WESTEC Services, Inc.

State Clearinghouse Number 80102409

The Final Environmental Impact Reports are composed of four documents:

Executive Summary -	A 51-page overview of the draft EIRs dated May 15, 1981. A "Final" Executive Summary will not be printed. This document is available in Spanish.
Volume I -	The basic reference document which consists of the draft Master Environmental Impact Report for development of the Salton Sea Anomaly and the Draft Environmental Impact Report for Magma Power Plant #3. The text of the draft has not been changed subsequent to public review except that numbers have been placed at appropriate places on some page margins which refer to specific comments in the Comments and Responses document.
Volume II -	Appendices
Comments and Responses -	Comments on the draft of Volumes I and II with responses to these comments. An errata sheet referring to the draft is also included.

FINAL
SALTON SEA ANOMALY
MASTER ENVIRONMENTAL IMPACT REPORT
AND
MAGMA POWER PLANT #3 (49 MW)
ENVIRONMENTAL IMPACT REPORT
VOLUME I

Prepared For:

County of Imperial
Courthouse
El Centro, California

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December 1981

Certified by Imperial County: ______________________

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SECTION I
INTRODUCTION

The County of Imperial is proposing to expand an existing Geothermal (G) Overlay Zone at the Salton Sea Anomaly from 20,000± acres (8100 ha) to 111,444 acres (45,119 ha), which will include onshore lands as well as offshore areas of the Salton Sea. A Geothermal Overlay Zone is necessary for the construction of geothermal power plants, thus implementation of the proposal will greatly expand the area in which power plants may be located. A separate but related project is being proposed by Magma Power Company which involves the construction and operation of a 49 MW (net) geothermal power plant within the existing Geothermal Overlay Zone.

In order to proceed with these two separate projects, the County of Imperial Planning Commission and Board of Supervisors must approve the rezoning for the expanded G-Overlay Zone, and, as a separate action, grant a Conditional Use Permit (CUP) to Magma Power Company to construct and operate their proposed 49 MW plant. As these decisions represent discretionary actions by the decision-making bodies, and because the projects may significantly affect the environment, the California Environmental Quality Act requires the preparation of an Environmental Impact Report (EIR).

An EIR is an informational document intended to inform public decision-makers (in this case, the County Planning Commission and Board of Supervisors), other responsible or interested agencies, and the general public of the environmental effects of the proposed project. The EIR process has been implemented to enable public agencies to evaluate a project in terms of its environmental consequences, to examine and implement methods for eliminating or reducing any adverse impacts, and to consider alternatives to the project as proposed. While the California Environmental Quality Act requires that major consideration be given to avoiding environmental damage, the responsible public agencies remain obligated to balance possible adverse effects against other public objectives, including economic and social goals, in determining whether and in what manner a project should be approved. Accordingly, this EIR has been prepared in compliance with the Imperial County's Rules to Implement the California Environmental Quality Act of 1970.

1.1 SCOPE AND PURPOSE OF THE SALTON SEA ANOMALY MASTER ENVIRONMENTAL IMPACT REPORT (MEIR) AND THE EIR FOR MAGMA'S PROPOSED 49 MW FACILITY

The scope of this report includes a MEIR addressing the cumulative environmental consequences, phased over a 30-year time horizon, of expanding the existing Geothermal (G) Overlay Zone to allow full development of the Salton Sea geothermal resource. It also includes a site-specific EIR for the construction and operation of the 49 MW power plant proposed by Magma Power Company.

The MEIR has been prepared to serve the following purposes:

1. Provide information on the cumulative environmental impacts associated with full geothermal development to better judge the significance of future individual project contributions to the overall impacts. This will serve to satisfy CEQA requirements regarding regional cumulative concerns.
2. Base the impact analysis on a geothermal development scenario which incorporates the best information currently available from both the private and the public sector for the pattern and timing of commercial power production within the Salton Sea Known Geothermal Resource Area (KGRA).
3. Provide an environmental data base which will allow future environmental documents to focus on those key issues identified in the MEIR as concerns for individual projects.
4. Produce a set of environmental constraint maps showing varying degrees of environmental concern within the proposed G-Overlay Zone.
5. Address as completely as practical, the potential environmental impacts associated with exploratory drilling activities and geothermal power production facilities which may be located offshore in the Salton Sea.
6. Based on identified environmental constraints and on the pattern of probable development within the G-Overlay Zone, identify potential areas for a centralized switchyard within the KGRA in accordance with the Transmission Corridor Element of the Imperial County General Plan. As visualized, this switchyard could gather the electricity produced by geothermal power plants within the KGRA and transmit it

to the Geothermal Collector Transmission Line System recently approved by the Imperial County Board of Supervisors.

7. Identify and analyze those mitigation measures that can be equitably applied to geothermal projects within the study area, and possibly throughout the Valley.
8. Discuss feasible alternatives to the proposed project.
9. In addition, an EIR for Magma's 49 MW power plant is included to provide a site specific environmental setting, impact analysis, and mitigation measure assessment for the proposed 49 MW power plant.

To fulfill these purposes, this report is organized such that the MEIR is discussed in Sections II through VII, followed by a separate analysis of the 49 MW power plant in Section VIII.

1.2 PREVIOUS ENVIRONMENTAL DOCUMENTATION

In preparing the Project Description and Existing Conditions portions of this report, WESTEC Services utilized, to the extent possible, previous environmental reports which were conducted for sites both within the study area as well as surrounding the study area. These reports are briefly summarized below.

1.2.1 Within the Study Area

1. Salton Sea Ten Megawatt Geothermal Demonstration Facility EIR

Southern California Edison (SCE) and Union Oil Company of California recently proposed the construction and operation of a 10 MW generation facility located about eight miles southwest of Niland which would utilize geothermal energy from the Salton Sea Known Geothermal Resource Area (KGRA). The EIR (which has been certified by the County) addressed the existing conditions and anticipated consequences of construction and operation of the facility, including the power plant, associated steam production and fluid reinjection facilities, pipeline corridors and transmission line corridors. The proposed project was recently approved by the County.

2. Forty-Nine Megawatt Geothermal Power Plant and Facilities EIR; Supplement to EIR -- Forty-Nine Megawatt to a Twenty-Eight Megawatt Geothermal Power Plant and Facilities

This EIR and Supplement addressed a range of issues at the project site, and within the surrounding areas. The project proposed construction and operation of a 28 MW (previously 49 MW) facility at the site of the Geothermal Loop Experimental Facility (GLEF) in the Salton Sea KGRA. Twelve production wells, six injection wells and an equal number of replacement wells were proposed; the entire project was recently approved by the County.

3. Imperial Valley Action Plan Transmission Corridor Study/Imperial County General Plan, Transmission Corridor Element EIR

A portion of this project is located within the study area. The objectives of this effort, jointly funded by the California Energy Commission (CEC) and the U.S. Department of Energy (DOE), were essentially threefold: (a) to identify an optimal geothermal collector system which would link four KGRAs into an integrated network consisting of 230 kilovolt (kV) transmission lines; (b) to identify optimal export corridors which would accommodate 500 kV transmission lines for use in transporting geothermal power from Imperial Valley to demand centers elsewhere; and (c) to prepare an Environmental Impact Report on the resultant Transmission Corridor Element of the Imperial County General Plan.

4. Imperial Valley Environmental Project (IVEP)

Lawrence Livermore Laboratory, operated by the University of California for the U.S. Department of Energy (DOE), has conducted a program of surveys, field measurements and analyses to characterize the existing environmental conditions in Imperial Valley. The purpose of this program was to ultimately assess the potential impact geothermal development could have on these conditions. The entire program included analyses of water quality, air quality, seismicity and subsidence, ecosystem structures, and health and socioeconomic conditions.

5. Geothermal Element of the Imperial County General Plan

This element established goals and policies to direct geothermal activities and electricity generation in Imperial County. Relevant environmental and social issues for the entire County were reviewed and analyzed for planning purposes.

6. Imperial Magma's Elmore Unit Exploratory Well Program Environmental Documentation

Eight exploratory wells from eight different drill pads were proposed and approved for this 1600-acre (648 ha) project area which is located on the site proposed for the 49 MW power plant that is addressed in Section VIII of this report.

1.2.2 Beyond the Study Area

Many EIRs, environmental reviews and reports have been processed within Imperial Valley for geothermal activities. These include the Heber Geothermal Project Master EIR, the North Brawley 10 MW Geothermal Power Plant EIR, the South Brawley Geothermal Exploration Project, the Salton Sea Solar Pond Project, the Superstition Hills Hazardous Waste Disposal Site EIR, and others. These reports summarized existing conditions for specific sites and described general regional conditions. In addition to these reports, other environmental reports focused on impacts associated with well drilling projects. This entire collection of reports represents a wide array of documented baseline conditions useful in the preparation of this MEIR and EIR.

1.3 PERMITTING PROCESS

Permit requirements vary generally with the type and size of the proposed geothermal activity as well as with the jurisdiction of the area proposed for development. The four types of geothermal activity which require permits include exploratory projects, field development projects, major flow and equipment testing projects, and power plants. In Imperial County, depending on whether the land is privately or federally owned, the permit process may be delegated to the County or to the Bureau of Land Management (BLM)/U.S. Geological Survey (USGS). These situations and other considerations are discussed below.

1.3.1 Privately Owned Land

In order to conduct any type of geothermal related activity on privately owned land, an applicant must first lease the land from the property owner. This transaction takes place between the applicant and the landowner and does not require County or other agency participation. Once a lease has been obtained, the application may apply for the geothermal activities described below.

1.3.1.1 Temperature Observation Holes (less than 2000 feet (610 m) in depth)

The purpose of these wells is solely for initial exploratory purposes to measure subsurface heat encountered at a depth no greater than 2000 feet (610 m). These wells do not require a County permit, however, the County does require an application for drilling of this nature. Currently the County does limit the number of wells per application to 25. The County reviews the sensitivity of the areas proposed for these wells, and if no significant constraints exist, approves an EIR Notice of Exemption without further environmental review or documentation. Often the locations of these wells are adjacent to a roadway. Thus in order to drill in the right-of-way, an encroachment permit must be obtained from the County Public Works Department. The California Division of Oil and Gas also must approve all temperature observation holes.

1.3.1.2 Exploratory Projects

Exploratory wells, or a "geothermal exploratory project," as defined in Section 21065.5 of the Public Resources Code, is a project which consists of "not more than six wells and associated drilling and testing equipment, whose chief and original purpose is to evaluate the presence and characteristics of geothermal resources prior to commencement of a geothermal field development... Wells included within a geothermal exploratory project must be located at least one-half mile from geothermal development wells which are capable of producing geothermal resources in commercial quantities." A geothermal exploratory project is considered to be a separate project from any subsequent geothermal field development.

Imperial County is unique in that it presently is the only county in California which is permitted to act as lead agency with authority to conduct environmental review for exploratory projects. Usually the State Division of Oil and Gas (DOG) of the Department of Conservation serves as the lead agency and carries this authority, however, as stated in Chapter 1271 of Assembly Bill No. 2644, "permit authority may be delegated to a county on a yearly basis by the DOG if the county has an acceptable Geothermal Element to the General Plan," and if the county is willing to follow certain requirements of the permit process. Because Imperial County has complied with these measures, DOG has granted it lead agency authority. The County has general authority for geothermal related land use decisions, and DOG primarily maintains technical subsurface authority.

When applying for an exploratory permit, the applicant must submit information required by the County; the County subsequently completes either one of two procedures: preparation of a Mitigated Negative Declaration or an Environmental Impact Report (EIR). Upon receipt of all required application materials, the entire exploratory permit process must be completed within 135 days, or 105 days if a Mitigated Negative Declaration is granted. Once the proposed exploratory project and associated environmental reports have been reviewed by the County, the DOG would grant final approval and the applicant may proceed with drilling for the purpose of evaluating resource characteristics. This permit does not authorize equipment testing or any flows of great duration. In addition, construction of sumps used for drilling mud and liquid disposal necessitates a permit from the Regional Water Quality Control Board (RWQCB).

1.3.1.3 Major Flow and Equipment Testing Projects

Imperial County further requires a permit for extraction of geothermal brine and major flow tests which test equipment for brine scaling, deposition, etc. To obtain an Equipment Testing Permit, the applicant must submit to the County all relevant information, including an environmental review. If a Master EIR was previously prepared, only a site specific EIR may be required. Requirements would vary with each project depending on the scope of the proposed activities. Once the permit was obtained, the applicant would be allowed to construct a production facility without a generator so that the production equipment could be used and tested for normal operation, yet no power would be produced.

1.3.1.4 Production Projects

Production projects include field development projects and power plants. The County is again the lead agency unless a proposed power plant would produce 50 or more net megawatts (MW) of power. In that case, the California Energy Commission (CEC) would become the lead agency and would have permit authority.

In order to receive a production permit from the County, the applicant must submit an EIR. If a Master EIR has been completed over an area in which the project would be located, the applicant may be required to conduct only an EIR which focuses on site specific considerations. The production permit is limited to areas contained within a Geothermal (G)-Overlay Zone. If the applicant desires a production permit outside a G-Overlay Zone, then a zone change must occur prior to approval of a production permit. An EIR is usually required for such a zone change although a single EIR may be used for both the zone change and production permit.

1.3.1.5 Regional Water Quality Control Board (RWQCB), Colorado River Region

The RWQCB requires from the applicant a Report of Waste Discharge which describes the types and amount of wastewater anticipated to occur after project implementation. If the proposed discharge is approved, the RWQCB issues a Waste Discharge Requirement Permit, and after project startup, the discharge is monitored for permit compliance. The RWQCB also requires a National Pollution Discharge Elimination System (NPDES) permit for any discharge to drains or surface waters which terminate in a navigable water or, in this case, the Salton Sea.

1.3.1.6 Air Pollution Control District (APCD), Imperial County

The APCD requires the applicant to obtain two permits, the first of which is an initial Authority to Construct permit. The applicant must submit all relevant information in order for the APCD to evaluate project-related air emissions. The second permit is the Permit to Operate which is issued if the applicant has complied with all regulations. A List of Criteria is concurrently issued which delineates total air emission-related requirements.

1.3.1.7 Other Permits

In addition to the above permits, the applicant must obtain permits from various responsible agencies. Each is discussed below.

a. Department of Health, Hazardous Materials and Management Section

This agency requires a permit for disposal if the solid waste is composed of extremely hazardous wastes. This Extremely Hazardous Waste Permit usually does not apply to any geothermal wastes. If no hazardous wastes are involved, the solid waste is disposed of at an approved site. The Health Department requires a permit for construction of large sumps.

b. Imperial Irrigation District (IID)

If the proposed project would need a large amount of water to operate, a water allocation from IID could be necessary. No permit would be required. Purchase of water from IID would be necessary.

c. Other Federal and State Agencies

The following agencies may be involved in granting approvals, permits or licenses for various project-related activities:

(1) Federal Communication Commission: License to Construct and Operate Electronic Transmitting Equipment.

(2) Federal Aviation Administration: Helistop Approval.

(3) State Department of Industrial Relations - Division of Industrial Safety: Permit to Operate Equipment (Pressure Vessels); CAL-OSHA Permit.

(4) State Department of Transportation (Caltrans): Overload Approval.

(5) State Department of Aeronautics: Helistop Site Approval.

d. Construction Related Agencies

Other routine permits may be required from local agencies for construction related purposes. Usually plot plans must accompany an application form. These permits or approvals could include:

(1) County Department of Building and Safety: Grading Permit; Building Permit for all construction activities; Sewer System; Service Water System; Fencing; Construction Trailer Permit; Temporary Power; Yard Lights, Motors and Transformers; Guard House; Certificate of Occupancy.

(2) County Department of Health - Sanitation District: Construction Trailer Permit.

(3) County Fire Department: Fire Protection System; Testing and Inspection.

(4) County Road Department: Overload Approvals; Encroachment Permits.

1.3.2 Federal/State Administered Land

State-owned and operated land falls under the jurisdiction of the State Lands Commission (SLC). The SLC requires a geothermal exploration or prospecting permit for exploratory projects, and requires a land use lease for proposed field development projects (California, State of, 1980). However, the SLC has recently proposed to transfer their lead agency authority to the County for any geothermal permitting activities, with the SLC retaining authority to review all applications. If federal land were also involved, then the lead agency would normally remain the County, yet both the state and federal agencies would review the applications (Hoagland, 1981).

The Bureau of Land Management (BLM) administers large areas of public lands (federal) in Imperial County, and administers the leasing of public lands for geothermal activities on these lands. Within the study area, the BLM administers two small areas on shore, one west of Niland near the Salton Sea, and the other in the mid-north portion of the study area. In addition, the BLM administers several other sections offshore under the sea (see Land Use, Section 3.8). The permit process for geothermal development of onshore and offshore lands is identical. The U.S. Geological Survey (USGS) is responsible for subsurface operation and construction on public lands, and the BLM is responsible for administering any surface activities. The USGS is the lead agency for permitting geothermal operations (Geothermal Resource Orders) but joint approval with the BLM is mandatory (Edney, 1981). The County has no authority over federal public lands, yet in accordance with the County's geothermal element, a cooperative effort has been established whereby the BLM/USGS will present at a public hearing of the County Planning Commission information pertaining to proposed geothermal production on public lands.

Before any proposal for development may occur, the applicant would need to obtain a lease from the BLM. Once this lease has been obtained, then the applicant may proceed with the application procedure which is described below.

