240
12/6/79

LR. 376

UCRL-52783

GEOTHERMAL ENVIRONMENTAL PROJECTS PUBLICATION LIST WITH ABSTRACTS 1975 THROUGH 1978

Y. E. Ricker
L. R. Anspaugh

MASTER

May 15, 1979

Work performed under the auspices of the U.S. Department of
Energy by the UCLLL under contract number W-7405-ENG-48.

DISCLAIMER

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

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

NOTICE

"This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately-owned rights."

NOTICE

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy \$; Microfiche \$3.00

Page Range	Domestic Price	Page Range	Domestic Price
001-025	\$ 4.00	326-350	\$12.00
026-050	4.50	351-375	12.50
051-075	5.25	376-400	13.00
076-100	6.00	401-425	13.25
101-125	6.50	426-450	14.00
126-150	7.25	451-475	14.50
151-175	8.00	476-500	15.00
176-200	9.00	501-525	15.25
201-225	9.25	526-550	15.50
226-250	9.50	551-575	16.25
251-275	10.75	576-600	16.50
276-300	11.00	601-up	— ¹
301-325	11.75		

^{1/} Add \$2.50 for each additional 100 page increment from 601 pages up.

LAWRENCE LIVERMORE LABORATORY
University of California/Livermore, California/94550

UCRL-52783

**GEOHERMAL ENVIRONMENTAL PROJECTS
PUBLICATION LIST WITH ABSTRACTS
1975 THROUGH 1978**

Y. E. Ricker
L. R. Anspaugh

MS. date: May 15, 1979

DISCLAIMER

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

CONTENTS

PREFACE	iii
ACKNOWLEDGMENTS	iv
ABSTRACT	v
MAIN LISTING	1
AUTHOR INDEX	47
KEYWORD INDEX	87

PREFACE

THIS REPORT PROVIDES POTENTIAL USERS WITH A REFERENCE TO THE MANY PUBLICATIONS WHICH ARE DIRECTLY A RESULT OF, OR ARE CLOSELY RELATED TO GEOTHERMAL ENVIRONMENTAL PROJECTS CONDUCTED BY THE ENVIRONMENTAL SCIENCES DIVISION AT LAWRENCE LIVERMORE LABORATORY. WE HAVE ALSO INCLUDED SEVERAL PUBLICATIONS OF OTHER AGENCIES WHO HAVE COLLABORATED IN THE IMPERIAL VALLEY ENVIRONMENTAL PROJECTS AND SEVERAL ADDITIONAL LLL PUBLICATIONS WHICH CONTAIN INFORMATION RELATED TO ENVIRONMENTAL CONCERNS. UNLESS OTHERWISE INDICATED, THESE PUBLICATIONS HAVE RESULTED FROM WORK FUNDED BY THE ASSISTANT SECRETARY FOR ENVIRONMENT OF THE U.S. DEPARTMENT OF ENERGY.

MANY OF THE LISTED PUBLICATIONS ARE LLL REPORTS. THESE REPORTS MAY BE PURCHASED FROM THE

NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
5285 PORT ROYAL ROAD
SPRINGFIELD, VIRGINIA 22161

ACKNOWLEDGMENTS

GRATEFUL ACKNOWLEDGMENT IS MADE FOR PERMISSION TO REPRODUCE THE FOLLOWING MATERIAL:

ID NO. 13: ABSTRACT FROM HEALTH PHYSICS, VOL. 31, PAGE 532 (1976) REPRODUCED BY PERMISSION OF THE HEALTH PHYSICS SOCIETY.

ID NO. 23: ABSTRACT FROM "TRACE SUBSTANCES IN ENVIRONMENTAL HEALTH-X," PAGE 287 (1976), UNIVERSITY OF MISSOURI, COLUMBIA, MO., REPRODUCED BY PERMISSION OF THE CURATORS OF THE UNIVERSITY OF MISSOURI.

ID NOS. 47 AND 49: ABSTRACTS FROM SOIL SCIENCE SOCIETY OF AMERICA JOURNAL VOL. 41, PAGES 323 AND 1092 (1977) REPRODUCED BY PERMISSION OF THE SOIL SCIENCE SOCIETY OF AMERICA.

ID NO. 48: ABSTRACT FROM SOIL SCIENCE VOL. 124 PAGE 117 (1977) WAS REPRODUCED BY PERMISSION OF WILLIAMS AND WILKINS PUBLISHING CO.

ID NO. 104: ABSTRACT FROM ENVIRONMENTAL SCIENCE AND TECHNOLOGY VOL. 12, PAGE 550 (1978) REPRINTED WITH PERMISSION OF THE AMERICAN CHEMICAL SOCIETY.

ABSTRACT

THIS REPORT CONTAINS 119 ABSTRACTS OF PUBLICATIONS RESULTING FROM OR CLOSELY RELATED TO GEOTHERMAL ENVIRONMENTAL PROJECTS CONDUCTED BY THE ENVIRONMENTAL SCIENCES DIVISION AT LAWRENCE LIVERMORE LABORATORY. PUBLICATIONS ARE LISTED CHRONOLOGICALLY FROM 1975 THROUGH 1978. THE MAIN ENTRIES ARE NUMBERED SEQUENTIALLY, AND INCLUDE THE FULL CITATION, AN ABSTRACT, AND SELECTED KEYWORDS. THIS SECTION IS FOLLOWED BY AN AUTHOR INDEX, AND A KEYWORD INDEX.

MAIN LISTING

UNITED STATES

- 1 **TITLE** *GEOHERMAL DEVELOPMENT OF THE SALTON TROUGH, CALIFORNIA AND MEXICO.*
AUTHOR PALMER, T.D.; HOWARD, J.H.; LANDE, D.P. (EDS.)
CITATION UCRL-51775 (1975)
ABSTRACT A GEOLOGICAL DESCRIPTION IS GIVEN OF THE SALTON TROUGH FOLLOWED BY A CHRONOLOGICAL HISTORY OF ATTEMPTS TO EXPLOIT THE AREA'S GEOTHERMAL RESOURCES. IN ADDITION, DETAILED DESCRIPTIONS ARE GIVEN OF ALL ONGOING GEOTHERMAL PROJECTS IN THE AREA AND THE ORGANIZATIONS CONDUCTING THEM.
KEYWORDS GEOLOGY; IMPERIAL VALLEY; RESOURCE STATUS

- 2 **TITLE** *CHARACTERISTICS OF GEOTHERMAL WELLS LOCATED IN THE SALTON SEA GEOTHERMAL FIELD, IMPERIAL COUNTY, CALIFORNIA.*
AUTHOR PALMER, T.D.
CITATION UCRL-51976 (1975)
ABSTRACT WE HAVE SUMMARIZED THE GEOPHYSICAL, GEOCHEMICAL, AND GEOTHERMAL CHARACTERISTICS OF WELLS LOCATED IN THE SALTON SEA GEOTHERMAL FIELD. BASED ON THE GEOTHERMAL CHARACTERISTICS OF THE WELLS, WE HAVE DEVELOPED A SUBSURFACE HEAT PROFILE FOR THE ENTIRE GEOTHERMAL FIELD. WE HAVE ALSO DRAWN MAPS OF TEMPERATURE CONTOURS FOR SPECIFIED DEPTHS THROUGHOUT THE FIELD.
KEYWORDS BRINE; GEOLOGY; IMPERIAL VALLEY; RESOURCE STATUS

- 3 **TITLE** *THE LLL GEOTHERMAL ENERGY DEVELOPMENT PROGRAM STATUS REPORT, JANUARY 1975 THROUGH AUGUST 1975.*
AUTHOR AUSTIN, A.L.; HOWARD, J.H.; LUNDBERG, A.W.; TARDIFF, G.E.
CITATION UCID-16954 (1975)
ABSTRACT THE MAJOR GOAL OF THE LLL GEOTHERMAL PROGRAM IS TO DEVELOP SYSTEMS FOR THE RECOVERY AND CONVERSION OF THE ENERGY STORED IN HOT-WATER DEPOSITS WITH PARTICULAR EMPHASIS ON THOSE CONTAINING MORE THAN 3 PERCENT TOTAL DISSOLVED SOLIDS. THE PROGRAM CONSISTS OF THREE BASIC ACTIVITIES; BRINE CHEMISTRY AND MATERIALS TECHNOLOGY, ENERGY CONVERSION AND SYSTEMS ENGINEERING; AND RESOURCE ASSESSMENT. THE PROGRAM ACTIVITIES, FINDINGS, AND PLANS ARE SUMMARIZED.
KEYWORDS BRINE; GEOLOGY; RESOURCE STATUS

- 4 **TITLE** *AN OVERVIEW OF THE IMPERIAL VALLEY ENVIRONMENTAL PROJECT.*
AUTHOR ANSPAUGH, L.R.; PHELPS, P.L. (EDS.)
CITATION UCID-17067 (1976)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HYDROGEN SULFIDE; IMPERIAL VALLEY; INTEGRATED ASSESSMENT; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY

- PREPARED BY THE LLL GEOTHERMAL ENERGY TECHNOLOGY GROUP WITH FUNDING FROM THE U.S. DOE DIVISION OF GEOTHERMAL ENERGY.

5 **TITLE** *IMPERIAL VALLEY ENVIRONMENTAL PROJECT.*

AUTHOR ANSPAUGH, L.R.; MCCALED, C.S.

CITATION ENERGY AND TECHNOLOGY REVIEW, MAY 1976. UCRL-52000-76-5, PP. 21-26 (1976)

ABSTRACT ERDA HAS DESIGNATED LLL TO HEAD UP A TWO-YEAR ENVIRONMENTAL STUDY THAT SHOULD ALLOW GOVERNMENT, POWER-COMPANY OFFICIALS, AND OTHER INTERESTED PARTIES TO ASSESS THE IMPACT OF GEOTHERMAL DEVELOPMENT ON CALIFORNIA'S IMPERIAL VALLEY. THE STUDY, FUNDED AT \$2.4 MILLION FOR FY 1977, WILL INVOLVE SOME 40 LLL INVESTIGATORS, 25 UNIVERSITY CONTRACTORS, AND SEVERAL STATE AND LOCAL GOVERNMENTAL AGENCIES. WORK ON THE PROJECT IS NOW UNDER WAY. MAJOR RESEARCH AREAS OF THIS COORDINATED STUDY INCLUDE AIR AND WATER QUALITY, EFFECTS ON THE ECOSYSTEM, SUBSIDENCE AND INDUCED SEISMICITY, HEALTH EFFECTS, AND SOCIOECONOMIC IMPACTS. THE STUDY WILL INCLUDE AN INTEGRATED ASSESSMENT TO FACILITATE DECISION-MAKING.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HEALTH EFFECTS; IMPERIAL VALLEY; INTEGRATED ASSESSMENT; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY

6 **TITLE** *THE 1972 FLOW OF ELECTRICAL ENERGY IN CALIFORNIA AND ITS RELATIONSHIP TO SELECTED COUNTY LEVEL CHARACTERISTIC PARAMETERS.*

AUTHOR HAVEN, K.F.

CITATION UCRL-52143 (1976)

ABSTRACT FLOWS OF ELECTRICAL ENERGY IN CALIFORNIA IN 1972 ARE ANALYZED BY UTILITY COMPANY AND BY CALIFORNIA COUNTY AND THE USE OF ELECTRICAL ENERGY IS SPECIFIED BY RESIDENTIAL, COMMERCIAL, INDUSTRIAL, AND PUBLIC SECTORS WITHIN EACH COUNTY. IN ADDITION REGRESSION ANALYSES WERE MADE COMPARING EACH OF THESE CATEGORIES OF COUNTY ELECTRICAL ENERGY USE TO NINE NONENERGY CHARACTERISTICS OF EACH COUNTY: COUNTY SIZE, COUNTY POPULATION, TOTAL COUNTY EMPLOYMENT, TOTAL COUNTY PAYROLL, TOTAL COUNTY COMMERCIAL EMPLOYMENT, THE PERCENTAGE OF OCCUPIED DWELLINGS IN THE COUNTY REPRESENTING SEPARATE LIVING STRUCTURES, THE AVERAGE NUMBER OF OCCUPANTS PER OCCUPIED DWELLING, COUNTY INDUSTRIAL EMPLOYMENT, AND TOTAL COUNTY HEATING AND COOLING DEGREE DAYS. THE NONECONOMIC CATEGORIES OF COUNTY SIZE, PERCENTAGE OF HOUSES IN THE COUNTY, AND AVERAGE NUMBER OF OCCUPANTS PER DWELLING EXERTED THE GREATER INFLUENCES ON ELECTRICAL DEMANDS IN THE FINAL SET OF REGRESSION EQUATIONS.

KEYWORDS SOCIOECONOMIC EFFECTS

7 TITLE *BALANCED PROGRAM PLAN. ANALYSIS FOR BIOMEDICAL AND ENVIRONMENTAL RESEARCH. VOLUME 9. GEOTHERMAL ENERGY.*

AUTHOR ANSPAUGH, L.R. (ED.)

CITATION ERDA-76/116(VOL.9) (1976)

ABSTRACT GEOTHERMAL ENERGY IS DEFINED SIMPLY AS THE HEAT OF THE EARTH. IT CONSTITUTES A SUBSTANTIAL RESOURCE WHICH CAN BE UTILIZED FOR THE PRODUCTION OF ELECTRICAL ENERGY AND OTHER USES, BUT IT HAS SO FAR NOT BEEN USED EXTENSIVELY IN THE UNITED STATES. THE GOALS OF THE ERDA GEOTHERMAL ENERGY PROGRAM INCLUDE THE GENERATION OF 6000 MW OF ELECTRIC POWER AND THE SUPPLY OF 0.1 QUAD/YEAR OF THERMAL POWER FOR NONELECTRIC APPLICATIONS BY 1985. THIS WOULD BE ACCOMPLISHED BY UTILIZING HYDROTHERMAL (STEAM AND HOT WATER) RESERVOIRS. THE LONG-TERM GOAL IS TO ACHIEVE A MUCH GREATER UTILIZATION THROUGH THE DEVELOPMENT OF ADVANCED TECHNOLOGIES FOR ADDITIONAL RESOURCE TYPES SUCH AS HOT DRY ROCK. THE PRIMARY ENVIRONMENTAL CONCERNS ARE THE NONCONDENSABLE GAS EMISSIONS, ESPECIALLY HYDROGEN SULFIDE; THE EMISSIONS FROM COOLING TOWERS INCLUDING SALTS AND DISSOLVED GASES; THE MANAGEMENT OF SPENT GEOTHERMAL EFFLUENTS; LAND SUBSIDENCE FOLLOWING THE EXTRACTION OF GEOTHERMAL FLUIDS; STIMULATION OF SEISMIC ACTIVITY BY THE SUBSURFACE INJECTION OF SPENT GEOTHERMAL FLUIDS; NOISE; LAND AND RESOURCE USE ALTERNATIVES; AND THE OCCURRENCE OF ACCIDENTS SUCH AS WELL BLOWOUTS. A COMPREHENSIVE PROGRAM OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH TO INVESTIGATE AND RECOMMEND SOLUTIONS TO THESE CONCERNS IS DEVELOPED. IT INCLUDES THE MEASUREMENT OF SOURCE TERMS, THE ACCUMULATION OF BASELINE AND FOLLOWUP DATA, THE STUDY OF LOCAL AND REGIONAL ECOSYSTEMS, DOCUMENTATION OF SUBSURFACE EFFECTS, COST/RISK/BENEFIT ANALYSES OF ALTERNATE TECHNOLOGIES, AND AN INTEGRATED ASSESSMENT OF THE HEALTH, SOCIAL AND ECONOMIC EFFECTS OF GEOTHERMAL ENERGY DEVELOPMENT. THE OVERALL PROGRAM IS PRESENTED AS THIRTEEN UNITS WITH A PRIORITY OF A, B, OR C ASSIGNED TO EACH. THE TOTAL RECOMMENDED PROGRAM WOULD COST \$8,300,000 IN FY 1977.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HEALTH EFFECTS; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; NOISE; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY

8 TITLE *A MODEL OF PHOTOSYNTHESIS AND GROWTH IN PLANTS UNDER STRESS BY GASEOUS POLLUTANTS. (ABSTRACT)*

AUTHOR KERCHER, J.R.

CITATION BULL. ECOL. SOC. AMER. 57, 36 (1976)

ABSTRACT A MODEL OF PLANT GROWTH HAS BEEN DEVELOPED WHICH SIMULATES THE PHOTOSYNTHESIS AND GROWTH OF PLANTS UNDER STRESS BY GASEOUS POLLUTANTS. THE MODEL SIMULATES THE EFFECT OF LIGHT, TEMPERATURE, AND LEAF WATER POTENTIAL ON STOMATAL RESISTANCE AND PHOTOSYNTHESIS; CONTINUOUSLY CALCULATES SOIL WATER CONTENT AND SOIL WATER POTENTIAL; SIMULATES PHOTOSYNTHATE ACCUMULATION AND ALLOCATION; AND COMPUTES FOLIAR, STEM, ROOT, AND FRUIT GROWTH. THE MODEL IS CONSTRUCTED TO RESPOND TO DAILY ENVIRONMENTAL CONDITIONS AND TO SIMULATE THE PLANT'S BEHAVIOR DURING THE COURSE OF A GROWING SEASON. APPLICATIONS OF THE MODEL TO CROPS GROWN IN AN ENVIRONMENT UNDER SALINE STRESS ARE DISCUSSED.

KEYWORDS ECOSYSTEM QUALITY, TERRESTRIAL; INTEGRATED ASSESSMENT; MODELS

9 TITLE A DESCRIPTION OF IMPERIAL VALLEY, CALIFORNIA, FOR THE ASSESSMENT OF IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT.

AUTHOR LAYTON, D.W.; ERMAK, D.L. (EDS.)

CITATION UCRL-52121 (1976)

ABSTRACT IMPENDING GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY OF CALIFORNIA HAS RAISED CONCERN OVER THE POSSIBLE IMPACTS OF SUCH DEVELOPMENT. AS AN INITIAL STEP IN IMPACT ASSESSMENT OF GEOTHERMAL PROJECTS, RELEVANT FEATURES OF THE VALLEY'S PHYSICAL AND HUMAN ENVIRONMENTS ARE DESCRIBED. PARTICULAR ATTENTION IS PLACED ON FEATURES THAT MAY EITHER INFLUENCE DEVELOPMENT OR BE AFFECTED BY IT. MAJOR AREAS OF CONSIDERATION INCLUDE THE VALLEY'S PHYSICAL RESOURCES (I.E., LAND, AIR, WATER, AND BIOLOGICAL RESOURCES), ECONOMIC, FISCAL, AND SOCIAL CHARACTERISTICS OF IMPERIAL COUNTY, AND GEOTHERMAL LAWS.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; IMPERIAL VALLEY; INTEGRATED ASSESSMENT; LAWS AND REGULATIONS; SOCIOECONOMIC EFFECTS; WATER QUALITY

10 TITLE IMPERIAL VALLEY ENVIRONMENTAL PROJECT, PROGRESS REPORT.

AUTHOR PHELPS, P.L.; ANSPAUGH, L.R. (EDS.)

CITATION UCRL-50044-76-1 (1976)

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 ENVIRONMENTAL 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: 1) AIR QUALITY 2) WATER QUALITY 3) ECOSYSTEM QUALITY 4) SUBSIDENCE AND SEISMICITY 5) SOCIOECONOMIC EFFECTS 6) HEALTH EFFECTS AND 7) INTEGRATED ASSESSMENT. A SUMMARY OF THE PROGRESS IN THESE AREAS DURING THE FIRST YEAR OF THIS PROJECT IS PRESENTED.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HEALTH EFFECTS; IMPERIAL VALLEY; INTEGRATED ASSESSMENT; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY

- 11 **TITLE** *POTENTIAL EFFECTS OF GEOTHERMAL ENERGY CONVERSION ON IMPERIAL VALLEY ECOSYSTEMS. (PROCEEDINGS OF THE FIRST WORKSHOP ON INTEGRATED ASSESSMENT OF ECOSYSTEM QUALITY).*
- AUTHOR** SHINN, J.H. (ED.)
- CITATION** UCRL-52196 (1976)
- ABSTRACT** THIS WORKSHOP ON POTENTIAL EFFECTS OF GEOTHERMAL ENERGY CONVERSION ON THE ECOLOGY OF IMPERIAL VALLEY, WHICH WAS CONDUCTED FROM NOVEMBER 8 THROUGH 11, 1976, BROUGHT TOGETHER PERSONNEL OF LAWRENCE LIVERMORE LABORATORY AND MANY COLLABORATORS UNDER THE SPONSORSHIP OF THE ERDA IMPERIAL VALLEY ENVIRONMENTAL PROJECT (IVEP). THIS REPORT REFLECTS THE EXPERTISE OF THE CONTRIBUTORS IN FIELD EXPERIENCE AND KNOWLEDGE OF THE LITERATURE, AND CONTAINS PRELIMINARY RESULTS FROM THE IVEP. THE LLL INTEGRATED ASSESSMENT TEAM IDENTIFIED THE ELECTRIC POWER POTENTIAL AND ITS ASSOCIATED EFFLUENTS, DISCHARGES, SUBSIDENCE, WATER REQUIREMENTS, LAND USE, AND NOISE. THE WORKING GROUPS ADDRESSED THE ECOLOGICAL PROBLEMS. WATER RESOURCE MANAGEMENT PROBLEMS INCLUDE FORCES ON WATER USE, IRRIGATION METHODS AND WATER USE FOR CROPS, WATER PRODUCTION, AND WATER ALLOCATION. AGRICULTURAL PROBLEMS ARE THE CONTAMINATION OF EDIBLE CROPS AND THE RECLAMATION OF SOIL. A STRATEGY IS DISCUSSED FOR PREDEVELOPMENT BASELINE DATA AND FOR IDENTIFICATION OF SOURCE TERM TRACERS. WILDLIFE RESOURCES MIGHT BE THREATENED BY HABITAT DESTRUCTION, POWERLINE IMPACTS, NOISE AND DISTURBANCE EFFECTS, GAS EMISSIONS, AND SECONDARY IMPACTS SUCH AS POPULATION PRESSURE. AQUATIC ECOSYSTEMS IN BOTH THE SALTON SEA AND FRESH WATERS HAVE POTENTIAL HAZARDS OF SALINITY AND TRACE METAL EFFECTS, AS WELL AS EXISTING STRESSES; BASELINE AND BIOASSAY STUDIES ARE DISCUSSED. PROBLEMS FROM AIR POLLUTION RESULTING FROM GEOTHERMAL RESOURCE DEVELOPMENT MIGHT OCCUR, PARTICULARLY TO VEGETATION AND POLLINATOR INSECTS. CONVERSION OF INJURY DATA TO PREDICTED ECONOMIC DAMAGE IS NEEDED. FINALLY, IMPERIAL VALLEY DESERT ECOSYSTEMS MIGHT BE THREATENED BY DESTRUCTION OF HABITAT AND THE POSSIBLE EFFECTS ON COMMUNITY STRUCTURE SUCH AS THOSE RESULTING FROM BRINE SPILLS.
- KEYWORDS** AIR QUALITY; BRINE; ECOSYSTEM QUALITY, AQUATIC; ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; IMPERIAL VALLEY; INTEGRATED ASSESSMENT; RESOURCE STATUS; NOISE; SOCIOECONOMIC EFFECTS; WATER QUALITY
- 12 **TITLE** *EXPOSURES OF FIELD-GROWN LETTUCE TO GEOTHERMAL AIR POLLUTION: PHOTOSYNTHETIC AND STOMATAL RESPONSES.*
- AUTHOR** SHINN, J.H.; CLEGG, B.R.; STUART, M.L.; THOMPSON, S.E.
- CITATION** J. ENVIRON. SCI. HEALTH A11, 603 (1976)
- ABSTRACT** FIELD-GROWN LETTUCE WAS EXPOSED IN-SITU TO A FACSIMILE GEOTHERMAL GAS MIXTURE (15 CO₂: 1 H₂S: 1 CH₄: 2 N₂ PARTS BY VOLUME ADDED TO AIR). THE OBJECTIVE WAS TO DETERMINE THE EFFECTS OF GEOTHERMAL AIR POLLUTION ON PHOTOSYNTHESIS AND STOMATAL DIFFUSION RESISTANCE DURING A THREE-HOUR PERIOD OF EXPOSURE. THE QUESTION WAS TO WHAT DEGREE THE EXTRA CO₂ MIGHT COMPENSATE FOR THE PHYTOTOXIC EFFECT OF H₂S DURING AN EXPOSURE ANALOGOUS TO FUMIGATION BY A TYPICAL GEOTHERMAL POWER PLANT PLUME. THE APPARENT MEAN VALUES INDICATE A STIMULATION OF PHOTOSYNTHESIS AND A RELAXATION OF STOMATAL RESISTANCE AT LOW CONCENTRATIONS. THERE IS NO SIGNIFICANT DEPRESSION OF PHOTOSYNTHESIS UNTIL EXPOSURE CONCENTRATIONS APPROACH 75 PPM CO₂: 5 PPM H₂S ADDED TO AIR. THE NORMAL VARIATION IN PHOTOSYNTHESIS IS SO HIGH (COEFFICIENT OF VARIATION .5) THAT IT IS NECESSARY TO TAKE MANY SAMPLES TO ESTABLISH A MEAN, AND THIS SHOULD BE CONSIDERED IN DESIGNING FUTURE EXPERIMENTS.
- KEYWORDS** AIR QUALITY; ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; IMPERIAL VALLEY

- 13 **TITLE** *MEASUREMENTS OF RADIOACTIVITY IN COOLING TOWER SLUDGE AT THE GEYSERS GEOTHERMAL FIELD, CALIFORNIA. (ABSTRACT)*
AUTHOR SERPA, D.P.; LORENZ, R.W.; ANSPAUGH, L.R.
CITATION HEALTH PHYS. 31, 532 (1976)
ABSTRACT DURING THE COURSE OF A PROJECT TO MEASURE NATURAL RADIOACTIVITY AT THE GEYSERS, MEASUREMENTS OF 210-PB IN COOLING TOWER SLUDGE WERE MADE. THE RESULTS OF THESE MEASUREMENTS INDICATED THAT 210-PB WAS CONCENTRATED IN THE SLUDGE. THUS, THIS STUDY WAS UNDERTAKEN TO MEASURE THE RADIOACTIVITY IN THE GEYSERS COOLING TOWER SLUDGE AND DETERMINE THE SOURCES OF 210-PB. THE RESULTS OF GAMMA SPECTROSCOPY OF SAMPLES OF COOLING TOWER SLUDGE HAVE SHOWN THE PRESENCE OF MANY FALLOUT RADIONUCLIDES, INCLUDING 137-CS, 125-SB, 106-RU/RH, AND COSMOGENIC 7-BE. THE PRESENCE OF THESE RADIONUCLIDES WAS UTILIZED TO ESTIMATE THE EXPECTED 210-PB ACTIVITY IN THE COOLING TOWER DUE TO ITS REMOVAL FROM AMBIENT AIR (SCRUBBING PROCESS). CONFIRMATION OF AIRBORNE 210-PB ACTIVITY WAS MADE BY AIR SAMPLING AND GAMMA SPECTROSCOPY. THIS STUDY DEMONSTRATED THAT THE MAJORITY OF THE RADIONUCLIDES, INCLUDING 210-PB, IN THE SLUDGE OF THE GEYSERS POWER PLANT COOLING TOWERS IS THE RESULT OF THE SCRUBBING OF RADIONUCLIDES FROM THE AIR AND IS NOT DUE TO RADIONUCLIDES CARRIED IN GEOTHERMAL STREAM.
KEYWORDS ECOSYSTEM QUALITY; GEYSERS, THE; RADIOACTIVITY
- 14 **TITLE** *JUDICIALLY ENFORCEABLE SUBSTANTIVE RIGHTS UNDER NEPA.*
AUTHOR WHARTON, J.C.
CITATION USF LAW REVIEW 10, 415 (1976)
ABSTRACT THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) WAS ENACTED IN 1970 TO EXPRESS A FEDERAL POLICY ON ENVIRONMENTAL QUALITY. NEPA MANDATED THAT FEDERAL AGENCIES UNDERTAKING ACTIONS THAT POSED POTENTIALLY ADVERSE ENVIRONMENTAL CONSEQUENCES FILE AN ENVIRONMENTAL IMPACT STATEMENT (EIS). THIS ARTICLE EXAMINES THE CASES WHICH HAVE HELD THAT COURTS HAVE THE RIGHT TO REVIEW THE SUBSTANCE OF THE AGENCY'S DECISION REGARDING THE PROPOSED PROJECT ONCE THE AGENCY HAS PROCEDURALLY COMPLIED WITH NEPA IN PREPARING ITS EIS. THE AUTHOR ALSO CONTENTS THAT MANY COURTS ARE SUB SILENTIO CONDUCTING SUBSTANTIVE REVIEW UNDER THE GUISE OF STRICT PROCEDURAL REQUIREMENTS AND EXAMINES SEVERAL CASES WHICH DEMONSTRATE HIS THESIS.
KEYWORDS ECOSYSTEM QUALITY; LAWS AND REGULATIONS
- 15 **TITLE** *THE LEGISLATIVE HISTORY OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT.*
AUTHOR WHARTON, J.C.; LEWIS, M.
CITATION UCRL-52188 (1976)
ABSTRACT FOLLOWING MUCH GENERAL CONCERN OVER POLLUTION AND ITS EFFECTS ON THE ENVIRONMENT, THE STATE OF CALIFORNIA PASSED THE ENVIRONMENTAL QUALITY ACT IN 1970. THIS STUDY EXAMINES THE SOURCE OF THE ACT, THE ACTIVITY IN THE LEGISLATURE PRIOR TO ITS PASSAGE, SOME OF THE CASES WHICH INTERPRETED ITS APPLICATIONS, AND THE LEGISLATIVE RESPONSES TO THOSE CASES. THE EVOLUTION OF THE MEANING OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) STARTED WITH FRIENDS OF MAMMOTH V. BOARD OF SUPERVISORS IN WHICH THE COURT FOUND THAT PRIVATE INDIVIDUALS HAD STANDING TO CHALLENGE DECISIONS OF GOVERNMENTAL ENTITIES WITHIN THE STATE. AN IMPACT REPORT ON A PROJECT'S EFFECT ON THE ENVIRONMENT IS REQUIRED FOR ANY ENTITLEMENT GIVEN TO A PRIVATE PERSON. THE LEGISLATIVE AMENDMENTS THAT INCORPORATED THE HOLDING OF FRIENDS OF MAMMOTH ARE DISCUSSED. THE SUBSTANTIVE AND THE PROCEDURAL ASPECTS OF CEQA ARE CRITICALLY EXAMINED WITH THE CONCLUSION THAT THE LEGISLATURE SHOULD INCLUDE A CLEARER STATEMENT OF THE SUBSTANTIVE RIGHTS CONTAINED IN CEQA.
KEYWORDS ECOSYSTEM QUALITY; LAWS AND REGULATIONS

•FUNDED BY THE PACIFIC GAS AND ELECTRIC CO.

- 16 **TITLE** *THE CLEAN AIR ACT; POWER PLANT OPERATION AND SULFUR DIOXIDE REGULATION.*
AUTHOR WHARTON, J.C.
CITATION UCRL-52182 (1976)
ABSTRACT THE CLEAN AIR ACT OF 1970 AND THE ENVIRONMENTAL PROTECTION AGENCY'S (EPA) REGULATIONS MADE PURSUANT TO THAT ACT ARE A MAJOR CONSTRAINT TO ELECTRICAL POWER PRODUCTION BY COALFIRED POWER PLANTS. AN EXAMINATION OF THE HISTORY OF THE ACT SHOWS A PROGRESSIVE TIGHTENING OF THE STANDARDS THAT APPLY TO THE POLLUTANTS EMITTED BY POWER PLANTS. ONE OF THE MOST RESTRICTIVE OUTGROWTHS OF THIS PROCESS IS THE ADOPTION OF STANDARDS THAT REQUIRE THAT TECHNOLOGY BE DEVELOPED TO MEET THOSE STANDARDS. IN ADDITION, THE GRANTING OF VARIANCES WAS SHARPLY CURTAILED BY REQUIRING THAT STRICT INFEASIBILITY BE SHOWN BEFORE GIVING A VARIANCE. THE COURT'S ESPOUSED RULE OF NONDETERIORATION IS A REAL BARRIER TO INDUSTRY'S DESIRE TO MOVE POLLUTION ACTIVITIES AWAY FROM POPULATION CENTERS. THE EPA IS TAKING THE APPROACH TO ENFORCEMENT OF AIR STANDARDS THAT ATTAINMENT CANNOT BE ACHIEVED WITHOUT SIGNIFICANT COST TO THE INDUSTRIES; THE REGULATIONS ATTEMPT TO RECOGNIZE THIS BY MAKING A DISTINCTION BETWEEN OLD AND NEW SOURCES IN ITS POWER-PLANT REGULATIONS. GENERALLY, TALL STACKS WILL BE ALLOWED ON OLD SOURCES BUT SCRUBBERS WILL BE REQUIRED ON NEW SOURCES. THE AGENCY ENCOURAGES USE OF TALL STACKS EXCEPT WHERE THEY ARE IN LIEU OF EMISSION CONTROLS. AT SOME FUTURE TIME, THE EPA COULD REQUIRE BOTH TALL STACKS AND SCRUBBERS IF NEEDED TO PROTECT HUMAN HEALTH.
KEYWORDS AIR QUALITY; LAWS AND REGULATIONS
- *17 **TITLE** *SAMPLING A TWO-PHASE GEOTHERMAL BRINE FLOW FOR CHEMICAL ANALYSIS.*
AUTHOR HILL, J.H.; MORRIS, C.J.
CITATION SAMPLING GEOTHERMAL EFFLUENTS, PROC. 1ST WORKSHOP, OCT. 20-21, 1975, LAS VEGAS, NEVADA, EPA-600/9-76-011, PP. 151-203 (1976)
ABSTRACT THIS REPORT DESCRIBES AN EXPERIMENT DESIGNED PRIMARILY TO DEFINE THE PROBLEMS ASSOCIATED WITH SAMPLING THE TWO-PHASE FLOW IN A PIPELINE OF GEOTHERMAL BRINE. ANALYSES REPORTED FOR 26 SAMPLES INCLUDE CHEMICAL COMPOSITION, OXIDATION POTENTIAL, PH, DENSITY, AND TOTAL SOLIDS. CHANGES IN BRINE COMPOSITION AS THE WELL OPERATED DURING A FOUR-WEEK PERIOD ARE EVALUATED. THE APPARATUS AND TECHNIQUES USED FOR SAMPLING ARE DESCRIBED AND EVALUATED.
KEYWORDS BRINE; IMPERIAL VALLEY
- *18 **TITLE** *THE LLL GEOTHERMAL INDUSTRIAL SUPPORT PROGRAM IN CHEMISTRY AND MATERIALS FOR FY76 AND FY77.*
AUTHOR QUONG, R.
CITATION UCID-17209 (1976)
ABSTRACT LLL HAS INITIATED AN INDUSTRIAL SUPPORT PROGRAM TO PROVIDE TECHNICAL ASSISTANCE TO JOINT ERDA/INDUSTRY PROJECTS. THIS SUPPORT PROGRAM IS CURRENTLY DIRECTED ONLY TOWARD THE JOINTLY FUNDED PROJECT CARRIED OUT BY SDG&E TO CONSTRUCT AND OPERATE THE GEOTHERMAL LOOP EXPERIMENTAL FACILITY (GLEF) AT NILAND, CALIFORNIA.
THIS REPORT DESCRIBES PLANS FOR AND PROGRESS IN: CHARACTERIZATION AND CONTROL OF SCALE AND SUSPENDED SOLIDS; BRINE AND EFFLUENT CHARACTERIZATION; AND EFFLUENT CONDITIONING FOR REINJECTION. ALSO DISCUSSED ARE PLANS FOR NONDESTRUCTIVE SURVEILLANCE OF THE CORROSION RATE OF PIPING AND COMPONENTS DURING GLEF OPERATION, AND PLANS FOR CORROSION TESTS OF SUBSTITUTE PLANT MATERIAL.
KEYWORDS BRINE; IMPERIAL VALLEY

*PREPARED BY THE LLL GEOTHERMAL ENERGY TECHNOLOGY GROUP WITH FUNDING FROM THE U.S. DOE DIVISION OF GEOTHERMAL ENERGY.

*19 TITLE *SCALING CHARACTERISTICS IN THE GEOTHERMAL LOOP EXPERIMENTAL FACILITY AT NILAND, CALIFORNIA.*

AUTHOR QUONG, R.

