where the data can be extracted by a minicomputer to produce an IBM-compatible nine-track tape. This tape can then be used as a transfer medium to the LLL computer system for data analysis. The hardware and software for this transfer mechanism are currently available. The software development for the data analysis is presently underway.

Mobile Air-Quality Laboratory

To supplement the fixed stations for specialized studies, a mobile air-quality field laboratory is under

Table 1. Air-quality and meteorological instrumentation used in a typical air-quality station.

Parameter	Instrument	Air quality	
		Measurement technique	Lower limit of sensitivity (ppmv) ^a
H ₂ S	Houston Atlas Model 825R	Colorimetry (lead acetate tape)	0.005
SO ₂	Thermo Electron Model 43	Pulsed UV fluorescence	0.005
O ₃	Dasibi Model 1003AH	UV Absorption photometry	0.003
NO, NO ₂ , NO _x	Thermo Electron Model 14D	Chemiluminescence	0.0005
CO ₂	Horiba Model PIR-2000	Nondispersive infrared spectrometry	5
Particles	Sierra Multiday Impactor Model 46206		

Meteorology

<u>Parameter</u>	<u>Sensor</u>
Wind direction	Climet wind vane with sin-cos potentiometer.
Wind speed	TechEcology 010 cup anemometers. Climet WS-011-1 cup anemometers.
Temperature	Climet 015-13 thermistors.
Humidity	WeatherMeasure HM111-P polymer thin-film capacitor.
Solar radiation	Eppley pyranometer.
Visibility	MRI 1550B Nephelometer.

^a Parts per million by volume.

Fig. 3. Schematic diagram of a typical air-quality station.

construction. Initially this unit will have the capability for making the air-quality and meteorological measurements shown in Table 2. It is anticipated that this capability will be expanded to include an analytical chemistry laboratory for performing a variety of source measurements. Real-time processing of data

will be possible with the addition of a minicomputer with disk file, magnetic-tape storage, graphics, printer, and plotter.

We selected the GMC Transmod mobile-home chassis as the base for the mobile laboratory because of its excellent road handling capabilities and a suspension system that

Fig. 4. An interior view of an air-quality station.

minimizes the shocks and vibrations to the instruments. Its interior finishing, including insulation, has just been completed. The instrument rack housing the analyzers is being installed and a 10-m fold-down meteorological tower is available for installation. This unit should be available for making the measurements shown in Table 2 by July 1977 without the real-time data-processing capability. It will take several additional months to develop the software for interfacing the minicomputer.

Gas Calibration Systems

To calibrate the air-quality instruments in the laboratory and in the field, it was necessary to construct two gas-calibration systems that will deliver gas streams containing known concentrations of test gases. These systems operate on the dilution principle. Cylinders containing gases in relatively high concentrations (1 to 50 ppmv) are diluted very accurately with clean air, referred to as zero air. One of

Table 2. Mobile air-quality laboratory capabilities.

Air quality	Meteorology
H_2S	Wind speed
SO_2	Wind direction
Total sulfur	Temperature
O_3	Relative humidity
NO	Solar radiation
NO_2	
NO_x	
CO	
CO_2	
CH_4	
Total hydrocarbons	
NH_3	
Particles	

these calibrators is a flexible, wide-range laboratory system for initial calibration of newly acquired instruments and recalibration of instruments returned from the field. A schematic diagram of the system is shown in Fig. 5. The zero-air system is a major component of the calibrator. Room air is passed through a series of filters, converters, and reagent beds to remove trace gases in the air stream to produce the zero air. The concentrated span gas, whose concentration is accurately known, is blended with zero air in a Teflon mixing chamber. The ratio of span gas to zero air can be accurately regulated by a combination of pressure and flow regulators and calibrated rotameters. Thus, it is possible to deliver a stream of air whose concentration of pollutant gas is accurately known and that can be varied to calibrate all ranges of the instruments. A photograph of this system is shown in Fig. 6 and is operable at this time.

For routine calibration of instruments within the air-quality stations, a field calibrator has been built. It is similar to the laboratory calibrator with appropriate modification for field adaptation. It is mounted on the bed of a pick-up truck, enabling us to deliver the calibration gas directly to the sample intake on the roof of the air-quality station.

The accuracy of these calibrators is being independently verified by the State of California Air and Industrial Hygiene Laboratory, Berkeley, California, under contract to this program. The cost of the contract is \$25,000. The scope of the work includes the calibration of the span-gas cylinders, the air-quality instruments, and the output of these calibrators. It also includes an audit of the entire operation of the six stations. In addition, the U.S. EPA (Las Vegas) will be responsible for the conduct of a systematic quality-assurance program, ensuring that valid data will be generated by the air-quality sensors. This service will be provided at no cost to this program.

These calibrators do not include an ozone-generation capability. The State of California Air Resources Board is currently calibrating our ozone analyzers on a cooperative basis.

Instrument Development

Since no commercial instrument is currently available that is capable of low-level ammonia measurements, L. Hrubesh at LLL is developing an ammonia monitor for our studies. It is based on the principle of the absorption of microwaves by rotating NH_3 molecules in their vapor phase. The absorption process is quantized,

Fig. 5. A schematic diagram of the gas-calibration system for laboratory use.

Fig. 6. A view of the gas-calibration system. The zero-air system may be seen on the left, the mixing manifold in the center, and an air-quality instrument on the right.

giving rise to a sharp resonance line. The sharpness of this line, coupled with the generation of very narrow-band-microwave radiation that is tunable to exact coincidence with the peak, provides high resolution for detecting ammonia without interference in an ambient-air mixture.

The analytical capability of this technique, not only for ammonia but for many other gases as well, has been well established as microwave

rotational spectroscopy. This technique has been used at LLL for the analysis of gases for nearly a decade. These are large laboratory instruments, but small, reliable, portable instruments based on this technique are needed for field measurements. Our development objective is to make a field-usable instrument specifically for ammonia gas. The microwave sources are solid-state oscillators that require little power and are

quite amenable to portable instrumentation, but they are too unstable with regard to frequency to stay on the peak of the ammonia absorption for the long periods required as a monitor. To solve this problem we have developed an automatic stabilization scheme that locks the microwave oscillator to the line peak, ensuring long-term accuracy for the ammonia measurement. The concept has been fully proved in a breadboard model.

In another breadboard model, as little as 50 ppbv ammonia in air has been detected by the microwave-absorption method. Additional sensitivity, extending the sensitivity to below 1 ppbv can be obtained by concentrating the sample with a material that can trap ammonia from an ambient flow, then release it upon heating for detection by the monitor. A device that automatically controls the trapping procedure and records the ammonia signal has already been developed and is under test. We expect to have a fully operational unit by February 1977.

Ambient-Air Measurements

Station No. 1 near the SDG&E facility has provided us with data on the ambient-air concentrations of H_2S , SO_2 , and O_3 as well as wind speed, wind direction, temperature, and relative humidity since June 1976.

The concentrations of these species are extremely low within the northern end of the Valley. The concentrations of H_2S generally average about $0.005 \pm 100\%$ ppmv, the lower limit of sensitivity of our instruments. Periodic excursions up to 0.02 to 0.03 ppmv have been measured. The causes of these excursions are not clear at this time, but may possibly be a result of nearby agricultural fertilizer applications. The SO_2 concentrations are also low, averaging about $0.005 \pm 100\%$ ppmv, the lower sensitivity of the instrument. Ozone concentrations, on the other hand, vary between 0.01 to 0.05 ppmv with maximum of 0.1 ppmv occurring occasionally. These values agree well with those measured by the State of California Air Resources Board Mobile Monitoring Unit at an adjacent site from January through March 1976. A summary of their data is given in Table 3. In addition, personnel from the U.S. Environmental Protection Agency (Las Vegas) have measured H_2S and SO_2 concentrations from July through September 1976 at the U.S. Bureau of Reclamation facility at East Mesa, at the town of Niland, and at a site approximately 2 km south of the SDG&E facility. All of their measurements provided values less than the detection limit of the flame-photometric detector (0.005 ppmv) with the exception of a few values that reached a maximum

Table 3. Summary of the air-monitoring data from the State of California Air Resources Board Mobile Unit.

Species	Units	Monitoring period	No. of measure- ments	Hourly concentrations		Average hourly concentration	Average maxi- mum hourly concentration	State of California and/or federal standard
				Low	High			
O ₃	ppmv	Jan 6-Mar 15, 1976	1393	0	0.10	0.02	0.04	0.08 (1 hr)
CO	ppmv	Jan 8-Mar 15, 1976	1367	0	2	0.1	0.3	35 (1 hr)
NO	ppmv	Jan 6-Mar 15, 1976	1647	0	0.09	<.01	0.02	
NO ₂	ppmv	Jan 6-Mar 15, 1976	1674	0	0.09	0.01	0.02	0.25 (1 hr)
NO _x	ppmv	Jan 6-Mar 15, 1976	1647	0	0.11	0.02	0.04	
TS	ppmv	Feb 25-Mar 15, 1976	437	0	0.03	<.01	<.01	
H ₂ S	ppmv	Feb 11-Mar 15, 1976	552	0	0	0	0	0.03 (1 hr)
SO ₂	ppmv	Feb 11-Mar 15, 1976	730	0	0	0	0	
THC	ppmv	Jan 8-Mar 15, 1976	1367	1.4	5.1	1.9	2.8	0.5 (1 hr)
CH ₄	ppmv	Jan 8-Mar 15, 1976	1367	1.4	5.1	1.9	2.7	
NMHC ^a	ppmv	Jan 8-Mar 15, 1976	1367	0	1.1	<.1	0.1	0.24 (3 hr)
TSP	µg/m ³	Jan 10-Mar 13, 1976	10	37	124	85		100 (24 hr)

^a Nonmethane hydrocarbons.

of 0.05 ppmv H_2S at the East Mesa facility when the measuring point was directly downwind from a geothermal-well operation. These contributions by the Air Resources Board and the Environmental Protection Agency were performed on a cooperative basis at no cost to this program. Such measurements were extremely useful during our start-up time.

We have also collected several particulate-filter samples at various locations within the Valley. Analyses of these filters by neutron activation, x-ray fluorescence, and atomic absorption reveal the presence of the following elements: Li, Na, Mg, Al, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Br, Rb, Sr, Y, Zr, Mo, Ba, La, Ce, Nd, Pb, U, and Th.

Source Measurements

Part of our effort has been directed toward measuring the noncondensable-gas emissions from the SGD&E Geothermal Loop Experimental Facility near Niland. The facility processes the high-salinity geothermal fluids from deep wells by flashing hot water under pressure into steam in four progressively lower-pressure stages. The separated steam is scrubbed and subsequently condensed in heat exchangers where it heats a secondary fluid in a closed

cycle system. The noncondensable gases present in the steam fraction are vented to the atmosphere through a 130-ft-tall stack, while the brine is returned to the geothermal reservoir by injection via another well. The noncondensable gas fraction was expected to consist primarily of CO_2 and lesser amounts of other chemical species, with H_2S being the pollutant of primary interest from an environmental viewpoint.

Sampling and analysis of geothermal fluids are fraught with much difficulty because of high temperatures and pressures as well as the multiplicity of complex chemical reactions that may occur within the sampling train. The laboratories involved in this part of the program are: the Battelle Pacific Northwest Laboratory (BNWL), the LFE Environmental Analysis Laboratories (LFE), the U.S. Environmental Protection Agency in Las Vegas (EPA), and the Lawrence Livermore Laboratory (LLL). The chemical species of interest and the measurements made by each laboratory are given in Table 4. Considerable duplication of effort exists among the laboratories. This is specifically designed into the program because of the variety of analytical techniques that will be employed. A number of samples will be collected simultaneously for intercomparison

Table 4. The chemical species that will be measured by each laboratory in the noncondensable gas emissions from the SDG&E facility.

Chemical species	LLL	LFE	BNWL	EPA
Hydrogen sulfide	X	X	X	
Ammonia	X	X	X	
Carbon dioxide	X	X		
Boron	X	X		
Fluorides	X	X	X	
Mercaptans	X			
Hydrogen	X			
Nitrogen	X			
Total hydrocarbons	X	X	X	
Methane	X	X	X	
Mercury			X	
Arsenic			X	
Selenium			X	
Radon		X		X
Particles		X		

studies. A summary of most of the analytical techniques for each chemical species is shown in Table 5.

Unfortunately, this effort has not yet yielded a large number of results. The operating characteristics of the SDG&E facility have been most erratic since the June 1976 start-up. Furthermore, on several occasions when we attempted to sample the noncondensable emissions, the gas stream was significantly contaminated with water and brine; this caused extreme analytical difficulties. Thus, only a few measurements have been made.

These were made by LLL chemists who were operating the LLL Total Flow System adjacent to the SDG&E facility. These two facilities are operating on the same well. Table 6 shows the range of concentrations of several chemical species that were measured. All of the H_2S measurements were made in the noncondensable emissions vented from the SDG&E facility, while the CO_2 , H_2 , N_2 , CH_4 , and C_2H_6 concentrations summarize measurements in the SDG&E and the Total Flow System noncondensable emissions. It should be valid to combine these

Table 5. The analytical techniques used in the geothermal source measurements.

Chemical species	Analytical techniques
Hydrogen sulfide	Electrolytic oxidation, specific ion electrode, flame photometry, lead acetate tape.
Ammonia	Microwave spectrometry, specific ion electrode.
Carbon dioxide	Mass spectrometry, gas chromatography.
Boron	Specific ion electrode.
Fluorides	Specific ion electrode.
Mercaptans	Microwave spectrometry.
Hydrogen	Mass spectrometry.
Nitrogen	Mass spectrometry.
Methane	Mass spectrometry, gas chromatography.
Mercury	Atomic absorption.
Arsenic	DC plasma discharge.
Selenium	DC plasma discharge.
Radon	Thermoluminiscent detection, alpha counting.
Particles	X-ray fluorescence, atomic absorption.

data because the same geothermal well was tapped. The H_2S concentrations vary by at least a factor of 3, from 1500 to 4900 ppmv. As expected, about 96 to 98% of the noncondensable gas is CO_2 . The contributions by H_2 , N_2 , CH_4 , and C_2H_6 are generally less than 1%.

We will conduct more detailed analyses as soon as the SDG&E facility becomes more operable. In addition, similar measurements will be made at

the U.S. Bureau of Reclamation East Mesa facility, Union Oil geothermal test operations near Brawley, and at other sites that become operable during the period of this program.

Airborne-Particle Studies

The sampling and analyses of airborne particles will be performed by investigators at the University of California at Davis under contract to LLL. The cost of the contract is

Table 6. Concentrations of various chemical species measured in the noncondensable emissions by LLL.

Species	No. of measurements	Concentration (by volume)
H ₂ S ^a	11	1500 - 4900 ppmv
CO ₂ ^b	4	96 - 98%
H ₂ ^b	4	<0.05 - 0.34%
N ₂ ^b	4	0.2 - 0.7%
CH ₄ ^b	4	0.5 - 1.4%
C ₂ H ₆ ^b	4	<0.03%

^a The H₂S analyses were performed by an electrolytic oxidation technique at the sampling site immediately after sample collection.

^b These analyses were performed by mass spectrometry at LLL.

\$100,000. The tasks include the following:

- Continuous monitoring of particles at the six air-quality stations. The particles will be collected by impaction in three size groups. These are 0.1 to 0.6 μ m, 0.6 to 3.6 μ m, and 3.6 to 20 μ m. Elemental analyses will be performed by ion-induced x-ray fluorescence. These data will form the basis for the statistical analyses of gas and particle correlations.
- Characterization of the elemental distributions in particles in

source-enriched areas near geothermal operations, feed lots, agricultural burning, fertilizer operations, as well as in particles transported across the southern border, etc.

The continuous monitoring at the fixed stations will be initiated during February 1977, while studies on the transport of particles across the border will begin during October 1976.

The characterization of particles in source-enriched areas requires the development of portable sampling instrumentation that will perform particle-size separation between coarse and fine particles at low cost while delivering samples suitable for gravimetric and elemental determinations. Thus, the U.C. Davis investigators designed and built a two-stage stacked-filter unit for this purpose. This device uses two Nuclepore filters in series to effect separation of coarse and fine particles with a cut point at about 3 μ m aerodynamic diameter. The unit was tested and provided sharp separation between coarse and fine particles as indicated by elemental composition and confirmed by impactor studies. Table 7 illustrates the behavior of the stacked filter unit in this test. The unit, including pump, intake manifold, and support weighs less than 20 lb and costs less than \$100. Eight such units are being built for this program.

Table 7. Elemental composition of coarse and fine particles as separated by a stacked filter unit.

	Elements measured (assumed source)			
	Al, Si, CA, Fe (Soil)	Na, Cl (Ocean)	S	Br, Pb (Autos)
Coarse	91%	75%	< 4%	20%
Fine	9%	25%	96%	80%

In addition to these studies, we will also collect regular 24-hr Hi-Vol samples at each of the six stations for mass-loading determinations. Rockwell International will perform these analyses under a \$1720 contract.

We also expect to acquire a virtual impactor with a cut point of about 2 μ m aerodynamic diameter for a more detailed investigation of sulfur speciation in the small size fraction. Investigators from Brookhaven National Laboratory and LLL will perform the analyses on a limited number of samples.

Atmospheric Transport Modeling

To develop a predictive capability for estimating the impact on air quality resulting from the development of a given geothermal-resource region, it is necessary to resort to modeling techniques. This will be accomplished with the use of LLL advanced three-dimensional flow models. These models utilize regional

topography and measured wind information to produce interpolated and extrapolated wind fields on an Eulerian grid superimposed over the topography. The wind fields are then adjusted for mass consistency to eliminate artificial convergences and divergences. These flow fields are then used as input to either the three-dimensional advection-diffusion particle-in-cell code (ADPIC), the two-dimensional coupled-transport-kinetics code (LIRAQ), or the three-dimensional reactive-plume model.

The particle-in-cell code is a numerical, three-dimensional, Cartesian, particle-diffusion code capable of computing the time-dependent dispersion of air pollutants under various conditions, including distorted advection fields, calm conditions, and complex topography. The code solves the three-dimensional advection-diffusion equation by the pseudo-velocity technique for a given mass-consistent wind field. This

code is currently operational at LLL. The LIRAQ code also utilizes numerical techniques to solve the advection-diffusion equation and the effects of photochemistry. Using the time-dependent transport parameters in the two horizontal dimensions and a prescribed set of chemical reactions, the code calculates the evolution and transport of a number of chemically reactive species. This code is also operational at LLL at this time. The reactive-plume model, presently under development by other programs at LLL applies the technique of fractional steps to the solution of the three-dimensional transport equation as well as incorporating chemical kinetics.

These codes have been developed specifically for assessing the impact resulting from relatively short-term releases on the order of hours to days. To simulate extended periods on the order of a year, the following two options are being explored by other programs:

- Stratify the meteorological data to reduce the amount of data required to present a 1-yr (or longer) data base without loss of informational content. This may be accomplished by categorizing the frequency and type of meteorological conditions and their order of occurrence during the period of interest.

- Reduce the running time of the code without loss of its capability for realistically simulating the major transport properties. This may be accomplished by removing some of the sophisticated options that are not needed for the long-term assessment problems.

We have not yet initiated any effort directly related to the Imperial Valley Environmental Program in the modeling area. However, this work should commence during the coming months when the air-quality field program becomes fully operational.

Summary

The objective of the program is to predict the potential change in air quality within the Imperial Valley resulting from the possible development of geothermal resources. Thus, the program has been designed to characterize the current state of the atmosphere of the Valley from an air-quality point of view and to measure the atmospheric transport properties on a Valley-wide basis. This will be accomplished by the fielding of six fixed-location air-quality and meteorological stations and a mobile laboratory to make measurements of gaseous and particulate pollutants. Geothermal source emissions of non-condensable gases are also being measured. These data may then serve

as input to our atmospheric transport models to predict the potential changes in air quality resulting from the operation of an array of postulated geothermal power plants.

We are currently installing the six air-quality stations in the Valley. The Niland station (No. 1) became operational during June 1976. Three stations will be operable during November 1976 with the remainder going on-line toward the end of CY 1976. The mobile laboratory will become available for air-quality measurements by July 1977. Geothermal-source measurements at the SDG&E facility at Niland are underway with similar measurements to be made at the East Mesa KGRA as well as other sites where geothermal development may occur during the duration of the program. The atmospheric modeling, utilizing existing three-dimensional LLL transport models, will be performed during 1977 and 1978.

The State of California Air Resources Board diverted their mobile air-quality laboratory during January to March 1976 to the northern part of the Imperial Valley to support this program. Their data, summarized in Table 3, show that the concentrations of gaseous pollutants are generally low, while particulate loading is fairly high. Measurements of H_2S , SO_2 , and O_3 have also been made by our fixed air-quality station near

Niland (No. 1) since June 1976. Its data agree well with those of Table 3. Similarly, the U.S. Environmental Protection Agency (Las Vegas) has confirmed that the H_2S and SO_2 concentrations within the northern part of the Valley are less than 0.005 ppmv. Measurements of H_2S concentrations made by the EPA at the East Mesa KGRA also revealed concentrations that were generally less than 0.005 ppmv except when the measuring point was directly downwind from a geothermal-well operation. At such times concentrations as high as 0.05 ppmv were detected.

Preliminary source measurements of the noncondensable gases emitted from the SDG&E facility indicate that roughly 97% is CO_2 with lesser amounts of H_2S , N_2 , H_2 , and CH_4 . The H_2S concentrations vary considerably. A range of 1500 to 4900 ppmv has been measured.

Much of the work will be performed by organizations other than LLL. A summary of the contracts let by the air quality program is given in Table 8. In addition, the Air Resources Board and the EPA will provide additional measurements periodically at no cost to this program. With in-house funding the EPA will also be responsible for conducting a quality-assurance program covering the operation of the six air-quality stations. EG&G is presently developing its

capability, with internal funds, to perform airborne measurements of selected gaseous and particulate pollutants. This capability will provide a means for obtaining vertical profiles of pollutants throughout the Valley, a

most valuable addition to the program. Sulfur speciation on particles will be investigated on a limited number of samples by investigators at Brookhaven National Laboratory and Lawrence Livermore Laboratory.

Table 8. Contracts let by the air-quality program.

Name	Organization (principal investigator)	Duration of work	Cost	Task
Particulate characterization	University of California/Davis (T.A. Cahill/ R.G. Flocchini)	10/76-4/78	\$100 K	<p>Perform elemental analyses of particle samples collected at the six fixed-location air-quality stations. The analyses will define the daily averaged elemental concentrations for each of three particle-size groups (0.1-0.65 μm, 0.65-3.6 μm, and 3.6-20 μm).</p> <p>The work will include the characterization of elemental distributions in air-borne particles as a function of particle size and time in the vicinity of specialized sources such as agricultural operations, transport across the southern border, etc.</p>
Gas calibration	State of California Air and Industrial Hygiene Lab. (E. Jeung)	9/76-10/77	\$ 25 K	Perform calibration of span-gas cylinders, gas analyzers, and LLL-constructed gas-dilution systems. Perform field audit of LLL air-quality instruments within the Imperial Valley.
Geothermal source-term measurements	LFE Environmental Analysis Lab. (A. Soinski)	6/76-12/77	\$ 15 K	Perform chemical analyses of the noncondensable emissions from geothermal operations. These analyses include the determination of hydrogen sulfide, ammonia, carbon dioxide, boron, fluorides, total hydrocarbons, methane, radon, and particles.
Mass-loading studies	Rockwell International (E. Perry)	11/76-12/77	\$1.72 K	Perform total mass measurements on filter samples collected at the six fixed stations.

Table 8 (cont.).

Name	Organization (principal investigator)	Duration of work	Cost	Task
Manpower assistance	Imperial Valley Air Pollution Control District (J. Taylor)	11/76-12/77	\$ 16 K	Provide part-time manpower to assist in the routine operation of the six fixed air-quality stations.

IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Water Quality

WATER QUALITY

Kenneth D. Pimentel and Neil B. Crow

Overview of Water Quality Study

One of the potentially significant environmental effects of geothermal development in the Imperial Valley is the possible contamination of surface waters by geothermal brines. Because these brines are moderately to highly saline, the major effect would be an increase in salinity. A problem exists in differentiating any such contamination, because the surface water used in the Imperial Valley is rather highly mineralized water from the Colorado River, and the agricultural practices result in the leaching of salts from the soils into drainage channels. It is conceivable that a transient pulse of salinity in drainage water resulting from leaching of agricultural lands could be confused with geothermal contamination. For these reasons, we are taking water samples for chemical analysis to establish baseline levels of salinity and patterns of trace-element composition. It is believed that geothermal brines have a different composition from surface water that will enable us to distinguish between the two kinds of water.

Thus far our program has concentrated on collection of grab samples

and their chemical analysis — essentially data gathering. In January 1976, we established sampling networks in the Salton Sea geothermal field area, centered on the SDG&E/ERDA Geothermal Test Facility, and collected samples on six trips before operations at the Test Facility commenced. We also have collected samples on a Valley-wide network. During the summer, grab-sampling networks were designed and field checked, and in October 1976 sampling began in the three other major geothermal areas in the Imperial Valley: North Brawley, Heber, and East Mesa. Progress has been made toward identifying a qualified contractor to perform routine chemical analyses on these samples. In November, we will finish selecting an in situ water-quality-monitoring system and will place an order for four to six units. A mobile water-quality van has been ordered and will be equipped for field use as soon as received. Task descriptions of our program are summarized in the following section. Detailed discussions of each of these tasks follow in the remaining sections.

Summary of Progress on Project Tasks

Water-Sampling Program

Valley-wide sampling program — Instituted sampling of Valley-wide network January 1976. Network was initially sampled on a 6-week basis.

Site-Specific Sampling Program -

Sampling instituted at the Salton Sea Geothermal Field area, centered on SDG&E/ERDA Geothermal Test Facility, in January 1976. The network was first sampled on a 3-week basis. Sampling networks for the North Brawley, Heber, and East Mesa KGRAs have been designed and were initiated during October 1976.

Recording Meter Network

It was decided that the recording conductivity meters being constructed at LLL early in the year would not be adequate to obtain the necessary data. Presently, commercial instrumentation to measure and record a number of water-quality parameters is being investigated, and an order for four to six units will be placed in November. The units will be used to monitor variation of water quality with time, primarily in local monitoring networks as well as in intensive studies anywhere in the Valley.

Ground-Water Monitoring

The first ground-water monitoring will take place at the East Mesa geothermal field, with samples taken from witness wells drilled by the Bureau of Reclamation near geothermal wells. A program plan for installation and sampling of monitoring wells at the Salton Sea, North Brawley, and the Heber geothermal fields is being prepared.

Full Water-Quality-Monitoring Station (Mobile)

Orders have been placed for a vehicle and equipment for this station. When the vehicle and equipment arrive, they will be moved to the Imperial Valley as soon as the mobile unit is usable. Added equipment will be installed as it is received.

Data Gathering

Data is being acquired from our own field program and from outside agencies such as the U.S. Geological Survey (USGS) Water Resources Division, the Imperial Irrigation District, and others.

Data Analysis and Storage

All available data has been placed in the IVEP data-storage and retrieval system. A program plan is in preparation to interpret data, with emphasis on pattern recognition and modeling techniques, using digitized data systems.

Imperial Valley Water-System

Modeling

A program plan is in preparation. We are investigating the feasibility of intensive study of small regions of the Imperial Valley, which may allow scaling-up of models to predict behavior of the Valley as a whole.

Salton Sea Study

Because of manpower shortage, a water quality study of the Salton Sea

is not being pursued actively. The program-plan preparation is being deferred for the present.

Chemical Support

We are establishing quality-control procedures, using standards from EPA and the USGS Water Resources Division. We are evaluating the performance of a number of candidate commercial analytical laboratories; when the results are received, we will be able to choose one for the bulk of our analytical work. We are also investigating alternate methods of multielement analysis to be done at LLL, which hopefully will provide less costly methods of obtaining accurate data.

Detailed Description of Progress on Project Tasks

Water Sampling Program

Valley-Wide Surface-Water-Sampling Network — Samples have been taken on the Valley-wide network, shown in Fig. 1, since January 1976. Some of these samples have been sent to chemical laboratories for analysis. Not all results have yet been received. At first samples were taken monthly, then every 6 weeks, and are now being collected again on a monthly basis.

Site-Specific Networks — In addition to the Valley-wide sampling network, site-specific grab-sampling networks have been established in the

four major KGRAs in the Valley: Salton Sea, North Brawley, Heber, and East Mesa. These are shown as insets in the map in Fig. 2, and shown individually in Figs. 3, 4, 5, and 6.

Salton Sea Geothermal-Field Area — The first site-specific network for water samples was established in the Salton Sea Geothermal Field with the first samples taken in January 1976. This area was chosen because of the impending start-up of the SDG&E/ERDA Geothermal Test Facility located in the area. It was also decided that the network should include the nearby test facilities situated at the Sinclair #4 well, approximately 1 mi south of the Geothermal Test Facility. The Sinclair #4 facility was operated by a consortium of Southern California Edison Co., Southern Pacific Land Co., and Phillips Petroleum Co.; the facility includes extensive brine-evaporation ponds that have been used intermittently over the past 10 years. The sampling sites for the Salton Sea KGRA are shown in Fig. 3.

The philosophy in choosing sampling sites was straightforward; for each of the two major types of water (irrigation water and drain water), sampling sites were established upstream and downstream of the geothermal operations. The upstream measurement provides a baseline of water

Fig. 1. Valley-wide water-sampling sites.

Fig. 2. Site-specific water-sampling networks in the four major KGRAs.

Fig. 3. Salton Sea KGRA water-sample sites.

Fig. 4. North Brawley KGRA water-sample sites.

Fig. 5. Heber KGRA water-sample sites.

Fig. 6. East Mesa KGRA water-sample sites.

quality in the specific watercourse sampled, and the measurement downstream indicates any additions to the water as it passes through the area. Clearly, geothermal effluents might not be the only additions to the water; baseline measurements before development have provided evidence of conditions that existed prior to startup of the SDG&E/ERDA Facility.

Water samples have been taken regularly since January; at first, sampling was carried out at 3-week intervals and more recently at 4-week intervals. Sampling techniques are based on generally accepted practices as established by the USGS and EPA. At this time, a number of samples taken on the sampling network have been analyzed chemically. Additional samples are currently being analyzed. The list of elements for which analyses were made is shown in Table 1.

Analyses typical of those received to date are shown in Table 2. Because our purpose here is comparison of analytical data obtained from samples of water with widely differing salinity, the data are presented as percent of total dissolved solids (TDS), which enables rapid comparison among samples. In an appendix to this section, full analyses of these samples are presented.

The normal surface water of the region is represented by the samples of irrigation water, agricultural-drain

Table 1. Chemical analyses of water samples. Complete list is for initial survey data; those with dots (•) are for routine analyses.

• Na	• As
• K	Ba
• Ca	Cd
• Mg	Co
• Li	Cu
• Cl	Fe
CO ₃	Hg
HCO ₃	• Mn
• SO ₄	Ni
• SiO ₂	Pb
NO ₃	• Rb
NH ₄	Se
• B	• Sr
F	• Zn

• Total dissolved solids, specific conductance, temperature, and pH.

water, and Salton Sea water. These have somewhat similar characteristics, though the drain water and Salton Sea water are progressively enriched in sodium chloride relative to the irrigation-source water. The analysis of geothermal brine shows a strikingly different compositional profile, being high in potassium relative to sodium and very low in sulfate relative to the surface waters. The brine also contains significant quantities of

Table 2. Chemical analyses of selected Imperial Valley waters (values shown in percent of total dissolved solids unless otherwise noted).

Chemical parameter	Irrigation canal	Agricultural drain	Contaminated drainage sump	Geothermal ¹ brine	Salton ¹ Sea
Na	20.4	20.8	15.1	21.9	28.3
K	0.71	0.29	2.7	5.60	0.46
Ca	9.7	7.5	14.3	10.1	2.57
Mg	2.1	2.96	0.94	0.276	2.90
Li	0.0095	0.0058	0.069	0.129	0.000086
Mn	0.00095	0.0064	0.21	0.44	0.000027
Cl	19.0	24.2	50.9	58.0	40.5
SO ₄	31.8	35.7	2.87	0.0071	22.0
Ba	0.0095	0.002	0.0025	0.41	<0.0027
Rb	<0.0002	<0.0004	0.0027	-	-
Zn	0.00095	0.0003	0.047	0.26	0.00017
Total dissolved solids, mg/l	1,052.	5,136.	48,106.	266,557.	37,082.
Specific conductance, μ mhos/cm at 25°C	1,650.	6,700.	75,000.	-	42,100.
pH	8.2	7.5	6.7	5.3	7.7
Na/K ratio	28.7	71.3	5.5	3.9	61.0

1. California Department of Water Resources, Geothermal Resources and the Water Resources of the Salton Sea Area, Bulletin 143-7, (1970).

lithium, an element so unusual in ordinary water that it is used as a tracer in groundwater studies. Additionally, the brines are high in manganese and zinc. The pH of the brines is about 5, while the average pH of surface water is near 8.

In the process of sampling, we encountered a sump with water containing an unusually high concentration of dissolved solids. This sump, Sump 116, is adjacent to an old geothermal-brine evaporation pond that is believed to be leaking into the adjacent soils. The sump is located near the northwest corner of the Sinclair #4 pond on Boyle Road 1/2 mi north of Lindsey Road. The anomalous nature of this water is shown in Fig. 7, which shows electrical conductivities determined at sampling stations in the Salton Sea KGRA. Conductivity is directly related to total dissolved solids. It should be noted that the quantity of water flowing into the sump was small. It was determined that the sump accumulates water from a tile system draining the field immediately east of the pond (to the right in the picture). Analysis of the water indicates the pattern of elements to be anomalous relative to the normal surface water.

We believe that the anomalous character of the contaminated water presents us with a powerful tool for detection of brine in surface water

in the Salton Sea field area. It is believed that the presence of a substantial amount of lithium in a surface-water sample would be strongly suggestive of an admixture of geothermal brine. If, in addition, the analysis of a sample were to show a low Na/K ratio, high manganese and zinc, low sulfate, and a pH somewhat more acidic than normal, we could say with high confidence that contamination of the water by geothermal brine had occurred. This tool is specific to the Salton Sea geothermal field area; we have very little information about brines at other fields. Caution is necessary in extrapolation to other areas. We must obtain brine samples from each field to determine whether the ratios of elements are similar to those seen at the Salton Sea field area. If some of these characteristics are typical of the brines in other areas, then very probably we can use a similar fingerprint.

Other geothermal field areas -

We have designed water-sampling networks for the other KGRAs in which geothermal activity is occurring; these are at North Brawley, Heber, and East Mesa. The stations have been field checked, and the first samples will be taken during October 1976. The networks are shown on Figs. 4, 5, and 6. Implementation of these site-specific networks will extend

Fig. 7. Specific conductance of water samples, Salton Sea KGRA, February 1976, mmho/cm at 25°C.

detailed sampling to the other active KGRAs in the Imperial Valley. This will provide extensive baseline data about water quality, especially with regard to trace metals, for all geothermal areas likely to see extensive development. Note that a number of witness wells are to be sampled at East Mesa; unlike the irrigated portion of the Imperial Valley, there is no surface-water system of canals and drains east of the East Highline Canal. However, there are better groundwater aquifers than are characteristic of the other KGRAs. Groundwater sampling will be discussed in more detail in a later section of this report.