1.3.2.1 Exploration Project

The applicant must submit to the BLM/USGS a Plan of Operation which gives an in-depth description of intentions such as number of wells, locations, depth, timing, fluids, reinjection versus a holding pond, and drilling techniques (Edney, 1981). The USGS provides a form for this report. Generally, the Geothermal Resources Orders (GROs), which are seven orders dictated by the USGS pertaining to development and operation of geothermal activities, form the basis for the type of information required in the Plan of Operation. If this Plan of Operation is approved, the proposed activity may be permitted.

1.3.2.2 Field Development

Again, a Plan of Operation must be submitted to the BLM/USGS describing the proposed activity. Only well development may be permitted at this stage.

1.3.2.3 Resource Usage

As in the previous two stages, a Plan of Operation must be submitted to the BLM/USGS describing each proposed activity. This stage of development includes power plant operation.

The BLM/USGS permit includes air, water, and land use considerations which are separate applications when applying through the County. Revisons to the existing federal environmental process are currently being discussed. A major Environmental Assessment (EA) will be required for each geothermal leasing operation, and a minor EA will be required for each application for geothermal operation.

1.3.3 Public Utilities Commission (PUC)

(71) Normally when an electrical system, facility transmission line or pipeline is constructed or enlarged, regardless of whether a proposed geothermal production project is located on state/federal or private land, a Certificate of Public Convenience and Necessity would have to be be obtained from the PUC. The PUC would then review the construction and expansion plans, including any concurrent environmental work. While this procedure would hold true for interconnecting a geothermal power plant with transmission facilities belonging to SCE or SDG&E it does not apply to the expansion of IID's tranmission facilities. IID can expand their transmission line network independent of PUC involvement (Legaspi, 1981).

SECTION II
PROJECT DESCRIPTION

Two distinctly separate but interrelated projects are addressed within this report. The first involves the expansion of the existing Geothermal (G) Overlay Zone to encompass most of the Salton Sea Known Geothermal Resource Area (KGRA), including offshore areas within the Salton Sea, plus 5000± additional acres (2000± ha) adjacent to and east of the existing KGRA which requires the preparation of a Master Environmental Impact Report (MEIR). Approximately 5120 acres (2073 ha) of the KGRA are not included in the study area because they were added by the U.S. Geological Survey after this project was initiated. This additional acreage is immediately south of the study area, and encompasses a portion of the New River. The second project referred to above involves the construction and operation of a 49 megawatt (MW) power plant within the existing G-Overlay Zone which requires a site specific EIR. This report deals with these two projects as separate entities except where there are overlapping considerations. (35)

2.1 PROJECT OBJECTIVES

The main objective of the first project which this report addresses is to enlarge and extend the Geothermal Overlay Zone in the Salton Sea KGRA from its current configuration and size (20,000± acres; 8100± ha) to encompass most of the KGRA plus an additional 5000± acres (2000± ha) adjacent to and immediately east of the KGRA for a study area of approximately 111,444 acres (45,119 ha). The significance of enlarging the G-Overlay Zone involves the restrictions on exploratory well drilling and power plant construction. As noted in the previous section on permitting, exploratory wells may be drilled with the approval of the County and the State Division of Oil and Gas (DOG) regardless of the existence of a G-Overlay Zone. On the other hand, geothermal power plants can only be constructed and operated on lands covered by the G-Overlay. Therefore, the effect of the proposed expansion, and an objective of the project, is to greatly enlarge the area within which geothermal power plants can be located, and then to control development in such a way as to minimize impacts to Imperial Valley's productive agricultural lands and environmental resources.

Implementation of the G-Overlay expansion proposal would facilitate fulfilling two other project objectives: to contribute to the development of an alternate energy source which, when combined with other similar efforts, will reduce the country's dependence on imported oil and help meet increased demands for power in the future;

and to contribute to the diversification of the economic base within Imperial County by providing increased employment opportunities and additional revenue sources from commercial geothermal development.

In addition to the foregoing objectives related to the G-Overlay expansion project, other objectives exist which relate specifically to the 49 MW power plant proposed by Magma Power Company. These objectives include the following: 1) to obtain a Conditional Use Permit (CUP) to construct and operate a 49 MW geothermal power plant within the Salton Sea KGRA; 2) to provide 49 MW of electrical power for transmission and use; and 3) to further demonstrate the commercial feasibility of generating power from the geothermal resources within the Salton Sea KGRA.

2.2 PROJECT LOCATION

As shown in Figures 2.2-1 through 2.2-5, the project area (111,444 acres; 45,119 ha) is located at the southeastern edge of the Salton Sea in Imperial County, California. About 54 percent (60,165 acres; 24,358 ha) of the study area lies within the Salton Sea itself. A description of the location of each of the major subareas involved in the project is provided below.

2.2.1 Proposed Geothermal Overlay Zone

The existing Geothermal Overlay Zone within the Salton Sea KGRA consists of about 20,000 acres (8100 ha). As shown in Figures 2.2-3 through 2.2-5, it is generally bounded on the south by Young and Albright Roads; on the east by Brandt Road and English Road; on the north by Beach Road; and on the west by the shoreline of the Salton Sea.

The proposed G-Overlay Zone would extend the existing configuration outward in all directions. As depicted in Figures 2.2-3 through 2.2-5, the proposed 111,444 acre (45,119 ha) G-Overlay Zone (which is coterminous with the study area) is about 91,444 acres (37,022 ha) larger than the existing G-Overlay Zone. In addition to extending the land portion of the G-Overlay Zone to the south and east, the proposed project would also encompass approximately 60,165 acres (24,358 ha) within the Salton Sea. This offshore area was previously included in the KGRA but not in the G-Overlay Zone.

As shown in Figure 2.2-3 and in the topographic maps (Figures 2.2-4 and 2.2-5), the southern boundary of the proposed G-Overlay Zone is defined by Bowles Road; the eastern boundary by the western outskirts of Calipatria, section lines just east of Highway 111, the western outskirts of Niland, the X Drain and Lateral, section lines just east of Cuff Road, and the section lines separating R13E from R14E; the northern boundary by the section lines one section north of the boundary between T9S and T10S; and the western boundary by a number of north-south section lines within the Salton Sea. The area that would be included within the proposed G-Overlay Zone includes portions of the following USGS 7.5 minute quadrangle maps: Frink, Wister, Niland, Obsidian Butte, Calipatria SW, Westmorland, and Iris Wash.

2.2.2 Magma Power Plant #3

As shown in Figure 2.2-4, the study area for the proposed 49 MW power plant would encompass approximately 1360 acres (551 ha) north and south of Sinclair Road, generally bounded on the west by Gentry Road and on the east by Kalin Road. The power plant itself would be located on 10.6 acres (4.3 ha) on the northwest corner of Sinclair and Garst Roads. More details are provided in Section VIII.

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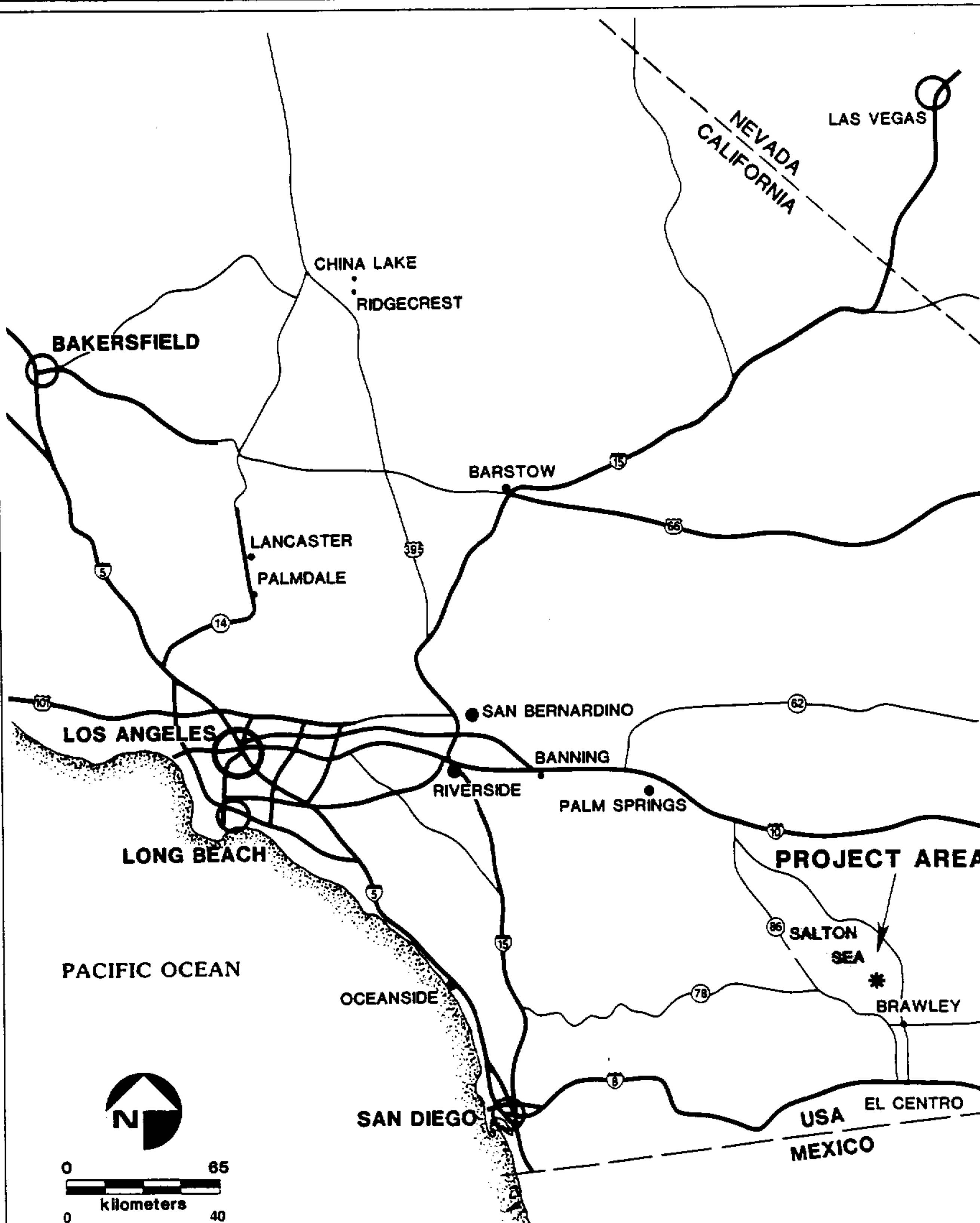
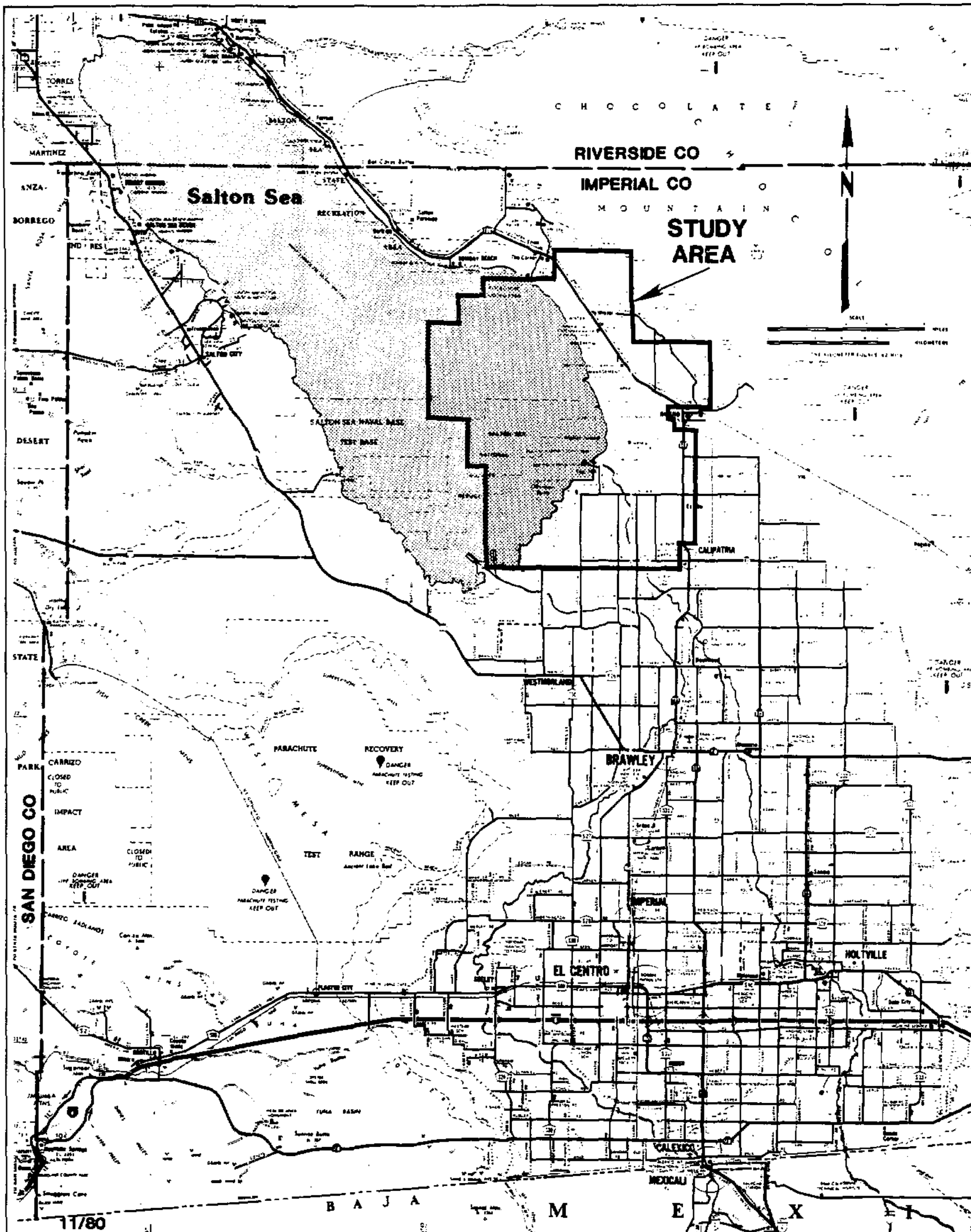


Regional Map

FIGURE 2.2-1

WESTEC Services, Inc.



Vicinity Map of Study Area (Proposed Geothermal Overlay Zone)