CITATION UCRL-52162 (1976)

ABSTRACT THE SAN DIEGO GAS & ELECTRIC COMPANY - U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION JOINT GEOTHERMAL LOOP EXPERIMENTAL FACILITY (GLEF), LOCATED AT NILAND IN THE IMPERIAL VALLEY, CALIFORNIA, BEGAN OPERATION IN MAY 1976. THE GLEF INCORPORATES A SEQUENTIAL FOUR-STAGE FLASH PROCESS TO SUCCESSIVELY LOWER TEMPERATURES AND PRESSURES WITH A BINARY FLUID ENERGY-CONVERSION CYCLE. APPROXIMATELY 300 HR OF INTERMITTENT OPERATION WERE LOGGED BEFORE SHUTDOWN OF THE FACILITY ON JUNE 16 FOR INSPECTION AND MAINTENANCE. SAMPLES OF THE BRINE, SUSPENDED SOLIDS, AND SCALE DEPOSITS WERE ANALYZED FOR BULK COMPOSITION AND MINERALOGY, BUT CORRELATION WITH TEMPERATURE AND PRESSURE IS VAGUE. IN GENERAL, A GALENA-RICH SCALE IS OBSERVED IN VALVES AND PIPING AHEAD OF THE FIRST-STAGE SEPARATOR, BECOMING MUCH LESS ABUNDANT BEYOND THAT POINT. THE BULK OF THE SCALE CONSISTS OF AN INCREASING PROPORTION OF AN IRON-RICH AMORPHOUS SILICA WITH PROCESS PROGRESSION. TRACE CRYSTALLINE PHASES, SUCH AS AKAGANEITE, KUTNAHORITE, AND SPHALERITE AND/OR WURTZITE, HAVE BEEN DETECTED OR ARE STRONGLY SUSPECTED IN THE SCALES. HALITE AND SYLVITE ARE FOUND PRIMARILY AS A RESULT OF NUMEROUS FACILITY SHUTDOWNS AND SUBSEQUENT COOLING OF THE RETAINED BRINE IN THE EQUIPMENT. BARITE IS FREQUENTLY PRESENT WHEN IRRIGATION WATER (USED FOR PRIMING THE WELLS) CONTAINING SO₄ IS MIXED WITH THE BRINE. CALCITE AND/OR ARAGONITE IS ALSO FOUND WHENEVER SEPARATED STEAM CONDENSATE IN CONTACT WITH CO₂ IS RECOMBINED WITH THE BRINE. CORROSION PRODUCTS, MAGNETITE AND HEMATITE, FORM AN INTEGRAL PART OF THE SCALE ADJACENT TO STEEL WALLS. THE SCALES ARE LAYERED WITH BANDS OF WIDELY DIFFERING MATERIAL. THE COLOR, TEXTURE, HARDNESS, AND THICKNESS OF THE DEPOSITS ALSO VARY CONSIDERABLY WITHIN LOCATIONS IN THE GLEF. A NEW METHOD OF IN-PROCESS SCALE BUILDUP SURVEILLANCE BASED ON RADIOGRAPHY WAS SUCCESSFULLY VERIFIED.

KEYWORDS BRINE; IMPERIAL VALLEY

*20 TITLE *POSSIBILITIES FOR CONTROLLING HEAVY METAL SULFIDES IN SCALE FROM GEOTHERMAL BRINES.*

AUTHOR JACKSON, D.D.; HILL, J.H.

CITATION UCRL-51977 (1976)

ABSTRACT HEAVY METAL SULFIDES FORM A SUBSTANTIAL PART OF THE SCALE SOLIDS DEPOSITING FROM HIGH-TEMPERATURE, HIGH-SALINE GEOTHERMAL BRINES. AN ASSESSMENT HAS BEEN MADE OF THE PROSPECTS FOR CONTROLLING THIS DEPOSITION BY CHEMICAL MODIFICATION OF THE BRINE. AN OUTLINE IS GIVEN OF THE TYPES OF REACTIONS INFLUENCING SULFIDE PRECIPITATION. IT IS SUGGESTED THAT TWO FACTORS AFFECTING SULFIDE SOLUBILITY AND THAT ARE AMENABLE TO CHEMICAL MODIFICATION OF THE BRINE ARE OXIDATION STATE AND PH. A PARTIAL OXIDATION PROCESS CAN BE USED TO CONVERT AQUEOUS SULFIDE SPECIES TO FREE SULFUR, A PROCESS FAVORED BY THERMODYNAMICS AND KINETICS. SOME OXIDIZING AGENTS ARE SUGGESTED FOR THIS PURPOSE. A DISCUSSION IS GIVEN OF THE POSSIBILITIES OF PRECIPITATING OTHER SOLID PHASES AFTER EXTENSIVE OXIDATION. IT IS CONCLUDED ON THE BASIS OF THE AVAILABLE DATA THAT THIS POSSIBILITY EXISTS, BUT THAT UNCERTAINTIES IN REACTION KINETICS, UNAVAILABLE DATA, AND SOLUTION COMPLEXITY MAKE AN EXACT ANALYSIS DIFFICULT. THE USEFULNESS OF A FIELD EVALUATION OF CHEMICAL MODIFICATION PROCESSES IS INDICATED.

KEYWORDS BRINE

*PREPARED BY THE LLL GEOTHERMAL ENERGY TECHNOLOGY GROUP WITH FUNDING FROM THE U.S. DOE DIVISION OF GEOTHERMAL ENERGY.

21 TITLE *THE ENVIRONMENTAL MONITORING PROBLEM; OPTIMAL SOLUTIONS FOR CONTROL AND SURVEILLANCE APPLICATIONS IN THE CASE OF INFREQUENT SAMPLING.*

AUTHOR PIMENTEL, K.D.

CITATION MODELING, IDENTIFICATION AND CONTROL IN ENVIRONMENTAL SYSTEMS, G.C. VANSTEENKISTE, ED., NORTH-HOLLAND PUB. CO., AMSTERDAM, PP.89-99 (1978)

ABSTRACT AN ENVIRONMENTAL MONITOR IS DEFINED AS A SYSTEM THAT ESTIMATES ENVIRONMENTAL POLLUTANT LEVELS THROUGHOUT AN ENVIRONMENTAL REGION FOR ALL TIMES IN A SPECIFIED TIME INTERVAL, USING MEASUREMENT DATA TAKEN ONLY AT DISCRETE LOCATIONS AND AT DISCRETE TIMES. TWO DISTINCT MONITORING PROBLEMS ARE POSED, THE FIRST FOR ENVIRONMENTAL FEEDBACK CONTROL APPLICATIONS, THE SECOND FOR SURVEILLANCE OR POLLUTANT LIMIT VIOLATION DETECTION. THE MAIN RESULTS ARE FOR THE SPECIAL CASE OF INFREQUENT SAMPLING. IF THE REQUIRED MEASUREMENTS ARE SPACED FAR ENOUGH APART IN TIME, CERTAIN TERMS IN THE ESTIMATION ERROR EQUATIONS DOMINATE THE ASYMPTOTIC RESPONSE YIELDING MATHEMATICALLY ELEGANT SOLUTIONS FOR INFREQUENT SAMPLING MONITORS.

KEYWORDS ECOSYSTEM QUALITY; MONITORING; MODELS

*22 TITLE *TERRESTRIAL MONITORING OF ELEMENTAL CONTAMINANTS AROUND GEOTHERMAL POWER PLANTS.*

AUTHOR CROCKETT, A.B.

CITATION GEOTHERMAL ENVIRONMENTAL SEMINAR '76. F.L. TUCKER AND M.D. ANDERSEN, EDS., GEOTHERMAL SEMINAR, LAKEPORT, CALIF., PP. 205-211 (1976)

ABSTRACT NO ABSTRACT AVAILABLE.

KEYWORDS BRINE; ECOSYSTEM QUALITY, TERRESTRIAL; MONITORING; IMPERIAL VALLEY

**23 TITLE *CHEMICAL FORMS OF MERCURY AND ARSENIC EMITTED BY A GEOTHERMAL POWER PLANT.*

AUTHOR CRECELIUS, E.A.; ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.

CITATION TRACE SUBSTANCES IN ENVIRONMENTAL HEALTH X. D.D. HEMPHILL, ED. PROC. CONF., UNIV. MISSOURI PP 287-293 (1976)

ABSTRACT AT THE CERRO PRIETO GEOTHERMAL POWER PLANT, LOCATED IN NORTHWESTERN MEXICO, HOT BRINE AND STEAM ARE SEPARATED AT THE WELL-HEAD AND THE BRINE IS DISCHARGED TO A POND. THE STEAM AND NONCONDENSABLE GASES (RICH IN CO₂ AND H₂S) PASS THROUGH A TURBINE AND CONDENSER AND THEN ENTER A COOLING TOWER. THE CONCENTRATION OF TOTAL HG IN NONCONDENSABLE GASES RANGED FROM 210-340 NG/L; COOLING TOWER AIR AVERAGED 0.56 NG/L; AND STEAM CONDENSATE AVERAGED 5200 NG/L. THE MAJORITY OF THE VOLATILE HG WAS PRESENT AS ELEMENTAL VAPOR. A MASS BALANCE FOR HG IN THE POWER PLANT INDICATED THAT 90% OF THE HG ENTERING THE PLANT WAS RELEASED TO THE ENVIRONMENT IN THE COOLING TOWER AIR AT A RATE OF 5.4 G/HR. BECAUSE ARSENIC WAS PRESENT MAINLY IN THE LIQUID PHASE, 99% OF THE AS IN THE WELL WATER WAS SEPARATED FROM THE STEAM AND WAS DISCHARGED TO THE BRINE EVAPORATION POND AT A RATE OF 2480 G/HR. BOTH AS-+3 AND AS-+5 WERE PRESENT IN ALL THE WATER SAMPLES. HYDROGEN SULFIDE WAS RELEASED FROM THE PLANT MAINLY WITH THE NONCONDENSABLE GAS AT A RATE OF 140 KG/HR.

KEYWORDS AIR QUALITY; BRINE; HYDROGEN SULFIDE

*FUNDED BY THE ENVIRONMENTAL PROTECTION AGENCY.

**FUNDED BY THE NATIONAL SCIENCE FOUNDATION.

- 24 **TITLE** *TRACE METAL SPECIATION IN SALINE WATERS AFFECTED BY GEOTHERMAL BRINES.*
AUTHOR SPOSITO, G.; PAGE, A.L.
CITATION UCRL-13790 (1977)
ABSTRACT A DESCRIPTION IS GIVEN OF THE CHEMICAL EQUILIBRIUM COMPUTER PROGRAM GEOCHEM, WHICH HAS BEEN DEVELOPED TO CALCULATE TRACE ELEMENT SPECIATION IN SOIL, IRRIGATION, DRAINAGE, OR SALTON SEA WATERS AFFECTED BY GEOTHERMAL BRINE. GEOCHEM IS APPLIED TO IRRIGATION WATER-BRINE MIXTURES AND TO SALTON SEA WATER-BRINE MIXTURES IN ORDER TO COMPUTE THE CHEMICAL SPECIATION OF THE ELEMENTS CD, CU, HG, NI, PB, AND ZN, ALONG WITH THE OXYANIONS OF AS AND B. THE RESULTS SUGGEST THAT THE COMPUTER SIMULATION CAN HAVE AN IMPORTANT EFFECT ON A PROGRAM FOR MANAGING BRINE SPILLS.
KEYWORDS BRINE; ECOSYSTEM QUALITY; ENVIRONMENTAL DATA MANAGEMENT; IMPERIAL VALLEY; WATER QUALITY
- 25 **TITLE** *GEOTHERMAL RESOURCE DEVELOPMENT: LAWS AND REGULATIONS.*
AUTHOR WHARTON, J.C.
CITATION UCRL-52327 (1977)
ABSTRACT THE DEVELOPMENT OF GEOTHERMAL RESOURCES IN CALIFORNIA IS BECOMING OF INCREASING INTEREST BECAUSE OF THE LARGE AMOUNTS OF THESE RESOURCES IN THE STATE. THE GEYSERS AREA IN NORTHERN CALIFORNIA HAS SEVERAL PRODUCING ELECTRICAL POWER PLANTS WHILE IMPERIAL COUNTY IN SOUTHERN CALIFORNIA HAS KNOWN RESERVES OF GEOTHERMAL RESOURCES. IN RESPONSE TO THIS INTEREST IN DEVELOPMENT, THE LEGISLATURE AND REGULATORY BODIES HAVE TAKEN ACTIONS TO INCREASE GEOTHERMAL POWER PRODUCTION. THIS REPORT DISCUSSES AND SETS FORTH THE IMPORTANT FEDERAL AND CALIFORNIA LAWS ON THE SUBJECT. PERTINENT FEDERAL AND STATE PROVISIONS ARE COMPARED, AND INCONSISTENCIES ARE DISCUSSED. AN IMPORTANT CONCEPT THAT NEEDS CLARIFICATION IS THE MANNER OF DESIGNATING AN AREA AS A "KNOWN GEOTHERMAL RESOURCE AREA". THE QUESTION OF DESIGNATING GEOTHERMAL RESOURCE AS A MINERAL IS NOT COMPLETELY RESOLVED, ALTHOUGH THERE IS AUTHORITY TENDING TOWARD THE FINDING THAT IT IS A MINERAL.
KEYWORDS LAWS AND REGULATIONS
- 26 **TITLE** *SIMULATIONS OF EFFECTS OF GEOTHERMAL POLLUTANTS ON CROP GROWTH USING A COMPUTER PLANT MODEL. (ABSTRACT)*
AUTHOR KERCHER, J.R.
CITATION BULL. ECOL. SOC. AMER. 58, 56 (1977)
ABSTRACT USING A PLANT GROWTH SIMULATOR, GROW1, SIMULATIONS HAVE BEEN MADE ON THE EFFECTS OF GEOTHERMAL POLLUTANTS ON SELECTED CROPS IN THE IMPERIAL VALLEY OF CALIFORNIA. GROW1 SIMULATES PHOTOSYNTHESIS, TRANSPIRATION, CHANGES SOIL WATER CONTENT, PHOTOSYNTHATE ALLOCATION AND RESPIRATION. TWO OF THE FOUR MAJOR FIELD CROPS FOR THE VALLEY, ALFALFA, COTTON, SUGAR BEETS, AND WHEAT, WERE SELECTED FOR PARAMETERIZATION OF GROW1. THE RELATIONSHIP BETWEEN H₂S STRESS AND CO₂ FERTILIZATION IS DISCUSSED. ALSO, THE IMPLICATIONS OF NET PHOTOSYNTHESIS AS A FUNCTION OF LEAF AREA INDEX ARE DISCUSSED.
KEYWORDS ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; MODELS

- 27 **TITLE** *PUMPING ENERGY REQUIREMENTS FOR IRRIGATION IN CALIFORNIA.*
AUTHOR KNUTSON, G.D.; CURLEY, R.G.; ROBERTS, E.B.; HAGAN, R.M.; CERVINKA, V.
CITATION UCRL-13788 (1977)
ABSTRACT PREVIOUS STUDIES HAVE SHOWN THAT OVER 95 PERCENT OF THE IRRIGATION PUMPING ENERGY IN CALIFORNIA IS SUPPLIED BY ELECTRIC MOTORS WHICH REQUIRE APPROXIMATELY 68 PERCENT OF THE DIRECT ELECTRICAL ENERGY USED BY CALIFORNIA AGRICULTURE. IT IS OBVIOUS THAT IRRIGATION IS A MAJOR USER OF ENERGY IN CALIFORNIA AGRICULTURE AND ALMOST ALL OF THAT ENERGY IS ELECTRICAL. THEREFORE, ONLY ELECTRICALLY POWERED PUMPS WERE CONSIDERED. THIS STUDY OF IRRIGATION ENERGY WAS MADE TO DETERMINE ENERGY USE BY CROP AND GEOGRAPHIC AREA. IT INCLUDES ALL ON-FARM IRRIGATION PUMPING PLUS PUMPING OF IRRIGATION WATER BY IRRIGATION DISTRICTS, AND PUMPING ENERGY FOR MOVING WATER IN THE STATE AND FEDERAL WATER PROJECTS. THE ENERGY VALUES REPRESENT ONLY PUMPING ENERGY AND DO NOT INCLUDE LOSSES FOR ELECTRICAL GENERATION AND DISTRIBUTION, OR ENERGY FOR MANUFACTURE AND CONSTRUCTION OF ANY IRRIGATION SYSTEM. THE INFORMATION PRESENTED IS INTENDED TO BE USED AS BACKGROUND DATA FOR ENERGY CONSERVATION EFFORTS AND FOR ENERGY ALLOCATION PROGRAMS THAT MAY BE REQUIRED AT SOME FUTURE DATE.
KEYWORDS INTEGRATED ASSESSMENT; SOCIOECONOMIC EFFECTS; WATER QUALITY; WATER RESOURCES
- 28 **TITLE** *IMPERIAL VALLEY ENVIRONMENTAL PROJECT: QUARTERLY DATA REPORT.*
AUTHOR NYHOLM, R.A.; ANSPAUGH, L.R. (COMP. AND EDS.)
CITATION UCID-17444-1 (1977)
ABSTRACT THIS REPORT IS A CATALOG OF SAMPLES COLLECTED AT THE IMPERIAL VALLEY GEOTHERMAL RESOURCE AREAS. IT CONSISTS LARGELY OF OUTPUTS FROM THE IVEP DATA BASE. INCLUDED ARE DATA ON AIR QUALITY, WATER QUALITY, ECOSYSTEM QUALITY, SUBSIDENCE AND SEISMICITY, SOCIOECONOMIC EFFECTS, AND MEASUREMENTS OF RADIOACTIVITY.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY, AQUATIC; ECOSYSTEM QUALITY, TERRESTRIAL; IMPERIAL VALLEY; INTEGRATED ASSESSMENT; RADIOACTIVITY; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY; NOISE
- 29 **TITLE** *GEOTHERMAL ENVIRONMENTAL OVERVIEW PROJECT.*
AUTHOR ANSPAUGH, L.R.
CITATION UCID-17632 (1977)
ABSTRACT THE BASIC PURPOSE OF THE GEOTHERMAL ENVIRONMENTAL OVERVIEW PROJECT IS TO SUMMARIZE AND ASSESS THE STATE OF ENVIRONMENTAL ISSUES OF THE TOP PRIORITY KGRAS FROM AMONG THE 37 KGRAS CURRENTLY IDENTIFIED BY THE DIVISION OF GEOTHERMAL ENERGY AS HAVING POSSIBILITY FOR COMMERCIAL DEVELOPMENT. THE OBJECTIVES OF THE OVERVIEW PROJECT ARE INVENTORY OF AVAILABLE DATA, ASSESSMENT OF AVAILABLE DATA, IDENTIFICATION OF DATA GAPS, AND IDENTIFICATION OF KEY ISSUES.
KEYWORDS ECOSYSTEM QUALITY; INTEGRATED ASSESSMENT
- *30 **TITLE** *THE GEYSERS GEOTHERMAL POWER PLANT: ENVIRONMENTAL IMPACT OF THE RELEASE OF 222-RN.*
AUTHOR SERPA, D.P.; ANSPAUGH, L.R.; PHELPS, P.L.; SOINSKI, A.J.
CITATION PG&E REPORT 420-77.22 (1977)
ABSTRACT THE EMISSION RATE OF 222-RN AT THE GEYSERS AVERAGES 3.2 MCI/(MWE-DAY). AMBIENT AIR CONCENTRATIONS OF SHORT-LIVED RADON DAUGHTERS ARE NOT INCREASED ABOVE THOSE REPORTED FOR OTHER LOCATIONS, EXCEPT IN A FEW AREAS OF POSSIBLE OCCUPATIONAL EXPOSURE. EXTERNAL EXPOSURE RATE MEASUREMENTS INDICATED NO SIGNIFICANT ACCUMULATION OF GAMMA-EMITTING RADON DAUGHTERS IN EITHER THE POWER PLANT COMPONENTS OR ENVIRONS.
KEYWORDS AIR QUALITY; GEYSERS, THE; RADON; RADIOACTIVITY

*FUNDED BY THE PACIFIC GAS AND ELECTRIC CO.

- 31 **TITLE** *DISCUSSION OF ENVIRONMENTAL ISSUES.*
AUTHOR ANSPAUGH, L.R.
CITATION ENVIRONMENTAL DEVELOPMENT PLAN (EDP) HYDROTHERMAL ENERGY SYSTEMS FY 1977. USERDA REPORT EDP/G 01(77) APPENDIX B (1977)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; NOISE; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY
- 32 **TITLE** *POTENTIAL GROWTH OF ELECTRIC POWER PRODUCTION FROM IMPERIAL VALLEY GEOTHERMAL RESOURCES.*
AUTHOR ERMAK, D.L.
CITATION UCRL-52252 (1977)
ABSTRACT THE GROWTH OF GEOTHERMAL ELECTRIC POWER OPERATIONS IN IMPERIAL VALLEY, CALIFORNIA IS PROJECTED OVER THE NEXT 40 YEARS. WITH COMMERCIAL POWER FORECAST TO BECOME AVAILABLE IN THE 1980'S, THE SCENARIO CONSIDERS THREE SUBSEQUENT GROWTH RATES: 40, 100, AND 250 MW PER YEAR. THESE GROWTH RATES, ALONG WITH ESTIMATES OF THE TOTAL RESOURCE SIZE, RESULT IN A MAXIMUM LEVEL OF ELECTRIC POWER PRODUCTION RANGING FROM 1000 TO 8000 MW TO BE ATTAINED IN THE 2010 TO 2020 TIME PERIOD. POWER PLANT SITING CONSTRAINTS ARE DEVELOPED AND USED TO MAKE SITING PATTERNS FOR THE 400- THROUGH 8000-MW LEVEL OF POWER PRODUCTION. TWO GEOTHERMAL TECHNOLOGIES ARE INCLUDED IN THE SCENARIO: FLASHED STEAM SYSTEMS THAT PRODUCE COOLING WATER FROM THE GEOTHERMAL STEAM CONDENSATE AND EMIT NONCONDENSABLE GASES TO THE ATMOSPHERE; AND HIGH PRESSURE, CONFINED FLOW SYSTEMS THAT INJECT THE GEOTHERMAL FLUID BACK INTO THE GROUND. AN ANALYSIS OF THE SCENARIO IS MADE WITH REGARD TO WELL DRILLING AND POWER PLANT CONSTRUCTION RATES, LAND USE, COOLING WATER REQUIREMENTS, AND HYDROGEN SULFIDE EMISSIONS.
KEYWORDS AIR QUALITY; HYDROGEN SULFIDE; IMPERIAL VALLEY; INTEGRATED ASSESSMENT; SOCIOECONOMIC EFFECTS; WATER QUALITY
- 33 **TITLE** *AN ANALYTICAL MODEL FOR AIR POLLUTANT TRANSPORT AND DEPOSITION FROM A POINT SOURCE.*
AUTHOR ERMAK, D.L.
CITATION ATMOSPHERIC ENVIRONMENT 11, 231 (1977)
ABSTRACT AN ATMOSPHERIC TRANSPORT AND DEPOSITION MODEL IS PRESENTED FOR POLLUTANTS EMITTED FROM AN ELEVATED POINT SOURCE OVER FLAT TERRAIN. THE MODEL IS OBTAINED FROM THE ANALYTIC SOLUTION OF THE ATMOSPHERIC DIFFUSION EQUATION WITH THE COEFFICIENTS OF EDDY DIFFUSION TAKEN TO BE FUNCTIONS OF DOWNWIND DISTANCE AND THE AVERAGE WIND VELOCITY TAKEN TO BE CONSTANT. GROUND DEPOSITION OF THE POLLUTANTS IS ACCOUNTED FOR BY (1) INCLUDING A GRAVITATIONAL SETTLING TERM IN THE ATMOSPHERIC DIFFUSION EQUATION AND BY (2) APPLYING AN ABSORPTIVE BOUNDARY CONDITION AT THE GROUND SURFACE. IN ORDER TO FACILITATE APPLICATION OF THE MODEL THE RESULTS FOR THE GENERAL SITUATION THAT INCLUDES SETTLING AND DEPOSITION (AND WHERE THE DISTRIBUTION IS NO LONGER GAUSSIAN) ARE EXPRESSED IN TERMS OF THE GAUSSIAN PLUME PARAMETERS, AND SPECIFICALLY THE CROSSWIND AND VERTICAL STANDARD DEVIATION FUNCTIONS. GRAPHS OF THE POLLUTANT AIR CONCENTRATION AND GROUND DEPOSITION FLUX ARE PRESENTED FOR A NUMBER OF DEPOSITION CONDITIONS.
KEYWORDS AIR QUALITY; INTEGRATED ASSESSMENT; MODELS
- 34 **TITLE** *REGIONAL CROP WATER USE, IMPERIAL VALLEY.*
AUTHOR PRUITT, W.O.
CITATION UCRL-13742 (1977)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS ECOSYSTEM QUALITY, TERRESTRIAL; IMPERIAL VALLEY; WATER QUALITY

35 TITLE THE NOVEMBER-DECEMBER 1976 EARTHQUAKE SWARMS IN NORTHERN IMPERIAL VALLEY, CALIF.: SEISMICITY ON THE BRAWLEY FAULT AND RELATED STRUCTURES. (ABSTRACT)

AUTHOR PUIS, G.; SCHNAPP, M.

CITATION TRANS. AMER. GEOPHYS. UNION (EOS) 58, 1188 (1977)

ABSTRACT THREE EARTHQUAKE SWARMS OCCURRED IN NORTHERN IMPERIAL VALLEY, CA., IN NOVEMBER AND DECEMBER 1976. TOGETHER THEY ROUGHLY OUTLINE THE TREND OF THE BRAWLEY FAULT (NNW) THAT HAS BEEN INFERRED FROM PAST SEISMICITY, BUT TWO SWARMS ALSO APPEAR RELATED TO STRUCTURES WITH DIFFERENT TRENDS. THE FIRST AND LARGEST SWARM OCCURRED DURING THE PERIOD NOVEMBER 4-10. IT GENERATED 213 LOCATABLE EVENTS, INCLUDING 9 EVENTS ML GREATER THAN OR EQUAL TO 4 DURING THE FIRST 12 HOURS. IT BEGAN WITH A CLUSTER OF EVENTS ABOUT 8 KM WEST OF CALIPATRIA. THE LARGEST EVENT IN THE SWARM, ML=4.9, OCCURRED IN THIS CLUSTER AND WAS FOLLOWED WITHIN AN HOUR BY EVENTS DEFINING A STEEPLY DIPPING PLANAR ZONE EXTENDING 5 KM WEST-SOUTHWEST OF THE CLUSTER. THESE OBSERVATIONS ARE CONSISTENT WITH SLIP ON A FAULT CONJUGATE TO THE INFERRED TREND OF THE BRAWLEY FAULT. THE SECOND SWARM OCCURRED DURING THE PERIOD NOVEMBER 11-17. IT GENERATED 62 LOCATABLE EVENTS; THE LARGEST WAS ML=3.4. IT BEGAN WITH A TIGHT CLUSTER OF EVENTS UNDER OBSIDIAN BUTTE, ABOUT 7 KM NORTHWEST OF THE FIRST CLUSTER IN THE FIRST SWARM; 2 1/2 DAYS LATER SEISMICITY SHIFTED AND CLUSTERED 1 KM NORTH-NORTHWEST OF OBSIDIAN BUTTE. THE AXIS OF THESE CLUSTERS IS AT A HIGH ANGLE TO THE INFERRED TREND OF THE BRAWLEY FAULT. EVENTS IN THIS SWARM CLUSTER TIGHTLY IN DEPTH AND DO NOT CONSPICUOUSLY OUTLINE A FAULT PLANE. THE THIRD SWARM OCCURRED DURING THE PERIOD DECEMBER 17-20. IT GENERATED 12 LOCATABLE EVENTS; THE LARGEST WAS ML=3.5. IT BEGAN WITH A TIGHT CLUSTER OF EVENTS 7 KM NORTH-NORTHWEST OF OBSIDIAN BUTTE, FOLLOWED 2 DAYS LATER BY A CLUSTER 3 KM FARTHER NORTH-NORTHWEST. THE AXIS OF THESE 2 CLUSTERS PARALLELS THE BRAWLEY FAULT. THE TEMPORAL SEQUENCE OF EARTHQUAKE CLUSTERS DURING THIS TWO-MONTH PERIOD IS SUGGESTIVE OF A NORTH-NORTHWESTWARD-MIGRATING DISPLACEMENT ON THE BRAWLEY FAULT THAT TRIGGERED DISPLACEMENTS ON RELATED STRUCTURES.

KEYWORDS SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY

*36 TITLE SWARM TECTONICS OF THE IMPERIAL AND BRAWLEY FAULTS OF SOUTHERN CALIFORNIA. (ABSTRACT)

AUTHOR JOHNSON, C.E.

CITATION TRANS. AMER. GEOPHYS. UNION (EOS) 58, 1188 (1977)

ABSTRACT MOST EARTHQUAKE SEQUENCES ASSOCIATED WITH THE BRAWLEY AND IMPERIAL FAULTS CAN BE CLASSIFIED AS SWARMS. SEVERAL DOZEN SUCH SEQUENCES OCCURRING SINCE 1950 HAVE BEEN REANALYZED USING A MASTER EVENT APPROACH AND A NEWLY DEVELOPED LOCATION PROGRAM BASED ON THE GENERALIZED INVERSE METHOD. RECENT DATA OBTAINED FROM AN AUTOMATED EARTHQUAKE RECORDING SYSTEM (CEDAR) AND THE JOINT USGS/CALTECH SEISMIC ARRAY DEMONSTRATE THAT WHILE SOME SWARMS SHOW A SPATIAL DISTRIBUTION CONSISTENT WITH THE TREND OF THE MAJOR THROUGH-GOING FAULTS, OTHERS ARE CLEARLY ASSOCIATED WITH TRANSVERSE STRUCTURES. MIGRATION OF SEISMICITY OVER LARGE DISTANCES IS NOT EVIDENT, ALTHOUGH IT APPEARS THAT A SWARM IN ONE AREA ENHANCES THE LIKELIHOOD OF SWARM ACTIVITY ON ADJACENT SECTIONS OF THE FAULT SYSTEM DURING THE FOLLOWING ONE TO TWO MONTHS. RECALIBRATION OF STATION DELAYS AND CONSISTENT RELOCATIONS OF MAJOR SEQUENCES OCCURRING SINCE 1950 SHOWS THAT MOST ACTIVITY IS CONFINED TO A NARROW ZONE EXTENDING FROM SOUTH OF THE MEXICAN BORDER TO A POINT BENEATH THE SALTON SEA. THE MAJOR FAULTS COMPRISING THIS ZONE ARE THE IMPERIAL FAULT, THE BRAWLEY FAULT AND ASSOCIATED TRANSVERSE STRUCTURES.

KEYWORDS SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY

*PARTIALLY FUNDED BY THE U.S. GEOLOGICAL SURVEY, USING DATA SUPPLIED BY DOE-AUGMENTED SEISMIC NETWORK.

- 37 **TITLE** *PRELIMINARY RESULTS OF THE 1976-1977 IMPERIAL VALLEY LEVELING SURVEYS.*
AUTHOR REESE, S.M.
CITATION NATIONAL GEODETIC SURVEY REPORT (1977)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY
- 38 **TITLE** *PRELIMINARY CATALOG OF EARTHQUAKES IN NORTHERN IMPERIAL VALLEY, OCTOBER 1, 1976 TO DECEMBER 1976.*
AUTHOR SCHNAPP, M.; FUIS, G.
CITATION U.S. GEOLOGICAL SURVEY, PASADENA, CALIF. REPORT (1977)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY
- 39 **TITLE** *GOVERNMENTAL COSTS AND REVENUES ASSOCIATED WITH GEOTHERMAL ENERGY DEVELOPMENT IN IMPERIAL COUNTY.*
AUTHOR GOLDMAN, G.; STRONG, D.
CITATION UCRL-13800 (1977)
ABSTRACT THIS STUDY ANALYZES THE COSTS AND REVENUE IMPLICATIONS OF DIRECT AND INDUCED GEOTHERMAL DEVELOPMENT FOR LOCAL GOVERNMENT AGENCIES. GEOTHERMAL RESOURCE DEVELOPMENT ALTERNATIVES, BASED ON ESTIMATES BY LLL, WILL HAVE A SIGNIFICANT EFFECT ON LOCAL FACILITIES AND SERVICES. THE COUNTY AND MOST SCHOOL DISTRICTS, THOUGH, CAN ANTICIPATE GREATER REVENUES THAN COSTS ASSOCIATED WITH DIRECT GEOTHERMAL DEVELOPMENT AND INDUCED RESIDENTIAL AND COMMERCIAL URBANIZATION. HOWEVER, ALL CITIES AND A FEW SCHOOL DISTRICTS LOCATED TOTALLY WITHIN MUNICIPAL BOUNDARIES WILL PROBABLY EXPERIENCE GREATER COSTS THAN REVENUES FROM DIRECT AND ESPECIALLY INDIRECT DEVELOPMENT. THIS RESULTS BECAUSE GEOTHERMAL WELL FIELDS AND POWER PLANTS ARE EXCLUDED BY ZONING ORDINANCE FROM CITY BOUNDARIES. HOWEVER, MOST OF THE INCREASE IN POPULATION AND COMMERCIAL ACTIVITY IS EXPECTED TO OCCUR WITHIN THE CITY BOUNDARIES. THIS SITUATION COULD BE MITIGATED BY MEASURES SUCH AS A CITY INCOME TAX OR A REDISTRIBUTION OF A PORTION OF THE COUNTY GEOTHERMAL TAX REVENUE.
KEYWORDS SOCIOECONOMIC EFFECTS; IMPERIAL VALLEY
- 40 **TITLE** *GEOTHERMAL ASSESSMENT AND AIR QUALITY.*
AUTHOR GUDIKSEN, P.H.
CITATION PROGRAM REPORT - FY 1977; ATMOSPHERIC AND GEOPHYSICAL SCIENCES DIV., PHYSICS DEPT. J.B. KNOX AND R.C. ORPHAN, EDS. UCRL-51444-77, PP. 27-36 (1977)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; IMPERIAL VALLEY

41 **TITLE** *SURVEY OF MODELS TO PREDICT THE EFFECT OF GEOTHERMAL POWER DEVELOPMENT ON DOMESTIC WATER SUPPLIES AND TO DESIGN POLLUTION MONITORING NETWORKS.*

AUTHOR PIMENTEL, K.D.

CITATION MODELING, IDENTIFICATION AND CONTROL IN ENVIRONMENTAL SYSTEMS, G.C. VANSTEENKISTE, ED., NORTH-HOLLAND PUB. CO., AMSTERDAM, PP. 651-662 (1978)

ABSTRACT THE IMPERIAL VALLEY IS A 2,000 KM² AGRICULTURAL REGION IN SOUTHERN CALIFORNIA WITH ANNUAL CROP VALUES OF MORE THAN \$500 MILLION. GEOTHERMAL RESERVES ESTIMATED AT 130 GWE-YRS WERE FOUND BENEATH THIS VALLEY. DEVELOPMENT OF THAT GEOTHERMAL ENERGY SHOULD OCCUR IN THE NEXT 10 TO 20 YEARS. TO ENSURE THAT DEVELOPMENT IS CARRIED OUT IN AN ENVIRONMENTALLY SOUND MANNER, LAWRENCE LIVERMORE LABORATORY IS ENGAGED IN A 3-YR STUDY OF THE ENVIRONMENTAL EFFECTS THAT DEVELOPMENT OF GEOTHERMAL POWER PRODUCTION MAY HAVE ON THE IMPERIAL VALLEY. THIS PAPER DESCRIBES PRELIMINARY WORK FOR A COMPUTER-MODELING STUDY TO DETERMINE EFFECTS OF SUCH ACTIVITY IN ONE REGION OF THE VALLEY UPON WATER QUALITY IN DOMESTIC ARTESIAN WATER WELLS IN AN AREA DOWNSTREAM FROM GEOTHERMAL WELLS. VARIOUS MODELS ARE CONSIDERED TO ESTIMATE CONTAMINANT CONCENTRATION AND TRANSPORT DYNAMICS AND TO DESIGN OPTIMAL MONITORING SYSTEMS FOR POLLUTION SURVEILLANCE OF THOSE DOMESTIC WATER WELLS.

KEYWORDS MODELS; MONITORING; WATER QUALITY; IMPERIAL VALLEY

*42 **TITLE** *CLIMATOLOGY AND AIR QUALITY OF LONG VALLEY GEOTHERMAL RESOURCE AREA.*

AUTHOR PETERSON, K.R.; PALMER, T.Y.

CITATION UCID-17459, REV.1 (1977)

ABSTRACT THE LONG VALLEY KNOWN GEOTHERMAL RESOURCE AREA IS ONE OF THE MORE PROMISING REGIONS FOR DEVELOPMENT OF A LARGE-SCALE GEOTHERMAL ENERGY CENTER. THIS REPORT DISCUSSES THE CLIMATOLOGY AND AIR QUALITY OF THE AREA. DETAILS ARE GIVEN ON THE TEMPERATURES, TEMPERATURE INVERSIONS, AND WINDS. ESTIMATES ARE PRESENTED FOR THE PRESENT AIR QUALITY AND FUTURE AIR QUALITY DURING AND FOLLOWING DEVELOPMENT OF THE RESOURCE AREA. ALSO DISCUSSED ARE PROJECT IMPACT FROM ADDED POLLUTANTS, NOISE, AND PRECIPITATION AUGMENTATION. THE MAJOR DELETERIOUS EFFECTS FROM DEVELOPMENT OF THE LONG VALLEY GEOTHERMAL RESOURCE AREA APPEAR TO BE DUE TO INCREASED DUST LOADING DURING AND FOLLOWING CONSTRUCTION, AND NOISE FROM PRODUCTION TESTING AND POTENTIAL WELL BLOWOUTS. INCREASED POLLUTION FROM RELEASE OF HYDROGEN SULFIDE AND OTHER POLLUTANTS ASSOCIATED WITH HOT WATER GEOTHERMAL WELLS SEEMS TO PRESENT NO PROBLEMS WITH REGARD TO SURROUNDING VEGETATION, POTENTIAL CONTAMINATION OF LAKE CROWLEY, AND ODOR PROBLEMS IN NEARBY COMMUNITIES. PRECIPITATION AUGMENTATION WILL PROBABLY INCREASE THE WATER LEVEL OF LAKE CROWLEY, AT THE EXPENSE OF POSSIBLE ADDITIONAL FOGGING AND ICING OF NEARBY HIGHWAYS.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HYDROGEN SULFIDE; NOISE; LONG VALLEY

*FUNDED BY THE U.S. DIVISION OF GEOTHERMAL ENERGY.