Recording Meter Network

The design and implementation of a recording meter network in the Salton Sea KGRA and in other areas of the Imperial Valley has been beset with budgetary, manpower, and scheduling problems. Finally, in October 1976, we are seeing outside vendors and actively seeking quotations. A proposal is in hand from one supplier with a trip scheduled for October 13 that should result in two more proposals from other suppliers. By the end of October, we will have decided on the equipment we need and can afford.

We have two recording conductivity-/temperature-meter systems in the final stages of construction at LLL. But since it was decided that their

original design was inadequate and because of manpower shortages that have delayed their completion, we decided to look outside the laboratory to find what was available commercially. We now hope to put together four to six units for monitoring temperature, specific conductance, pH, flow rate, turbidity, and some specific ions. Placement of these monitoring-system units will be in the site-specific geothermal areas: Salton Sea field, North Brawley, Heber, and East Mesa. To exploit their portability, we hope to use them also in intense short-term studies that will assist in the subsequent redesign of the site-specific grab-sampling networks, to add or eliminate grab-sampling sites, and to better determine adequate grab-sampling frequency. The two simpler systems in construction at LLL will be completed for use until the commercial units are obtained.

Groundwater-Monitoring System

Sampling of observation wells near the production wells at East Mesa, to begin in October, will be the first sampling of groundwater in this program. The central part of the Imperial Valley, where the other KGRAs are situated, is underlain largely by lake beds, primarily fine silts and clays, at the depths to which groundwater wells are drilled. Because these sediments are relatively impermeable,

yields from the few wells drilled in the vicinity of the Salton Sea, North Brawley, and Heber KGRAs are very small. Furthermore, because the fine-grained sediments are retentive of salts, the salinity of the water produced from the wells is so high — from 3000 to 10,000 ppm TDS — that the water is not of beneficial use. At least one witness well in each KGRA will be constructed, both to document the baseline water quality in the immediate vicinity of possible geothermal production and to determine if any of the wells are leaking into the near-surface groundwater at a rate sufficient to contaminate the surface water into which the groundwater may flow. Such wells will also determine if any locally permeable rocks exist in the vicinity of the KGRAs that might contain higher quality water. These wells will be drilled to a depth of 100 to 200 ft, and cased with slotted plastic so that any water present in the rocks will drain into them. They will be sampled on the same basis as the surface-water channels in the site-specific network.

At East Mesa, where the near-surface rocks are more permeable, ground-water sampling will be a major part of the site-specific sampling program. Because the witness wells are very small in diameter,

it may be necessary to develop special sampling techniques, to be based on experience, for the wells. Sampling is to commence in October 1976.

Mobile Water-Quality Laboratory

We are presently in the process of obtaining and equipping a mobile laboratory to enable us to make chemical analyses at the time of collection, and to preserve samples more effectively for more accurate determinations in regular laboratories. We would like to measure some elements, such as nitrates, ammonia, and dissolved gases, that are ephemeral and disappear rapidly after the sample is taken. Analysis at the time of sampling will produce better results for such elements. Other elements can be measured in the field, using equipment in the van. Facilities will be installed in the van to preserve elements in the samples that might change in concentration with time unless handled in special ways. This will make possible laboratory analysis of biological parameters, for example, by refrigerating appropriate samples.

An order for the basic vehicle was placed in August 1976; capital equipment, including a power plant, refrigerator, and sampling and analytical equipment, was ordered early in September. Upon delivery of the truck, working tables and equipment

shelves and racks will be installed, together with insulation and air conditioning to control the high temperatures characteristic of the Imperial Valley. As soon as the unit is equipped sufficiently to support sampling, it will be moved to the Imperial Valley. As other kinds of equipment are received, they will be installed in the unit.

Data Gathering

Large numbers of water samples have been taken in the Imperial Valley. Most of these have been taken and analyzed by two organizations, the Imperial Irrigation District (IID) and the Water Resources Division of the U.S. Geological Survey. The IID data include over 15 years of analyses of the common constituents and 26 years of TDS measurements at a number of points in the Valley. However, there are no trace-metal data. The U.S. Geological Survey data have been accumulated for several years and include measurements of some trace metals. We have contacted the responsible individuals in the USGS, and it is apparent that the data can be obtained in a digitized format compatible with the IVEP data-storage and management system.

We plan to continue our efforts to obtain data from all available sources.

Data Analysis

Analysis of initial analytical chemical results from grab samples taken in Imperial Valley has made apparent the need for digital techniques; the amount of data being accumulated is overwhelming and impossible to interpret by hand. Sorting, searching, and statistical routines are now being sought to aid in interpretation of the water-quality data. However, patterns are showing up that indicate surface-water contamination by geothermal fluids, as mentioned previously. Furthermore, initial results have shown which chemical elements are of importance and which can be eliminated from routine analyses; see Table 1.

Pattern recognition and modeling are seen as important tools for understanding the water-quality data being generated and, indeed, in refining and reorienting the water-quality data being taken. We are also evaluating such techniques.

Modeling and Simulation

Mathematical modeling, and computer simulation with these models, is seen as an important part of the water-quality study, as well as all other elements of the IVEP. Models of surface and groundwater hydrology are now being sought to better understand the implications of geothermal-power development on water-quality and

water-resource allocation problems. A direct product of modeling should be a determination of adequate grab-sampling strategies — spatial and temporal frequency — for continued monitoring in the Imperial Valley. Uses of models in resource planning include testing various cooling-water supply/demand scenarios on a model of the Valley water system. Impacts on the drain-water quality and the Salton Sea are to be studied using models. For these reasons, modeling is thought to be of such importance that initial contacts have been made with a group of outside consultants experienced in water-quality and water-management models to advise us of how to proceed with construction of models for water quality and quantity in the Imperial Valley.

Salton Sea Study

Plans to sample water in the Salton Sea are not being actively pursued at present. However, occasional grab samples in the Sea will be made to document baseline levels of major and trace constituents. Equipment is now being sought that will permit sampling at precise depths in the Sea. This would permit sea-water sampling along profile transects of the Sea at various longitudes and latitudes. Data are desired to understand better the salinity and temperature distributions in the Sea,

as well as trace-element concentrations. Sediment sampling is seen as important to document baseline chemical speciation on the sea bottom near the mouths of the Alamo and New Rivers. We plan to acquire LANDSAT imagery to study circulation patterns and surface temperatures in the Sea.

Chemical Support

In this study, as in any water-quality study, chemistry of necessity plays an important role. To date we have had chemical analysis of our samples done both by groups at LLL and by commercial analytical laboratories in Southern California, both in and outside the Imperial Valley. Agreement among the results of the analyses by various laboratories thus far has been good, in general. To find one outside laboratory whose work we can trust, we are in the final stages (note: by the time the status report is published, we expect that these samples will have been shipped) of preparing a large group of samples to send to four laboratories: one in the Imperial Valley, two in the Los Angeles region, and one to our own chemistry group at LLL. Of the samples analyzed, 40% will be for quality assurance, consisting of duplicates, splits, and standards — samples containing known mineral and trace elements. The standards were obtained from the

U.S. Geological Survey Water Resources Division and the Environmental Protection Agency. Analysis of our samples by these four groups will provide not only valuable information of the chemical constituents of the water samples we have been taking, but also indications of the errors inherent in the analyses. We will then be in a position to assess the accuracy and precision of the results obtained by the various laboratories and to choose one to perform the bulk of our subsequent work.

Since expanding the grab-sampling program from the Valley-wide and Salton Sea KGRA networks (Figs. 1 and 3), we will be collecting nearly 75 samples per month if our present sampling trips continue at the same frequency. Furthermore, we will be analyzing each sample for nearly 20 chemical species; that amounts to 18,000 analyses in FY 77 alone. For this reason, we are pursuing alternate multielement techniques expected to be available for production work here at LLL. Among the most promis-

ing of these is the neutron activation analysis system being developed for the National Uranium Resource Evaluation (NURE) Program. Other production-oriented methods within LLL are being investigated in an attempt to avoid the extremely high costs of wet-chemical analyses. In addition, refinement of the grab-sampling networks will take place when sufficient data have accumulated to allow us to cut down the number of samples taken. Special investigations, using a recently purchased automatic stream sampler will allow us to take samples at closely spaced points in time. Thus, we can assess quantitatively the variation in water-stream quality and then determine proper grab-sampling intervals. A portable spectrophotometer has been purchased for the field determination of some specific chemicals. Additionally, current ion-specific-electrode technology is being reviewed to determine what may be appropriate for use in the Imperial Valley.

Appendix A. Chemical Analysis of Typical Imperial Valley Water.

Table A-1. Irrigation water, Vail 4 canal, Gentry at Young Roads (T12SR13E-9R), sampled 2/25/76 (LLL).

Parameter	Concentration	
	mg/l (ppm)	% TDS
Na	215.	20.4
K	7.5	0.71
Ca	102.	9.7
Mg	22.	2.1
Li	0.1	0.0095
Cl	200.	19.0
CO ₃	16.4	1.56
HCO ₃	140.	13.3
SO ₄	335.	31.8
NO ₃	0.2	0.02
NH ₄	<0.03	<0.003
B	0.32	0.03
F	0.35	0.033
As	0.002	0.0002
Ba	0.10	0.0095
Cd	<0.0005	<0.00005
Co	0.005	0.0005
Cu	0.002	0.0002
Fe	0.03	0.003
Hg	0.0014	0.00013
Mn	0.01	0.00095
Ni	<0.005	<0.0005
Pb	0.004	0.0004
Rb	<0.02	<0.0002
Se	<0.001	<0.000095
Sr	-	-
Zn	0.010	0.00095
Total dissolved solids (TDS)	1,052.	
Specific conductance, at 25°C	1,650.	
Temperature, °C	18.3	
pH	8.2	

Table A-2. Drainwater, Vail 4 drain, Gentry at Foss Roads (T11SR13E-34N),
sampled 2/25/76 (LLL).

Parameter	Concentration	
	mg/l (ppm)	% TDS
Na	1,070.	20.8
K	15.	0.29
Ca	385.	7.5
Mg	152.	2.96
Li	0.3	0.0058
Cl	1,245.	24.2
CO ₃	<2.5	<0.05
HCO ₃	307.	6.0
SO ₄	1,833.	35.7
NO ₃	8.3	0.16
NH ₄	<0.03	<0.0006
B	0.97	0.019
F	0.15	0.003
As	0.004	0.00008
Ba	0.10	0.002
Cd	<0.0005	<0.00001
Co	0.010	0.0002
Cu	0.002	0.00023
Fe	0.09	0.018
Hg	0.0044	0.000086
Mn	0.33	0.0064
Ni	<0.005	<0.0001
Pb	0.008	0.00016
Rb	<0.02	<0.0004
Se	<0.0010	<0.00002
Sr	-	-
Zn	0.015	0.0003
Total dissolved solids (TDS)	5,136.	
Specific conductance, at 25°C	6,700.	
Temperature, °C	21.5	
pH	7.5	

Table A-3. Drainwater, Sump 116, Boyle at Kuns Roads (T12SR13E-4K), sampled 2/26/76 (LLL).

Parameter	Concentration	
	mg/l (ppm)	% TDS
Na	7,250.	15.1
K	1,305.	2.7
Ca	6,855.	14.3
Mg	450.	0.94
Li	33.	0.069
Cl	24,490.	50.9
CO ₃	<2.5	<0.005
HCO ₃	350.	0.73
SO ₄	1,380	2.87
NO ₃	2.9	0.006
NH ₄	21.	0.044
B	31.2	0.065
F	0.20	0.00042
As	<0.002	<0.0000042
Ba	1.2	0.0025
Cd	0.0065	0.000014
Co	0.04	0.000083
Cu	0.13	0.00027
Fe	1.35	0.0028
Hg	0.0008	0.0000016
Mn	100.	0.21
Ni	0.04	0.000083
Pb	0.82	0.0017
Rb	1.3	0.0027
Se	<0.005	<0.00001
Sr	-	-
Zn	22.5	0.047
Total dissolved solids (TDS)	48,106.	
Specific conductance, at 25°C	75,000.	
Temperature, °C	22.2	
pH	6.7	

Table A-4. Geothermal brine, Sinclair 4 well, Boyle at Lindsey Roads (T12SR13E-4Q), sampled 7/5/76.¹

Parameter	Concentration	
	mg/l (ppm)	% TDS
Na	58,443.	21.9
K	14,918.	5.60
Ca	26,992.	10.1
Mg	736.	0.276
Li	344.	0.129
Cl	154,590.	58.0
CO ₃	-	-
HCO ₃	0.	0.
SO ₄	19.	0.0071
NO ₃	5.	0.0019
NH ₄	442.	0.166
B	332.	0.125
F	14.	0.0053
As	10.	0.0038
Ba	1,100.	0.41
Cd	<0.005	<0.000002
Co	<0.0005	<0.0000002
Cu	3.	0.001
Fe	1,340.	0.503
Hg	<0.2	0.00008
Mn	1,475.	0.553
Ni	<4.	<0.002
Pb	60.	0.023
Rb	-	-
Se	-	-
Sr	448.	0.168
Zn	600.	0.26
Total dissolved solids (TDS)	226,557.	1
Specific conductance, at 25°C	-	-
Temperature °C	>100.	-
pH	5.3	-

1. Calif. Dept. of Water Resources, Bulletin 143-7 (1970).

Table A-5. Seawater, Salton Sea, U.S. Navy Salton Sea Base (T11SR11E-21P),
sampled 6/8/67.¹

Parameter	Concentration	
	mg/l (ppm)	% TDS
Na	10,500.	28.3
K	172.	0.46
Ca	954.	2.57
Mg	1,078.	2.90
Li	3.2	0.000086
Cl	15,000.	40.5
CO ₃	0.	0.
HCO ₃	203.	0.55
SO ₄	8,146.	22.0
NO ₃	14.	0.038
NH ₄	-	-
B	9.20	0.025
F	3.2	0.0086
As	0.0	0.
Ba	<1.	<0.0027
Cd	<0.005	<0.000013
Co	<0.0005	<0.0000013
Cu	0.0050	0.000013
Fe	0.0100	0.000027
Hg	<.2	<0.00054
Mn	0.01	0.000027
Ni	0.003	0.0000081
Pb	<0.002	<0.0000054
Rb	-	-
Se	-	-
Sr	11.	0.03
Zn	0.062	0.00017
Total dissolved solids (TDS)	37,082.	
Specific conductance, at 25 °C	42,100.	
Temperature, °C	25.	
pH	7.7	

1. Calif. Dept. of Water Resources, Bulletin 143-7 (1970).

IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Ecosystem Quality

ECOSYSTEM QUALITY

Joseph H. Shinn

The Ecosystem Quality group is organized into seven teams, each keyed to a specific task, but sharing personnel and facilities. Most teams are supported by one or more contracts.

Site-Specific Baselines

A sampling grid was established around the San Diego Gas and Electric site (SDG&E) as shown on the map of Fig. 1. The LLL team collected soil and crop samples in January 1976 at the points marked (X). In February 1976 a team from the EPA Las Vegas Environmental Monitoring and Support Laboratory also established a grid and collected alfalfa (A), grasses (G), lettuce (L), and sugar beets (B), as well as soil samples at the points indicated in Fig. 1. The samples have not yet been analyzed completely. The LLL preliminary results show that the soils have a higher than expected content of Ca, Mg, Br, Mo, Ni, Zn, Mn, and Fe; but because of the alluvial history of the soils and the difficulty selecting suitable controls, interpretation of the results will take additional time. The LLL grid also included samples collected adjacent to the Southern California Edison site (SCE) at Sinclair No. 4 well (see Fig. 1). Further sample collection will be

postponed until a decision is made by SCE to develop or abandon the site.

Shoreline Habitats

About 100 ducks (several species) and 20 geese (two species) were collected beginning October 1975 in cooperation with the U.S. Fish and Wildlife Service and the California Department of Fish and Game. We utilized vital organs from birds that were shot legally by hunters and from poached birds that were confiscated by law enforcement officers at the Wildlife Refuges (see map, Fig. 2). About 10 other species of birds representing a cross-section of feeding types were collected as well; these included shorebirds and sparrow hawks. Rodents were collected in the vicinity of the SDG&E site and the Wildlife Refuges. A control population of waterfowl at the Sacramento National Wildlife Refuge was also sampled. After dissection, selected tissues were freeze-dried and stored. Elemental analyses by neutron activation analysis, x-ray fluorescence analysis, and atomic absorption spectrophotometry were undertaken on tissues from pintail ducks and snow geese to determine natural variability in the Imperial Valley population. In duck and goose livers the coefficients of variation ($s/\bar{x}$) were: 0.3 to 0.4 for Fe, Mn, Ca, Ni, and Zn; 0.45 to 0.60 for Cu and Br; and 0.7

KEY

* Geothermal wells

o Sumps

A,B,G,L EPA Monitoring and Support Lab. samples

X LLL crop and soil samples

Fig. 1. Map showing locations where site-specific baseline samples were collected during FY 1976 in the Salton Sea Known Geothermal Resource Area.

Fig. 2. Map showing locations throughout Imperial Valley where baseline studies are in progress.

for Se. These variations are much greater than the errors of the analytical methods. It was decided that a second year collection of duck and geese samples should be made because of the variability in the populations and because of natural environmental differences from year to year. This study is continuing and interim reports will be issued in January 1977. Elemental analysis on collected and preserved shorebird, hawk, and rodent tissue is also continuing; reports will also be issued in January 1977. The rate-limiting step in these studies is the chemical analysis.

A contract was let to study the most important endangered species in the Valley. ("Ecology of the Yuma Clapper Rail in Imperial Valley, California," Arizona State University, Tempe, Arizona, Department of Zoology, Robert D. Ohmart, 1 June 1976 to 30 September 1977, \$10,000.) Objectives are to determine total breeding population, monitor migratory arrival and departure dates, search for wintering population in the Imperial Valley, map and describe habitat, determine feeding habits, determine chronology of the reproductive cycle, determine mortality factors, determine effects of the rising Salton Sea and of geothermal development, and devise a Clapper Rail management plan.

Another contract was let for the study of noise and habitat intrusion

effects. ("Noise/Construction Effects of Geothermal Development on Wildlife Refuge Usage," St. Mary's College of California, Moraga, California, Philip Leitner, 1 July 1976 to 1 July 1977, \$19,000.) The objectives are to determine sound-pressure levels (SPL) of background activity and typical geothermal development activity of the liquid-dominated systems, to predict SPL that may occur at wildlife refuges, to establish seasonal patterns of wildlife-refuge usage near KGRAs, determine case histories of wildlife response to noise and disturbance effects including power-line effects, and to recommend mitigation measures as necessary.

Aquatic Studies

The aquatic team is subdivided into Salton Sea-fishes study and Pileworm and freshwater studies.

Salton Sea Fishes

Early plankton tows and assays were completed, and preliminary Salton Sea-fish collections were made by an LLL team. Contract assistance for this was planned for June, but the contract was actually awarded in September; details are given later. Baseline fish samples were collected in mid-April and mid-July (see map, Fig. 2), using a 150-ft, standard, graded gill net. About 20 fish of each of the 3 major species in a

range of sizes were collected each time. Morphometric measurements made were weight, standard length, age (based upon otolith annulation plus annulation on vertebral centra), and fin-ray counts. (The asymmetry of fin-rays is a standard indication of stress.) Tissues preserved for analyses were muscle, gill, bone, kidney, liver, gut contents, skin, and remains. Beach seines were used to collect mollies for similar morphometric analyses near the mouths of freshwater streams.

Ecological studies showed that there are frequent die-offs resulting from unknown reasons, but at least one kill (21 April) near the Alamo River mouth was apparently a result of Salton Sea flooding and washing-out of adjacent, old geothermal-brine ponds (see map, Fig. 2). Population dynamics estimated from die-offs show a ratio of 100:1 of both croaker to corvina (predator) and croaker to threadfin shad in the 3- to 5-in. class. The ratio of croaker to sargo was about 300:1. Attempts to locate and collect eggs and larvae of corvina were unsuccessful although it is known that spawning occurred in August. Bioassays to determine toxicity of geothermal brine to croaker larvae showed that the median lethal level (TLM) was 36 hr with 500-ppm geothermal brine (from the Magmamax-1 well at the SDG&E site) in Salton Sea

water and 24 hr with 5000-ppm geothermal brine in Salton Sea water, while the normal TLM was 72 hr. Adult fish (mostly croaker) have been captured and transplanted into the LLL 2000-gal circulating Salton Sea-water system for further studies.

Elemental analyses have not been completed on preserved baseline fish tissue. Elements of particular interest because of a high concentration in geothermal brines compared to sea water are Mn, Zn, Fe, Li, Cd, Ba, Se, Cu, and Rb.

A contract was awarded to determine toxicity and assist in interpretation of baseline collections. ("Salton Sea Fishes - Baseline Study and Corvina Toxicity Study," California State University at Hayward, Department of Biological Sciences, Richard E. Tullis, 1 October 1976 to 30 September 1977, \$26,000.) Objectives are to collect and prepare fish tissues from major and minor Salton Sea-fish species for baseline trace-element analyses, indices of fish stress, and biomass and spawning estimates for corvina, and to determine sensitivity of major fishes to geothermal brines and existing stress.

A contract was also awarded for assistance in sampling. ("Salton Sea Sampling Program," California Department of Fish and Game, Robert Hulquist, Fisheries Biologist, 1 October 1976 to 30 September 1977,

\$4600.) Personnel will be provided to sample fish, to maintain sampling gear, and to prepare and ship fish samples to LLL.

Pileworm and Freshwater Studies

The polychete worm Neanthes, commonly called the pileworm, is a sediment dweller and detritus converter that is a food for every major fish in the Salton Sea. The pileworm is important as a bioassay organism for toxicological effects of geothermal brines as well as a key organism for determining baseline transfer rates of metals from contaminated river-borne sediments into the marine-food chain. Pileworms were collected beginning in February 1976 at the four sites around the Salton Sea (see Fig. 2). A site near the discharge point of agricultural drains from the SDG&E and SCE sites was included (Fig. 1). Collections were required again in March, April, June, July, August, and October because of sampling and culturing problems. Sampling will continue on a quarterly basis. Initial elemental analyses were performed by neutron activation analysis, x-ray fluorescence, and atomic absorption spectrophotometry to determine baseline levels of elemental composition after the worms had expelled all sediment from their digestive tract. A study was made of retention of key elements by captured worms. Both the chemical

analyses and interpretation of these data will take more time. A bioassay study of Zn toxicity and retention was performed on captured worms. With a background of 0.1 ppm Zn, the addition of 50 ppm Zn to sea water caused the worms to retain as much as 5 ppm for longer than 21 days. The time to 100% lethality (TL) for these pileworms was 0.5 days at 50 ppm Zn, 4.8 days at 20 ppm Zn, and 12 days at 10 ppm Zn. These data are relevant to SDG&E plans to discharge Zn-contaminated cooling water. Unanswered questions about Zn retention and osmotic regulation will be examined. ("Pileworm Larval Success at Higher Salton Sea Salinities," Department of Zoology, Pomona College, California, Larry C. Oglesby, 1 July 1976 to 30 September 1977, \$10,000.) The objectives are to determine salinity effects (possibly resulting from geothermal development) on egg and larva from acclimated adults, to determine survival of planktonic larva and adults in the Salton Sea compared to Pacific Ocean control populations, and to determine the effects of seasonal temperature changes on the above.

A freshwater studies program was initiated after the April IVEP Advisory Panel Review indicated that economically important populations of fish in agricultural drains had been overlooked. We are cooperating with the Colorado River Regional Water

Quality Control Board (WQCB) and plan to do baseline elemental-analysis studies and to do bioassays with geothermal brine on Gambusia affinis (mosquitofish), both at LLL and with contract assistance. ("Bioassay Procedures to Evaluate Acute Toxicity of Salinity and Geothermal Pollutants to Gambusia affinis," North Carolina Central University, Durham, North Carolina, William L. Mills, 1 October 1976 to 30 September 1977, \$10,000.) The objectives are to develop a series of static bioassay tests to determine salinity tolerance and acute toxicity of geothermal brine to juvenile and adult mosquitofish that are native to Imperial Valley, to conduct experiments to determine the synergistic effect on toxicity of population levels, to determine the acute toxicity of several metals that are components of geothermal brine (Fe, Mn, Zn, and Cu), and to identify synergistic or antagonistic effects.

Agriculture

Four Imperial Valley dairies (see map, Fig. 2) are sampled regularly and the milk is analyzed for contaminant trace elements. A number of control samples are obtained from the nation-wide EPA milk network. A Valley-wide collection system has recently been established for lettuce, sugar beets, melon, and alfalfa with the aid of contract labor from the University of California, Agricultural

Extension Service. (1 October 1976 to 30 September 1977, \$10,000.) This network will consist of collection points at each of the four major KGRAs, at the U.S. Department of Agriculture (USDA) and the University of California experimental farms, and at farms throughout the Imperial Valley where local growers' organizations periodically conduct experiments (see map, Fig. 2). By cooperating with existing projects, we obtain more accurate records of treatment, such as historical data on fertilization, irrigation, planting, etc., that are important for interpretation of observed elemental compositions.

Contract support has been obtained to determine "Solute Movement in Soils Following Brine Spills." (Department of Soil Science and Agricultural Engineering, University of California, Riverside, W. A. Jury, 1 July 1976 to 30 September 1977, \$15,000.) The objective is to predict the long-term effects of a geothermal brine deposit on the soil surface in terms of its movement through the soil and eventual appearance in groundwaters or artificial drains. A contract has also been awarded to determine "Trace Metal Speciation in Saline Waters Affected by Geothermal Brines." (Kearney Foundation of Soil Science, University of California, Riverside, Garrison Sposito, \$15,000.) The objectives are to calculate the

trace-metal chemical equilibria for cases of geothermal-brine intrusion into waters and soils of the Imperial Valley.

Desert Habitats

The baseline studies in the Imperial Valley deserts adjacent to KGRAs are being performed by a team from the University of California at Los Angeles (UCLA) Laboratory for Nuclear Medicine and Radiation Biology under the general supervision of Dr. Evan Romney. Vegetation, soil, and mammals were collected in three field sorties from February to April 1976 in the Dunes KGRA and near geothermal wells in the East Mesa KGRA (see map, Fig. 2). At East Mesa, Wells 5-1, 6-2, 8-1, and 31-1 were collection points. A dimensional analysis of diversity in vegetation species, ground cover, and biomass was completed for both KGRAs. Soil microarthropods were studied in March, July, and August 1976 by the UCLA group. Samples of insects and soil were collected by day and night. Few microarthropods were found except near citrus groves adjacent to Well 31-1. Chemical analyses (especially Na, Cl, and Mg) have been performed on all insects and soil samples near the site where Well 31-1 was vented in the past. Preliminary studies of salinity effects on soil arthropods have been conducted. A beetle Eleodes has been

selected for bioassay studies, beginning with field studies on population dynamics, larval development, feeding mechanisms, and the amounts and nature of food. The bioassays will determine the responses of beetle-larva populations to geothermal-induced salinity changes. A mammal study was initiated, and baselines of elemental burdens in vital organs (muscle, hide, stomach/colon) of kangaroo rats are in progress. A bird study has been started with vegetation/habitat mapping using aerial photographs and the assistance of William Rhoads of EG&G.

Consumptive Water Use

A project was initiated to determine the actual water requirements of crop plants in preparation for more intensive management of consumptive water use. (A "Regional Crop Water-Use Bulletin" is being prepared under a contract to the Department of Water Science and Engineering, University of California at Davis, William O. Pruitt, 1 July 1976 to 30 December 1976, \$3200.) The objectives are to utilize existing California crop evapotranspiration rates and state-of-the-art methods to estimate Imperial Valley water use. (Specific "Imperial Valley Evapotranspiration and Crop Ecology Studies" are being provided under a memorandum of agreement with USDA Imperial Valley Conservation Research Center, Brawley,

California, Burl Meek, 1 July 1976 to 30 September 1977, \$10,000.) The objectives are to measure evapotranspiration of crops using unique facilities at the Center — a 3m × 3m weighing lysimeter and a micrometeorological, Bowen-Ratio System — and to obtain crop water-use rates for critical periods (e.g. heat advection from the dry desert) when standard methods grossly underestimate evaporation rates. The Center also provides services to other Ecosystem Quality Teams under the terms of the agreement (see map, Fig. 2). The LLL Team conducted its own micrometeorological evapotranspiration measurements to augment the Bowen-Ratio measurements, to standardize the different methods of measurement, and to explore the effects of heat advection on evapotranspiration from alfalfa. This experiment is complete and the data are being processed.

Air Pollution Effects

Short-term exposures of lettuce and sugar beet plants to a facsimile geothermal air pollutant were carried out by the LLL team at the Imperial Valley Conservation Research Center (see map, Fig. 2) using an array of circular, open-top chambers 3 m in diameter and 1.22 m high, as shown in Fig. 3. The exposures of 3-hr duration were intended to simulate geothermal power plant plumes, and the

gas mixture (15 CO₂: 1 H₂S: 1 CH₄: 2N₂ parts by volume added to air) had a stimulatory effect on lettuce photosynthesis at low concentration (less than 15 ppm CO₂ and 1 ppm H₂S, etc.) and a depressing effect at higher concentrations (greater than 75 ppm CO₂ and 5 ppm H₂S, etc.).¹ These experiments will be carried out with other crops and the synergism with existing Imperial Valley air pollution (ozone) will also be explored. (A contract to study "Synergistic Effects of H₂S, CO₂ and O₃ on Vegetable Crop Yields" was awarded to Department of Vegetable Crops, University of California, Davis, James P. Bennett, 1 October 1976 to 1 October 1977, \$10,000.) The objectives are to determine the susceptibility of tomato, onion, and bean plants in a joint experiment with LLL, using controlled fumigations of the geothermal-facsimile gases in situ. (Chronic exposure of alfalfa, lettuce, sugar beets, and cotton to CO₂-H₂S mixtures is being performed in "Supplemental Studies of Air Pollution Effects for Imperial Valley Environmental Programs," Statewide Air Pollution

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1. J. H. Shinn, B. R. Clegg, M. L. Stuart, and S. E. Thompson, "Exposures of Field-Grown Lettuce to Geothermal Air Pollution — Photosynthetic and Stomatal Responses," J. Environ. Sci. Health A11, 603 (1976).

Fig. 3. Field-fumigation experiments at the U.S. Department of Agriculture Field Station near Brawley, California. Plants receive short-term exposures to a gas mixture simulating the noncondensable gases to be released by geothermal power plants. Transpiration and photosynthetic rates are measured during the exposure period.

Research Center, Riverside, California, C. Ray Thompson, 1 July 1976 to 30 September 1977, \$10,000.) The objectives are to determine the changes in crop visual symptoms, height, and biomass production under controlled, chronic exposures in greenhouses. (A contract was awarded to study the "Mortality and Life-Span

of Honeybees Exposed to Hydrogen Sulfide Gas," Department of Entomology, University of California, Riverside, E. Laurence Atkins, 1 July 1976 to 1 October 1977, \$5,000.) The objectives are to use proven bioassay methods to determine whether these economically important pollinator insects are susceptible to geothermal air pollutants.

Characteristics of the deposition rates of geothermal gases have been inferred for lettuce and alfalfa through measurements of the rate of exchange of other gases (CO_2 , H_2O) in crop fields. These data are being analyzed and the measurements are continuing periodically during the winter growing season. It is expected that the deposition of air pollutants will vary by more than 100-fold because of biological rate-limiting factors.

Summary Note

All of the teams reporting progress here will be participating in a 3-day workshop, 8-11 November 1976, involving the LLL teams, the 14 contractors, the UCLA team, and guests such as representatives of SDG&E, SCE, U.S. Fish and Wildlife Service, and ERDA. The purpose of this workshop will be to produce a comprehensive, integrated report on the Ecosystem Quality Sub-Program.

IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Subsidence and Seismicity

SUBSIDENCE AND SEISMICITY

Neil B. Crow

Introduction

Any significant subsidence or seismic activity that might be induced by geothermal activity, primarily the production and reinjection into the formation of geothermal brines, would engender serious environmental concern in the Imperial Valley community. The detection of such earth movements in the presence of a high level of naturally occurring ground surface subsidence and a degree of earthquake activity among the highest in the United States requires careful documentation of the present levels of activity and monitoring of any incremental movements. The program we have established to accomplish these results is given in the following outline and discussed in more detail in the following sections.

Our studies in this section have involved extensive cooperation with other agencies — Federal, State, and local. Our major accomplishments include the encouragement of a resurvey of the Imperial Valley Subsidence Detection Network by an interagency group, and a contract with the California Division of Oil and Gas, which manages the resurvey, to contribute \$35,000 toward the cost of the work. We have also established a local subsidence-detection network in the Salton Sea geothermal field area,

centered on the SDG&E/ERDA Geothermal Test Facility. This work was done under contract to LLL by the Imperial County Department of Public Works; the total amount was approximately \$10,500.

To obtain detailed seismic coverage in the Salton Sea area and to obtain uniform coverage in the Valley-wide network of seismometers, we have contracted with the U.S. Geological Survey (USGS) to install six seismometer stations in the Salton Sea area. These units will be tied into the USGS regional network of seismometers. Data from these seismometers will be telemetered to the USGS regional data-processing center and analyzed data supplied to LLL. Our cost for installation and the first year of operation is approximately \$60,000. Installation of the seismographs is now complete and telemetering is being established.

Summary of Progress on Project Tasks

Subsidence

Valley-wide subsidence-detection network — Milestone: Complete 2/78

Accomplishments: Contract for \$35,000 let to California Division of Oil and Gas for partial support of resurvey of the interagency Imperial Valley Subsidence Detection Network. LLL was instrumental in encouraging resurvey of this network, which is to be done this winter (1976-77). Field

work should be completed by early spring 1977, and data reduced by the end of CY 1977.

Site-specific subsidence-detection networks — Milestone: Complete 2/78

Accomplishments: Established subsidence-detection network in the Salton Sea Geothermal Field area, centering on the SDG&E/ERDA Geothermal Test Facility. Networks for other geothermal areas at North Brawley and Heber are currently being designed.

Horizontal motion-detection

network — Funds were not available in spring 1976. Now preparing to negotiate with potential contractors for work to improve existing nets.

Subsidence-detection equipment —

Study of this type of equipment under way. Funds have not been available during FY 76. Will negotiate for extensometer at North Brawley during FY 77.

Data analysis — Second-order surface elevations from subsidiary network have been obtained for the 1971-72 and 1973-74 surveys and used to analyze localized surface movements. When both first- and second-order data from 1976-77 survey become available it will be used to interpret land-surface movements.

Subsidence modeling — Program plan in preparation. Program to be operational 9/77.

Seismicity

Seismographic networks (including data analysis) — Accomplishments:

Under an LLL contract for \$69,000, the U.S. Geological Survey is installing 6 seismometers in the area of the Salton Sea geothermal field that are to be connected to the USGS regional telemetered network. The contract also includes the first year of operation. The field installation was completed in October 1976 and presently telemetering connections are being made. Data will be available by winter 1976-77.

Seismic study of the Imperial

Valley — Program plan is being developed. One product of study will be the creation of a new seismic-velocity model of the Imperial Valley, essential to more accurate determination of the location of earthquake hypocenters (foci), that will be essential in distinguishing naturally occurring earthquakes from any that might result from geothermal activity.