FIGURE 2.2-2

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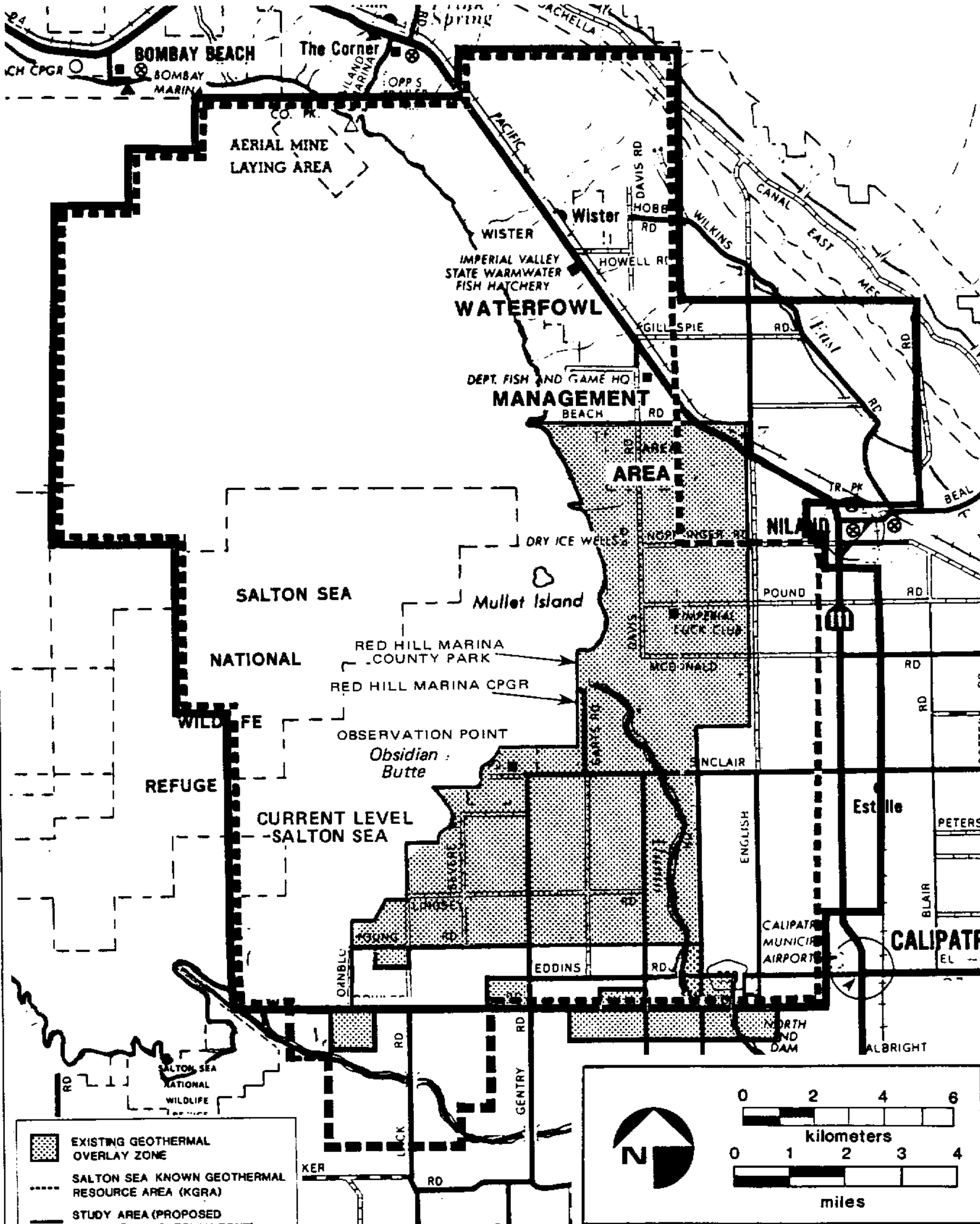
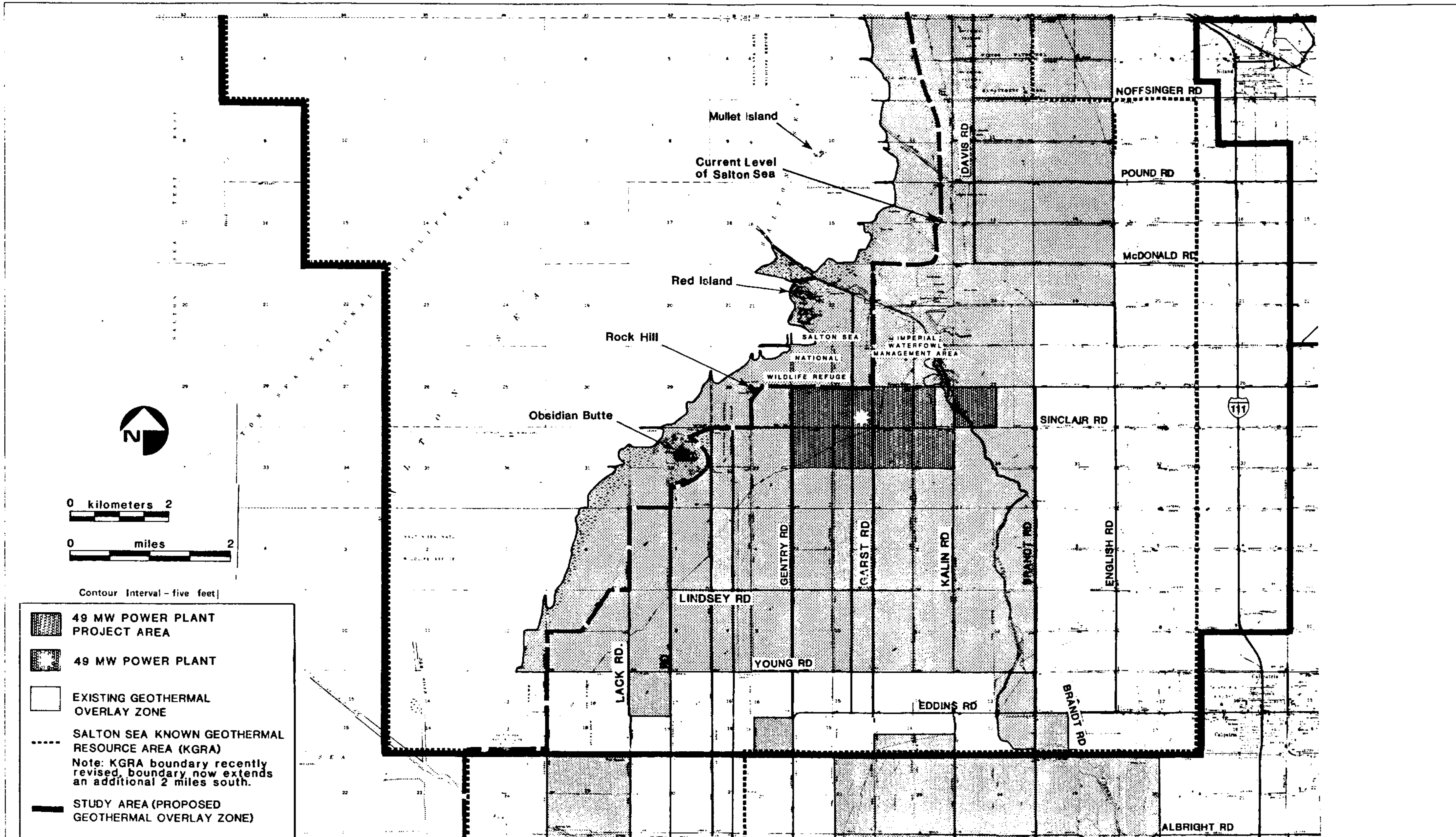


Project Area

FIGURE 2.2-3

WESTEC Services, Inc.



Topographic Map of the Project Area - Part 1

FIGURE 2.2-4

2.3 HISTORY OF LOCAL DEVELOPMENT

The history of geothermal development in the Salton Sea Anomaly is documented in several publications (Palmer, 1975; Imperial County, 1977 and 1980; SDG&E, 1980). A description of the historical events is provided in this MEIR as Appendix 2.3. Only a brief description along with Table 2.3-1, a well inventory, and Figures 2-3.1 and 2.3-2 which provide well locations, are included at this point in the text.

The earliest known wells (Pioneer 1, 2, 3) were drilled around 1927 for the recovery of carbon dioxide (CO_2) that was used to make dry ice. Numerous shallow wells supported this activity. In 1957 Kent Imperial Corporation drilled an oil exploration well but found steam and water instead. This well, designated Sinclair 1, is considered to be the discovery well for the Salton Sea Anomaly. In 1961 successful exploratory wells were drilled in Cerro Prieto, Mexico which demonstrated the potential for geothermal power within the Salton Trough, which includes the Salton Sea Anomaly. Between 1961 and 1965 several more wells were drilled in the vicinity of Sinclair 1, however early efforts were hindered by brine handling problems. An additional series of wells was drilled between 1972 and the present time by a number of different firms and more intense testing activities were undertaken. According to the currently available information for the study area (shown on Table 2.3-1), 77 wells have been drilled and either abandoned or used for reinjection, 13 have been drilled and are being used, and 43 have been permitted but are not yet drilled.

Extensive testing was conducted at San Diego Gas and Electric's (SDG&E) Geothermal Loop Experimental Facility (GLEF), completed in June 1976, using two wells, Magmamax 1 and Woolsey 1, as brine sources. The GLEF tested various technologies, antiscaling techniques, and brine-handling methods. Test results have greatly increased the confidence that brine handling and scaling problems can be successfully dealt with in a power production facility. As a result, Magma Power Company has received a permit to construct and operate a 28 MW geothermal power plant at the GLEF site using some of the existing equipment. The plant would consist of a 20 MW flash steam component and a low pressure binary booster to provide the remaining eight megawatts. In addition, Southern California Edison is building and will operate a 10 MW dual flash system in the Salton Sea Anomaly with Union Oil supplying the steam. Other major developers are continuing their exploration and evaluation efforts with an intensifying interest to construct geothermal power plants.

Table 2.3-1

WELL INVENTORY

Well Designation	Operator	Location (Sec., T&R)	Year Completed	Status	Map Reference No. (see Figures 2.3-1 and 2.3-2)
Pioneer 1	Pioneer Development Co.	10, 11S, 13E	1927	ADN	1
Pioneer 2	Pioneer Development Co.	10, 11S, 13E	1927	ADN	2
Pioneer 3	Pioneer Development Co.	10, 11S, 13E	1928	ADN	3
Salton Sea Chemical Products 1	Salton Sea Chemical Corp.	28, 11S, 13E	1932	ADN	10
Salton Sea Chemical Products 5	Salton Sea Chemical Corp.	25, 11S, 13E	1933	ADN	11
Imperial CO_2 Field (55 wells)		1, 2, 11, 12, 11S, 13E	1933-54	ADN	72
Chandler/Staton 1	Chandler and Staton	19, 11S, 14E	1935	ADN	8
Sinclair 1	Kent, Imperial Corp.	10, 12S, 13E	1958	ADN	4
Sinclair 2	Kent, Imperial Corp.	10, 12S, 13E	1961	ADN	5
Sportsman 1	Imperial Thermal Products, Inc.	23, 11S, 13E	1961	ADN	81
IID 1	Imperial Thermal Products, Inc.	23, 11S, 13E	1962	ADN	33
Sinclair 3	Kent, Imperial Corp.	10. 12S, 13E	1963	ADN	6
IID 2	Imperial Thermal Products, Inc.	22, 11S, 13E	1963	ADN	34
River Ranch 1	Imperial Magma	24, 11S, 13E	1964	ADN	45
State of California 1	Imperial Thermal Products, Inc.	23, 11S, 13E	1964	ADN	46
Elmore 1	Imperial Magma	27, 11S, 13E	1964	ADA	47
Sinclair 4	Kent, Imperial Corp.	4, 12S, 13E	1964	ADN	7
Hudson 1	Imperial Magma	13, 11S, 13E	1964	ADN	48
IID 3	Imperial Thermal Products, Inc.	23, 11S, 13E	1965	ADN	35
Magmamax 1	Imperial Magma	33, 11S, 13E	1972	ADA	49
Woolsey 1	Imperial Magma	33, 11S, 13E	1972	ADA	53
Magmamax 3	Imperial Magma	33, 11S, 13E	1972	ADR	51
Magmamax 2	Imperial Magma	33, 11S, 13E	1972	ADR	50
Magmamax 4	Imperial Magma	33, 11S, 13E	1972	ADA	52
Elmore 3	Imperial Magma	27, 11S, 13E	1974	ADA	71
Landers 1	Mapco Geothermal	20, 12S, 13E		ADA	76
Landers 2	Mapco Geothermal	20, 12S, 13E		ADA	77
Landers 3	Mapco Geothermal	20, 12S, 13E		ADR	78
Biff 1	Sardi Oil Co.	24, 12S, 13E		ADN	80
Sardi 1	Sardi Oil Co.	24, 12S, 13E		ADN	79
Woolsey 5			1979		
Sinclair 13	Union Oil	5, 12S, 13E	1980	ADA	16
Sinclair 15	Union Oil	5, 12S, 13E	1979-80	ADA	18
IID 5	Union Oil	5, 12S, 13E	1979-80	ADA	37
IID 6	Union Oil	5, 12S, 13E	1979-80	ADA	38
Fee 1	Republic Geothermal	17, T11S, R14E	1980	ADA	56
Britz 3	Republic Geothermal	20, T11S, R14E	1979-80	ADA	66

Table 2.3-1 (Continued)

Well Designation	Operator	Location (Sec., T&R)	Year Completed	Status	Map Reference No. (see Figures 2.3-1 and 2.3-2)
Sinclair 10	Union Oil	4, 12S, 13E		A	13
Sinclair 11	Union Oil	4, 12S, 13E		A	14
Sinclair 12	Union Oil	5, 12S, 13E		A	15
Sinclair 14	Union Oil	8, 12S, 13E		A	17
Sinclair 16	Union Oil	5, 12S, 13E		A	19
Sinclair 17	Union Oil	5, 12S, 13E		A	20
Sinclair 18	Union Oil	5, 12S, 13E		A	21
Sinclair 19	Union Oil	5, 12S, 13E		A	22
Sinclair 20	Union Oil	5, 12S, 13E		A	23
Sinclair 21	Union Oil	4, 12S, 13E		A	24
Sinclair 22	Union Oil	4, 12S, 13E		A	25
Sinclair 23	Union Oil	4, 12S, 13E		A	26
Sinclair 24	Union Oil	8, 12S, 13E		A	27
Sinclair 25	Union Oil	4, 12S, 13E		A	28
Sinclair 26	Union Oil	9, 12S, 13E		A	29
Sinclair 27	Union Oil	8, 12S, 13E		A	30
Sinclair 28	Union Oil	8, 12S, 13E		A	31
Sinclair 29	Union Oil	9, 12S, 13E		A	32
IID 7	Union Oil	32, 11S, 13E		A	39
IID 8	Union Oil	33, 11S, 13E		A	40
IID 9	Union Oil	5, 12S, 13E		A	41
IID 10	Union Oil	5, 12S, 13E		A	42
IID 11	Union Oil	5, 12S, 13E		A	43
IID 12	Union Oil	5, 12S, 13E		A	44
Fee 2	Republic Geothermal	17, T11S, R14E	1980	ADA	57
Fee 3	Republic Geothermal	17, T11S, R14E		A	58
Fee 4	Republic Geothermal	17, T11S, R14E		A	59
Fee 5	Republic Geothermal	17, T11S, R14E		A	60
Fee 6	Republic Geothermal	17, T11S, R14E		A	61
Fee 7	Republic Geothermal	17, T11S, R14E		A	62
Fee 8	Republic Geothermal	17, T11S, R14E		A	63
Britz 1	Republic Geothermal	20, T11S, R14E		A	64
Britz 2	Republic Geothermal	20, T11S, R14E		A	65
Britz 4	Republic Geothermal	20, T11S, R14E		A	67
Britz 5	Republic Geothermal	20, T11S, R14E		A	68
Britz 6	Republic Geothermal	20, T11S, R14E		A	69
Elmore 2	Imperial Magma	27, 11S, 13E		A	70
Elmore 4	Imperial Magma	26, 11S, 13E		A	82
Elmore 5	Imperial Magma	27, 11S, 13E		A	83

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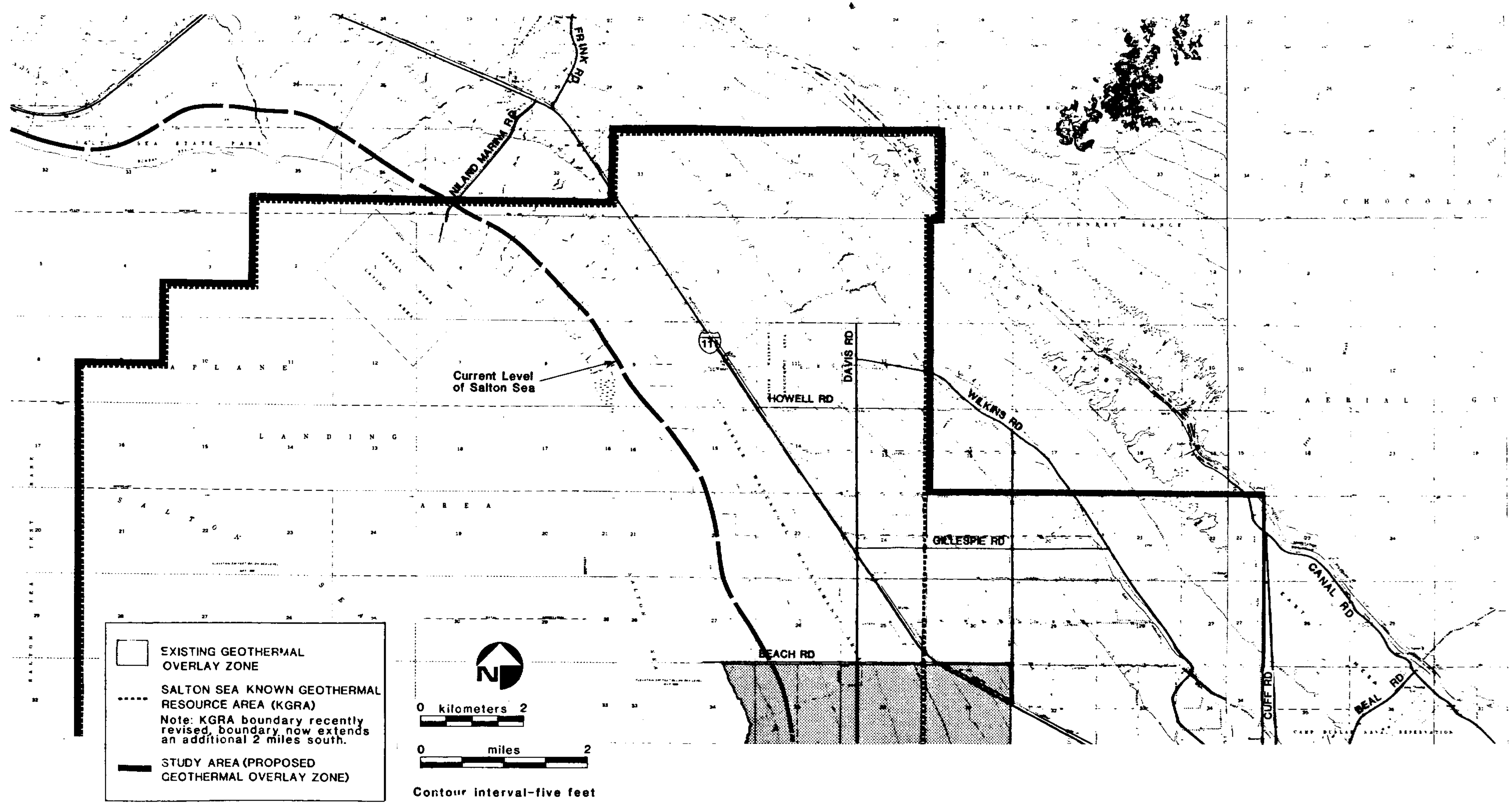
Table 2.3-1 (Continued)