43. **TITLE** *EFFECTS OF H₂S, H₂S+CO₂, AND SO₂ ON LETTUCE, SUGAR BEETS, ALFALFA, AND COTTON.*
AUTHOR THOMPSON, C.R.; KATS, G.
CITATION UCRL-13782 (1977)
ABSTRACT THE PRESENT STUDIES WERE CONDUCTED TO AID IN PREDICTING WHAT EFFECTS EMISSION OF H₂S AND CO₂ FROM GEOTHERMAL ENERGY DEVELOPMENT WOULD CAUSE IN THE IMPERIAL VALLEY ON FOUR IMPORTANT CROPS; LETTUCE, ALFALFA, SUGAR BEETS AND COTTON. A TREATMENT WAS ADDED IN WHICH THE EFFECTS OF SO₂ IN AMOUNTS EQUAL TO H₂S WERE USED AND THE INJURY CAUSED BY THE TWO POLLUTANTS WERE COMPARED. TEST RESULTS SHOW A STIMULATION IN LETTUCE GROWTH WITH CONTINUOUS FUMIGATION WITH 30 PPB H₂S, AND STIMULATED FRESH WEIGHT OF LEAVES AND ROOTS OF SUGAR BEETS. THREE HUNDRED PPB H₂S REDUCED GROWTH OF LETTUCE AND SUGAR BEETS, AND REDUCED SUGAR CONTENT IN ROOTS OF SUGAR BEETS. ADDITION OF 50 PPM CO₂ HAD NO EFFECT IN REVERSING THE EFFECT OF 300 PPB H₂S. COTTON WAS RELATIVELY RESISTANT TO 300 PPB H₂S. THE H₂S HAD AN UNUSUAL EFFECT IN PROMOTING FLOWERING AND SET OF BOLLS. ALFALFA SHOWS EITHER GROWTH REDUCTION WITH 300 PPB H₂S OR NO EFFECT, DEPENDING ON THE PARTICULAR CUTTING. SO₂ CAUSES ACUTE LEAF INJURY TO SUGAR BEETS AT 300 PPB AND LESSER SIMILAR EFFECTS ON LETTUCE DURING PERIODS OF HIGH HUMIDITY. TEST RESULTS SUGGEST THAT SO₂ IS MORE TOXIC TO THESE SPECIES DURING HIGHLY HUMID PERIODS BUT THAT ON A CHRONIC BASIS WITH PLANTS GROWING IN LESSER HUMIDITY, H₂S CAUSES MORE GROWTH DEPRESSION.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; IMPERIAL VALLEY
44. **TITLE** *INTERACTIVE EFFECTS OF H₂S AND O₃ ON THE YIELD OF SNAP BEANS (PHASEOLUS VULGARIS L.).*
AUTHOR BENNETT, J.P.; BARNES, K.; SHINN, J.H.
CITATION UCRL-13807 (1977)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE
45. **TITLE** *PHOTOSYNTHESIS AND STOMATAL RESISTANCE RESPONSE TO OZONE AND/OR HYDROGEN SULFIDE EXPOSURES IN FIELD GROWN SNAP BEANS. (ABSTRACT)*
AUTHOR BINGHAM, G.E.; COYNE, P.I.; BENNETT, J.P.; SHINN, J.H.
CITATION AGRONOMY ABS. 1977, 97 (1977)
ABSTRACT LIGHT RESPONSE OF STOMATAL RESISTANCE AND PHOTOSYNTHESIS WERE MADE ON FIELD GROWN SNAP BEANS EXPOSED TO OZONE AND/OR HYDROGEN SULFIDE. THE BEANS WERE GROWING IN A UNIFORM PLOT; TREATMENTS WERE IMPOSED USING OPEN-TOP EXPOSURE CHAMBERS, WITH H₂S AND O₃ INJECTED BETWEEN THE ROWS. TREATMENTS CONSISTED OF FOUR H₂S LEVELS (0, 0.74, 3.25, 5.25 PPM), TWO O₃ LEVELS (0, 0.072 PPM) AND WERE ARRANGED FACTORIALY. BACKGROUND POLLUTION WAS MINIMIZED BY FILTERING ALL AIR BEFORE ADDING THE POLLUTANT MIXTURE. THE BEANS WERE FUMIGATED FOUR HOURS A DAY CENTERED ABOUT SOLAR NOON, FROM LATE COTYLEDON STAGE THROUGH EARLY FRUIT SET. PHOTOSYNTHESIS AND STOMATAL RESISTENCE MEASUREMENTS WERE TAKEN ON RECENTLY FULLY EXPANDED LEAVES AT THE EARLY FLOWER STAGE. MEASUREMENTS WERE MADE AT 25 C USING A PORTABLE, STEADY-STATE MINICUVETTE SYSTEM. ALL COMBINATIONS OF O₃ AND H₂S AND THE TWO HIGHER LEVELS OF H₂S SHOWED LOWER PHOTOSYNTHESIS RATES AND INCREASED STOMATAL RESISTANCE. EVIDENCE OF SULFUR FERTILIZATION WAS FOUND IN THE LOW SULFUR TREATMENT.
KEYWORDS ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE

46 TITLE A LINEAR GRADIENT CHAMBER FOR EXPOSING FIELD PLANTS TO CONTROLLED LEVELS OF AIR POLLUTANTS.

AUTHOR SHINN, J.H.; CLEGG, B.R.; STUART, M.L.

CITATION UCRL-80411 (1977)

ABSTRACT A LINEAR-GRADIENT CHAMBER FOR CONTROLLED EXPOSURE OF PLANTS IN THE FIELD TO AIR POLLUTANTS IS DESCRIBED. THE RATIO OF CHAMBER WALL TO GROUND AREA WAS MINIMIZED TO REDUCE THE CHAMBER EFFECT. THE DESIGN OF THIS CHAMBER OVERCOMES SOME OF THE DIFFICULTIES OF THE CIRCULAR, OPEN-TOP CHAMBERS CURRENTLY IN USE BY USING A LINEAR CONCENTRATION GRADIENT OF POLLUTANT GAS IN A RECTANGULAR, OPEN-TOP CHAMBER. PLANTS GROWN IN ROWS ARE EXPOSED TO SULFUR GASES AND OZONE DILUTED WITH AIR. THE NEW CHAMBER ALLOWS A GREATER POSSIBILITY OF STATISTICAL REGRESSION ANALYSIS OF THE DOSE-RESPONSE DATA BECAUSE THE EXPOSURE RATE IS A CONTINUOUS VARIABLE. DESPITE THE LARGE NATURAL VARIABILITY IN MEASUREMENTS SUCH AS DRY MATTER PRODUCTION AND A RELATIVE INSENSITIVITY TO H₂S, THE DOSE-RESPONSE OF SNAP BEANS TO H₂S, SO₂, AND O₃ COULD BE DETERMINED BECAUSE OF THE FLEXIBILITY ALLOWED IN THE TREATMENT OF DATA.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE

*47 TITLE ON THE CHEMICAL FOUNDATION OF THE SODIUM ADSORPTION RATIO.

AUTHOR SPOSITO, G.; MATTIGOD, S.V.

CITATION SOIL SCI. SOC. AMER. J. 41, 323 (1977)

ABSTRACT THE THEORETICAL CHEMICAL BASIS OF THE SODIUM ADSORPTION RATIO (SAR) WAS EXAMINED IN ORDER TO CLARIFY TWO IMPORTANT ISSUES THAT ARISE IN CONNECTION WITH THE PROBLEM OF ESTIMATING POTENTIAL SODIUM HAZARD: (I) THE RELATION BETWEEN SAR AND THE THEORY OF CATION EXCHANGE, AND (II) THE IMPLICATIONS OF THE UNIVERSAL PRACTICE OF REPLACING SAR BY WHAT MAY BE TERMED THE PRACTICAL SAR, WHICH EMPLOYS TOTAL CONCENTRATIONS OF NA, CA, AND MG INSTEAD OF THEIR FREE CATIONIC CONCENTRATIONS. IN REGARD TO (I), IT WAS CONFIRMED THAT SAR CAN BE GIVEN A CHEMICAL BASIS IN TERMS OF THE GAPON CATION EXCHANGE EQUILIBRIUM CONSTANT WHICH IS PROVIDED IN THIS PAPER WITH A RIGOROUS DERIVATION FOR THE FIRST TIME. THE GAPON CONSTANT IS SHOWN TO DIFFER FROM THE VANSELOW EXCHANGE CONSTANT ONLY BECAUSE OF THE (ARBITRARY) CONVENTION ADOPTED AS TO WHAT ENTITY IS TERMED THE LIGAND IN THE CATION EXCHANGE REACTION. IN REGARD TO (II), IT WAS SHOWN THROUGH A DIRECT CALCULATION OF SAR AND THE PRACTICAL SAR FOR 161 DIFFERENT SOIL SOLUTIONS OR WATER EXTRACTS, UTILIZING A COMPREHENSIVE CHEMICAL EQUILIBRIUM COMPUTER PROGRAM, THAT AN EXACT FUNCTIONAL RELATIONSHIP BETWEEN THE TWO PARAMETERS DOES NOT EXIST. ONLY A STATISTICAL CORRELATION BETWEEN SAR AND PRACTICAL SAR COULD BE ESTABLISHED BECAUSE OF THE RANDOM VARIATION IN THE COMPOSITION OF METAL-COMPLEXING ANIONS IN THE SOIL SOLUTIONS OR WATER EXTRACTS. THESE ANIONS REDUCE THE FREE CATIONIC CONCENTRATIONS OF NA, CA, AND MG, BUT THEIR AMOUNTS ARE NOT CHEMICALLY RELATED TO THE PRESENCE OF THE METALS AND, THEREFORE, TO THE VALUE OF THE PRACTICAL SAR. IT FOLLOWS THAT THE PRACTICAL SAR HAS NO EXACT CHEMICAL RELATION TO THE THEORY OF CATION EXCHANGE, ALTHOUGH ITS USE IN STRICTLY EMPIRICAL STUDIES OF NA HAZARD MAY BE JUSTIFIED, IN A STATISTICAL SENSE, BY ITS ACKNOWLEDGED PRACTICAL VALUE.

KEYWORDS ECOSYSTEM QUALITY, TERRESTRIAL

• PARTIALLY FUNDED BY THE KEARNEY FOUNDATION OF SOIL SCIENCE.

- 48 **TITLE** *THE PRINCIPLE OF HARD AND SOFT ACIDS AND BASES AS APPLIED TO EXCHANGEABLE CATION SELECTIVITY IN SOIL.*
- AUTHOR** SULLIVAN, P.J.
- CITATION** SOIL SCI. 124, 117 (1977)
- ABSTRACT** THE PRINCIPLE OF HARD SOFT ACIDS AND BASES, HSAB, WHICH CAN PREDICT STABLE COMPLEX FORMATION, IS REVIEWED. IN THE SOIL SYSTEM, CATION EXCHANGE SELECTIVITY CAN BE COMPARED TO COMPLEX FORMATION, WHICH CAN THEN BE DESCRIBED IN TERMS OF HSAB THEORY. IT IS THEN DEMONSTRATED BY COMPARING SOFTNESS VALUES TO OBSERVED CATION EXCHANGE SELECTIVITY IN SOILS, THAT THE MAJORITY OF SOIL EXCHANGE MATERIALS BEHAVE AS RELATIVELY SOFT BASES.
- KEYWORDS** ECOSYSTEM QUALITY, TERRESTRIAL
-
- 49 **TITLE** *ESTIMATED ASSOCIATION CONSTANTS FOR SOME COMPLEXES OF TRACE METALS WITH INORGANIC LIGANDS.*
- AUTHOR** MATTIGOD, S.V.; SPOSITO, G.
- CITATION** SOIL SCI. SOC. AMER. J. 41, 1092 (1977)
- ABSTRACT** CHEMICAL EQUILIBRIUM STUDIES OF TRACE METALS IN SOILS BY AN ION-ASSOCIATION MODEL REQUIRE RELIABLE DATA ON THERMODYNAMIC ASSOCIATION CONSTANTS FOR VARIOUS METAL-LIGAND COMPLEXES. THEREFORE, AVAILABLE EXPERIMENTAL DATA AT 25 DEGREES C WERE COMPILED FOR COMPLEXES OF THE TRANSITION METAL CAT MN-2+, FE-2+, NI-2+, CU-2+, AND ZN-2+ WITH THE LIGANDS CO3-2-, HCO3-, SO4-2-, HSO4-, PO4-3-, HPO4-2-, H2PO4-, CL-, AND OH-.
- HOWEVER, EXPERIMENTAL VALUES OF THE THERMODYNAMIC ASSOCIATION CONSTANTS FOR MANY OF THE COMPLEXES WERE NOT AVAILABLE. THIS LACK OF INFORMATION WAS ALLEVIATED BY EMPLOYING THE THEORETICAL MODEL OF KESTER AND PYTKOWICZ AND THE SEMIEMPIRICAL MODELS OF NIEBOER AND MCBRYDE, AND VAN PANTHALEON VAN ECK TO MAKE ESTIMATES OF THE AS YET UNMEASURED ASSOCIATION CONSTANTS. THESE ESTIMATED CONSTANTS WERE TABULATED IN A COMPACT FORM ALONG WITH THE EXPERIMENTAL VALUES. THIS COMPILATION OF 100 ASSOCIATION CONSTANTS, ALTHOUGH PROVISIONAL, SHOULD PROVE HELPFUL IN A VARIETY OF STUDIES ON TRACE METAL EQUILIBRIA IN SOILS UNTIL MORE RELIABLE EXPERIMENTAL DATA BECOME AVAILABLE.
- KEYWORDS** ECOSYSTEM QUALITY, TERRESTRIAL
-
- 50 **TITLE** *GROW1: A CROP GROWTH MODEL FOR ASSESSING IMPACTS OF GASEOUS POLLUTANTS FROM GEOTHERMAL TECHNOLOGIES.*
- AUTHOR** KERCHER, J.R.
- CITATION** UCRL-52247 (1977)
- ABSTRACT** A PRELIMINARY MODEL OF PHOTOSYNTHESIS AND GROWTH OF FIELD CROPS WAS DEVELOPED TO ASSESS THE EFFECTS OF GASEOUS POLLUTANTS, PARTICULARLY AIRBORNE SULFUR COMPOUNDS, RESULTING FROM ENERGY PRODUCTION FROM GEOTHERMAL RESOURCES. THE MODEL SIMULATES PHOTOSYNTHESIS AS A FUNCTION OF SUCH VARIABLES AS IRRADIANCE, CO2, DIFFUSION RESISTANCES, AND INTERNAL BIOCHEMICAL PROCESSES. THE MODEL ALLOCATES THE PRODUCTS OF PHOTOSYNTHESIS TO STRUCTURAL (LEAF, STEM, ROOT, AND FRUIT) AND STORAGE COMPARTMENTS OF THE PLANT. THE SIMULATIONS EN-COMPASS THE ENTIRE GROWING SEASON FROM GERMINATION TO SENESCENCE. WE DESCRIBE THE MODEL CONCEPTUALLY AND MATHEMATICALLY AND PROVIDE EXAMPLES OF MODEL OUTPUT FOR VARIOUS LEVELS OF POLLUTANT STRESS. ALSO, WE OUTLINE FUTURE DEVELOPMENTS THAT WOULD IMPROVE THIS PRELIMINARY MODEL AND DISCUSS ITS APPLICATIONS.
- KEYWORDS** ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; MODELS

• PARTIALLY FUNDED BY THE ENVIRONMENTAL PROTECTION AGENCY AND THE KEARNEY FOUNDATION OF SOIL SCIENCE.

51 TITLE BASELINE STUDIES IN THE DESERT ECOSYSTEM AT EAST MESA GEOTHERMAL TEST SITE, IMPERIAL VALLEY, CALIFORNIA.

AUTHOR ROMNEY, E.M.; WALLACE, A.; LUNT, O.R.; ACKERMAN, T.A.; KINNEAR, J.E.

CITATION UCLA-12-1143 (1977)

ABSTRACT THE ENVIRONMENTAL BIOLOGY DIVISION WAS INVITED TO UNDERTAKE BASELINE STUDIES IN SUPPORT OF GEOTHERMAL DEVELOPMENT ACTIVITIES AT THE EAST MESA KGRA IN OCTOBER 1975, AS PART OF THE IMPERIAL VALLEY ENVIRONMENTAL PROJECT DEVELOPED FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION BY LAWRENCE LIVERMORE LABORATORY. BASELINE DATA REPORTED HEREIN FOR SOIL, VEGETATION, AND SMALL MAMMAL COMPONENTS OF THE EAST MESA DESERT ECOSYSTEM REPRESENT A COLLECTION PERIOD FROM OCTOBER 1975 TO SEPTEMBER 1977. INASMUCH AS CHANGES IN SALT BALANCE FROM GEOTHERMAL BRINE SOURCES ARE OF POTENTIAL IMPACT UPON THE ECOSYSTEM, CONSIDERABLE ANALYTICAL EFFORT WAS GIVEN TO THE DETERMINATION OF ELEMENT CONSTITUENTS IN SOIL, PLANT, AND ANIMAL SAMPLES. A PRELIMINARY SYNTHESIS OF DATA WAS DONE TO INVESTIGATE THE HETEROGENEITY OF ELEMENT CONSTITUENTS AMONG THE SAMPLED POPULATION AND TO SUMMARIZE RESULTS. FINDINGS INDICATE THAT PERIODIC SAMPLING AND CHEMICAL ANALYSIS OF VEGETATION AROUND AN INDUSTRIALIZED GEOTHERMAL ENERGY SOURCE IS PROBABLY THE BEST WAY TO MONITOR THE SURROUNDING ECOSYSTEM FOR ASSURING CONTAINMENT OF ANY RESOURCE POLLUTANTS.

KEYWORDS BRINE; ECOSYSTEM QUALITY, TERRESTRIAL; MONITORING; IMPERIAL VALLEY

*52 TITLE SOLIDS CONTROL FOR HIGH SALINITY GEOTHERMAL BRINES.

AUTHOR HILL, J.H.; OTTO, C.H.; MORRIS, C.J.

CITATION GEOTHERM. RESOUR. COUNC. TRANS. 1, 139 (1977)

ABSTRACT SOLIDS WHICH PRECIPITATE WHEN HIGH SALINITY GEOTHERMAL BRINES ARE COOLED CAN CAUSE EXTENSIVE EROSION AND PLUGGING TO OCCUR IN POWER PLANT COMPONENTS. DURING REINJECTION OF SPENT BRINE, THEY MAY ALSO CAUSE PLUGGING OF THE FORMATION ADJACENT TO THE REINJECTION WELLS. THIS REPORT DESCRIBES WORK DONE TO CHARACTERIZE THESE SOLIDS AND CONTROL THEIR PRODUCTION BY ACIDIFYING THE BRINE TO A PH <4.5. AT THIS TIME, CONTROL BY ACIDIFICATION SEEMS TO OFFER AN ATTRACTIVE ALTERNATIVE TO CONVENTIONAL METHODS (FILTERING, SETTLING, ETC.) FOR REMOVING SUSPENDED SOLIDS FROM SPENT BRINE PRIOR TO REINJECTION.

KEYWORDS BRINE

*53 TITLE SCALE AND SOLIDS DEPOSITION IN THE SDG&E/U.S. ERDA GEOTHERMAL LOOP EXPERIMENTAL FACILITY AT NILAND, CALIFORNIA.

AUTHOR QUONG, R.; BISHOP, H.K.; HILL, J.H.

CITATION GEOTHERM. RESOUR. COUNC. TRANS. 1, 249 (1977)

ABSTRACT THE SCALE DEPOSITION RATE AND THE PRODUCTION OF SUSPENDED SOLIDS DURING THE OPERATION OF THE SDG&E/U.S. ERDA GEOTHERMAL LOOP EXPERIMENTAL FACILITY ARE DESCRIBED. IN GENERAL SCALING AND TOTAL SUSPENDED SOLIDS INCREASE WITH PROCESS PROGRESSION TO LOWER TEMPERATURES. THE MAJOR SCALE CONSTITUENT IS AN IRON-RICH AMORPHOUS SILICA. HEAVY METAL SULFIDES, MAINLY GALENA, COMPRISE AS MUCH AS 40 WT% IN SCALES DEPOSITED IN THE 1ST STAGE, DECREASING TO LESS THAN A PERCENT IN THE INJECTION PIPE. THE ELEMENTAL COMPOSITION OF THE SUSPENDED SOLIDS IN THE BRINE IS SIMILAR TO THE COMPOSITION OF THE SCALE DEPOSITED AT THE SAME LOCATION. THE EXCEPTION IS IN THE 1ST STAGE, WHERE METAL SULFIDE ENRICHMENT OCCURS IN THE SCALE DEPOSITS.

KEYWORDS BRINE; IMPERIAL VALLEY

*PREPARED BY THE LLL GEOTHERMAL ENERGY TECHNOLOGY GROUP WITH FUNDING FROM THE U.S. DOE DIVISION OF GEOTHERMAL ENERGY.

***54 TITLE REMOVAL OF SILICA FROM SPENT GEOTHERMAL BRINE.**

AUTHOR RYON, R.W.; HILL, J.H.

CITATION UCID-17702 (1977)

ABSTRACT THIS REPORT IS BASED ON PRELIMINARY SURVEY EXPERIMENTS CONDUCTED AT THE LLL SALTON SEA GEOTHERMAL TEST SITE IN APRIL AND MAY, 1977. THE ADDITION OF CAUSTIC TO RAISE THE BRINE PH TO APPROXIMATELY 6 PRECIPITATED SILICA AND OTHER MATERIALS. THE ADDITION OF FLOCCULATING AGENTS, SUCH AS FERRIC HYDROXIDE, AIDS SETTLING AND FILTRATION. SMALL-SCALE PILOT PLANT STUDIES ARE RECOMMENDED.

KEYWORDS BRINE; IMPERIAL VALLEY

***55 TITLE THE LLL GEOTHERMAL ENERGY PROGRAM STATUS REPORT JANUARY 1976 - JANUARY 1977.**

AUTHOR AUSTIN, A.L.; LUNDBERG, A.W.; OWEN, L.B.; TARDIFF, G.E.

CITATION UCRL-50046-76 (1977)

ABSTRACT THIS REPORT IS IN FIVE SECTIONS. THEY ARE PROGRAM DESCRIPTION; PROGRAM PLANS AND RESULTS; ENERGY CONVERSION ENGINEERING; BRINE CHEMISTRY AND MATERIALS; AND EARTH SCIENCES PROGRAM. RESEARCH ON BRINE CHEMISTRY AND MATERIALS TECHNOLOGY HAS BEEN PRINCIPALLY CONCERNED WITH IDENTIFYING AND TESTING BRINE-MODIFICATION METHODS TO PREVENT SCALE AND SOLIDS DEPOSITION. ACIDIFICATION IS THE METHOD OF PRIMARY INTEREST. CHEMISTRY AND MATERIALS SUPPORT FOR THE GEOTHERMAL LOOP EXPERIMENTAL FACILITY (GLEF) INCLUDED RESEARCH ON CHARACTERIZATION OF BRINE AND STEAM FLOWS THROUGH THE GLEF, DEVELOPMENT OF AN IN-PROCESS SCALE-SURVEILLANCE TECHNIQUE, DEVELOPMENT OF SAMPLING METHODS FOR SUSPENDED SOLIDS, AND BASELINE CHARACTERIZATION OF THE PHYSICAL AND CHEMICAL NATURE OF THE SCALE AND SOLIDS PRODUCED. METHODS FOR MINIMIZING SCALE AND SOLIDS DEPOSITION IN THE GLEF OPERATION WERE STUDIED. A PLANT MATERIALS TEST AND EVALUATION PROGRAM WAS INITIATED. PROGRESS IS REPORTED IN THE EARTH SCIENCES STUDIES ON THE SALTON SEA GEOTHERMAL FIELD, INCLUDING GEOLOGICAL STUDIES, GEOPHYSICAL STUDIES, RESOURCE ASSESSMENT, AND INJECTION STUDIES.

KEYWORDS BRINE; GEOLOGY; RESOURCE STATUS; SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY

***56 TITLE DETERMINATION OF THE RATE OF FORMATION OF SOLIDS FROM HYPERSALINE GEOTHERMAL BRINE AS A FUNCTION OF PH.**

AUTHOR HARRAR, J.E.; OTTO, C.H.; HILL, J.H.; MORRIS, C.J.; LIM, R.; DEUTSCHER, S.B.

CITATION UCID-17596 (1977)

ABSTRACT THIS REPORT IS A PRELIMINARY DESCRIPTION OF THE RESULTS OBTAINED IN THE ANALYSIS OF THE EFFLUENT BRINE FROM THE LLL FOUR-STAGE FLASH SYSTEM. OF PRINCIPAL INTEREST WAS THE RATE OF FORMATION OF SUSPENDED SOLIDS AND THE RATE OF DECREASE OF DISSOLVED SILICON (OR SILICA) IN THE SOLUTION AS A FUNCTION OF THE PH OF THE EFFLUENT BRINE. THE EXPERIMENTS WERE CONDUCTED USING MAGMAX NO. 1 BRINE AT THE LLL TEST FACILITY NEAR CALIPATRIA, CALIFORNIA. THE WELL-HEAD BRINE WAS ACIDIFIED IN THE FLASH SYSTEM TO PH VALUES OF 5.0, 4.0, AND 3.0, PLUS OR MINUS 0.2 PH UNIT, AND THE SOLIDS AND SILICA IN THE EFFLUENT AT ABOUT 90 DEGREES C WERE MEASURED, RESPECTIVELY, BY FILTRATION AND ATOMIC ABSORPTION SPECTROPHOTOMETRY. CHANGES IN SOLIDS AND SILICA CONCENTRATION WERE DETERMINED AFTER HOLDING THE BRINE AT 90 PLUS OR MINUS 5 DEGREES C FOR PERIODS OF TIME UP TO ONE WEEK. RESULTS ARE GIVEN OF TESTS TO DETERMINE THE EFFECT ON FORMATION OF SOLIDS OF DILUTING BRINE WITH PURE WATER. DATA ARE SUMMARIZED ON PARTICLE SIZE DISTRIBUTION IN BRINE.

KEYWORDS BRINE; IMPERIAL VALLEY

***PREPARED BY THE LLL GEOTHERMAL ENERGY TECHNOLOGY GROUP WITH FUNDING FROM THE U.S. DOE DIVISION OF GEOTHERMAL ENERGY.**

- 57 **TITLE** *STATUS OF BASELINE SAMPLING FOR ELEMENTS IN SOIL AND VEGETATION AT FOUR KGRA'S IN THE IMPERIAL VALLEY, CALIFORNIA.*
- AUTHOR** CROCKETT, A.B.; WIERSMA, G.B.
- CITATION** GEOTHERM. RESOUR. COUNC. TRANS. 1, 65 (1977)
- ABSTRACT** THE EPA'S ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY IN LAS VEGAS, NEVADA, IS PARTICIPATING IN A MAJOR GEOTHERMAL BASELINE STUDY OF THE IMPERIAL VALLEY IN CALIFORNIA. STATISTICALLY BASED SAMPLING DESIGNS HAVE BEEN DEVELOPED FOR MONITORING ELEMENTAL LEVELS IN SOILS AND CROPS AT THE SAN DIEGO GAS AND ELECTRIC/U.S. ENERGY RESEARCH AND DEVELOPMENT (SDGE/ERDA) ADMINISTRATION TEST FACILITY AT THE SALTON SEA AND THE KNOWN GEOTHERMAL RESOURCE AREAS AT HEBER, NORTH BRAWLEY AND EAST MESA. SAMPLES HAVE BEEN COLLECTED AT ALL LOCATIONS. ANALYSES OF SAMPLES COLLECTED AROUND THE SDGE/ERDA TEST FACILITY INDICATE THAT THERE ARE NO SIGNIFICANT DIFFERENCES IN SOIL RESIDUE LEVELS OF LITHIUM AND MANGANESE BETWEEN THE 50 SITES. HOWEVER, THERE ARE SIGNIFICANT DIFFERENCES BETWEEN SITES FOR ZINC.
- KEYWORDS** ECOSYSTEM QUALITY, TERRESTRIAL; MONITORING; IMPERIAL VALLEY
-
- 58 **TITLE** *MERCURY EMISSIONS FROM GEOTHERMAL POWER PLANTS.*
- AUTHOR** ROBERTSON, D.E.; CRECELIUS, E.A.; FRUCHTER, J.S.; LUDWICK, J.D.
- CITATION** SCIENCE 163, 1094 (1977)
- ABSTRACT** GEOTHERMAL STEAM USED FOR POWER PRODUCTION CONTAINS SIGNIFICANT QUANTITIES OF VOLATILE MERCURY. MUCH OF THIS MERCURY ESCAPES TO THE ATMOSPHERE AS ELEMENTAL MERCURY VAPOR IN COOLING TOWER EXHAUSTS. MERCURY EMISSIONS FROM GEOTHERMAL POWER PLANTS, ON A PER MEGAWATT (ELECTRIC) BASIS, ARE COMPARABLE TO RELEASES FROM COAL-FIRED POWER PLANTS.
- KEYWORDS** AIR QUALITY
-
- 59 **TITLE** *THE MORTALITY AND LIFESPAN OF HONEY BEES EXPOSED TO HYDROGEN SULFIDE GAS AS AN AIR POLLUTANT. INTERIM REPORT.*
- AUTHOR** ATKINS, E.L.
- CITATION** LLL INTERIM REPORT (1977)
- ABSTRACT** THIS REPORT DESCRIBES EXPERIMENTS TO DETERMINE THE ENVIRONMENTAL EFFECTS OF ATMOSPHERIC HYDROGEN SULFIDE ON HONEY BEE WORKERS. THE DATA COLLECTED SHOW THAT CONTINUOUS EXPOSURES TO HYDROGEN SULFIDE GAS AS AN AIR POLLUTANT SIGNIFICANTLY SHORTENS THE LIFESPAN OF HONEY BEE WORKERS AT CONCENTRATIONS OF 100 PPB UPWARDS. THE CO₂ IN THE COMBINATION OF 300 PPB H₂S PLUS 50 PPB CO₂ IS MORE HAZARDOUS THAN 300 PPB OF H₂S ALONE. WE NEED FURTHER DATA TO DETERMINE THE EFFECT ON HONEY BEES OF EXPOSURE TO H₂S AT VARIOUS DOSAGES AND FOR VARIOUS INTERMITTANT PERIODS OF DAILY EXPOSURE.
- KEYWORDS** ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; IMPERIAL VALLEY
-
- FUNDED BY THE ENVIRONMENTAL PROTECTION AGENCY.
- FUNDED BY THE NATIONAL SCIENCE FOUNDATION.

- 60 TITLE** *SNAP BEAN YIELD AND PARTITIONING RESPONSES TO OZONE AND HYDROGEN SULFIDE EXPOSURES IN THE FIELD. (ABSTRACT)*
- AUTHOR** BENNETT, J.P.; SHINN, J.H.
- CITATION** AGRONOMY ABS. 1977, 96 (1977)
- ABSTRACT** SNAP BEANS WERE GROWN IN A FIELD USING TRADITIONAL METHODS AND 20 FOOT PLOTS WERE FUMIGATED WITH CONCENTRATIONS OF OZONE RANGING FROM 0.046-0.127 PPM AND HYDROGEN SULFIDE FROM 0.30-7.0 PPM IN SEVERAL COMBINATIONS. GAS MIXTURES WERE INTRODUCED INTO THE PLANT CANOPY BY MEANS OF A BLOWER AND PLASTIC DUCT ASSEMBLY WITH 70 CM WALLS AROUND THE PLOT, THUS ELIMINATING ANY SERIOUS CHAMBER PROBLEMS. FUMIGATIONS FOR 4 HRS/DAY BEGAN AFTER EMERGENCE OF THE FIRST TRIFOLIATE AND CONTINUED INTERMITTENTLY THROUGHOUT THE GROWING PERIOD UNTIL POD SET. LEAF INJURY SCORES, NUMBER OF LEAVES, POD AND FLOWERING PLANTS WERE RECORDED WEEKLY THROUGHOUT THE EXPERIMENT PERIOD. MEASUREMENTS OF ECONOMIC YIELD, BIOYIELD, LEAF AREA, BRANCH, RACEME, AND POD NUMBER WERE TAKEN AT MARKET MATURITY 55 DAYS AFTER EMERGENCE AND BULK HARVESTS WERE TAKEN AT 62 DAYS. A SIGNIFICANT DOSE-RESPONSE RELATIONSHIP FOR H₂S WAS FOUND FOR LEAF VISIBLE INJURY AND RATE OF LEAF APPEARANCE DURING THE VEGETATIVE GROWTH PERIOD BUT O₃ HAD NO EFFECT. INDIVIDUAL PLANTS HARVESTED AT 55 DAYS SHOWED A 53% REDUCTION IN TOTAL POD FRESH WEIGHT (FROM 42.4 G TO 20.0 G) BY THE HIGHEST H₂S/O₃ DOSE COMPARED TO THE CONTROLS AND AN EVEN GREATER REDUCTION IN DRY WEIGHT. PLANTS HARVESTED AT 62 DAYS HAD RECOVERED FROM THE AIR POLLUTION STRESS AND SHOWED ONLY A 1% REDUCTION IN POD FRESH WEIGHT/PLANT. MORE GROWTH, PARTITIONING, AND YIELD RESULTS WILL BE PRESENTED.
- KEYWORDS** ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; IMPERIAL VALLEY
-
- *61 TITLE** *WATER QUALITY MANAGEMENT FOR IMPERIAL VALLEY GEOTHERMAL DEVELOPMENT.*
- AUTHOR** SWAJIAN, A.; MORRIS, G.L.; PIMENTEL, K.D.
- CITATION** GEOTHERM. RESOUR. COUNC. TRANS. 2, 631 (1978)
- ABSTRACT** NO ABSTRACT AVAILABLE.
- KEYWORDS** BRINE; MONITORING; WATER QUALITY; IMPERIAL VALLEY
-
- 62 TITLE** *MONITORING NATURAL SUBSIDENCE AND SEISMICITY IN THE IMPERIAL VALLEY AS A BASIS FOR EVALUATING POTENTIAL IMPACTS OF GEOTHERMAL PRODUCTION.*
- AUTHOR** CROW, N.B.; KASAMEYER, P.W.
- CITATION** GEOTHERM. RESOUR. COUNC. TRANS. 2, 125 (1978)
- ABSTRACT** MONITORING PROGRAMS DESIGNED TO OBTAIN BASELINE DATA ABOUT NATURAL SUBSIDENCE AND SEISMICITY IN THE IMPERIAL VALLEY ARE DESCRIBED. THE DATA OBTAINED HAVE NOT YET BEEN STUDIED IN DETAIL, BUT PRELIMINARY ANALYSIS INDICATES THAT SUBSTANTIAL LEVELS OF NATURAL SUBSIDENCE AND SEISMICITY ARE OCCURRING IN THE REGION OF THE IMPERIAL VALLEY. STUDIES TO CHARACTERIZE SUBSIDENCE AND TO ATTEMPT TO RELATE IT TO THE GEOLOGIC STRUCTURE OF THE REGION ARE UNDERWAY. WORK DONE BY THE U.S. GEOLOGICAL SURVEY, BASED ON DATA FROM A SEISMOGRAPHIC NETWORK AUGMENTED AS PART OF OUR PROGRAM, HAVE SHOWN THAT EARTHQUAKE SWARMS ARE CHARACTERISTIC IN THE IMPERIAL VALLEY AND THAT THE PATTERN OF RECENT SWARMS CAN BE CORRELATED WITH REGIONAL TECTONIC ACTIVITY. USE OF SUCH PATTERNS WILL MAKE IT EASIER TO DISTINGUISH BETWEEN NATURAL AND ANY INDUCED ACTIVITY WHICH MIGHT RESULT FROM GEOTHERMAL POWER PRODUCTION. THIS WORK WAS CARRIED OUT AS PART OF THE IMPERIAL VALLEY ENVIRONMENTAL PROJECT.
- KEYWORDS** MONITORING; SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY

*PARTIALLY FUNDED BY THE CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, COLORADO RIVER BASIN REGION.

63 TITLE OBSERVATIONS ON WATER BIRD FLIGHT PATTERNS AT SALTON SEA, CALIFORNIA, OCTOBER 1976 - FEBRUARY 1977.

AUTHOR LEITNER, P.; GRANT, G.S.