Ground-Movement Studies

Valley-Wide Subsidence Detection

The possibility of subsidence induced by geothermal activity was recognized early in the 70's as a potential problem to the irrigated agriculture in the Imperial Valley. Local authorities, primarily the Imperial County Department of Public

Works and the Imperial Irrigation District, were concerned with the possible impact of subsidence on the irrigation and drainage systems of the Valley. They were joined by the California Division of Oil and Gas, which regulates geothermal wells, and the U.S. Geological Survey Subsidence Research Office, located in Sacramento. This group of agencies was instrumental in establishing a network of precisely surveyed land-surface elevations in the Imperial Valley. The work was done by an inter-agency committee, the Imperial Valley Subsidence Detection Committee (IVSDC), composed of these and other agencies with an interest in the subject. The network was established in the winter of 1970-71; it consists of first- and second-order leveling as shown in Fig. 1. The order of leveling is an indication of its precision: first-order leveling is highly precise and correspondingly expensive; only a few survey crews, primarily those of the National Geodetic Survey (NGS), are capable of attaining the required precision. Second-order leveling is slightly less precise, but still of high quality. In the Imperial Valley, crews of the Imperial County Department of Public Works and the Imperial Irrigation District are capable of such work. In the establishment of the survey, the first-order work was done by NGS crews, and the local

agency crews were joined by State and Federal agency crews capable of second-order work. The NGS survey linked the first-order part of the network to the national first-order leveling network, thus tying the Imperial Valley network to sea-level elevations at San Diego.

During the winter of 1973-74, the IVSDC sponsored the first resurvey of the Imperial Valley level network. The results of this resurvey made possible the determination of the changes in surface elevation that occurred during the period between the two surveys. Substantial surface-elevation changes had occurred in the 2-year period between surveys.

Lofgren of the USGS Subsidence Research Office published a paper in 1974 reporting the results of the first-order leveling;¹ subsidence of as much as 13 cm had taken place, primarily in the north end of the Imperial Valley near the Salton Sea (Fig. 1). This subsidence, at the rate of over 5 cm/yr, occurred in the virtual absence of any geothermal production. It is imperative to document such substantial naturally-occurring regional movement as a baseline so that any possible incremental movement resulting from geothermal development can be detected.

One of the early objectives of the IVEP has been to arrange another resurvey of the precision-leveling

Fig. 1. Vertical movement in Imperial Valley, 1972-1974; from Lofgren.¹

network at the earliest possible time. Discussions were initiated with key members of the Imperial Valley Subsidence Detection Committee in the latter part of 1975; while this group had a real interest in redoing the leveling, there was a serious concern for the sources of funding. Indication of fiscal support by ERDA crystallized the situation. In January 1976, a meeting of the IVSDC was held in El Centro, where it was decided to redo the survey in the winter of 1976-77. Subsequent negotiations have resulted in a contribution from ERDA through the IVEP of \$35,000 towards the cost of the surveying. The transfer of funds has been carried out under a contract between LLL and the California Division of Oil and Gas (DOG). The latter has acted as funding manager of all the surveys. The agency accepts funding both in money and in kind - the local agencies normally contribute a part of the operating expenses of their survey crews as much of their share of the cost - and disburses funds as necessary to pay for the work. LLL's \$35,000 will be allocated largely to the Imperial County Department of Public Works and the Imperial Irrigation District for the costs of their survey crews, who do much of the second-order leveling. The first-order work will be done by the National

Geodetic Survey, with a substantial part of their funding coming from the private sector - the geothermal operators in the Imperial Valley - via the Western Oil and Gas Association. The remainder of the funding for the first-order work comes out of the NGS budget; a tie-in to the national network and other survey lines that the NGS deems desirable will be funded in this way. For instance, during the 1973-74 survey, the NGS carried a first-order line completely around the Salton Sea.

Data from the 1976-77 resurvey should be available late in 1977. At that time, we will analyze any changes that have occurred in the region. It is intended that the leveling will continue in the future at 2- or 3-year intervals.

Site-Specific Subsidence-Detection Networks

In addition to the regional subsidence-detection network, we believe that it is necessary to obtain as much information as possible about more local movements of the land surface resulting from naturally occurring causes. Indeed, such local movements may be indicative of differential subsidence that could well be more significant than the more generalized changes resulting from regional movements. It is imperative to have as much baseline data as possible to

establish a level of activity upon which any subsidence induced by geothermal activity — primarily production and injection of geothermal fluids — would be superimposed.

Some data about local movements already exist; as part of the conditions for a geothermal development permit, Imperial County requires the operators of geothermal wells to survey a vertical elevation tieline to the nearest part of the Valley-wide subsidence detection network. These data are on file in the County Department of Public Works and are public information.

We are supplementing these well ties by localized subsidence-detection networks. The first of these to be established is in the Salton Sea geothermal field area and is centered on the SDG&E/ERDA Geothermal Test Facility. This network is shown in Fig. 2. It is designed to create a cross-connected mesh so that any local surface-elevation change can be characterized accurately. We intend to resurvey the network again this winter in conjunction with the resurvey of the Valley-wide network. This will provide the first opportunity to detect local surface-elevation changes with this network.

We will establish similar networks at both the North Brawley and Heber Geothermal Fields. It will be necessary to coordinate our efforts with

those of other agencies and the geothermal operators; because development is currently proceeding in both areas, it may be possible to maximize the usefulness of the well tie-ins to determine local surface-elevation changes. Design of networks for these areas is currently underway.

Surface-elevation surveys at the East Mesa Geothermal Field have been carried out by the Bureau of Reclamation, which operates geothermal wells in that area. The Bureau is a member of the IVSDC, and their data are coordinated with the Valley-wide survey. Information from their surveys is public record.

Horizontal Motion-Detection Network

The Imperial Valley is a tectonically active area, bounded on the east and west by major active faults that are part of the San Andreas fault system of Southern and Central California. The major sense of motion on the San Andreas fault system in the Imperial Valley is right-lateral strike-slip faulting; in other words, the block to the west of a fault moves northwestward relative to the block on the east of the fault. Additionally, in the Imperial Valley there is significant vertical movement on the faults that is not characteristic of the regions more northwesterly along the system. While any vertical movement will be monitored by the

- Approximate location of Imperial County first- and second-order bench marks.
- Approximate location of company second-order bench marks.
- × Approximate location of additional ERDA/LLL second-bench marks.

Fig. 2. Local leveling network near ERDA/SDG&E and SCE sites.

subsidence Detection Network, it is important to obtain data about the amount of lateral surface movement on the floor of the Imperial Valley. To this end, two programs are being carried out.

Large-Scale Trilateration Network

The Imperial Valley is partially covered by a large-scale trilateration network maintained by the Crustal Strain Group of the USGS (Fig. 3). The primary purpose of the network is to detect horizontal movement of the land surface in the vicinity of the San Andreas Fault zone of Southern and Central California. Trilateration is based on the use of laser-based distance-measuring equipment. These instruments are extremely accurate, and geodetic surveying has been revolutionized by their use. Trilateration is quite inexpensive and rapid compared to the previously employed triangulation method, which depends on the use of theodolites to measure angles over long distances. Because of the low expense and high accuracy of the trilateration process, we have discussed with the Crustal Strain Group the possibility of extending their trilateration network south and east to cover the remainder of the Imperial Valley. Unfortunately, the Crustal Strain Group was unable to participate in this effort, primarily because of logistic difficulties -- the flat terrain of the Valley

does not have the hills necessary to set up their equipment at heights sufficient to permit large-scale surveying. There are two methods of obtaining accurate horizontal control in the Valley: to connect the existing small-scale trilateration networks, discussed in the following section, by traverses to give the necessary coverage; and to repeat the work of R. Mason of the Imperial College of London. Dr. Mason has worked on a traverse across the Imperial Valley from east to west that gives some quantitative estimates of the horizontal motion along several of the faults that traverse the Imperial Valley. We will request a proposal from the USGS Subsidence Research Office to perform the traverses between the local networks, and Dr. Mason is to submit an informal proposal in the near future, describing his work and the cost of repeating it. We will choose the most cost-effective combination to obtain the coverage we require.

Small-Scale Horizontal Motion Detection Networks

Because local movements along a fault zone are fully as important as large-scale movements, smaller-scale horizontal-control networks have been established at the geothermal fields; this work has been done by the USGS Subsidence Research Office, as reported by Lofgren in 1974.¹ The

Fig. 3. Regional network of horizontal control; from Lofgren.¹

equipment used is similar in principle to the distance-measuring equipment employed in large-scale trilateration, but is designed for smaller distances and is lower in cost. The results obtained over the shorter distances are equally accurate, and the surveys can be made at remarkably low cost. All that is necessary is to occupy

a station with the instrument and move a target to any number of desired points nearby. The time required for each observation is very brief. Networks of this type have been established at Salton Sea, North Brawley, Heber, and East Mesa KGRAs. The network at the Salton Sea is shown in Fig. 4. We will discuss the necessity

Fig. 4. Network of horizontal control in Buttes area; from Lofgren.¹

and accomplishment of additional local coverage with the Subsidence Research Office; additionally, as mentioned previously, we will request a proposal for inter-ties between the local networks to obtain larger-scale control.

Subsidence Detection Equipment

Extensometers (Fig. 5) that allow determination of the depth of the subsidence have been installed at the Salton Sea field, at Heber, and at East Mesa by the USGS Subsidence Research Office. The type of extensometer installed in the Imperial Valley consists of a moderately deep, cased well (800 to 1200 ft). A string of tubing is placed in the well and anchored at the bottom of the well in such a way that the top of the string of tubing is free to move vertically. Appropriate recording devices are attached to the top of the tubing to record its movement relative to the land surface. If subsidence or compaction occurs below the point at which the tubing is fixed, the top of the tubing will move downward relative to the land surface. If, on the other hand, subsidence or compaction occurs above the fixed base of the tubing, the top of the tubing will move up relative to the land surface. Because the fixed point is chosen so that it is above the potentially productive geothermal reservoir but well below the surface, it will be

possible to determine if a given subsidence effect is probably a result of geothermal activity or other causes.

At this time, there is no extensometer at North Brawley. We plan to have one installed there, most probably by contract with the USGS Subsidence Research Office.

We are presently beginning studies of other types of subsidence-detection equipment, such as tiltmeters and slope meters that may be valuable in early documentation of local differential subsidence. We will procure and install such devices if studies show that this would be useful.

Tide gauges are currently in place around the Salton Sea. By appropriate reduction of data from such gauges, it is possible to detect very small land surface movements in the vicinity of the Sea. We are studying the possibility of adding tide gauges at the

Fig. 5. Surface deformation in an extraction-injection area; from Lofgren.¹

Sea in coordination with the activities of the Subsidence Research Office of the USGS and Imperial County.

Subsidence Modeling

We intend to make a study of subsidence, using the capabilities of the Earth Sciences Division at LLL.

It is intended to take advantage of other work being done to coordinate with the subsidence study. The phenomenon of land-surface subsidence involves three processes:

- the pore-pressure drop around producing wells resulting from fluid flow in the reservoir,
- the time-dependent compaction of the reservoir rocks, and
- the propagation of that compaction upwards towards the surface.

Each process depends upon certain rock properties — porosity, pore pressure, permeability, and the strength of the rock-fluid system — that include a time-dependent factor. The LLL rock-mechanics program can model and test in the laboratory the pressure-porosity behavior of sands and shales from the Imperial Valley. An attempt would be made to relate the response of material to measurable parameters such as major mineral content; grain, pore, and fracture size; permeability; and the like. Such relationships would allow extrapolation to other areas.

Joint LLL and Lawrence Berkeley Laboratory (LBL) field experiments

are planned for the Salton Sea Geothermal Field to determine the communication between injection and production wells. Pressure measurements will be made in wells near a flowing well to estimate how easily injected fluid can migrate toward the production well, reducing the pore-pressure drop there. These measurements may allow an upper limit to be placed on the ultimate pressure drop assuming complete reinjection of fluid.

Because pressure drop is an important factor in the occurrence of subsidence, such information may be used to make some predictions of subsidence. Specifically, if the well-to-well permeability is high and a small ultimate pressure drop is predicted, then an upper bound can be placed on the magnitude of subsidence. Knowing the extent of probable subsidence, we can assess the environmental impact more accurately.

Seismicity Studies

When production of geothermal fluids for electric-power production takes place in the Imperial Valley, it will be necessary to reinject the fluid for the following reasons: disposal of the produced brine, maintenance of reservoir pressure, and control of subsidence. Seismic activity has been induced in other areas of the U.S. by high-pressure injection of fluid into wells. Field

experience at the Salton Sea Geothermal Field has been that injection can be carried out at low pressure; the pressure gradient formed at the formation face by the differential between the densities of the cooled fluid moving down the well bore and the hot water in place in the reservoir has been sufficient to permit injection of water into the formation. While low-pressure injection has not been implicated in inducing seismicity, the possibility cannot be dismissed.

Detection of any earthquakes related to geothermal production will be complicated by the fact that the Imperial Valley is one of the most tectonically active regions in the United States. Furthermore, geothermal fields are usually associated with active faults, making it necessary to distinguish between naturally occurring seismic activity and any increment resulting from geothermal development.

Two criteria are considered to be useful for detecting induced earthquakes: a change in the frequency-magnitude statistics in the vicinity of the geothermal field and a change in the location (particularly depth) of events coincident with geothermal production. Both criteria require baseline measurements of the seismicity in the Imperial Valley before geothermal production begins, and our

program presently centers on obtaining such baseline data.

Vertical Seismometer Network

The U.S. Geological Survey has maintained a 16-station seismograph network in the Imperial Valley for 3 years (Fig. 6). A major objective of our program has been the strengthening of this network. One of our major accomplishments this year has been the issuance of a contract to the USGS to install six seismograph stations in the vicinity of the Salton Sea Geothermal Field; the network is shown in Fig. 7. Installation of the stations was completed late in the fall of 1976, and the stations have been connected to the USGS data-processing network. The stations provide detailed coverage of the immediate area. As a result of the installation of these stations, the regional network has been expanded to provide uniform coverage of the Imperial Valley from the Salton Sea to the Mexican border. The network was designed to locate all events in the Valley with Richter magnitude greater than 1 to 2. Smaller events are masked at large distances by the high seismic noise level in the region. The Valley-wide seismic network is providing data for frequency-magnitude statistics that will be applicable to any geothermal area in the Valley. The contract also

Fig. 6. Seismograph network in Imperial Valley (USGS) (▲), showing added ERDA/LLL stations near Salton Sea geothermal field (●). (Modified from Johnson and Hadley.²)

provides the USGS with a number of portable stations to be placed in case a swarm of earthquakes occurs; if set up immediately in the vicinity of a swarm, such portable stations can provide invaluable information about the seismic behavior during such events. All data from the network will be furnished to us as a part of the contract.

We are presently designing additional local networks in the vicinity of geothermal fields from

which power production is planned. Small-scale networks will be designed to provide more accurate hypocenter^{*} locations and sensitivity to earthquakes of smaller magnitude near the geothermal fields. Local networks already exist at two of the fields:

* The hypocenter of an earthquake is the point within the earth at which the earthquake occurs - in other words, the focus. The epicenter of an earthquake is the point on the earth's surface directly above the hypocenter or focus.

- △ Existing seismic station
- New seismic stations

Fig. 7. Detail of seismic network in Salton Sea area.

the LLL-sponsored expansion of the USGS network near the Salton Sea field covers that area, and the Bureau of Reclamation is operating a network at East Mesa. Networks will be installed at Heber and North Brawley, using designs developed in close coordination with the companies planning to produce the fields and the USGS. The design of the local networks will be based on computer codes used by the LLL Seismic Monitoring Program to estimate the resolution of a seismic network, assuming a level of seismic noise and uncertainty in seismic-velocity models.

An extremely important aspect of discrimination between naturally occurring and induced earthquakes is the availability of a correct model of seismic velocity. The effects of the errors produced by use of an erroneous model can be very important if depth of the event is one criterion for labeling a natural earthquake. Recent evidence indicates that this criterion may be useful. Johnson and Hadley² at the California Institute of Technology have studied the results of seismographic data around the Brawley earthquake swarm of January 1975. The hundreds of events comprising the swarm were shown to occur below the sedimentary layers at a depth greater than 4 km (Fig. 8). Geothermal production and reinjection

would affect these sedimentary layers and would not be expected to cause deeper events. Unfortunately the potential error in depth location for these earthquakes is substantial because of an inadequate velocity model for the Imperial Valley. Two field studies will enable improvement of seismic velocity models for the Valley: the USGS plans calibration explosions to provide known inputs into the regional system, including the new Salton Sea stations, for FY 1977; and in March-April 1975, LLL sponsored a seismic-refraction survey in the Salton Sea KGRA area by the University of California at Riverside. The refraction survey included the detonation of a relatively large explosion to obtain the data. The data obtained from these two studies will provide input for construction of a new seismic-velocity model. With seismographic records of the travel time of an energy input of known magnitude, it is possible to calculate the characteristic velocities of each of the different kinds of rocks in the region. Because the velocity model is so important for correct interpretation of seismic events, we believe that construction of a new model is a vital part of our program. We will construct this during FY 1977.

Fig. 8. Hypocenters of earthquakes, Brawley swarm of January, 1975. Magnitude of earthquake indicated by size of cross; from Johnson and Hadley.²

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IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Socioeconomic Effects

SOCIOECONOMIC EFFECTS

Kendall F. Haven

General

The three goals of the IVEP Socio-economic Impact Assessment program are to characterize the potential range of local impacts of a large-scale geothermal development, to identify the actors and actions within the socioeconomic sphere that are capable of affecting the progress of geothermal development and its impacts, and to identify potential areas of conflict that are associated with large-scale geothermal development. Task definitions and task sequential flows were defined during initial planning for the IVEP.

Progress Summary

The first IVEP status report¹ included general socioeconomic methodology, initial coordination efforts, and task organization. Since that date (March to 1 October 1976) the following progress in the socioeconomic program element was made:

- Four reports²⁻⁵ have been completed and submitted for publication as laboratory reports that cover all aspects of the characterization of the Imperial Valley socioeconomic system.
- All tasks scheduled are now active and on-schedule with the exception of two, the Salton Sea Recreational Study and the Fiscal Service Stress

Analysis. The basic cause for these delays is a lack of requested manpower. Both studies will be covered later through outside contracts.

- Tasks and subtasks for three supporting contracts (approximately \$50,000) for the socioeconomic element have been identified, potential vendors contacted, and contracts submitted to the LLL Purchasing Department.

Individual Task-Progress Summary.

Several major tasks in the socioeconomic element were scheduled for initiation or continuation during the March to October 1976 period.

On-Going Program Coordination.

Active program coordination and arrangements for information exchange are being maintained with a number of local, state, and private sector organizations (see Table 1): To date this information exchange has been used for scenario development and for characterization of the existing system.

Characterization of the California and Imperial County Electrical Flow Systems.

This study was completed and the resulting report submitted for publication.⁵ In addition to the characterization of the county according to the quantity of electrical energy flow from the county to other parts of

Table 1. On-going relationships with outside organizations.

Organization	General program coordination	Baseline information exchange	Scenario development
Imperial County staff	X	X	X
University of California, Riverside	X	X	X
California Institute of Technology	X	X	
University of California, Berkeley Agricultural Extension	X	X	X
University of California, Berkeley Sea Grant Program	X		X
California Energy Resources Conservation and Development Commission	X		X
Jet Propulsion Laboratory	X	X	X
U.S. Environmental Protection Agency	X		
California State Office of Planning and Research	X	X	X
Engineering Economics, Inc.	X	X	
Geonomics, Inc.	X	X	
Economic Sciences, Inc.	X	X	X
California State Employment Development Department	X	X	

California (see Tables 2 and 3 for examples of typical information for Imperial County), linear-regression analysis was made to detect significant correlations between the county level of energy consumption and major characteristic parameters in the county not related to energy.

Imperial County Economic, Fiscal,
and Social Characterization.

Initial characterization of the Imperial County Economic, Fiscal, and Social structure has been completed on schedule and reported.²⁻⁴ These results are summarized in the Integrated Assessment section of this report.

Table 2. Imperial County electrical energy budget for 1972 and 1974.

	1972		1974	
	kWh	Intercounty dollar flow	kWh	Intercounty dollar flow
1. Energy generation				
steam	527,193,700		575,773,800	
hydro	254,305,181		266,139,502	
other	1,431,380		25,298,639	
2. Energy imports				
U.S. Bur. Rec.	232,425,378	-\$1,187,745	216,745,747	-\$1,349,743
S. Cal. Edison	107,453,242	-1,211,240	128,720,462	-2,220,769
Yuma County	1,248,753	-4,059	1,339,724	-4,354
IID Riverside County Plants	1,608,630	0	9,365,621	0
3. Energy exports				
SDG&E	19,200	+133	568,000	+4,672
Riverside County Sales	328,460,167	+5,149,680	310,664,739	+6,301,695
4. Total available in- county electrical energy	797,186,897		912,718,756	
5. Total in-county sales	660,265,987		759,202,361	
6. Nonsale uses	10,729,210		9,962,519	
7. Known losses	130,229,921		142,148,552	
8. Discrepancy	-4,038,221		+1,405,324	
9. % Increase in county sales	N/A		+15.0%	
10. Net intercounty dollar flow		+2,746,734		+2,731,501

Comparative Area Study.

Many tentative study sites for a comparative case-study analysis have been reviewed to date. Table 4 lists the principal sites still under consideration for comparison to development in Imperial County. Basic characterization data for these sites

have been collected; however, data analysis has not proceeded.

Model Identification and Development.

The two major models for this study are an economic sectoral model and a county/subcounty fiscal model. A 1972 base year input/output model

Table 3. Imperial County electrical energy sales and use data for 1972.

	kWh	County totals		County per capita
		% of state total	Rank	Rank
Population		0.38	32	32
Residential electrical sales	276,337,423	0.69	28	16
Commercial electrical sales	256,908,979	0.54	30	15
Industrial electrical sales	76,738,153	0.19	30	34
Sales to public sector	50,525,443	0.47	22	12
Total commercial use	256,921,968	0.54	30	16
Total industrial use	76,738,153	0.19	30	34
Total public sector use	61,254,653	0.39	23	12
Total sales	660,509,998	0.47	28	19
Total county use	671,252,197	0.46	29	20

was developed in March 1976 by Engineering Economics, Inc. under a National Science Foundation grant and updated to reflect 1975 changes. Efforts in this program are being directed toward refinement of recreation-related sectors and agricultural sectors within this basic model. Predictive modeling of the impact of geothermal development on the Imperial County economy will be based on historical information for The Geysers development in Sonoma County. A basic county per-capita-service model for Imperial County based on 1975-76 data is under development. This model will be refined and extended to sub-county levels under a contract with U.C. Berkeley. A recreational study

of the Salton Sea area is being carried out under contract for the assessment of the impact of major alterations in that resource. All model identification and development activities are proceeding on schedule with original time estimates.

Initial Scenario Development.

Basic power-production scenarios for each major Imperial County KGRA are being developed by the Jet Propulsion Laboratory (JPL). These scenarios will be used without alteration by this program. Scenario elements developed by this program include direct-employment and population changes, tax revenues associated with geothermal development, and developmental constraints. Figure

Table 4.. Potential comparative area study case sites.

State	Site area	Type of development
California	Sonoma County	The Geysers geothermal
Oregon	Clatsop County	Major industrial (aluminum plant)
Wyoming	Campbell County	Coal-field development
Wyoming	Sweetwater County	Coal-field development
Idaho	Idaho Falls	National Reactor Test Station
Montana	Rosebud County	Coal-field development
North Dakota	Jamestown	General industrial development
North Dakota	Mercer County	Coal-field development
North Dakota	Stark County	Coal-field development
Colorado	Mesa County	Oil-shale development
Colorado	Garfield County	Oil-shale development
Colorado	Pitkin County	General service-related development
Ohio	Carroll County	Coal strip mining
Ohio	Harrison County	Coal strip mining
Texas	Not yet selected	On-shore oil-field development
Louisiana	Not yet selected	On-shore oil-field development
Florida	Escambia County	Oil-field development
Indiana	Pike County	Coal strip mining
Rhode Island	Tiverton	Refinery construction

1 shows the areas that are potentially excluded from geothermal development if power plants were prohibited from: the preservation zones of the county and within a half mile of their boundaries, cities and within a mile of their boundaries, the Salton Sea, critical habitats and wildlife refuges, and within a mile radius of feedlots, schools, and hospitals. Constraint analyses are based on county-zoning ordinances, county

ultimate-land-use plans, state and federal preserves and critical habitat areas, and various proposed plans for the Geothermal Element of the County General Plan. The socioeconomic portion of this work has been completed.

Preliminary Assessment.

Work on a preliminary assessment is now under way based on preliminary scenarios, system characterization, and project models mentioned above.

Fig. 1. Areas potentially excluded from geothermal development if power plants are restricted from: preservation zones and within a half mile of their boundaries, cities and within a mile of their boundaries, the Salton Sea, critical habitats and wildlife refuges, and areas within a mile radius of feedlots, schools, and hospitals.

The methodology is shown diagrammatically in Fig. 2. The goal of this phase of the assessment process is to identify areas of critical concern for further study and general order-of-magnitude estimates of large-scale

developmental impacts. The Detailed Studies listed on Fig. 2 are those that have been tentatively identified as areas for further detailed study. Work on this is proceeding on schedule.

Fig. 2. Assessment methodology for socioeconomic impacts.

References

1. L. R. Anspaugh and P. L. Phelps, Eds., *An Overview of the Imperial Valley Environmental Project*, Lawrence Livermore Laboratory, Rept. UCID-17067 (1976).
2. K. F. Haven, "County Economic Characterization," in *A Description of Imperial Valley, California, for the Assessment of Impacts of Geothermal Energy Development*, (D. W. Layton and D. L. Ermak, Eds.), Lawrence Livermore Laboratory, Rept. UCRL-52121 (in press).
3. K. F. Haven, "County Fiscal Characterization," in *A Description of Imperial Valley, California, for the Assessment of Impacts of Geothermal Energy Development*, (D. W. Layton and D. L. Ermak, Eds.), Lawrence Livermore Laboratory, Rept. UCRL-52121 (in press).
4. K. F. Haven, "Social Characterization of Imperial County," in *A Description of Imperial Valley, California, for the Assessment of Impacts of Geothermal Energy Development*, (D. W. Layton and D. L. Ermak, Eds.), Lawrence Livermore Laboratory, Rept. UCRL-52121 (in press).
5. K. F. Haven, *The 1972 Flow of Electrical Energy in California and Its Relationship to Selected County Level Characteristic Parameters*, Lawrence Livermore Laboratory, Rept. UCRL-52143 (1976).

SECRET

1. The purpose of this document is to provide information regarding the activities of the [redacted] in the [redacted] area.

2. The [redacted] has been observed in the [redacted] area, and it is believed that it is engaged in [redacted] activities.

3. It is recommended that the [redacted] be monitored closely, and any further activities be reported immediately.

4. The [redacted] is a [redacted] organization, and its activities are of [redacted] interest.

5. This document is classified [redacted] and should be handled accordingly.

IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Health Effects

HEALTH EFFECTS

Lynn R. Anspaugh

During initial planning for the Imperial Valley Environmental Project (IVEP), it was recognized that a health-effects element of the Project would be highly desirable. This was not because adverse health effects from geothermal effluents were anticipated on the basis of known facts, but because health effects are the endpoint of major concern. A complete integrated project must therefore address health effects, and not merely by the completion of calculational exercises without the benefit of actual data. The collection of health-effects data beyond readily available mortality statistics, however, can be very difficult and expensive. On the other hand, the population in Imperial County is rather small, and the possibility of detecting actual health effects due to geothermal effluents is severely limited if only mortality data are available. Because of these conceptual design dilemmas and because any conceivable health effects would not be expected for several years, it was decided to delay the implementation of health-effects studies. Personnel of the Division of Biomedical and Environmental Research (DBER) of the Energy Research and Development Administration (ERDA) concurred in this decision. Since then, the ERDA-DBER has designated a Manager for

Human Health Studies Programs, who would have ERDA funding and scientific management responsibility for an IVEP health-effects study.

Efforts have continued to define a health-effects program that will be implemented during 1977. Contacts have been established with the Epidemiological Studies Laboratory and the Air and Industrial Hygiene Laboratory of the California Department of Health and with the Imperial County Health Department. It is anticipated that these agencies will be funded to perform much of the actual health studies. The California Department of Health has had relevant experience¹ in conducting studies in the vicinity of pulp mills, which also release H₂S.

We anticipate that the health-effects studies will include four major tasks. The first will be to examine available source-term data for expected effluents and to review the relevant scientific literature for known health effects. The expected output would be a published review that would contain dose-response curves for specific effluents, a relative ranking of the effluents in terms of possible effects, and recommendations for basic health-effects research, if appropriate. The need for dose-response curves is great, not only for geothermal energy but for all energy sources. It is unfortunate that at least one author² has

attempted to set health-effects priorities for geothermal effluents based upon the naive assumption of a universal no-threshold, linear-dose response. This resulted in very high priorities assigned to manganese and iron, two elements which are essential for human health.

The second task would be to establish an exemplary program for reporting health statistics in Imperial County. The goals would include a more rapid accumulation of mortality data in a form suitable for summarization and analysis, and comparison of these data to past trends in Imperial County and to data for the entire U.S., the State of California, and counties of similar characteristics. Morbidity data would also be collected from available sources such as hospitals and records kept by other government agencies. Such a program should be of significant benefit to Imperial County and State health authorities for numerous purposes.

The third task would be to conduct community-response surveys. The

purpose would be to document the perception of the annoyance and health effects of odor pollution in Imperial County. This aspect of the study is primarily oriented toward the potential effects of H_2S emissions. These response studies would include measurements of H_2S concentrations in ambient air and measurements of odor pollution by dynamic olfactometry. These studies should be structured to provide baseline data, as Imperial County has many current sources of odor pollution such as feedlots. Resurveys would be necessary as geothermal development proceeds.

The fourth task would be to review occupational health programs at all geothermal facilities and to examine whether special health monitoring programs would be desirable. Such programs would have the goals of providing added protection to occupational personnel and in providing the earliest possible detection of health effects should they occur.

References

1. J. R. Goldsmith, Ed., *Health and Annoyance Impact of Odor Pollution*, U.S. Environmental Protection Agency, Rept. EPA-650/1-75-001, NTIS, Springfield, Va. (1973).
2. L. Schieler, "Geothermal Effluents, Their Toxicity and Prioritization," in *Proc. First Workshop on Sampling Geothermal Effluents, Las Vegas, Nevada, October 20-21, 1977*, U.S. EPA Environmental Monitoring & Support Laboratory, Las Vegas, Nevada, Rept. EPA-600/9-76-011 (1976).

IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Integrated Assessment

INTEGRATED ASSESSMENT

Introduction

David W. Layton

An end goal of the Integrated Assessment Program is to produce a set of impact assessments of alternative geothermal scenarios in the Imperial Valley. Other important responsibilities of the program are to review the adequacy and relevancy of the data measurement programs and to transfer information to government agencies, legislative bodies, and planning groups.

To conduct the assessment, work has proceeded in several areas. First, relevant historic information has been collected on the region and presented in a general report. Work has also progressed on a set of geothermal energy scenarios which include levels and timing of energy production, technology characterizations, and considerations of power plant siting criteria. Concurrent with the scenario development has been the modification of a Gaussian air pollution model for use in preliminary air quality assessments. This effort will serve as a basis for a more detailed modeling study to be conducted in conjunction with the Air Quality Element. The impacts of gaseous pollutants on selected crops will be simulated by a crop growth model that has been developed during the past year. Additional work has been done on legal

analysis of geothermal legislation and on the legal aspects of water supply utilization. Research on the potential water resource impacts of geothermal facilities rounds out the initial assessment tasks.

Data acquired by the measurement groups (i.e., air quality, water quality, ecosystem quality, etc.) of IVEP have been systematically entered into a data base for future retrieval and analyses. And as part of the information transfer function of the Integrated Assessment Program, data is now being prepared for submission to the Air Resources Board of California. Important contacts have been made with Imperial County and the Imperial Irrigation District, the primary political units in the Valley, in order to facilitate the exchange of information.

Description of the Imperial Valley, California

Donald L. Ermak and David W. Layton

Before an assessment of the impacts of geothermal energy development in the Imperial Valley can take place, the existing physical and biological environments of the region must be characterized. Therefore, the initial efforts of the Integrated Assessment group in the IVEP were to acquire relevant background information on the Valley, to analyze it, and then to describe significant features that

would affect future assessments. The end product of those tasks is a report entitled, "A Description of Imperial Valley, California, for Assessment of the Impacts of Geothermal Energy Development," edited by David Layton and Donald Ermak.¹

Principal features of the Valley include:

- The irrigation of about 475,000 acres of agricultural lands,
- A desert climate characterized by an annual rainfall of under 3 inches, hot summers, and mild winters,
- High particulate loadings in the atmosphere that exceed annual primary and secondary air-pollution standards,
- Nearly three million acre-feet of water imported from the Colorado River each year,
- Surface-water salinities that vary between 900 ppm total dissolved solids (TDS) in canals to over 39,000 ppm TDS in the Salton Sea,
- An agricultural economy dominated by livestock and dairy products, field crops, and vegetable crops,
- A soil-salinity problem that has necessitated the development of an extensive subsurface-drainage system,
- The existence of a sport fishery in the Salton Sea as well as state and federal game refuges,

- A geothermal-energy potential of over 4,000 megawatts for 25 years,
- A county budget of \$38.7 million during fiscal year 1976 for a per-capita budget of \$519.8, and
- A county population of just under 84,000 in 1974.

The following paragraphs, taken from the introduction of the Imperial Valley characterization report, contain additional background information.

Land and Air Resources

"The Imperial Valley occupies the lowest part of the Colorado Desert. It receives water from the Colorado River to support about 475,000 acres of irrigated lands. The waste waters from these lands help sustain the Salton Sea, California's largest inland body of water. Geologically the Valley is characterized by earthquakes, active faults, and natural subsidence. Hot summers, mild winters, and an average annual rainfall of under 3 inches define its climate; stable atmospheric conditions, westerly winds, and night time inversions are important meteorological features. The most prominent characteristic of the air quality is the high levels of suspended particles that exceed federal standards.

Water Resources

"Nearly 3 million acre-feet (af) of Colorado River water are diverted

to the Valley each year by the Imperial Irrigation District. To distribute that water and remove unwanted waste waters, over 3,000 miles of canals and drainage ditches cover the Valley. Waste waters entering the Salton Sea have caused its level to rise for many years, and the sea is now at its highest elevation in recent years. Surface water salinity ranges from about 900 ppm total dissolved solids (TDS) in the All American Canal to almost 39,000 ppm in the Salton Sea. Sediments underlying the Valley contain more than a billion acre-feet of ground water having salinity less than 35,000 ppm. Natural recharge in this arid region is quite low, yet millions of acre-feet have been added to shallow aquifers from canal seepage.

Biological Resources

"There is an extensive, irrigated agricultural region, a quasi-marine inland saltern ecosystem, state and federal game reserves with many shorebirds and waterfowl, five endangered species of birds, freshwater and riparian ecosystems, and extensive desert communities in the Imperial Valley. Agricultural lands produced gross sales in 1974 of \$557 million of which \$155 million was in livestock and dairy products, \$284 million in field crops, and \$103 million in vegetable crops. In acreage harvested, the most important crops are alfalfa,

wheat, cotton, sugar beets, lettuce, sorghum, pasture ryegrass, cantaloupes, carrots, barley, asparagus, onions, and tomatoes. The unique climate is such that most vegetable crops grow in the winter months and most field crops grow in the spring and summer months. Soil salinity problems are important in the Valley and require large amounts of Colorado River water for leaching and an extensive underground pipe drainage system to carry off water and dissolved salts. The leached salts are eventually emptied into the Salton Sea. Of the many attempts to introduce new species into the Sea, only a few have been successful. Currently there are eight fish and seven invertebrate species. The sea has high levels of nutrients that create an unusually high productivity ($0.75 \text{ g/m}^3/\text{day}$ of carbon fixation). Extensive shorebird (35 species) and waterfowl (47 species) (excluding swans, ducks, geese, cranes, and rails) populations exist around the Salton Sea especially in the state and federal game refuges. The Salton Sea is on the Pacific Flyway and hosts large migratory populations (a total of 9.7 million waterfowl use days in 1971 for the Salton Sea National Wildlife Refuge). Outside the irrigated areas in the Valley lies the Sonoran desert. Typical desert communities of creosote brush, sage, mesquite, ironwood, and desert

willow dominate the Glamis, East Mesa, and Dunes Known Geothermal Resource Areas (KGRAs). In these KGRAs some areas are dominated by dune communities of very sparse vegetation and a shifting, sandy soil. The balance of the area in these KGRAs is mixed bajada (alluvial fans) communities or creosote communities.