Well Designation	Operator	Location (Sec., T&R)	Year Completed	Status	Map Reference No. (see Figures 2.3-1 and 2.3-2)
Wiest 1	Imperial Magma	27, 11S, 13E		A	87
Wiest 2	Imperial Magma	26, 11S, 13E		A	88
Wiest 3	Imperial Magma	26, 11S, 13E		A	89
Baretta 1	Imperial Magma	27, 11S, 13E		A	90
River Ranch 2	Imperial Magma	25, 11S, 13E		A	91

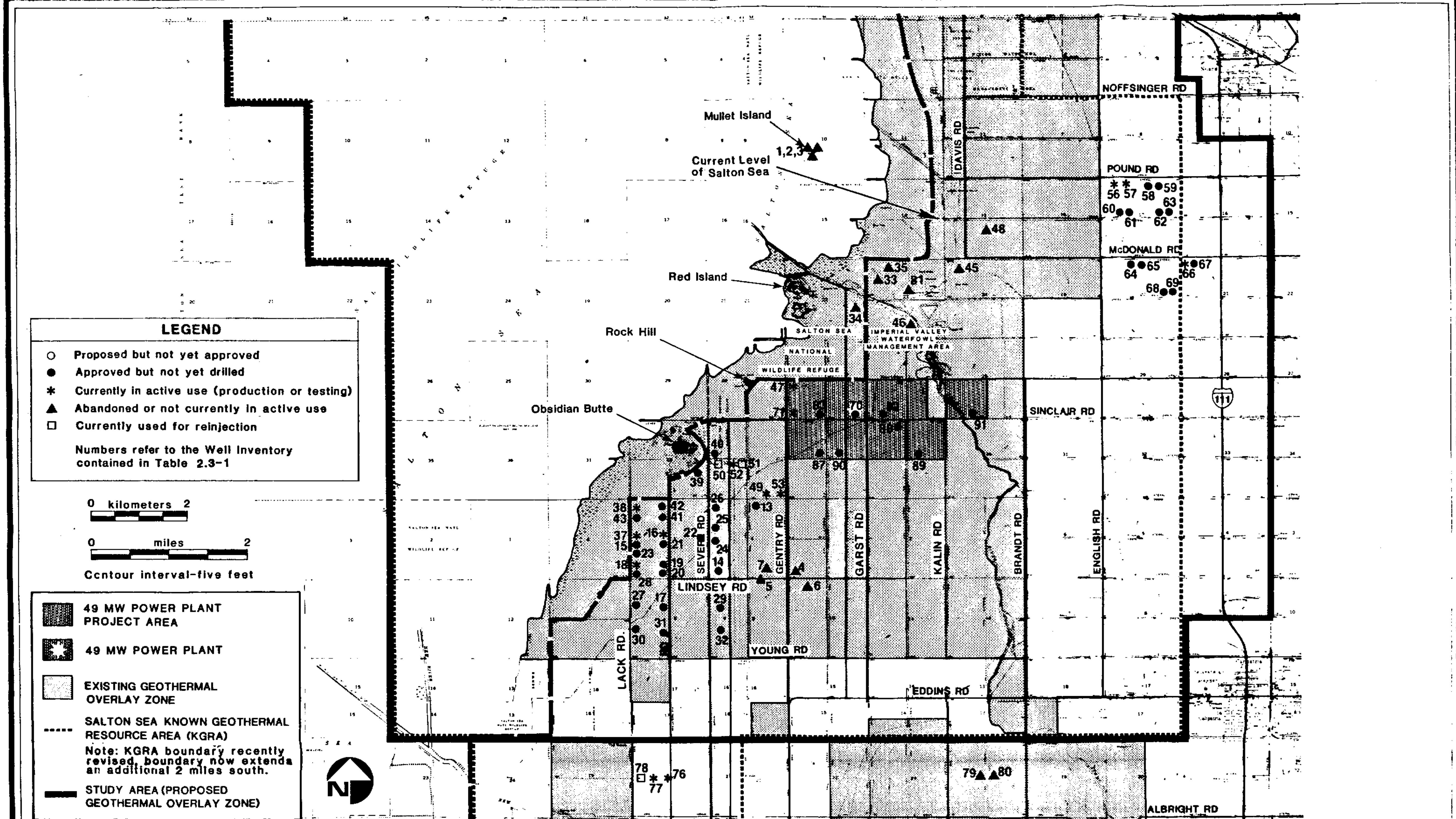
Status:

P - Proposed but not yet approved.
A - Approved but not yet drilled.
ADA - Approved and drilled; currently in active use.
ADN - Approved and drilled; abandoned or not currently in active use.
ADR - Approved and drilled; currently used for reinjection.



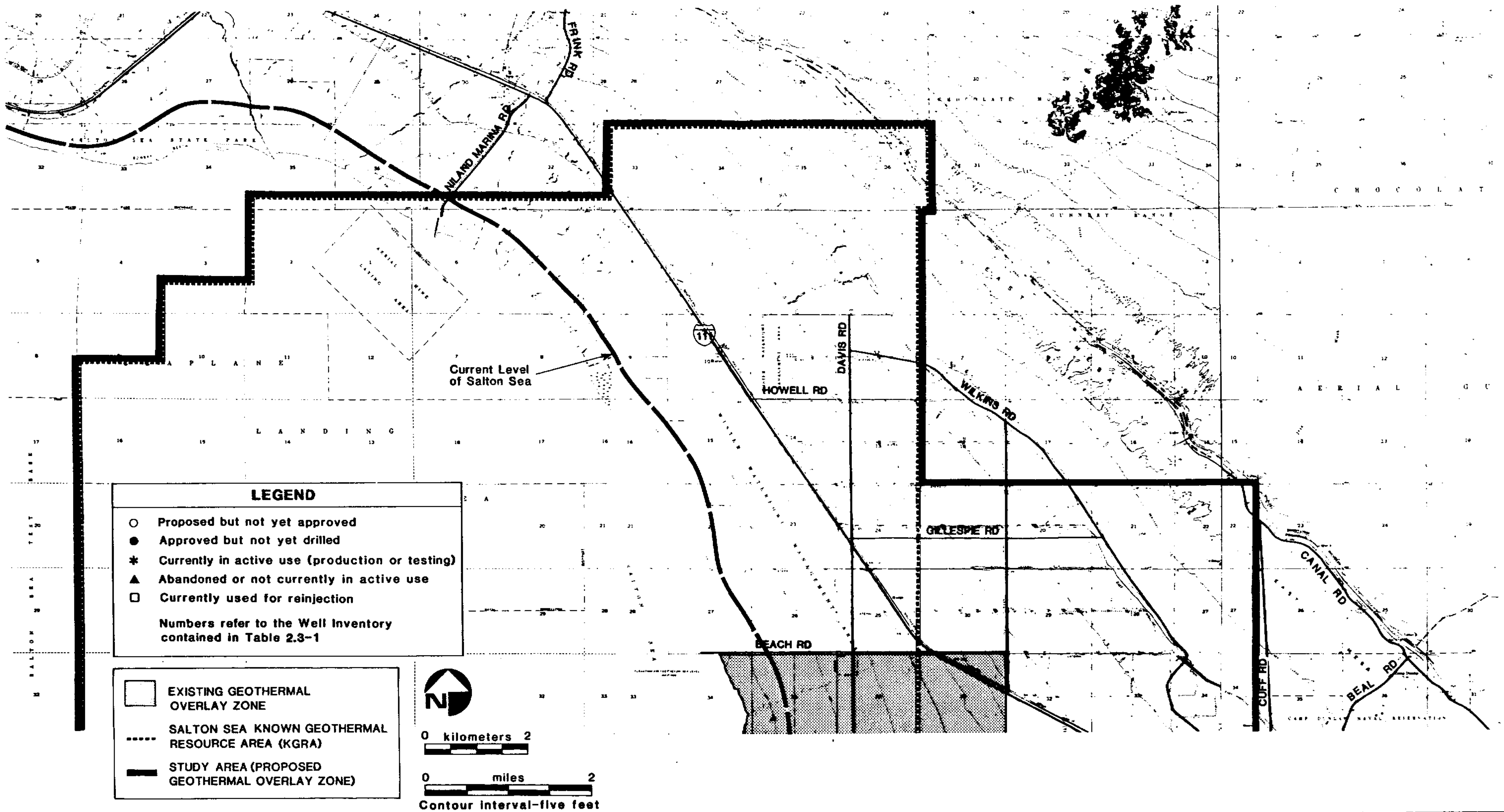
Topographic Map of the Project Area - Part 2

FIGURE 2.2-5



Well Locations Part I

FIGURE 2.3-1



Well Locations Part II

FIGURE 2.3-2

2.4 RESERVOIR CHARACTERISTICS AND RESOURCE CAPABILITIES

2.4.1 General Reservoir Characteristics

Considerable data have been generated regarding the size, magnitude, production potential, and physical characteristics of the Salton Sea Anomaly. Figure 2.4-1 (Bouguer Anomaly Map) depicts positive gravity anomalies, which coincide with thermal anomalies and thus are used to map the geothermal resource. The Salton Sea Anomaly, which is the largest of several geothermal anomalies in the Salton Trough, is oriented in a northwest-southeast direction with its center in the vicinity of the Salton Buttes (Obsidian Butte, Red Hill, and Rock Hill). This anomaly is characterized by high heat flow, magnetic highs and a gravity high as shown in Figure 2.4-1. The heat itself is stored in two mediums, liquid and rock.

In general, it can be stated that the Salton Sea Anomaly possesses two characteristics which are considerably different from other anomalies within the Imperial Valley: higher temperatures and higher salinity. Table 2.4-1 illustrates these differences.

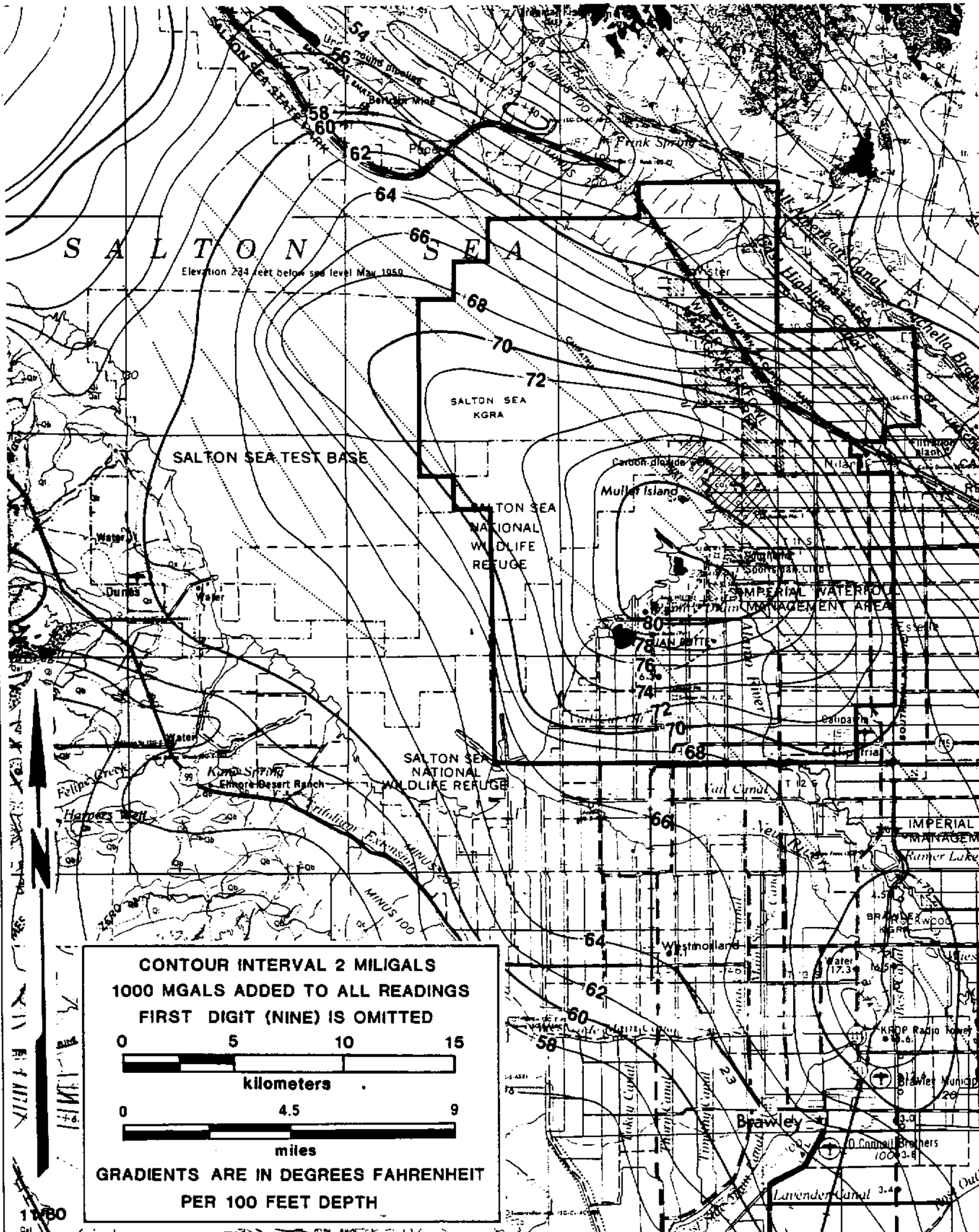
Table 2.4-1

IMPERIAL VALLEY GEOTHERMAL ANOMALIES
TEMPERATURE AND SALINITY DIFFERENCES

KGRA	Approximate Temperature	Approximate Salinity (TDS in ppm)
Salton Sea	500°F(260°C)*	250,000 - 350,000
Brawley	500°F(260°C)*	70,000 - 200,000*
Heber	370°F(190°C)	2,000 - 50,000
East Mesa	360°F(180°C)	14,000 - 20,000

Source: Imperial County, 1977
*Developer Consensus, 1981

In addition, the noncondensable gas content of the brines at the Salton Sea Anomaly has been found to be low. Initial tests showed about a 3 percent content, but subsequent tests have found less than 1 percent of noncondensable gases in the brine (SDG&E, 1980). These three factors (high temperatures, high salinity and low noncondensable gases) which exist within the Salton Sea Anomaly dictate the type of energy conversion



Bouguer Anomaly and Geothermal Gradient Map of the Imperial Valley, California

FIGURE 2.4-1

technology to be used, as well as the design of brine handling and other power plant components. These factors and the ensuing technology and design decisions for development within the Salton Sea KGRA are discussed further in Section 2.6.

Tables 2.4-2 and 2.4-3 provide an overview of the characteristics of the geothermal resource within the Salton Sea Anomaly. The information was consolidated from numerous sources. Appendix 2.4 of this MEIR includes a data base consisting of currently available well inventory information as well as specific test results for many wells in the Salton Sea Anomaly.

2.4.1.1 Well Depth

The last series of exploratory and production wells drilled near the center of the Anomaly (1972 to the present) was directed at determining the best method of extracting heat from the geothermal reservoir. These wells range from about 2000 feet to as much as 6000 feet in depth (600-1800 m). It is the consensus of the geothermal developers with leaseholds in the Salton Sea Anomaly that the average well depth in the future will be between 2800 feet (853 m) and 3500 feet (1067 m) but this depends on reservoir configuration and characteristics which are not completely known at this time. However, wells drilled farther east on Republic Geothermal's leaseholds just southwest of Niland are expected to continue to be 8000 to 10,000 feet in depth (2439 to 3049 m).

2.4.1.2 Downhole Temperature

As would be expected, the downhole temperatures encountered tend to vary with depth and with distance from the center of the anomaly. (This can be better understood from the depth versus temperature tables contained in Palmer, 1975.)

The most recent series of wells which were drilled between 1972 and the present has recorded temperatures generally in the 460°F to 540°F range (238°C to 282°C), although Magmamax 3 drilled in 1972 recorded a downhole temperature of 580°F (304°C) at 4002 feet (1220 m). Temperature gradients for these wells averaged just under 48°F (8.8°C) per 100 feet of depth. Based on an average well depth of 2800 to 3500 feet (854-1067 m) the average downhole temperature for future development is expected to be about 500°F (260°C).