CITATION UCRL-13818 (1978)

ABSTRACT THIS INVESTIGATION WAS PART OF THE EXTENSIVE BASELINE STUDY OF IMPERIAL VALLEY ECOSYSTEMS CARRIED OUT DURING THE IMPERIAL VALLEY ENVIRONMENTAL PROJECT (IVEP). A MAJOR TASK OF THIS STUDY WAS TO DOCUMENT THE REGIONAL FLIGHT PATTERNS OF BIRD POPULATIONS. VAST NUMBERS OF SHOREBIRDS AND WATERBIRDS ARE KNOWN TO USE THIS REGION DURING MIGRATION AND MAY SPEND THE ENTIRE WINTER HERE. THE HIGH VOLTAGE ELECTRIC TRANSMISSION LINES WHICH WILL BE REQUIRED IN CONNECTION WITH FUTURE GEOTHERMAL POWER PLANTS COULD POSE A SERIOUS HAZARD TO THESE BIRD POPULATIONS. BASELINE DATA CONCERNING THE LOCATIONS OF HEAVILY TRAVELLED FLIGHT CORRIDORS AND THE TYPICAL RANGE OF FLIGHT ALTITUDES WOULD PROVIDE A VALUABLE INPUT TO DECISIONS ON TRANSMISSION LINE SITING. THE IMPACTS OF TRANSMISSION LINES ON MIGRATORY BIRDS ARE POORLY UNDERSTOOD, BUT IT IS KNOWN THAT THEY CAN BE A CAUSE OF MORTALITY WHERE LARGE CONCENTRATIONS OF BIRDS FLY AT LOW ELEVATIONS UNDER CONDITIONS OF POOR VISIBILITY. CONSTRUCTION OF TRANSMISSION LINES THROUGH OR ADJACENT TO BIRD HABITATS MAY ALSO REDUCE OR ELIMINATE USE OF RESTING OR FEEDING AREAS. FINALLY, HUNTING SUCCESS CAN BE AFFECTED WHERE WATERFOWL ARE FORCED TO CHANGE FLIGHT PATTERNS.

KEYWORDS ECOSYSTEM QUALITY; IMPERIAL VALLEY

64 TITLE SOLUTE-TRAVEL TIME ESTIMATES FOR TILE-DRAINED FIELDS III. REMOVAL OF A GEOTHERMAL BRINE SPILL FROM SOIL BY LEACHING.

AUTHOR JURY, W.A.; WEEKS, L.V.

CITATION UCRL-13792 (1978)

ABSTRACT THE TIME REQUIRED TO LEACH A SLUG OF SALINE, SODIC GEOTHERMAL BRINE FROM THE POINT OF INJECTION TO THE TILE OUTLET OF AN ARTIFICIALLY DRAINED FIELD IS CALCULATED. SPRINKLER, COMPLETE, AND PARTIAL PONDING LEACHING METHODS ARE COMPARED AS A FUNCTION OF DRAIN SPACING AND INITIAL LOCATION OF THE SPILL, WITH PONDING REQUIRING MORE WATER BUT LESS TIME TO LEACH BRINE OUT OF THE SYSTEM FOR ALL SITUATIONS EXCEPT WHERE THE BRINE SPILL OCCURS NEAR THE MIDPOINT BETWEEN TILE LINES. CALCULATION RESULTS ARE PRESENTED IN DIMENSIONLESS PARAMETERS WHICH SCALE THE DRAINAGE SYSTEM DIMENSIONS AND THE SOIL WATER TRANSPORT PROPERTIES. RESULTS SUGGEST THAT RECLAMATION OF FINE TEXTURED SOILS COULD REQUIRE A PROHIBITIVE AMOUNT OF TIME UNLESS THE BRINE SPILL IS LOCALIZED AROUND A DRAIN.

KEYWORDS BRINE; WATER QUALITY; IMPERIAL VALLEY

65 TITLE AN ENVIRONMENTAL GEOLOGY WORKSHOP FOR THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCES AREA.

AUTHOR LEDBETTER, G.; CROW, N.B.

CITATION UCRL-52418 (1978)

ABSTRACT AT THE REQUEST OF THE U.S. DEPARTMENT OF ENERGY, LAWRENCE LIVERMORE LABORATORY (LLL) IS STUDYING WAYS IN WHICH THE ENVIRONMENTAL QUALITY OF THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCES AREA MAY BE PROTECTED FROM ANY SIGNIFICANT HARMFUL CONSEQUENCES OF FUTURE GEOTHERMAL DEVELOPMENT. THE LLL STUDY INCLUDES THE EFFECTS OF DEVELOPMENT ON AIR AND WATER QUALITY, GEOLOGY, THE ECOSYSTEM, SOCIOECONOMICS, AND NOISE. THE GEOTHERMAL RESOURCE IMPACT PROJECTION STUDY (GRIPS) HAS GRANTS TO UNDERTAKE SIMILAR WORK. ON 28 AND 29 NOVEMBER 1977, LLL AND GRIPS JOINTLY SPONSORED A WORKSHOP AT SONOMA STATE COLLEGE AT WHICH KNOWLEDGEABLE EARTH SCIENTISTS PRESENTED THEIR VIEWS ON THE POTENTIAL GEOLOGICAL HAZARDS OF GEOTHERMAL DEVELOPMENT. THE WORKSHOP PRODUCED RECOMMENDATIONS FOR STUDIES IN GEOLOGICAL MAPPING, SLOPE STABILITY, SUBSIDENCE, SEISMICITY, AND GROUNDWATER HYDROLOGY. THESE RECOMMENDATIONS WILL BE EVALUATED ALONG WITH OTHER CONSIDERATIONS AND IN CONJUNCTION WITH THE OTHER SUBJECTS OF THE LLL STUDY. THE RESULTS OF THE STUDY WILL BE CONTAINED IN A PREPLANNING REPORT OF FINAL RECOMMENDATIONS TO THE DEPARTMENT OF ENERGY.

KEYWORDS GEOLOGY; SUBSIDENCE AND SEISMICITY; WATER QUALITY; GEYSERS, THE

66 TITLE BASELINE MEASUREMENTS OF GEOLOGIC EVENTS CAN REMOVE POTENTIAL ROADBLOCKS TO GEOTHERMAL DEVELOPMENT. (ABSTRACT)

AUTHOR KASAMEYER, P.W.; CROW, N.B.

CITATION ABSTRACTS OF PAPERS OF THE 144TH NATIONAL MEETING, FEB. 12-17, 1978, (A. HERSCHMAN, ED.) AAAS, WASHINGTON, D.C. (1978)

ABSTRACT LARGE-SCALE PRODUCTION OF ELECTRICITY FROM GEOTHERMAL FLUIDS IN SOUTHERN CALIFORNIA MAY POSSIBLY CAUSE ADVERSE ENVIRONMENTAL EFFECTS SUCH AS WATER POLLUTION, EARTHQUAKES, OR SUBSIDENCE. THE LLL IMPERIAL VALLEY ENVIRONMENTAL PROJECT, IN COOPERATION WITH SEVERAL ORGANIZATIONS, IS MAKING BASELINE MEASUREMENTS OF WATER CHEMISTRY, SEISMOLOGY, AND SURFACE ELEVATION BEFORE PRODUCTION STARTS. NATURAL GEOLOGIC EVENTS HAVE BEEN OBSERVED WHICH MIGHT HAVE BEEN CONSIDERED ENVIRONMENTAL EFFECTS OF PRODUCTION HAD FULL PRODUCTION BEEN IN PROGRESS. DOCUMENTATION OF THE VARIABILITY OF NATURAL GEOLOGIC ACTIVITY IS REDUCING THE RISK THAT PUBLIC REACTION TO A NATURAL EVENT WILL STOP PRODUCTION. ONE EVENT WAS AN EARTHQUAKE SWARM. FEWER THAN 40 EARTHQUAKES PER MONTH WERE DETECTED NEAR THE NILAND FIELD IN 5 MONTHS. OVER 300 EARTHQUAKES OCCURRED IN THE SIXTH MONTH. ASSUMING THE EVENTS HAD A STATIONARY POISSON DISTRIBUTION, THE CHANGE IN SEISMICITY IS HIGHLY IMPROBABLE. BECAUSE THE NATURAL SEISMICITY RATE IS VARIABLE IT IS NOT A PRACTICAL DISCRIMINANT BETWEEN NATURAL AND PRODUCTION-RELATED EVENTS. THE DEPTH-OF-FOCUS OR SOURCE-MECHANISM MAY BE A BETTER DISCRIMINANT.

KEYWORDS GEOLOGY; SUBSIDENCE AND SEISMICITY; WATER QUALITY; IMPERIAL VALLEY

*67 TITLE SAMPLING AND CHARACTERIZATION OF SUSPENDED SOLIDS IN BRINE FROM MAGMAMAX NO.1 WELL.

AUTHOR HILL, J.H.; OTTO, C.H.

CITATION SAMPLING GEOTHERMAL EFFLUENTS, PROC. 2ND WORKSHOP, FEB. 15-17, 1977, LAS VEGAS, NEVADA. EPA-600/7-78-121, PP. 46-54 (1978)

ABSTRACT WHEN HIGH TEMPERATURE, HIGH SALINITY GEOTHERMAL BRINES ARE COOLED, APPRECIABLE QUANTITIES OF SOLIDS PRECIPITATE. THESE SUSPENDED SOLIDS CAN CAUSE EXTENSIVE EROSION AND PLUGGING IN POWER PLANT COMPONENTS. IN ADDITION, THERE IS CONSIDERABLE CONCERN THAT REINJECTION OF THESE SOLIDS WITH SPENT BRINE MAY PLUG THE GEOLOGIC FORMATION ADJACENT TO THE REINJECTION WELLS. THIS REPORT DESCRIBES WORK DONE TO SAMPLE THESE SOLIDS AND CHARACTERIZE THEM SO THAT PROCESSES CAN BE DEvised FOR THEIR REMOVAL OR CONTROL. SUSPENDED SOLIDS PRODUCED IN BRINE FROM MAGMAMAX #1 WELL CONSIST PRIMARILY OF AN IRON-RICH AMORPHOUS SILICA GEL. A SAMPLING APPARATUS TO FILTER THESE SOLIDS OUT OF HIGH TEMPERATURE, HIGH PRESSURE BRINE STREAMS IS DESCRIBED. THEIR CHEMICAL COMPOSITION AND PHYSICAL DESCRIPTION IS DISCUSSED. RATES OF PRODUCTION OF SUSPENDED SOLIDS ARE GIVEN FOR BRINES FLASHED THROUGH NOZZLES AND FLASHED IN STEAM SEPARATORS. CONTROL OF SOLIDS PRODUCTION BY ACIDIFICATION TO A PH <4.5 IS DESCRIBED. AT THIS TIME, CONTROL BY ACIDIFICATION SEEMS TO OFFER AN ATTRACTIVE ALTERNATIVE TO CONVENTIONAL METHODS (FILTERING, SETTLING, ETC.) FOR REMOVING SUSPENDED SOLIDS FROM SPENT BRINE PRIOR TO REINJECTION.

KEYWORDS BRINE; IMPERIAL VALLEY

**68 TITLE FINAL REPORT ON THE INVESTIGATION OF THE IMPACT OF THE RELEASE OF 222-RN, ITS DAUGHTERS AND PRECURSORS AT THE GEYSERS GEOTHERMAL FIELD AND SURROUNDING AREA.

AUTHOR ANSPAUGH, L.R.

CITATION LAWRENCE LIVERMORE LABORATORY ENVIRONMENTAL SCIENCES DIVISION REPORT (1978)

ABSTRACT THE GEYSERS IS AN AREA OF NATURAL GEOTHERMAL ACTIVITY WHICH IS BEING UTILIZED FOR THE GENERATION OF ELECTRICAL ENERGY. ELEVEN UNITS ARE CURRENTLY IN OPERATION WITH A NET ELECTRICAL OUTPUT OF 502 MWE. THE STEAM WHICH IS UTILIZED CONTAINS LESS THAN 1 PERCENT BY WEIGHT OF NONCONDENSABLE GASES. INCLUDED IN THIS NONCONDENSABLE GAS FRACTION IS THE RADIOACTIVE NOBLE GAS, 222-RN.

THIS STUDY WAS UNDERTAKEN TO INVESTIGATE THE SIGNIFICANCE OF THE RELEASE OF 222-RN AND OTHER NATURALLY OCCURRING RADIONUCLIDES AT THE GEYSERS. THE PRIMARY HAZARD DUE TO 222-RN IS THE POTENTIAL INHALATION OF ITS SHORT-LIVED DAUGHTERS, OF WHICH THE FIRST AND FOURTH DECAY BY ALPHA EMISSION.

THE RESULTS OF 266 SHORT-TERM (5 MIN) MEASUREMENTS OF THE CONCENTRATION IN AIR OF THE SHORT-LIVED DAUGHTER RADIONUCLIDES ARE REPORTED AND ANALYZED. MEASUREMENTS INSIDE THE STEAM EXHAUST PIPES AND CONDENSERS AT UNITS 1, 2, AND 4 AND OVER THE HOTWELL AT UNITS 1 AND 2 INDICATED THE INFLUENCE OF A LOCAL SOURCE. THE OTHER MEASUREMENTS WERE LOGNORMALLY DISTRIBUTED WITH A GEOMETRIC MEAN CONCENTRATION OF 0.00112 WL AND A GEOMETRIC SIGMA OF 2. 1. THIS IS EQUIVALENT TO REPORTED MEASUREMENTS OF BACKGROUND CONCENTRATIONS DUE TO THE NATURAL EXHALATION OF 222-RN FROM SOIL. THE HIGHEST CONCENTRATIONS WHICH INDICATED THE INFLUENCE OF A LOCAL SOURCE WERE MEASURED IN LOCATIONS WHICH ARE GENERALLY INACCESSIBLE. HOWEVER, SOME EMPLOYEES MAY SPEND SOME TIME AT THESE LOCATIONS. THE HIGHEST CONCENTRATION MEASURED WAS 0.105 WL WHICH IS IN EXCESS OF THE APPLICABLE STANDARD OF 1 PCI/L OR 0.01 WL FOR CONTINUOUS EXPOSURE IN UNCONTROLLED AREAS. WE CALCULATE THAT AN EMPLOYEE COULD SPEND 40 PERCENT OF HIS 40-HR WORK WEEK IN THIS ATMOSPHERE WITHOUT EXCEEDING THE STANDARD $\{0.01 \text{ WL} \times 168 / (0.105 \text{ WL} \times 40) = 0.4\}$; SUCH PROLONGED EXPOSURES ARE NOT CONSIDERED POSSIBLE.

RESULTS OF 576 LONG-TERM (1 WEEK) MEASUREMENTS OF THE CONCENTRATION IN AIR OF SHORT-LIVED RADON DAUGHTERS ARE ALSO REPORTED. MEASUREMENTS WERE MADE AT A TOTAL OF 36 LOCATIONS INCLUDING AREAS WITHIN THE GEYSERS POWER PLANT AND UPWIND AND DOWNWIND COMMUNITIES. THE HIGHEST MEASURED CONCENTRATION WAS 0.0030 WL AND THE ARITHMETIC MEAN OF ALL MEASUREMENTS WAS 0.00050 WL. THE HIGHER CONCENTRATIONS WERE ALL MEASURED AT LOCATIONS SUBSEQUENTLY FOUND TO HAVE HIGHER CONCENTRATIONS IN SOIL OF 226-RA, THE PARENT

*PREPARED BY THE LLL GEOTHERMAL ENERGY TECHNOLOGY GROUP WITH FUNDING FROM USDOE DIV OF GEOTHERMAL ENERGY

**FUNDED BY THE PACIFIC GAS AND ELECTRIC COMPANY.

RADIONUCLIDE OF 222-RN.

222-RN ITSELF WAS ALSO MEASURED WITH THE USE OF TWO CONTINUOUSLY RECORDING SYSTEMS. THE HIGHEST MEASURED CONCENTRATION WAS 1.4 PCI/L AT A DOWNWIND LOCATION WHICH IS IN AN AREA OF ELEVATED CONCENTRATION OF 226-RA IN SOIL. CONCENTRATIONS WERE WELL BELOW THIS MOST OF THE TIME.

MEASUREMENT RESULTS ARE ALSO REPORTED FOR SUSPENDED PARTICULATES, 210-PB, AND 230-TH CONCENTRATIONS IN AIR AND THEIR DISTRIBUTIONS WITH PARTICLE SIZE AS DETERMINED BY THE USE OF A CASCADE IMPACTOR; THE CONCENTRATION OF 210-PB AND GAMMA-EMITTING RADIONUCLIDES IN AIR; THE CONCENTRATION OF 210-PB IN VEGETATION; THE CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN SOIL; THE TOTAL EXTERNAL GAMMA EXPOSURE RATES WITH PARTICULAR REFERENCE TO THE GEYSERS POWER PLANT AREA; THE RATES OF 222-RN EXHALATION FROM SOIL; AND THE RATE OF 222-RN EMISSION FROM A NATURAL FUMAROLE. WITH THE EXCEPTION OF THE FUMAROLE, ALL MEASUREMENT RESULTS WERE WITHIN NORMAL BACKGROUND LEVELS AND FAR BELOW ANY APPLICABLE STANDARDS. THE FUMAROLE WAS FOUND TO BE EMITTING 222-RN AT THE RATE OF 0.7 PCI/SEC.

ON THE BASIS OF MEASUREMENTS OF 222-RN IN STEAM, IT IS CALCULATED THAT THE MAXIMUM RATE OF RELEASE OF 222-RN IS 1.43 CI/DAY FROM THE OPERATION OF THE ELEVEN UNITS OF THE GEYSERS POWER PLANT. AN EQUAL AMOUNT OF 222-RN IS RELEASED DUE TO THE NATURALLY OCCURRING PROCESS OF EXHALATION FROM A 15 M² AREA OF SOIL SURFACE HAVING A WORLD-WIDE AVERAGE EXHALATION RATE OF 0.75 ATOM/CM²/SEC.

THE CONCLUSION IS REACHED THAT THE OPERATION OF THE GEYSERS POWER PLANT HAS NO DISCERNIBLE IMPACT UPON THE RADIOLOGICAL ENVIRONMENT OF THE SURROUNDING AREA. THIS IS BECAUSE THE AMOUNT OF 222-RN RELEASED BY THE OPERATION OF THE POWER PLANT IS SMALL IN COMPARISON TO THE 222-RN EXHALED FROM SOIL IN THE GENERAL AREA.

KEYWORDS AIR QUALITY; RADIOACTIVITY; GEYSERS, THE; RADON

- 69 **TITLE** *REPRODUCTION AND SURVIVAL OF THE PILEWORM NEREIS SUCCINEA IN HIGHER SALTON SEA SALINITIES.*
AUTHOR OGLESBY, L.C.
CITATION UCRL-13848 (1978)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS ECOSYSTEM QUALITY, AQUATIC; BRINE; IMPERIAL VALLEY

- 70 **TITLE** *THE SALTON SEA SAMPLING PROGRAM: BASELINE AND TOXICITY STUDIES.*
AUTHOR TULLIS, R.E.
CITATION UCRL-13849 (1978)
ABSTRACT THIS REPORT PROVIDES BASELINE DATA ON SEVERAL OF THE SALTON SEA FISHES. MORPHOMETRIC AND MERISTIC DATA ARE PRESENTED AS A BASELINE TO EVALUATE ANY ACCUMULATION AND PHYSIOLOGICAL STRESS THAT MAY RESULT FROM GEOTHERMAL DEVELOPMENT. TRACE ELEMENTS WERE ANALYZED IN SELECTED TISSUES OR WHOLE FISH. THE TRACE ELEMENTS EVALUATED WERE K, CA, FE, CU, ZN, BR, RB, SR, AND PB. THE MAJOR FISHES STUDIED WERE CORVINA (CYNOSCION XANTHULUS), GULF CROAKER (BAIRDIELLA ICISTIVUS), AND MOLLY (POECILIA LATAPINNA). OTHER FISHES OCCASIONALLY TESTED WERE TILAPIA SP. AND SARGO (ANISOTREMUS DAVIDSONII). GEOTHERMAL BRINE RESIDUE CAN ACCUMULATE IN THE SALTON SEA BY SEEPAGE AND RUNOFF. SINCE LITTLE IS KNOWN OF THE TOXIC EFFECTS OF THIS BRINE TO THE FISH POPULATIONS WITHIN THE SEA, EXPERIMENTS WERE CARRIED OUT TO DETERMINE CONCENTRATIONS OF BRINE THAT WOULD PRODUCE FISH MORTALITY AND OTHER PHYSIOLOGICAL ABNORMALITIES.
KEYWORDS ECOSYSTEM QUALITY, AQUATIC; BRINE; IMPERIAL VALLEY

- 71 **TITLE** ACUTE TOXICITY OF GEOTHERMAL EFFLUENTS TO FRY OF *TILAPIA ZILLII*. (ABSTRACT).
AUTHOR IRELAND, R.R.
CITATION ABSTRACTS OF PAPERS PRESENTED AT THE AMERICAN FISHERIES SOCIETY 108TH ANNUAL MEETING, AUGUST 20-25, 1978. UNIV. RHODE ISLAND, KINGSTON, R.I. P.41 (1978)
ABSTRACT GEOTHERMAL ENERGY DEVELOPMENT IN THE IMPERIAL VALLEY, CALIFORNIA, INTRODUCES THE POTENTIAL THREAT OF A MASSIVE INFLUX OF HYDROTHERMAL FLUIDS INTO THE LOCAL AQUATIC ECOSYSTEM. THESE GEOTHERMAL BRINES ARE EXCEPTIONALLY SALINE AND ARE ABUNDANT IN HEAVY METALS AND OTHER TOXIC CONSTITUENTS. TO ASSESS THEIR TOXICITY, STATIC ACUTE BIOASSAYS (96 HRS) WERE PERFORMED USING THE FRY OF THE ECONOMICALLY IMPORTANT CICHLID, *TILAPIA ZILLII*. WHOLE GEOTHERMAL BRINE, BOTH NATURAL AND ARTIFICIAL, AND A SPECTRUM OF ITS MOST ABUNDANT OR POTENTIALLY TOXIC ELEMENTS WERE TESTED IN BOTH HARD AND SOFT WATER. THE PH AND TEMPERATURE WERE MAINTAINED AT 7.5 AND 20 DEGREES C, RESPECTIVELY. THE LC50 VALUES WERE CALCULATED USING A PROBIT COMPUTER PROGRAM DESIGNED FOR THIS PURPOSE. ANALYSES OF IONIC AND TOTAL TRACE ELEMENT CONCENTRATIONS IN THE BIOASSAY SOLUTIONS WERE DONE BY ATOMIC ABSORPTION SPECTROSCOPY AND OPTICAL EMISSION SPECTROSCOPY. RELATIVE TOXICITY INDICES, I.E. THE RATIO OF AN ELEMENT'S CONCENTRATION IN THE GEOTHERMAL BRINE TO ITS LC50, IMPLICATED MN, ZN, LI, AND B AS PRIMARY CONCERNS IN THIS HARD WATER SYSTEM. SOFT WATER LC50'S WERE COMPARABLE WITH THOSE IN PUBLISHED LITERATURE. A CHEMICAL EQUILIBRIUM COMPUTER PROGRAM WAS UTILIZED TO GAIN INSIGHT INTO THE CHEMICAL SPECIATION AND DYNAMICS WHEN GEOTHERMAL BRINE IS SPILLED INTO RECEIVING NATURAL WATERS.
KEYWORDS ECOSYSTEM QUALITY, AQUATIC; BRINE; IMPERIAL VALLEY
- 72 **TITLE** A SCENARIO FOR GEOTHERMAL ELECTRIC POWER DEVELOPMENT IN IMPERIAL VALLEY.
AUTHOR ERMAK, D.L.
CITATION ENERGY 3, 203 (1978)
ABSTRACT THE GROWTH OF GEOTHERMAL ELECTRIC POWER OPERATIONS IN IMPERIAL VALLEY, CALIFORNIA IS PROJECTED OVER THE NEXT 40 YEARS. WITH COMMERCIAL POWER FORECAST TO BECOME AVAILABLE IN THE 1980'S, THE SCENARIO CONSIDERS THREE SUBSEQUENT GROWTH RATES OF 40, 100, AND 250 MEGAWATTS (MW)PER YEAR. THESE GROWTH RATES, ALONG WITH ESTIMATES OF THE TOTAL RESOURCE SIZE, RESULT IN A MAXIMUM LEVEL OF ELECTRIC POWER PRODUCTION RANGING FROM 1000 TO 8000 MW TO BE ATTAINED IN THE 2010 TO 2020 TIME PERIOD. POWER PLANT SITING CONSTRAINTS ARE DEVELOPED AND USED TO MAKE SITING PATTERNS FOR THE 400 THROUGH THE 8000 MW LEVEL OF POWER PRODUCTION. TWO GEOTHERMAL TECHNOLOGIES ARE INCLUDED IN THE SCENARIO: FLASHED STEAM SYSTEMS WHICH CAN PRODUCE THEIR OWN COOLING WATER FROM THE GEOTHERMAL STEAM CONDENSATE AND WHICH EMIT NONCONDENSABLE GASES TO THE ATMOSPHERE; AND HIGH PRESSURE, CONFINED FLOW SYSTEMS WHICH INJECT ALL THE GEOTHERMAL FLUID BACK INTO THE GROUND. AN ANALYSIS OF THE SCENARIO IS MADE WITH REGARD TO WELL DRILLING AND POWER PLANT CONSTRUCTION RATES, LAND USAGE, COOLING WATER REQUIREMENTS, AND HYDROGEN SULFIDE EMISSIONS.
KEYWORDS SOCIOECONOMIC EFFECTS; WATER QUALITY; RESOURCE STATUS; HYDROGEN SULFIDE; AIR QUALITY; IMPERIAL VALLEY; INTEGRATED ASSESSMENT

- 73 **TITLE** *NUMERICAL INTEGRATION OF THE LANGEVIN EQUATION: MONTE CARLO SIMULATION.*
AUTHOR ERMAK, D.L.; BUCKHOLTZ, H.
CITATION UCRL-80735 (1978)
ABSTRACT MONTE CARLO TECHNIQUES ARE DERIVED FOR SOLVING THE LANGEVIN EQUATIONS OF MOTION FOR A SYSTEM OF N INTERACTING BROWNIAN PARTICLES IN A HEAT BATH. THE LANGEVIN EQUATIONS ARE COUPLED TOGETHER BY PAIR FORCES BETWEEN THE BROWNIAN PARTICLES AND INCLUDE AN EXTERNAL FORCE TERM. BOTH THE ORDINARY LANGEVIN EQUATION AND A MORE GENERAL FORM OF THE EQUATION USING AN EXPONENTIAL MEMORY FUNCTION IN THE FRICTION TERM ARE TREATED. THE METHODS PRESENTED IN THIS PAPER ALLOW CONSIDERABLE FREEDOM IN SELECTING THE SIZE OF THE TIME STEP.
KEYWORDS INTEGRATED ASSESSMENT; MATHEMATICAL METHODS
- 74 **TITLE** *PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.*
AUTHOR ANSPAUGH, L.R.; CROW, N.B.; GUDIKSEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.
CITATION UCRL-52248 (1978)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY, AQUATIC; ECOSYSTEM QUALITY, TERRESTRIAL; HEALTH EFFECTS; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY
- 75 **TITLE** *BROWNIAN DYNAMICS WITH HYDRODYNAMIC INTERACTIONS.*
AUTHOR ERMAK, D.L.; MCCAMMON, J.A.
CITATION J. CHEM. PHYS. 69, 1352 (1978)
ABSTRACT A METHOD FOR SIMULATING THE BROWNIAN DYNAMICS OF N PARTICLES WITH THE INCLUSION OF HYDRODYNAMIC INTERACTIONS IS DESCRIBED. THE PARTICLES MAY ALSO BE SUBJECT TO THE USUAL INTERPARTICLE OR EXTERNAL FORCES (E.G., ELECTROSTATIC) WHICH HAVE BEEN INCLUDED IN PREVIOUS METHODS FOR SIMULATING BROWNIAN DYNAMICS OF PARTICLES IN THE ABSENCE OF HYDRODYNAMIC INTERACTIONS. THE PRESENT METHOD IS DERIVED FROM THE LANGEVIN EQUATIONS FOR THE N PARTICLE ASSEMBLY, AND THE RESULTS ARE SHOWN TO BE CONSISTENT WITH THE CORRESPONDING FOKKER-PLANCK RESULTS. SAMPLE CALCULATIONS ON SMALL SYSTEMS ILLUSTRATE THE IMPORTANCE OF INCLUDING HYDRODYNAMIC INTERACTIONS IN BROWNIAN DYNAMICS SIMULATIONS. THE METHOD SHOULD BE USEFUL FOR SIMULATION STUDIES OF DIFFUSION LIMITED REACTIONS, POLYMER DYNAMICS, PROTEIN FOLDING, PARTICLE COAGULATION AND OTHER PHENOMENA IN SOLUTION.
KEYWORDS INTEGRATED ASSESSMENT; MATHEMATICAL METHODS
- 76 **TITLE** *ENVIRONMENTAL READINESS DOCUMENT. HYDROTHERMAL ELECTRIC AND DIRECT HEAT. COMMERCIALIZATION PHASE III PLANNING.*
AUTHOR ANSPAUGH, L.R.; PHELPS, P.L. (CONTRIBUTING AUTHORS)
CITATION DOE/ERD-0005 (1978)
ABSTRACT NO ABSTRACT AVAILABLE
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; ENVIRONMENTAL CONTROL; HEALTH EFFECTS; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; LAWS AND REGULATIONS; NOISE; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY; WATER RESOURCES; IMPERIAL VALLEY

- 77 **TITLE** *ENVIRONMENTAL, HEALTH AND SAFETY ISSUES.*
AUTHOR ANSPAUGH, L.R.
CITATION ENVIRONMENTAL DEVELOPMENT PLAN (EDP) GEOTHERMAL ENERGY SYSTEMS 1977. US DOE REPORT DOE/EDP-0014 CHAPTER 3 PP. 21-24 (1978)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HEALTH EFFECTS; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; NOISE; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY
- 78 **TITLE** *ENVIRONMENTAL ISSUES.*
AUTHOR ANSPAUGH, L.R.
CITATION ENVIRONMENTAL DEVELOPMENT PLAN (EDP) GEOTHERMAL ENERGY SYSTEMS 1977. US DOE REPORT DOE/EDP-0014 APPENDIX B. PP. B1-B7 (1978)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; HEALTH EFFECTS; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; NOISE; RADIOACTIVITY; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY
- 79 **TITLE** *A GENERAL CROP GROWTH MODEL FOR SIMULATING IMPACTS OF GASEOUS EFFLUENTS FROM GEOTHERMAL TECHNOLOGIES.*
AUTHOR KERCHER, J.R.
CITATION PROC. 1978 SUMMER COMPUTER SIMULATION CONF. PP. 526-531 (1978)
ABSTRACT A GENERAL MODEL (GROW1) OF PHOTOSYNTHESIS AND GROWTH OF FIELD CROPS WAS DEVELOPED TO ASSESS THE EFFECTS OF GASEOUS POLLUTANTS, PARTICULARLY AIRBORNE SULFUR COMPOUNDS, RESULTING FROM ENERGY PRODUCTION FROM GEOTHERMAL RESOURCES. THE MODEL SIMULATES PHOTOSYNTHESIS AS A FUNCTION OF SUCH VARIABLES AS IRRADIANCE, CO₂ DIFFUSION RESISTANCE, AND INTERNAL BIOCHEMICAL PROCESSES. THE MODEL ALLOCATES THE PRODUCTS OF PHOTOSYNTHESIS TO STRUCTURAL (LEAF, STEM, ROOT, AND FRUIT) AND STORAGE (LEAF AND MAIN) COMPARTMENTS OF THE PLANT. THE SIMULATIONS ENCOMPASS THE ENTIRE GROWING SEASON FROM GERMINATION TO SENESCENCE. WE DESCRIBE THE MODEL CONCEPTUALLY AND MATHEMATICALLY AND PROVIDE EXAMPLES OF MODEL OUTPUT FOR VARIOUS LEVELS OF POLLUTANT STRESS. WE OUTLINE FUTURE APPLICATIONS AND FUTURE MODEL DEVELOPMENTS.
KEYWORDS ECOSYSTEM QUALITY, TERRESTRIAL; INTEGRATED ASSESSMENT; MODELS
- 80 **TITLE** *WATER FOR LONG TERM GEOTHERMAL ENERGY PRODUCTION IN THE IMPERIAL VALLEY.*
AUTHOR LAYTON, D.W.
CITATION UCRL-52576 (1978)
ABSTRACT THE GEOTHERMAL RESOURCES OF CALIFORNIA'S IMPERIAL VALLEY COULD EVENTUALLY PRODUCE AN ESTIMATED 3,000 TO 5,000 MW OF ELECTRICITY FOR 30 YEARS, PROVIDED THAT ADEQUATE COOLING WATER IS AVAILABLE FOR FUTURE POWER PLANTS. THERE ARE 5 POSSIBLE SOURCES OF COOLING WATER: IRRIGATION WATER, AGRICULTURAL WASTE WATERS, STEAM CONDENSATE, GROUND WATER, AND WATER FROM THE SALTON SEA. TECHNICAL, ENVIRONMENTAL, AND REGULATORY CONSTRAINTS, HOWEVER, COULD ACT TOGETHER TO LIMIT THE AVAILABILITY OF THOSE WATER SUPPLIES. TO STUDY HOW WATER RELATED CONSTRAINTS COULD AFFECT GEOTHERMAL DEVELOPMENT, 6 COMBINATIONS OF DIFFERENT POLICIES AFFECTING WATER SUPPLIES WERE DEFINED TO REPRESENT POTENTIAL REGULATORY CONTROLS. A RANGE OF FUTURE AGRICULTURAL WATER USE CONDITIONS WERE ALSO SPECIFIED, AND THEY ALONG WITH THE 6 POLICY COMBINATIONS, WERE USED TO DETERMINE WHETHER COOLING WATER DEFICITS CONSTRAINING GEOTHERMAL ENERGY PRODUCTION WOULD EMERGE. A COMPANION ANALYSIS OF CHANGES IN THE ELEVATION AND SALINITY OF THE SALTON SEA CAUSED BY GEOTHEMAL WATER USE WAS ALSO MADE.
KEYWORDS WATER QUALITY; WATER RESOURCES; IMPERIAL VALLEY; INTEGRATED ASSESSMENT

- 81 TITLE** *A METHODOLOGY FOR ASSESSING THE POTENTIAL IMPACT ON AIR QUALITY RESULTING FROM GEOTHERMAL RESOURCE DEVELOPMENT IN THE IMPERIAL VALLEY.*
- AUTHOR** GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; LANGE, R.
- CITATION** PROC. INT. CLEAN AIR CONF., CLEAN AIR SOC. AUSTRALIA AND NEW ZEALAND, BRISBANE, AUSTRALIA, MAY 15-18, PP. 719-734 (1978)
- ABSTRACT** THIS PAPER PRESENTS THE METHODOLOGY IN USE IN THE IMPERIAL VALLEY FOR ASSESSING THE POTENTIAL IMPACT ON AIR QUALITY THAT MAY RESULT FROM THE DEVELOPMENT OF GEOTHERMAL RESOURCES. THE INSTALLATION OF A NETWORK OF AIR QUALITY STATIONS FOR CHARACTERIZING THE AIR QUALITY AND ATMOSPHERIC TRANSPORT PROPERTIES IN THE VALLEY PRIOR TO DEVELOPMENT IS DISCUSSED. ANALYSES OF GEOTHERMAL FLUIDS FOR VARIOUS GASES ARE PERFORMED TO EVALUATE THE POTENTIAL EMISSION RATES FROM FUTURE GEOTHERMAL POWER PLANTS. THE PRINCIPAL POLLUTANT OF CONCERN IS H₂S BECAUSE OF ITS NOXIOUS ODOR AND POTENTIAL RELEASE RATE. THESE ESTIMATED SOURCE EMISSION RATES AND THE APPROPRIATE METEOROLOGICAL MEASUREMENTS ARE USED AS INPUT TO A THREE-DIMENSIONAL, ATMOSPHERIC TRANSPORT CODE TO ESTIMATE THE POTENTIAL CHANGES IN AIR QUALITY THAT RESULT FROM VARIOUS SCENARIOS FOR DEVELOPMENT OF GEOTHERMAL POWER.
- KEYWORDS** AIR QUALITY; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; MODELS; MONITORING; IMPERIAL VALLEY
-
- 82 TITLE** *BIOASSAY PROCEDURES TO EVALUATE THE ACUTE TOXICITY OF SALINITY, PESTICIDES, AND GEOTHERMAL POLLUTANTS TO GAMBUSIA AFFINIS.*
- AUTHOR** MILLS, W.L.
- CITATION** UCRL-13382 (1978)
- ABSTRACT** THE SALINITY TOLERANCE OF GAMBUSIA AFFINIS WAS DETERMINED IN STATIC BIOASSAYS. GAMBUSIA EASILY TOLERATED SALINITY OF 47.5% IN 96 HOUR STATIC BIOASSAYS. SURVIVAL AT THIS LEVEL WAS 93.3% WITH THE LOWEST SURVIVAL BEING 68.% AT 40.% SALINITY. THE ACUTE TOXICITIES OF ENDRIN, DDT, ALDRIN, AND DIELDRIN TO GAMBUSIA WERE DETERMINED BY STATIC AND INTERMITTENT-FLOW BIOASSAYS. TOXICITY WAS MEASURED AS THE MEDIAN LETHAL CONCENTRATION FOR 96-HR EXPOSURES. MEDIAN LETHAL CONCENTRATION VALUES WERE LOWER IN THE INTERMITTENT-FLOW BIOASSAYS THAN IN STATIC BIOASSAYS. WE ALSO COMPARED RESIDUE CONCENTRATIONS IN SURVIVING AND DEAD FISH FROM THE INTERMITTENT-FLOW BIOASSAYS. RESIDUE CONCENTRATIONS IN FISH THAT DIED DURING TESTS WERE HIGHER THAN THOSE OF FISH THAT SURVIVED. HOWEVER, THE RANGE OF CONCENTRATIONS IN DEAD AND LIVING FISH OVERLAPPED.
- KEYWORDS** ECOSYSTEM QUALITY, AQUATIC; BRINE
-
- 83 TITLE** *WATER SUPPLY DILEMMAS OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY OF CALIFORNIA.*
- AUTHOR** LAYTON, D.W.
- CITATION** WATER RES. BULL. 14, 133-143 (1978)
- ABSTRACT** THERE ARE FOUR KNOWN GEOTHERMAL RESOURCE AREAS IN THE IMPERIAL VALLEY THAT HAVE A COMBINED POTENTIAL OF OVER 4,000 MEGAWATTS OF ELECTRICAL ENERGY FOR 25 YEARS. THE WATER RESOURCES AVAILABLE TO SUPPORT GEOTHERMAL ENERGY DEVELOPMENT ARE IMPORTED COLORADO RIVER WATER, AGRICULTURAL WASTE WATERS, SALTON SEA WATER, AND GROUND WATER. IN ADDITION, GEOTHERMAL POWER PLANTS CAN PRODUCE THEIR OWN COOLING WATER IN THE FORM OF STEAM CONDENSATE. NEVERTHELESS, THE RELATIVELY HIGH WATER REQUIREMENTS OF GEOTHERMAL FACILITIES ALONG WITH A SERIES OF REAL AND POTENTIAL CONSTRAINTS MAY CAUSE WATER SUPPLY DILEMMAS INVOLVING BOTH THE ACQUISITION AND USE OF COOLING WATER. IMPORTANT CONSTRAINTS ARE INSTITUTIONAL POLICIES, WATER SUPPLY COSTS, TECHNICAL PROBLEMS, AND IMPACTS UPON THE SALTON SEA. THIS PAPER EXAMINES THESE CONSTRAINTS AND RELATED DILEMMAS IN LIGHT OF RELEVANT INFORMATION ON THE VALLEY'S WATER RESOURCES, GEOTHERMAL RESOURCES AND ENERGY TECHNOLOGIES, COOLING WATER REQUIREMENTS, AND WATER SUPPLY OPTIONS.
- KEYWORDS** SOCIOECONOMIC EFFECTS; WATER QUALITY; WATER RESOURCES; IMPERIAL VALLEY; INTEGRATED ASSESSMENT