Geothermal Resources

"As early as 1927 efforts were made to develop the geothermal resources in the Imperial Valley. Mineral extraction, carbon dioxide recovery, and power production have all been attempted, but with limited success. Some of the current geothermal activities are electric power conversion research, impact studies of proposed geothermal projects, base-line environmental studies, and exploratory drilling. Of the 6 KGRAs, only the Salton Sea, Heber, East Mesa, and Brawley areas are expected to be developed. Estimates of their total electrical potential are under 5,000 MW for 30 years. The Salton Sea KGRA has the greatest energy potential because of its high down-hole temperatures (average of 286°C), yet it may be the hardest to develop since brines found there average over 200,000 ppm TDS. In comparison, the Heber KGRA has geothermal fluids of around 20,000 ppm TDS, while those

of the East Mesa KGRA are about 2,100 ppm TDS. Other relevant characteristics of the geothermal fluids in the valley include a steam content of between 10 to 25% by weight and the presence of minor amounts of noncondensable gases.

County Economic Characterization

"The Imperial County economy is dominated by agriculture, its associated support services, and product processing. Agricultural activities are dominated by beef cattle and by general field crops. In 1974, 85.9% of the total valley acreage was planted in field crops with a total dollar value of \$284 million. There was a decline in beef production in 1974 with 720,000 head raised in valley feed lots (down from 798,000 in 1973) with a total value of \$151 million (down from \$186 million in 1973). While strong in the agricultural sectors, the Imperial County economy is weak in manufacturing and construction activity compared to the state as a whole. Recent county employment patterns show a steady decline in agricultural employment (down 48% between 1960 and 1970) as agriculture has become more mechanized. During the same time, a steady increase occurred in nonagricultural employment. Mexican greencard labor represents under 2% of the county nonagricultural employment and

roughly 70% of the agricultural work force. Within the county, El Centro is the industrial, commercial, and general economic center representing well over half of all county retail sales. A second significant center is Calexico, which is located on the U.S.-Mexico border and serves both Imperial County and Mexican markets.

County Fiscal Characterization

"The Imperial County budget for fiscal year 1976 totaled \$38.7 million for a per capita budget of \$519.8. About 25% of the county's revenues that year came from the federal government, and a second 25% came from the state of California. Income from local taxes and fines accounted for 26.5% of the county's income. The remainder of fiscal 1976 income was derived from carry over and service charges.

During the fiscal year, \$30.8 million was spent on education by the school districts. The average cost per year per student in an elementary school was \$1,220, while that of a secondary school student was \$1,385. These figures have increased over the past decade by 110% for secondary education and by 170% for elementary education.

County Social Characterization

"The 1974 population of Imperial County is estimated to be just under 84,000; the 1970 official census figure was 74,492. Approximately

95% of the population is concentrated on the agriculturally rich land of Imperial Valley. The 1970 census reveals major characteristics of this population: an unusually low percentage of young adults (ages 18 to 24); a high percentage of children under 13 yr old; a large number of Mexican-Americans, as would be expected of a border county; the highest percentage of any California county of adults with minimal educational attainment (less than an 8th grade education); and, finally, income levels comparable to most other California counties.

Geothermal Laws

"Statutes and regulations made at federal, state, and county levels have a strong influence on the development of geothermal resources in the Imperial Valley. The Geothermal Steam Act of 1970 governs the leasing of federal lands for geothermal projects. Important conditions of the Act are an acreage limitation on leases and the exemption of federal lands related to the protection of wildlife. Regulations promulgated under the legislation are designed to protect the environment as much as possible from the effects of geothermal development. The federal government also operates a loan guaranty program for geothermal projects. California statutes directly associated with geothermal

resources control the leasing of state lands and the drilling of geothermal wells. Certification of geothermal power plants is done by the state's Energy Resources Conservation and Development Commission. Imperial County also has regulations that involve geothermal activities. Those regulations ensure that geothermal projects are conducted in a manner that is consistent with existing environmental laws and regulations, county land use zones, and other specific conditions."

Geothermal Scenarios for Imperial Valley

Donald L. Ermak

The goal of this task is to develop a set of scenarios that describe potential levels of geothermal development in Imperial Valley over the next 30 years. Each final scenario will include: the level of electric-power production for each Known Geothermal Resource Area (KGRA) in Imperial Valley, the number and size of each power plant required to meet the power-production levels, the location of existing or planned geothermal-power plants, the designation of those geographical regions in which the remaining power plants are to be sited, the cooling water requirements and the residual emissions from the power plants. These scenarios will be evaluated under other tasks for the

impacts upon air quality, available water, biota, agriculture, and human health. Current efforts are summarized below.

The Jet Propulsion Laboratory (JPL) is developing power-production scenarios for each Imperial Valley KGRA. A preliminary version of the JPL report² has been reviewed. The nominal scenario calls for 4500 MW of electric power production in Imperial Valley by 2020. This is in fairly good agreement with the maximum-power-production levels predicted by Towse³ and other recent predictions (for a review see Ref. 4). Consequently, the power-production levels proposed by JPL will be used in the LLL scenarios for Imperial Valley.

The designation of geographical areas for future power-plant siting requires the consideration of numerous factors including resource location, available water, proximity to cities, conflicts in land use, and seismic risk. We are developing a set of siting criteria for determining the areas of geothermal development for each scenario. The main criteria seem to be the following:

- Power plants must be located near (<1 mi) the geothermal wells since large energy losses occur in transporting geothermal fluids.

- There is a maximum size for power plants (about 100 MWe) because of the distribution of the resources.
- There are exclusion areas (cities, habitats of endangered species, etc.) within the Imperial Valley KGRAs in which geothermal development cannot occur.
- The total size of the exclusion areas will be significantly affected by the buffer zones required by local ordinances.

The emissions from geothermal power plants depend upon the chemical composition of the fluids, the geothermal technology, and the control technology. The chemical composition of the geothermal fluids for many of the wells in Imperial Valley have been analyzed.⁴ The amount of noncondensable gases associated with the fluids has not been measured in Imperial Valley; however, this is being pursued by the IVEP Air Quality field program and will be incorporated into the scenario development as the data are obtained. The possibility of an outside contract is now being considered for the technology-description portions of this task because of personnel reductions in the Integrated Assessment group.

We are developing a set of preliminary scenarios to be circulated among the other working groups for review and for use as the basis for initial

assessments. These scenarios will include:

- The electric power-production level in MWe for each KGRA,
- The number and size of each power plant to be located in each KGRA,
- The locations of existing or proposed power plants, and
- The geographical areas for siting additional power plants to meet the proposed power-production level.

An LLL report covering the initial Integrated Assessment activities on scenario development is in preparation.⁵

A Model of Crop Photosynthesis and Growth under Gaseous Pollutant Stress

James R. Kercher

Introduction

One of the tools being developed for environmental assessments of the impact of geothermal development is a general model of photosynthesis and plant growth. This model is general enough for modification and parameterization for any of the number of crops grown in the Imperial Valley. The model simulates photosynthesis as a direct function of temperature, sunlight, CO₂ concentration in air, stomatal resistance, and biochemical parameters of the plant. Indirectly, photosynthesis is treated as a function of relative humidity, plant

moisture stress, and soil salinity since these parameters affect transpiration and stomatal resistance. A coupled set of ordinary differential equations is used to describe growth and allocation of photosynthate during the growing season. These equations contain temperature-dependent expressions for respiration to account for photosynthate loss. Respiration is modeled as two components, maintenance respiration and growth-dependent respiration.

A preliminary version of the model is currently implemented to run on LLL computers. This version is parameterized mainly with data taken from corn. Hypothetical environmental parameters are used for model testing and computer-code debugging. These values are typical of what might be expected in the summer months in a temperate climate.

Model Inputs

The model requires four types of data:

- Climatic data including latitude, incident-light levels, total radiation into canopy, total radiation absorbed by the ground, air temperature, precipitation, wind above the canopy, and wet- and dry-bulb temperatures.
- Plant parameters including parameters to calculate stomatal resistance as a function of light,

temperature, and water stress; parameters to calculate the turbulent-diffusion resistance of the canopy and the wind profile; parameters to calculate leaf-boundary-layer resistance; values of cell-wall- and protoplasm-diffusion resistance of mesophyll cells; biochemical parameters involved in photosynthesis; respiration rate of leaves at a base temperature and Q_{10} value; maintenance-respiration rate per unit biomass; growth-respiration rate per unit biomass added per unit time; total-leaf-area index of mature plants; growth parameters of leaf, stem, fruit, and root; and translocation parameters of leaf storage influencing photosynthesis and movement from leaf to main storage.

- Soil parameters including soil temperature; soil salinity; parameters for calculating soil-water potential from soil-moisture content, soil resistance from soil conductivity; depth of soil compartment; and root resistance to water flow.
- Pollution data including daily maximum and diurnal distribution; and parameters for calculating photosynthesis reduction or enhancement as a function of pollutant load.

Model Structure: Photosynthesis and Growth

The model structure is outlined in Fig. 1. Atmospheric CO_2 diffuses into the plant to the chloroplast through the leaf-boundary layer, the stomata, the cell wall, and the protoplasm. Leaf-boundary-layer resistance is determined by wind. Stomatal resistance is determined by light level, temperature, and water stress. The CO_2 is then converted to CH_2O by the absorption and conversion of the energy of light quanta (photosynthesis). Light levels are calculated in the canopy as a function of time of day and canopy structure. The thickness of the canopy (leaf-area index F) is determined by the biomass in the leaf-

structure compartment, x_1 . The photosynthate generated in the canopy is entered into a leaf-storage compartment, x_2 . From the leaf-storage compartment, the photosynthate first meets the demands of the leaf-structure compartment including growth, respiration, and maintenance respiration. Remaining photosynthate is translocated, T_3 , to the main-storage compartment, x_3 . The respiration demands, including both maintenance and growth respiration, of main storage, stem x_4 , fruit x_5 , and roots x_6 are met by main storage. In addition, main storage meets the growth demands (T_4 , T_5 , and T_6) of compartments x_4 , x_5 , and x_6 . The equations for growth and allocation are

$$\frac{dx_1}{dt} = T_1,$$

$$\frac{dx_2}{dt} = \frac{S_2 P_n H(P_n)}{S_2 + x_2/x_1} + H(-P_n)P_n - (1+r_g(t))T_1 - T_2 - r_m(T)T_2,$$

$$\frac{dx_3}{dt} = T_3 - (1+r_g)(T_4 + T_5 + T_6) - r_m(T_r)x_6 - r_m(T)(x_3 + x_4 + x_5),$$

$$\frac{dx_4}{dt} = T_4 - r_m(T)x_4 H(a_4 x_4^\alpha - x_3),$$

$$\frac{dx_5}{dt} = T_5 - r_m(T)x_5 H(a_4 x_4^\alpha - x_3),$$

and

$$\frac{dx_6}{dt} = T_6 - r_m(T_r)x_6 H(a_4 x_4^\alpha - x_3),$$

where P_n = net photosynthetic rate ($\text{g/m}^2/\text{da}$),

$$H(x) = \begin{cases} 1 & x > 0 \\ 0 & x < 0, \end{cases}$$

r_g = growth respiration rate (function of temperature),

r_m = maintenance respiration rate (function of temperature),

and S_2 , a_4 , and α are empirical parameters of growth. The equations for T_1 , T_3 , T_4 , T_5 , and T_6 are:

$$T_1 = e_1 x_1 \left[k_D H(D_L - t) + k_n H(t - D_L) \right] \frac{x_2/x_1}{c_2 + x_2/x_1} (1 - P_{\ell t d n s} x_1/a_2 F_o),$$

$$T_3 = T_{rns} x_2 \left[\frac{a_1 x_2}{x_1 + x_2} - \frac{b x_3}{x_3 + x_4 + x_5 + x_6} \right] H \left[\frac{a_1 x_2}{x_1 + x_2} - \frac{b x_3}{x_3 + x_4 + x_5 + x_6} \right] H \left[\frac{x_2}{x_1 + x_2} - S_2' \right],$$

$$T_4 = e_4 \alpha x_4^{\alpha'} H(x_3 - a_4 x_4^{\alpha'}) \frac{x_3 - a_4 x_4^{\alpha'}}{b_4 + x_3 - a_4 x_4^{\alpha'}},$$

$$T_5 = H(\tau - \tau_0) e_4 \beta x_5 H(\tau_1 - \tau) H(x_3 - a_4 x_4^{\alpha'}),$$

and

$$T_6 = \frac{K}{|\Psi_s|} x_6 \frac{x_3 - a_4 x_4^{\alpha'}}{b_4 + x_3 - a_4 x_4^{\alpha'}} H(x_3 - a_4 x_4^{\alpha'}).$$

The parameters, e_1 , T_{rns} , and e_4 , are empirical growth or translocation parameters with units of da^{-1} ; and k_D , k_n , c_2 , a_1 , b , S_2' , α , β , and α' are empirical growth parameters of allocation and are unitless. τ is a physiological time parameter, τ_0 initiates fruit growth (degree-da), and τ_1 terminates fruit growth. a_4 and b_4 are in units of $(g/m^2)^{-\alpha'}$ and g/m^2 , respectively. K is a root-growth parameter in units of bars da^{-1} . Ψ_s is soil water potential. D_L is the length of the day. F_o is maximum leaf area index allowed. $P_{\ell t d n s}$ is the

number of plants/ m^2 and a_2 converts leaf biomass to leaf-area index with units g/m^2 .

$P_{\ell t d n s}$ is the number of plants/ m^2 and a_2 converts leaf biomass to leaf-area index with units g/m^2 .

A detailed model description is being prepared as an LLL report.

This submodel has relied in part on the work of Shugart, *et al.*,⁶ Curry,^{7,8} and Chen, *et al.*⁹

Model Structure: Water Budget and Transpiration

This submodel calculates water stress and provides information to

Fig. 1. Crop-growth-model framework. The environmental variables of light, wind, CO_2 concentration, temperature, and precipitation determine behavior of plant properties. The model shown here traces the factors determining photosynthesis, respiration, and the allocation of photosynthate. The leaf submodel is in the center of the diagram with leaf resistances on the left and the biochemical model on the right. Solid lines are flow of photosynthate. Dashed lines are causal flow in information-controlling processes.

the stomatal resistance in the photosynthesis submodel. We have implemented a relatively simple model that we have modified from the work of Curry and Chen.^{7,8} We are now implementing a more complex model that is based on the work of Goldstein and Mankin.¹⁰ The version adapted from Curry is shown in Fig. 2. A differential equation of the rate of change

of soil-water content equalling the difference between precipitation rate and transpiration rate is integrated to determine soil-water content. Soil-water content determines soil-water potential, and soil-water potential determines stomatal resistance. Stomatal resistance along with climatological variables determines transpiration rate. A second, more

Fig. 2. Evapotranspiration model as a modified version of a model by Curry.^{7,8} Solid lines are flow of water. Dashed lines are causal flows of information from one variable controlling another variable. Center portion is leaves with variables of temperature T_2 and water vapor pressure P_2 . F is leaf-area index, which determines the number of canopy layers. Crooked lines are resistances to water-vapor flow.

complex model is being implemented because of the inadequacy of the first model in determining stomatal resistance. Stomatal resistance is known to fluctuate during the day as the radiative load increases transpiration rates, which in turn increase plant-water stress. Hence the second model shown in Fig. 3 uses leaf-water potential to determine stomatal

resistance. In this model, translocation from the soil is equated to transpiration to calculate leaf-water potential, which is then used to calculate stomatal resistance. As before, the state variables are water contents in three storage compartments: canopy storage x_9 , soil-surface zone storage x_8 , and rooting-zone storage x_7 . The time derivative

Fig. 3. Evapotranspiration model as a modified version of a model by Goldstein and Mankin.¹⁰ Solid lines represent the flow of water. Dashed lines represent flow of information from one variable to another where the first controls the second. In this model, leaf potential ψ_L controls translocation and stomatal resistance, which in turn controls transpiration. Transpiration is set equal to translocation.

of each compartment is equated to the difference between input and output rates.

A detailed description of these processes will be given in the LLL report in preparation.

Preliminary Example of Model

Results

In Fig. 4, we show a typical output of the current version of the model in the case of no pollution. It is parameterized by corn data from Sinclair,¹¹ Stewart,¹² and Curry and Chen.⁸ Respiration values for cotton (Thornley and Heskith)¹³ are used.

In Fig. 5, we show the model output with a pollution level of SO_2 at 10 ppm, and in Fig. 6 we show the output with a pollution level of SO_2 at 50 ppm. The data to parameterize the pollution-effects function were taken from Bennet and Hill¹⁴ and are valid for barley and alfalfa. Notice the enhanced growth at 10 ppm and the deleterious effects at 50 ppm.

Further Research and Modifications

The model needs developmental work in several areas. First of all, pollution effects are handled at an empirical level and not a biochemical level. Second, the current section on water stress and stomatal control is currently being altered along the lines suggested above because the current version is unrealistic and inadequate. Third, the root-growth algorithm is giving results

counter to experimental evidence on the effects of soil salinity on root growth.

Future plans in modeling pollutant effects on plant growth include the eventual incorporation of effects of nutrient levels on plant growth. This topic is crucial in understanding the growth-enhancing properties of some pollutants at low concentrations. Finally, this point raises the whole question of synergisms and antagonisms, whether between pollutants or between pollutants and nutrients. This problem is fundamental to understanding the behavior of vegetative systems under pollutant stress. It is an area in which integrated research projects on energy technologies are uniquely capable of providing leadership by coupling sophisticated field-research efforts and computer-modeling techniques.

Legal and Institutional Aspects of Water Management Alternatives

David W. Layton and James C. Wharton

Two major sources of cooling water for geothermal power plants in the Imperial Valley are imported Colorado River water and drainage water from irrigated agriculture contained in the Valley's rivers and drains. The use of those waters, however, is governed by a body of law that involves statutes and court decisions on the

Fig. 4. Output of model for growth without pollution stress.

Fig. 5. Output of model for growth with a constant pollutant stress of 10 ppm SO₂ with data for barley and alfalfa with stress effects.

Fig. 6. Output of model for growth with a constant pollutant stress of 50 ppm SO_2 .

state and federal level. A preliminary review of existing laws indicates that several questions need to be addressed to evaluate the availability of cooling water from a legal point of view. Those questions revolve around laws affecting the appropriation of surface waters and the distribution of water to users within an irrigation district. The specific questions being considered are as follows:

- How is Colorado River water allocated to California appropriators during times of both excess and reduced flows?

The answer to this question requires information related to the

water rights of California users of Colorado River water and the statutes and court decisions controlling the allocation of river water. To date, background material has been acquired on water rights and on the 1964 decree of the U.S. Supreme Court concerning the appropriation of Colorado River water by Arizona and California. The relationship of the existing water rights to the court decree must now be defined. It is expected that relevant information can be obtained on that relationship from the Colorado River Board of California.

- Is there public water in the New and Alamo Rivers? And if so, can it be appropriated for evaporative-cooling devices?

The second question requires an analysis of existing state laws and administrative regulations involving the appropriation of surface water. Discussions will also be held with staff working for the California State Water Resources Control Board, the agency responsible for granting water rights on unappropriated waters. Another aspect of this question is whether the control board regards the water in the New and Alamo Rivers as being fresh. If it does, the appropriation of water for cooling purposes may be hindered by existing board policy.¹⁵

- What are the legal implications of using agricultural drainage waters in the Imperial Irrigation District?

A review of past court decisions will probably provide the basic answers to apparent discrepancies in existing laws affecting drain waters.

It appears that under Section 20078 of the California State Water Code an irrigation district is empowered to salvage or recapture water for beneficial uses and presumably that water could be in drains. However, at least one court decision¹⁶ has ruled that the state has jurisdiction over unappropriated water in drains. That decision along with other relevant court cases must be examined to determine the legal status of drain water in an irrigation district.

- Could the purchase of land within the irrigation district guarantee the delivery of water?

This final question could become quite important if the irrigation district at some future time decided not to allocate irrigation water to geothermal power plants. In such a situation an electric utility planning to operate a plant might be able to avoid that constraint by leasing or buying a certain amount of farmland within the district and then use the water normally consumed in irrigation for power-plant cooling.

Research on this particular question will again entail a review of present statutes and appropriate court decisions.

Comparison of the Effectiveness of Federal and State Geothermal Lease Laws

James C. Wharton

A preliminary study¹⁷ of the laws that pertain to the development of geothermal resources in the Imperial Valley was completed. The study describes federal statutes, federal licenses and permits, state geothermal lease statutes, state regulation of geothermal wells, and regulation of the geothermal resource. The federal law is primarily contained in the Geothermal Steam Act of 1970.¹⁸ This Act provides for geothermal leases and the use of associated geothermal

steam resources underlying public lands. The Secretary of the Interior is authorized to issue leases for the development of geothermal steam and the associated geothermal steam resources in much the same manner as he was authorized to lease land for development of their oil and gas deposits under the Mineral Leasing Act of 1920, as amended.¹⁹ The definitions under the mineral leasing laws were amended to include geothermal resources:

"Mineral leasing laws shall mean the Geothermal Steam Act of 1970 which are amendatory of or supplementary to any of the foregoing Acts; Leasing Act minerals shall mean all minerals which are provided in the mineral leasing laws and all geothermal steam and associated geothermal resources which, upon the effective date of the Geothermal Steam Act of 1970, are provided in that Act to be disposed of thereunder (30 U.S. Code Section 530)."

The Secretary of the Interior may issue leases for the development and utilization of geothermal steam and associated geothermal resources in any national forest or other lands administered by the Department of Agriculture through the Forest Service, including public, withdrawn, and acquired lands, and in lands that have been conveyed by the United States subject to a reservation of the United States of the geothermal steam and associated geothermal

resources therein.²⁰ The definitions of geothermal lease, geothermal steam, and associated geothermal resources are given in the Act.¹⁸

Certain federal lands are exempted from geothermal leasing. Geothermal leases shall not be issued for lands administered in accordance with the Act of August 25, 1919, for lands within a national recreation area, for lands in a fish hatchery administered by the Secretary, wildlife refuge, wildlife range, game range, wildlife-management area, waterfowl-production area, or for lands acquired or reserved for the protection and conservation of fish and wildlife that are threatened with extinction, for tribally or individually owned Indian trust or restricted lands, within or without the boundaries of Indian reservations.²¹

Although the Secretary of the Interior has the power to lease lands that have been conveyed by the United States subject to a reservation of the mineral rights under Section 1002,²⁰ this does not decide who owns the geothermal resource. Under Section 1020,²² the Secretary of the Interior may, upon finding that development of geothermal resources is imminent, report to the Attorney General, and the Attorney General is directed to institute an appropriate proceeding in the United States district court of the district in which

such lands are located to quiet the title of the United States in the geothermal resource. In the event that the resource is reserved to the United States, their development may be enjoined until compliance with leasing requirements. Thus, Congress evaded the issue of the ownership of the geothermal resource and deferred it to the courts.

To further complicate the matter, the reservation of mineral rights to the United States may reserve only part of the geothermal resource and leave part of the resource in private hands. In a letter by the Deputy Solicitor, U.S. Department of the Interior, Edward Weinberg states that water has not been treated as a mineral in the public land laws. No statute has been passed by Congress that treats water as a mineral. Thus, if the geothermal resource is treated as water, it would not be reserved. On the other hand, any minerals connected with the geothermal steam would be subject to the mineral reservation. In the federal act, the geothermal resource is characterized as geothermal steam. Geothermal steam is essentially just subterranean water heated to a high temperature and would not be reserved to the United States, according to the Solicitor. Not all geothermal resource is geothermal steam.

In California the definition of geothermal resource that predates the Geothermal Steam Act is somewhat different than the federal characterization. Public Resources Code Section 6903²³ defines geothermal resources as follows: "For purposes of this chapter, 'Geothermal Resources' shall mean the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas or other hydrocarbon gas or other hydrocarbon substance." Since the definition of the geothermal resource includes the energy "in, resulting from, or created by, or which may be extracted from," heat, this definition covers energy in the form of pressure as well as heat. This broad-based definition also clearly includes hot-rock massifs and geopressed fluids because of the particular language used. Solute minerals and other substances are part of the resource, but the heat-exchange mediums themselves appear to be excluded. The language limits the resource to energy, heat and pressure, and minerals and does not

include the transfer medium unless "other products" is interpreted to mean and include the heat-transfer medium. The California law makes clear distinctions between wells for water, geothermal energy, and oil and gas. Section 3742.2²⁴ provides for certificates of primary purpose that create a rebuttable presumption of absolute title to geothermal resources from wells that are primarily for the purpose of producing geothermal resources and not for the purpose of producing water usable for domestic or irrigation purposes. Furthermore, Division 7 of the California Water Code Section 13710²⁵ declares that water wells do not include oil and gas wells, or geothermal wells. This seems to settle the matter that under California law geothermal resources are not water resources, which is completely the opposite of the federal situation discussed above.

In reviewing the cases under the National Environmental Policy Act (NEPA), 42 U.S. Code Sections 4321 et seq.,²⁶ it is clear that environmental considerations must be taken into account in the development of the geothermal resource. On the other hand, as long as the procedural requirements of the Act are met, NEPA should not be a particularly egregious impediment to geothermal development. As the study of substantive rights under NEPA shows, it is

only the rare case of grave environmental harm where a project cannot proceed under any circumstances.^{27,28} However, from the draft report of the Department of the Interior, it is expected that geothermal power development will create less pollution than energy production from hydrocarbon conversion or atomic conversion.²⁹

The State of California has passed several laws and regulations that pertain to geothermal-resource development. The State Energy Resources Conservation and Development Commission has exclusive power to certify all sites and related facilities. The Energy Commission must obtain comments from local, regional, state, and federal agencies. Power plants up to 100 megawatts may be exempted from Commission requirements.³⁰ However, this has been limited to special-use situations and probably is not available as an exception for operation of a power plant by a public utility to supply public power. On the other hand, the Code only applies to plants over 50 megawatts.³¹

Thermal power plant means any stationary or floating electrical generating facility using any source of thermal energy with a generating capacity of 50 megawatts or more and any facilities appurtenant thereto.

The final report on the comparison of the federal and state laws on

geothermal power will include case law that has arisen on the question of ownership of the geothermal resource when there has been a reservation of mineral rights. Although not mentioned above but discussed in the preliminary report, UCRL-52121,¹⁷ the definition of known geothermal resource is not the same in the state and federal statutes. In addition, California statutes use the term in two different senses. Since the designation of an area as a KGRA has special consequences under the bidding requirements, these differences will be compared and discussed.

Atmospheric Model Modification for Imperial Valley

Donald L. Ermak

The purpose of this task is to modify and improve existing atmospheric models for air-quality assessment of the LLL scenarios for geothermal development in Imperial Valley. The major pollutant of concern resulting from geothermal operations in Imperial Valley is hydrogen sulfide. It is aesthetically unpleasant because of its unpleasant odor even at very low concentrations, has adverse effects upon agriculture at moderate concentrations (>75 ppm), and is toxic at high concentrations (not expected from geothermal operations). It is also believed to undergo chemical transformation to sulfur dioxide,

which in turn is chemically transformed to sulfate compounds that have adverse human health effects. Other geothermal pollutants of concern include ammonia, particles, and trace elements (especially boron).

Initial air-quality assessments will use an LLL-modified version of the EPA Climatological Dispersion Model (CDM).³² The model calculates long-term (seasonal or annual) average-pollutant concentrations at the ground level using average emission rates and a joint frequency distribution of wind direction, wind speed, and atmospheric stability. CDM is based upon the standard Gaussian plume model and uses the Pasquill dispersion parameters. The original model does not consider chemical transformations to secondary or tertiary compounds, deposition onto ground surfaces, gravitational settling in the case of particles, and multiple sources.

To treat the pollutants expected from the Imperial Valley geothermal operations, the additional atmospheric effects discussed above must be included in the model. During the period covered by this report, several of these improvements have been added to the model. The code has been extended to handle first-order chemical transformation chains of up to three species, $A \rightarrow B \rightarrow C$. Using the source depletion approach, the

effect of ground deposition is included for each species. In the case of particles, a non-Gaussian plume model³³ has been developed to include the effects of gravitational settling. In addition to calculating the ground level concentration, the improved model also calculates the deposition flux, the total ground-deposition rate within the study region, and the total rate at which pollutants are transported out of the study region by the wind. Present and future efforts on this model include: improving the treatment of inversion layers, extending the code to handle multiple pollutant sources, and improving the graphics-display package.

More sophisticated atmospheric-pollutant-transport models can be used when detailed meteorological data is available (for example, consecutive hourly meteorological measurements for periods of a year). Two modeling approaches are being considered for this situation. The first approach requires extensive modification of the LLL three-dimensional particle in cell code³⁴ and the two-dimensional coupled transport-kinetics code³⁵ to simulate extended periods of time rather than short periods (hours to days) for which they are presently applicable. The second approach is to use a trajectory model such as that developed at the Brookhaven

National Laboratory.³⁶ Trajectory models are currently in use for long-term assessments. Both modeling approaches require a wind-field model³⁷ to generate time and spatially varying wind fields from meteorological data taken at fixed locations.

Water Resource Impacts of Geothermal Facilities

David W. Layton

Geothermal power plants suffer from thermal inefficiencies caused by reservoir temperatures that are generally below 300°C (572°F). As a consequence, substantial amounts of heat must be rejected for each kilowatt-hour of electricity generated. And to effectively remove that waste heat, large amounts of cooling water will be required for evaporative cooling devices like mechanical-draft wet-cooling towers and spray ponds. Other cooling technologies such as wet-dry towers or even dry towers could significantly reduce water use, but only at great expense. A recent study³⁸ has shown that for intermediate-load coal-fired power plants in the Yellowstone River Basin dry-cooling towers became economically feasible when the price of water reached about \$750 per acre-foot. Currently the water rate charged by the Imperial Irrigation District is just \$4.75 per acre-foot, far below the level that would prompt

the use of dry-cooling technologies.

To predict the availability of surface water for future geothermal facilities, regression analysis will be used to define the historic relationship between cropping patterns and water use in the valley. That relationship will then serve as the basis for analyzing the effect potential cropping patterns and irrigation practices will have on irrigation requirements and waste water flows. Evapotranspiration estimates of cropping patterns will also be calculated to supplement the regression analysis. Once future water supply conditions are specified, the changes in quantity and quality (salinity) of water flowing in the New and Alamo Rivers will be determined using water consumption rates of different geothermal development scenarios.

IVEP Data-Base Plan, Data Base, and Data Management

Robert A. Nyholm

Data acquisition, exchange, display, and management were recognized as integral elements of the Imperial Valley Environmental Project during its initial stages. To develop a data-base system, several tasks have been established to:

- Develop a data-base plan,
- Develop a mass-storage capability — investigate and

assess existing data-base-management systems,

- Coordinate data input and exchange,
- Fit existing associated data bases to the IVEP data base,
- Assist IVEP Integrated Assessment staff with data acquisition, formatting, and display, and
- Investigate existing geocoding systems.

IVEP Data-Base Plan

An analysis of the data-recording, formatting, and usage problems began with a thorough evaluation of the needs of all IVEP survey programs and user groups. Estimates were made of:

- Perceivable data types,
- Volume of data,
- Rate of data updating and modification,
- Anticipated use (analysis, modeling, inquiry, report generation),
- Level of information retrieval, and
- Relationship of other (non-LLL) data bases.

An initial data-base plan was then conceived and tested, using the Water Quality Survey Program as a source of data. After several modifications, the plan was implemented by all survey programs.

The system is designed to provide a consistent and concise vehicle by which information is to be reported for inclusion into the project data-base network. Currently, the scheme

has the capability of retaining the following information:

- Sample identification (official unique number)
- Sample-aliquot number,
- Date of sample collection,
- Time of sample collection,
- Latitude-longitude (degrees and decimal minutes),
- Sampling level (i.e., depth, tower level, altitude in decimal meters,
- Location of sampling by map site (grid coordinates),
- Location of sampling by narration (i.e., word description),
- Type of sample (i.e., water, soil, vegetation, bird, aquatic, etc.),
- Sample key words,
- Narrative comments (pertaining to sample),
- Parameters analyzed,
- Measurement (i.e., analytical result),
- Associated percent error,
- Method of analysis,
- Group that performed analysis (laboratory and laboratory group),
- Unit in which data is reported,
- Validity indicator,
- Narrative remark (pertaining to parameter),
- Missing data flag,
- Non-detectable data flag with detection limit, and
- Narrative type data.

These items of data will normally be

input via punched cards. Alternate modes of entry are from teletypewriter and magnetic-tape card-image files.

Data-entry forms have been developed to help facilitate input. Figure 7 is an example. These forms are particularly useful to the efficient experimenter who is collecting field samples. Plans are currently being made to provide him with a bound notebook of forms so that data forms are filled out in the field and other field notebooks may be eliminated.

Referring to Fig. 7, there are four defined card types. CARD TYPE is a field to be used by the network; it will inform the system of the kind of information to expect. It will also be used to sort and sequence punched cards should they accidentally be dropped. Data-field description proceeds by CARD TYPE series as follows:

100 Series - CARD TYPE 100 is the

Header/Description card. It defines all fixed information.

IDENTIFIER: The sample IDENTIFIER is a seven character field made up of six SAMPLE NUMBER characters and one SAMPLE ALIQUOT NUMBER character. This identifier must be unique to the project data base (so that program data bases may be merged without conflicting identifiers). It is the link to all associated sample information.

Recorded By: _____

Group: _____

Date: _____

DATA ENTRY FORMS

Sample Types: Gas Meteorologic
Social Economic
Water Soil Sediment Vegetation
Mammal Bird Aquatic Other

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
CARD TYPE				IDENTIFIER							Date				TIME				GEOGRAPHIC LOCATION												LEVEL				ALTERNATE LOCATION/IDENTIFICATION																																												
system use				Sample Number							A	YYMMDD				Grab Time HHMMSS				Longitude E W DDDMM,MMM												Latitude N S DDMM,MMM				(meters)																																											
0 1 0 0																																																																															

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
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0 2 0 0																																																																															

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CARD TYPE				IDENTIFIER							COMMENTS (Additional Cards May Be Appended- User: increment "Card Type" by 1 per card)																																																																				
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CARD TYPE				IDENTIFIER							PARAMETER							VALUE							ERR	MTD	LAB	VALIDITY							UNIT	REMARKS																																											
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Fig. 7. IVEP data-entry form.

To samples that are later separated for analysis (i.e., dissection, water samples sent to separate laboratories for analysis, etc.) a SAMPLE ALIQUOT NUMBER is assigned.

DATE: The date field is a self-explanatory data field it is the date of sample collection recorded as YYMMDD.

TIME: The time field is similar to the date field; it is the local time of sample collection recorded as HHMMSS.