2.4.1.3 Salinity

The County's Geothermal Element indicated a total dissolved solids (TDS) range of 250,000 to 350,000 parts per million (ppm) within the Anomaly. Ermak (1977), on the other hand, produced an estimate of 200,000 ppm. Actual test results obtained at the GLEF recorded a salinity range for the geothermal brine of 200,000 to 245,000

Table 2.4-2

SALTON SEA ANOMALY
GENERAL RESOURCE CHARACTERISTICS AND RELATED DATA

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	Representative (or Average) Measurement	Range
Depth to Reservoir Basement:	6000 ft (1829 m)[3]*	N/A
Well Depth:		
1972 to 1980	3100 ft (945 m)[1,6]	2400 to 4368 ft (732-1332 m)[1,6] 8000 to 10,000 ft (2400-3000 m) (Republic)*
Temperature:		
Downhole	500°F (260°C)[8]	370°F to 680°F (188-360°C)[7]
Wellhead	375°F (191°C)[5]	370°F to 406°F (188°C-208°C)[6]
Salinity (TDS in ppm):	225,000[5]	200,000 to 350,000[2,3]
Flow Rate (Mass Flow):	400,000 lb/hr[5] (181,000 kg/hr)	100,000 to 625,500 lb/hr[3] (45,000 to 283,000 kg/hr)
Pressure (psi at wellhead):	150[5]	18 to 585[3] 120 to 285[5]
Steam Content (percent by weight):	15[8]	10-22[6,8]
Noncondensable Gases (percent by weight):	<1[5]	0.12 to 3[4,5,6]
Fluid Enthalpy (cal/g):	243[2]	210 to 285[2]

N/A = Not Available

Sources:

1. Palmer, 1975
2. Division of Oil and Gas, 1975
3. Imperial County, 1977
4. Ermak, 1977
5. SDG&E, 1980
6. Well Data (see Appendix 2.4)
7. Based on 14 wells drilled to depths of 1600 to 8000 feet (487-2439 m) (Palmer 1975)
8. Geothermal developers' consensus

* Best estimate

Table 2.4-3

CHEMICAL ANALYSIS OF BRINE BY WEIGHT FOR THE SALTON SEA ANOMALY

Compound	Data From Five Wells (mg/l)[1,2] Average	Range	Expected Wellhead Brine Composition (mg/l)[2,3]
Chloride (Cl^-)	165,800	93,650-210,700	109,000-155,000
Sodium (Na)	58,565	36,340-78,000	43,000-65,000
Calcium (Ca)	29,000	14,550-37,735	19,000-29,000
Potassium (K)	17,440	7,820-20,690	7,000-16,500
Magnesium (Mg)	760	10-2,225	4-150
Bicarbonate (HCO_3^-)	225	60-390	N.E.
Sulfate ($SO_4^=$)	49	30-75	N.E.
Carbon Dioxide (CO_2)	N/A	N/A	1,400-9,800
Manganese (Mn)	N/A	N/A	677-1,400
Strontium (Sr)	N/A	N/A	337-460
Boron (B)	N/A	N/A	244-390
Ammonia (NH_3)	N/A	N/A	280-450
Iron (Fe)	N/A	N/A	220-680
Lithium (Li)	N/A	N/A	135-250
Silicon (Si)	N/A	N/A	130-250
Zinc (Zn)	N/A	N/A	102-500
Bromide (Br^-)	N/A	N/A	80-363
Lead (Pb)	N/A	N/A	16-91
Barium (Ba)	N/A	N/A	10-800
Hydrogen Sulfide (H_2S)	N/A	N/A	7.4-22.3
Arsenic (As)	N/A	N/A	2.2-7.4
Copper (Cu)	N/A	N/A	1.4-3.0
Chromium (Cr)	N/A	N/A	0-0.2
Radon (Rn) 222	N/A	N/A	N/A
Specific Gravity at 60°F (15°C)	N/A	N/A	1.14-1.19

[1] Appendix 2.4 (Sportsman 1, IID 1 and 2, Sinclair 3 and 4)

[2] mg/l = ppm x specific gravity

[3] Imperial County, 1980

N.E. = No Estimate

N/A = Not Available

ppm, and 40,000 to 80,000 ppm for the steam portion of the resource. Sodium, calcium and potassium salts were the major constituents. For purposes of this MEIR a representative salinity of 225,000 ppm (TDS) has been used.

2.4.1.4 Flow Rates

Imperial County's Geothermal Element of the General Plan indicates a probable flow rate range of 100,000 to 625,500 pounds per hour (45,400-283,700 kg/hr). Design criteria for the 10 MW power plant proposed by Union Oil/SCE utilize a flow rate of 400,000 lbs/hr, which is expected to decline to approximately 300,000 lbs/hr over a 30-year period (Imperial County, 1980). The 400,000 lbs/hr flow rate is considered to be the average rate expected for future development.

2.4.1.5 Wellhead Pressure

Tests to date indicate that the wellhead pressures encountered at the GLEF of 120-285 psi should be fairly representative of those to be expected in future geothermal projects. The typical wellhead pressure that will be found in the Salton Sea Anomaly is considered to be 150 psi.

2.4.1.6 Noncondensable Gases

A ten-day flow test by Magma/NARCO in 1972 at one of the production wells on the GLEF site produced a brine mixture which contained three percent noncondensable gases by weight. Of the total noncondensable gases, carbon dioxide was found to be the major component (98 percent), with hydrogen sulfide (H_2S) constituting only 0.25 percent of the noncondensable gases. Further testing at the GLEF wells produced considerably lower percentages for noncondensable gases. The final report (SDG&E, 1980) estimated that much less than one percent (0.12 percent) of the geothermal brine consisted of noncondensable gases. Regarding the composition of the noncondensable gases themselves, tests show that they consist primarily of carbon dioxide (CO_2) with small concentrations of nitrogen (N_2), methane (CH_4), and hydrogen sulfide (H_2S). However their composition may vary geographically from well to well and also over time. For impact assessment purposes the noncondensable portion of the brine has been assumed to be one percent for the Salton Sea Anomaly. This is likely to represent a worst case situation for air quality impact assessment.

2.4.2 Resource Capabilities and Production Estimates

Several fairly recent publications provide detailed discussions of the amount of stored heat within the geothermal reservoirs of Imperial Valley, including the Salton Sea Anomaly (Layton and Ermak, 1976; Ermak, 1977; Imperial County, 1977; Muffler, 1978; DOE, 1980). These documents make use of a number of prior studies and represent the best data currently available as to stored heat estimates and the extent of commercial power that could be extracted from the resource within the foreseeable future. Table 2.4-4 provides a summary of five estimates of the amount of heat stored in the geothermal reservoir within the Salton Sea Anomaly (Layton and Ermak, 1976; Muffler, 1978). A brief explanation of why the estimates differ is offered in the footnotes at the bottom of the table.

Muffler, 1978, describes the process and problems associated with estimating the conversion of stored heat within a reservoir (such as that shown in Table 2-4.4) into electrical energy. This process involves basically two major steps:

1. Estimating that portion of the stored heat that could be recovered "at the surface, under reasonable assumptions of future technology and economics," and

2. Estimating "the efficiency with which the resource can be converted into electrical energy" (Muffler, 1978).

Through a series of complex equations involving geothermal recovery factors, wellhead enthalpy, and heat to energy conversion factors, both of these steps have been accomplished for the Salton Sea KGRA. Muffler, 1978, estimates that of the 97×10^{18} Joules (J) stored within the Salton Sea Anomaly, approximately 24×10^{18} J (or 25 percent) will be available at the wellhead in the form of thermal energy. Of this amount only 8.1×10^{18} J (or 34 percent) can be converted into available work. Following the application of a factor to account for mechanical and other losses that occur in a real power cycle, an estimate of 3400 MW of available electrical energy for a period of 30 years was calculated for the Salton Sea KGRA (Muffler, 1978; U.S. DOE, 1980).

Table 2.4-4

SALTON SEA ANOMALY
STORED HEAT ESTIMATES

	Estimate of Stored Heat (10^{18} Joules)
Renner *et al.*, 1975[1]	87.9
Nathenson and Muffler, 1975[2]	22.0
Towne, 1975[3]	11.0
Biehler, 1976[4]	31.2
Muffler, 1978[5]	97.0 (± 28)

Source: Layton and Ermak, 1976; Muffler, 1978.

Footnotes:

1. Based on estimates of total heat in rock and water within the reservoir volume to a depth of 10,000 feet (3048 m); reservoir temperatures >150°C (302°F); and volumetric specific heat estimate of 0.6 cal/cm^3/°C.

2. Used figures of Renner *et al.*, 1975 and assumed net recovery factor of 25 percent.

3. Based on fluid temperatures of 230°C (446°F) or greater and temperature gradient maps of Combs, 1971, to calculate reservoir volume; usable fluid assumed to extend 1000 feet (305 m) below 230°C (446°F) isothermal surface or 7000 feet (2134 m), whichever was less, plus a wellhead enthalpy of 1.0 to 1.3 x 10^6 J/kg; a specific yield of 0.16, and a fluid density of 1 g/cm^3.

4. Based on use of Bouger gravity maps, specific yield of 0.16, a wellhead enthalpy of 1.3 x 10^6 J/kg, and a fluid density of 1 g/cm^3.

5. Based on same methodology as Renner *et al.*, 1975, with refinement of temperature estimates; prime difference between estimates of Muffler, 1978, and Renner *et al.*, 1975, involves an increase in the reservoir area from 54 to 60 km^2, which overcompensated a temperature decrease from 340°C to 323°C (644°F to 613°F).

2.5 DEVELOPMENT SCENARIO

2.5.1 Full Field Development

Based on a number of assumptions and considering a wide range of factors which affect the rate of geothermal development, Ermak (1977) established low, medium, and high growth scenarios for the Salton Sea Anomaly. These were published as 300 MW, 1400 MW and 4000 MW respectively for the year 2010. After careful review of the assumptions and factors used by Ermak in his estimates and considering new data and developments in the three years since Ermak published his predictions, it is the concensus of the involved geothermal developers and the steering committee for this project that the medium growth scenario of 1400 MW by the year 2010 is the "most probable" production estimate for the Salton Sea Anomaly. For the medium growth scenario, Ermak (1977) predicted 100 MW by 1985, 300 MW by 1991, and 1400 by 2010. Plans already formulated for the Salton Sea Anomaly, however, suggest a different rate of development as presented and discussed below.

2.5.2 Rate and Timing of Power Generation Growth

If approved, the expansion of the G-Overlay Zone would encompass approximately 111,444 acres (45,119 ha) of land within the Salton Sea Anomaly (see Figures 2.2-2 through 2.2-5). Four major geothermal developers are currently conducting the exploratory and production activities within this area. Table 2.5-1 provides an indication of the extent of leaseholds currently held by these producers within the study area. The leased areas themselves (in 1981) are shown in Figures 2.5-1 and 2.5-2.

There are applications approved or pending for three power plants which, when completed, will have the capacity to produce a total of 87 MW of electrical power. Table 2.5-2 is based on current information gathered from the producers and provides the most probable scenario for the development of electrical generating capacity within the Salton Sea Anomaly. Figure 2.5-3 shows the probable geographical distribution of the power generating facilities. The siting criteria are discussed subsequently in Section 2.6.1.

An application has already been recently approved by Imperial County for Union Oil/SCE for the construction of the 10 MW demonstration facility shown in Table 2.5-2 as having an in-service date of 1982. It is proposed for development on 20 acres of unincorporated vacant land at the shore of the Salton Sea in the northwestern quarter of Section 5, T12S, R13E (see Figure 2.5-3). An EIR on the 10 MW project is on file with the County and has been used as one of the resource documents for this MEIR.

Table 2.5-1

SALTON SEA KGRA
GEOTHERMAL LEASES - 1981

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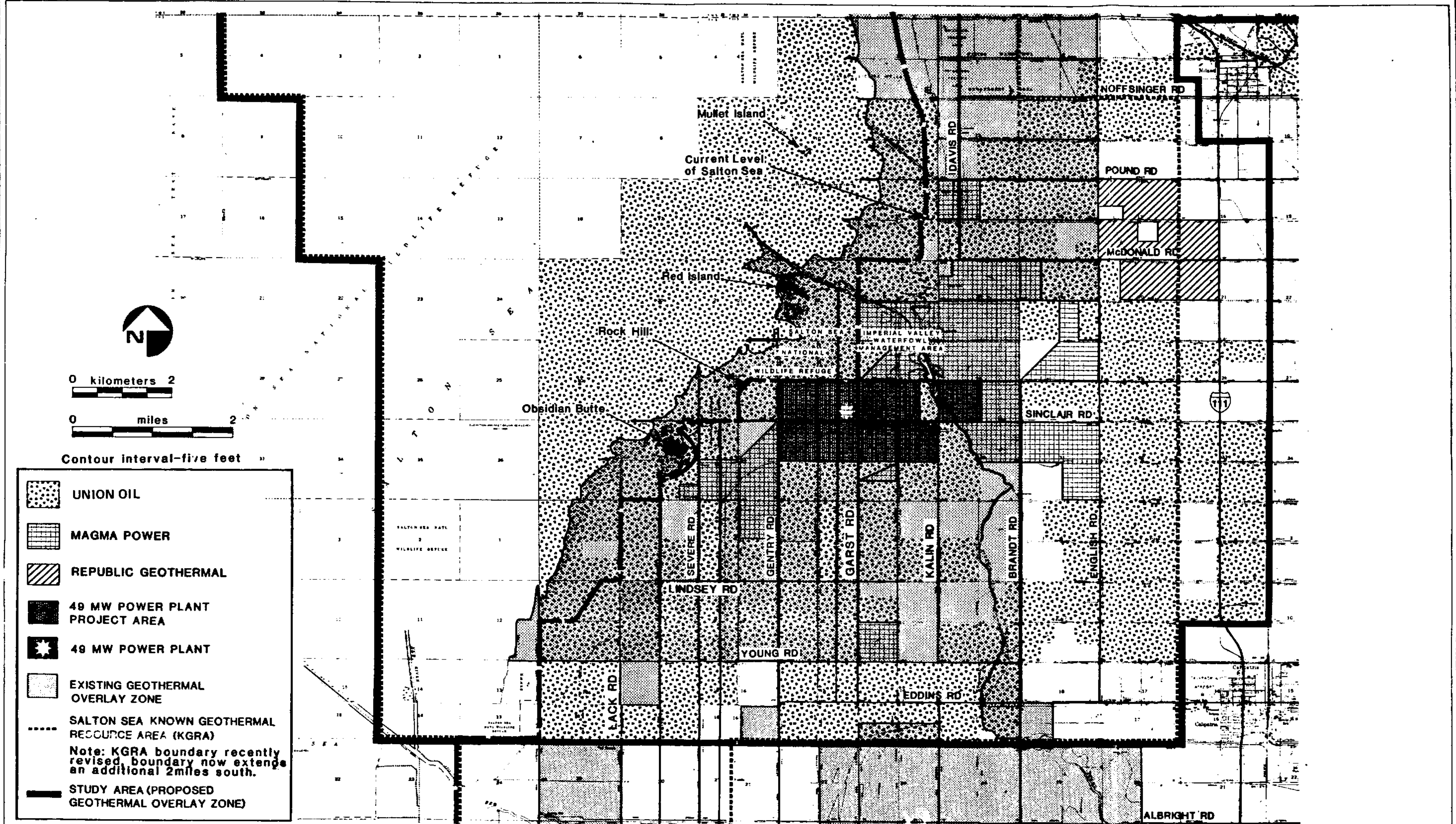
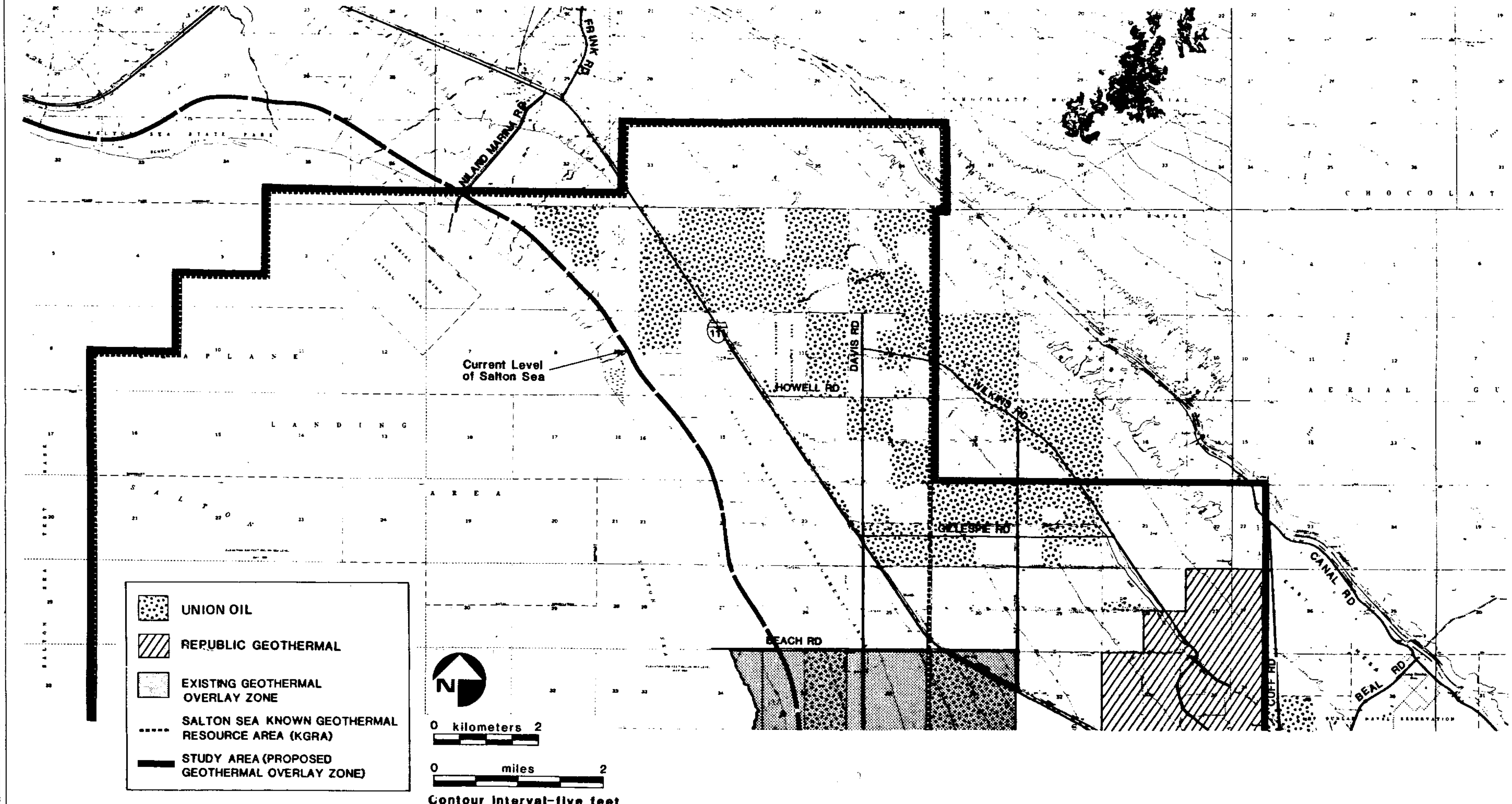
Lessee	Geothermal Leases 1981 (approx. acreage)
Union Oil Company	30,000 (12,146 ha)
Magma Power Company	7,500 (3,036 ha)
Republic Geothermal	3,900 (1,579 ha)
(1,700 ac (688 ha) southwest of Niland; 2,200 ac (891 ha) northwest of Niland)	
New Albion Resources Company	0
TOTAL:	41,400 (16,761 ha)



Geothermal Leases - Part 1

FIGURE 2.5-1



Geothermal Leases Part II

FIGURE 2.5-2

Table 2.5-2

MOST PROBABLE POWER PLANT
DEVELOPMENT SCENARIO*

70

Year In Service	Applicant	Estimated Gross Generating Capacity (MW)	Cumulative Gross Generating Capacity Within the Salton Sea KGRA (MW)
1982	Union Oil/SCE[1]	10	10
	Magma[1]	28	38
1984	Magma[1,2]	49	87
1985	Republic	50	137
	Union Oil/SCE	50	187
1986	Magma	100[3]	287
	Union Oil	100[3]	387
1987	Republic	50	437
	Magma	100[3]	537
	Union Oil	100[3]	637
1988	Magma	100[3]	737
	Union Oil	100[3]	837
1989	Magma	50	887
	Union Oil	100[3]	987
1992	Republic	50	1,037
1995	Republic	50	1,087
1996	Unknown	100[3]	1,187
1997	Unknown	100[3]	1,287
1998-2010	New capacity is expected to come on line at an approximate rate of 50 megawatts every two years until the "most probable" growth estimate of 1400 MW is achieved within the KGRA.		