- 84 **TITLE** *ASYMPTOTIC ESTIMATION ERROR GROWTH APPLIED TO MONITORING.*
AUTHOR PIMENTEL, K.D.
CITATION APPLICATIONS OF KALMAN FILTER TO HYDROLOGY, HYDRAULICS, AND WATER RESOURCES. PROC. AGU CHAPMAN CONF., PITTSBURGH, PA., MAY 1978. UNIV. PITTSBURGH, PP. 681-690 (1978)
ABSTRACT THE GROWTH OF ESTIMATION ERROR IN THE KALMAN FILTER IS STUDIED IN PROBLEMS OF MONITORING POLLUTANT DISPERSAL IN A CONFINED AQUIFER. ASYMPTOTIC PROPERTIES IN THE ERROR GROWTH RESULT FOR SYSTEMS WITH DIFFUSIVE TRANSPORT AND HOMOGENEOUS BOUNDARY CONDITIONS. THESE PROPERTIES LEAD TO SIMPLE SOLUTIONS TO THE OPTIMAL DESIGN OF POLLUTANT MONITORING SYSTEMS, THE MINIMUM-COST MEASUREMENT PROGRAM WHICH MAINTAINS THE ERROR IN THE POLLUTANT ESTIMATE BELOW A GIVEN BOUND.
KEYWORDS MATHEMATICAL METHODS; MONITORING; WATER QUALITY
- 85 **TITLE** *CHEMICAL FINGERPRINTS TO ASSESS THE EFFECTS OF GEOTHERMAL DEVELOPMENT ON WATER QUALITY IN IMPERIAL VALLEY.*
AUTHOR PIMENTEL, K.D.; IRELAND, R.R.; TOMPKINS, G.A.
CITATION GEOTHERM. RESOUR. COUNC. TRANS. 2, 527 (1978)
ABSTRACT A TWO-YEAR BASELINE WATER QUALITY STUDY IN IMPERIAL VALLEY, TOGETHER WITH NEWLY AVAILABLE BRINE CHEMISTRY DATA, HAS LED US TO PROPOSE A MINIMUM LIST OF CHEMICALS THAT SHOULD BE MEASURED IN FUTURE MONITORING PROGRAMS TO ENSURE THAT GEOTHERMAL DEVELOPMENT DOES NOT ADVERSELY AFFECT WATER QUALITY.
KEYWORDS BRINE; IMPERIAL VALLEY; MONITORING; WATER QUALITY
- 86 **TITLE** *AIR QUALITY ASSESSMENT STUDIES OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY.*
AUTHOR GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; NYHOLM, R.A.
CITATION GEOTHERM. RESOUR. COUNC. TRANS. 2, 235 (1978)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; IMPERIAL VALLEY; MONITORING; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT
- 87 **TITLE** *IDENTIFICATION OF ENVIRONMENTAL CONTROL TECHNOLOGIES FOR GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY OF CALIFORNIA.*
AUTHOR SNOEBERGER, D.F.; HILL, J.H.
CITATION UCRL-52548 (1978)
ABSTRACT DESCRIPTIONS ARE PROVIDED OF ENVIRONMENTAL CONTROL TECHNOLOGIES COMING INTO USE FOR MANAGEMENT OF ENVIRONMENTAL IMPACTS FROM GEOTHERMAL DEVELOPMENTS IN THE IMPERIAL VALLEY OF CALIFORNIA. THE TIME PERIOD CONSIDERED IS AN EARLY PHASE OF DEVELOPMENT, TO 1985. CONTROL OF H₂S (CONTAINMENT, SEPARATION, DISPERSAL), MANAGEMENT OF LIQUID WASTE (PRETREATMENT, SUBSURFACE INJECTION), MANAGEMENT OF LAND SUBSIDENCE (FLUID INJECTION) AND PREVENTION OF UNDESIRABLE INDUCED SEISMICITY ARE CONSIDERED.
KEYWORDS ECOSYSTEM QUALITY; HYDROGEN SULFIDE; IMPERIAL VALLEY; SUBSIDENCE AND SEISMICITY; WATER QUALITY; ENVIRONMENTAL CONTROL

- 88 TITLE** IDENTIFICATION OF ENVIRONMENTAL ISSUES ASSOCIATED WITH THE UTILIZATION OF GEOTHERMAL ENERGY. (ABSTRACT)
- AUTHOR** ANSPAUGH, L.R.
- CITATION** ENERGY AND ENVIRONMENTAL GOALS: COMPATIBILITY THROUGH ENVIRONMENTAL CONTROLS, ABSTRACTS OF U.S. DOE ENVIRONMENTAL CONTROL SYMPOSIUM, NOV. 28-30, 1978, WASHINGTON, D.C. P.25 (1978)
- ABSTRACT** GEOTHERMAL ENERGY, THE STORED HEAT OF THE EARTH, IS A MAJOR RESOURCE AND CAN MAKE A SIGNIFICANT CONTRIBUTION TO THE NATION'S ENERGY SUPPLY IN THE FUTURE. THREE TYPES OF RESOURCES ARE OF NEAR-TERM INTEREST; HYDROTHERMAL CONVECTION SYSTEMS, HOT-DRY ROCKS, AND GEOPRESSURED SYSTEMS. THE UTILIZATION OF HYDROTHERMAL CONVECTION SYSTEMS HAS BEEN DEMONSTRATED THROUGHOUT THE WORLD, AND THE ENVIRONMENTAL PROBLEMS ARE WELL KNOWN. THEY CONSIST OF THE RELEASE OF NONCONDENSED VAPORS AND GASES, PRIMARILY HYDROGEN SULFIDE, TO THE ATMOSPHERE; THE SAFE DISPOSAL OF LARGE AMOUNTS OF SPENT GEOTHERMAL FLUIDS; THE POSSIBLE OCCURRENCE OF LAND SUBSIDENCE AND ENHANCED SEISMIC ACTIVITY; THE PRODUCTION OF HIGH LEVELS OF NOISE; AND GENERAL PROBLEMS INVOLVING SOCIAL, CULTURAL, ECONOMIC, AND POLITICAL ISSUES. PROBLEMS AT ANY PARTICULAR SITE WILL BE HIGHLY DEPENDENT UPON LOCAL CONDITIONS SUCH AS RESERVOIR CHARACTERISTICS AND THE NATURE OF THE LOCAL REGION. ENERGY EXTRACTION SYSTEMS HAVE NOT YET BEEN FULLY DEMONSTRATED FOR HOT-DRY ROCK OR GEOPRESSURED SYSTEMS. HOWEVER, WE CAN ANTICIPATE THAT ESSENTIALLY THE SAME ENVIRONMENTAL PROBLEMS WILL BE ENCOUNTERED WITH THE SAME SITE-SPECIFIC NATURE OF THE SEVERITY OF THE PROBLEMS.
- KEYWORDS** HYDROGEN SULFIDE; NOISE; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; AIR QUALITY; WATER QUALITY; GEOPRESSURE; HOT DRY ROCKS; ENVIRONMENTAL CONTROL; INTEGRATED ASSESSMENT
-
- 89 TITLE** AIR POLLUTION EFFECTS ON VEGETATION FROM GEOTHERMAL DEVELOPMENT.
- AUTHOR** SHINN, J.H.
- CITATION** ANNUAL PROGRESS REPORT ON STUDIES OF AIR POLLUTION EFFECTS ON VEGETATION. UCID-17714 PP. 21-26 (1978)
- ABSTRACT** NO ABSTRACT AVAILABLE.
- KEYWORDS** ECOSYSTEM QUALITY; HYDROGEN SULFIDE
-
- 90 TITLE** REGIONAL ASSESSMENT OF AIR POLLUTION IMPACT ON VEGETATION BY MATHEMATICAL MODELING.
- AUTHOR** SHINN, J.H. KERCHER, J.R.
- CITATION** ANNUAL PROGRESS REPORT ON STUDIES OF AIR POLLUTION EFFECTS ON VEGETATION. UCID-17714 PP.27-29 (1978)
- ABSTRACT** NO ABSTRACT AVAILABLE.
- KEYWORDS** ECOSYSTEM QUALITY; INTEGRATED ASSESSMENT; HYDROGEN SULFIDE; MODELS

91 **TITLE** *GEYSERS-CALISTOGA KGRA GEOTHERMAL ENVIRONMENTAL OVERVIEW: WATER QUALITY.*

AUTHOR MOORE, S.F.; PIMENTEL, K.D.; KRONE, R.B.

CITATION RMA-7100 (1978)

ABSTRACT THIS IS AN INTERIM REPORT OF THE WATER QUALITY STUDY FOR THE GEYSERS-CALISTOGA KGRA GEOTHERMAL ENVIRONMENTAL OVERVIEW. WATER QUALITY ISSUES RAISED AT A JOINT INDUSTRY - GOVERNMENT-ACADEMIC-PUBLIC WORKSHOP INCLUDED EROSION AND SEDIMENTATION, ACCIDENTAL SPILLS, COOLING TOWER DRIFT DEPOSITION, GROUNDWATER USE AND CONTAMINATION, AND ISSUES ASSOCIATED WITH THE DEVELOPMENT OF NEWLY-DISCOVERED HOT-WATER GEOTHERMAL RESOURCES. THE MAJOR AREAS OF INFORMATION NEED WERE IDENTIFIED AS BETTER INFORMATION ON SOIL/WATER/CHEMICAL INTERACTIONS (ACCUMULATION, AVAILABILITY, TRANSPORT, SPECIES, ETC.) AND BETTER HYDROLOGIC DATA, PARTICULARLY DURING STORM EVENTS. RECOMMENDATIONS INCLUDED: OBTAINING BETTER INFORMATION ON THE CHARACTERISTICS OF THE HOT-WATER GEOTHERMAL RESOURCE AND CONVERSION TECHNOLOGIES; OBTAINING BASELINE DATA IN THE HOT-WATER AREA; TRACE ELEMENT SOURCE, TRANSPORT, AND FATE STUDIES; CHEMICAL DEPOSITION AND ACCUMULATION STUDIES AROUND EXISTING COOLING TOWERS IN THE STEAM RESOURCE AREA; IMPACT ASSESSMENT OF ACCIDENTAL SPILLS IN THE STEAM RESOURCE AREA; AND DEVELOPMENT OF GUIDELINES TO DISTINGUISH EFFECTS OF NATURAL GEOTHERMAL ACTIVITY FROM THOSE CAUSED BY GEOTHERMAL DEVELOPMENT.

KEYWORDS GEYSERS, THE; WATER QUALITY

92 **TITLE** *AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOL. 1: ISSUES AND RECOMMENDATIONS.*

AUTHOR ERMAK, D.L.; PHELPS, P.L.

CITATION UCRL-52496, VOL.1 (1978)

ABSTRACT GEOTHERMAL RESOURCE DEVELOPMENT AT THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCE AREA (KGRA) HAS BEEN IMPEDED BY CONCERNS OVER THE IMPACTS OF DEVELOPMENT ON LOCAL COMMUNITIES AND ENVIRONMENT. ISSUES HAVE ARISEN ON AIR QUALITY, WATER QUALITY, GEOLOGIC EFFECTS, ECOSYSTEM EFFECTS, NOISE EFFECTS, SOCIOECONOMIC IMPACTS, AND HEALTH EFFECTS. THIS REPORT IDENTIFIES AND ESTABLISHES PRIORITIES AMONG THESE ISSUES AND RECOMMENDS NEEDED RESEARCH AND ASSESSMENT STUDIES TO RESOLVE EACH ISSUE. THE MAJOR REQUIREMENT IS FOR MORE EFFECTIVE CONTROL OVER EMISSIONS OF HYDROGEN SULFIDE, A CONSTITUENT OF THE GEOTHERMAL STEAM. OTHER HIGH PRIORITY NEEDS ARE RELATED TO CONTROLLING NOISE FROM GEOTHERMAL DEVELOPMENT, LAND-USE CONFLICTS BETWEEN GEOTHERMAL AND OTHER POTENTIAL USES, IMPACTS FROM LANDSLIDE AND SOIL EROSION INDUCED BY GEOTHERMAL DEVELOPMENT, AND PROTECTION OF RARE AND ENDANGERED SPECIES IN THE REGION.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; GEOLOGY; GEYSERS, THE; HYDROGEN SULFIDE; MONITORING; NOISE; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY; HEALTH EFFECTS

- 93 **TITLE** *AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOL. 3: NOISE.*
- AUTHOR** LEITNER, P.
- CITATION** UCRL-52496, VOL.3 (1978)
- ABSTRACT** NOISE FROM GEOTHERMAL RESOURCE DEVELOPMENT AT THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCE AREA (KGRA) WILL CAUSE COMMUNITY ANNOYANCE UNLESS NOISE-LEVEL STANDARDS ARE SET AND ADHERED TO. VENTING OF STEAM IS THE LOUDEST SOURCE OF NOISE AND CAN REACH 100 TO 125 DBA AT 20 TO 100 FT; MOST OF THE OTHER NOISE SOURCES FALL BELOW 100 DBA AND ARE THOSE USUALLY ASSOCIATED WITH CONSTRUCTION AND INDUSTRIAL PROJECTS. ENOUGH DATA EXIST FOR ASSESSMENT AND DECISION MAKING, BUT THEY ARE SCATTERED AND MUST BE COMPILED. IN ADDITION, COMMUNITIES MUST DECIDE ON THEIR CRITERIA FOR NOISE LEVELS. RESIDENTIAL AREAS IN THE GEYSERS-CALISTOGA KGRA WILL REQUIRE MORE STRINGENT CONTROLS ON NOISE THAN WILL THE OPEN SPACE OF WHICH THE KGRA IS PRIMARILY COMPOSED. EXISTING TECHNOLOGY CAN REDUCE NOISE LEVELS SOMEWHAT, BUT MORE EFFECTIVE SILENCING DEVICES ARE NEEDED, PARTICULARLY ON STEAM VENTING SYSTEMS.
- KEYWORDS** GEYSERS, THE; NOISE
-
- *94 **TITLE** *CHEMICAL CHARACTERIZATION OF GASES AND VOLATILE HEAVY METALS IN GEOTHERMAL EFFLUENTS.*
- AUTHOR** ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.; WILKERSON, C.L.; CRECELIUS, E.A.; EVANS, J.C.
- CITATION** GEOTHERM. RESOUR. COUNC. TRANS. 2, 579-582 (1978)
- ABSTRACT** NO ABSTRACT AVAILABLE.
- KEYWORDS** AIR QUALITY; BRINE; GEYSERS, THE; HYDROGEN SULFIDE; RADON; WATER QUALITY
-
- 95 **TITLE** *GEOTHERMAL ENVIRONMENTAL RESEARCH.*
- AUTHOR** PIMENTEL, K.D.
- CITATION** MECHANICAL ENGINEERING DEPARTMENT RESEARCH ENGINEERING DIVISION; 1977 ACTIVITIES HIGHLIGHTS REPORT. T. MERRILL, ED. UCID-17804-77, PP.35-46 (1978)
- ABSTRACT** PRELIMINARY RESULTS OF A 13-MONTH BASELINE STUDY OF WATER QUALITY IN IMPERIAL VALLEY ARE PRESENTED. DIFFERENCES AMONG GEOTHERMAL BRINES THROUGHOUT THE VALLEY ARE DISCUSSED AS POTENTIAL SOURCE TERMS OF WATER POLLUTION. CHEMISTRY OF DIFFERENT TYPES OF WATER FOUND IN THE AREA ARE PRESENTED. CASE STUDIES OF THE POLLUTION OF AN AGRICULTURAL DRAIN AND MONITORING OF DOMESTIC WATER WELLS ARE DESCRIBED. SUGGESTIONS ARE MADE FOR CONTINUED MONITORING OF WATER QUALITY IN THE VALLEY AS GEOTHERMAL DEVELOPMENT PROCEEDS.
- KEYWORDS** BRINE; IMPERIAL VALLEY; MONITORING; WATER QUALITY

*PARTIALLY FUNDED BY THE NATIONAL SCIENCE FOUNDATION.

- 96 **TITLE** *CLOSED FORM SOLUTIONS TO THE SENSITIVITY EQUATIONS IN THE FREQUENCY DOMAIN AND TIME DOMAIN FOR LINEAR MODELS OF ECOSYSTEMS.*
- AUTHOR** KERCHER, J.R.
- CITATION** UCRL-81340 (1978)
- ABSTRACT** WE DERIVE AND PRESENT CLOSED FORM SOLUTIONS FOR THE PROPERTIES OF LINEAR, DONGR-CONTROLLED, CONSTANT COEFFICIENT MODELS OF ECOSYSTEMS. THE PROPERTIES SOLVED ARE THE FREQUENCY RESPONSE, FREQUENCY RESPONSE UNDER FEEDBACK, SENSITIVITY OF THE FREQUENCY RESPONSE TO CHANGES IN THE MODEL PARAMETERS, AND SENSITIVITY OF THE TIME DOMAIN SOLUTION TO CHANGES IN MODEL PARAMETERS. THE LAST IS KNOWN AS TRANSIENT SENSITIVITY. ALL SOLUTIONS ARE IN EXPANSIONS IN THE EIGENVECTORS WITH THE EIGENVALUES DETERMINING THE ANALYTIC PROPERTIES IN THE FREQUENCY DOMAIN AND THE TRANSIENT BEHAVIOR IN THE TIME DOMAIN. THE COMPUTER IMPLEMENTATION PRODUCES FAST CODES BECAUSE THE EIGENVALUES AND EIGENVECTORS NEED ONLY BE FOUND ONCE IN ORDER TO CALCULATE RESULTS FOR MANY DIFFERENT TIMES OR MANY DIFFERENT FREQUENCIES. ALL SOLUTIONS ARE VALID FOR DEGENERATE EIGENVALUES PROVIDING LINEARLY INDEPENDENT EIGENVECTORS CAN BE FOUND WITH THE ALGORITHMS FOR SOLVING THE EIGENVALUE EQUATION.
- KEYWORDS** ECOSYSTEM QUALITY; MODELS; MATHEMATICAL METHODS; INTEGRATED ASSESSMENT
- 97 **TITLE** *ASSESSMENTS OF GEOTHERMAL POLLUTANT IMPACTS ON SUGAR BEETS USING COMPUTER MODELING. (ABSTRACT)*
- AUTHOR** KERCHER, J.R.
- CITATION** BULL. ECOL. SOC. AMER. 59, 77 (1978)
- ABSTRACT** A SUGAR BEET SIMULATION MODEL BEETGROW2 AND THE PHOTOSYNTHESIS SUBMODEL PHOTO HAVE BEEN USED TO ASSESS THE EFFECTS OF GEOTHERMAL POLLUTANTS IN THE IMPERIAL VALLEY. THE MODELS WERE FIT TO THE SUGAR BEET PHOTOSYNTHESIS DATA OF SHINN (1976) AND THE SUGAR BEET GROWTH DATA OF THOMPSON (1978). BOTH SETS OF DATA WERE TAKEN IN FIELD FUMIGATION STUDIES USING UP TO 2.PPM H₂S IN PHOTOSYNTHESIS STUDIES AND .3 PPM H₂S IN THE GROWTH STUDIES. THE MODELS RECONCILED THE APPARENT DISCREPANCIES BETWEEN THE TWO EXPERIMENTS. TRADEOFFS BETWEEN THE EFFECTS OF CO₂ FERTILIZATION AND H₂S FUMIGATION ON PHOTOSYNTHESIS AND GROWTH ARE SHOWN. THE RELATIONSHIPS OF TEMPERATURE, SOIL SALINITY, LIGHT LEVEL, AND WATER STRESS TO POLLUTANT STRESS EFFECTS ARE ALSO DISCUSSED.
- KEYWORDS** ECOSYSTEM QUALITY; HYDROGEN SULFIDE; MODELS; IMPERIAL VALLEY; INTEGRATED ASSESSMENT
- 98 **TITLE** *ENVIRONMENTAL ASSESSMENT REPORT (EAR) FOR GEOTHERMAL ENERGY SYSTEMS.*
- AUTHOR** ANSPAUGH, L.R.; PHELPS, P.L.
- CITATION** UCRL-81910 (1978)
- ABSTRACT** NO ABSTRACT AVAILABLE.
- KEYWORDS** AIR QUALITY; ECOSYSTEM QUALITY; HEALTH EFFECTS; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; NOISE; RADON; RESOURCE STATUS; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; WATER QUALITY
- 99 **TITLE** *USES OF WARMED WATER IN AGRICULTURE. FINAL REPORT.*
- AUTHOR** GARRETT, R.E.
- CITATION** UCRL-13930 (1978)
- ABSTRACT** NO ABSTRACT AVAILABLE.
- KEYWORDS** ECOSYSTEM QUALITY; SOCIOECONOMIC EFFECTS; WATER QUALITY

- 100 TITLE IMPACT OF A GEOTHERMAL DEVELOPMENT UPON A WEED CONTROL FISH, *TILAPIA ZILLII*, IN IMPERIAL VALLEY, CALIFORNIA. (ABSTRACT)
AUTHOR IRELAND, R.R.
CITATION UCRL-81037 (1978)
ABSTRACT HYDROTHERMAL FLUIDS RELEASED FOR GEOTHERMAL ENERGY IN IMPERIAL VALLEY, CALIFORNIA ARE AMONGST THE WORLD'S MOST SALINE AND CONTAMINATED (TDS:250,000 PPM). INADVERTENT RELEASE OF THIS GEOTHERMAL BRINE INTO THE LOCAL AQUATIC ECOSYSTEM POSES AN IMMEDIATE THREAT TO THE ECONOMICALLY IMPORTANT, BIOLOGICAL WEED CONTROL FISH *TILAPIA ZILLII*. ACUTE TOXICITY TESTS WERE PERFORMED USING WHOLE BRINE, BOTH NATURAL AND ARTIFICIAL, AND A SPECTRUM OF ITS TOXIC CONSTITUENTS. A CHEMICAL EQUILIBRIUM COMPUTER PROGRAM WAS USED TO DETERMINE THE DYNAMICS OF ELEMENTAL SPECIATION IN THIS HARD WATER SYSTEM AND ITS EFFECT UPON TOXICITY.
KEYWORDS BRINE; ECOSYSTEM QUALITY; AQUATIC; IMPERIAL VALLEY; WATER QUALITY
- 101 TITLE PREDICTION OF SUBSIDENCE DUE TO HOT BRINE PRODUCTION IN THE SALTON SEA GEOTHERMAL FIELD.
AUTHOR SCHATZ, J.F.; CHENEY, J.A.; KASAMEYER, P.W.
CITATION UCRL-80984 (1978)
ABSTRACT A METHOD OF ESTIMATING A REASONABLE UPPER BOUND TO LONG-TERM SUBSIDENCE CAUSED BY THE COMPACTION OF A POROUS FLUID RESERVOIR IS DISCUSSED. THE METHOD IS APPLIED TO THE SALTON SEA GEOTHERMAL FIELD. THE SUBSIDENCE PREDICTION RELIES ON AN ESTIMATE OF LONG-TERM COMPRESSIBILITY MADE BY OBSERVING POROSITY VS. DEPTH IN THE EXISTING SEDIMENTARY LAYERS. PREDICTIONS OF SUBSIDENCE AT THE SALTON SEA FIELD FOR A MODERATE LEVEL OF PRODUCTION AND REINJECTION ARE IN THE RANGE OF A FEW FEET AT MOST, ALTHOUGH HIGH PRODUCTION COULD CAUSE GREATER SUBSIDENCE. FAVORABLE COMPARISON OF OUR METHOD IS MADE WITH OBSERVED SUBSIDENCE AT WAIRAKI, NEW ZEALAND.
KEYWORDS BRINE; SUBSIDENCE AND SEISMICITY; IMPERIAL VALLEY
- 102 TITLE HABITAT REQUIREMENTS AND POPULATION CHARACTERISTICS OF THE CLAPPER RAIL (*RALLUS LONGIROSTRIS YUMANENSIS*) IN THE IMPERIAL VALLEY OF CALIFORNIA.
AUTHOR BENNETT, W.W.; OHMART, R.D.
CITATION UCRL-13813 (1978)
ABSTRACT HABITAT REQUIREMENTS AND POPULATION CHARACTERISTICS OF THE YUMA CLAPPER RAIL WERE EXAMINED IN THE IMPERIAL VALLEY OF CALIFORNIA DURING 1977. RAILS USED FRESH WATER AREAS CONTAINING MATURE STANDS OF CATTAIL AND BULRUSH. WATER LEVEL VARIATION WAS FOUND TO INFLUENCE THE PERMANENCE OF TERRITORIES AND THE BREEDING EFFORT. MARSH AREAS WITH PERMANENT SHALLOW WATER THROUGH THE BREEDING SEASON CONTAINED HIGHEST RAIL DENSITIES. HATCHING SUCCESS WAS HIGH (90%), BUT SO WAS CHICK MORTALITY, PERHAPS DUE TO THE CHICKS' INABILITY TO SWIM, THE GREAT VARIABILITY OF WATER LEVELS, AND POSSIBLE PREDATION. CLAPPER RAILS BEGAN ARRIVING IN THE IMPERIAL VALLEY IN MID-MARCH AND REMAINED UNTIL THE BEGINNING OF OCTOBER. TIME OF APPEARANCE AND DISAPPEARANCE OF CRAYFISH WAS CLOSELY CORRELATED WITH THE ARRIVAL AND DEPARTURE DATES OF CLAPPER RAILS. NINETY PERCENT OF THE TERRITORIES OF PAIRED BIRDS CONTAINED HIGH NUMBERS OF CRAYFISH. A COMPLETE CENSUS OF THE VALLEY DURING THE LATTER HALF OF MAY, USING TAPE-RECORDED CALLS, ELICITED RESPONSES FROM 160 INDIVIDUALS. A SMALL OVERWINTERING POPULATION REMAINED AS DETERMINED BY THE SAMPLING OF HIGH DENSITY AREAS IN JANUARY AND NOVEMBER. RAIL MANAGEMENT SUGGESTIONS BASED ON THE RESULTS OF THIS PAPER ARE PROPOSED.
KEYWORDS ECOSYSTEM QUALITY; IMPERIAL VALLEY

- 103 **TITLE** *ECOLOGICAL EFFECTS OF ATMOSPHERIC RELEASES FROM SYNTHETIC FUELS PROCESSES.*
AUTHOR SHINN, J.H.; KERCHER, J.R.
CITATION UCRL-81691 (1978)
ABSTRACT THIS PAPER DISCUSSES THE PRIMARY ECOLOGICAL EFFECTS OF EXPOSURE TO SYNTHETIC FUELS GAS-STREAM EMISSIONS. THE PRIMARY IMPACTS WILL BE ON VEGETATION DUE TO A COMBINATION OF PHYTOTOXIC GASES. LITTLE IS KNOWN ABOUT THE EFFECTS OF POTENTIAL TRACE GAS EMISSIONS SUCH AS COS, CS₂, HYDROCARBONS, AND VOLATILE METALS, BUT THE MOST IMPORTANT PHYTOACTIVE GASES ARE CO₂ AND H₂S. WITH THE AID OF A MODEL, PHOTOSYNTHESIS AND GROWTH EFFECTS ARE INVESTIGATED, BASED ON EXPERIMENTAL, BIOASSAY DOSE RESPONSE DATA WITH MIXTURES OF GASES. THE THRESHOLD CONCENTRATION FOR GROWTH INJURY (DRY MATTER PRODUCTION) IS AN ORDER OF MAGNITUDE LOWER THAN FOR PHOTOSYNTHESIS. CO₂ AMELIORATES H₂S EFFECTS; AND OTHER ENVIRONMENTAL INFLUENCES ON DOSE-RESPONSE WERE DEMONSTRATED BY THE MODEL. URBAN SMOG (OZONE) INCREASES THE TOXICITY OF H₂S. HOWEVER, UNDER WORST CASE CONDITIONS (CHRONIC EXPOSURE, NO CO₂ PRESENT), THE THRESHOLD FOR LEAF INJURY IS ABOUT 0.2 PPM H₂S.
KEYWORDS ECOSYSTEM QUALITY; HYDROGEN SULFIDE; MODELS; INTEGRATED ASSESSMENT
- 104 **TITLE** *EFFECTS OF CONTINUOUS HYDROGEN SULFIDE FUMIGATION ON CROP AND FOREST PLANTS.*
AUTHOR THOMPSON, C.R.; KATS, G.
CITATION ENVIRON. SCI. TECHNOL. 12, 550 (1978)
ABSTRACT CONTINUOUS FUMIGATION OF ALFALFA, THOMPSON SEEDLESS GRAPES, LETTUCE, SUGAR BEETS, CALIFORNIA BUCKEYE, PONDEROSA PINE, AND DOUGLAS FIR WITH 3000 PARTS PER BILLION HYDROGEN SULFIDE IN GREENHOUSES CAUSED LEAF LESIONS, DEFOLIATION, REDUCED GROWTH, AND DEATH OF SENSITIVE SPECIES. THREE HUNDRED PPB CAUSED LESSER BUT SIMILAR EFFECTS. SULFUR ACCUMULATED IN LEAVES DEPENDING UPON DOSAGE. FASTER GROWING PLANTS ACCUMULATED SULFUR MORE RAPIDLY. LOWER LEVELS OF H₂S, 30 PPB AND SOMETIMES 100 PPB, CAUSED SIGNIFICANT STIMULATION IN GROWTH OF LETTUCE, SUGAR BEETS, AND ALFALFA. THE STIMULATION OCCURRED AT CERTAIN TIMES OF YEAR AND MAY BE INFLUENCED BY TEMPERATURE AND/OR HUMIDITY.
KEYWORDS ECOSYSTEM QUALITY, TERRESTRIAL; HYDROGEN SULFIDE; IMPERIAL VALLEY; GEYSERS, THE
- 105 **TITLE** *AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOLUME 2 AIR QUALITY.*
AUTHOR ROSEN, L.C.; MOLENKAMP, C.R.
CITATION UCRL-52496, VOL.2 (1978)
ABSTRACT THIS REPORT IDENTIFIES KEY ISSUES, EVALUATES AVAILABLE INFORMATION, AND RECOMMENDS AREAS OF RESEARCH RELATED TO CHANGES IN AIR QUALITY RESULTING FROM DEVELOPMENT OF GEOTHERMAL RESOURCES AT THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCE AREA. OF ALL THE EMITTED POLLUTANTS, HYDROGEN SULFIDE AND BORON ARE IDENTIFIED AS PRODUCING DETRIMENTAL EFFECTS ON THE ENVIRONMENT. WE RECOMMEND ADDITIONAL RESEARCH DIRECTED TOWARDS 1) REDUCING EMISSIONS OF THESE IDENTIFIED POLLUTANTS, 2) DEVELOPING A NUMERICAL TRANSPORT AND DIFFUSION MODEL FOR COMPLEX TERRAIN, AND 3) VALIDATING THIS MODEL WITH ADDITIONAL AIR-QUALITY AND METEOROLOGICAL DATA COLLECTED AT THE GEYSERS.
KEYWORDS AIR QUALITY; GEYSERS, THE; ECOSYSTEM QUALITY; HYDROGEN SULFIDE

106 TITLE AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOLUME 5 ECOSYSTEM QUALITY.

AUTHOR LEITNER, P.

CITATION UCRL-52496, VOL.5 (1978)

ABSTRACT INCREASED UTILIZATION OF GEOTHERMAL STEAM FOR GENERATION OF ELECTRICITY IN THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCE AREA (KGRA) HAS RAISED CONCERNS ABOUT POSSIBLE ADVERSE IMPACTS ON THE NATURAL AND AGRICULTURAL ECOSYSTEMS OF THE REGION. OBJECTIVES OF THE GEOTHERMAL OVERVIEW PROJECT FOR THIS KGRA WERE IDENTIFICATION OF ECOSYSTEM ISSUES, EVALUATION OF THE EXISTING DATA BASE, AND RECOMMENDATION OF ADDITIONAL RESEARCH NEEDED TO RESOLVE KEY ISSUES. THE ISSUE OF HIGHEST PRIORITY IS THE LACK OF COMPLETE AND ACCURATE DATA ON THE STATUS AND DISTRIBUTION OF RARE OR ENDANGERED PLANTS AND ANIMALS WITHIN THE KGRA.

SEVERAL STUDIES ARE RECOMMENDED TO PROVIDE ADEQUATE INFORMATION: A KGRA-WIDE EFFORT TO IDENTIFY RARE PLANTS AND THEIR HABITATS; A SITE-SPECIFIC DETERMINATION OF PEREGRINE FALCON FORAGING HABITAT; AND A COMPILATION OF AVAILABLE DATA ON OTHER WILDLIFE SPECIES OF SPECIAL CONCERN. MEDIUM-PRIORITY ISSUES INCLUDE THE POSSIBLE IMPACTS OF HYDROGEN SULFIDE EMISSIONS ON VINEYARD AND ORCHARD CROPS AND THE ECOLOGICAL EFFECTS OF BORON AND HEAVY METALS RELEASED FROM GEOTHERMAL POWER PLANTS IN COOLING TOWER DRIFT. THE POTENTIAL FOR ADVERSE EFFECTS IS UNCERTAIN AND RESEARCH SHOULD BE INITIATED PROMPTLY TO DETERMINE WHETHER THESE EFFLUENTS POSE SERIOUS PROBLEMS. A THIRD MEDIUM-PRIORITY ISSUE CONCERNS THE POTENTIAL FOR LONG-TERM CUMULATIVE IMPACTS OF GEOTHERMAL DEVELOPMENT ON NATURAL ECOSYSTEMS. TO DETECT AND EVALUATE SUCH EFFECTS, IT WILL BE NECESSARY TO CARRY OUT ADDITIONAL BASELINE STUDIES OF TERRESTRIAL AND AQUATIC ECOSYSTEMS AND TO FOLLOW THIS WITH CAREFULLY DESIGNED MONITORING PROGRAMS. SEVERAL ISSUES WERE GIVEN LOW PRIORITY IN PLANNING FOR ADDITIONAL RESEARCH NEEDS. FOR EXAMPLE, FURTHER STUDIES OF THE BIOLOGICAL EFFECTS OF ACCIDENTAL SPILLS OF STEAM CONDENSATE AND OTHER POTENTIALLY HAZARDOUS WASTES ARE NOT RECOMMENDED AT THIS TIME; EMPHASIS SHOULD BE PLACED ON SPILL PREVENTION. GEOTHERMAL NOISE EFFECTS ON WILDLIFE HAVE BEEN STUDIED WITHIN THE KGRA; BECAUSE OF METHODOLOGICAL PROBLEMS, ADDITIONAL WORK WOULD PROBABLY NOT BE PRODUCTIVE. WATER VAPOR AND AEROSOL EMISSIONS FROM COOLING TOWERS MAY AFFECT AGRICULTURAL OPERATIONS BY INCREASING THE FREQUENCY OF FOGGING AND ICING CONDITIONS. STUDIES ELSEWHERE, HOWEVER, SHOULD YIELD SUFFICIENT DATA TO RESOLVE THIS ISSUE.