GEOGRAPHIC LOCATION is recorded as Latitude/Longitude (degrees and decimal minutes) or by an alternate Survey Program Fixed Site Code. The code must be found somewhere on the Type 100 card whether it be embedded in the IDENTIFIER or written separately in the ALTERNATE LOCATION field. Code definition is discussed below.

LEVEL is the depth/altitude indicator recorded as decimal meters referenced to the surface elevation.

200 Series - CARD TYPE 200 is the sample Type/Keyword card. To date, 12 IVEP SAMPLE TYPES are defined. These include: Gas, Meteorologic, Social, Economic, Water, Soil, Sediment, Vegetation, Mammal, Bird, Aquatic, and Other. KEYWORDS further define SAMPLE TYPE. The keywords are later to be used for a selective search on Sample Type

whereas SAMPLE TYPE is used to selectively search on the IVEP Data Base. Keywords or phrases of up to but not to exceed 56 characters are allowable provided they contain no blanks, commas, or semicolons. It is by any one or combination of these three characters that keywords are to be separated. Multiple Type 200 cards are permissible.

300 Series - CARD TYPE 300 SERIES is reserved for narrative COMMENTS. There can be up to 100 Comment Cards per IDENTIFIER number. Sequencing of the comment cards is controlled by the CARD TYPE field number (300 through 399). Again IDENTIFIER serves as the sample link.

400 Series - All analytical results are to be reported on the 400 Type data card. Narrative-type data may also be reported here. PARAMETER: The parameter to be reported is identified in Columns 12 through 23. The entry may be written anywhere within the confines of the field. Parametric synonyms may be entered instead of the parameter. This capability will prove particularly useful for short-hand notation when recording trace-element constituents. Parameter and synonym definitions will be discussed below.

VALUE: Numerical results of analysis are reported anywhere within Columns 24 to 33. The accepted format is either F or E, that is to say, the number "1234" is entered as 1234. or 1.234E3. Note that both formats demand a decimal to be written. If for some reason a parameter is to be reported but its numerical value is unknown, a question mark ? is entered in the VALUE field. For parameters that give narrative results, the alpha string is written in the REMARKS field (Columns 54 through 80) as will be explained below.

ERROR: Percent error of analysis is reported in Columns 34 through 36. Accepted format here is I or F; i.e., a 10% error is reported as either "10" or "10.". If the percent error is truly not known, a triple question mark ??? is entered in the field. If percent error has no meaning or is not applicable, a triple asterisk *** is entered. This is particularly convenient for narrative-data recordings. If a parameter is found to be below the minimum detectable limit, NDL is entered for the percent error and the minimum detectable limit is entered for VALUE.

METHOD: The method by which VALUE was determined is reported in

Columns 37 through 39. A table of allowable codes will be discussed below. For data of the narrative type, a triple asterisk *** is entered in the field.

LABORATORY: The laboratory responsible for VALUE is entered in Columns 40 through 42. Again, a code table will be defined below.

VALIDITY: Columns 43 through 50 are to remain blank while reporting data. During preprocessing, all parametric data will be initially assigned an unverified indicator N in Column 43 and category indicator G in Column 44 with the date defined in Columns 45 through 50 in the YYMMDD format. When reviewed, verified, and released by the originator, the indicators will be changed to Y and, P or F, respectively. The abbreviations are - verification: N-no, Y=yes; categorization: G-first guess, P-preliminary, F-final.

UNIT: Allowable unit codes as they are to appear in Columns 51 through 53 are tabulated and discussed below. Non-numeric information receives a triple asterisk *** or NUN as an assigned unit.

REMARKS: Pertinent remarks concerning PARAMETER are made in Columns 54 through 80. Additional comments may be made on Type 300 Series cards if necessary. Non-

numeric information is reported in this field also - VALUE must then be left blank.

IVEP Data Base

To initiate the data-base plan, each survey program was first assigned an alpha character for identification (see Table 1). Subsequent data are then reported by a sample number beginning with that character. Hence, a block of sample numbers were allocated for the duration of IVEP for each survey program. Program leaders are responsible for distribution of these block numbers.

Six code files (computer-code tables) were developed. Table 2 outlines the format of these six files. The current contents of each file are in Tables 3 through 8.

Table 3 is the fixed-site-code file; it relates each survey program's fixed-site code to a specific latitude,

longitude, and geographic area reported by township, range, section, and quarter section whenever applicable.

Narrative definition is also provided. The first column indicates for which survey program the code is defined. The second column is the number of samples (tally) that have the same site origin. Columns 4 through 7 define the associated latitude, longitude, township/range, and narrative description, respectively.

Similarly, Table 4 is the keywords-code file; Table 5 the parameter-code file. Column description is defined at the head of each listing.

Tables 6 through 8 are the analytical method-, laboratory-of-analysis-, and unit-code file listings. An asterisk * implies that the code is used by all survey programs. Again column description is defined at the file head.

Table 1. IVEP survey-program identifiers.

Code	Responsible individual
A = LLL-IVEP Air Quality Program	P. Gudiksen
E = State electrical energy data	C. Hall
H = LLL Health Effects Program	L. Anspaugh
M = IVEP miscellaneous data bases	R. Nyholm
S = LLL IVEP Socioeconomic Program	C. Hall
T = Reserved for test-data sets	R. Nyholm
V = LLL-IVEP Ecosystems Program	J. Shinn
W = LLL-IVEP Water Quality Program	K. Pimentel

Table 2. IVEP code formats (80-column punched-card image)

<u>Site code</u>	- Col. 3:	Program identification
	Cols. 5-13:	Update tally
	Cols. 26-34:	Latitude (N DDMM.MMM)
	Cols. 36-45:	Longitude (E/DDMM.MMM)
	Cols. 47-56:	Township - Range location
		[left adjusted and reported as:
		Township (two digits and N or S);
		Range (two digits and E or W);
		Section Number (two digits = 1 thru 36);
		Lot Number (one character = A thru R);
		Well Number (if applicable)]
	Cols. 61-80:	Free field description, if desired
<u>Keyword</u>	- Col. 3:	Program identification
	Cols. 5-13:	Update tally
	Cols. 15-70:	Keyword or string (cannot contain any spaces, commas, or semicolons and must be left adjusted)
	Cols. 71-80:	Definition of keyword
<u>Parameter code</u>	- Col. 3:	Program identification
	Cols. 5-13:	Update tally
	Cols. 15-26:	Parameter (left adjusted)
	Cols. 28-37:	Synonym #1 (left adjusted)
	Cols. 39-48:	Synonym #2 (left adjusted)
	Cols. 50-55:	Parameter code (if eventually required)
	Cols. 56-80:	Remarks, if any
<u>Method code</u>	- Col. 3:	Program identification (first card only)
	Cols. 5-7:	Method code (left adjusted)
	Cols. 9-10:	Card-sequence number for that particular method code
	Cols. 12-80:	Method description
<u>Laboratory code</u>	-	Codes as assigned by IVEP Data Base Manager
<u>Unit code</u>	-	Codes as assigned by IVEP Data Base Manager

Each of the above files may be updated or appended at any time. Additional survey-program identifiers may be affixed as required.

As noted above, the code files have been developed for indicative information. Each is input to a Fortran-computer program (preprocessor) that performs extensive error checking and

sorts input-data files. All detected errors generate messages to an output file. Code-file tallies are updated when no apparent errors exist. Column one of the output-file-data line indicates the status of that line. A "C" implies that the line has been processed and is presumed to be correct. An "E" means an error exists, and an

Table 3. IVEP site-code file.

(Continued) Table 3. IVEP

PAGE

		0 SITE-CODE* LATITUDE* LONGITUDE* TOWN/RANGE	FREE-COMMENT-FIELD**
1	T	0 SITE-TEST* N1234.567 W12345.678 TEST---SET	
2	T	-0 1	NILAND STATION
3	A	-0 2	IMPERIAL STATION
4	A	-0 3	HEBER STATION
5	A	-0 4	EAST-MESA STATION
6	A	-0 5	ELMORE STATION
7	A	-0 6	BRAWLEY STATION
8	A	4 0590000100	059000-1100 BURB
9	E	4 1825000100	182500-1100 GLEN
10	E	4 2230000700	223000-1700 ELCE
11	E	4 2745000700	274500-1700 HARB
12	E	4 2745000800	274500-1800 HAYN
13	E	4 2745001200	274500-1200 SCAT
14	E	4 2745001600	274500-1600 VALL
15	E	4 3700000300	370000-1300 AVON
16	E	4 3700001400	370000-1400 ANTI
17	E	4 3700003100	370000-3100 HUMB
18	E	4 3700003200	370000-3200 HUPT
19	E	4 3700003600	370000-3600 KERN
20	E	4 3700004100	370000-4100 MART
21	E	4 3700004400	370000-4400 MORR
22	E	4 3700004500	370000-4500 MOSS
23	E	4 3700004900	370000-4900 OLEU
24	E	4 3700005700	370000-5700 PITT
25	E	4 3700005900	370000-5900 POTR
26	E	4 3700007200	370000-7200 GEYS
27	E	4 3745000100	374500-1100 BROA
28	E	3 3745000200	374500-1200 GLNA
29	E	4 4335000300	433500-1300 ENCI
30	E	4 4335000500	433500-1500 SILV
31	E	4 4335000600	433500-1600 SOBY
32	E	4 4335000700	433500-1700 STAB
33	E	4 4505000100	450500-1100 ALAM
34	E	4 4505001400	450500-1400 COOL
35	E	4 4505001500	450500-1500 ELSE
36	E	4 4505001600	450500-1600 ETIW
37	E	4 4505002000	450500-2000 HIGH
38	E	4 4505002100	450500-2100 HUBE
39	E	4 4505002700	450500-2700 LONG
40	E	4 4505003100	450500-3100 MAND
41	E	4 4505003900	450500-3900 REDO
42	E	4 4505004100	450500-4100 SANB
43	E	4 4505004300	450500-4300 SANO
44	E	4 4505004700	450500-4700 ORBE
45	E	1 EL CENTRO	EL CENTRO, CALIF.
46	M	2 0500	CALIFORNIA STATE
47	S	4 0501	ALAMEDA
48	S	4 0502	ALPINE
49	S	4 0503	AMADOR
50	S	4 0504	BUTTE
51	S	4 0505	CALAVERAS
52	S	4 0506	COLUSA
53	S	4 0507	CONTRA COSTA
54	S	4 0508	DEL NORTE
55	S	4 0509	EL DORADO
56	S	4 0510	FRESNO
57	S	4 0511	GLENN
58	S	4 0512	HUMBOLT
59	S	4 0513	IMPERIAL
60	S		

FPC utility
plant codePlant
identificationState
codeCounty
code

County name

Table 3. (Continued)

PAGE

61	S	4	0514				INYO
62	S	4	0515				KERN
63	S	4	0516				KINGS
64	S	4	0517				LAKE
65	S	4	0518				LASSEN
66	S	4	0519				LOS ANGELES
67	S	4	0520				MADERA
68	S	4	0521				MARIN
69	S	4	0522				MARIPOSA
70	S	4	0523				MENDOCINO
71	S	4	0524				MERCED
72	S	4	0525				MODOC
73	S	4	0526				MONO
74	S	4	0527				MONTEREY
75	S	4	0528				NAPA
76	S	4	0529				NEVADA
77	S	4	0530				ORANGE
78	S	4	0531				PLACER
79	S	4	0532				PLUMAS
80	S	4	0533				RIVERSIDE
81	S	4	0534				SACRAMENTO
82	S	4	0535				SAN BENITO
83	S	4	0536				SAN BERNARDINO
84	S	4	0537				SAN DIEGO
85	S	4	0538				SAN FRANCISCO
86	S	4	0539				SAN JOAQUIN
87	S	4	0540				SAN LUIS OBISPO
88	S	4	0541				SAN MATEO
89	S	4	0542				SANTA BARBARA
90	S	4	0543				SANTA CLARA
91	S	4	0544				SANTA CRUZ
92	S	4	0545				SHASTA
93	S	4	0546				SIERRA
94	S	4	0547				SISKIYOU
95	S	4	0548				SOLANO
96	S	4	0549				SONOMA
97	S	4	0550				STANISLAUS
98	S	4	0551				SUTTER
99	S	4	0552				TEHAMA
100	S	4	0553				TRINITY
101	S	4	0554				TULARE
102	S	4	0555				TUOLUMNE
103	S	4	0556				VENTURA
104	S	4	0557				YOLO
105	S	4	0558				YUBA
106	V	-0	BEACH	N3329.23	W11554.09	08S10E12M	MECCA BEACH CAMPGRD
107	V	-0	DESERT	N3323.92	W11601.59	09S09E	DESERT SHORES (RMJ)
108	V	-0	ELMORE	N3308.60	W11547.60	12S11E02G	ELMORE RANCH
109	V	-0	HILL	N3312.64	W11536.75	11S13E21A	REDHILL MARINA
110	V	-0	LANDIN	N3306.36	W11545.21	12S12E20E	BENSON'S LANDING
111	V	-0	MARINA	N3320.21	W11540.10	10S12E01A	NILALAND MARINA
112	V	-0	NAVAL	N3311.72	W11550.12	11S11E21N	NAVAL BASE PIER
113	V	-0	OBSDI	N3310.49	W11541.82	11S13E32B	OBSDIAN BUTTE
114	V	-0	REFUGE	N3311.01	W11542.19	11S13E28G	SSNWF AT OBSER. PT
115	V	198	SNWR				SACRAM NATL WILD REF
116	V	-0	WISTER				WISTER WATERFOWL RE
117	V	647	WNWR				WISTER NATL WILD REF
118	V	-0	YABMOB	N3320.85	W11543.91	09S12E33M	BOMBAY MARINA
119	V	62	11S13E			11S13E	
120	V	56	12S13E			12S13E	

Table 3. (Continued)

PAGE

121	W	-0 AA				
122	W	11 AB	N3307.995	W11536.835	12S13E09R	CANAL, VAIL4/VAIL4A
123	W	10 AC	N3307.995	W11536.800	12S13E10N	VAIL4 D. GENTRY/YOUN
124	W	-0 AD				
125	W	-0 AE				
126	W	-0 AF				
127	W	-0 AG				
128	W	5 AH	N3240.520	W11522.145	17S15E10B	ALAMO R. • BORDER
129	W	6 AI	N3239.965	W11530.155	17S14E14Q	NEW R. • BORDER
130	W	-0 AJ				
131	W	7 AK	N3311.930	W11535.770	11S13E23E	ALAMO R. GARST RD BR
132	W	6 AL	N3305.985	W11538.660	12S13E29E	NEW R. • LACK RD BR
133	W	8 AM	N3258.725	W11527.960	13S15E31E	ALAMO R. SR78 E BRAW
134	W	-0 AN				
135	W	-0 AO				
136	W	-0 AP				
137	W	1 AQ				
138	W	-0 AR				
139	W	10 AS	N3309.815	W11536.820	11S13E33H	VAIL4 C. GENTRY/FOSS
140	W	10 AT	N3310.160	W11536.785	11S13E34E	VAIL4 D. GENTRY/MCKE
141	W	11 AU	N3310.160	W11536.825	11S13E33H	VAIL4 C. GENTRY/MCKE
142	W	10 AV	N3308.865	W11537.305	12S13E04P	VAIL4A D. BOYLE/LIN
143	W	-0 AW				
144	W	10 AZ	N3310.580	W11537.295	11S13E33B	DRAIN, PUMICE/VAIL4A
145	W	10 BA	N3310.135	W11537.285	11S13E33K	SUMP9 BOYLE/MCKENDRY
146	W	11 BB	N3310.160	W11537.325	11S13E33L	VAIL4A C. BOYLE/MCKE
147	W	11 BC	N3310.560	W11537.810	11S13E33D	SUMP45 SEVERE/MCKEND
148	W	11 BD	N3309.285	W11537.305	12S13E04F	SUMP116 BOYLE/KUNS
149	W	11 BE	N3308.390	W11537.290	12S13E09K	SUMP120 BOYLE S LIND
150	W	10 BF	N3310.130	W11536.780	11S13E34M	SUMP15 GENTRY/MCKEN
151	W	11 BG	N3309.745	W11537.305	11S13E33Q	VAIL4A D. BOYLE/FOSS
152	W	10 BH	N3308.820	W11537.290	12S13E09B	SUMP82 BOYLE/LINDSEY
153	W	10 BI	N3310.130	W11537.810	11S13E33M	SUMP42 SEVERE/KUNS
154	W	10 BJ	N3310.300	W11537.855	12S13E04D	SUMP43 SEVERE/FOSS
155	W	6 BK	N3241.845	W11516.825	17S15W01Q	CANAL, EAST HIGHLINE
156	W	8 BL	N3300.273	W11531.535	13S14E21K	NEW R. SR111 N BRAHL
157	W	9 BM	N3310.160	W11537.825	11S13E33G	VAIL4A D. BOYLE/MCKE
158	W	6 BN	N3309.800	W11536.855	11S13E33R	ERDA/SDGE SET POND
159	W	6 BO	N3309.800	W11536.925	11S13E33R	ERDA/SDGE SPRAY POND
160	W	4 BP	N3309.800	W11536.975	11S13E33R	ERDA/SDGE BRINE POND
161	W	2 CA	N3300.045	W11533.615	13S14E19Q	SPRUCE C. BRANDT/FRE
162	W	2 CB	N3300.325	W11532.595	13S14E20G	SUMP238 HOV,S ANDRE
163	W	2 CC	N3300.325	W11532.568	13S14E20G	SPRUCE1 D. HOV,S AND
164	W	2 CD	N3300.617	W11532.605	13S14E17Q	SUMP89 HOVLEY/ANDRE
165	W	2 CE	N3300.617	W11532.576	13S14E17Q	SPRUCE3 D. HOVL/ANDR
166	W	2 CF	N3300.331	W11531.418	13S14E21H	SPRUCE1 D. NEAR NEW
167	W	2 CG	N3300.617	W11531.265	13S14E16R	SPRUCE3 D. NEAR NEW
168	W	2 CH	N3301.174	W11531.267	13S14E09R	SPRUCE5 D. NEAR NEW
169	W	2 CJ	N3301.187	W11533.075	13S14E08N	SPRUCE5 D. SM1 W HOV
170	W	2 CK	N3301.767	W11532.077	13S14E04N	SPRUCE5 C. SPILL
171	W	2 CL	N3301.924	W11531.540	13S14E04Q	NEW R. 111BR N RUTHE
172	W	2 CM	N3301.764	W11531.267	13S14E04R	BEST D. RUTH. BY NEW
173	W	2 CN	N3301.787	W11531.035	13S14E03N	ROCKWOOD C. RUTH/JEF
174	W	2 CP	N3300.906	W11530.491	13S14E15G	SUMP192 BEST,N WARD
175	W	2 CQ	N3300.906	W11530.491	13S14E15G	BEST D. BEST,N WARD
176	W	2 CR	N3300.620	W11531.022	13S14E15N	LIVESLEY D. AT SEW P
177	W	2 CS	N3300.046	W11530.491	13S14E22Q	BEST C. BEST/SHANK
178	W	2 EA	N3241.162	W11527.207	17S15E08K	CENT.MAIN C. BY RITT
179	W	1 EB	N3241.656	W11530.606	17S14E02P	BEECH C. COLE/PRUETT
180	W	2 EC	N3241.954	W11531.443	17S14E03K	SUMP108 WARE,N COLE

Table 3. (Continued)

PAGE

181	W	1 ED	N3242.094	W11534.190	17S14E06H	BEECH C. SPILL W CLA
182	W	2 EE	N3242.500	W11533.559	17S14E05C	BEECH D. CLARK/WILLO
183	W	2 EF	N3242.939	W11531.465	16S14E33J	SUMP273 WARE,N JASPR
184	W	2 EG	N3243.378	W11532.480	16S14E32A	SUMP321 FAWC,W DOGWD
185	W	2 EH	N3242.949	W11532.992	16S14E32L	SUMP397 CORFMN,N WIL
186	W	2 EI	N3242.964	W11534.090	16S14E31M	SUMP137 W CLRK,S WAH
187	W	-0 EJ	N3244.730	W11534.111	16S14E19E	DATE D. E LABRU,S MC
188	W	2 EK	N3244.267	W11533.535	16S14E30B	DATE C. CLRK/CORRELL
189	W	2 EL	N3244.258	W11532.539	16S14E29B	DRAIN DATE3/DATE3A
190	W	2 EM	N3244.258	W11532.518	16S14E29B	DGWDLAT2 C. FNWT/COR
191	W	2 EN	N3244.258	W11532.139	16S14E29B	SUMP88 FRNSWTH/CORRL
192	W	2 EO	N3244.240	W11532.004	16S14E28D	DOGWD C. DGWD/CORREL
193	W	2 EP	N3244.272	W11531.010	16S14E22N	DAFDL C. PITZ/CORREL
194	W	1 ER	N3242.609	W11534.580	16S13E36R	CENT.MAIN C. LABR/WI
195	W	2 GA	N3249.404	W11516.996	15S16E26A	E.HIGHLN C. EHL16DRP
196	W	2 GB	N3249.043	W11516.953	15S16E26J	E.HIGHLN14 D.BY EHL14
197	W	2 GC	N3249.078	W11518.662	15S16E27E	HLTVLMAIN D.N KAVANA
198	W	2 GD	N3248.609	W11516.879	15S16E35A	HLTVLMAIN D. KAVANAU
199	W	2 GE	N3247.742	W11516.744	16S16E01D	HLTVL2C D. BY EHL 11
200	W	2 GF	N3246.838	W11517.549	16S16E11C	WARREN D. S80/GREASE
201	W	2 GG	N3246.060	W11516.309	16S16E12P	WARREN D. S80/18
202	W	2 GH	N3246.060	W11516.260	16S16E12Q	E.HIGHLN C. S80/18
203	W	2 GI	N3247.070	W11515.176	16S17E06Q	SLOUGH 6-2 EAST MESA
204	W	1 00				DUMMY FILLER
205	•					
206		LAST UPDATE WAS ON	760924			
207						
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Table 4. IVEP keyword file.

PAGE

		KEY-WORD-----	DEFINATION
1	T	-0 KEY-WORD-----	PARAMETER
2	A	-0 ANGLE-WIND	PARAMETER
3	A	-0 ANGLE2-WIND	PARAMETER
4	A	-0 HUMIDITY	PARAMETER
5	A	-0 MEAN-CO2	PARAMETER
6	A	-0 MEAN-H2S	PARAMETER
7	A	-0 MEAN-NO	PARAMETER
8	A	-0 MEAN-NOX	PARAMETER
9	A	-0 MEAN-NO2	PARAMETER
10	A	-0 MEAN-O3	PARAMETER
11	A	-0 MEAN-SO2	PARAMETER
12	A	-0 PEAK-CO2	PARAMETER
13	A	-0 PEAK-H2S	PARAMETER
14	A	-0 PEAK-NO	PARAMETER
15	A	-0 PEAK-NOX	PARAMETER
16	A	-0 PEAK-NO2	PARAMETER
17	A	-0 PEAK-O3	PARAMETER
18	A	-0 PEAK-SO2	PARAMETER
19	A	-0 SIGMA-THETA	PARAMETER
20	A	-0 SIGMA2-THETA	PARAMETER
21	A	-0 SOLAR-RADIATION	PARAMETER
22	A	-0 SPEED-WIND	PARAMETER
23	A	-0 SPEED2-WIND	PARAMETER
24	A	-0 TEMP-AIR	PARAMETER
25	A	-0 TEMP-DEW	PARAMETER
26	A	-0 TEMP2-AIR	PARAMETER
27	A	-0 GAS	SAMP. TYPE
28	A	-0 METEOROLOGIC	SAMP. TYPE
29	E	26 BAY	COOL TYPE
30	E	10 MUNICIPAL	COOL TYPE
31	E	22 OCEAN	COOL TYPE
32	E	2 RIVER	COOL TYPE
33	E	12 WELLS	FUEL1
34	E	2 GEOTHERMAL	FUEL1
35	E	2 NUCLEAR	FUEL1
36	E	67 OIL	FUEL2
37	E	70 NATURAL-GAS	SAMP. TYPE
38	E	74 ENERGY	TYPE PLANT
39	E	-0 INDUSTRIAL	TYPE PLANT
40	E	74 POWER-PLANT	TYPE PLANT
41	E	-0 RE-INFRY	*
42	M	-0 STABILITY	*
43	M	-0 WIND	SAMP. TYPE
44	M	-0 METEOROLOGIC	ECONOMIC
45	S	-0 FISCAL	ECONOMIC
46	S	-0 SECTOR-EMPLOYMENT	FISCAL
47	S	-0 BUDGET	FISCAL
48	S	-0 PC-BUDGET	SAMP. TYPE
49	S	-0 ECONOMIC	SAMP. TYPE
50	S	-0 SOCIAL	SOCIAL
51	S	-0 EDUCATION	SOCIAL
52	S	-0 INCOME	SOCIAL
53	S	-0 POPULATION	SOCIAL
54	S	-0 POVERTY	SOCIAL
55	V	5 FIELD	SAMPLING
56	V	5 BACKGROUND	ACTION
57	V	34 COLLECT-PLANT	ACTION
58	V	20 COLLECT-SOIL	ANIMAL
59	V	-0 FISH	ANIMAL
60	V	-0 WORM	

Table 4. (Continued)

61	V	5 AVOSET	BIRD
62	V	710 DUCK	BIRD
63	V	117 GOOSE	BIRD
64	V	5 PELICAN	BIRD
65	V	9 PHEASANT	BIRD
66	V	5 SHOREBIRD	BIRD CLASS
67	V	5 WATERBIRD	BIRD CLASS
68	V	6 ALFALFA	CROP
69	V	3 BARLEY	CROP
70	V	3 BERMUDA-GRASS	CROP
71	V	3 COTTON	CROP
72	V	3 HAY	CROP
73	V	9 LETTUCE	CROP
74	V	6 MILO	CROP
75	V	3 ONION	CROP
76	V	3 ORCHARD-GRASS	CROP
77	V	36 SUGAR-BEET	CROP
78	V	12 CRUST	D-*
79	V	60 PLOWED	D-CROP
80	V	69 BARE	D-FIELD
81	V	9 CUT	D-GROWTH
82	V	-0 PLANTED	D-GROWTH
83	V	3 SPROUTING	D-GROWTH
84	V	63 DRY	D-WATER
85	V	-0 FLOODED	D-WATER
86	V	54 WET	D-WATER
87	V	-0 -0.0E+00	DEPTH
88	V	55 003	DEPTH
89	V	55 306	DEPTH
90	V	9 BALDPATE	DUCK
91	V	10 BUFFLEHEAD	DUCK
92	V	4 CANVASBACK	DUCK
93	V	15 CINNAMONTEAL	DUCK
94	V	20 GADWALL	DUCK
95	V	5 GOLDENEYE	DUCK
96	V	205 GREENWINGTEAL	DUCK
97	V	30 MALLARD	DUCK
98	V	187 PINTAIL	DUCK
99	V	10 REDHEAD	DUCK
100	V	50 RUDDYDUCK	DUCK
101	V	140 SHOVELER	DUCK
102	V	25 WIDGEON	DUCK
103	V	-0 BAIRDILLA	FISH
104	V	-0 CORVINA	FISH
105	V	-0 MOLLY	FISH
106	V	-0 SARGO	FISH
107	V	10 CANADAGOOSE	GOOSE
108	V	107 SNOWGOOSE	GOOSE
109	V	6 DRAIN-DITCH	LOCATION
110	V	-0 IRR-DITCH	LOCATION
111	V	198 SNWR	LOCATION
112	V	648 WNR	LOCATION
113	V	4 GOPHER	MAMMAL
114	V	171 BRAIN	ORGAN
115	V	-0 GIZZARD	ORGAN
116	V	-0 GONAD	ORGAN
117	V	169 HEART	ORGAN
118	V	168 KIDNEY	ORGAN
119	V	170 LIVER	ORGAN
120	V	171 LUNG	ORGAN

PAGE

Table 4. (Continued)

PAGE

121	V	1 MUSCLE	ORGAN
122	V	-0 WINGTIP	ORGAN
123	V	-0 BRINE	PARAMETER
124	V	8 QUARTERLY	PARAMETER
125	V	-0 SACRIFICE-TIME	PARAMETER
126	V	-0 SALINITY	PARAMETER
127	V	-0 TOXICITY	PARAMETER
128	V	-0 ZINC	PARAMETER
129	V	5 AQUATIC	SAMP. TYPE
130	V	846 BIRD	SAMP. TYPE
131	V	4 MAMMAL	SAMP. TYPE
132	V	-0 OTHER	SAMP. TYPE
133	V	-0 SEDIMENT	SAMP. TYPE
134	V	110 SOIL	SAMP. TYPE
135	V	51 VEGETATION	SAMP. TYPE
136	V	5 WATER	SAMP. TYPE
137	V	-0 POOL	SAMPLE
138	V	-0 TIME	SERIAL
139	V	-0 FEMALE	SEX
140	V	-0 MALE	SEX
141	V	-0 BONE	TISSUE
142	V	5 PILEWORM	WORM
143	W	3 BEECH	LOCATION
144	W	1 BEECHSPILL	LOCATION
145	W	6 BEST	LOCATION
146	W	3 CENTRALMAIN	LOCATION
147	W	-0 CENTRALMAIN	LOCATION
148	W	2 DAFFODIL	LOCATION
149	W	2 DATE	LOCATION
150	W	2 DATE3/DATE3A	LOCATION
151	W	2 DOGWOOD	LOCATION
152	W	2 DOGWOODLAT2	LOCATION
153	W	10 EAST-HIGHLINE	LOCATION
154	W	-0 EAST-HIGHLINE14	LOCATION
155	W	4 HOLTVILLEMAIN	LOCATION
156	W	2 HOLTVILLE2C	LOCATION
157	W	2 LIVESLEY	LOCATION
158	W	-0 PUMICE	LOCATION
159	W	9 PUMICE/VAIL4A	LOCATION
160	W	2 ROCKWOOD	LOCATION
161	W	16 SDGE-SITE	LOCATION
162	W	-0 SPRUCE	LOCATION
163	W	2 SPRUCELAT5SPILL	LOCATION
164	W	4 SPRUCE1	LOCATION
165	W	4 SPRUCE3	LOCATION
166	W	6 SPRUCE5	LOCATION
167	W	39 VAIL4	LOCATION
168	W	11 VAIL4/VAIL4A	LOCATION
169	W	35 VAIL4A	LOCATION
170	W	-0 VAIL4A/PUMICE	LOCATION
171	W	-0 VAIL4A/VAIL4	LOCATION
172	W	4 WARREN	LOCATION
173	W	-0 BRINE	POND
174	W	-0 SETTLING	POND
175	W	-0 SPRAY	POND
176	W	20 ALAMO	RIVER
177	W	22 NEW	RIVER
178	W	-0 OTHER	SAMP. TYPE
179	W	-0 SEDIMENT	SAMP. TYPE
180	W	328 WATER	SAMP. TYPE

Table 4. (Continued)

PAGE

181	W	2 6-2	SLOUGH
182	W	2 108	SUMP
183	W	11 116	SUMP
184	W	11 120	SUMP
185	W	2 137	SUMP
186	W	10 15	SUMP
187	W	-0 16	SUMP
188	W	2 192	SUMP
189	W	2 238	SUMP
190	W	2 273	SUMP
191	W	2 321	SUMP
192	W	2 397	SUMP
193	W	10 42	SUMP
194	W	10 43	SUMP
195	W	11 45	SUMP
196	W	10 82	SUMP
197	W	2 88	SUMP
198	W	2 89	SUMP
199	W	10 9	SUMP
200	W	74 CANAL	WATER
201	W	92 DRAIN	WATER
202	W	-0 POND	WATER
203	W	1 REDISTILLED	WATER
204	W	42 RIVER	WATER
205	W	2 SLOUGH	WATER
206	W	101 SUMP	WATER
207	*	LAST UPDATE WAS ON 760924	
208			
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Table 5. IVEP parameter file.