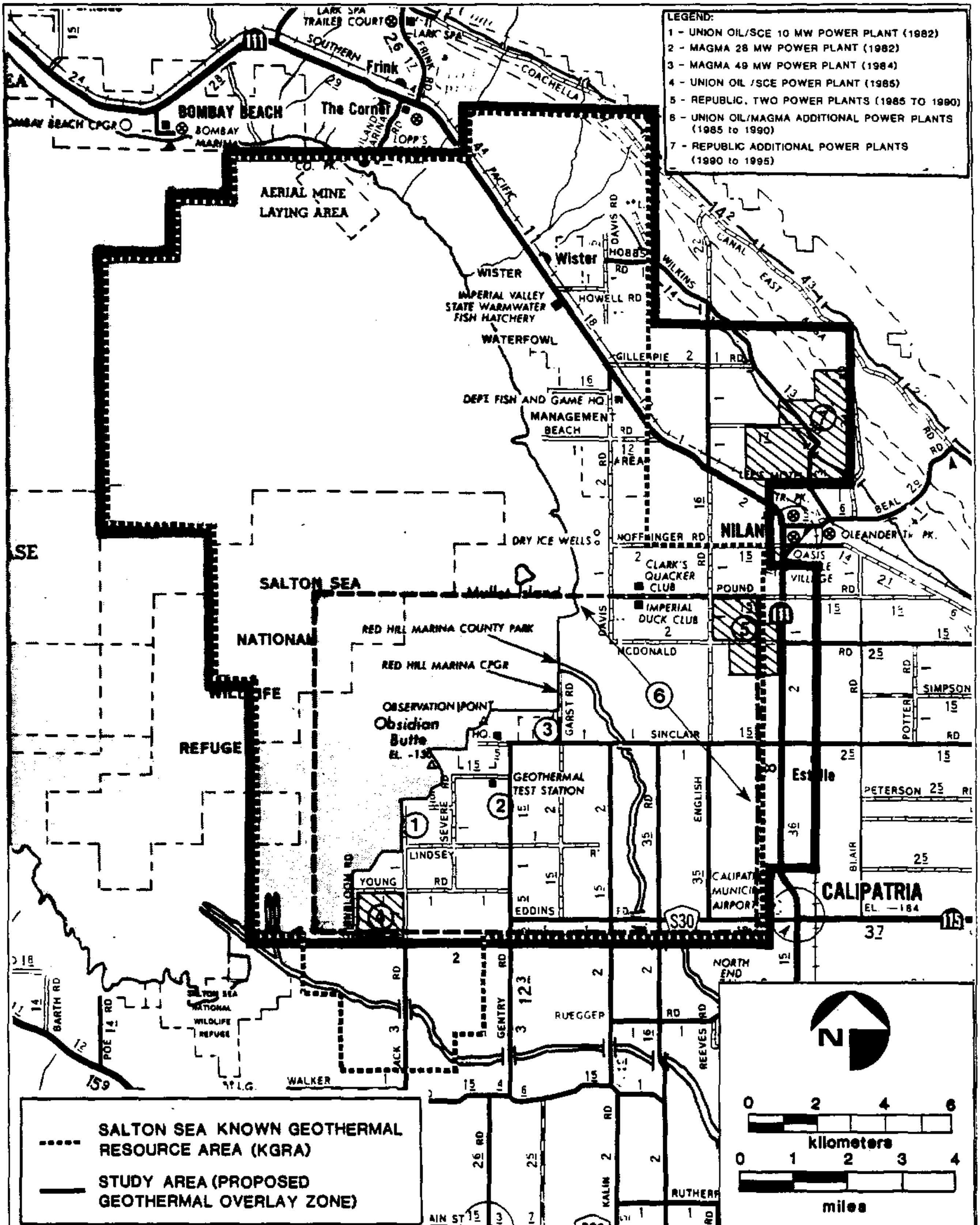
*Based on relatively optimistic geothermal developers' estimates of their future plans 73

[1] Application for CUP received by County

[2] Discussed in Section VIII of this MEIR

[3] May be one or two power plants

36



Potential Power Plant Locations and Development Scenario

FIGURE 2.5-3

An application has also been approved by the County for Magma Power Company's 28 MW commercial power plant with an in-service date of 1982. It will be constructed on the site of the San Diego Gas & Electric Company's existing Geothermal Loop Experimental Facility (GLEF) (see Figure 2.5-3). As with the Union/SCE application, an EIR (plus a supplement to reflect a relocation and reduction in capacity to 28 MW from 49 MW) has been approved by the County.

A second geothermal power plant application has been submitted to the County by Magma Power for a 49 MW plant between Gentry Road and Kalin Road (see Figure 2.5-3). A full description of the proposed power plant and its expected impacts are contained in Section VIII of this MEIR.

Because geothermal development generally proceeds radially outward from the first discoveries, it is probable that these three power plants will form the nucleus for future growth within the Salton Sea KGRA. However, current explorations by Republic Geothermal farther east within the study area appear to be promising and, as shown in Table 2.5-2, at least one 50 MW power plant is expected to exist in this area by 1985. The five power plants listed in Table 2.5-2 with an in-service date of 1985 or earlier are shown in Figure 2.5-3. Locations for the last two (Republic and Union/SCE) are not precisely known at this time; therefore, the potential site areas shown in Figure 2.5-3 for these two facilities were approximated by WESTEC Services using existing and projected data as a basis.

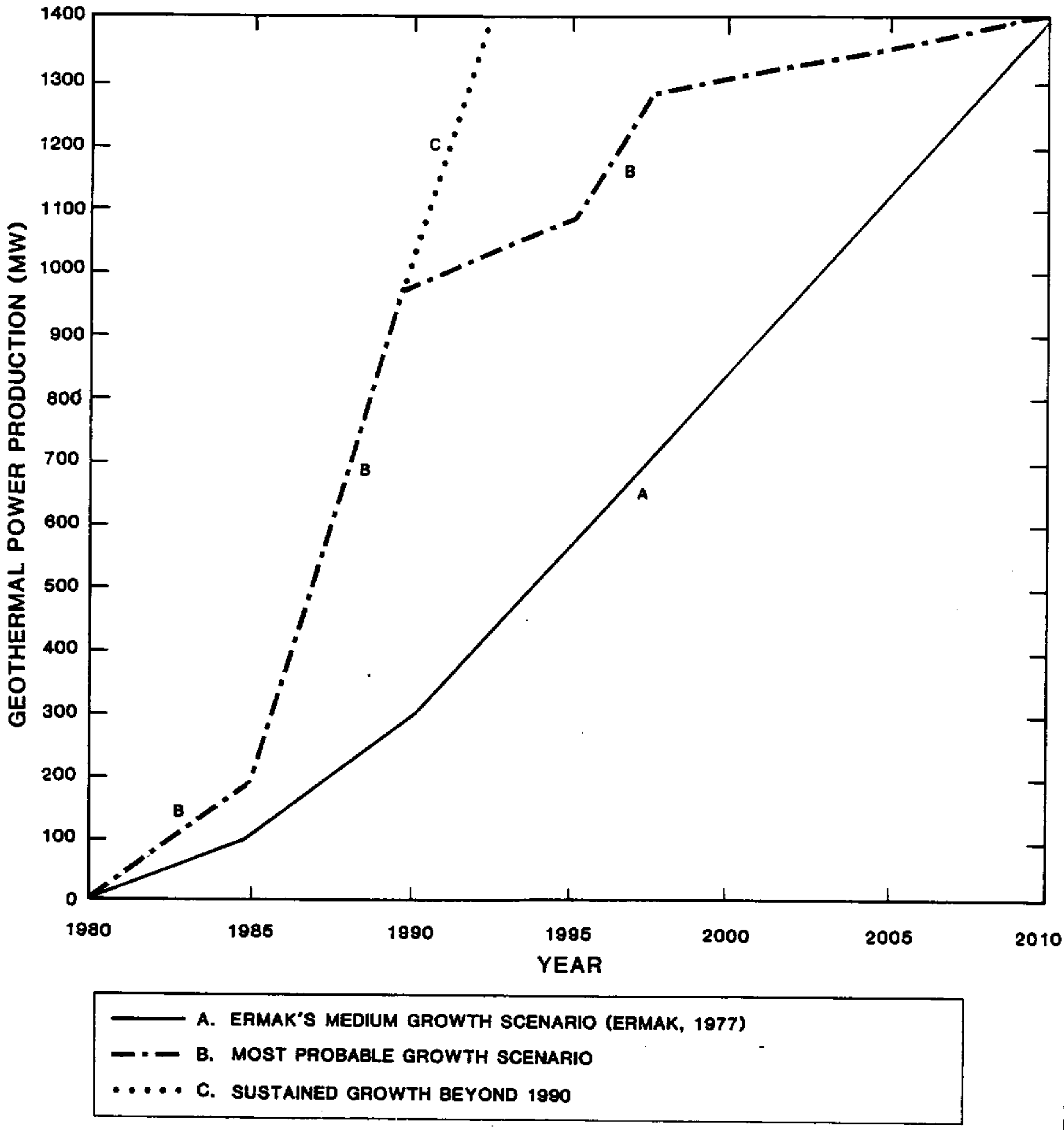
Between 1985 and 1990, an additional 16 power plants with a combined generating capability of approximately 800 MW are expected to be placed in service (see Table 2.5-2). The total of 16 additional plants is based on the assumption that each will produce 50 MW. However, the possibility exists that 100 MW plants might be built instead. If so, only nine additional plants would be built during the 1985-1990 time frame instead of 16. It is probable that these plants (either 9 or 16) would be located somewhere within the potential site areas shown in Figure 2.5-3. However, because of the uncertainties regarding projections this far in the future, and because the technology will continue to evolve, the confidence level represented in the 1985 to 1990 development pattern is much less than for the five plants projected for the 1980 to 1985 time frame.

By 1990, based on the foregoing projections and assumptions, a total of 21 power plants (or 14, if 100 MW plants become a reality) will be producing roughly 1000 MW of electricity from geothermal resources within the Salton Sea KGRA (see Table 2.5-2). If this were to occur, development within the KGRA will have progressed to roughly 70 percent of the total commercial power production reflected in the "most probable" development scenario (1400 MW by 2010), leaving a remainder of only 400 MW to be developed over the following 20 years. Of this figure, Republic Geothermal has indicated that two 50 MW power plants would probably be constructed between 1990 and 1995 on their leaseholds. It is possible that both Magma and Union would construct additional power plants as well during the 1990 to 1995 period; however, if the foregoing projections occur, each will have reached their estimated total production figure by 1990 (400± MW for Magma and 460± MW for Union). Therefore, the period beyond 1990 is felt to be considerably less reliable for prediction purposes than either the 1980-85 or the 1985-90 period.

Figure 2.5-4 offers growth curves which represent three geothermal development scenarios that may occur between now and the year 2010. It translates Ermak's estimates and the developers' estimates shown in Table 2.5-2 into a graphical representation. Curve A represents the "medium" growth projection developed by Ermak in 1977. While the total power production estimate of 1400 MW by the year 2010 is assumed to be valid for purposes of this MEIR, the chronological path represented by Curve A varies considerably from the development patterns visualized by current developers (Curve B). The developers' curve (produced from Table 2.5-2) also assumes a total production figure of 1400 MW by 2010, but is based on the producers' expected development patterns instead of on Ermak's 1977 estimates.

A third possibility is that the initial results of the earlier power plants (between now and 1985) will prove to be most encouraging, and will produce a growth pattern that will not only meet the somewhat optimistic plan of the developers, but will permit the steep growth rate of Curve B between 1985 and 1990 to continue into the future (shown as Curve C on Figure 2.5-4). In this scenario the 1400 MW total would be reached by 1992, or 18 years before that projected by Ermak (1977). If this were to occur, it is probable that the total production figure of 1400 MW in 30 years would be adjusted upward.

The relationship between potential offshore geothermal activities within the Salton Sea itself and the development scenarios discussed above deserves mention. Inasmuch as a large portion of the KGRA lies offshore within the Salton Sea, it is probable that some development will occur in this area. However, it is likely that such development will take place several years behind that which will occur onshore. Between now and 1985, it is possible that applications will be received by the County for wells to be drilled offshore. Between 1985 and 1990 as many as 16 additional power



Possible Growth Scenarios

FIGURE 2.5-4

plants (or as few as 9 if 100 MW plants are built) are anticipated within the KGRA. As shown in Figure 2.5-3, it is possible that one or more of these plants could be located offshore within the Sea itself. If so, they would probably be built near or beyond 1990. Criteria for siting such plants, as well as the approach and methodologies anticipated for their construction and operation, are described in appropriate subsections of Section 2.6.

As part of this MEIR effort, a series of environmental constraint maps have been developed so that these considerations can be used in future siting efforts. These maps delineate areas of maximum, major, moderate, and minimal constraint (defined in Section III) in regard to the development of geothermal facilities. As such, it is highly probable that they will influence the rate and geographical pattern of the development scenarios shown in Figure 2.5-3 and Table 2.5-2.

2.5.3 Most Probable Development Scenario

The scenario that is to be the subject of analysis for purposes of this MEIR is the one based on actual development plans of the geothermal leaseholders in the Salton Sea Anomaly. This scenario is judged to be "most probable." It is derived from information in Table 2.5-2, depicted in Figure 2.5-3, and shown as Curve B in Figure 2.5-4. It demonstrates development of 1400 MW of generating capacity over a 30 year time period. Scenarios with more rapid development or higher production estimates such as that shown by Curve C on Figure 2.5-4 will be treated in Section 7.0, "Alternatives to the Proposed Project," and will be considered as worst-case for analysis purposes.

2.5.4 Confidence Levels and Known Data Gaps

The information contained in Appendix 2.4 represents the best data currently available to WESTEC Services in regard to existing and planned wells and well test results. When combined with the discussions and data sources covered in the previous pages, it comprises the most thorough base of information available as to the size and the characteristics of the geothermal resource within the Salton Sea Anomaly. This information has been assimilated and condensed into summary form and was previously presented in Tables 2.4-2 and 2.4-3.

A sufficiently high degree of confidence exists in the minds of the geothermal developers to convince them that commercial power production within the Salton Sea KGRA is feasible. This confidence level has been demonstrated by the submittal of applications for three geothermal power plants within the Anomaly, and by a continued commitment to exploration and further development of the resource.

On the other hand a fairly low level of confidence must be assigned the estimates made to date as to the total size and extent of heat stored within the reservoir. As depicted earlier in Table 2.4-4, estimates of stored heat range from 11.0 x 10^{18} J (Towne, 1975) to 97.0 x 10^{18} J (Muffler, 1978). Likewise, estimates of the depth to the floor of the reservoir vary from 6000 feet (Imperial County, 1977) to 10,000 feet (3048 m) (Renner et al., 1975).

Regarding specific test results from various wells drilled to date throughout the Anomaly, Appendix 2.4 contains the most complete set of data available for use within this MEIR. As can be seen from the number of blanks contained in the Appendix, as well as the differences in recorded data, considerable information gaps and wide variations exist in the measurements obtained for various characteristics. These variations occur from well to well and within the same well over time. It is difficult therefore to readily establish a single set of parameters which adequately represents the entire Anomaly. On the other hand, data from individual wells have provided sufficient information to enable the involved developers to identify specific problem areas and to develop technical solutions. Therefore, until more exploration and testing are accomplished, generally a "medium" confidence level seems appropriate.