KEYWORDS ECOSYSTEM QUALITY; GEYSERS, THE; HYDROGEN SULFIDE; NOISE

107 TITLE WATER QUALITY STUDY IMPORTANT IN DEVELOPING THE IMPERIAL VALLEY AS A GEOTHERMAL ENERGY RESOURCE.

AUTHOR PIMENTEL, K.D.

CITATION MECHANICAL ENGINEERING DEPARTMENT QUARTERLY REVIEW JULY THROUGH SEPTEMBER, 1978. UCRL-50016-78-3, PP. 14-19 (1978)

ABSTRACT THE DETERMINATION OF A COMPREHENSIVE DATA BASE OF BASELINE WATER QUALITY CONDITIONS BEFORE GEOTHERMAL DEVELOPMENT BEGINS IS AN IMPORTANT STEP IN WATER QUALITY MANAGEMENT. USING THESE DATA, DEVELOPERS, REGULATORS, AND ENVIRONMENTALISTS CAN ASSESS THE IMPACTS THAT GEOTHERMAL DEVELOPMENT IS LIKELY TO HAVE ON THE VALLEY'S WATER RESOURCES IN THE FUTURE, AS WELL AS DETECT ANY CHANGES THAT MAY OCCUR BY MAKING SIMILAR MEASUREMENTS IN FUTURE MONITORING PROGRAMS.

KEYWORDS BRINE; IMPERIAL VALLEY; MONITORING; WATER QUALITY

- 108 **TITLE** *PRELIMINARY ENVIRONMENTAL ASSESSMENTS OF KNOWN GEOTHERMAL RESOURCE AREAS IN THE UNITED STATES.*
- AUTHOR** PHELPS, P.L.; ERMAK, D.L.; ANSPAUGH, L.R.; JACKSON, C.D.; MILLER, L.A.
- CITATION** GEOTHERM. RESOUR. COUNC. TRANS. 2, 523-525 (1978)
- ABSTRACT** NO ABSTRACT AVAILABLE.
- KEYWORDS** AIR QUALITY; ECOSYSTEM QUALITY; GEYSERS, THE; NOISE; WATER QUALITY
-
- 109 **TITLE** *PHOTOSYNTHESIS AND STOMATAL LIGHT RESPONSE IN SNAP BEANS EXPOSED TO HYDROGEN SULFIDE AND OZONE.*
- AUTHOR** COYNE, P.I.; BINGHAM, G.E.
- CITATION** J. AIR POLLUT. CONTROL ASSOC. 28, 1119-1123 (1978)
- ABSTRACT** APPARENT PHOTOSYNTHESIS AND LEAF STOMATAL CONDUCTANCE WERE MEASURED IN WELL-WATERED, FIELD-GROWN SNAP BEANS FUMIGATED WITH VARIOUS LEVELS OF H₂S ALONE AND IN THE PRESENCE OF 0.072 PPM OZONE. MEAN CONCENTRATIONS OF H₂S WERE 0, 0.74, 3.25, AND 5.03 PPM. PLANTS WERE FUMIGATED FOR 4 H EACH DAY CENTERED ON MIDDAY, BEGINNING AT THE FIRST TRIFOLIATE LEAF STAGE THE YOUNGEST FULLY EXPANDED LEAVES WERE SAMPLED AT THE EARLY STAGES OF FLOWERING AFTER 18 PLUS OR MINUS 2 D OF FUMIGATION. HYDROGEN SULFIDE AT 0.74 PPM INCREASED MAXIMUM STOMATAL CONDUCTANCE (C_{MAX}) BY 25 PERCENT AND STIMULATED MAXIMUM APPARENT PHOTOSYNTHESIS (P_{MAX}) BY 10 PERCENT. HIGHER CONCENTRATIONS OF H₂S DEPRESSED STOMATAL OPENING AND CO₂ UPTAKE, AND OZONE AMPLIFIED THE DAMAGE PRODUCED BY H₂S. AT THE HIGHEST H₂S CONCENTRATION PLUS OZONE, C_{MAX} WAS 41 PERCENT, AND P_{MAX} WAS 52 PERCENT OF THE CONTROL. BOTH C_{MAX} AND P_{MAX} RESPONDED SIMILARLY TO THE EIGHT TREATMENTS BUT THE DIFFERENCE BETWEEN MAXIMUM AND MINIMUM RESPONSES WAS GREATER FOR CONDUCTANCE. LACK OF A DIRECT CORRESPONDENCE BETWEEN CHANGES IN CONDUCTANCE AND PHOTOSYNTHESIS INDICATES THAT MESOPHYLL RESISTANCE TO CO₂ TRANSFER WAS MORE LIMITING THAN CO₂ DIFFUSION THROUGH THE STOMATA AT HIGH LIGHT INTENSITIES. AN EXAMINATION OF THE INCREASE IN PHOTOSYNTHESIS AS A FUNCTION OF CONDUCTANCE TENDS TO CONFIRM THIS HYPOTHESIS SINCE MAXIMUM PHOTOSYNTHESIS WAS APPROACHED AT LOWER CONDUCTANCES AS STRESS INCREASED. THE INITIAL SLOPE OF THE CURVES OF BOTH CONDUCTANCE AND PHOTOSYNTHESIS AS A FUNCTION OF IRRADIANCE DECREASED WITH INCREASING STRESS, SUGGESTING DECREASED SENSITIVITY TO LIGHT. THIS INDICATES AN INCREASED SLUGGISHNESS IN THE GUARD CELLS, WHICH IS PROBABLY RELATED TO INDUCED LEAF SENESCENCE CAUSED BY THE POLLUTANTS. IT ALSO INDICATES A LOSS OF PHOTOCHEMICAL CONVERSION EFFICIENCY RESULTING FROM LOSS OF CHLOROPHYLL AND DEVELOPMENT OF NECROTIC AREAS ON THE LEAVES OF THE MORE STRESSED PLANTS. EFFECTS OF H₂S AND H₂S PLUS OZONE ON GAS EXCHANGE ARE COMPARED WITH YIELD DATA FROM A SIMULTANEOUS FIELD STUDY OF THE SAME PLOTS.
- KEYWORDS** AIR QUALITY; ECOSYSTEM QUALITY; TERRESTRIAL; HYDROGEN SULFIDE
-
- 110 **TITLE** *A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.*
- AUTHOR** NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.
- CITATION** UCRL-13913 (1978)
- ABSTRACT** THIS REPORT PRESENTS THE RESULTS OF RESEARCH BY THE INSTITUTE FOR ENVIRONMENTAL STUDIES AT LOUISIANA STATE UNIVERSITY, TO DEVELOP A PLAN FOR THE LONG-TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED/GEOTHERMAL RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION. THIS WORK WAS SPONSORED BY THE LAWRENCE LIVERMORE LABORATORY AS PART OF A CONTRACT WITH THE U.S. DEPARTMENT OF ENERGY.
- IT HAS BEEN ASSUMED THAT FULL-SCALE DEVELOPMENT OF THE LOUISIANA GEOPRESSURED RESOURCE WILL INVOLVE 50 OR MORE SITES, EACH 130-160 SQUARE KILOMETERS (50-60 SQUARE MILES) IN AREA. FOR EACH SITE, WE ENVISION 15-20 PRODUCING WELLS, EACH PRODUCING SOME 40,000 BARRELS/DAY OF FLUID, 30-40 DISPOSAL WELLS, GAS SEPARATION FACILITIES, ONE 25 MEGAWATT

POWER PLANT, AND ABOUT 200 MILES OF PIPELINE.

WHEREAS THIS STUDY CONSIDERED THE EFFECTS OF THE DEVELOPMENT ACTIVITIES WITH THE ABOVE LISTED FACILITIES, IT WAS BEYOND THE SCOPE OF THE STUDY TO CONSIDER THE POSSIBLE EFFECTS OF ANCILLARY DEVELOPMENT ACTIVITIES - THAT IS INDUSTRIAL, COMMERCIAL AND RESIDENTIAL ACTIVITIES RESULTING FROM NON-ELECTRIC USES OF GEOPRESSURED FLUIDS. IT IS RECOMMENDED THAT IMPACTS STEMMING FROM SUCH ANCILLARY ACTIVITIES BE CAREFULLY STUDIED, AND THE RESULTS INCORPORATED INTO THE OVERALL ENVIRONMENTAL ASSESSMENT.

THE MAJOR ENVIRONMENTAL ISSUES STEM FROM POSSIBLE IMPACTS WHICH MIGHT RESULT FROM: (1) SUBSIDENCE ASSOCIATED WITH REMOVING A LARGE VOLUME OF FLUIDS AT HIGH RATES; AND (2) DISPOSAL OF EQUALLY LARGE VOLUMES OF SPENT FLUIDS BY REINJECTION INTO SHALLOW AQUIFERS. PLANS FOR THE MEASUREMENT AND ANALYSIS OF GEOLOGIC EFFECTS INCLUDE: (1) MEASUREMENTS RELATED TO SUBSIDENCE, FAULT ACTIVATION, AND SEISMICITY; (2) SAMPLING AND TESTING TO DETERMINE THE MECHANICAL PROPERTIES OF THE GEOLOGIC UNITS INVOLVED AS AN AID IN THE INTERPRETATION OF THE EFFECTS MEASURED IN (1); AND (3) COMPUTER MODELING BY THE FINITE ELEMENT METHOD TO PROVIDE A BASIS FOR PREDICTING FUTURE GEOLOGIC EFFECTS.

THE SOUTH LOUISIANA COASTAL REGION IS CHARACTERIZED BY HIGHLY DIVERSE AND PRODUCTIVE AQUATIC AND WETLAND ECOSYSTEMS. THE ECONOMIC VALUE OF THESE WETLANDS DERIVES FROM THEIR USE AS HABITAT BY IMPORTANT COMMERCIAL SPECIES OF FISH, WATERFOWL, AND FUR ANIMALS; AND FROM MINERAL PRODUCTION. THE VALUE OF THE COASTAL WETLANDS IN TERMS OF RECREATIONAL ACTIVITIES IS ALSO VERY HIGH. SUBSIDENCE, SHOULD IT OCCUR, WOULD HAVE A SIGNIFICANT ADVERSE IMPACT ON THIS REGION. MUCH OF THE STUDY AREA HAS VERY LOW ELEVATIONS AND RELIEF, AND IS THEREFORE VULNERABLE TO EXTENSIVE INUNDATION FROM ANY MEASURABLE AMOUNT OF SUBSIDENCE. MARSH WOULD BE CONVERTED TO OPEN WATER, MARKEDLY REDUCING BIOLOGICAL PRODUCTIVITY, WITH THE GEOPRESSURED PRODUCER POSSIBLY FACING PRIVATE SUITS FOR DAMAGES OR EVEN INJUNCTIVE RELIEF. PLANS HAVE BEEN DEVELOPED FOR THE ASSESSMENT OF IMPACTS ON ECOSYSTEM QUALITY (1) OFF-SHORE; (2) IN THE COASTAL REGION; AND (3) IN THE UPLAND AND FOREST REGIONS. EACH PLAN INVOLVES THE SAMPLING OF THE BIOTA, THE WATER, AND THE SUBSTRATE, WITH BIOASSAYS ON SELECTED ORGANISMS.

REGARDING WATER QUALITY, THERE IS CONCERN THAT THE LARGE VOLUMES OF WATER THAT MUST BE DISPOSED OF, SUBSURFACE, MAY OVERTAX THE RECEIVING AQUIFER WITH PERHAPS LEAKAGE OF FLUIDS UP FAULT PLANES; OR THAT ABANDONED OIL AND GAS WELLS IN THE VICINITY MAY BE BREACHED. BOTH GROUND WATER AND SURFACE WATERS COULD BE ADVERSELY AFFECTED SHOULD THIS OCCUR. CAUSES FOR CONCERN INCLUDE SALINITY, TEMPERATURE, AND TOTAL QUANTITY OF HEAT TO BE DISSIPATED; AS WELL AS LOW DISSOLVED OXYGEN CONTENT, AND POSSIBLE TRACE AMOUNTS OF HYDROGEN SULFIDE, AMMONIA, COPPER, BORON, AND OTHER TOXIC IONS. PLANS FOR ASSESSING IMPACTS ON WATER QUALITY INCLUDE PROVISIONS FOR DETERMINING GROUND-WATER USES IN THE VICINITY OF A GEOPRESSURED SITE, MAPPING GROUND-WATER RESOURCES, IDENTIFYING SITES OF POSSIBLE LEAKAGE, AND SAMPLING GROUND-WATER SOURCES USED FOR DOMESTIC AND AGRICULTURAL WATER SUPPLY. SURFACE WATER QUALITY STUDIES ARE TO INCLUDE MONTHLY SAMPLING AND TESTING.

AIR QUALITY IMPACTS ARE EXPECTED TO BE MINOR AS COMPARED TO POTENTIAL IMPACTS ON WATER AND ECOSYSTEM QUALITY. THE MAJOR ATMOSPHERIC EMISSION FROM A GEOPRESSURED POWER PLANT WILL BE THE STEAM PLUMES FROM WET COOLING TOWERS. LOCALIZED FOGGING WILL BE POSSIBLE. FORTUNATELY, WEATHER CONDITIONS IN SOUTH LOUISIANA ARE GENERALLY FAVORABLE FOR THE DISPERSION OF ATMOSPHERIC POLLUTANTS. IF THE LAKE CHARLES, AND BATON ROUGE TO NEW ORLEANS

AREAS ARE AVOIDED, IT IS LIKELY THAT ALL STATE AND FEDERAL AIR QUALITY STANDARDS CAN BE MET. THERE WILL, OF COURSE, BE SOME LOCALIZED NOISE, BUT IT SHOULD BE POSSIBLE TO DESIGN AROUND THIS POTENTIAL PROBLEM. PLANS FOR AIR QUALITY ASSESSMENT STUDIES INCLUDE THE INSTALLATION OF THREE FIXED LOCATION BASELINE AIR MONITORING STATIONS, EQUIPPED TO OBTAIN METEOROLOGICAL DATA. ADDITIONAL FIXED MONITORING STATIONS MAY BE NEEDED DEPENDING ON THE LOCATIONS AND CONFIGURATIONS OF THE WELL SITES ONCE SELECTED. MOBILE TESTING WILL ALSO BE DESIRABLE TO DETERMINE UPWIND AND DOWNWIND CONCENTRATIONS OF SELECTED POLLUTANTS.

THE LIKELY EXTENT OF THE ABOVE DESCRIBED POTENTIAL ENVIRONMENTAL IMPACTS IS UNKNOWN AT THE PRESENT TIME; THUS, DETAILED STUDIES SHOULD CONTINUE, BEGINNING WITH RESERVOIR TESTING ACTIVITIES. AS MORE INFORMATION BECOMES AVAILABLE, APPROPRIATE DEFINITIVE PLANS MUST BE INCORPORATED INTO THE OVERALL DESIGN OF THE RESOURCE DEVELOPMENT SO AS TO STRIKE AN ACCEPTABLE BALANCE BETWEEN ENERGY DEVELOPMENT AND ENVIRONMENTAL QUALITY.

A BRIEF SUMMARY OF THE OVERALL PLAN FOR THE ASSESSMENT OF ENVIRONMENTAL IMPACTS FROM GEOPRESSURED RESOURCE DEVELOPMENT ACTIVITIES AT A SINGLE PROSPECT CONCLUDES THIS ABSTRACT.

GEOLOGICAL EFFECTS: (OVERALL PRIORITY; HIGH) 1) ESTABLISH BASELINE CONDITIONS: SUBSIDENCE HISTORY, SURFACE ELEVATIONS, SEISMICITY. 2) MONITOR IMPACTS: SURFACE ELEVATION CHANGES, FAULT MOVEMENT, SEISMICITY. 3) DETERMINE COMPACTION CHARACTERISTICS THROUGH LABORATORY MATERIALS TESTING AND IN SITU ROCK MECHANICS TESTS. 4) MODEL RESERVOIR AND OVERBURDEN RESPONSE TO PRODUCTION. 5) ANALYZE DATA AND REPORT RESULTS.

AIR QUALITY: (OVERALL PRIORITY; LOW) 1) ESTABLISH REGIONAL BASELINE CONDITIONS. 2) ESTABLISH SITE SPECIFIC BASELINE CONDITIONS. 3) TEST AND MONITOR EMISSION STREAMS. 4) MONITOR AIR QUALITY. 5) PERFORM DISPERSION MODELING STUDIES. 6) ANALYZE DATA AND REPORT RESULTS.

WATER QUALITY: SURFACE WATER: (OVERALL PRIORITY; MEDIUM) 1) ESTABLISH BASELINE CONDITIONS: HYDROLOGY, WATER QUALITY, USAGE. 2) TEST AND MONITOR EMISSION STREAMS. 3) MONITOR SURFACE WATER QUALITY. 4) ANALYZE DATA AND REPORT RESULTS.

WATER QUALITY: GROUND WATER: (OVERALL PRIORITY; HIGH) 1) ESTABLISH BASELINE CONDITIONS: CONFIGURATION, DEPTH, GROUND-WATER QUALITY, USAGE. 2) INVENTORY EXISTING WELLS. 3) MONITOR GROUND WATER QUALITY. 4) ANALYZE DATA AND REPORT RESULTS.

ECOSYSTEM QUALITY: (OVERALL PRIORITY; MEDIUM TO HIGH) 1) ESTABLISH BASELINE CONDITIONS: SUBSTRATE, BIOLOGICAL SURVEYS, BIOASSAYS. 2) MONITOR BIOLOGICAL POPULATIONS. 3) ASSESS IMPACTS. 4) CONDUCT SPECIAL STUDIES. 5) ANALYZE DATA AND REPORT RESULTS.

KEYWORDS AIR QUALITY; BRINE; ECOSYSTEM QUALITY; GEOLOGY; HYDROGEN SULFIDE; MONITORING; RESOURCE STATUS; SUBSIDENCE AND SEISMICITY; WATER QUALITY; GEOPRESSURE

111 TITLE *ATMAS: A THREE-DIMENSIONAL ATMOSPHERIC TRANSPORT MODEL TO TREAT MULTIPLE AREA SOURCES.*

AUTHOR ERMAK, D.L.; NYHOLM, R.A.; LANGE, R.

CITATION UCRL-52603 (1978)

ABSTRACT ATMAS, AN ATMOSPHERIC TRANSPORT COMPUTER MODEL, ESTIMATES THE CONCENTRATION OF GASEOUS SPECIES EMITTED FROM MULTIPLE AREA SOURCES. IT CAN HANDLE SPACE- AND TIME-VARYING WIND FIELDS, FIRST-ORDER CHEMICAL TRANSFORMATIONS, GROUND DEPOSITION, AND INVERSION EFFECTS. THE MODEL PRESENTED HERE IS BASED ON THE THREE-DIMENSIONAL ADVECTION-DIFFUSION EQUATION TO DESCRIBE ATMOSPHERIC TRANSPORT. ATMAS SOLVES THIS EQUATION AND CALCULATES THE CONCENTRATION LEVELS USING THE PARTICLE-IN-CELL METHOD. THE MODEL CALCULATES SHORT-TERM (HOURLY) AVERAGE CONCENTRATIONS OVER PERIODS RANGING FROM A MONTH TO A YEAR; IT CAN ALSO CALCULATE LONGER AVERAGES BY VARYING THE AVERAGING TIME. WE PRESENT A DEMONSTRATION OF THE MODEL, ALONG WITH THE OUTPUT OF THE COMPUTER CODE. OUTPUT FROM THE CODE TYPICALLY INCLUDES ISOPLETH MAPS SHOWING THE CALCULATED CONCENTRATION LEVELS AND THE PROBABILITY WITH WHICH GIVEN THRESHOLDS OR STANDARDS ARE EXCEEDED DURING THE SIMULATION PERIOD.

KEYWORDS AIR QUALITY; HYDROGEN SULFIDE; IMPERIAL VALLEY; MODELS; MONITORING; INTEGRATED ASSESSMENT

- 112 **TITLE** *A MODEL OF LEAF PHOTOSYNTHESIS AND THE EFFECTS OF SIMPLE GASEOUS COMPOUNDS (H₂S AND SO₂).*
AUTHOR KERCHER, J.R.
CITATION UCRL-52643 (1978)
ABSTRACT WE PRESENT A THEORETICAL DEVELOPMENT OF A LEAF MODEL AND THE EFFECTS OF SIMPLE SULFUR COMPOUNDS (H₂S AND SO₂) ON PHOTOSYNTHESIS BASED ON BIOCHEMICAL MECHANISMS. THE MODEL IS DEVELOPED TO INTERPRET SHORT-TERM FUMIGATION EXPERIMENTS AND TO USE WITH SEASON-LONG FUMIGATION EXPERIMENT TO ASSESS THE EFFECTS OF THESE COMPOUNDS ON GROWTH. THE MODEL IS DESIGNED AS A SUBMODEL IN A GROWTH-AND-ALLOCATION MODEL OF THE PLANT.
INCLUDED IN THIS DEVELOPMENT ARE AN ANALYSIS OF THE DIFFUSION OF CO₂ AND SULFUR COMPOUNDS INTO THE LEAF, ENZYMATIC INTERACTIONS OF SULFUR IN DARK AND LIGHT REACTIONS OF PHOTOSYNTHESIS, TEMPERATURE DEPENDENCE OF THE KINETICS AND DENATURIZATION OF ENZYMES, METABOLISM OF SULFUR COMPOUNDS AND A HYPOTHESIS FOR THE LONG-TERM EFFECTS OF SULFUR COMPOUNDS. WE CAN EXPLAIN ENHANCED PHOTOSYNTHESIS AT LOW H₂S LEVELS, DEPRESSION OF PHOTOSYNTHESIS AT HIGH H₂S LEVELS, THRESHOLD TO EFFECTS OF SULFUR POLLUTANTS, AND THE NATURE OF THE TEMPERATURE DEPENDENCE OF PHOTOSYNTHESIS.
WE HAVE USED PARAMETERS IN THE MODEL FOR SUGAR BEETS FROM DATA IN THE LITERATURE AND FROM EXPERIMENTS FUNDED THROUGH LLL. WE HAVE ANALYZED THE PROPERTIES OF THE MODEL AND DISCUSS DATA AND EXPERIMENTS STILL REQUIRED, SENSITIVITIES OF THE MODEL TO PARAMETERS AND VARIABLES, IMPLICATIONS TO ASSESSMENTS, AND THE SETTING OF STANDARDS FOR GASEOUS POLLUTANTS.
KEYWORDS ECOSYSTEM QUALITY; HYDROGEN SULFIDE; INTEGRATED ASSESSMENT; MODELS
- 113 **TITLE** *MULTIPLE SOURCE DISPERSION MODEL.*
AUTHOR ERMAK, D.L.; NYHOLM, R.A.
CITATION UCRL-52592 (1978)
ABSTRACT MSDM IS A COMPUTER CODE FOR CALCULATING POLLUTANT CONCENTRATIONS AND SURFACE DEPOSITION RATES FROM A LARGE NUMBER OF POINT SOURCES AND WITHIN A SPATIAL RANGE OF APPROXIMATELY 100 KM. THE MODEL IS BASED ON THE GAUSSIAN PLUME CONCEPT WITH MODIFICATIONS TO SIMULATE THE EFFECTS OF PLUME RISE, FIRST ORDER CHEMICAL TRANSFORMATIONS, GRAVITATIONAL SETTLING, SURFACE DEPOSITION, AND AN INVERSION LAYER. TWO MODES OF OPERATION CAN BE EMPLOYED: CLIMATOLOGICAL OR INSTANTANEOUS. IN THE CLIMATOLOGICAL MODE, LONG-TERM (MONTHLY TO YEARLY) AVERAGES ARE CALCULATED USING A JOINT FREQUENCY DISTRIBUTION OF WIND SPEED, WIND DIRECTION, AND ATMOSPHERIC STABILITY FOR THE TIME PERIOD OVER WHICH THE AVERAGE IS TO BE TAKEN. SHORT-TERM (HOURLY) AVERAGES FOR A SPECIFIC SET OF METEOROLOGICAL CONDITIONS ARE CALCULATED IN THE INSTANTANEOUS MODE. TECHNICAL DETAILS OF THE MODEL ARE PRESENTED WITH A DESCRIPTION OF THE DATA REQUIREMENTS AND THE PROGRAM OUTPUT. FOUR EXAMPLE PROBLEMS AND A COMPLETE PROGRAM LISTING ARE INCLUDED IN THE APPENDICES.
KEYWORDS AIR QUALITY; MODELS; IMPERIAL VALLEY; INTEGRATED ASSESSMENT
- 114 **TITLE** *ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL. 1.*
AUTHOR WHITE, K.L.; HILL, A.C.; URSENBACH, W.O. (EDS.)
CITATION UCRL-13955 VOL.1 (1978)
ABSTRACT NO ABSTRACT AVAILABLE.
KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; ENVIRONMENTAL DATA MANAGEMENT; GEOLOGY; HYDROGEN SULFIDE; NOISE; RESOURCE STATUS; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; UTAH; WATER RESOURCES; WATER QUALITY

115 **TITLE** *ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL.2.*

AUTHOR WHITE, K.L.; HILL, A.C.; URSENBAACH, W.O. (EDS.)

CITATION UCRL-13955 VOL.2 (1978)

ABSTRACT NO ABSTRACT AVAILABLE.

KEYWORDS AIR QUALITY; ECOSYSTEM QUALITY; ENVIRONMENTAL DATA MANAGEMENT; GEOLOGY; HYDROGEN SULFIDE; NOISE; RESOURCE STATUS; SOCIOECONOMIC EFFECTS; SUBSIDENCE AND SEISMICITY; UTAH; WATER RESOURCES; WATER QUALITY

116 **TITLE** *AN EXPLORATORY DATA ANALYSIS OF PHOTOCHEMICAL OXIDANTS IN THE IMPERIAL VALLEY, CALIFORNIA.*

AUTHOR AXELROD, M.C.

CITATION ELECTRONICS ENGINEERING DEPARTMENT QUARTERLY REPORT NO.3 1978, UCRL-50025-78-3, PP.25-34 (1978)

ABSTRACT THE DEPARTMENT OF ENERGY (DOE) HAS DESIGNATED LLL AS THE LEAD LABORATORY IN A COMPREHENSIVE PROGRAM TO ASSESS THE IMPACT OF GEOTHERMAL ENERGY IN THE IMPERIAL VALLEY, CALIFORNIA. THE ELECTRONICS ENGINEERING DEPARTMENT IN SUPPORT OF THE LABORATORY'S DIVISION OF ENVIRONMENTAL SCIENCES HAS CONTRIBUTED TO THIS IMPERIAL VALLEY ENVIRONMENTAL PROGRAM (IVEP), BOTH IN DATA COLLECTION AND DATA ANALYSIS. INSTRUMENTATION FOR SIX FIXED-SITE AIR QUALITY MONITORING STATIONS AND A MOBILE VAN WERE DESIGNED, DEVELOPED, DEPLOYED, AND MAINTAINED BY ELECTRONICS ENGINEERS AND TECHNICIANS. PART OF OUR MANDATE FOR THE PROGRAM IS TO SUMMARIZE THE SOME 1.5 MILLION MEASUREMENTS IN A FORM SUITABLE FOR DISSEMINATION TO INDUSTRY AND GOVERNMENT. TO DO THIS, WE APPLIED A NUMBER OF INTERESTING GRAPHICAL AND STATISTICAL TECHNIQUES, WHICH MAY BE APPLICABLE TO OTHER PROGRAMS.

KEYWORDS AIR QUALITY; ENVIRONMENTAL DATA MANAGEMENT; IMPERIAL VALLEY; MONITORING

117 **TITLE** *RADIOMETRIC LAND-SURFACE TEMPERATURE MAPPING.*

AUTHOR DEL GRANDE, N.K.

CITATION UCRL-82001 (1978)

ABSTRACT THE APPLICATION OF AN ADVANCED, AIRBORNE, RADIOMETRIC TECHNIQUE FOR MAPPING LAND-SURFACE TEMPERATURES IS DESCRIBED. THE TECHNIQUE USES A DUAL-BAND INFRARED SCANNER WITH FILTERED-WAVELENGTH INTERVALS CENTERED NEAR 5 AND 11 MICROMETERS. LAND TEMPERATURE PATTERNS LOOK ALIKE WITH 5- AND 11- MICROMETER THERMAL IMAGERY. THIS STRONGLY SUPPORTS THE THESIS THAT THE LAND RADIATES LIKE A GRAYBODY SURFACE. CALIBRATED DUAL-BAND THERMAL IMAGERY PROVIDES A QUANTITATIVE MEASURE OF LAND-SURFACE TEMPERATURES NOT POSSIBLE WITH A SINGLE-BAND TECHNIQUE.

THE TECHNIQUE WAS TESTED AT LONG VALLEY, A KNOWN GEOTHERMAL RESOURCE AREA IN CALIFORNIA. LAND-TEMPERATURE DIFFERENCES OF 0.2 TO 0.3 DEGREES C AND LARGER WERE RESOLVED. INTERFERENCE FROM ATMOSPHERIC AND SURFACE VARIABLES, FOR THE MOST PART, DID NOT MASK THE PREDAWN SURFACE-TEMPERATURE MANIFESTATIONS OF GEOTHERMAL HEAT. PRIOR TO SUNRISE, SURFACE TEMPERATURE VARIATIONS CORRELATED STRONGLY WITH 2-M-DEEP SOIL TEMPERATURE VARIATIONS MEASURED AT SOME 10 REPRESENTATIVE LOCATIONS BY PREVIOUS INVESTIGATORS.

THE PATTERN OF PREDAWN LAND-SURFACE TEMPERATURES WERE STRIKINGLY SIMILAR TO 6- AND 10-M-DEEP TEMPERATURE CONTOURS. THE LATTER CORRELATED WITH THE BEHAVIOR OF TEMPERATURE GRADIENTS FROM 10 TO 30 M, WHICH WERE 6 TO 30 TIMES NORMAL. THIS BEHAVIOR ORIGINATED FROM DEEP-RESERVOIR DISCHARGE OVER THE UPPER 300-M LAYER.

DUAL-BAND RADIOMETRIC SURVEYS PROVIDE A UNIQUE GEOPHYSICAL METHOD FOR MAPPING THE SURFACE-TEMPERATURE MANIFESTATIONS OF GEOTHERMAL HEAT. MORE WIDESPREAD USE OF THIS TECHNIQUE APPEARS WARRANTED.

KEYWORDS ENVIRONMENTAL DATA MANAGEMENT; LONG VALLEY

118 TITLE AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA. VOLUME 4. ENVIRONMENTAL GEOLOGY

AUTHOR CROW, N.B.

ABSTRACT THIS REPORT IS ONE OF A SERIES OF VOLUMES REPORTING THE RESULTS OF AN OVERVIEW STUDY OF ENVIRONMENTAL ISSUES IN THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCE AREA REGION IN THE NORTHERN CALIFORNIA COAST RANGES. PART 1 PRESENTS THE RECOMMENDED PROJECTS TOGETHER WITH SUPPORTING DISCUSSIONS OF THE ENVIRONMENTAL ISSUES AND RELATED GEOLOGIC INFORMATION, THUS SERVING AS AN EXECUTIVE SUMMARY. THESE RECOMMENDATIONS ARE INTENDED AS A GUIDE TO DETAILED PLANNING, AND ARE NOT PROJECT WORK STATEMENTS. PART 2 IS A REVIEW OF THE PUBLISHED AND OPEN-FILE EARTH SCIENCES LITERATURE ABOUT THE REGION. IT DESCRIBES THE REGIONAL FRAMEWORK OF THE GEOLOGY, GEOPHYSICS, AND HYDROLOGY AND PROVIDES INFORMATION ABOUT THE GEOTHERMAL RESOURCES AND THE SEVERAL KINDS OF GEOLOGIC HAZARDS -- ACCELERATED EROSION INCLUDING LANDSLIDES, POTENTIAL INTERRELATIONSHIPS BETWEEN GEOTHERMAL FLUIDS AND BOTH POTABLE AND THERMAL GROUND WATER, SUBSIDENCE, AND INDUCED SEISMICITY -- THAT MAY AFFECT THE ENVIRONMENT AS CONSEQUENCES OF GEOTHERMAL DEVELOPMENT.

STUDIES SHOULD BE CONCENTRATED IN RELATIVELY SMALL AREAS WHERE GEOTHERMAL DEVELOPMENT IS LIKELY. SOME OF THE PROJECTS RECOMMENDED ARE: 1) PLANNING ASSESSMENTS (NORMALLY AT MAP SCALES OF 1:24,000) OF THE POTENTIAL FOR ACCELERATED EROSION, LANDSLIDES, AND RELATED HAZARDS FOR SMALL KEY LOCALITIES LIKELY TO BE DEVELOPED FOR GEOTHERMAL PRODUCTION. 2) CHARACTERIZING POTABLE AND THERMAL GROUND-WATER RESOURCES LIKELY TO BE AFFECTED BY GEOTHERMAL DEVELOPMENT. THIS INCLUDES A RECONNAISSANCE GEOHYDROLOGIC STUDY AND PERIODIC COLLECTION OF WATER CHEMISTRY AND FLOW DATA FROM IMPORTANT GROUNDWATER SOURCES FOR A PERIOD OF 1-3 YEARS. 3) CONTINUING EXISTING LAND SURFACE MOVEMENT AND SEISMOGRAPH NETWORKS AROUND THE GEYSERS FIELD, AND EXTENDING THEM TO THE REGION TO THE NORTHEAST OF PRESENT PRODUCTION.

THE APPENDIX TO THIS REPORT IS A COMPREHENSIVE BIBLIOGRAPHY OF SCIENTIFIC INFORMATION ABOUT THE CLEAR LAKE-THE GEYSERS REGION, COMPILED BY DAVID P. ADAM OF THE U.S. GEOLOGICAL SURVEY, MENLO PARK, CALIFORNIA.

KEYWORDS ECOSYSTEM QUALITY; GEOLOGY; GEYSERS THE; SUBSIDENCE AND SEISMICITY; WATER QUALITY

119 TITLE AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA. VOLUME 6. WATER QUALITY

AUTHOR PIMENTEL, K.D.

ABSTRACT THIS REPORT IDENTIFIES KEY ISSUES, ASSESSES AVAILABLE INFORMATION, AND RECOMMENDS RESEARCH RELATED TO WATER QUALITY DEGRADATION RESULTING FROM GEOTHERMAL DEVELOPMENT IN THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCE AREA. DATA NECESSARY FOR MAKING DECISIONS TO MINIMIZE DAMAGE WHILE ALLOWING DEVELOPMENT IS LACKING IN THREE AREAS: 1) FOR THE WHOLE KGRA, THERE IS INSUFFICIENT INFORMATION ON THE RELATION OF INDUSTRY-RELATED CONSTRUCTION TO EROSION, WITH ITS RESULTING INCREASE IN SEDIMENT AND SILT IN AREA STREAMS. 2) THE EFFECTS OF COOLING TOWER DRIFT ON SOILS AND VEGETATION NEAR POWER PLANTS SHOULD BE STUDIED AS PRECURSORS OF POTENTIAL EFFECTS ON WATER QUALITY. 3) FOR THE HOT-WATER RESOURCE AREA IN THE EASTERN PORTION OF THE KGRA, A LONG-RANGE PROGRAM OF WATER QUALITY MONITORING IS NEEDED TO ESTABLISH A BASELINE.

WE RECOMMEND THAT FUTURE FUNDING FOR WATER QUALITY RESEARCH BE CONCENTRATED IN THESE THREE AREAS OF INQUIRY.

KEYWORDS GEYSERS THE; WATER QUALITY

AUTHOR INDEX

ACKERMAN, T.A.

51 BASELINE STUDIES IN THE DESERT ECOSYSTEM AT EAST MESA GEOTHERMAL TEST SITE, IMPERIAL VALLEY, CALIFORNIA.

UCLA-12-1143 (1977)

ROMNEY, E.M.; WALLACE, A.; LUNT, O.R.; ACKERMAN, T.A.; KINNEAR, J.E.

ANSPAUGH, L.R.

4 AN OVERVIEW OF THE IMPERIAL VALLEY ENVIRONMENTAL PROJECT.

UCID-17067 (1976)

ANSPAUGH, L.R.; PHELPS, P.L. (EDS.)

7 BALANCED PROGRAM PLAN. ANALYSIS FOR BIOMEDICAL AND ENVIRONMENTAL RESEARCH. VOLUME 9. GEOTHERMAL ENERGY.

ERDA-76/116(VOL.9) (1976)

ANSPAUGH, L.R. (ED.)

31 DISCUSSION OF ENVIRONMENTAL ISSUES.

ENVIRONMENTAL DEVELOPMENT PLAN (EDP) HYDROTHERMAL ENERGY SYSTEMS FY 1977. USERDA REPORT

EDP/G 01(77) APPENDIX B (1977)

ANSPAUGH, L.R.

98 ENVIRONMENTAL ASSESSMENT REPORT (EAR) FOR GEOTHERMAL ENERGY SYSTEMS.

UCRL-81910 (1978)

ANSPAUGH, L.R.; PHELPS, P.L.