PAGE

		0	PARAMETER***	SYNONYM1**	SYNONYM2**	*CODE*	REMARKS*****
1	T	-0	ANGLE-WIND				
2	A	-0	ANGLE2-WIND				
3	A	-0	HUMIDITY				
4	A	-0	MEAN-CO2				
5	A	-0	MEAN-H2S				
6	A	-0	MEAN-NO				
7	A	-0	MEAN-NOX				
8	A	-0	MEAN-NO2				
9	A	-0	MEAN-O3				
10	A	-0	MEAN-SO2				
11	A	-0	PEAK-CO2				
12	A	-0	PEAK-H2S				
13	A	-0	PEAK-NO				
14	A	-0	PEAK-NOX				
15	A	-0	PEAK-NO2				
16	A	-0	PEAK-O3				
17	A	-0	PEAK-SO2				
18	A	-0	SIGMA-THETA				
19	A	-0	SIGMA2-THET				
20	A	-0	SOLAR-RAD				
21	A	-0	SPEED-WIND				
22	A	-0	SPEED2-WIND				
23	A	-0	TEMP-AIR				
24	A	-0	TEMP2-AIR				
25	E	72	COOLING-TYPE				
26	E	72	HEAT-RATING				
27	E	72	PARTICULATES				
28	E	72	AQC-REGION				AIR QUALITY CONTROL REG.
29	E	72	AVG-H2O-CONS				AVERAGE H2O CONSUMED
30	E	72	H2O-SOURCE				COOLING H2O SOURCE
31	E	72	OWNER	COMPANY			CORPORATE OWNER
32	E	72	COUNTY				COUNTY NAME
33	E	-0	DOC				DIESEL OIL CONSUMED
34	E	72	GENERATION				ELECTRICAL GENERATION
35	E	72	TYPE				FUEL TYPE
36	E	72	NGC				NATURAL GAS CONSUMED
37	E	72	PLT-CAPACITY	CAPACITY			PLANT CAPACITY
38	E	72	NAME				PLANT NAME
39	E	72	ROC				RESIDUAL OIL CONSUMED
40	E	72	S-CONTENT				SULFUR CONTENT
41	E	72	SO2				SULFUR DIOXIDE
42	E	72	NOX				TOTAL NITROGEN OXIDES
43	E	72	UPC				UTILITY PLANT CODE
44	E	1	FORMAT				FILE FORMAT DESCRIPTION
45	M	1	FILENAME				IVEP DATA BASE FILE
46	S	59	ED-A:00-07YR				ADULT EDUCATION
47	S	59	ED-A:08 YR				ADULT EDUCATION
48	S	59	ED-A:09-11YR				ADULT EDUCATION
49	S	59	ED-A:12 YR				ADULT EDUCATION
50	S	59	ED-A:13-15YR				ADULT EDUCATION
51	S	59	ED-A:16+ YR				ADULT EDUCATION
52	S	58	CO \$-CON/RE				CONT. & RESERVE
53	S	58	COPCS-CON/RE				CONT. & RESERVE
54	S	59	POP:CO TOTAL				COUNTY POPULATION BY AGE
55	S	58	CO \$-P-PROT				COURTS,POLICE,FIRE
56	S	58	COPCS-P-PROT				COURTS,POLICE,FIRE
57	S	58	CO \$-DEBTSE				DEBT SERVICES
58	S	58	COPCS-DEBTSE				DEBT SERVICES
59	S	58	CO \$-EDUC				EDUCATION
60	S						

Table 5. (Continued)

PAGE

61	S	58 COPCS-EDUC	EDUCATION
62	S	59 IN-F:00-04K\$	FAMILY INCOME
63	S	59 IN-F:04-06K\$	FAMILY INCOME
64	S	59 IN-F:06-08K\$	FAMILY INCOME
65	S	59 IN-F:08-10K\$	FAMILY INCOME
66	S	59 IN-F:10-15K\$	FAMILY INCOME
67	S	59 IN-F:15-25K\$	FAMILY INCOME
68	S	59 IN-F:25+ K\$	FAMILY INCOME
69	S	58 CO \$-GGV/PA	GEN. GOV. & PLANT ACQ.
70	S	58 COPCS-GGV/PA	GEN. GOV. & PLANT ACQ.
71	S	58 CO \$-GADMIN	GENERAL ADMINISTRATION
72	S	58 COPCS-GADMIN	GENERAL ADMINISTRATION
73	S	58 CO \$-HEALTH	HEALTH
74	S	58 COPCS-HEALTH	HEALTH
75	S	58 CO \$-H/SANI	HEALTH,SANITATION
76	S	58 COPCS-H/SANI	HEALTH,SANITATION
77	S	59 IN-I:00-04K\$	INDIVIDUAL INCOME
78	S	59 IN-I:04-06K\$	INDIVIDUAL INCOME
79	S	59 IN-I:06-08K\$	INDIVIDUAL INCOME
80	S	59 IN-I:08-10K\$	INDIVIDUAL INCOME
81	S	59 IN-I:10-15K\$	INDIVIDUAL INCOME
82	S	59 IN-I:15+ K\$	INDIVIDUAL INCOME
83	S	58 CO \$-PLTACQ	PLANT ACQUISITION
84	S	58 COPCS-PLTACQ	PLANT ACQUISITION
85	S	59 POP:00-13 YR	POPULATION BY AGE
86	S	59 POP:14-17 YR	POPULATION BY AGE
87	S	59 POP:18-24 YR	POPULATION BY AGE
88	S	59 POP:25-34 YR	POPULATION BY AGE
89	S	59 POP:35-44 YR	POPULATION BY AGE
90	S	59 POP:45-54 YR	POPULATION BY AGE
91	S	59 POP:55-64 YR	POPULATION BY AGE
92	S	59 POP:64+ YR	POPULATION BY AGE
93	S	59 POP:AMER-IND	POPULATION BY RACE
94	S	59 POP:BLACK	POPULATION BY RACE
95	S	59 POP:CHINESE	POPULATION BY RACE
96	S	59 POP:FILIPINO	POPULATION BY RACE
97	S	59 POP:JAPANESE	POPULATION BY RACE
98	S	59 POP:OTHER	POPULATION BY RACE
99	S	59 POP:SP-AMER	POPULATION BY RACE
100	S	59 POP:WHITE	POPULATION BY RACE
101	S	59 POVERTY:FAMS	POVERTY FAMILIES
102	S	59 POVERTY:INDS	POVERTY INDIVIDUALS
103	S	58 CO \$-P-ASST	PUBLIC ASSISTANCE
104	S	58 COPCS-P-ASST	PUBLIC ASSISTANCE
105	S	58 CO \$-COURTS	PUBLIC PROTECTION
106	S	58 CO \$-FIRE	PUBLIC PROTECTION
107	S	58 CO \$-POLICE	PUBLIC PROTECTION
108	S	58 COPCS-COURTS	PUBLIC PROTECTION
109	S	58 COPCS-FIRE	PUBLIC PROTECTION
110	S	58 COPCS-POLICE	PUBLIC PROTECTION
111	S	58 CO \$-P-WAYS	PUBLIC WAYS & FACILITIES
112	S	58 COPCS-P-WAYS	PUBLIC WAYS & FACILITIES
113	S	58 CO \$-RECRE	RECREATION
114	S	58 COPCS-RECRE	RECREATION
115	S	58 CO \$-SANI	SANITATION
116	S	58 COPCS-SANI	SANITATION
117	S	59 SECTOR 0.	SECTOR EMPLOYMENT
118	S	59 SECTOR 100.	SECTOR EMPLOYMENT
119	S	59 SECTOR 200.	SECTOR EMPLOYMENT
120	S	59 SECTOR 300.	SECTOR EMPLOYMENT

Table 5. (Continued)

PAGE

121	S	59 SECTOR 800.	SECTOR EMPLOYMENT
122	S	59 SECTOR 900.	SECTOR EMPLOYMENT
123	S	59 SECTOR 1000.	SECTOR EMPLOYMENT
124	S	59 SECTOR 1300.	SECTOR EMPLOYMENT
125	S	59 SECTOR 1381.	SECTOR EMPLOYMENT
126	S	59 SECTOR 1382.	SECTOR EMPLOYMENT
127	S	59 SECTOR 1500.	SECTOR EMPLOYMENT
128	S	59 SECTOR 1600.	SECTOR EMPLOYMENT
129	S	59 SECTOR 1700.	SECTOR EMPLOYMENT
130	S	59 SECTOR 2000.	SECTOR EMPLOYMENT
131	S	59 SECTOR 2010.	SECTOR EMPLOYMENT
132	S	59 SECTOR 2030.	SECTOR EMPLOYMENT
133	S	59 SECTOR 2040.	SECTOR EMPLOYMENT
134	S	59 SECTOR 2060.	SECTOR EMPLOYMENT
135	S	59 SECTOR 2090.	SECTOR EMPLOYMENT
136	S	59 SECTOR 2200.	SECTOR EMPLOYMENT
137	S	59 SECTOR 2400.	SECTOR EMPLOYMENT
138	S	59 SECTOR 2500.	SECTOR EMPLOYMENT
139	S	59 SECTOR 2600.	SECTOR EMPLOYMENT
140	S	59 SECTOR 2700.	SECTOR EMPLOYMENT
141	S	59 SECTOR 2800.	SECTOR EMPLOYMENT
142	S	59 SECTOR 2870.	SECTOR EMPLOYMENT
143	S	59 SECTOR 2900.	SECTOR EMPLOYMENT
144	S	59 SECTOR 3000.	SECTOR EMPLOYMENT
145	S	59 SECTOR 3200.	SECTOR EMPLOYMENT
146	S	59 SECTOR 3300.	SECTOR EMPLOYMENT
147	S	59 SECTOR 3400.	SECTOR EMPLOYMENT
148	S	59 SECTOR 3520.	SECTOR EMPLOYMENT
149	S	59 SECTOR 3530.	SECTOR EMPLOYMENT
150	S	59 SECTOR 3600.	SECTOR EMPLOYMENT
151	S	59 SECTOR 3700.	SECTOR EMPLOYMENT
152	S	59 SECTOR 3800.	SECTOR EMPLOYMENT
153	S	59 SECTOR 3900.	SECTOR EMPLOYMENT
154	S	59 SECTOR 4100.	SECTOR EMPLOYMENT
155	S	59 SECTOR 4150.	SECTOR EMPLOYMENT
156	S	59 SECTOR 4200.	SECTOR EMPLOYMENT
157	S	59 SECTOR 4221.	SECTOR EMPLOYMENT
158	S	59 SECTOR 4500.	SECTOR EMPLOYMENT
159	S	59 SECTOR 4600.	SECTOR EMPLOYMENT
160	S	59 SECTOR 4700.	SECTOR EMPLOYMENT
161	S	59 SECTOR 4800.	SECTOR EMPLOYMENT
162	S	59 SECTOR 4900.	SECTOR EMPLOYMENT
163	S	59 SECTOR 4931.	SECTOR EMPLOYMENT
164	S	59 SECTOR 4940.	SECTOR EMPLOYMENT
165	S	59 SECTOR 4950.	SECTOR EMPLOYMENT
166	S	59 SECTOR 4970.	SECTOR EMPLOYMENT
167	S	59 SECTOR 5010.	SECTOR EMPLOYMENT
168	S	59 SECTOR 5040.	SECTOR EMPLOYMENT
169	S	59 SECTOR 5050.	SECTOR EMPLOYMENT
170	S	59 SECTOR 5200.	SECTOR EMPLOYMENT
171	S	59 SECTOR 5300.	SECTOR EMPLOYMENT
172	S	59 SECTOR 5400.	SECTOR EMPLOYMENT
173	S	59 SECTOR 5500.	SECTOR EMPLOYMENT
174	S	59 SECTOR 5600.	SECTOR EMPLOYMENT
175	S	59 SECTOR 5700.	SECTOR EMPLOYMENT
176	S	59 SECTOR 5800.	SECTOR EMPLOYMENT
177	S	59 SECTOR 5900.	SECTOR EMPLOYMENT
178	S	59 SECTOR 6000.	SECTOR EMPLOYMENT
179	S	59 SECTOR 6500.	SECTOR EMPLOYMENT
180	S	59 SECTOR 7010.	SECTOR EMPLOYMENT

Table 5. (Continued)

PAGE

181	S	59	SECTOR 7030.			SECTOR EMPLOYMENT
182	S	59	SECTOR 7200.			SECTOR EMPLOYMENT
183	S	59	SECTOR 7300.			SECTOR EMPLOYMENT
184	S	59	SECTOR 7512.			SECTOR EMPLOYMENT
185	S	59	SECTOR 7800.			SECTOR EMPLOYMENT
186	S	59	SECTOR 7900.			SECTOR EMPLOYMENT
187	S	59	SECTOR 7940.			SECTOR EMPLOYMENT
188	S	59	SECTOR 8000.			SECTOR EMPLOYMENT
189	S	59	SECTOR 8060.			SECTOR EMPLOYMENT
190	S	59	SECTOR 8200.			SECTOR EMPLOYMENT
191	S	59	SECTOR 8600.			SECTOR EMPLOYMENT
192	S	59	SECTOR10000.			SECTOR EMPLOYMENT
193	S	59	SECTOR10700.			SECTOR EMPLOYMENT
194	S	59	SECTOR15000.			SECTOR EMPLOYMENT
195	S	59	SECTOR19000.			SECTOR EMPLOYMENT
196	S	59	SECTOR40000.			SECTOR EMPLOYMENT
197	S	59	SECTOR50000.			SECTOR EMPLOYMENT
198	S	59	SECTOR52000.			SECTOR EMPLOYMENT
199	S	59	SECTOR60000.			SECTOR EMPLOYMENT
200	S	59	SECTOR70000.			SECTOR EMPLOYMENT
201	S	58	CO \$-TOTAL			TOTAL BUDGET
202	S	58	COPCS-TOTAL			TOTAL BUDGET
203	V	5	CONDUCTIVITY	CON	COND	
204	V	-0	COUNT			
205	V	5	PH			
206	V	-0	STD-LENGTH	LENGTH		
207	V	5	TEMPERATURE	TEMP		
208	V	-0	WEIGHT			
209	V	-0	ACTINIUM	AC	89	ELEMENT
210	V	45	ALUMINUM	AL	13	ELEMENT
211	V	-0	AMERICIUM	AM	95	ELEMENT
212	V	49	ANTIMONY	SB	51	ELEMENT
213	V	-0	ARGON	AR	18	ELEMENT
214	V	65	ARSENIC	AS	33	ELEMENT
215	V	-0	ASTATINE	AT	85	ELEMENT
216	V	45	BARIUM	BA	56	ELEMENT
217	V	-0	BERKELIUM	BK	97	ELEMENT
218	V	-0	BERYLLIUM	BE	4	ELEMENT
219	V	-0	BISMUTH	BI	83	ELEMENT
220	V	-0	BORON	B	5	ELEMENT
221	V	224	BROMINE	BR	35	ELEMENT
222	V	10	CADMIUM	CD	48	ELEMENT
223	V	61	CALCIUM	CA	20	ELEMENT
224	V	-0	CALIFORNIUM	CA	20	ELEMENT
225	V	-0	CARBON	C	6	ELEMENT
226	V	46	CERIUM	CE	58	ELEMENT
227	V	48	CESIUM	CS	55	ELEMENT
228	V	46	CHLORINE	CL	17	ELEMENT
229	V	48	CHROMIUM	CR	24	ELEMENT
230	V	52	COBALT	CO	27	ELEMENT
231	V	187	COPPER	CU	29	ELEMENT
232	V	-0	CURIUM	CM	96	ELEMENT
233	V	39	DYSPROSIUM	DY	66	ELEMENT
234	V	-0	EINSTEINIUM	ES	99	ELEMENT
235	V	-0	ERBIUM	ER	68	ELEMENT
236	V	46	EUROPIUM	EU	63	ELEMENT
237	V	-0	FERMIUM	FM	100	ELEMENT
238	V	-0	FLUORINE	F	9	ELEMENT
239	V	-0	FRANCIUM	FR	87	ELEMENT
240	V	-0	GADOLINIUM	GD	64	ELEMENT

Table 5. (Continued)

PAGE

241	V	31 GALLIUM	GA	31	ELEMENT
242	V	-0 GERMANIUM	GE	32	ELEMENT
243	V	-0 GOLD	AU	79	ELEMENT
244	V	46 HAFNIUM	HF	72	ELEMENT
245	V	-0 HELIUM	HE	2	ELEMENT
246	V	-0 HOLMIUM	HO	67	ELEMENT
247	V	-0 HYDROGEN	H	1	ELEMENT
248	V	18 INDIUM	IN	49	ELEMENT
249	V	6 IODINE	I	53	ELEMENT
250	V	-0 IRIIDIUM	IR	77	ELEMENT
251	V	230 IRON	FE	26	ELEMENT
252	V	-0 KRYPTON	KR	36	ELEMENT
253	V	44 LANTHANUM	LA	57	ELEMENT
254	V	72 LEAD	PB	82	ELEMENT
255	V	-0 LITHIUM	LI	3	ELEMENT
256	V	44 LUTETIUM	LU	71	ELEMENT
257	V	48 MAGNESIUM	MG	12	ELEMENT
258	V	222 MANGANESE	MN	25	ELEMENT
259	V	-0 MENDELEVIUM	MD	101	ELEMENT
260	V	5 MERCURY	HG	80	ELEMENT
261	V	39 MOLYBDENUM	MO	42	ELEMENT
262	V	43 NEODYMIUM	ND	60	ELEMENT
263	V	-0 NEON	NE	10	ELEMENT
264	V	-0 NEPTUNIUM	NP	93	ELEMENT
265	V	152 NICKEL	NI	28	ELEMENT
266	V	-0 NIOBIUM	NB	41	ELEMENT
267	V	-0 NITROGEN	N	7	ELEMENT
268	V	-0 NOBELIUM	NO	102	ELEMENT
269	V	-0 OSMIUM	OS	76	ELEMENT
270	V	-0 OXYGEN	O	8	ELEMENT
271	V	1 PALLADIUM	PD	46	ELEMENT
272	V	-0 PHOSPHORUS	P	15	ELEMENT
273	V	-0 PLATINUM	PT	78	ELEMENT
274	V	-0 PLUTONIUM	PU	94	ELEMENT
275	V	-0 POLONIUM	PO	84	ELEMENT
276	V	228 POTASSIUM	K	19	ELEMENT
277	V	-0 PRASEODYMIUM	PR	59	ELEMENT
278	V	-0 PROMETHIUM	PM	61	ELEMENT
279	V	-0 PROTACTINIUM	PA	91	ELEMENT
280	V	-0 RADIUM	RA	88	ELEMENT
281	V	-0 RADON	RN	86	ELEMENT
282	V	-0 RHENIUM	RE	75	ELEMENT
283	V	-0 RHODIUM	RH	45	ELEMENT
284	V	225 RUBIDIUM	RB	37	ELEMENT
285	V	-0 RUTHENIUM	RU	44	ELEMENT
286	V	45 SAMARIUM	SM	62	ELEMENT
287	V	50 SCANDIUM	SC	21	ELEMENT
288	V	174 SELENIUM	SE	34	ELEMENT
289	V	1 SILICON	SI	14	ELEMENT
290	V	6 SILVER	AG	47	ELEMENT
291	V	52 SODIUM	NA	11	ELEMENT
292	V	61 STRONTIUM	SR	38	ELEMENT
293	V	-0 SULFUR	S	16	ELEMENT
294	V	48 TANTALUM	TA	73	ELEMENT
295	V	-0 TECHNETIUM	TC	43	ELEMENT
296	V	-0 TELLURIUM	TE	52	ELEMENT
297	V	43 TERBIUM	TB	65	ELEMENT
298	V	-0 THALLIUM	TL	81	ELEMENT
299	V	46 THORIUM	TH	90	ELEMENT
300	V	-0 THULIUM	TM	69	ELEMENT

Table 5. (Continued)

301	V	-0 TIN	SN	50	ELEMENT
302	V	35 TITANIUM	TI	22	ELEMENT
303	V	21 TUNGSTEN	W	74	ELEMENT
304	V	40 URANIUM	U	92	ELEMENT
305	V	31 VERADIUM	V	23	ELEMENT
306	V	-0 XENON	XE	54	ELEMENT
307	V	45 YTTERBIUM	YB	70	ELEMENT
308	V	5 YTTRIUM	Y	39	ELEMENT
309	V	230 ZINC	ZN	30	ELEMENT
310	V	63 ZIRCONIUM	ZR	40	ELEMENT
311	V	-0 FRC-RAY	FRCR		FINRAY COUNTS
312	V	-0 FRC-SPINE1	FRCS1	FRCS	FINRAY COUNTS
313	V	-0 FRC-SPINE2	FRCS2		FINRAY COUNTS
314	W	56 BICARBONATE	HC03		
315	W	56 CARBONATE	C03		
316	W	286 CONDUCTIVITY	CON	COND	
317	W	1 CO2			
318	W	24 NH4			
319	W	24 NO3			
320	W	345 PH			
321	W	110 RES-TEMP	TEMP-RES		
322	W	111 RESISTIVITY	RESIS	RES	
323	W	57 SO4			
324	W	56 TDS			
325	W	329 TEMP-SOURCE	SOURCE TEMP		
326	W	78 VOLUME-LWA	VOL-LG		
327	W	162 VOLUME-SWA	VOL-SM		
328	W	-0 ACTINIUM	AC	89	ELEMENT
329	W	-0 ALUMINUM	AL	13	ELEMENT
330	W	-0 AMERICIUM	AM	95	ELEMENT
331	W	-0 ANTIMONY	SB	51	ELEMENT
332	W	-0 ARGON	AR	18	ELEMENT
333	W	16 ARSENIC	AS	33	ELEMENT
334	W	-0 ASTATINE	AT	85	ELEMENT
335	W	65 BARIUM	BA	56	ELEMENT
336	W	-0 BERKELIUM	BK	97	ELEMENT
337	W	-0 BERYLLIUM	BE	4	ELEMENT
338	W	-0 BISMUTH	BI	83	ELEMENT
339	W	56 BORON	B	5	ELEMENT
340	W	-0 BROMINE	BR	35	ELEMENT
341	W	25 CADMIUM	CD	48	ELEMENT
342	W	65 CALCIUM	CA	20	ELEMENT
343	W	-0 CALIFORNIUM	CA	20	ELEMENT
344	W	-0 CARBON	C	6	ELEMENT
345	W	-0 CERIUM	CE	58	ELEMENT
346	W	-0 CESIUM	CS	55	ELEMENT
347	W	64 CHLORINE	CL	17	ELEMENT
348	W	-0 CHROMIUM	CR	24	ELEMENT
349	W	25 COBALT	CO	27	ELEMENT
350	W	41 COPPER	CU	29	ELEMENT
351	W	-0 CURIUM	CM	96	ELEMENT
352	W	-0 DYSPROSIUM	DY	66	ELEMENT
353	W	-0 EINSTEINIUM	ES	99	ELEMENT
354	W	-0 ERBIUM	ER	68	ELEMENT
355	W	-0 EUROPIUM	EU	63	ELEMENT
356	W	-0 FERMIUM	FM	100	ELEMENT
357	W	24 FLUORINE	F	9	ELEMENT
358	W	-0 FRANCIUM	FR	87	ELEMENT
359	W	-0 GADOLINIUM	GD	64	ELEMENT
360	W	-0 GALLIUM	GA	31	ELEMENT

PAGE

Table 5. (Continued)

PAGE

361	W	-0 GERMANIUM	GE	32	ELEMENT
362	W	-0 GOLD	AU	79	ELEMENT
363	W	-0 HAFNIUM	HF	72	ELEMENT
364	W	-0 HELIUM	HE	2	ELEMENT
365	W	-0 HOLMIUM	HO	67	ELEMENT
366	W	-0 HYDROGEN	H	1	ELEMENT
367	W	-0 IODINE	I	49	ELEMENT
368	W	-0 IODINE	I	53	ELEMENT
369	W	-0 IRIDIUM	IR	77	ELEMENT
370	W	41 IRON	FE	26	ELEMENT
371	W	-0 KRYPTON	KR	36	ELEMENT
372	W	-0 LANTHANUM	LA	57	ELEMENT
373	W	41 LEAD	PB	82	ELEMENT
374	W	57 LITHIUM	LI	3	ELEMENT
375	W	-0 LUTETIUM	LU	71	ELEMENT
376	W	65 MAGNESIUM	MG	12	ELEMENT
377	W	41 MANGANESE	MN	25	ELEMENT
378	W	-0 MENDELEVIIUM	MD	101	ELEMENT
379	W	25 MERCURY	HG	80	ELEMENT
380	W	-0 MOLYBDENUM	MO	42	ELEMENT
381	W	-0 NEODYMIUM	ND	60	ELEMENT
382	W	-0 NEON	NE	10	ELEMENT
383	W	-0 NEPTUNIUM	NP	93	ELEMENT
384	W	25 NICKEL	NI	28	ELEMENT
385	W	-0 NIOBIUM	NB	41	ELEMENT
386	W	-0 NITROGEN	N	7	ELEMENT
387	W	-0 NOBELIUM	NO	102	ELEMENT
388	W	-0 OSMIUM	OS	76	ELEMENT
389	W	-0 OXYGEN	O	8	ELEMENT
390	W	-0 PALLADIUM	PD	46	ELEMENT
391	W	-0 PHOSPHORUS	P	15	ELEMENT
392	W	-0 PLATINUM	PT	78	ELEMENT
393	W	-0 PLUTONIUM	PU	94	ELEMENT
394	W	-0 POLONIUM	PO	84	ELEMENT
395	W	65 POTASSIUM	K	19	ELEMENT
396	W	-0 PRASEODYMIUM	PR	59	ELEMENT
397	W	-0 PROMETHIUM	PM	61	ELEMENT
398	W	-0 PROTACTINIUM	PA	91	ELEMENT
399	W	-0 RADIUM	RA	88	ELEMENT
400	W	-0 RADON	RN	86	ELEMENT
401	W	-0 RHENIUM	RE	75	ELEMENT
402	W	-0 RHODIUM	RH	45	ELEMENT
403	W	57 RUBIDIUM	RB	37	ELEMENT
404	W	-0 RUTHENIUM	RU	44	ELEMENT
405	W	-0 SAMARIUM	SM	62	ELEMENT
406	W	-0 SCANDIUM	SC	21	ELEMENT
407	W	17 SELENIUM	SE	34	ELEMENT
408	W	-0 SILICON	SI	14	ELEMENT
409	W	-0 SILVER	AG	47	ELEMENT
410	W	65 SODIUM	NA	11	ELEMENT
411	W	38 STRONTIUM	SR	38	ELEMENT
412	W	-0 SULFUR	S	16	ELEMENT
413	W	-0 TANTALUM	TA	73	ELEMENT
414	W	-0 TECHNETIUM	TC	43	ELEMENT
415	W	-0 TELLURIUM	TE	52	ELEMENT
416	W	-0 TERBIUM	TB	65	ELEMENT
417	W	-0 THALLIUM	TL	81	ELEMENT
418	W	-0 THORIUM	TH	90	ELEMENT
419	W	-0 THULIUM	TM	69	ELEMENT
420	W	-0 TIN	SN	50	ELEMENT

Table 5. (Continued)

PAGE

421	W	-0 TITANIUM	TI	22	ELEMENT
422	W	-0 TUNGSTEN	W	74	ELEMENT
423	W	-0 URANIUM	U	92	ELEMENT
424	W	-0 VERADIUM	V	23	ELEMENT
425	W	-0 XENON	XE	54	ELEMENT
426	W	-0 YTTERBIUM	YB	70	ELEMENT
427	W	-0 YTTRIUM	Y	39	ELEMENT
428	W	81 ZINC	ZN	30	ELEMENT
429	W	-0 ZIRCONIUM	ZR	40	ELEMENT
430	•	LAST UPDATE WAS ON 760924			
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Table 6. IVEP experimental method-code file.

PAGE

1	T	MTD	01	METHOD CODE IN COLUMNS 5-7, CARD SEQUENCE NUMBER IN COLUMNS 9 AND 10,
2	•	MTD	02	COLUMNS 12 THRU 80 USED TO DEFINE METHOD, LIMIT IS 99 SEQUENCED CARDS
3	•	AAS	01	ATOMIC ABSORPTION
4	•	ASP	01	ANODIC STRIPPING POLAROGRAPHY
5	•	COL	01	COLORIMETRY
6	•	CSP	01	CATHODIC STRIPPING POLAROGRAPHY
7	•	EMS	01	EMISSION SPECTROSCOPY
8	•	FES	01	FLAME EMISSION
9	•	GRA	01	GRAVIMETRIC
10	•	ISE	01	ION-SPECIFIC ELECTRODE
11	•	NAA	01	NEUTRON ACTIVATION
12	•	RTC	01	REAL TIME CLOCK
13	•	TIT	01	TITRATION
14	•	XRF	01	X-RAY FLUORESCENCE
15	A	CIL	01	CHEMILUMINESCENCE
16	A	CUP	01	CUP ANEONMETER
17	A	EHG	01	ELECTROSTATIC-HG
18	A	IRA	01	IR ABSORPTION
19	A	LAT	01	LEAD ACETATE TAPE
20	A	PFL	01	PULSE FLO
21	A	RAD	01	RADIOMETER
22	A	SGM	01	SIGMA METER
23	A	TBP	01	THERMISTOR
24	A	TFC	01	THIN-FILM CAPACITOR
25	A	UVA	01	UV ABSORPTION
26	A	VNE	01	VANE
27	V	CBP	01	CONDUCTIVITY BY PROBE
28	V	ELP	01	ELAPSED
29	V	KNT	01	BY COUNT
30	V	PHM	01	PH BY METER
31	V	RUL	01	MEASUREMENT BY RULER
32	V	SCL	01	SCALE WEIGHT
33	V	TBP	01	TEMPERATURE BY PROBE
34	W	AOA	01	AOAC 4TH ED. 1970, METHOD 33.010
35	W	CBB	01	CONDUCTIVITY VIA BECKMAN SOLUBILITY BRIDGE
36	W	CBP	01	CONDUCTIVITY BY PROBE
37	W	PHH	01	PH BY HACH
38	W	PHM	01	PH BY METER
39	W	PHP	01	PH BY LITMIS PAPER
40	W	RBM	01	RESISTIVITY BY METER
41	W	TBP	01	TEMPERATURE BY PROBE
42	W	TBT	01	TEMPERATURE BY THERMOMETER
43	W	VBF	01	VOLUME BY FLASK
44	W	102	01	APHA AND AWWA METHOD 102, 13TH ED. STANDARD METHODS
45	W	121	01	APHA AND AWWA METHOD 121D, 13TH ED. STANDARD METHODS
46	W	148	01	APHA AND AWWA METHOD 148C, 13TH ED. STANDARD METHODS
47	W	156	01	APHA AND AWWA METHOD 156C, 13TH ED. STANDARD METHODS
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Table 7. IVEP Laboratory-of-Analysis-code file.

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1 T LAB LAB CODE IN COLUMNS 5-7, CODE DEFINATION IN COLUMNS 9 THRU 80
2 • LLL LAWRENCE LIVERMORE LABORATORY
3 • ??? UNKNOWN SOURCE
4 A LLA LAWRENCE LIVERMORE LABORATORY IVEP AIR QUALITY SURVEY PROGRAM
5 E AQD AIR QUALITY CONTROL DISTRICT
6 E FPC FEDERAL POWER COMMISSION DOCUMENTS
7 E PLT INDIVIDUAL PLANT OR FACTORY
8 E ARB CALIFORNIA STATE AIR RESOURCES BOARD
9 S S05 STATE OF CALIFORNIA
10 S C01 CALIFORNIA COUNTY CODE IDENTIFIERS C01 THRU C58
11 S C02 CALIFORNIA COUNTY CODE
12 S C03 CALIFORNIA COUNTY CODE
13 S C04 CALIFORNIA COUNTY CODE
14 S C05 CALIFORNIA COUNTY CODE
15 S C06 CALIFORNIA COUNTY CODE
16 S C07 CALIFORNIA COUNTY CODE
17 S C08 CALIFORNIA COUNTY CODE
18 S C09 CALIFORNIA COUNTY CODE
19 S C10 CALIFORNIA COUNTY CODE
20 S C11 CALIFORNIA COUNTY CODE
21 S C12 CALIFORNIA COUNTY CODE
22 S C13 CALIFORNIA COUNTY CODE
23 S C14 CALIFORNIA COUNTY CODE
24 S C15 CALIFORNIA COUNTY CODE
25 S C16 CALIFORNIA COUNTY CODE
26 S C17 CALIFORNIA COUNTY CODE
27 S C18 CALIFORNIA COUNTY CODE
28 S C19 CALIFORNIA COUNTY CODE
29 S C20 CALIFORNIA COUNTY CODE
30 S C21 CALIFORNIA COUNTY CODE
31 S C22 CALIFORNIA COUNTY CODE
32 S C23 CALIFORNIA COUNTY CODE
33 S C24 CALIFORNIA COUNTY CODE
34 S C25 CALIFORNIA COUNTY CODE
35 S C26 CALIFORNIA COUNTY CODE
36 S C27 CALIFORNIA COUNTY CODE
37 S C28 CALIFORNIA COUNTY CODE
38 S C29 CALIFORNIA COUNTY CODE
39 S C30 CALIFORNIA COUNTY CODE
40 S C31 CALIFORNIA COUNTY CODE
41 S C32 CALIFORNIA COUNTY CODE
42 S C33 CALIFORNIA COUNTY CODE
43 S C34 CALIFORNIA COUNTY CODE
44 S C35 CALIFORNIA COUNTY CODE
45 S C36 CALIFORNIA COUNTY CODE
46 S C37 CALIFORNIA COUNTY CODE
47 S C38 CALIFORNIA COUNTY CODE
48 S C39 CALIFORNIA COUNTY CODE
49 S C40 CALIFORNIA COUNTY CODE
50 S C41 CALIFORNIA COUNTY CODE
51 S C42 CALIFORNIA COUNTY CODE
52 S C43 CALIFORNIA COUNTY CODE
53 S C44 CALIFORNIA COUNTY CODE
54 S C45 CALIFORNIA COUNTY CODE
55 S C46 CALIFORNIA COUNTY CODE
56 S C47 CALIFORNIA COUNTY CODE
57 S C48 CALIFORNIA COUNTY CODE
58 S C49 CALIFORNIA COUNTY CODE
59 S C50 CALIFORNIA COUNTY CODE
60 S C51 CALIFORNIA COUNTY CODE

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Table 7. (Continued)

PAGE

61	S C52 CALIFORNIA COUNTY CODE
62	S C53 CALIFORNIA COUNTY CODE
63	S C54 CALIFORNIA COUNTY CODE
64	S C55 CALIFORNIA COUNTY CODE
65	S C56 CALIFORNIA COUNTY CODE
66	S C57 CALIFORNIA COUNTY CODE
67	S C58 CALIFORNIA COUNTY CODE
68	S CEN U.S. BUREAU OF THE CENSUS
69	S CBP U.S. DEPT OF COMMERCE, COUNTY BUSINESS PATTERNS
70	V LLV LAWRENCE LIVERMORE LABORATORY IVEP ECO-SYSTEM FIELD SURVEY PROGRAM
71	W GHT GHT LABORATORIES OF IMPERIAL VALLEY, INC.
72	W VET HOWARD AGRICULTURE CONSULTATION AND RESEARCH, BRAWLEY, CA.
73	W LCH LAWRENCE LIVERMORE LABORATORY CHEMISTRY GROUP
74	W LLW LAWRENCE LIVERMORE LABORATORY IVEP WATER QUALITY FIELD SURVEY PROGRAM
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Table 8. IVEP unit-code file.

PAGE

1 T UNT UNIT CODE IN COLUMNS 5-7, CODE DEFINATION IN COLUMNS 9 THRU 80
2 • 015 MICROGRAMS PER CUBIC METER
3 • 001 MICROGRAMS PER GRAM
4 • 002 MICROGRAMS PER GRAM ASH
5 • 003 MICROGRAMS PER GRAM DRY
6 • 004 MICROGRAMS PER GRAM WET
7 • 005 MICROGRAMS PER KILOGRAM
8 • 006 MICROGRAMS PER KILOGRAM DRY
9 • 007 MICROGRAMS PER KILOGRAM WET
10 • 009 MICROGRAMS PER LITER
11 • 008 MICROGRAMS PER MILLIGRAM
12 • 010 MICROGRAMS PER MILLILITER
13 • 014 MICROGRAMS PER SAMPLE
14 • 012 MICROGRAMS PER SCF
15 • 011 MICROGRAMS PER SQUARE CENTIMETER
16 • 013 MICROGRAMS PER STAGE
17 A DEG DEGREES THETA
18 A STD LOCAL TIME REPORTED AS YYMMDDHHMM
19 A MPS METERS PER SECOND
20 A PPB PARTS PER BILLION
21 A PPM PARTS PER MILLION
22 E AFY ACRE-FEET PER YEAR
23 E BPY BARRELS PER YEAR
24 E BTU BTU
25 E BKH BTU PER KILOWATT-HOUR
26 E KBY KILOBARRELS PER YEAR
27 E KTY KILOTONS PER YEAR
28 E MHR MEGAWATT-HOURS
29 E MHY MEGAWATT-HOURS PER YEAR
30 E MWT MEGAWATTS
31 E MWE MEGAWATTS ELECTRIC
32 E MCF MILLION CUBIC FEET
33 E PER PERCENT
34 E TPY TONS PER YEAR
35 S \$\$\$ DOLLARS
36 S FAM FAMILIES
37 S POP PEOPLE
38 V A3S ABSOLUTE COUNT
39 V CTM CENTIMETERS
40 V KNT COUNT
41 V GMS GRAMS
42 V HRS HOURS
43 V KGM KILOGRAM
44 V MTS METERS
45 V MGM MILLIGRAMS
46 W DGC DEGREES CENTIGRADE
47 W DGF DEGREES FAHRENHEIT
48 W DGK DEGREES KELVIN
49 W GPL GRAMS PER LITER
50 W LIT LITERS
51 W UPL MICROGRAMS PER LITER
52 W UMC MICROMHOS/CENTIMETER
53 W MPL MILLIGRAMS PER LITER
54 W MMC MILLIMHOS/CENTIMETER
55 W NUN NO ASSOCIATED UNIT
56 W OMM OHM-METERS
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"M" reports the error. Finally, a "U" indicates that the code files have been updated for the information given on that data line. A brief summary is provided at the end of each output file. Corrections may be made as necessary via teletypewriter or punched cards.

Tables 9 through 12 are examples of card-image-data files. Table sequence 9 portrays the processing procedure of an error-dubbed-input file (Table 9a). Table 9b is the first output file; Table 9c is the output of the corrected version of Table 9b. Finally Table 9d is the final output file as it appears in the IVEP Data Base. Note that the final file reflects updating of the code files discussed above.

Table 10 again demonstrates the processing procedure. Note that the geographic information, i.e. latitude and longitude, has been generated from the fixed-site code embedded within the identifier. Also, use was made of the parameter-synonym file (Table 5).

Tables 11 and 12 are typical data files; the first is an example of input from the Socioeconomic Program Table 12 presents soil-sample data taken by the Ecosystems Program at depths of zero to three inches (0D3) and three to six (3D6) inches.

No analytical results have yet been reported for sample VKS001B

as shown by the missing 400-type cards.