Finally, it should be noted that the majority of the wells drilled to date have been in the same general areas, thus leaving large portions of the Anomaly relatively unexplored, including offshore areas within the Salton Sea (see Figures 2.5-1 and 2.5-2). Therefore, until a considerable amount of further drilling and testing occurs in these areas, and the results are analyzed, a complete picture of the Salton Sea Anomaly and its ultimate development potential will not be available.

2.6 TECHNICAL DISCUSSION OF PROPOSED PROJECT

2.6.1 Siting Criteria

Ermak (1977) provides an excellent discussion of geothermal power plant siting criteria, much of which remains valid today. Application of these criteria specifically to the Salton Sea Anomaly, coupled with actual development plans and other factors, produces the following conclusions with regard to future geothermal development within the Salton Sea KGRA:

1. The power plants currently proposed (and probably those in the future) will utilize production wells that would normally be located within one-half to one mile of the plant site; none will be farther than two miles away due to the high heat losses that would occur.

2. The first three plants are proposed for construction on sites which are onshore, just southwest of the center of the Salton Sea Anomaly. Assuming successful results from these first plants, future development will probably tend to fill in the spaces between these three plants without being placed too close to cause inadvertent early drawdown and resultant heat loss in the reservoir; conflict with other wells, either production or injection; or problems with ongoing geothermal production activities. Following this fill-in pattern (or possibly concurrent with it), future development will probably radiate outward from the nucleus formed by these first plants. One or more exceptions to this pattern may occur. Assuming that Republic Geothermal is successful in its drilling and testing efforts farther east within the KGRA, it is probable that a power plant will be built south of Niland, as shown in Table 2.5-2 and Figure 2.5-3. This plant would form a separate growth center in this area of the Anomaly which would serve as a nucleus for future power plant development nearby. It is doubtful that these two geographically separate growth areas will expand outward to potentially conflict with each other, however. Additionally, it is probable that future exploration and testing will justify creation of power plants elsewhere within the Anomaly, for example, north of Niland or in the Sea itself. If this were to occur, additional nuclei would be created which could form the basis for additional power plants nearby.

3. As development and exploration proceed it is probable that power plants will be built offshore within the Salton Sea. Slant or directional drilling could serve to delay such development by allowing access from land sites to portions of the geothermal reservoir beneath the Sea. However, the shallowness of the reservoir will limit such drilling and, as pipeline distances become greater and the best onshore sites are developed, a greater need will exist to develop well fields and possibly build power plants within the Salton Sea itself.

4. Similarly, it is probable that through additional exploratory efforts, the need will again arise to expand the KGRA and the G-Overlay Zone outward. This will be particularly true for those areas which have seen little or no exploratory well drilling to date, such as areas beyond the KGRA within the Salton Sea, and farther west or north along the shore of the Sea.

74 5. The first plants, plus their networks of pipelines and production, makeup, and injection wells, will probably extend over an area of about 13 acres per megawatt, only a small portion of which would actually be occupied by facilities.

6. Because of the high geothermal fluid temperatures found in the Salton Sea KGRA, fewer wells will be required to support a given plant size than within other KGRAs in Imperial Valley; likewise, the size of well fields for a given plant will also be smaller (roughly half the size) in the Salton Sea area than in the other KRGAs.

7. Because of the governmental permit process, it is probable that future plants will be optimally sized at 49 MW (or possibly below) with a 30 year life span rather than 100 MW as indicated in Ermak (1977). However, if the existing permit process were to change, capacities as large as 110 MW (gross) could conceivably be built as long as the resource and production well area is sufficiently large to support it.

One of the purposes of this Master EIR is to build upon the prior assumptions regarding constraint information and siting criteria, and to more precisely define those areas that can readily accept geothermal development, those that cannot, and those that may be able to, provided adequate mitigation and safeguards are taken. This information has been expressed not only in narrative form within the MEIR but also visually by utilizing a series of maps which can be used to more precisely define areas of maximum, high, moderate and low constraint to power plant construction and well siting. This effort has thus been designed to 1) utilize the resources and technology constraints described by Ermak which remain essentially valid, and 2) build upon the rather general constraint and siting criteria contained in prior publications, in order to produce a document and accompanying maps which describe, in some detail, areas of major constraint that should be considered in future geothermal development siting.

2.6.2 Access Roads and Well Site Preparation

Preparation of a typical drilling site would involve grading (clearing and levelling) approximately 1 to 1.5 acres (0.4 to 0.6 ha) per well which would contain onsite disposal areas (sumps), an equipment staging and activity area, and a drill pad. Access to the site would normally be gained via one of the many dirt or paved roads which traverse the area. However, in order to accommodate heavy vehicles, it is probable that some new access roads to each individual drill site would have to be constructed and stabilized with crushed rock, depending on the conditions found at each site location. In addition, bridging of certain of the irrigation canals or drainage ditches may be necessary.

Site preparation, including drill rig assembly, should require approximately one to two weeks per well. Construction activities will take place during daylight hours and will employ 12 to 15 persons onsite.

2.6.3 Exploration, Production and Injection Wells

2.6.3.1 Well Development Scenario

Ermak (1977) projected the need for .35 wells per megawatt of capacity. The assumptions forming the basis of that projection include: an average flow rate of 441,000 lbs/hr; downhole temperatures of $545^{\circ}F$ ($285^{\circ}C$); steam content of 30 percent; two million lbs/hour of steam per 100 MW of power; a need for half as many injection wells as production wells; and replacement wells at the rate of two production wells every five years. Ermak therefore derived the need for 15 production wells, 8 injection wells, and 12 replacement wells per 100 MW for a total of 35 wells per 100 MW over a 30 year period, or .35 wells per megawatt.

However, since Ermak's analysis in 1977, three years of data and additional brine handling experience have accumulated. Several of Ermak's assumptions may not represent average conditions at the Salton Sea Anomaly as they are known today. As indicated in Table 2.4-2, the average flow rate estimate is now 400,000 lbs/hr. Average downhole temperatures of $500^{\circ}F$ ($260^{\circ}C$) are more likely and the steam content of the brine is approximated at 15 percent rather than 30 percent. For a 50 MW power plant, which is a size more likely to be built, one million lbs/hr of steam will be needed. Using the information stated above on resource characteristics, 16 production wells would be needed for a 50 MW power plant. The number of injection wells that would be needed is hard to predict because the high total dissolved solids content of the brine poses a difficult problem for reinjection without plugging the formation. The final number will depend on future technological developments. It could be as low as 5 or as high as about 12. Adopting Ermak's assumption of half as many injection wells as production wells would result in a prediction of 8 injection wells per 50 MW capacity. This appears to provide a reasonable estimate of the average number that will be needed and thus will be used for analysis purposes. The necessary number of replacement wells is also hard to predict. The technological and resource uncertainties, however, indicate that Ermak's assumption of two every five years may be too optimistic. Therefore, for impact analyses purposes in this MEIR which will ensure that any error will result in overestimating rather than underestimating impacts, it will be assumed that one replacement well will be permitted for each production and injection well over the 30 year life span of a facility. The assumptions discussed above therefore lead to the well requirements shown in Table 2.6-1.

Table 2.6-1

WELL REQUIREMENTS

Type of Wells	Number of Wells per 50 MW Capacity
Production	16
Injection	8
Replacement	24
Total	48
Number of Wells per MW	.96

It should be recognized that this prediction of the number of necessary wells is highly sensitive to the assumptions made about the resource characteristics. Some wells may produce at only 300,000 lbs/hr of brine while others may produce 600,000 lbs/hr.; similarly, the steam content could vary from 10 to 22 percent. A 50 MW power plant would need 33 production wells if supplied by wells having a 300,000 lbs/hr flow rate and brine with a 10 percent steam content. This is in contrast to the 8 production wells needed for 50 MW if flow rates of 600,000 lbs/hr and a steam content of 22 percent are available. For the purpose of assessing environmental impacts in this MEIR it is felt that the well requirements stated in Table 2.6-1 will provide the basis for the most meaningful analysis. They are derived from assumptions about the resource conditions which are somewhat pessimistic. Therefore, they should result in assessments which are more likely to overestimate impacts rather than underestimate them.

The well development scenario which is based on the power plant development scenario of Table 2.5-2 and the well requirements of Table 2.6-1 is shown in Table 2.6-2.

Table 2.6-2

WELL DEVELOPMENT SCENARIO

Period	No. of Power Plants[1]		Estimated Power Production (MW)		No. of Wells Required[2]: Production		Injection		Replacement[3]		Total[4]	
	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative
1980-1985	5	5	187	187	60	60	30	30	15	15	105	105
1985-1990	16	21	800	987	256	316	128	158	79	94	463	568
1990-2010	8	29	413	1400	132	448	66	224	448	542	646	1214

[1] Assumes 50 MW power plants based on scenario shown in Table 2.5-2

[2] Based on well requirements in Table 2.6-1

[3] At the rate of .016 well per year per MW (.48 wells/MW over 30 years)

[4] Assumes all new power plants are operating in the first year of the time period designated

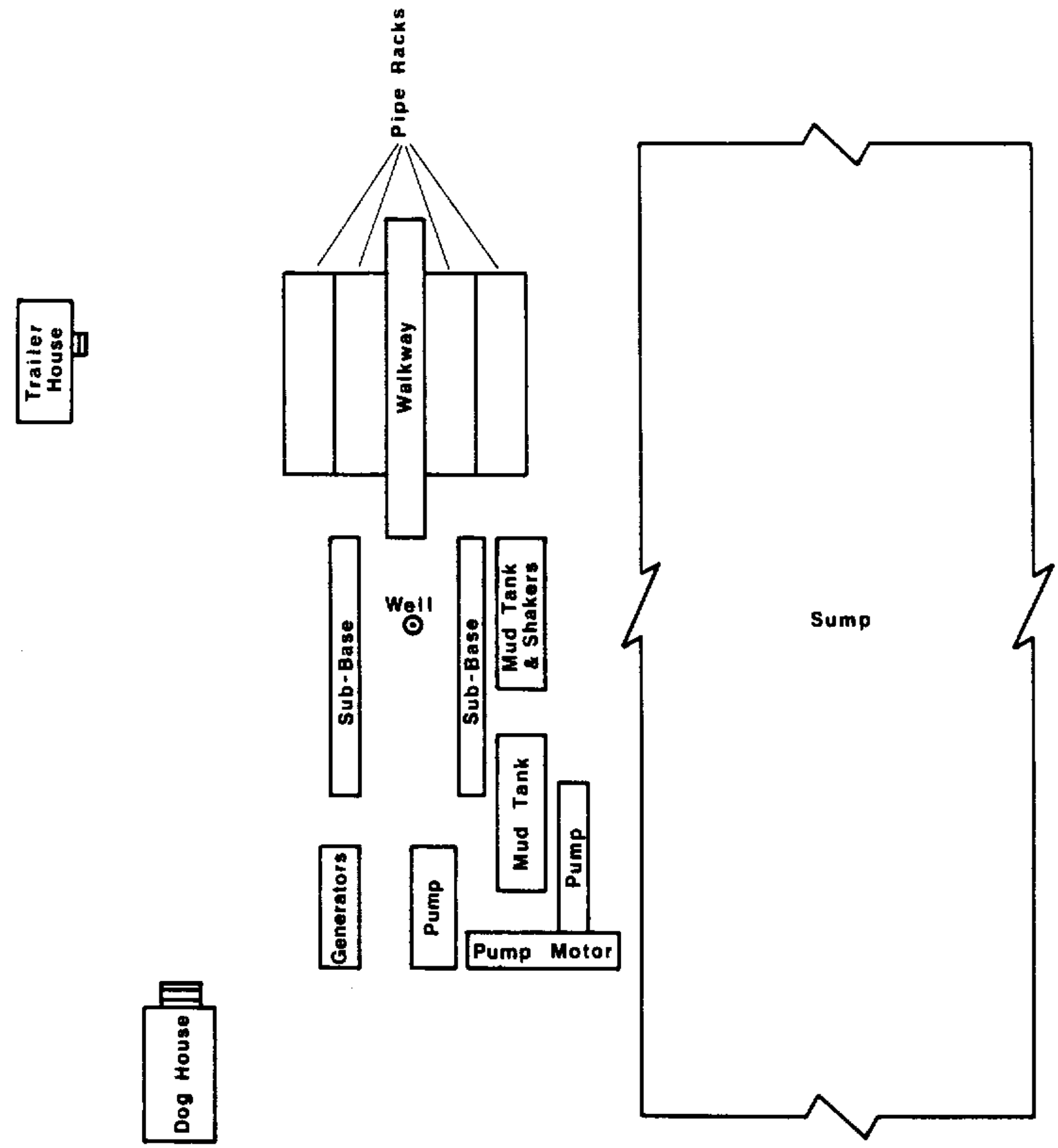
2.6.3.2 Well Siting

The best information currently available as to well spacing is based on developer generated data. In order to maintain the productivity of the reservoir over a 30 year period, they indicate that initially, at least, the bottom hole spacing of production wells will probably vary between 20 and 30 acres (8 and 12 ha) per well, and that injection wells will have a bottom hole spacing of 10 to 20 acres. As more information is gathered, it may be possible to reduce the distance between wells, but in the early stages of development within the Salton Sea Anomaly these estimates will probably apply. Assuming a well spacing of 30 acres (12 ha) per production well and 20 acres (8 ha) per injection well, the areal extent of well fields to support a 50 MW (net) power plant would be approximately 640 acres (2.6 km^2) within the Salton Sea KGRA. Therefore an initial well field of about 13 acres per MW (5 ha) is necessary. It is not certain if replacement wells will be placed between existing wells or if an additional 30 acre and 20 acre spacing will be needed for production and injection wells, respectively. If additional acreage is necessary, the total land area required would be 26 acres per MW. It should be emphasized that only a small fraction of this land area will actually be disturbed, however, with the balance available for agricultural or other use.

Although it is normally desirable to cluster wells on single pads, from both a cost and an environmental disruption viewpoint, this technique is not as compatible with the characteristics of the Salton Sea geothermal reservoir as it is elsewhere within Imperial Valley. In order to effectively cluster wells, it is necessary to utilize directional or slant drilling to still be able to maintain appropriate bottom hole spacing. The reservoir within the Salton Sea Anomaly tends to be relatively shallow, therefore such drilling methods can be utilized only to a limited degree for the purpose of clustering wells. However, slant drilling can be used to provide some buffer between well drilling and sensitive areas. In 3000 to 6000 foot (914 to 1829 m) wells a horizontal distance of 600 to 1300 feet (183 to 296 m) can be gained relatively easily and economically by by slant drilling. In this MEIR it will be assumed that only one well per pad will be drilled in order to analyze worst case conditions.

2.6.3.3 Drilling Operations

A topview of a typical drillsite layout during drilling operations is shown in Figure 2.6-1. The relative locations of the well head, drilling equipment, drilling sump, and ancillary features are illustrated. Drilling operations are carried on 24 hours a day, seven days a week until the total depth is reached. An estimated 3 to 5 weeks



Source: WESTEC Services, Inc., 1980b

Layout of Typical Drillsite

FIGURE 2.6-1

will be required to drill each well, and approximately 12 to 15 persons will be working at each site at any one time. Well drilling operations are regulated by the California Division of Oil and Gas (CDOG). CDOG regulations cover the drilling program, the casing program and the provision of blowout protection equipment (BOPE). A description of drilling procedures with appropriate figures is provided as Appendix 2.6-1 of this MEIR.

2.6.4 Onshore Power Plant Construction

As noted in previous sections, a typical 50 MW geothermal power plant would occupy about 10 to 15 acres (4 to 6 ha), while its system of pipelines, cooling towers, access roads, and wells, both production and injection, would be located around the plant at maximum distances of 0.5 to 1.5 miles (0.8 to 2.4 km). The whole system could thus extend over two to three sections of land. However, the only land that would be unusable for other purposes, such as agriculture, grazing, open space, etc., would be the 15 acres (6 ha) for the power plant itself, roughly 1.5 acres (0.6 ha) per well during drilling, 0.4 acres per well after drilling (0.2 ha), and the routes of the access roads and pipelines. Using earlier assumptions and projections, a typical 50 MW power plant operation would thus require the land areas shown in Table 2.6-3.

Table 2.6-3

LAND REQUIREMENTS - 50 MW PRODUCTION

	Facility		Acres Needed for 50 MW Capacity
40	Power plant site		15± acres (6 ha)
136	Well sites		10± acres (4 ha) (24 wells at 0.4 ac/well)[1]
	Pipelines and access roads		10± acres (4 ha)
		TOTAL:	35± acres (14 ha)

[1] Although each well normally would require about 1.5 acres (0.6 ha) for preparation and drilling, after it is completed the area required for maintenance or reworking can be reduced to roughly one-fourth this size (Goldsmith, 1976).

At this rate, the twenty-eight 50 MW power plants that would be required to generate the most probable production level (1400 MW by 2010) would directly impact a total of only 980 acres (397 ha) within the Salton Sea study area, using the assumption that all are developed onshore. This constitutes only a very small fraction (<1 percent) of the total land within the study area. Transmission line rights-of-way and canals for transporting cooling water to the plants could increase the above estimates somewhat.