78 ENVIRONMENTAL ISSUES.

ENVIRONMENTAL DEVELOPMENT PLAN (EDP) GEOTHERMAL ENERGY SYSTEMS 1977. US DOE REPORT

DOE/EDP-0014 APPENDIX B. PP. B1-B7 (1978)

ANSPAUGH, L.R.

76 ENVIRONMENTAL READINESS DOCUMENT. HYDROTHERMAL ELECTRIC AND DIRECT HEAT.

COMMERCIALIZATION PHASE III PLANNING.

DOE/ERD-0005 (1978)

ANSPAUGH, L.R.; PHELPS, P.L. (CONTRIBUTING AUTHORS)

77 ENVIRONMENTAL, HEALTH AND SAFETY ISSUES.

ENVIRONMENTAL DEVELOPMENT PLAN (EDP) GEOTHERMAL ENERGY SYSTEMS 1977. US DOE REPORT

DOE/EDP-0014 CHAPTER 3 PP. 21-24 (1978)

ANSPAUGH, L.R.

ANSPAUGH, L.R. (CONTD.)

68 FINAL REPORT ON THE INVESTIGATION OF THE IMPACT OF THE RELEASE OF 222-RN, ITS DAUGHTERS AND PRECURSORS AT THE GEYSERS GEOTHERMAL FIELD AND SURROUNDING AREA.
LAWRENCE LIVERMORE LABORATORY ENVIRONMENTAL SCIENCES DIVISION REPORT (1978)
ANSPAUGH, L.R.

29 GEOTHERMAL ENVIRONMENTAL OVERVIEW PROJECT.
UCID-17632 (1977)
ANSPAUGH, L.R.

88 IDENTIFICATION OF ENVIRONMENTAL ISSUES ASSOCIATED WITH THE UTILIZATION OF GEOTHERMAL ENERGY. (ABSTRACT)
ENERGY AND ENVIRONMENTAL GOALS: COMPATIBILITY THROUGH ENVIRONMENTAL CONTROLS, ABSTRACTS OF U.S. DOE ENVIRONMENTAL CONTROL SYMPOSIUM, NOV. 28-30, 1978, WASHINGTON, D.C. P.25 (1978)
ANSPAUGH, L.R.

5 IMPERIAL VALLEY ENVIRONMENTAL PROJECT.
ENERGY AND TECHNOLOGY REVIEW, MAY 1976. UCRL-52000-76-5, PP. 21-26 (1976)
ANSPAUGH, L.R.; MCCALEB, C.S.

10 IMPERIAL VALLEY ENVIRONMENTAL PROJECT, PROGRESS REPORT.
UCRL-50044-76-1 (1976)
PHELPS, P.L.; ANSPAUGH, L.R. (EDS.)

28 IMPERIAL VALLEY ENVIRONMENTAL PROJECT: QUARTERLY DATA REPORT.
UCID-17444-1 (1977)
NYHOLM, R.A.; ANSPAUGH, L.R. (COMP. AND EDS.)

13 MEASUREMENTS OF RADIOACTIVITY IN COOLING TOWER SLUDGE AT THE GEYSERS GEOTHERMAL FIELD, CALIFORNIA. (ABSTRACT)
HEALTH PHYS. 31, 532 (1976)
SERPA, D.P.; LORENZ, R.W.; ANSPAUGH, L.R.

74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.
UCRL-52248 (1978)
ANSPAUGH, L.R.; CROW, N.B.; GUDIKNEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.

ANSPAUGH, L.R. (CONTD.)

108 PRELIMINARY ENVIRONMENTAL ASSESSMENTS OF KNOWN GEOTHERMAL RESOURCE AREAS IN THE UNITED STATES.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 523 (1978)

PHELPS, P.L.; ERMAK, D.L.; ANSPAUGH, L.R.; JACKSON, C.D.; MILLER, L.A.

30 THE GEYSERS GEOTHERMAL POWER PLANT: ENVIRONMENTAL IMPACT OF THE RELEASE OF 222-RN.

PG&E REPORT 420-77.22 (1977)

SERPA, D.P.; ANSPAUGH, L.R.; PHELPS, P.L.; SOINSKI, A.J.

ATKINS, E.L.

59 THE MORTALITY AND LIFESPAN OF HONEY BEES EXPOSED TO HYDROGEN SULFIDE GAS AS AN AIR POLLUTANT. INTERIM REPORT.

LLL INTERIM REPORT (1977)

ATKINS, E.L.

AUSTIN, A.L.

3 THE LLL GEOTHERMAL ENERGY DEVELOPMENT PROGRAM STATUS REPORT, JANUARY 1975 THROUGH AUGUST 1975.

UCID-16954 (1975)

AUSTIN, A.L.; HOWARD, J.H.; LUNDBERG, A.W.; TARDIFF, G.E.

55 THE LLL GEOTHERMAL ENERGY PROGRAM STATUS REPORT JANUARY 1976 - JANUARY 1977.

UCRL-50046-76 (1977)

AUSTIN, A.L.; LUNDBERG, A.W.; OWEN, L.B.; TARDIFF, G.E.

AXELROD, M.C.

81 A METHODOLOGY FOR ASSESSING THE POTENTIAL IMPACT ON AIR QUALITY RESULTING FROM GEOTHERMAL RESOURCE DEVELOPMENT IN THE IMPERIAL VALLEY.

PROC. INT. CLEAN AIR CONF., CLEAN AIR SOC. AUSTRALIA AND NEW ZEALAND, BRISBANE, AUSTRALIA, MAY 15-18; PP. 719-734 (1978)

GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; LANGE, R.

86 AIR QUALITY ASSESSMENT STUDIES OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 235 (1978)

GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; NYHOLM, R.A.

AXELROD, M.C. (CONTD.)

- 116 AN EXPLORATORY DATA ANALYSIS OF PHOTOCHEMICAL OXIDANTS IN THE IMPERIAL VALLEY, CALIFORNIA.
ELECTRONICS ENGINEERING DEPARTMENT QUARTERLY REPORT NO.3 1978, UCRL-50025-78-3, PP.25-34
(1978)
AXELROD, M.C.

BACHMAN, A.L.

- 110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN
THE LOUISIANA GULF COAST REGION.
UCRL-13913 (1978)
NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.;
NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

BARNES, K.

- 44 INTERACTIVE EFFECTS OF H₂S AND O₃ ON THE YIELD OF SNAP BEANS (PHASEOLUS VULGARIS L.).
UCRL-13807 (1977)
BENNETT, J.P.; BARNES, K.; SHINN, J.H.

BENNETT, J.P.

- 44 INTERACTIVE EFFECTS OF H₂S AND O₃ ON THE YIELD OF SNAP BEANS (PHASEOLUS VULGARIS L.).
UCRL-13807 (1977)
BENNETT, J.P.; BARNES, K.; SHINN, J.H.

- 45 PHOTOSYNTHESIS AND STOMATAL RESISTANCE RESPONSE TO OZONE AND/OR HYDROGEN SULFIDE
EXPOSURES IN FIELD GROWN SNAP BEANS. (ABSTRACT)
AGRONOMY ABS. 1977, 97 (1977)
BINGHAM, G.E.; COYNE, P.I.; BENNETT, J.P.; SHINN, J.H.

- 60 SNAP BEAN YIELD AND PARTITIONING RESPONSES TO OZONE AND HYDROGEN SULFIDE EXPOSURES IN THE
FIELD. (ABSTRACT)
AGRONOMY ABS. 1977, 96 (1977)
BENNETT, J.P.; SHINN, J.H.

BENNETT, W.W.

- 102 HABITAT REQUIREMENTS AND POPULATION CHARACTERISTICS OF THE CLAPPER RAIL (*RALLUS LONGIROSTRIS YUMANENSIS*) IN THE IMPERIAL VALLEY OF CALIFORNIA.
UCRL-13813 (1978)
BENNETT, W.W.; OHMART, R.D.

BINGHAM, G.E.

- 45 PHOTOSYNTHESIS AND STOMATAL RESISTANCE RESPONSE TO OZONE AND/OR HYDROGEN SULFIDE EXPOSURES IN FIELD GROWN SNAP BEANS. (ABSTRACT)
AGRONOMY ABS. 1977, 97 (1977)
BINGHAM, G.E.; COYNE, P.I.; BENNETT, J.P.; SHINN, J.H.

- 109 PHOTOSYNTHESIS AND STOMATAL LIGHT RESPONSE IN SNAP BEANS EXPOSED TO HYDROGEN SULFIDE AND OZONE.
J. AIR POLLUT. CONTROL ASSOC. 28, 1119-1123 (1978)
COYNE, P.I.; BINGHAM, G.E.

BISHOP, H.K.

- 53 SCALE AND SOLIDS DEPOSITION IN THE SDG&E/U.S. ERDA GEOTHERMAL LOOP EXPERIMENTAL FACILITY AT NILAND, CALIFORNIA.
GEOTHERM. RESOUR. COUNC. TRANS. 1, 249 (1977)
QUONG, R.; BISHOP, H.K.; HILL, J.H.

BRYAN, C.F.

- 110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.
UCRL-13913 (1978)
NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

BUCKHOLTZ, H.

- 73 NUMERICAL INTEGRATION OF THE LANGEVIN EQUATION: MONTE CARLO SIMULATION.
UCRL-80735 (1978)
ERMAK, D.L.; BUCKHOLTZ, H.

CERVINKA, V.

27 PUMPING ENERGY REQUIREMENTS FOR IRRIGATION IN CALIFORNIA.

UCRL-13788 (1977)

KNUTSON, G.D.; CURLEY, R.G.; ROBERTS, E.B.; HAGAN, R.M.; CERVINKA, V.

CHENEY, J.A.

101 PREDICTION OF SUBSIDENCE DUE TO HOT BRINE PRODUCTION IN THE SALTON SEA GEOTHERMAL FIELD.

UCRL-80984 (1978)

SCHATZ, J.F.; CHENEY, J.A.; KASAMEYER, P.W.

CLEGG, B.R.

46 A LINEAR GRADIENT CHAMBER FOR EXPOSING FIELD PLANTS TO CONTROLLED LEVELS OF AIR POLLUTANTS.

UCRL-80411 (1977)

SHINN, J.H.; CLEGG, B.R.; STUART, M.L.

12 EXPOSURES OF FIELD-GROWN LETTUCE TO GEOTHERMAL AIR POLLUTION: PHOTOSYNTHETIC AND STOMATAL RESPONSES.

J. ENVIRON. SCI. HEALTH A11, 603 (1976)

SHINN, J.H.; CLEGG, B.R.; STUART, M.L.; THOMPSON, S.E.

COYNE, P.I.

45 PHOTOSYNTHESIS AND STOMATAL RESISTANCE RESPONSE TO OZONE AND/OR HYDROGEN SULFIDE EXPOSURES IN FIELD GROWN SNAP BEANS. (ABSTRACT)

AGRONOMY ABS. 1977, 97 (1977)

BINGHAM, G.E.; COYNE, P.I.; BENNETT, J.P.; SHINN, J.H.

109 PHOTOSYNTHESIS AND STOMATAL LIGHT RESPONSE IN SNAP BEANS EXPOSED TO HYDROGEN SULFIDE AND OZONE.

J. AIR POLLUT. CONTROL ASSOC. 28, 1119-1123 (1978)

COYNE, P.I.; BINGHAM, G.E.

CRECELIUS, E.A.

- 94 CHEMICAL CHARACTERIZATION OF GASES AND VOLATILE HEAVY METALS IN GEOTHERMAL EFFLUENTS.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 579-582 (1978)
ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.; WILKERSON, C.L.; CRECELIUS, E.A.; EVANS,
J.C.
- 23 CHEMICAL FORMS OF MERCURY AND ARSENIC EMITTED BY A GEOTHERMAL POWER PLANT.
TRACE SUBSTANCES IN ENVIRONMENTAL HEALTH X. D.D. HEMPHILL, ED. PROC. CONF., UNIV. MISSOURI
PP 287-293 (1976)
CRECELIUS, E.A.; ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.
- 58 MERCURY EMISSIONS FROM GEOTHERMAL POWER PLANTS.
SCIENCE 163, 1094 (1977)
ROBERTSON, D.E.; CRECELIUS, E.A.; FRUCHTER, J.S.; LUDWICK, J.D.

CROCKETT, A.B.

- 57 STATUS OF BASELINE SAMPLING FOR ELEMENTS IN SOIL AND VEGETATION AT FOUR KGRA'S IN THE
IMPERIAL VALLEY, CALIFORNIA.
GEOTHERM. RESOUR. COUNC. TRANS. 1, 65 (1977)
CROCKETT, A.B.; WIERSMA, G.B.
- 22 TERRESTRIAL MONITORING OF ELEMENTAL CONTAMINANTS AROUND GEOTHERMAL POWER PLANTS.
GEOTHERMAL ENVIRONMENTAL SEMINAR '76. F.L. TUCKER AND M.D. ANDERSEN, EDS., GEOTHERMAL
SEMINAR, LAKEPORT, CALIF., PP. 205-211 (1976)
CROCKETT, A.B.

CROW, N.B.

- 65 AN ENVIRONMENTAL GEOLOGY WORKSHOP FOR THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCES
AREA.
UCRL-52418 (1978)
LEDBETTER, G.; CROW, N.B.
- 118 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA. VOLUME 4.
ENVIRONMENTAL GEOLOGY
CROW, N.B.

CROW, N.B. (CONTD.)

66 BASELINE MEASUREMENTS OF GEOLOGIC EVENTS CAN REMOVE POTENTIAL ROADBLOCKS TO GEOTHERMAL DEVELOPMENT. (ABSTRACT)
ABSTRACTS OF PAPERS OF THE 144TH NATIONAL MEETING, FEB. 12-17, 1978, (A. HERSCHMAN, ED.)
AAAS, WASHINGTON, D.C. (1978)
KASAMEYER, P.W.; CROW, N.B.

62 MONITORING NATURAL SUBSIDENCE AND SEISMICITY IN THE IMPERIAL VALLEY AS A BASIS FOR EVALUATING POTENTIAL IMPACTS OF GEOTHERMAL PRODUCTION.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 125 (1978)
CROW, N.B.; KASAMEYER, P.W.

74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.
UCRL-52248 (1978)
ANSPAUGH, L.R.; CROW, N.B.; GUDIKSEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.

CUNNINGHAM, K.J.

110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.
UCRL-13913 (1978)
NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

CURLEY, R.G.

27 PUMPING ENERGY REQUIREMENTS FOR IRRIGATION IN CALIFORNIA.
UCRL-13788 (1977)
KNUTSON, G.D.; CURLEY, R.G.; ROBERTS, E.B.; HAGAN, R.M.; CERVINKA, V.

DEL GRANDE, N.K.

117 RADIOMETRIC LAND-SURFACE TEMPERATURE MAPPING.
UCRL-82001 (1978)
DEL GRANDE, N.K.

DEUTSCHER, S.B.

- 56 DETERMINATION OF THE RATE OF FORMATION OF SOLIDS FROM HYPERSALINE GEOTHERMAL BRINE AS A FUNCTION OF PH.

UCID-17596 (1977)

HARRAR, J.E.; OTTO, C.H.; HILL, J.H.; MORRIS, C.J.; LIM, R.; DEUTSCHER, S.B.

ERMAK, D.L.

- 9 A DESCRIPTION OF IMPERIAL VALLEY, CALIFORNIA, FOR THE ASSESSMENT OF IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT.

UCRL-52121 (1976)

LAYTON, D.W.; ERMAK, D.L. (EDS.)

- 81 A METHODOLOGY FOR ASSESSING THE POTENTIAL IMPACT ON AIR QUALITY RESULTING FROM GEOTHERMAL RESOURCE DEVELOPMENT IN THE IMPERIAL VALLEY.

PROC. INT. CLEAN AIR CONF., CLEAN AIR SOC. AUSTRALIA AND NEW ZEALAND, BRISBANE, AUSTRALIA, MAY 15-18, PP. 719-734 (1978)

GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; LANGE, R.

- 72 A SCENARIO FOR GEOTHERMAL ELECTRIC POWER DEVELOPMENT IN IMPERIAL VALLEY.

ENERGY 3, 203 (1978)

ERMAK, D.L.

- 86 AIR QUALITY ASSESSMENT STUDIES OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 235 (1978)

GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; NYHOLM, R.A.

- 33 AN ANALYTICAL MODEL FOR AIR POLLUTANT TRANSPORT AND DEPOSITION FROM A POINT SOURCE.

ATMOSPHERIC ENVIRONMENT 11, 231 (1977)

ERMAK, D.L.

- 92 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOL. 1: ISSUES AND RECOMMENDATIONS.

UCRL-52496, VOL.1 (1978)

ERMAK, D.L.; PHELPS, P.L.

- 111 ATMAS: A THREE-DIMENSIONAL ATMOSPHERIC TRANSPORT MODEL TO TREAT MULTIPLE AREA SOURCES.

UCRL-52603 (1978)

ERMAK, D.L.; NYHOLM, R.A.; LANGE, R.

ERMAK, D.L. (CONTD.)

75 BROWNIAN DYNAMICS WITH HYDRODYNAMIC INTERACTIONS.

J. CHEM. PHYS. 69, 1352 (1978)

ERMAK, D.L.; MCCAMMON, J.A.

113 MULTIPLE SOURCE DISPERSION MODEL.

UCRL-52592 (1978)

ERMAK, D.L.; NYHOLM, R.A.

73 NUMERICAL INTEGRATION OF THE LANGEVIN EQUATION: MONTE CARLO SIMULATION.

UCRL-80735 (1978)

ERMAK, D.L.; BUCKHOLTZ, H.

32 POTENTIAL GROWTH OF ELECTRIC POWER PRODUCTION FROM IMPERIAL VALLEY GEOTHERMAL RESOURCES.

UCRL-52252 (1977)

ERMAK, D.L.

108 PRELIMINARY ENVIRONMENTAL ASSESSMENTS OF KNOWN GEOTHERMAL RESOURCE AREAS IN THE UNITED STATES.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 523 (1978).

PHELPS, P.L.; ERMAK, D.L.; ANSPAUGH, L.R.; JACKSON, C.D.; MILLER, L.A.

EVANS, J.C.

94 CHEMICAL CHARACTERIZATION OF GASES AND VOLATILE HEAVY METALS IN GEOTHERMAL EFFLUENTS.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 579-582 (1978)

ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.; WILKERSON, C.L.; CRECELIUS, E.A.; EVANS, J.C.

FRUCHTER, J.S.

94 CHEMICAL CHARACTERIZATION OF GASES AND VOLATILE HEAVY METALS IN GEOTHERMAL EFFLUENTS.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 579-582 (1978)

ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.; WILKERSON, C.L.; CRECELIUS, E.A.; EVANS, J.C.

23 CHEMICAL FORMS OF MERCURY AND ARSENIC EMITTED BY A GEOTHERMAL POWER PLANT.

TRACE SUBSTANCES IN ENVIRONMENTAL HEALTH X. D.D. HEMPHILL, ED. PROC. CONF., UNIV. MISSOURI PP 287-293 (1976)

CRECELIUS, E.A.; ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.

FRUCHTER, J.S. (CONTD.)

58 MERCURY EMISSIONS FROM GEOTHERMAL POWER PLANTS.

SCIENCE 163, 1094 (1977)

ROBERTSON, D.E.; CRECELIUS, E.A.; FRUCHTER, J.S.; LUDWICK, J.D.

FUIS, G.

38 PRELIMINARY CATALOG OF EARTHQUAKES IN NORTHERN IMPERIAL VALLEY, OCTOBER 1, 1976 TO DECEMBER 1976.

U.S. GEOLOGICAL SURVEY, PASADENA, CALIF. REPORT (1977)

SCHNAPP, M.; FUIS, G.

35 THE NOVEMBER-DECEMBER 1976 EARTHQUAKE SWARMS IN NORTHERN IMPERIAL VALLEY, CALIF.:

SEISMICITY ON THE BRAWLEY FAULT AND RELATED STRUCTURES. (ABSTRACT)

TRANS. AMER. GEOPHYS. UNION (EOS) 58, 1188 (1977)

FUIS, G.; SCHNAPP, M.

GARRETT, R.E.

99 USES OF WARMED WATER IN AGRICULTURE. FINAL REPORT.

UCRL-13930 (1978)

GARRETT, R.E.

GOLDMAN, G.

39 GOVERNMENTAL COSTS AND REVENUES ASSOCIATED WITH GEOTHERMAL ENERGY DEVELOPMENT IN IMPERIAL COUNTY.

UCRL-13800 (1977)

GOLDMAN, G.; STRONG, D.

GRANT, G.S.

63 OBSERVATIONS ON WATER BIRD FLIGHT PATTERNS AT SALTON SEA, CALIFORNIA, OCTOBER 1976 - FEBRUARY 1977.

UCRL-13818 (1978)

LEITNER, P.; GRANT, G.S.

GUDIKNEN, P.H.

- 81 A METHODOLOGY FOR ASSESSING THE POTENTIAL IMPACT ON AIR QUALITY RESULTING FROM GEOTHERMAL RESOURCE DEVELOPMENT IN THE IMPERIAL VALLEY.

PROC. INT. CLEAN AIR CONF., CLEAN AIR SOC. AUSTRALIA AND NEW ZEALAND, BRISBANE, AUSTRALIA, MAY 15-18, PP. 719-734 (1978)

GUDIKNEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; LANGE, R.

- 86 AIR QUALITY ASSESSMENT STUDIES OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 235 (1978)

GUDIKNEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; NYHOLM, R.A.

- 40 GEOTHERMAL ASSESSMENT AND AIR QUALITY.

PROGRAM REPORT - FY 1977; ATMOSPHERIC AND GEOPHYSICAL SCIENCES DIV., PHYSICS DEPT. J.B. KNOX AND R.C. ORPHAN, EDS. UCRL-51444-77, PP. 27-36 (1977)

GUDIKNEN, P.H.

- 74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.

UCRL-52248 (1978)

ANSPAUGH, L.R.; CROW, N.B.; GUDIKNEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.

HAGAN, R.M.

- 27 PUMPING ENERGY REQUIREMENTS FOR IRRIGATION IN CALIFORNIA.

UCRL-13788 (1977)

KNUTSON, G.D.; CURLEY, R.G.; ROBERTS, E.B.; HAGAN, R.M.; CERVINKA, V.

HARRAR, J.E.

- 56 DETERMINATION OF THE RATE OF FORMATION OF SOLIDS FROM HYPERSALINE GEOTHERMAL BRINE AS A FUNCTION OF PH.

UCID-17596 (1977)

HARRAR, J.E.; OTTO, C.H.; HILL, J.H.; MORRIS, C.J.; LIM, R.; DEUTSCHER, S.B.

HARRISON, D.P.

- 110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.

UCRL-13913 (1978)

NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

HAVEN, K.F.

- 74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.

UCRL-52248 (1978)

ANSPAUGH, L.R.; CROW, N.B.; GUDIKSEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.

- 6 THE 1972 FLOW OF ELECTRICAL ENERGY IN CALIFORNIA AND ITS RELATIONSHIP TO SELECTED COUNTY LEVEL CHARACTERISTIC PARAMETERS.

UCRL-52143 (1976)

HAVEN, K.F.

HILDING, R.K.

- 110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.

UCRL-13913 (1978)

NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

HILL, A.C.

- 114 ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL. 1.

UCRL-13955 VOL.1 (1978)

WHITE, K.L.; HILL, A.C.; URSENBACH, W.O. (EDS.)

- 115 ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL.2.

UCRL-13955 VOL.2 (1978)

WHITE, K.L.; HILL, A.C.; URSENBACH, W.O. (EDS.)

HILL, J.H.

- 56 DETERMINATION OF THE RATE OF FORMATION OF SOLIDS FROM HYPERSALINE GEOTHERMAL BRINE AS A FUNCTION OF PH.
UCID-17596 (1977)
HARRAR, J.E.; OTTO, C.H.; HILL, J.H.; MORRIS, C.J.; LIM, R.; DEUTSCHER, S.B.
- 87 IDENTIFICATION OF ENVIRONMENTAL CONTROL TECHNOLOGIES FOR GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY OF CALIFORNIA.
UCRL-52548 (1978)
SNOEBERGER, D.F.; HILL, J.H.
- 20 POSSIBILITIES FOR CONTROLLING HEAVY METAL SULFIDES IN SCALE FROM GEOTHERMAL BRINES.
UCRL-51977 (1976)
JACKSON, D.D.; HILL, J.H.
- 54 REMOVAL OF SILICA FROM SPENT GEOTHERMAL BRINE.
UCID-17702 (1977)
RYON, R.W.; HILL, J.H.
- 17 SAMPLING A TWO-PHASE GEOTHERMAL BRINE FLOW FOR CHEMICAL ANALYSIS.
SAMPLING GEOTHERMAL EFFLUENTS, PROC. 1ST WORKSHOP, OCT. 20-21, 1975, LAS VEGAS, NEVADA, EPA-600/9-76-011, PP. 181-203 (1976)
HILL, J.H.; MORRIS, C.J.
- 67 SAMPLING AND CHARACTERIZATION OF SUSPENDED SOLIDS IN BRINE FROM MAGMAMAX NO.1 WELL.
SAMPLING GEOTHERMAL EFFLUENTS, PROC. 2ND WORKSHOP, FEB. 15-17, LAS VEGAS, NEVADA. EPA-600/7-78-121, PP. 46-54 (1978) YR 1978
HILL, J.H.; OTTO, C.H.
- 53 SCALE AND SOLIDS DEPOSITION IN THE SDG&E/U.S. ERDA GEOTHERMAL LOOP EXPERIMENTAL FACILITY AT NILAND, CALIFORNIA.
GEOTHERM. RESOUR. COUNC. TRANS. 1, 249 (1977)
QUONG, R.; BISHOP, H.K.; HILL, J.H.
- 52 SOLIDS CONTROL FOR HIGH SALINITY GEOTHERMAL BRINES.
GEOTHERM. RESOUR. COUNC. TRANS. 1, 139 (1977)
HILL, J.H.; OTTO, C.H.; MORRIS, C.J.

HOWARD, J.H.

- 1 GEOTHERMAL DEVELOPMENT OF THE SALTON TROUGH, CALIFORNIA AND MEXICO.
UCRL-51775 (1975)
PALMER, T.D.; HOWARD, J.H.; LANDE, D.P. (EDS.)

- 3 THE LLL GEOTHERMAL ENERGY DEVELOPMENT PROGRAM STATUS REPORT, JANUARY 1975 THROUGH AUGUST 1975.
UCID-16954 (1975)
AUSTIN, A.L.; HOWARD, J.H.; LUNDBERG, A.W.; TARDIFF, G.E.

IRELAND, R.R.

- 71 ACUTE TOXICITY OF GEOTHERMAL EFFLUENTS TO FRY OF TILAPIA ZILLII. (ABSTRACT).
ABSTRACTS OF PAPERS PRESENTED AT THE AMERICAN FISHERIES SOCIETY 108TH ANNUAL MEETING, AUGUST 20-25, 1978. UNIV. RHODE ISLAND, KINGSTON, R.I. P.41 (1978)
IRELAND, R.R.

- 85 CHEMICAL FINGERPRINTS TO ASSESS THE EFFECTS OF GEOTHERMAL DEVELOPMENT ON WATER QUALITY IN IMPERIAL VALLEY.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 527 (1978)
PIMENTEL, K.D.; IRELAND, R.R.; TOMPKINS, G.A.

- 100 IMPACT OF A GEOTHERMAL DEVELOPMENT UPON A WEED CONTROL FISH, TILAPIA ZILLII, IN IMPERIAL VALLEY, CALIFORNIA. (ABSTRACT)
UCRL-81037 (1978)
IRELAND, R.R.

JACKSON, C.D.

- 108 PRELIMINARY ENVIRONMENTAL ASSESSMENTS OF KNOWN GEOTHERMAL RESOURCE AREAS IN THE UNITED STATES.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 523 (1978)
PHELPS, P.L.; ERMAK, D.L.; ANSPAUGH, L.R.; JACKSON, C.D.; MILLER, L.A.

JACKSON, D.D.

- 20 POSSIBILITIES FOR CONTROLLING HEAVY METAL SULFIDES IN SCALE FROM GEOTHERMAL BRINES.
UCRL-51977 (1976)
JACKSON, D.D.; HILL, J.H.

JOHNSON, C.E.

- 36 SWARM TECTONICS OF THE IMPERIAL AND BRAWLEY FAULTS OF SOUTHERN CALIFORNIA. (ABSTRACT).
TRANS. AMER. GEOPHYS. UNION (EOS) 58, 1188 (1977)
JOHNSON, C.E.

JURY, W.A.

- 64 SOLUTE-TRAVEL TIME ESTIMATES FOR TILE-DRAINED FIELDS III. REMOVAL OF A GEOTHERMAL BRINE
SPILL FROM SOIL BY LEACHING.
UCRL-13792 (1978)
JURY, W.A.; WEEKS, L.V.

KASAMEYER, P.W.

- 66 BASELINE MEASUREMENTS OF GEOLOGIC EVENTS CAN REMOVE POTENTIAL ROADBLOCKS TO GEOTHERMAL
DEVELOPMENT. (ABSTRACT)
ABSTRACTS OF PAPERS OF THE 144TH NATIONAL MEETING, FEB. 12-17, 1978, (A. HERSCHMAN, ED.)
AAAS, WASHINGTON, D.C. (1978)
KASAMEYER, P.W.; CROW, N.B.

- 62 MONITORING NATURAL SUBSIDENCE AND SEISMICITY IN THE IMPERIAL VALLEY AS A BASIS FOR
EVALUATING POTENTIAL IMPACTS OF GEOTHERMAL PRODUCTION.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 125 (1978)
CROW, N.B.; KASAMEYER, P.W.

- 101 PREDICTION OF SUBSIDENCE DUE TO HOT BRINE PRODUCTION IN THE SALTON SEA GEOTHERMAL FIELD.
UCRL-80984 (1978)
SCHATZ, J.F.; CHENEY, J.A.; KASAMEYER, P.W.

KATS, G.

- 104 EFFECTS OF CONTINUOUS HYDROGEN SULFIDE FUMIGATION ON CROP AND FOREST PLANTS.
ENVIRON. SCI. TECHNOL. 12, 550 (1978)
THOMPSON, C.R.; KATS, G.

- 43 EFFECTS OF H₂S, H₂S+CO₂, AND SO₂ ON LETTUCE, SUGAR BEETS, ALFALFA, AND COTTON.
UCRL-13782 (1977)
THOMPSON, C.R.; KATS, G.

KERCHER, J.R.

79 A GENERAL CROP GROWTH MODEL FOR SIMULATING IMPACTS OF GASEOUS EFFLUENTS FROM GEOTHERMAL TECHNOLOGIES.
PROC. 1978 SUMMER COMPUTER SIMULATION CONF. PP. 526-531 (1978)
KERCHER, J.R.

112 A MODEL OF LEAF PHOTOSYNTHESIS AND THE EFFECTS OF SIMPLE GASEOUS COMPOUNDS (H₂S AND SO₂).
UCRL-52643 (1978)
KERCHER, J.R.

8 A MODEL OF PHOTOSYNTHESIS AND GROWTH IN PLANTS UNDER STRESS BY GASEOUS POLLUTANTS.
(ABSTRACT)
BULL. ECOL. SOC. AMER. 57, 36 (1976)
KERCHER, J.R.

97 ASSESSMENTS OF GEOTHERMAL POLLUTANT IMPACTS ON SUGAR BEETS USING COMPUTER MODELING.
(ABSTRACT)
BULL. ECOL. SOC. AMER. 59, 77 (1978)
KERCHER, J.R.

96 CLOSED FORM SOLUTIONS TO THE SENSITIVITY EQUATIONS IN THE FREQUENCY DOMAIN AND TIME DOMAIN FOR LINEAR MODELS OF ECOSYSTEMS.
UCRL-81340 (1978)
KERCHER, J.R.

103 ECOLOGICAL EFFECTS OF ATMOSPHERIC RELEASES FROM SYNTHETIC FUELS PROCESSES.
UCRL-81691 (1978)
SHINN, J.H.; KERCHER, J.R.

50 GROW1: A CROP GROWTH MODEL FOR ASSESSING IMPACTS OF GASEOUS POLLUTANTS FROM GEOTHERMAL TECHNOLOGIES.
UCRL-52247 (1977)
KERCHER, J.R.

90 REGIONAL ASSESSMENT OF AIR POLLUTION IMPACT ON VEGETATION BY MATHEMATICAL MODELING.
ANNUAL PROGRESS REPORT ON STUDIES OF AIR POLLUTION EFFECTS ON VEGETATION. UCID-17714 PP. 27-29 (1978)
SHINN, J.H. KERCHER, J.R.

KERCHER, J.R. (CONTD.)

- 26 SIMULATIONS OF EFFECTS OF GEOTHERMAL POLLUTANTS ON CROP GROWTH USING A COMPUTER PLANT MODEL. (ABSTRACT)
BULL. ECOL. SOC. AMER. 58, 56 (1977)
KERCHER, J.R.

KINNEAR, J.E.

- 51 BASELINE STUDIES IN THE DESERT ECOSYSTEM AT EAST MESA GEOTHERMAL TEST SITE, IMPERIAL VALLEY, CALIFORNIA.
UCLA-12-1143 (1977)
ROMNEY, E.M.; WALLACE, A.; LUNT, O.R.; ACKERMAN, T.A.; KINNEAR, J.E.

KNUTSON, G.D.

- 27 PUMPING ENERGY REQUIREMENTS FOR IRRIGATION IN CALIFORNIA.
UCRL-13788 (1977)
KNUTSON, G.D.; CURLEY, R.G.; ROBERTS, E.B.; HAGAN, R.M.; CERVINKA, V.

KRONE, R.B.

- 91 GEYSERS-CALISTOGA KGRA GEOTHERMAL ENVIRONMENTAL OVERVIEW: WATER QUALITY.
RMA-7100 (1978)
MOORE, S.F.; PIMENTEL, K.D.; KRONE, R.B.

LAMSON, K.C.

- 81 A METHODOLOGY FOR ASSESSING THE POTENTIAL IMPACT ON AIR QUALITY RESULTING FROM GEOTHERMAL RESOURCE DEVELOPMENT IN THE IMPERIAL VALLEY.
PROC. INT. CLEAN AIR CONF., CLEAN AIR SOC. AUSTRALIA AND NEW ZEALAND, BRISBANE, AUSTRALIA, MAY 15-18, PP. 719-734 (1978)
GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; LANGE, R.

- 86 AIR QUALITY ASSESSMENT STUDIES OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 235 (1978)
GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; NYHOLM, R.A.

LANDE, D.P.

- 1 GEOTHERMAL DEVELOPMENT OF THE SALTON TROUGH, CALIFORNIA AND MEXICO.
UCRL-51775 (1975)
PALMER, T.D.; HOWARD, J.H.; LANDE, D.P. (EDS.)

LANGE, R.

- 81 A METHODOLOGY FOR ASSESSING THE POTENTIAL IMPACT ON AIR QUALITY RESULTING FROM GEOTHERMAL RESOURCE DEVELOPMENT IN THE IMPERIAL VALLEY.
PROC. INT. CLEAN AIR CONF., CLEAN AIR SOC. AUSTRALIA AND NEW ZEALAND, BRISBANE, AUSTRALIA, MAY 15-18, PP. 719-734 (1978)
GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; LANGE, R.

- 111 ATMAS: A THREE-DIMENSIONAL ATMOSPHERIC TRANSPORT MODEL TO TREAT MULTIPLE AREA SOURCES.
UCRL-52603 (1978)
ERMAK, D.L.; NYHOLM, R.A.; LANGE, R.

LAYTON, D.W.

- 9 A DESCRIPTION OF IMPERIAL VALLEY, CALIFORNIA, FOR THE ASSESSMENT OF IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT.
UCRL-52121 (1976)
LAYTON, D.W.; ERMAK, D.L. (EDS.)

- 80 WATER FOR LONG TERM GEOTHERMAL ENERGY PRODUCTION IN THE IMPERIAL VALLEY.
UCRL-52576 (1978)
LAYTON, D.W.

- 83 WATER SUPPLY DILEMMAS OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY OF CALIFORNIA.
WATER RES. BULL. 14, 133-143 (1978)
LAYTON, D.W.

LEDBETTER, G.

- 65 AN ENVIRONMENTAL GEOLOGY WORKSHOP FOR THE GEYSERS-CALISTOGA KNOWN GEOTHERMAL RESOURCES AREA.
UCRL-52418 (1978)
LEDBETTER, G.; CROW, N.B.

LEITNER, P.

93 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOL. 3: NOISE.

UCRL-52496, VOL.3 (1978)

LEITNER, P.

106 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOLUME 5 ECOSYSTEM QUALITY.

UCRL-52496, VOL.5 (1978)

LEITNER, P.

63 OBSERVATIONS ON WATER BIRD FLIGHT PATTERNS AT SALTON SEA, CALIFORNIA, OCTOBER 1976 - FEBRUARY 1977.

UCRL-13818 (1978)

LEITNER, P.; GRANT, G.S.

LEWIS, M.

15 THE LEGISLATIVE HISTORY OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT.

UCRL-52188 (1976)

WHARTON, J.C.; LEWIS, M.

LIM, R.

56 DETERMINATION OF THE RATE OF FORMATION OF SOLIDS FROM HYPERSALINE GEOTHERMAL BRINE AS A FUNCTION OF PH.

UCID-17596 (1977)

HARRAR, J.E.; OTTO, C.H.; HILL, J.H.; MORRIS, C.J.; LIM, R.; DEUTSCHER, S.B.