The Air Quality Program and miscellaneous data bases do not fit the IVEP Data-Base Plan conveniently. The Air Quality group generates an enormous number of data points; most miscellaneous non-LLL data bases are not directly compatible with the IVEP Data Base format. For these reasons each will be reported separately and indexed in such a manner to conform with the IVEP Data-Base Plan.

Air Quality data are transferred to the IVEP Data-Base via computer-disk files. Each file consists of multiple records reported by time for individual fixed-site gas/meteorologic sampling stations. Files are named as follows: A**YMDDmdd where A = LLL Air Quality Program

identifier,

** = the fixed-site-station identifier,

Y = the last digit of the year of the first data record,

M = the month of the first data record (1 through 9, J, K, L),

DD = the day of the first data record (zero filled),

m = the month of the last data record (1 thru 9, J, K, L), and

dd = the day of the last data record (zero filled).

Table 9a. Data-input file 1 (State electrical energy data).

PAGE

751	0400E72STABPLT-CAPACITY96.	??????FPC	MWE
752	0400E72STABROC 110.	??????FPC	KBY
753	0400E72STABS-CONTENT .4	??????FPC	PER
754	0400E72STABS02 .15	??????FPC	KTY
755	0400E72STABTYPE	*****FPC	***OIL,GAS
756	0400E72STABUPC	*****FPC	***433500-0700
757	0100E72VALL72***		274500
758	0200E72VALLENERGYABC POWER-PLANT OIL,MUNICIPAL		;; NAT.-GAS REFINERY
759	0400E72VALLGENERATION 2235800	??????FPC	MHY
760	0400E72VALLAQC-REG	*****FPC	***024
761	0400E72VALLHEAT-RATING 11608.	??????FPC	BKH
762	0400E72VALLNAME	***FPC	***VALLEY
763	0400E72VALLNGC 20078.	??? FPC	MCF
764	0400E72VALLNOX 5.65	???ZZZXXX	KTY
765	0400E72VALLOWNER	*****YYY	***LOS ANGELES WATER AND POWER
766	0400E72VALLAVG-H2O-CONS7.227	??????FPC	AFY
767	0400E72VALLPLT-CAPACITY545.6	??????FPC	ZZZ
768	0400E72VALLROC 778.	??????FPC	KBY
769	0400E72VALLCOOLING-TYPE	*****FPC	***COOLING-TOWER
770	0300E72VALL INFORMATION SOURCE = FPC-S-246 (1975)		
771	0400E72VALLH2O-SOURCE	*****FPC	***
772	0400E72VALLPARTICULATES.02	??????FPC	
773	0400E72VALLS-CONTENT .45	??????	PER
774	0400E72VALLCOUNTY	*****FPC	***LOS ANGELES
775	0400E72VALLS02 1.39	??????FPC	KTY
776	0400E72VZZZTYPE	*****FPC	***OIL,GAS
777	0400X72VALLUPC	*****FPC	***274500-1600
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Note: There are 20 demonstration errors purposely entered here for sample E72VALL. The preprocessor will identify these errors (see Table 9b).

Table 9b. Output file 1.1 (Output of input-data set Table 9a.)

				PAGE
751	C400E72STABPLT-CAPACITY96.	??????FPCNP760926MWE		
752	C400E72STABROC 110.	??????FPCNP760926KBY		
753	C400E72STABS-CONTENT .4	??????FPCNP760926PER		
754	C400E72STABS02 .15	??????FPCNP760926KTY		
755	C400E72STABTYPE	*****FPCNP760926***OIL,GAS		
756	C400E72STABUPC	*****FPCNP760926***433500-0700		
757	M100E72VALL			ERROR-- SITE CODE UNDEFINED
758	M100E72VALL			ERROR-- NO LOCATION KNOWN
759	E100E72VALL72****	274500		
760	M200E72VALL			ERROR-- UNDEFINED SAMPLE TYPE
761	M200E72VALL			ERROR-- SAMPLE TYPE NOT A KEY
762	M200E72VALL 'NAT.-GAS;			=UNDEFINED KEY ERROR
763	M200E72VALL 'REFINERY;			ILLEGAL KEYWORD PAIR ERROR
764	E200E72VALLENERGYABC POWER-PLANT OIL,MUNICIPAL ;; NAT.-GAS REFINERY			
765	C300E72VALL INFORMATION SOURCE = FPC-S-246 (1975)			ERROR-- UNDEFINED PARAMETER
766	M400E72VALLAQC-REG	*****FPC *****024		
767	E400E72VALLAQC-REG	??????FPCNP760926AFY		
768	C400E72VALLAVG-H2O-CONST.227	*****FPCNP760926***COOLING-TOWER		
769	C400E72VALLCOOLING-TYPE	*****FPCNP760926***LOS ANGELES		
770	C400E72VALLCOUNTY			ERROR-- BAD VALUE SPECIFIED
771	M400E72VALLGENERATION	??????FPC MHY		ERROR-- NO VALUE OR REMARK
772	E400E72VALLGENERATION 2235800	*****FPC ***		
773	M400E72VALLH2O-SOURCE	??????FPCNP760926BKH		ERROR-- BAD ERROR FORMAT
774	E400E72VALLH2O-SOURCE	***FPC ***VALLEY		ERROR-- NO METHOD CODE
775	C400E72VALLHEAT-RATING 11608.	??? FPC MCF		ERROR-- BAD METHOD CODE= ZZZ
776	M400E72VALLNAME	*****YYY ***LOS ANGELES WATER AND POWER		ERROR-- BAD LAB CODE= XXX
777	E400E72VALLNAME	??????FPC		ERROR-- BAD LAB CODE= YYY
778	M400E72VALLNGC	??????FPC		ERROR-- NO UNIT CODE
779	E400E72VALLNGC 20078.	??????FPC ZZZ		ERROR-- BAD UNIT CODE= ZZZ
780	M400E72VALLNOX	??????FPCNP760926KBY		ERROR-- NO LAB CODE
781	M400E72VALLNOX	?????? PER		
782	E400E72VALLNOX 5.65	??????FPCNP760926KTY		ERROR-- MISSING 100 TYPE CARD
783	M400E72VALLOWNER	*****FPCNP760926***OIL,GAS		ERROR-- BAD SAMPLE PROGRAM ID
784	E400E72VALLOWNER	*****FPCNP760926***274500-1600		ERROR-- MISSING 100 TYPE CARD
785	M400E72VALLPARTICULATES			
786	E400E72VALLPARTICULATES.02			
787	M400E72VALLPLT-CAPACITY			
788	E400E72VALLPLT-CAPACITY545.6			
789	C400E72VALLROC 778.			
790	M400E72VALLS-CONTENT			
791	E400E72VALLS-CONTENT .45			
792	C400E72VALLS02 1.39			
793	M400E72VZZZ			
794	C400E72VZZZTYPE			
795	M400X72VALL			
796	M400X72VALL			
797	E400X72VALLUPC			
798	M 2760926 TOTAL NUMBER CARDS READ=	777		
799	M 2760926 NUMBER DATA ENTRIES ATTEMPTED=	777		
800	M 2760926 NUMBER CARDS ASSIGNED=	0		
801	M 2760926 TOTAL NUMBER LINES WRITTEN=	797		
802	M 2760926 NUMBER ERRORS WRITTEN=	20		
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Table 9c. Output file 1.2 (Output of corrected data set Table 9b.)

PAGE

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751 C400E72STABPLT-CAPACITY96.      ??????FPCNP760926MWE
752 C400E72STABROC      110.      ??????FPCNP760926KBY
753 C400E72STABS-CONTENT      .4      ??????FPCNP760926PER
754 C400E72STABS02      .15      ??????FPCNP760926KTY
755 C400E72STABTYPE      ??????FPCNP760926KTY
756 C400E72STABUPC      *****FPCNP760926***OIL,GAS
757 C1Q0E72VALL72****      *****FPCNP760926***433500-0700
758 C200E72VALLENERGY      2745001600
759 C300E72VALL INFORMATION SOURCE = FPC-S-246 (1975)
760 C400E72VALLAQC-REGION      *****FPCNP760926***024
761 C400E72VALLAVG-H2O-CONST.227      ??????FPCNP760926AFY
762 C400E72VALLCOOLING-TYPE      *****FPCNP760926***COOLING-TOWER
763 C400E72VALLCOUNTY      *****FPCNP760926***LOS ANGELES
764 C400E72VALLGENERATION 2235800.      ??????FPCNP760926MHY
765 C400E72VALLH2O-SOURCE      *****FPCNP760926***MUNICIPAL
766 C400E72VALLHEAT-RATING 11608.      ??????FPCNP760926BKH
767 C400E72VALLNAME      *****FPCNP760926***VALLEY
768 C400E72VALLNGC      20078.      ??????FPCNP760926MCF
769 C400E72VALLNOX      5.65      ??????FPCNP760926KTY
770 C400E72VALLOWNER      *****FPCNP760926***LOS ANGELES WATER AND POWER
771 C400E72VALLPARTICULATES.02      ??????FPCNP760926KTY
772 C400E72VALLPLT-CAPACITY545.6      ??????FPCNP760926MWE
773 C400E72VALLROC      778.      ??????FPCNP760926KBY
774 C400E72VALLS-CONTENT      .45      ??????FPCNP760926PER
775 C400E72VALLS02      1.39      ??????FPCNP760926KTY
776 C400E72VALLTYPE      *****FPCNP760926***OIL,GAS
777 C400E72VALLUPC      *****FPCNP760926***274500-1600
778 M Z760926      TOTAL NUMBER CARDS READ=      777
779 M Z760926      NUMBER DATA ENTRIES ATTEMPTED=      777
780 M Z760926      NUMBER CARDS ASSIGNED=      0
781 M Z760926      TOTAL NUMBER LINES WRITTEN=      777
782 M Z760926      NUMBER ERRORS WRITTEN=      0
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Table 9d. Output file 1.3 (Final output file -- code-file updates indicated.)

PAGE

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751 U400E72STABLT-CAPACITY96.      ??????FPCNP760926MWE
752 U400E72STABROC      110.      ??????FPCNP760926KBY
753 U400E72STABS-CONTENT      .4      ??????FPCNP760926PER
754 U400E72STABS02      .15      ??????FPCNP760926KTY
755 U400E72STABTYPE      ??????FPCNP760926***OIL,GAS
756 U400E72STABUPC      ??????FPCNP760926***433500-0700
757 U100E72VALL72***      2745001600
758 U200E72VALLENERGY      POWER-PLANT;OIL;MUNICIPAL;NATURAL-GAS;
759 U300E72VALL INFORMATION SOURCE = FPC-S-246 (1975)
760 U400E72VALLAQ-REGION      *****FPCNP760926***024
761 U400E72VALLAVG-H2O-CONST7.227      ??????FPCNP760926AFY
762 U400E72VALLCOOLING-TYPE      *****FPCNP760926***COOLING-TOWER
763 U400E72VALLCOUNTY      *****FPCNP760926***LOS ANGELES
764 U400E72VALLGENERATION 2235800.      ??????FPCNP760926MHY
765 U400E72VALLH2O-SOURCE      *****FPCNP760926***MUNICIPAL
766 U400E72VALLHEAT-RATING 11608.      ??????FPCNP760926BKH
767 U400E72VALLNAME      *****FPCNP760926***VALLEY
768 U400E72VALLNGC      20078.      ??????FPCNP760926MCF
769 U400E72VALLNOX      5.65      ??????FPCNP760926KTY
770 U400E72VALLOWNER      *****FPCNP760926***LOS ANGELES WATER AND POWER
771 U400E72VALLPARTICULATES.02      ??????FPCNP760926KTY
772 U400E72VALLPLT-CAPACITY545.6      ??????FPCNP760926MWE
773 U400E72VALLROC      778.      ??????FPCNP760926KBY
774 U400E72VALLS-CONTENT      .45      ??????FPCNP760926PER
775 U400E72VALLS02      1.39      ??????FPCNP760926KTY
776 U400E72VALLTYPE      *****FPCNP760926***OIL,GAS
777 U400E72VALLUPC      *****FPCNP760926***274500-1600
778 M      Z760926      TOTAL NUMBER CARDS READ=      777
779 M      Z760926      NUMBER DATA ENTRIES ATTEMPTED=      777
780 M      Z760926      NUMBER CARDS ASSIGNED=      0
781 M      Z760926      TOTAL NUMBER LINES WRITTEN=      777
782 M      Z760926      NUMBER ERRORS WRITTEN=      0
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Table 10a. Data-input file 2 (LLL Water Quality Survey Program.)

PAGE

1	C100WAB03*	7602251400			GENTRY YOUNG
2	C200WAB03*	WATER	CANAL	VAIL4/VAIL4A	
3	C400WAB03*	COND	1.43	???CBPLLW	MMC
4	C400WAB03*	PH	8.2	???PHMLLW	NUN
5	C400WAB03*	TEMP-SOURCE	18.3	???TBTLLW	DGC
6	C400WAB03*	VOLUME-LWA	11.1	???VBFLW	LIT
7	C303WAB031	RAWUNFILTERED			
8	C400WAB031	AS	.004	???COLGHT	MPL
9	C400WAB031	B	.35	14.COLGHT	MPL
10	C400WAB031	BA	.12	20.AASGHT	MPL
11	C400WAB031	CD	.0006	???ASPGHT	MPL
12	C400WAB031	CO		.005NDLAASGHT	MPL
13	C400WAB031	CU	.016	???ASPGHT	MPL
14	C400WAB031	CU	.25	28.AASVET	MPL
15	C400WAB031	FE	.22	20.AASGHT	MPL
16	C400WAB031	FE	1.475	5.0AASVET	MPL
17	C400WAB031	HG	.0024	20.AASGHT	MPL
18	C400WAB031	MN	.01	20.AASGHT	MPL
19	C400WAB031	MN	.1	40.AASVET	MPL
20	C400WAB031	NI		.005 NDLAASGHT	MPL
21	C400WAB031	PB	.027	NDLAASVET	MPL
22	C400WAB031	PB	.030	???ASPGHT	MPL
23	C400WAB031	SE		.001 NDLCSPGHT	MPL
24	C400WAB031	ZN	.010	20.AASGHT	MPL
25	C400WAB031	ZN	1.14	3.0AASVET	MPL
26	C400WAB032	B	.32	16.COLGHT	MPL
27	C400WAB032	CL	.19	5.3TITLCH	GPL
28	C400WAB032	CL	199.	???AOAVET	MPL
29	C400WAB032	CL	200.	5.0TITGHT	MPL
30	C400WAB032	COND	1.6	2.0CBVET	MMC
31	C400WAB032	COND	1650.	3.0CBPGHT	UMCCOMPENSATED TO 25 C
32	C400WAB032	CO3	13.	23.102VET	MPL
33	C400WAB032	CO3	16.4	12.TITGHT	MPL
34	C400WAB032	F	.35	14.COLGHT	MPL
35	C400WAB032	F	.55	30.121VET	MPL
36	C400WAB032	F	.6	33.ISELCH	MPL
37	C400WAB032	HCO3	140.	1.4TITGHT	MPL
38	C400WAB032	HCO3	172.	1.7102VET	MPL
39	C400WAB032	NH4		.03 NDLTITGHT	MPL
40	C400WAB032	NH4	.12	NDLISEVET	PPM
41	C400WAB032	NH4	.1	NDLISELCH	MPL
42	C400WAB032	NO3	4.4	NDLISEVET	MPL
43	C400WAB032	NO3	.2	50.COLGHT	MPL
44	C400WAB032	NO3	4.5	11.ISELCH	MPL
45	C400WAB032	PH	8.00	.62PHMGHT	NUN
46	C400WAB032	PH	8.54	.23PHMVET	NUN
47	C400WAB032	SO4	.40	5.0TITLCH	GPL
48	C400WAB032	SO4	335.	6.0GRAGHT	MPL
49	C400WAB032	SO4	385.	4.8156VET	MPL
50	C400WAB032	TDS	1090.	5.0148VET	MPL
51	C400WAB032	TDS	1052.	5.0GRAGHT	MPL
52	C301WAB033	ACIDIFIED HCL			
53	C302WAB034	ACIDIFIED HNO3			
54	C400WAB034	BA	1.	NDLAASLCH	MPL
55	C400WAB034	CALCIUM	92.	2.2AASLCH	MPL
56	C400WAB034	CD	.05	NDLAASLCH	MPL
57	C400WAB034	CO	.1	NDLAASLCH	MPL
58	C400WAB034	CU	.05	NDLAASLCH	MPL
59	C400WAB034	FE	.05	NDLAASLCH	MPL
60	C400WAB034	HG	.0005	NDLAASLCH	MPL

└─ Site Code

Note: Samples are identified by WXYijk
 where: W = LLL Water Quality Survey Program
 XY = fixed site code
 ij = field trip designation
 k = major aliquot. An asterisk (*)
 implies that the information
 pertains to all k.

Table 10b. Output file 2.1 (Output of input-data set Table 10a.)

PAGE

1	C100WAB03*	7602251400	W11536.835N3307.995	GENTRY YOUNG
2	C200WAB03*	WATER	CANAL;VAIL4/VAIL4A;	
3	C400WAB03*	CONDUCTIVITY	1.43	???CBPLLWNP760926MMC
4	C400WAB03*	PH	8.2	???PHMLLWNP760926NUN
5	C400WAB03*	TEMP-SOURCE	18.3	???TBTLLWNP760926DGC
6	C400WAB03*	VOLUME-LWA	11.1	???VBFLLWNP760926LIT
7	C303WAB031	RAWUNFILTERED		
8	C400WAB031	ARSENIC	.004	???COLGHTNP760926MPL
9	C400WAB031	BARIUM	.12	20.AASGHTNP760926MPL
10	C400WAB031	BORON	.35	14.COLGHTNP760926MPL
11	C400WAB031	CADMIUM	.0006	???ASPGHTNP760926MPL
12	C400WAB031	COBALT	.005	NDLAASGHTNP760926MPL
13	C400WAB031	COPPER	.016	???ASPGHTNP760926MPL
14	C400WAB031	COPPER	.25	28.AASVETNP760926MPL
15	C400WAB031	IRON	.22	20.AASGHTNP760926MPL
16	C400WAB031	IRON	1.475	5.0AASVETNP760926MPL
17	C400WAB031	LEAD	.027	NDLAASVETNP760926MPL
18	C400WAB031	LEAD	.030	???ASPGHTNP760926MPL
19	C400WAB031	MANGANESE	.01	20.AASGHTNP760926MPL
20	C400WAB031	MANGANESE	.1	40.AASVETNP760926MPL
21	C400WAB031	MERCURY	.0024	20.AASGHTNP760926MPL
22	C400WAB031	NICKEL	.005	NDLAASGHTNP760926MPL
23	C400WAB031	SELENIUM	.001	NDLCSPGHTNP760926MPL
24	C400WAB031	ZINC	.010	20.AASGHTNP760926MPL
25	C400WAB031	ZINC	1.14	3.0AASVETNP760926MPL
26	C400WAB032	BICARBONATE	140.	1.4TITGHTNP760926MPL
27	C400WAB032	BICARBONATE	172.	1.7102VETNP760926MPL
28	C400WAB032	BORON	.32	16.COLGHTNP760926MPL
29	C400WAB032	CARBONATE	13.	23.102VETNP760926MPL
30	C400WAB032	CARBONATE	16.4	12.TITGHTNP760926MPL
31	C400WAB032	CHLORINE	.19	5.3TITLCHNP760926GPL
32	C400WAB032	CHLORINE	199.	???A0AVETNP760926MPL
33	C400WAB032	CHLORINE	200.	5.0TITGHTNP760926MPL
34	C400WAB032	CONDUCTIVITY	1.6	2.0CBVETNP760926MMC
35	C400WAB032	CONDUCTIVITY	1650.	3.0CBPGHTNP760926UMCCOMPENSATED TO 25 C
36	C400WAB032	FLUORINE	.35	14.COLGHTNP760926MPL
37	C400WAB032	FLUORINE	.55	30.121VETNP760926MPL
38	C400WAB032	FLUORINE	.6	33.ISELCHNP760926MPL
39	C400WAB032	NH4	.03	NDLTITGHTNP760926MPL
40	C400WAB032	NH4	.12	NDLISEVETNP760926PPM
41	C400WAB032	NH4	.1	NDLISELCHNP760926MPL
42	C400WAB032	NO3	4.4	NDLISEVETNP760926MPL
43	C400WAB032	NO3	.2	50.COLGHTNP760926MPL
44	C400WAB032	NO3	4.5	11.ISELCHNP760926MPL
45	C400WAB032	PH	8.00	.62PHMGHTNP760926NUN
46	C400WAB032	PH	8.54	.23PHMVTNP760926NUN
47	C400WAB032	SO4	.40	5.0TITLCHNP760926GPL
48	C400WAB032	SO4	335.	6.0GRAGHTNP760926MPL
49	C400WAB032	SO4	385.	4.8156VETNP760926MPL
50	C400WAB032	TDS	1090.	5.0148VETNP760926MPL
51	C400WAB032	TDS	1052.	5.0GRAGHTNP760926MPL
52	C301WAB033	ACIDIFIED HCL		
53	C302WAB034	ACIDIFIED HNO3		
54	C400WAB034	BARIUM	1.	NDLAASLCHNP760926MPL
55	C400WAB034	CADMIUM	.05	NDLAASLCHNP760926MPL
56	C400WAB034	CALCIUM	92.	2.2AASLCHNP760926MPL
57	C400WAB034	COBALT	.1	NDLAASLCHNP760926MPL
58	C400WAB034	COPPER	.05	NDLAASLCHNP760926MPL
59	C400WAB034	IRON	.05	NDLAASLCHNP760926MPL
60	C400WAB034	LEAD	.5	NDLAASLCHNP760926MPL

Note: 1) Preprocessor insertion of latitude/longitude information via the fixed-site code defined in Table 3.

2) Preprocessor insertion of the parameter via the synonyms defined in Table 5.

Table 11a. County social data (LLL Socioeconomic Program).

PAGE

1	U100S7000S*700101	0500	CALIFORNIA
2	U200S7000S1 SOCIAL	POPULATION;	
3	U400S7000S1POP:00-13 YR	5140376.*****CENNP760915POP	
4	U400S7000S1POP:14-17 YR	1517023.*****CENNP760915POP	
5	U400S7000S1POP:18-24 YR	2424333.*****CENNP760915POP	
6	U400S7000S1POP:25-34 YR	2664863.*****CENNP760915POP	
7	U400S7000S1POP:35-44 YR	2368576.*****CENNP760915POP	
8	U400S7000S1POP:45-54 YR	2324106.*****CENNP760915POP	
9	U400S7000S1POP:55-64 YR	1711533.*****CENNP760915POP	
10	U400S7000S1POP:64+ YR	1806905.*****CENNP760915POP	
11	U400S7000S1POP:CO TOTAL	19953134.*****CENNP760915POP	
12	U200S7000S2 SOCIAL	POPULATION;	
13	U400S7000S2POP:AMER-IND	91018.*****CENNP760915POP	
14	U400S7000S2POP:BLACK	1400143.*****CENNP760915POP	
15	U400S7000S2POP:CHINESE	170131.*****CENNP760915POP	
16	U400S7000S2POP:FILIPINO	138859.*****CENNP760915POP	
17	U400S7000S2POP:JAPANESE	213280.*****CENNP760915POP	
18	U400S7000S2POP:OTHER	178671.*****CENNP760915POP	
19	U400S7000S2POP:SP-AMER	3101589.*****CENNP760915POP	
20	U400S7000S2POP:WHITE	17761032.*****CENNP760915POP	
21	U200S7000S3 SOCIAL	EDUCATION;	
22	U400S7000S3ED-A:00-07YR	1197277.*****CENNP760915POP	
23	U400S7000S3ED-A:08 YR	953235.*****CENNP760915POP	
24	U400S7000S3ED-A:09-11YR	1911855.*****CENNP760915POP	
25	U400S7000S3ED-A:12 YR	3566578.*****CENNP760915POP	
26	U400S7000S3ED-A:13-15YR	1784772.*****CENNP760915POP	
27	U400S7000S3ED-A:16+ YR	1462266.*****CENNP760915POP	
28	U200S7000S4 SOCIAL	INCOME;	
29	U400S7000S4IN-F:00-04K\$	619484.*****CENNP760915FAM	
30	U400S7000S4IN-F:04-06K\$	465188.*****CENNP760915FAM	
31	U400S7000S4IN-F:06-08K\$	558620.*****CENNP760915FAM	
32	U400S7000S4IN-F:08-10K\$	624520.*****CENNP760915FAM	
33	U400S7000S4IN-F:10-15K\$	1398973.*****CENNP760915FAM	
34	U400S7000S4IN-F:15-25K\$	1029394.*****CENNP760915FAM	
35	U400S7000S4IN-F:25+ K\$	305076.*****CENNP760915FAM	
36	U200S7000S5 SOCIAL	INCOME;	
37	U400S7000S5IN-I:00-04K\$	1329664.*****CENNP760915POP	
38	U400S7000S5IN-I:04-06K\$	316309.*****CENNP760915POP	
39	U400S7000S5IN-I:06-08K\$	260871.*****CENNP760915POP	
40	U400S7000S5IN-I:08-10K\$	166534.*****CENNP760915POP	
41	U400S7000S5IN-I:10-15K\$	175146.*****CENNP760915POP	
42	U400S7000S5IN-I:15+ K\$	78975.*****CENNP760915POP	
43	U200S7000S6 SOCIAL	POVERTY;	
44	U400S7000S6POVERTY:FAMS	421200.*****CENNP760915POP	
45	U400S7000S6POVERTY:INDS	563218.*****CENNP760915POP	
46	U100S7001S*700101	0501	ALAMEDA
47	U200S7001S1 SOCIAL	POPULATION;	
48	U400S7001S1POP:00-13 YR	260560.*****CENNP760915POP	
49	U400S7001S1POP:14-17 YR	76870.*****CENNP760915POP	
50	U400S7001S1POP:18-24 YR	147101.*****CENNP760915POP	
51	U400S7001S1POP:25-34 YR	149779.*****CENNP760915POP	
52	U400S7001S1POP:35-44 YR	121426.*****CENNP760915POP	
53	U400S7001S1POP:45-54 YR	125228.*****CENNP760915POP	
54	U400S7001S1POP:55-64 YR	92530.*****CENNP760915POP	
55	U400S7001S1POP:64+ YR	99710.*****CENNP760915POP	
56	U400S7001S1POP:CO TOTAL	1073184.*****CENNP760915POP	
57	U200S7001S2 SOCIAL	POPULATION;	
58	U400S7001S2POP:AMER-IND	5688.*****CENNP760915POP	
59	U400S7001S2POP:BLACK	161282.*****CENNP760915POP	
60	U400S7001S2POP:CHINESE	20072.*****CENNP760915POP	

Note: County data is identified as SijmnAp
 where: S = IVEP Socioeconomic Program
 ij = year for which the data applies
 mn = county for which the data applies
 A = identifies Social, Fiscal, or
 Economic data type
 p = data segment. An asterisk (*)
 implies the information
 pertains for all p

Table 11b. County fiscal data (LLL Socioeconomic Program).

PAGE

1	U100S7601F1760701		0501	ALAMEDA
2	U200S7601F1 ECONOMIC	FISCAL;BUDGET:		
3	U400S7601F1CO \$-CON/RE	0.*****C01NP760915\$\$\$		
4	U400S7601F1CO \$-COURTS	0.*****C01NP760915\$\$\$		
5	U400S7601F1CO \$-DEBTSE	0.*****C01NP760915\$\$\$		
6	U400S7601F1CO \$-EDUC	0.*****C01NP760915\$\$\$		
7	U400S7601F1CO \$-FIRE	0.*****C01NP760915\$\$\$		
8	U400S7601F1CO \$-GADMIN	0.*****C01NP760915\$\$\$		
9	U400S7601F1CO \$-GGV/PA	0.*****C01NP760915\$\$\$		
10	U400S7601F1CO \$-H/SANI	0.*****C01NP760915\$\$\$		
11	U400S7601F1CO \$-HEALTH	0.*****C01NP760915\$\$\$		
12	U400S7601F1CO \$-P-ASST	0.*****C01NP760915\$\$\$		
13	U400S7601F1CO \$-P-PROT	0.*****C01NP760915\$\$\$		
14	U400S7601F1CO \$-P-WAYS	0.*****C01NP760915\$\$\$		
15	U400S7601F1CO \$-PLTACQ	0.*****C01NP760915\$\$\$		
16	U400S7601F1CO \$-POLICE	0.*****C01NP760915\$\$\$		
17	U400S7601F1CO \$-RECRE	0.*****C01NP760915\$\$\$		
18	U400S7601F1CO \$-SANI	0.*****C01NP760915\$\$\$		
19	U400S7601F1CO \$-TOTAL	0.*****C01NP760915\$\$\$		
20	U100S7601F2760701		0501	ALAMEDA
21	U200S7601F2 ECONOMIC	FISCAL;PC-BUDGET:		
22	U400S7601F2COPC\$-CON/RE	0.*****C01NP760915\$\$\$		
23	U400S7601F2COPC\$-COURTS	0.*****C01NP760915\$\$\$		
24	U400S7601F2COPC\$-DEBTSE	0.*****C01NP760915\$\$\$		
25	U400S7601F2COPC\$-EDUC	0.*****C01NP760915\$\$\$		
26	U400S7601F2COPC\$-FIRE	0.*****C01NP760915\$\$\$		
27	U400S7601F2COPC\$-GADMIN	0.*****C01NP760915\$\$\$		
28	U400S7601F2COPC\$-GGV/PA	0.*****C01NP760915\$\$\$		
29	U400S7601F2COPC\$-H/SANI	0.*****C01NP760915\$\$\$		
30	U400S7601F2COPC\$-HEALTH	0.*****C01NP760915\$\$\$		
31	U400S7601F2COPC\$-P-ASST	0.*****C01NP760915\$\$\$		
32	U400S7601F2COPC\$-P-PROT	0.*****C01NP760915\$\$\$		
33	U400S7601F2COPC\$-P-WAYS	0.*****C01NP760915\$\$\$		
34	U400S7601F2COPC\$-PLTACQ	0.*****C01NP760915\$\$\$		
35	U400S7601F2COPC\$-POLICE	0.*****C01NP760915\$\$\$		
36	U400S7601F2COPC\$-RECRE	0.*****C01NP760915\$\$\$		
37	U400S7601F2COPC\$-SANI	0.*****C01NP760915\$\$\$		
38	U400S7601F2COPC\$-TOTAL	0.*****C01NP760915\$\$\$		
39	U100S7602F1760701		0502	ALPINE
40	U200S7602F1 ECONOMIC	FISCAL;BUDGET:		
41	U400S7602F1CO \$-CON/RE	0.*****C02NP760915\$\$\$		
42	U400S7602F1CO \$-COURTS	0.*****C02NP760915\$\$\$		
43	U400S7602F1CO \$-DEBTSE	0.*****C02NP760915\$\$\$		
44	U400S7602F1CO \$-EDUC	0.*****C02NP760915\$\$\$		
45	U400S7602F1CO \$-FIRE	0.*****C02NP760915\$\$\$		
46	U400S7602F1CO \$-GADMIN	0.*****C02NP760915\$\$\$		
47	U400S7602F1CO \$-GGV/PA	0.*****C02NP760915\$\$\$		
48	U400S7602F1CO \$-H/SANI	0.*****C02NP760915\$\$\$		
49	U400S7602F1CO \$-HEALTH	0.*****C02NP760915\$\$\$		
50	U400S7602F1CO \$-P-ASST	0.*****C02NP760915\$\$\$		
51	U400S7602F1CO \$-P-PROT	0.*****C02NP760915\$\$\$		
52	U400S7602F1CO \$-P-WAYS	0.*****C02NP760915\$\$\$		
53	U400S7602F1CO \$-PLTACQ	0.*****C02NP760915\$\$\$		
54	U400S7602F1CO \$-POLICE	0.*****C02NP760915\$\$\$		
55	U400S7602F1CO \$-RECRE	0.*****C02NP760915\$\$\$		
56	U400S7602F1CO \$-SANI	0.*****C02NP760915\$\$\$		
57	U400S7602F1CO \$-TOTAL	0.*****C02NP760915\$\$\$		
58	U100S7602F2760701		0502	ALPINE
59	U200S7602F2 ECONOMIC	FISCAL;PC-BUDGET:		
60	U400S7602F2COPC\$-CON/RE	0.*****C02NP760915\$\$\$		

Note: County data is identified as SijmnAp
 where: S = IVEP Socioeconomic Program
 ij = year for which the data applies
 mn = county for which the data applies
 A = identifies Social, Fiscal, or
 Economic data type
 p = data segment. An asterisk (*)
 implies the information
 pertains for all p

Table 11c. County economic data (LLL Socioeconomic Program).

PAGE

1	U100S7200E1720301		0500	CALIFORNIA
2	U200S7200E1 ECONOMIC	SECTOR-EMPLOYMENT;		
3	U400S7200E1SECTOR	0.	5589019.	*****CBPNP760915POP
4	U400S7200E1SECTOR	100.	274340.	*****CBPNP760915POP
5	U400S7200E1SECTOR	200.	242070.	*****CBPNP760915POP
6	U400S7200E1SECTOR	300.	32450.	*****CBPNP760915POP
7	U400S7200E1SECTOR	800.	524.	*****CBPNP760915POP
8	U400S7200E1SECTOR	900.	1864.	*****CBPNP760915POP
9	U400S7200E1SECTOR	1000.	1228.	*****CBPNP760915POP
10	U400S7200E1SECTOR	1300.	16386.	*****CBPNP760915POP
11	U400S7200E1SECTOR	1381.	2048.	*****CBPNP760915POP
12	U400S7200E1SECTOR	1382.	522.	*****CBPNP760915POP
13	U400S7200E1SECTOR	1500.	83839.	*****CBPNP760915POP
14	U400S7200E1SECTOR	1600.	62280.	*****CBPNP760915POP
15	U400S7200E1SECTOR	1700.	166859.	*****CBPNP760915POP
16	U400S7200E1SECTOR	2000.	143191.	*****CBPNP760915POP
17	U400S7200E1SECTOR	2010.	15490.	*****CBPNP760915POP
18	U400S7200E1SECTOR	2030.	45816.	*****CBPNP760915POP
19	U400S7200E1SECTOR	2040.	6133.	*****CBPNP760915POP
20	U400S7200E1SECTOR	2060.	3854.	*****CBPNP760915POP
21	U400S7200E1SECTOR	2090.	15658.	*****CBPNP760915POP
22	U400S7200E1SECTOR	2200.	12655.	*****CBPNP760915POP
23	U400S7200E1SECTOR	2400.	47755.	*****CBPNP760915POP
24	U400S7200E1SECTOR	2500.	39888.	*****CBPNP760915POP
25	U400S7200E1SECTOR	2600.	34305.	*****CBPNP760915POP
26	U400S7200E1SECTOR	2700.	88680.	*****CBPNP760915POP
27	U400S7200E1SECTOR	2800.	47941.	*****CBPNP760915POP
28	U400S7200E1SECTOR	2870.	2897.	*****CBPNP760915POP
29	U400S7200E1SECTOR	2900.	15358.	*****CBPNP760915POP
30	U400S7200E1SECTOR	3000.	44718.	*****CBPNP760915POP
31	U400S7200E1SECTOR	3200.	49553.	*****CBPNP760915POP
32	U400S7200E1SECTOR	3300.	48650.	*****CBPNP760915POP
33	U400S7200E1SECTOR	3400.	106511.	*****CBPNP760915POP
34	U400S7200E1SECTOR	3520.	2331.	*****CBPNP760915POP
35	U400S7200E1SECTOR	3530.	13380.	*****CBPNP760915POP
36	U400S7200E1SECTOR	3600.	192906.	*****CBPNP760915POP
37	U400S7200E1SECTOR	3700.	196661.	*****CBPNP760915POP
38	U400S7200E1SECTOR	3800.	34922.	*****CBPNP760915POP
39	U400S7200E1SECTOR	3900.	33702.	*****CBPNP760915POP
40	U400S7200E1SECTOR	4100.	29733.	*****CBPNP760915POP
41	U400S7200E1SECTOR	4150.	2636.	*****CBPNP760915POP
42	U400S7200E1SECTOR	4200.	90958.	*****CBPNP760915POP
43	U400S7200E1SECTOR	4221.	851.	*****CBPNP760915POP
44	U400S7200E1SECTOR	4500.	62057.	*****CBPNP760915POP
45	U400S7200E1SECTOR	4600.	871.	*****CBPNP760915POP
46	U400S7200E1SECTOR	4700.	14552.	*****CBPNP760915POP
47	U400S7200E1SECTOR	4800.	142177.	*****CBPNP760915POP
48	U400S7200E1SECTOR	4900.	60407.	*****CBPNP760915POP
49	U400S7200E1SECTOR	4931.	24510.	*****CBPNP760915POP
50	U400S7200E1SECTOR	4940.	3147.	*****CBPNP760915POP
51	U400S7200E1SECTOR	4950.	6061.	*****CBPNP760915POP
52	U400S7200E1SECTOR	4970.	274.	*****CBPNP760915POP
53	U400S7200E1SECTOR	5010.	36078.	*****CBPNP760915POP
54	U400S7200E1SECTOR	5040.	66011.	*****CBPNP760915POP
55	U400S7200E1SECTOR	5050.	2766.	*****CBPNP760915POP
56	U400S7200E1SECTOR	5200.	38165.	*****CBPNP760915POP
57	U400S7200E1SECTOR	5300.	205448.	*****CBPNP760915POP
58	U400S7200E1SECTOR	5400.	161124.	*****CBPNP760915POP
59	U400S7200E1SECTOR	5500.	185062.	*****CBPNP760915POP
60	U400S7200E1SECTOR	5600.	70072.	*****CBPNP760915POP

Note: County data is identified as SijmnAp
 where: S = IVEP Socioeconomic Program
 ij = year for which the data applies
 mn = county for which the data applies
 A = identifies Social, Fiscal, or
 Economic data type
 p = data segment. An asterisk (*)
 implies the information
 pertains for all p

Table 12.. Soil-sample data (LLL Ecological Systems Survey Program).