LORENZ, R.W.

13 MEASUREMENTS OF RADIOACTIVITY IN COOLING TOWER SLUDGE AT THE GEYSERS GEOTHERMAL FIELD, CALIFORNIA. (ABSTRACT)

HEALTH PHYS. 31, 532 (1976)

SERPA, D.P.; LORENZ, R.W.; ANSPAUGH, L.R.

LUDWICK, J.D.

- 94 CHEMICAL CHARACTERIZATION OF GASES AND VOLATILE HEAVY METALS IN GEOTHERMAL EFFLUENTS.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 579-582 (1978)
ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.; WILKERSON, C.L.; CRECELIUS, E.A.; EVANS,
J.C.
- 23 CHEMICAL FORMS OF MERCURY AND ARSENIC EMITTED BY A GEOTHERMAL POWER PLANT.
TRACE SUBSTANCES IN ENVIRONMENTAL HEALTH X. D.D. HEMPHILL, ED. PROC. CONF., UNIV. MISSOURI
PP 287-293 (1976)
CRECELIUS, E.A.; ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.
- 58 MERCURY EMISSIONS FROM GEOTHERMAL POWER PLANTS.
SCIENCE 163, 1094 (1977)
ROBERTSON, D.E.; CRECELIUS, E.A.; FRUCHTER, J.S.; LUDWICK, J.D.

LUNDBERG, A.W.

- 3 THE LLL GEOTHERMAL ENERGY DEVELOPMENT PROGRAM STATUS REPORT, JANUARY 1975 THROUGH AUGUST
1975.
UCID-16954 (1975)
AUSTIN, A.L.; HOWARD, J.H.; LUNDBERG, A.W.; TARDIFF, G.E.
- 55 THE LLL GEOTHERMAL ENERGY PROGRAM STATUS REPORT JANUARY 1976 - JANUARY 1977.
UCRL-50046-76 (1977)
AUSTIN, A.L.; LUNDBERG, A.W.; OWEN, L.B.; TARDIFF, G.E.

LUNT, O.R.

- 51 BASELINE STUDIES IN THE DESERT ECOSYSTEM AT EAST MESA GEOTHERMAL TEST SITE, IMPERIAL
VALLEY, CALIFORNIA.
UCLA-12-1143 (1977)
ROMNEY, E.M.; WALLACE, A.; LUNT, O.R.; ACKERMAN, T.A.; KINNEAR, J.E.

MATTIGOD, S.V.

- 49 ESTIMATED ASSOCIATION CONSTANTS FOR SOME COMPLEXES OF TRACE METALS WITH INORGANIC LIGANDS.
SOIL SCI. SOC. AMER. J. 41, 1092 (1977)
MATTIGOD, S.V.; SPOSITO, G.

MATTIGOD, S.V. (CONTD.)

- 47 ON THE CHEMICAL FOUNDATION OF THE SODIUM ADSORPTION RATIO.
SOIL SCI. SOC. AMER. J. 41, 323 (1977)
SPOSITO, G.; MATTIGOD, S.V.

MCCALEB, C.S.

- 5 IMPERIAL VALLEY ENVIRONMENTAL PROJECT.
ENERGY AND TECHNOLOGY REVIEW, MAY 1976. UCRL-52000-76-5, PP. 21-26 (1976)
ANSPAUGH, L.R.; MCCALEB, C.S.

MCCAMMON, J.A.

- 75 BROWNIAN DYNAMICS WITH HYDRODYNAMIC INTERACTIONS.
J. CHEM. PHYS. 69, 1352 (1978)
ERMAK, D.L.; MCCAMMON, J.A.

MILLER, L.A.

- 108 PRELIMINARY ENVIRONMENTAL ASSESSMENTS OF KNOWN GEOTHERMAL RESOURCE AREAS IN THE UNITED STATES.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 523 (1978)
PHELPS, P.L.; ERMAK, D.L.; ANSPAUGH, L.R.; JACKSON, C.D.; MILLER, L.A.

MILLS, W.L.

- 82 BIOASSAY PROCEDURES TO EVALUATE THE ACUTE TOXICITY OF SALINITY, PESTICIDES, AND GEOTHERMAL POLLUTANTS TO GAMBUSIA AFFINIS.
UCRL-13382 (1978)
MILLS, W.L.

MOLENKAMP, C.R.

- 105 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOLUME 2 AIR QUALITY.
UCRL-52496, VOL.2 (1978)
ROSEN, L.C.; MOLENKAMP, C.R.

MOORE, S.F.

- 91 GEYSERS-CALISTOGA KGRA GEOTHERMAL ENVIRONMENTAL OVERVIEW: WATER QUALITY.
RMA-7100 (1978)
MOORE, S.F.; PIMENTEL, K.D.; KRONE, R.B.

MORRIS, C.J.

- 56 DETERMINATION OF THE RATE OF FORMATION OF SOLIDS FROM HYPERSALINE GEOTHERMAL BRINE AS A
FUNCTION OF PH.
UCID-17596 (1977)
HARRAR, J.E.; OTTO, C.H.; HILL, J.H.; MORRIS, C.J.; LIM, R.; DEUTSCHER, S.B.

- 17 SAMPLING A TWO-PHASE GEOTHERMAL BRINE FLOW FOR CHEMICAL ANALYSIS.
SAMPLING GEOTHERMAL EFFLUENTS, PROC. 1ST WORKSHOP, OCT. 20-21, 1975, LAS VEGAS, NEVADA,
EPA-600/9-76-011, PP. 181-203 (1976)
HILL, J.H.; MORRIS, C.J.

- 52 SOLIDS CONTROL FOR HIGH SALINITY GEOTHERMAL BRINES.
GEOTHERM. RESOUR. COUNC. TRANS. 1, 139 (1977)
HILL, J.H.; OTTO, C.H.; MORRIS, C.J.

MORRIS, G.L.

- 61 WATER QUALITY MANAGEMENT FOR IMPERIAL VALLEY GEOTHERMAL DEVELOPMENT.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 631 (1978)
SWAJIAN, A.; MORRIS, G.L.; PIMENTEL, K.D.

MULLER, R.A.

- 110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN
THE LOUISIANA GULF COAST REGION.
UCRL-13913 (1978)
NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.;
NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

NEWCHURCH, E.J.

- 110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.

UCRL-13913 (1978)

NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

NEWMAN, J.P.

- 110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.

UCRL-13913 (1978)

NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

NYHOLM, R.A.

- 86 AIR QUALITY ASSESSMENT STUDIES OF GEOTHERMAL DEVELOPMENT IN THE IMPERIAL VALLEY.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 235 (1978)

GUDIKSEN, P.H.; AXELROD, M.C.; ERMAK, D.L.; LAMSON, K.C.; NYHOLM, R.A.

- 111 ATMAS: A THREE-DIMENSIONAL ATMOSPHERIC TRANSPORT MODEL TO TREAT MULTIPLE AREA SOURCES.

UCRL-52603 (1978)

ERMAK, D.L.; NYHOLM, R.A.; LANGE, R.

- 28 IMPERIAL VALLEY ENVIRONMENTAL PROJECT: QUARTERLY DATA REPORT.

UCID-17444-1 (1977)

NYHOLM, R.A.; ANSPAUGH, L.R. (COMP. AND EDS.)

- 113 MULTIPLE SOURCE DISPERSION MODEL.

UCRL-52592 (1978)

ERMAK, D.L.; NYHOLM, R.A.

OGLESBY, L.C.

- 69 REPRODUCTION AND SURVIVAL OF THE PILEWORM NEREIS SUCCINEA IN HIGHER SALTON SEA SALINITIES.

UCRL-13848 (1978)

OGLESBY, L.C.

OHMART, R.D.

102 HABITAT REQUIREMENTS AND POPULATION CHARACTERISTICS OF THE CLAPPER RAIL (*RALLUS LONGIROSTRIS YUMANENSIS*) IN THE IMPERIAL VALLEY OF CALIFORNIA.
UCRL-13813 (1978)
BENNETT, W.W.; OHMART, R.D.

OTTO, C.H.

56 DETERMINATION OF THE RATE OF FORMATION OF SOLIDS FROM HYPERSALINE GEOTHERMAL BRINE AS A FUNCTION OF PH.
UCID-17596 (1977)
HARRAR, J.E.; OTTO, C.H.; HILL, J.H.; MORRIS, C.J.; LIM, R.; DEUTSCHER, S.B.

67 SAMPLING AND CHARACTERIZATION OF SUSPENDED SOLIDS IN BRINE FROM MAGMAMAX NO.1 WELL.
SAMPLING GEOTHERMAL EFFLUENTS, PROC. 2ND WORKSHOP, FEB. 15-17, LAS VEGAS, NEVADA. EPA-600/7-78-121, PP. 46-54 (1978) YR 1978
HILL, J.H.; OTTO, C.H.

52 SOLIDS CONTROL FOR HIGH SALINITY GEOTHERMAL BRINES.
GEOTHERM. RESOUR. COUNC. TRANS. 1, 139 (1977)
HILL, J.H.; OTTO, C.H.; MORRIS, C.J.

OWEN, L.B.

55 THE LLL GEOTHERMAL ENERGY PROGRAM STATUS REPORT JANUARY 1976 - JANUARY 1977.
UCRL-50046-76 (1977)
AUSTIN, A.L.; LUNDBERG, A.W.; OWEN, L.B.; TARDIFF, G.E.

PAGE, A.L.

24 TRACE METAL SPECIATION IN SALINE WATERS AFFECTED BY GEOTHERMAL BRINES.
UCRL-13790 (1977)
SPOSITO, G.; PAGE, A.L.

PALMER, T.D.

2 CHARACTERISTICS OF GEOTHERMAL WELLS LOCATED IN THE SALTON SEA GEOTHERMAL FIELD, IMPERIAL COUNTY, CALIFORNIA.
UCRL-51976 (1975)
PALMER, T.D.

PALMER, T.D. (CONTD.)

- 1 GEOTHERMAL DEVELOPMENT OF THE SALTON TROUGH, CALIFORNIA AND MEXICO.
UCRL-51775 (1975)
PALMER, T.D.; HOWARD, J.H.; LANDE, D.P. (EDS.)

PALMER, T.Y.

- 42 CLIMATOLOGY AND AIR QUALITY OF LONG VALLEY GEOTHERMAL RESOURCE AREA.
UCID-17459, REV.1 (1977)
PETERSON, K.R.; PALMER, T.Y.

PETERSON, K.R.

- 42 CLIMATOLOGY AND AIR QUALITY OF LONG VALLEY GEOTHERMAL RESOURCE AREA.
UCID-17459, REV.1 (1977)
PETERSON, K.R.; PALMER, T.Y.

PHELPS, P.L.

- 92 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOL. 1: ISSUES AND RECOMMENDATIONS.
UCRL-52496, VOL.1 (1978)
ERMAK, D.L.; PHELPS, P.L.

- 4 AN OVERVIEW OF THE IMPERIAL VALLEY ENVIRONMENTAL PROJECT.
UCID-17067 (1976)
ANSPAUGH, L.R.; PHELPS, P.L. (EDS.)

- 98 ENVIRONMENTAL ASSESSMENT REPORT (EAR) FOR GEOTHERMAL ENERGY SYSTEMS.
UCRL-81910 (1978)
ANSPAUGH, L.R.; PHELPS, P.L.

- 76 ENVIRONMENTAL READINESS DOCUMENT. HYDROTHERMAL ELECTRIC AND DIRECT HEAT.
COMMERCIALIZATION PHASE III PLANNING.
DOE/ERD-0005 (1978)
ANSPAUGH, L.R.; PHELPS, P.L. (CONTRIBUTING AUTHORS)

- 10 IMPERIAL VALLEY ENVIRONMENTAL PROJECT, PROGRESS REPORT.
UCRL-50044-76-1 (1976)
PHELPS, P.L.; ANSPAUGH, L.R. (EDS.)

PHELPS, P.L. (CONTD.)

- 74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.

UCRL-52248 (1978)

ANSPAUGH, L.R.; CROW, N.B.; GUDIKSEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.

- 108 PRELIMINARY ENVIRONMENTAL ASSESSMENTS OF KNOWN GEOTHERMAL RESOURCE AREAS IN THE UNITED STATES.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 523 (1978)

PHELPS, P.L.; ERMAK, D.L.; ANSPAUGH, L.R.; JACKSON, C.D.; MILLER, L.A.

- 30 THE GEYSERS GEOTHERMAL POWER PLANT: ENVIRONMENTAL IMPACT OF THE RELEASE OF 222-RN.

PG&E REPORT 420-77.22 (1977)

SERPA, D.P.; ANSPAUGH, L.R.; PHELPS, P.L.; SOINSKI, A.J.

PIMENTEL, K.D.

- 119 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA. VOLUME 6. WATER QUALITY

PIMENTEL, K.D.

- 84 ASYMPTOTIC ESTIMATION ERROR GROWTH APPLIED TO MONITORING.

APPLICATIONS OF KALMAN FILTER TO HYDROLOGY, HYDRAULICS, AND WATER RESOURCES. PROC. AGU CHAPMAN CONF., PITTSBURGH, PA., MAY 1978. UNIV. PITTSBURGH, PP. 681-690 (1978)

PIMENTEL, K.D.

- 85 CHEMICAL FINGERPRINTS TO ASSESS THE EFFECTS OF GEOTHERMAL DEVELOPMENT ON WATER QUALITY IN IMPERIAL VALLEY.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 527 (1978)

PIMENTEL, K.D.; IRELAND, R.R.; TOMPKINS, G.A.

- 95 GEOTHERMAL ENVIRONMENTAL RESEARCH.

MECHANICAL ENGINEERING DEPARTMENT RESEARCH ENGINEERING DIVISION; 1977 ACTIVITIES HIGHLIGHTS REPORT. T. MERRILL, ED. UCID-17804-77, PP. 35-46 (1978)

PIMENTEL, K.D.

- 91 GEYSERS-CALISTOGA KGRA GEOTHERMAL ENVIRONMENTAL OVERVIEW: WATER QUALITY.

RMA-7100 (1978)

MOORE, S.F.; PIMENTEL, K.D.; KRONE, R.B.

PIMENTEL, K.D. (CONTD.)

- 74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.

UCRL-52248 (1978)

ANSPAUGH, L.R.; CROW, N.B.; GUDIKSEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.

- 41 SURVEY OF MODELS TO PREDICT THE EFFECT OF GEOTHERMAL POWER DEVELOPMENT ON DOMESTIC WATER SUPPLIES AND TO DESIGN POLLUTION MONITORING NETWORKS.

MODELING, IDENTIFICATION AND CONTROL IN ENVIRONMENTAL SYSTEMS, G.C. VANSTEENKISTE, ED., NORTH-HOLLAND PUB. CO., AMSTERDAM, PP. 651-662 (1978)

PIMENTEL, K.D.

- 21 THE ENVIRONMENTAL MONITORING PROBLEM; OPTIMAL SOLUTIONS FOR CONTROL AND SURVEILLANCE APPLICATIONS IN THE CASE OF INFREQUENT SAMPLING.

MODELING, IDENTIFICATION AND CONTROL IN ENVIRONMENTAL SYSTEMS, G.C. VANSTEENKISTE, ED., NORTH-HOLLAND PUB. CO., AMSTERDAM, PP. 89-99 (1978)

PIMENTEL, K.D.

- 61 WATER QUALITY MANAGEMENT FOR IMPERIAL VALLEY GEOTHERMAL DEVELOPMENT.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 631 (1978)

SWAJIAN, A.; MORRIS, G.L.; PIMENTEL, K.D.

- 107 WATER QUALITY STUDY IMPORTANT IN DEVELOPING THE IMPERIAL VALLEY AS A GEOTHERMAL ENERGY RESOURCE.

MECHANICAL ENGINEERING DEPARTMENT QUARTERLY REVIEW JULY THROUGH SEPTEMBER, 1978. UCRL-50016-78-3, PP. 14-19 (1978)

PIMENTEL, K.D.

PRUITT, W.O.

- 34 REGIONAL CROP WATER USE, IMPERIAL VALLEY.

UCRL-13742 (1977)

PRUITT, W.O.

QUONG, R.

- 53 SCALE AND SOLIDS DEPOSITION IN THE SDG&E/U.S. ERDA GEOTHERMAL LOOP EXPERIMENTAL FACILITY AT NILAND, CALIFORNIA.

GEOTHERM. RESOUR. COUNC. TRANS. 1, 249 (1977)

QUONG, R.; BISHOP, H.K.; HILL, J.H.

QUONG, R. (CONTD.)

19 SCALING CHARACTERISTICS IN THE GEOTHERMAL LOOP EXPERIMENTAL FACILITY AT N1LAND,
CALIFORNIA.
UCRL-52162 (1976)
QUONG, R.

18 THE LLL GEOTHERMAL INDUSTRIAL SUPPORT PROGRAM IN CHEMISTRY AND MATERIALS FOR FY76 AND
FY77.
UCID-17209 (1976)
QUONG, R.

REESE, S.M.

37 PRELIMINARY RESULTS OF THE 1976-1977 IMPERIAL VALLEY LEVELING SURVEYS.
NATIONAL GEODETIC SURVEY REPORT (1977)
REESE, S.M.

REHAGE, J.A.

110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN
THE LOUISIANA GULF COAST REGION.
UCRL-13913 (1978)
NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.;
NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

ROBERTS, E.B.

27 PUMPING ENERGY REQUIREMENTS FOR IRRIGATION IN CALIFORNIA.
UCRL-13788 (1977)
KNUTSON, G.D.; CURLEY, R.G.; ROBERTS, E.B.; HAGAN, R.M.; CERVINKA, V.

ROBERTSON, D.E.

94 CHEMICAL CHARACTERIZATION OF GASES AND VOLATILE HEAVY METALS IN GEOTHERMAL EFFLUENTS.
GEOTHERM. RESOUR. COUNC. TRANS. 2, 579-582 (1978)
ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.; WILKERSON, C.L.; CRECELIUS, E.A.; EVANS,
J.C.

ROBERTSON, D.E. (CONTD.)

- 23 CHEMICAL FORMS OF MERCURY AND ARSENIC EMITTED BY A GEOTHERMAL POWER PLANT.
TRACE SUBSTANCES IN ENVIRONMENTAL HEALTH X. D.D. HEMPHILL, ED. PROC. CONF., UNIV. MISSOURI
PP 287-293 (1976)
CRECELIUS, E.A.; ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.

- 58 MERCURY EMISSIONS FROM GEOTHERMAL POWER PLANTS.
SCIENCE 163, 1094 (1977)
ROBERTSON, D.E.; CRECELIUS, E.A.; FRUCHTER, J.S.; LUDWICK, J.D.

ROBISON, W.L.

- 74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA,
IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.
UCRL-52248 (1978)
ANSPAUGH, L.R.; CROW, N.B.; GUDIKSEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.;
ROBISON, W.L.; SHINN, J.H.

ROMNEY, E.M.

- 51 BASELINE STUDIES IN THE DESERT ECOSYSTEM AT EAST MESA GEOTHERMAL TEST SITE, IMPERIAL
VALLEY, CALIFORNIA.
UCLA-12-1143 (1977)
ROMNEY, E.M.; WALLACE, A.; LUNT, O.R.; ACKERMAN, T.A.; KINNEAR, J.E.

ROSEN, L.C.

- 105 AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA, VOLUME 2
AIR QUALITY.
UCRL-52496, VOL.2 (1978)
ROSEN, L.C.; MOLENKAMP, C.R.

RYON, R.W.

- 54 REMOVAL OF SILICA FROM SPENT GEOTHERMAL BRINE.
UCID-17702 (1977)
RYON, R.W.; HILL, J.H.

SCHATZ, J.F.

- 101 PREDICTION OF SUBSIDENCE DUE TO HOT BRINE PRODUCTION IN THE SALTON SEA GEOTHERMAL FIELD.
UCRL-80984 (1978)
SCHATZ, J.F.; CHENEY, J.A.; KASAMEYER, P.W.

SCHNAPP, M.

- 38 PRELIMINARY CATALOG OF EARTHQUAKES IN NORTHERN IMPERIAL VALLEY, OCTOBER 1, 1976 TO
DECEMBER 1976.
U.S. GEOLOGICAL SURVEY, PASADENA, CALIF. REPORT (1977)
SCHNAPP, M.; FUIS, G.
- 35 THE NOVEMBER-DECEMBER 1976 EARTHQUAKE SWARMS IN NORTHERN IMPERIAL VALLEY, CALIF.:
SEISMICITY ON THE BRAWLEY FAULT AND RELATED STRUCTURES. (ABSTRACT)
TRANS. AMER. GEOPHYS. UNION (EOS) 58, 1188 (1977)
FUIS, G.; SCHNAPP, M.

SERPA, D.P.

- 13 MEASUREMENTS OF RADIOACTIVITY IN COOLING TOWER SLUDGE AT THE GEYSERS GEOTHERMAL FIELD,
CALIFORNIA. (ABSTRACT)
HEALTH PHYS. 31, 532 (1976)
SERPA, D.P.; LORENZ, R.W.; ANSPAUGH, L.R.
- 30 THE GEYSERS GEOTHERMAL POWER PLANT: ENVIRONMENTAL IMPACT OF THE RELEASE OF 222-RN.
PG&E REPORT 420-77.22 (1977)
SERPA, D.P.; ANSPAUGH, L.R.; PHELPS, P.L.; SOINSKI, A.J.

SHINN, J.H.

- 46 A LINEAR GRADIENT CHAMBER FOR EXPOSING FIELD PLANTS TO CONTROLLED LEVELS OF AIR
POLLUTANTS.
UCRL-80411 (1977)
SHINN, J.H.; CLEGG, B.R.; STUART, M.L.
- 89 AIR POLLUTION EFFECTS ON VEGETATION FROM GEOTHERMAL DEVELOPMENT.
ANNUAL PROGRESS REPORT ON STUDIES OF AIR POLLUTION EFFECTS ON VEGETATION. UCID-17714 PP.
21-26 (1978)
SHINN, J.H.

SHINN, J.H. (CONTD.)

- 103 ECOLOGICAL EFFECTS OF ATMOSPHERIC RELEASES FROM SYNTHETIC FUELS PROCESSES.
UCRL-81691 (1978)
SHINN, J.H.; KERCHER, J.R.
- 12 EXPOSURES OF FIELD-GROWN LETTUCE TO GEOTHERMAL AIR POLLUTION: PHOTOSYNTHETIC AND STOMATAL RESPONSES.
J. ENVIRON. SCI. HEALTH A11, 603 (1976)
SHINN, J.H.; CLEGG, B.R.; STUART, M.L.; THOMPSON, S.E.
- 44 INTERACTIVE EFFECTS OF H₂S AND O₃ ON THE YIELD OF SNAP BEANS (*PHASEOLUS VULGARIS* L.).
UCRL-13807 (1977)
BENNETT, J.P.; BARNES, K.; SHINN, J.H.
- 45 PHOTOSYNTHESIS AND STOMATAL RESISTANCE RESPONSE TO OZONE AND/OR HYDROGEN SULFIDE EXPOSURES IN FIELD GROWN SNAP BEANS: (ABSTRACT)
AGRONOMY ABS. 1977, 97 (1977)
BINGHAM, G.E.; COYNE, P.I.; BENNETT, J.P.; SHINN, J.H.
- 74 PLAN FOR THE LONG-TERM ASSESSMENT OF ENVIRONMENTAL QUALITY IN IMPERIAL VALLEY, CALIFORNIA, IN RELATIONSHIP TO THE DEVELOPMENT OF GEOTHERMAL RESOURCES.
UCRL-52248 (1978)
ANSPAUGH, L.R.; CROW, N.B.; GUDIKSEN, P.H.; HAVEN, K.F.; PHELPS, P.L.; PIMENTEL, K.D.; ROBISON, W.L.; SHINN, J.H.
- 11 POTENTIAL EFFECTS OF GEOTHERMAL ENERGY CONVERSION ON IMPERIAL VALLEY ECOSYSTEMS. (PROCEEDINGS OF THE FIRST WORKSHOP ON INTEGRATED ASSESSMENT OF ECOSYSTEM QUALITY).
UCRL-52196 (1976)
SHINN, J.H. (ED.)
- 90 REGIONAL ASSESSMENT OF AIR POLLUTION IMPACT ON VEGETATION BY MATHEMATICAL MODELING. ANNUAL PROGRESS REPORT ON STUDIES OF AIR POLLUTION EFFECTS ON VEGETATION. UCID-17714 PP. 27-29 (1978)
SHINN, J.H. KERCHER, J.R.
- 60 SNAP BEAN YIELD AND PARTITIONING RESPONSES TO OZONE AND HYDROGEN SULFIDE EXPOSURES IN THE FIELD. (ABSTRACT)
AGRONOMY ABS. 1977, 96 (1977)
BENNETT, J.P.; SHINN, J.H.

SNOEBERGER, D.F.

- 87 IDENTIFICATION OF ENVIRONMENTAL CONTROL TECHNOLOGIES FOR GEOTHERMAL DEVELOPMENT IN THE
IMPERIAL VALLEY OF CALIFORNIA.
UCRL-52548 (1978)
SNOEBERGER, D.F.; HILL, J.H.

SOINSKI, A.J.

- 30 THE GEYSERS GEOTHERMAL POWER PLANT: ENVIRONMENTAL IMPACT OF THE RELEASE OF 222-RN.
PG&E REPORT 420-77.22 (1977)
SERPA, D.P.; ANSPAUGH, L.R.; PHELPS, P.L.; SOINSKI, A.J.

SPOSITO, G.

- 49 ESTIMATED ASSOCIATION CONSTANTS FOR SOME COMPLEXES OF TRACE METALS WITH INORGANIC LIGANDS.
SOIL SCI. SOC. AMER. J. 41, 1092 (1977)
MATTIGOD, S.V.; SPOSITO, G.

- 47 ON THE CHEMICAL FOUNDATION OF THE SODIUM ADSORPTION RATIO.
SOIL SCI. SOC. AMER. J. 41, 323 (1977)
SPOSITO, G.; MATTIGOD, S.V.

- 24 TRACE METAL SPECIATION IN SALINE WATERS AFFECTED BY GEOTHERMAL BRINES.
UCRL-13790 (1977)
SPOSITO, G.; PAGE, A.L.

STRONG, D.

- 39 GOVERNMENTAL COSTS AND REVENUES ASSOCIATED WITH GEOTHERMAL ENERGY DEVELOPMENT IN IMPERIAL
COUNTY.
UCRL-13800 (1977)
GOLDMAN, G.; STRONG, D.

STUART, M.L.

- 46 A LINEAR GRADIENT CHAMBER FOR EXPOSING FIELD PLANTS TO CONTROLLED LEVELS OF AIR
POLLUTANTS.
UCRL-80411 (1977)
SHINN, J.H.; CLEGG, B.R.; STUART, M.L.

STUART, M.L. (CONTD.)

12 EXPOSURES OF FIELD-GROWN LETTUCE TO GEOTHERMAL AIR POLLUTION: PHOTOSYNTHETIC AND STOMATAL RESPONSES.

J. ENVIRON. SCI. HEALTH A11, 603 (1976)

SHINN, J.H.; CLEGG, B.R.; STUART, M.L.; THOMPSON, S.E.

SULLIVAN, P.J.

48 THE PRINCIPLE OF HARD AND SOFT ACIDS AND BASES AS APPLIED TO EXCHANGEABLE CATION SELECTIVITY IN SOIL.

SOIL SCI. 124, 117 (1977)

SULLIVAN, P.J.

SWAJIAN, A.

61 WATER QUALITY MANAGEMENT FOR IMPERIAL VALLEY GEOTHERMAL DEVELOPMENT.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 631 (1978)

SWAJIAN, A.; MORRIS, G.L.; PIMENTEL, K.D.

TARDIFF, G.E.

3 THE LLL GEOTHERMAL ENERGY DEVELOPMENT PROGRAM STATUS REPORT, JANUARY 1975 THROUGH AUGUST 1975.

UCID-16954 (1975)

AUSTIN, A.L.; HOWARD, J.H.; LUNDBERG, A.W.; TARDIFF, G.E.

55 THE LLL GEOTHERMAL ENERGY PROGRAM STATUS REPORT JANUARY 1976 - JANUARY 1977.

UCRL-50046-76 (1977)

AUSTIN, A.L.; LUNDBERG, A.W.; OWEN, L.B.; TARDIFF, G.E.

THOMPSON, C.R.

104 EFFECTS OF CONTINUOUS HYDROGEN SULFIDE FUMIGATION ON CROP AND FOREST PLANTS.

ENVIRON. SCI. TECHNOL. 12, 550 (1978)

THOMPSON, C.R.; KATS, G.

43 EFFECTS OF H₂S, H₂S+CO₂, AND SO₂ ON LETTUCE, SUGAR BEETS, ALFALFA, AND COTTON.

UCRL-13782 (1977)

THOMPSON, C.R.; KATS, G.

THOMPSON, S.E.

12 EXPOSURES OF FIELD-GROWN LETTUCE TO GEOTHERMAL AIR POLLUTION: PHOTOSYNTHETIC AND STOMATAL RESPONSES.

J. ENVIRON. SCI. HEALTH A11, 603 (1976)

SHINN, J.H.; CLEGG, B.R.; STUART, M.L.; THOMPSON, S.E.

TOMPKINS, G.A.

85 CHEMICAL FINGERPRINTS TO ASSESS THE EFFECTS OF GEOTHERMAL DEVELOPMENT ON WATER QUALITY IN IMPERIAL VALLEY.

GEOTHERM. RESOUR. COUNC. TRANS. 2, 527 (1978)

PIMENTEL, K.D.; IRELAND, R.R.; TOMPKINS, G.A.

TULLIS, R.E.

70 THE SALTON SEA SAMPLING PROGRAM: BASELINE AND TOXICITY STUDIES.

UCRL-13849 (1978)

TULLIS, R.E.

URSENBACH, W.O.

114 ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL. 1.

UCRL-13955 VOL.1 (1978)

WHITE, K.L.; HILL, A.C.; URSENBACH, W.O. (EDS.)

115 ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL.2.

UCRL-13955 VOL.2 (1978)

WHITE, K.L.; HILL, A.C.; URSENBACH, W.O. (EDS.)

WALLACE, A.

51 BASELINE STUDIES IN THE DESERT ECOSYSTEM AT EAST MESA GEOTHERMAL TEST SITE, IMPERIAL VALLEY, CALIFORNIA.

UCLA-12-1143 (1977)

ROMNEY, E.M.; WALLACE, A.; LUNT, O.R.; ACKERMAN, T.A.; KINNEAR, J.E.

WEEKS, L.V.

- 64 SOLUTE-TRAVEL TIME ESTIMATES FOR TILE-DRAINED FIELDS III. REMOVAL OF A GEOTHERMAL BRINE SPILL FROM SOIL BY LEACHING.

UCRL-13792 (1978)

JURY, W.A.; WEEKS, L.V.

WHARTON, J.C.

- 25 GEOTHERMAL RESOURCE DEVELOPMENT: LAWS AND REGULATIONS.

UCRL-52327 (1977)

WHARTON, J.C.

- 14 JUDICIALLY ENFORCEABLE SUBSTANTIVE RIGHTS UNDER NEPA.

USF LAW REVIEW 10, 415 (1976)

WHARTON, J.C.

- 16 THE CLEAN AIR ACT; POWER PLANT OPERATION AND SULFUR DIOXIDE REGULATION.

UCRL-52182 (1976)

WHARTON, J.C.

- 15 THE LEGISLATIVE HISTORY OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT.

UCRL-52188 (1976)

WHARTON, J.C.; LEWIS, M.

WHITE, K.L.

- 114 ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL. 1.

UCRL-13955 VOL.1 (1978)

WHITE, K.L.; HILL, A.C.; URSENBACH, W.O. (EDS.)

- 115 ENVIRONMENTAL OVERVIEW REPORT ON UTAH GEOTHERMAL RESOURCE AREAS. VOL.2.

UCRL-13955 VOL.2 (1978)

WHITE, K.L.; HILL, A.C.; URSENBACH, W.O. (EDS.)

WIERSMA, G.B.

- 57 STATUS OF BASELINE SAMPLING FOR ELEMENTS IN SOIL AND VEGETATION AT FOUR KGRA'S IN THE IMPERIAL VALLEY, CALIFORNIA.

GEOTHERM. RESOUR. COUNC. TRANS. 1, 65 (1977)

CROCKETT, A.B.; WIERSMA, G.B.

WILCOX, R.E.

110 A PLAN FOR THE LONG TERM ENVIRONMENTAL ASSESSMENT OF GEOPRESSURED RESOURCE DEVELOPMENT IN THE LOUISIANA GULF COAST REGION.

UCRL-13913 (1978)

NEWCHURCH, E.J.; BRYAN, C.F.; HARRISON, D.P.; MULLER, R.A.; WILCOX, R.E.; BACHMAN, A.L.; NEWMAN, J.P.; CUNNINGHAM, K.J.; HILDING, R.K.; REHAGE, J.A.

WILKERSON, C.L.

94 CHEMICAL CHARACTERIZATION OF GASES AND VOLATILE HEAVY METALS IN GEOTHERMAL EFFLUENTS. GEOTHERM. RESOUR. COUNC. TRANS. 2, 579-582 (1978)

ROBERTSON, D.E.; FRUCHTER, J.S.; LUDWICK, J.D.; WILKERSON, C.L.; CRECELIUS, E.A.; EVANS, J.C.

KEYWORD INDEX

AIR QUALITY

4	5	7	9	10	11	12	16	23	28
30	31	32	33	40	42	43	44	46	58
68	72	74	76	77	78	81	86	88	92
94	98	105	108	109	110	111	113	114	115
116									

BRINE

2	3	11	17	18	19	20	22	23	24
51	52	53	54	55	56	61	64	67	69
70	71	82	85	94	95	100	101	107	110

ECOSYSTEM QUALITY

4	5	7	9	10	13	14	15	21	24
29	31	42	63	76	77	78	87	89	90
92	96	97	98	99	102	103	105	106	108
110	112	114	115	118					

ECOSYSTEM QUALITY, AQUATIC

11	28	69	70	71	74	82	100		
----	----	----	----	----	----	----	-----	--	--

ECOSYSTEM QUALITY, TERRESTRIAL

8	11	12	22	26	28	34	43	44	45
46	47	48	49	50	51	57	59	60	74
79	104	109							

ENVIRONMENTAL CONTROL

76	87	88							
----	----	----	--	--	--	--	--	--	--

ENVIRONMENTAL DATA MANAGEMENT

24	114	115	116	117					
----	-----	-----	-----	-----	--	--	--	--	--

GEOLOGY

1	2	3	55	65	66	92	110	114	115
118									

GEOPRESSURE

110	88								
-----	----	--	--	--	--	--	--	--	--

GEYSERS, THE

13	30	65	68	91	92	93	94	104	105
106	108	118	119						

HEALTH EFFECTS

5	7	10	74	76	77	78	92	98
---	---	----	----	----	----	----	----	----

HOT DRY ROCKS

88

HYDROGEN SULFIDE

4	7	11	12	23	26	31	32	42	43
44	45	46	50	59	60	72	74	76	77
78	81	86	87	88	89	90	92	94	97
98	103	104	105	106	109	110	111	112	114
115									

IMPERIAL VALLEY

1	2	4	5	9	10	11	12	17	18
19	22	24	28	32	34	35	36	37	38
39	40	41	43	51	53	54	55	56	57
59	60	61	62	63	64	66	67	69	70
71	72	74	76	80	81	83	85	86	87
95	97	100	101	102	104	107	111	113	116

INTEGRATED ASSESSMENT

4	5	7	8	9	10	11	26	27	28
29	31	32	33	50	72	73	74	75	76
77	78	79	80	81	83	86	88	90	96
97	98	99	111	112	113				

LAWS AND REGULATIONS

9	14	15	16	25	76
---	----	----	----	----	----

LONG VALLEY

42	117
----	-----

MATHEMATICAL METHODS

73	75	84	96
----	----	----	----

MODELS

8	21	26	33	41	50	79	81	90	96
97	103	111	112	113					

MONITORING

21	22	41	51	57	61	62	81	84	85
86	92	95	107	110	111	116			

NOISE

7	11	28	31	42	76	77	78	88	92
93	98	106	108	114	115				

RADIOACTIVITY

13	28	30	68	78					
----	----	----	----	----	--	--	--	--	--

RADON

30	68	94	98						
----	----	----	----	--	--	--	--	--	--

RESOURCE STATUS

1	2	3	11	55	72	98	110	114	115
---	---	---	----	----	----	----	-----	-----	-----

SOCIOECONOMIC EFFECTS

4	5	6	7	9	10	11	27	28	31
32	39	72	74	76	77	78	83	88	92
98	99	114	115						

SUBSIDENCE AND SEISMICITY

4	5	7	10	28	31	35	36	37	38
55	62	65	66	74	76	77	78	87	88
92	98	101	110	114	115	118			

UTAH

114	115								
-----	-----	--	--	--	--	--	--	--	--

WATER QUALITY

4	5	7	9	10	11	24	27	28	31
32	34	41	61	64	65	66	72	76	77
78	80	83	84	85	87	88	91	92	94
95	98	99	100	107	108	110	114	115	118
119									

WATER RESOURCES

27	76	80	83	114	115				
----	----	----	----	-----	-----	--	--	--	--