PAGE

4648	U100VKS001A760203	003	11S13E27N	IVS1501	
4649	U200VKS001ASOIL	ALFALFA; DRY; 003; COLLECT-PLANT;			
4650	U399VKS001AKAA034	1VS-1501 0-3 INCH SOIL	VKS001A		
4651	U400VKS001AALUMINUM	5.703E+04	ASDMTDLCHNP760926001KAA034	FINXKAA01	3.139E+03
4652	U400VKS001AANTIMONY	8.263E-01	ASDMTDLCHNP760926001KAA034	FINXKAA01	9.876E-02
4653	U400VKS001AARSENIC	9.323E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	6.899E-01
4654	U400VKS001ABARIUM	4.883E+02	ASDMTDLCHNP760926001KAA034	FINXKAA01	2.289E+01
4655	U400VKS001ABROMINE	0.000E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.617E+00
4656	U400VKS001ACALCIUM	5.039E+04	ASDMTDLCHNP760926001KAA034	FINXKAA01	5.648E+03
4657	U400VKS001ACERIUM	6.582E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.510E+00
4658	U400VKS001ACESIUM	7.239E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.373E-01
4659	U400VKS001ACHROMIUM	4.723E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.447E+00
4660	U400VKS001ACOBALT	1.030E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	2.158E-01
4661	U400VKS001ADYSPROSIUM	4.396E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.349E-01
4662	U400VKS001AEUROPIUM	8.913E-01	ASDMTDLCHNP760926001KAA034	FINXKAA01	2.473E-02
4663	U400VKS001AGALLIUM	1.997E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	6.511E+00
4664	U400VKS001AHAFNIUM	4.869E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.166E-01
4665	U400VKS001AIRON	2.727E+04	ASDMTDLCHNP760926001KAA034	FINXKAA01	2.927E+02
4666	U400VKS001ALANTHANUM	3.471E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	5.256E-01
4667	U400VKS001ALUTETIUM	5.653E-01	ASDMTDLCHNP760926001KAA034	FINXKAA01	3.714E-02
4668	U400VKS001AMAGNESIUM	0.000E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	5.318E+04
4669	U400VKS001AMANGANESE	4.681E+02	ASDMTDLCHNP760926001KAA034	FINXKAA01	3.796E+00
4670	U400VKS001ANEODYMIUM	2.976E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.879E+00
4671	U400VKS001APOTASSIUM	1.814E+04	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.068E+03
4672	U400VKS001ARUBIDIUM	1.192E+02	ASDMTDLCHNP760926001KAA034	FINXKAA01	4.170E+00
4673	U400VKS001ASAMARIUM	5.514E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	2.134E-01
4674	U400VKS001ASCANDIUM	9.888E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	7.960E-02
4675	U400VKS001ASODIUM	5.242E+03	ASDMTDLCHNP760926001KAA034	FINXKAA01	5.992E+01
4676	U400VKS001ASTRONTIUM	2.531E+02	ASDMTDLCHNP760926001KAA034	FINXKAA01	5.732E+01
4677	U400VKS001ATANTALUM	1.079E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	7.124E-02
4678	U400VKS001ATERIUM	6.820E-01	ASDMTDLCHNP760926001KAA034	FINXKAA01	5.183E-02
4679	U400VKS001ATHORIUM	1.059E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.682E-01
4680	U400VKS001ATITANIUM	3.579E+03	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.235E+03
4681	U400VKS001ATUNGSTEN	9.761E-01	ASDMTDLCHNP760926001KAA034	FINXKAA01	7.487E-01
4682	U400VKS001AURANIUM	3.123E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.919E-01
4683	U400VKS001AVERADIUM	5.816E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	2.361E+01
4684	U400VKS001AYTTERBIUM	2.649E+00	ASDMTDLCHNP760926001KAA034	FINXKAA01	1.061E-01
4685	U400VKS001AZINC	8.353E+01	ASDMTDLCHNP760926001KAA034	FINXKAA01	7.120E+00
4686	U400VKS001AZIRCONIUM	1.199E+02	ASDMTDLCHNP760926001KAA034	FINXKAA01	4.966E+01
4687	U100VKS001B760203	306	11S13E27N	IVS1501	
4688	U200VKS001BSOIL	ALFALFA; DRY; 306; COLLECT-PLANT;			
4689	U100VKS002A760203	003	11S13E33D	IVS1502	
4690	U200VKS002ASOIL	BARE; DRY; CRUST; 003;			
4691	U399VKS002AKAA035	1VS-1502 0-3 INCH SOIL	VKS002A		
4692	U400VKS002AALUMINUM	5.480E+04	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.426E+03
4693	U400VKS002AANTIMONY	8.922E-01	ASDMTDLCHNP760926001KAA035	FINXKAA01	9.127E-02
4694	U400VKS002AARSENIC	9.289E+00	ASDMTDLCHNP760926001KAA035	FINXKAA01	4.273E-01
4695	U400VKS002ABARIUM	4.730E+02	ASDMTDLCHNP760926001KAA035	FINXKAA01	2.932E+01
4696	U400VKS002ABROMINE	0.000E+00	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.534E+00
4697	U400VKS002ACALCIUM	5.284E+04	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.644E+03
4698	U400VKS002ACERIUM	6.844E+01	ASDMTDLCHNP760926001KAA035	FINXKAA01	2.054E+00
4699	U400VKS002ACESIUM	7.295E+00	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.306E-01
4700	U400VKS002ACHLORINE	8.923E+02	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.585E+02
4701	U400VKS002ACHROMIUM	4.881E+01	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.711E+00
4702	U400VKS002ACOBALT	1.057E+01	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.898E-01
4703	U400VKS002ADYSPROSIUM	4.243E+00	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.910E-01
4704	U400VKS002AEUROPIUM	9.245E-01	ASDMTDLCHNP760926001KAA035	FINXKAA01	2.576E-02
4705	U400VKS002AGALLIUM	2.414E+01	ASDMTDLCHNP760926001KAA035	FINXKAA01	3.765E+00
4706	U400VKS002AHAFNIUM	5.441E+00	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.249E-01
4707	U400VKS002AINDIUM	1.124E-01	ASDMTDLCHNP760926001KAA035	FINXKAA01	1.103E-01

Associated with each data file is a set of information cards. The cards are of four types - 0100, 0200, 0300 Series, 0400. Card types are defined in Columns 1 through 4; the first seven characters of the fixed-site-data file A**YMDDmdd resides in Columns 5 through 11 on all card types.

Card Type 0100 - Cols. 12-14: contain the last three characters of the fixed-site-data file A**YMDDmdd.

Cols. 15-17: always contain asterisks (**).

Cols. 43-50: contain the above-ground level at which data were collected. Units are decimal-meters.

Card Type 0200 - There exists one or more type 0200 cards for each data file.

Cols. 12-23: contain the data type - METEOROLOGIC or GAS.

Cols. 24-80: contain the space-comma-, or semi-colon-delimited parameters associated with the data type defined.

Card Type 0300 Series - All noteworthy comments pertaining to the data file are written on 0300 Series cards in Columns 12 through 80.

Sequencing of the cards is made through the last two digits of the card type, i.e., Card Types 0300-0399.

Card Type 0400 - Card Type 0400 is a data-format-description card. There exists one type 0400 card for each parameter written into the data file.

Cols. 12-23: contain the parameter name.

Cols. 34-36: contain the percent error associated with that parameter.

Cols. 37-39: contain the code of the method used to measure that parameter.

Cols. 40-42: contain the code of the Laboratory that is responsible for those data values.

Cols. 51-53: contain the code of the unit in which the data are reported.

Cols. 54-80: remark on the columns and format in which the data is written, for example: ASCII Fl0.3 in 21-30.

This set of information cards per data file contribute to the contents of an index file that does conform with the IVEP Data-Base Plan. Table 13 contains information related to an experimental test-data set; actual data has not been entered as of September 28, 1976.

Miscellaneous data bases are handled in a similar manner. Descriptive information is entered on card types 100, 200, 300, and 400. These

cards are then entered into an index file of all miscellaneous data bases. Table 14 is an up-to-date listing of that file.

Data Management

The usual problem of data storage associated with large data bases is of no real significance on the Octopus System at the Lawrence Livermore Laboratory. The IBM Photostore, one component of the system, provides sufficient available storage with rapid access and modest reliability at a cost-effective price. However, data-handling problems related to manipulation, selective retrieval, analysis, and display are problems that will plague this project. For this reason, action has been taken to evaluate the long-term solution to data-management needs of the IVEP.

An investigation into the availability of a data-base-management system compatible with LLL's computer facility and capable of providing such desirable features as subfile extraction, concurrent retrieval, etc. has

thus far led to consideration of the following software packages:

1. Master Control — developed by Lawrence Livermore Laboratory
2. Feudal — developed by Lawrence Livermore Laboratory
3. System 2000 — developed by MRI Corp. of Austin, Texas

As yet, no formal assessment of the above candidates has been made. It is, however, generally agreed upon that Feudal will be experimentally implemented because of its availability and low overhead cost.

Until any one data-base-management system is extensively tested by IVEP researchers, it will not be accepted as the official operating system.

At this time, data storage continues to make use of the Photostore. Retrieval is made possible through several multipurpose Fortran codes. Data manipulation and analysis require special purpose programs.

The availability of geocoded software packages for data display has also been investigated. Information is currently being gathered on all known available systems.

Table 13. Index file to air-quality data (LLL Air Quality Survey Program).

PAGE

1	0100A026L01L23***		10.0
2	0200A026L01GAS	MEAN-SO2 MEAN-H2S MEAN-O3	
3	0200A026L01GAS	PEAK-SO2 PEAK-H2S	
4	0200A026L01METEOROLOGIC	TEMP-AIR HUMIDITY SPEED-WIND ANGLE-WIND	
5	0400A026L01MEAN-SO2	*****??PFLLLA	PPB G1 15 F6.1 .001
6	0400A016L01MEAN-H2S	*****??LATLLA	PPB G1 21 F6.1 .001
7	0400A016L01MEAN-O3	*****??UVALLA	PPB G1 27 F6.1 .001
8	0400A016L01MEAN-NO	*****??CILLLA	PPB G1 33 F6.1 .001
9	0400A016L01MEAN-NO2	*****??CILLLA	PPB G1 39 F6.1 .001
10	0400A016L01MEAN-NOX	*****??CILLLA	PPB G1 45 F6.1 .001
11	0400A026L01PEAK-SO2	*****??PFLLLA	PPB G2 15 F6.1 .001
12	0400A016L01PEAK-H2S	*****??LATLLA	PPB G2 21 F6.1 .001
13	0400A016L01PEAK-O3	*****??UVALLA	PPB G2 27 F6.1 .001
14	0400A016L01PEAK-NO	*****??CILLLA	PPB G2 33 F6.1 .001
15	0400A016L01PEAK-NO2	*****??CILLLA	PPB G2 39 F6.1 .001
16	0400A016L01PEAK-NOX	*****??CILLLA	PPB G2 45 F6.1 .001
17	0400A016L01TEMP-AIR	*****??TBPLLA	DGC M1 15 F6.1 1.0
18	0400A016L01HUMIDITY	*****??TFCLLA	PER M1 21 F6.1 1.0
19	0400A016L01SPEED-WIND	*****??CUPLLA	MPS M1 27 F6.1 1.0
20	0400A016L01ANGLE-WIND	*****??VNELLA	DEG M1 33 F6.1 1.0
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Table 14. Index file to miscellaneous data bases.

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1 U100MNOAA 5401--5812** EL CENTRO CALIFORNIA
2 U200MNOAA METEOROLOGICSTABILITY;WIND;
3 U310MNOAA NOAASTAR IS A METEOROLOGIC DATA FILE FOR THE CITY OF EL CENTRO.
4 U320MNOAA IT WAS OBTAINED FROM THE NATIONAL CLIMATIC CENTER, ASHVILLE, N.C. BY
5 U330MNOAA DON ERMAK FOR USE IN POLLUTANT TRANSPORT CALCULATIONS. THE MAJOR
6 U340MNOAA PART OF THE DATA IS JOINT FREQUENCY DISTRIBUTIONS OF WIND SPEED, WIND
7 U350MNOAA DIRECTION, AND PASQUILL STABILITY CLASS. THERE ARE FOUR DISTRIBUT-
8 U360MNOAA IONS: ONE AVERAGED OVER EACH OF THE FOUR SEASONS AND ONE AVERAGED ON
9 U365MNOAA AN ANNUAL BASIS. THE JOINT FREQUENCY DISTRIBUTIONS WERE CALCULATED
10 U370MNOAA BY THE NCC USING THE STAR PROGRAM FROM HOURLY METEOROLOGICAL
11 U375MNOAA MEASUREMENTS TAKEN AT EL CENTRO FROM JAN. 1954 TO DEC. 1958.
12 U376MNOAA STABILITY CLASSES ARE A, B, C, D, E, F, AND * WHICH IS THE
13 U377MNOAA COMPOSITE OF A THRU F INCLUSIVE.
14 U380MNOAA THE SEASONS ARE:
15 U390MNOAA DJF DEC THRU FEB
16 U395MNOAA MAM MAR THRU MAY
17 U396MNOAA JJA JUNE THRU AUGUST
18 U397MNOAA SON SEPT THRU NOVEMBER
19 U399MNOAA ANN IS THE ANNUAL CALCULATION.
20 U400MNOAA FILENAME *****LLLN760924***NOAASTAR
21 U400MNOAA FORMAT *****LLLN760924***2F10.6,17(6F10.6,A10,F10.6)
22 M Z760924 TOTAL NUMBER CARDS READ= 21
23 M Z760924 NUMBER DATA ENTRIES ATTEMPTED= 21
24 M Z760924 NUMBER CARDS ASSIGNED= 0
25 M Z760924 TOTAL NUMBER LINES WRITTEN= 21
26 M Z760924 NUMBER ERRORS WRITTEN= 0
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Imperial Valley Environmental Project
Supporting Activities

IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Remote Sensing

REMOTE SENSING

Thomas D. Palmer

The Imperial Valley Environmental Project (IVEP) is currently receiving remote sensing support from EG&G, Inc., Las Vegas, Nevada, for continuing projects in the Salton Trough area. Support activities are under the direction of Project Scientist, Jerry Lackey. EG&G airborne remote sensing capabilities provided under this support are summarized as follows:

- Conventional color and black and white photography at low to high altitude using fixed wing aircraft.
- Multispectral aerial photography using four band camera systems mounted on fixed-wing aircraft.
- Airborne radiometric surveys using fixed-wing or helicopter aircraft.
- Thermal infrared mapping at various wavelengths from fixed-wing aircraft.
- A flying platform for guest experiments such as airborne-particulate sampling.

Direct support to the IVEP consists of the following activities:

Airborne Sampling:

The Air Quality element of the IVEP is preparing to utilize EG&G aircraft and air-collection equipment to collect gas and particulate samples over Imperial Valley.

Results are of interest to Imperial Valley meteorology-modeling activities in progress. Additionally, EG&G is preparing to conduct airborne remote-sensing flights to evaluate vertical concentrations of airborne pollutants such as plumes generated at geothermal test sites.

Airborne Radiometric Survey

Various elements of the IVEP are planning to utilize information derived from airborne surveys, such as mapping brine-intrusion areas and definition of geological features. EG&G has completed a low-level detailed survey of the Niland geothermal test site and plans to survey other geothermal test sites throughout the Imperial Valley in the Heber, East Mesa, and Brawley areas. The survey of the East Mesa area will be completed by January 1977 and the other areas will be done later in the year. EG&G is preparing to evaluate effluent-source terms for geothermal test sites utilizing helicopter aircraft to monitor test-site plume distribution. This work will coincide with the first scheduled continuous operation of the San Diego Gas & Electric test site.

Airborne Photography

EG&G has completed large-format photography of the entire Salton Trough area including the Coachella

FLIGHT PATH LOCATION

SALTON SEA
DATE FLOWN - DEC. 3, 1973
PERF #880
ALTITUDE - 25,000 FT.

Fig. 1. A representative "shingle" of large-format photography available for the Imperial Valley area.

Valley, Salton Sea, Imperial Valley, East Mesa, and West Mesa areas (Fig. 1). These photographs have been used to prepare a large, high-altitude, color mosaic map of the entire area. This photographic map is being utilized by IVEP elements for regional reference work. Large-format photography is also being conducted on a site-designated basis to provide working base maps at a 1:24,000 scale. These maps are of particular value in mapping various baseline data such as croplands, refuge areas, irrigation systems, and general land-use patterns.

Large-format photography is of high value to the IVEP as a documentation tool to periodically record natural and cultural changes surrounding specific geothermal sites. EG&G is periodically producing high-resolution photographs of operating geothermal sites and various other sites of interest. Oblique photography will also be provided of the six IVEP meteorology stations, the San Diego test site, Mosquite Lake, Brawley test site, Heber test site, East Mesa test site, and the USDA Brawley field station.

Thermal Imaging

EG&G has provided images of specified areas in the Imperial Valley, using thermal infrared technology for the purpose of mapping

existing thermal conditions surrounding geothermal test sites and documenting any changes that occur (Fig. 2). This work provides reference baseline data to various IVEP elements, allowing them to spot changes that may be related to geothermal activities such as crop response to geothermal effluents. Completed activities include imaging an operating well in the Brawley area, mapping river deltas along the Salton Sea shoreline, and imaging the San Diego test site. Future work will involve a periodic resurvey of the same areas. EG&G will also provide single thermal images of the Mesquite Lake area to determine fault-line location and of Salton Sea circulation patterns to determine temperature-distribution patterns and identification.

Multispectral Imaging

EG&G has completed imaging of several geothermal test sites in the Niland and Brawley areas using multispectral photography. This work has provided baseline reference data for IVEP studies that require a knowledge of normal crop and seasonal changes in lands surrounding geothermal test sites. Response by plants to geothermal pollutants can be determined by comparison to original photos (Fig. 3). This type of basic multispectral documentation will be conducted at other Valley-wide

Fig. 2. Thermal infrared imagery of the SDG&E/ERDA Geothermal Loop Test Facility near Niland, California. Light areas (cool) correspond to the brine holding ponds, spray pond, settling pond, and at the right to flood waters resulting from heavy rains. Dark areas (hot) correspond to buildings and various pipelines.

Fig. 3. A partial example (false color) of multispectral imagery of the Sinclair #4 geothermal well site near Niland, California. Prominent features are the brine holding ponds (middle left) and agricultural crops (lower right). The patchy appearance of agricultural crops is typical of the Valley and is generally due to salt accumulation problems caused by poor drainage.

geothermal sites this year.

Additional multispectral imaging will be taken on a one-time basis of a known fault location, a known

brine spill, and a known crop-damage location for the purpose of providing reference data on known areas.

1. The first part of the report
describes the general situation
of the country and the
state of the economy.

2. The second part of the report
describes the results of the
survey and the conclusions
drawn from it.

Imperial Valley Environmental Project

The Imperial Valley Environmental Project is a multi-year study of the environmental conditions of the Imperial Valley. The project is a joint effort of the Imperial Valley College and the Imperial Valley Water Conservation District. The project is designed to provide a comprehensive study of the environmental conditions of the Imperial Valley, including the water resources, the land use, and the air quality. The project is a joint effort of the Imperial Valley College and the Imperial Valley Water Conservation District. The project is designed to provide a comprehensive study of the environmental conditions of the Imperial Valley, including the water resources, the land use, and the air quality.

Imperial Valley

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IMPERIAL VALLEY ENVIRONMENTAL PROJECT

Research Support Contracts

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RESEARCH SUPPORT CONTRACTS

Thomas D. Palmer

Research Support Contracts

The following summarizes IVEP research-support contracts totaling \$467,800 that are currently placed with various universities and government agencies as ERDA-designated "directed procurements." These contracts were placed during FY 1976, but most of the work will be done in FY 1977. We anticipate that several additional research-support contract will be placed in 1977.

Air Quality

Characterization of airborne particulates throughout the Imperial Valley area .	University of California/Davis \$100K
Calibration and standardization of air-quality analytical equipment and gases.	State of California Air and Industrial Hygiene Laboratory \$25K
Manpower assistance for air-quality monitoring stations.	County of Imperial \$16K

Subsidence/Seismicity Effects

Establishment of a subsidence-monitoring network around the SDG&E/ERDA Test Facility.	County of Imperial \$12K
Installation of a 6-station seismic-monitoring network around the Salton Sea Geothermal Field.	U.S. Geological Survey \$69K
Resurvey of the Imperial Valley Subsidence Detection Network. (This represents a contribution to a large network, which is also funded by government agencies and private developers.)	State of California Division of Oil and Gas \$35K

Socioeconomic Effects

Fiscal impacts in Imperial County due to geothermal development	University of California, Berkeley \$16K
Leadership, community decisions, and geothermal energy development: Imperial County.	University of California, Riverside \$20K
Analysis of Salton Sea recreational uses and potential impacts from local geothermal development.	University of California, Berkeley \$7.6K

Ecosystem Quality

Analysis of solute movement in soils following geothermal brine spills.	University of California, Riverside \$15K
Analysis of Pileworm-larval success at elevated Salton Sea salinity.	Pomona College \$10K
Analysis of Yuma Clapper Rail ecology for Imperial Valley geothermal areas.	Arizona State University \$10K
Analysis of geothermal pollutant effects upon honeybee production and mortality.	University of California, Riverside \$5K
Supplemental fumigation studies of geothermal pollutant effects on Imperial Valley crops.	University of California, Riverside \$10K
Analysis of Imperial Valley crop-water use and a regional comparison.	University of California, Davis \$3.2K
Trace-metal speciation of geothermal brine following contamination of soils.	University of California, Riverside \$15K

Effects on wildlife-refuge areas from geothermal development activities, particularly noise	St. Mary's College, Moraga \$19K
Analysis of Imperial Valley evapotranspiration and crop ecology.	U.S. Dept. Agriculture Brawley Research Station \$10K
Fish-sampling program in Salton Sea area for baseline characterization.	State of California Department of Fish & Game \$4.6K
Analysis of effects from geothermal power-plant effluents on Salton Sea organisms.	California State College, Hayward \$26K
Imperial Valley crop sampling for baseline characterization.	State of California Agricultural Extension Service \$9.8K
Evaluation of toxicity from geothermal brines and pollutants to <u>Gambusia affinis</u> .	North Carolina Central University \$10K
Evaluation of the synergistic effects of hydrogen sulfide, carbon dioxide, and ozone on Imperial Valley crop yields.	University of California, Davis \$9.9K
Workshop on potential ecological problems and needed research in Imperial Valley.	University of California, Riverside \$9.7K

**Imperial Valley Environmental Project
Advisory Panel**

Imperial Valley Environmental Project Advisory Panel

Lynn R. Anspaugh

INTRODUCTION

During initial planning for the Imperial Valley Environmental Project (IVEP), it was strongly recommended by the funding agency, the Energy Research and Development Administration, that an Advisory Panel be established. LLL management agreed and established such a panel. It reports to Dr. Roger Batzel, Director of the Laboratory, through Dr. Mortimer Mendelsohn, Laboratory Program Director for Biomedical and Environmental Research. It was agreed that the Panel would have four primary functions:

- Review the research plans for adequacy and relevance,
- Monitor the progress of the research,
- Provide a mechanism for informing other agencies of detailed research plans and results in a timely fashion, and
- Serve as a focus of coordination to avoid needless duplication of effort.

PANEL SELECTION

An attempt was made to select Panel members from organizations who had already established geothermal programs in Imperial County, who have

specific regulatory or general environmental responsibilities in Imperial Valley, who had already established applicable environmental programs related to geothermal energy, or who have general interests in the energy and environment area. Because we desired to have a relatively small interactive group, designated individuals were requested to represent all the interests of their parent organizations.

Early in CY 1976, letters were sent to the following individuals requesting that they either serve on the Advisory Panel or name a representative.

Dr. James L. Liverman
Assistant Administrator for
Environment and Safety
Energy Research and Development
Administration
Washington, D.C.

Dr. Wilson K. Talley
Assistant Administrator for
Research and Development
Environmental Protection Agency
Washington, D.C.

Dr. Cyril L. Comar
Director, Environmental Assessment
Department
Electric Power Research Institute
Palo Alto, California

Mr. Willard M. Spaulding, Jr.
National Geothermal Environmental
Advisor
U.S. Fish and Wildlife Service
Sacramento, California

Dr. Claire T. Dedrick
Secretary for Resources
State of California
Sacramento, California

Mr. J. B. Moore
Vice President, Advanced Engineering
Southern California Edison Company
Rosemead, California

Mr. Joseph F. Dietz
Manager, Environmental
Coordination
San Diego Gas & Electric Company
San Diego, California

Mr. David E. Pierson
Director of Public Works
County of Imperial
El Centro, California

Mr. Michael McCloskey
Executive Director
Sierra Club
San Francisco, California

Mr. Reid T. Stone
Area Geothermal Supervisor
U.S. Geological Survey
Menlo Park, California

Mr. Loyd H. Forrest
Executive Director
Energy Resources Conservation and
Development Commission
State of California
Sacramento, California

Dr. Ralph Perhac
Program Manager
Advanced Environmental Research
and Technology
National Science Foundation
Washington, D.C.

FIRST ADVISORY PANEL MEETING

The first meeting of the Advisory Panel was held on April 15, 1976, at the Lawrence Livermore Laboratory in Livermore, California. The specific purposes of this first meeting were to review the research plans for the

IVEP and to achieve a better coordination of the research of several organizations with overlapping interests and goals.

Those attending the first Panel meeting were

Panel Members

Mr. David E. Pierson, Chairman
(pro tem)
Director of Public Works
County of Imperial
El Centro, California

Mr. James W. Burns
Assistant to the Secretary
The Resources Agency
State of California
Sacramento, California

Dr. Sie Ling Chiang
Chief, Environmental and Safety
Section
Conservation Division
U.S. Geological Survey
Menlo Park, California

Mr. E. Ross Deter
Senior Environmental Planner
Energy Resources Conservation and
Development Commission
Sacramento, California

Mr. Joseph F. Dietz
Manager, Environmental Coordination
San Diego Gas & Electric Company
San Diego, California
(Mr. Dietz also represented the
Geothermal Resources Council.)

Dr. Ralph Perhac
Program Manager
Advanced Environmental Research and
Technology
National Science Foundation
Washington, D.C.
(Dr. Perhac also represented the
Electric Power Research Institute,
his present employer.)

Mr. Willard M. Spaulding, Jr.
National Geothermal Environmental
Advisor
U.S. Fish and Wildlife Service
Sacramento, California
Dr. Ian Straughan
Environmental Investigations
Section
Research and Development Office
Southern California Edison Company
Rosemead, California

Mr. Hodge R. Wasson
Acting Manager, Geothermal/Solar
Division of Technology Overview
Energy Research and Development
Administration
Washington, D.C.

Dr. G. Bruce Wiersma
Chief, Pollutant Pathways Branch
Environmental Monitoring and
Support Laboratory
Environmental Protection Agency
Las Vegas, Nevada

Panel Alternates

Dr. Douglas A. James
Environmental Programs
Division of Biomedical and
Environmental Research
Energy Research and Development
Administration
Washington, D.C.

Mr. Ronald R. Loose
Chief, Environmental Studies
Branch
Division of Geothermal Energy
Energy Research and Development
Administration
Washington, D.C.

Mr. Gary B. Stacey
Region V
Department of Fish and Game
State of California
Long Beach, California

Mr. Reid T. Stone
Area Geothermal Supervisor
Conservation Division
U.S. Geological Survey
Menlo Park, California

Observers

Mr. Perry L. Herrgesell
Region V
Department of Fish and Game
State of California
Long Beach, California

Mr. Lowell A. Miller
Environment and Safety Division
Energy Research and Development
Administration
San Francisco, California

Mr. W. J. O'Brien
Manager, Technology Overview
Environment and Safety Group
The Aerospace Corporation
Germantown, Maryland

Mr. Carl M. York
Consultant (Under contract to ERDA)
Oakland, California

The Sierra Club had nominated Professor Hamilton Hess to serve on the Advisory Panel. However, Professor Hess, who volunteers his time for Sierra Club activities, subsequently declined to serve because of conflicting commitments. Professor Philip R. Pryde of San Diego State University was then designated, but at a date too late to attend the April 15 meeting.

The agenda for the first Panel meeting included presentations by all leaders of the IVEP and an Executive Session where Panel Members were invited to provide candid comments.

The comments were generally favorable to the Project, but many constructive criticisms were also received. Concern was expressed that the overall image of the Project is

negative with too much emphasis on possible adverse impacts and not enough on the positive impacts of geothermal development. In particular, it was recommended that the Project move positively to facilitate the achievement of beneficial impacts. Concern was also expressed that there was too much emphasis on the Salton Sea and peripheral issues at the expense of the agricultural system including the critical issues of water quantity and quality. The Panel recommended that more attention be given to quality assurance efforts and to validation of models. Both the Socioeconomic Effects and the

Integrated Assessment programs were criticized as being unfocused and unbounded. Numerous more specific recommendations were also provided by the Panel.

LLL management has responded by implementing many of the recommendations. Quality-assurance efforts have been expanded, and beneficial possibilities of geothermal development are being emphasized. Management changes have taken place in both the Socioeconomic Effects and Integrated Assessment programs, although not as a direct result of the Panel's recommendations.

Imperial Valley Environmental Project
Schedule

Imperial Valley Environmental Project Schedule

Paul L. Phelps

Schedules for each of the IVEP elements are shown on the attached pages. Almost all of the IVEP will be completed in FY 1978. Some data analysis and impact studies will continue into FY 1979. Also some monitoring associated with actual or potential

releases of geothermal effluents into the environment will be done. Total IVEP efforts in FY 1979 are expected to be below 20% of the FY 1978 efforts. Various progress and technical reports will be issued throughout the duration of the IVEP.

BKI/gw/vt

	FY 76	FY 77	FY 78	FY 79	FY 80
1.0 <u>Air Quality</u>					
1.1 Instrumentation Design, construction, fielding of air-quality-monitoring stations					
1.2 Baseline measurements: Gases (ambient) Particulates (ambient) Meteorology					
1.3 Geothermal source measure- ments: (Noncondensable gases, volatiles)					
1.4 Specific nongeothermal source characterizations					
1.5 Measurement and character- ization of pollutants transported into Imperial Valley					
1.6 Transport/diffusion modeling for various geothermal power development scenarios					
1.7 Long-term minimal monitoring, site-specific					
1.8 Reports					
1.8.1 Preliminary					
1.8.2 Final					

2.1 Baseline data; characterization and monitoring

2.1.1 Salton Sea KGRA
Irrigation canals
Drainage canals

2.1.2 Brawley KGRA
Irrigation canals
Drainage canals

2.1.3 Heber KGRA
Irrigation canals
Drainage canals

2.1.4 East Mesa KGRA
Irrigation canals
Drainage canals

2.1.5 Fresh water rivers and canals

2.1.6 Source characterization - geothermal wells all KGRA's

2.1.7 Ground water via monitoring wells

2.1.8 Geothermal holding and cooling ponds

2.1.9 Salton Sea

FY 76

FY 77

FY 78

FY 79

FY 80

2.0 Water Quality (Continued)

2.2 Evaluation of impacts from water management options for cooling towers and injection

2.3 Reports

2.3.1 Preliminary

2.3.2 Final

[illegible]

3.0 Subsidence/Seismicity

3.1 Valley-wide subsidence
detection network

3.2 Site-specific subsidence
detection networks

3.3 Horizontal movement
detection network

3.4 Seismograph networks

3.5 Subsidence modeling

3.6 Reports

3.6.1 Preliminary

3.6.2 Final

FY 76

FY 77

FY 78

FY 79

FY 80

	FY 76	FY 77	FY 78	FY 79	FY 80
3.1 Valley-wide subsidence detection network					
3.2 Site-specific subsidence detection networks					
3.3 Horizontal movement detection network					
3.4 Seismograph networks					
3.5 Subsidence modeling					
3.6 Reports					
3.6.1 Preliminary					
3.6.2 Final					

- - - Work performed by non-IVEP efforts

4.8 Reports

4.8.2 Final

The diagram shows a 6x6 grid. The first four columns are defined by vertical lines. The first four rows are defined by horizontal lines. The fifth row is empty. The sixth row contains six dots, one in each column. The dots are located at the intersections of the horizontal lines and the vertical lines.

5.0 Socioeconomics

5.1 Imperial Valley fiscal, economic, social, and energy-systems characterizations

5.2 Initial development scenarios

5.3 Recreation study

5.4 Service-demands study

5.5 Tax study

5.6 Reports

5.6.1 Preliminary

5.6.2 Final

FY 76

FY 77

FY 78

FY 79

FY 80

FY 76

FY 77

FY 78

FY 79

FY 80

6.0 Health Effects

6.1 Ranking of pollutants:
Possible health effects
Dose-response curves

6.2 Set up and maintain
exemplary Health Statistics
Program in Imperial Valley

6.3 Conduct community-
response surveys

6.4 Review occupational health
programs

6.5 Reports

6.5.1 Preliminary

6.5.2 Final

7.7 Evaluate air-pollutant changes in the Imperial Valley due to proposed geothermal development

[illegible]