Construction activities associated with each plant would involve creation of access roads and well site preparation, construction of the power plant and other onsite systems, placement of production and injection pipelines, and construction of power lines to transmit the electricity into IID's network and probably beyond. These activities will be similar to those established in the geothermal industry for many years as documented in prior publications (Imperial County, 1979 and 1980; Magma, 1980). Such activities would require the use of heavy equipment over a period of time to construct the power plant.

A system of above-ground pipelines will be necessary to connect the power plant with the production, injection and replacement wells. Insulated pipelines with either horizontal expansion loops or vertical expansion joints which rise 10 to 15 feet (3.0 to 4.6 m) into the air will be placed on the ground to connect the plant and its system of wells. Wherever possible, these pipelines will be placed next to the borders of fields or along access roads in order to minimize the amount of land affected.

2.6.5 Offshore Development

As noted earlier, a portion of the geothermal resource lies below the Salton Sea, thus heat recovery would require offshore drilling activity. The majority of the offshore portion of the study area is administered or owned by either the Bureau of Land Management or the Imperial Irrigation District, with the involved areas being almost evenly split between these two agencies. In addition, some smaller individual offshore areas totalling about 800 acres are privately owned (Legaspi, 1981). The permitting process for offshore development is not significantly different from that required for onshore activity, as outlined earlier in Section 1.3. Drilling methods that would be used offshore would probably be similar to those used in offshore hydrocarbon exploration and production. The following discussion describes two alternative methods which could be used during exploratory activities, plus two scenarios for future development if producible resources are identified.

2.6.5.1 Exploration Activities

At least exploratory drilling alternatives exist. One involves the use of conventional onshore exploratory equipment. Under this method, directional drilling would occur along the shore to identify resource areas which would then be extrapolated from the shoreline into gradually deeper water. Wells would be placed at intervals ranging from 1300 to 2600 feet (396 to 793 m) along the shoreline. If a viable resource is encountered from an onshore site, then the exploratory alternative described below would probably be instituted.

This second alternative drilling method would rely on the use of swamp barges. These barges are capable of floating in very shallow water to allow positioning of the drilling unit directly above the potential drill site. The barge would be positioned and the pontoons filled with water, causing the barge to sink to the bottom. Typical drilling equipment carried on a swamp barge normally includes drawworks, pumps, prime movers, and a rotary table in addition to a derrick and cranes. Exploratory activities would originate in near-shore areas with eventual expansion into deeper water.

Exploration is anticipated to be conducted with parameters established in current drilling policies in the area. Standard procedure is to allow a total of six exploratory wells to be drilled over a period of two years. Initially, this amount is believed to be sufficient in the Salton Sea area to prove any resource that may be found. It is expected, however, that the success ratio will decline over a period of 10 years or more as development within the Salton Sea KGRA expands (Robinson, 1981). Drilling procedures, casing programs, etc. will be similar to those used in onshore explorations as described in Appendix 2.6-1. It is probable that domestic waste would be stored on board the vessel and periodically hauled to shore for disposal in an approved manner.

The amount of labor required to conduct drilling operations is similar to that of hydrocarbon exploration. An estimated 10 persons per shift would be required for a medium-sized well.

2.6.5.2 Production Scenarios

a. Offshore Islands

There are several factors within the offshore portion of the study area favorable to the construction of offshore islands, first and foremost being the relatively shallow water depth in the Salton Sea. The initial thrust of development is expected to be within 3 miles (5 km) of the shoreline. Maximum depth within this area is approximately 25 feet (7.6 m). It is a relatively simple procedure to fill a site with sand, gravel, and other materials to provide a ground surface in the sea on which to drill, thus precluding the need for some permanent type of offshore platform. Steel, which is normally used in the construction of such platforms, is much more expensive than gravel and the other fill materials which would be used for island construction. In addition, ship builders are the major manufacturers of such platforms and no ship building facilities are located in the Salton Sea area which could be used to construct a platform following the standard procedures used in the oil industry.

A series of islands could provide an effective drilling surface support for offshore extraction of the geothermal resource. Two alternatives exist for the design of island development. The first would include one large central island which would support a power plant in addition to one or two drilling pads. A series of three or four satellite islands supporting only drilling and reinjection operations would be connected by pipeline. The other alternative method would involve the placement of the power plant onshore. The resource would be transported through a pipeline along an elevated causeway from the islands to the power plant; however, the limiting factor for this scheme is the distance between the resource recovery area and the power plant location.

Initially, a causeway would be built out to the island location. Trucks laden with the fill materials would drive out to the end and dump their loads into the Salton Sea to form the island. Island construction generally occurs in a series of stages or lifts. The first lift is a broad, low lying dome of sand which forms the island base. Quarry materials are placed upon the sand base and are then infilled with more sand to form the second and third lifts. The edges are terraced and sloped at a much steeper angle than the first lift. Large rocks are then placed around the entire island for stabilization and erosion prevention purposes and would extend well below the water level. The height of the island would be dependent on the following factors: wave action and currents; wind intensity; and rise in the level of the Salton Sea.

Previous investigation aimed at determining the makeup and characteristics of the floor and underlying foundation of the Salton Sea as well as the availability of suitable fill or dike material were conducted within the study area by BLM in 1968 and 1972. The results of these surveys are documented in Department of the Interior (1974). They indicate that the floor of the Sea in this area consists primarily of sediments deposited by the New and Alamo Rivers plus other tributaries. This sediment is chemically reduced, dark gray to black clay with infrequent sandy lenses. Its organic content ranges from minor to heavy with a consistency similar to heavy grease, although the upper surface contains mostly suspended material with little or no consistency. The observed thickness of this sediment ranged from less than one foot (0.3 m) to 16 feet (5 m). It would not be suitable as a foundation or as a source of dike or island construction materials.

Underlying this sediment are foundation materials which comprise in large part lacustrine deposits. Typically, these materials are clay, with interbeds of silt, sand, and clay admixtures. Areas adjacent to Obsidian Butte and Red Hill appear to be underlain by volcanic rocks largely of rhyolitic composition.

These findings are in general conformance with the preliminary results of geotechnical and offshore soils work conducted along the western shore of the Salton Sea by Jet Propulsion Laboratory (JPL) and WESTEC Services in conjunction with a proposed solar pond generating station, although the depositional influences of the New and Alamo Rivers are not present at the solar pond site.

Regarding suitable fill material for dike or island construction, the BLM surveys as well as JPL's more recent investigations indicated that subfloor materials within the Salton Sea would probably be adequate for such purposes. In addition, alluvial-fan materials in the eastern part of the study area and just beyond it, develops from the Chocolate Mountains, are of suitable quality and quantity for any offshore development. Typically, these materials are silty to clayey gravels with interbeds of gravel-sand mixtures.

Although no specific design has yet been developed or even proposed for offshore development, a rough estimate of the design and material requirements that might be needed for offshore development using islands and causeways can be made. For purposes of this discussion it will be assumed that the islands and causeways would be built on the subsea foundation surface rather than in a dredged depression. Based on the results of additional site specific surveys, it is possible that much, if not all, of the top 1 to 16 feet of unsuitable bottom material may have to be removed and disposed to obtain an adequate foundation.

The large central island supporting the power plant, cooling towers, brine treatment facilities, and two drilling pads would require an estimated 15 surface acres (Robinson, 1981). A typical layout for hydrocarbon exploration conducted from offshore islands is expected to be the model for similar geothermal activities. In essence, production, storage, and treatment facilities would be located in the center of the island, surrounded by drilling and reinjection wells.

Previous endeavors have proven a slope ratio of two to one to be adequate for the production of stable islands (Nellis, 1981). Since it is anticipated that initial development will occur in near-shore areas, a maximum depth of 25 feet (7.6 m) would most likely be encountered. At this depth, a central island extending 10 feet (3.0 m) above the water level with the specifications outlined above would require approximately one million cubic yards of compacted fill material. In addition, the 3240 feet (988 m) of perimeter would require clay and large rocks to stabilize the edges and prevent erosion. The surrounding mountain ranges would most likely be the source of these materials.

Satellite islands, containing only production and injection units, would each require between 500,000 and 750,000 cubic yards of compacted fill depending on the number of wells included on each island. The number of islands required is dependent upon the productive capabilities of the resource and the size of the power plant.

Island access is vital for various reasons other than resource transmission. The daily transportation of supplies, personnel, and vehicles would occur in addition to the less frequent transfer of equipment and waste.

Access to the islands could be accomplished in any of three ways:

1. Boat or Barge - Equipment and materials could be transported by this means between island and shore as has been done in the Long Beach Harbor. This is a costly method, especially considering the lack of ships and ship building facilities in the Salton Sea area.

2. Riprap Causeway - Access would be provided for vehicles transporting equipment and materials. A pipeline could be located along the top for transportation of the geothermal resource if an onshore location is chosen for the power plant. A riprap causeway requires construction similar to that of the islands. It is estimated that a causeway with a width of 30 feet (9.1 m), a slope ratio of 2 to 1, and an average height of 20 feet (6.1 m) would require roughly 1400 cubic feet of compacted fill per linear foot. Riprap would provide additional slope stability. Amounts required would be determined by length.

3. Pier - An elevated structure resting on a series of posts could provide vehicular access. In addition, pipes carrying the geothermal resource could be extended along this structure if the power plant is to be located onshore. One advantage of this alternative involves water circulation, which could still occur underneath this structure instead of being blocked by infilling for causeway access. This method is also believed to be more cost-effective in its construction and maintenance than the other alternatives.

Operational characteristics of exploration and production wells plus other plant support facilities, including cooling towers, will be the same as those described in Section 8.1 for onshore facilities associated with Magma's proposed 49 MW power plant.

b. Reclamation

The reclamation alternative would entail the construction of levees and the use of pumps to reclaim inundated areas. The process is similar to previous reclamation activities in Europe and San Francisco Bay. Level maintenance and pumping will be the responsibility of the geothermal industry.

Typical procedures for the preparation of subsea lands to be reclaimed are initiated at the shoreline. The load carrying capacity of the soil determines one of the first procedures. In many instances, dredging the areas which will eventually underlie the levees must occur. The dredged material can be transported to shore, dried, and eventually reused in levee construction. Precautions would have to be taken to provide onshore holding basins for this material during the evaporation process to insure that runoff does not reenter the Salton Sea.

Once the site is prepared, levees are raised as barriers against the sea water. In addition to dredge materials, sand and gravel are compressed to provide the basic levee material. The sea side is lined with heavy riprap to prevent erosion and destructive wave action.

The actual acreage required to conduct drilling and power plant operations is much smaller than the area that would be enclosed within the dikes. Once the land is ready for development, fill dirt is spread over the designated drilling areas to provide a level, dry surface for pad construction. Six to eight pads require between 5 and 10 acres (2.0 ha and 4.0 ha) with an additional 5 acres (2.0 ha) required for a power plant site (Robinson, 1981).

Of utmost importance to the success of this system is adequate pumping which would have to be conducted constantly. Power produced at the geothermal site could be used to run the pumps to prevent flooding within the reclaimed area.

If a production area is found using this method, expansion could occur toward other adjacent areas to gain access to additional quantities of the resource. The expansion capabilities of the reclamation alternative are favorable to this type of development. Existing levees can be used to provide one or two sides for the new area of reclamation, thus reducing material requirements for the expansion. Construction procedures would follow along the same lines which have been previously noted.

Typically, levee width at the top is approximately 20 feet (6.1 m) and the elevated surface is used for transportation purposes. A requirement of the County would call for at least three feet of freeboard. The amount of fill material necessary to construct a levee is affected by several factors such as:

1. The load-bearing capacity of the soil on which levee construction will occur.

2. The choice of construction materials, since some will compact more than others.

3. The required design load. If uses other than roads are planned for the uppermost section of the levees, the slopes may have to be increased or more durable materials will have to be used.

4. Seismicity of the area in relation to ground displacement, groundshaking or liquefaction of the soil.

5. Wind and wave action which can carry levee materials from the site.

As an indication of the amount of material that might be required for levee construction, it is assumed that a 10 foot (3.0 m) high levee, 20 feet wide (6.1 m), with a slope ratio of 2:1 would be constructed. Also, an assumption can be made that no infilling, which is a common method used to increase the strength of the levee by dredging the area and refilling it with compacted materials, will occur. Using these figures and assumptions, a total of 400 cubic feet per linear foot of compacted fill material would be required in addition to the stabilizing rocks and riprap which line the water side of the levee.

Since reclamation is an extension of land into the sea, many features are similar to those of land operations. The disposal of solid waste is not expected to be as much of a problem as it would be with the island alternative. Procedures generally follow those established for existing operations in Imperial Valley.

No additional structures will be required to provide access to drilling sites since roads are usually built on top of the levees. In addition, resource transmission pipes may be located adjacent to the roadways. As expansion of the reclaimed area occurs, so does access, simultaneously.

The intention of the reclamation alternative is to provide features similar to a normal land environment. Therefore, operational characteristics of exploration and production wells and other plant support facilities, including cooling towers, will be the same as those described for onshore facilities associated with a typical power plant.

2.6.6 Electrical Power Generation

2.6.6.1 Most Probable Power Conversion Technologies

Basically two different technologies have been considered for converting the geothermal resource within Imperial Valley into electrical energy: flashed steam and binary conversion. A simplified version of each of these cycles is shown in Figures 2.6-2 and 2.6-3, and is described below.

In the flashed steam conversion cycle (Figure 2.6-2), electricity is generated as follows (U.S. DOE, 1980):

a. Steam is separated from a liquid-steam mixture as it comes from a geothermal production well or well field;

b. The separated steam is expanded through a turbine that runs a generator which produces electricity;

c. Steam exhausted from the turbine is condensed by a direct contact or surface condenser; and

d. The resultant condensate is either sent to an evaporation cooling system (such as a cooling tower) as makeup water or is disposed of by injection with the spent geothermal brine.

Modifications to this basic one-stage flash cycle also exist, such as multistage flash where the fluid is flashed two or more times, or a combined flash/binary cycle where heat remaining in the fluid following one or more flash steps is passed through a heat exchanger (binary) cycle.

The binary process, shown in Figure 2.6-3, produces electricity as follows (U.S. DOE, 1980):

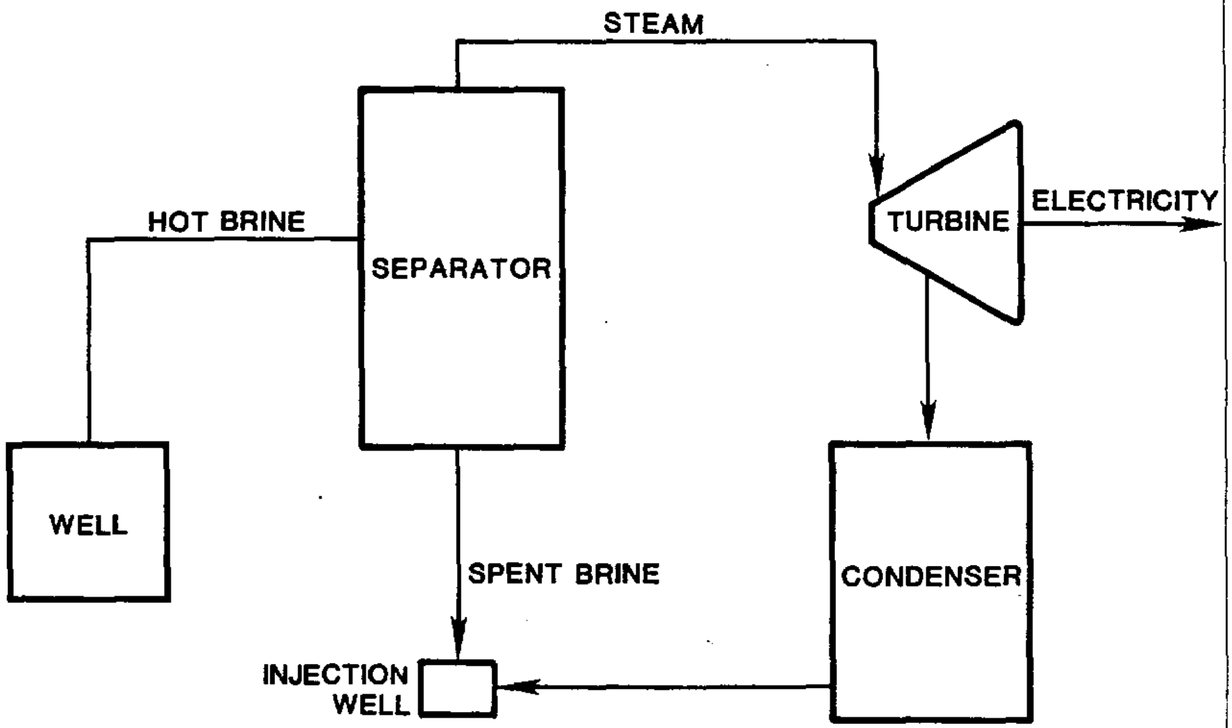
a. Geothermal fluid from a production well is passed through a heat exchanger where heat from the brine is transferred to a secondary (binary) fluid which vaporizes;

b. The vapor flows from the heat exchanger to drive a turbogenerator which produces electricity;

c. The secondary working fluid is then condensed and, inasmuch as it operates within a confined cycle, flows back into the heat exchanger for vaporization and reuse; and

d. After passing through the heat exchanger, the geothermal fluids
100 are reinjected into the underground reservoir.

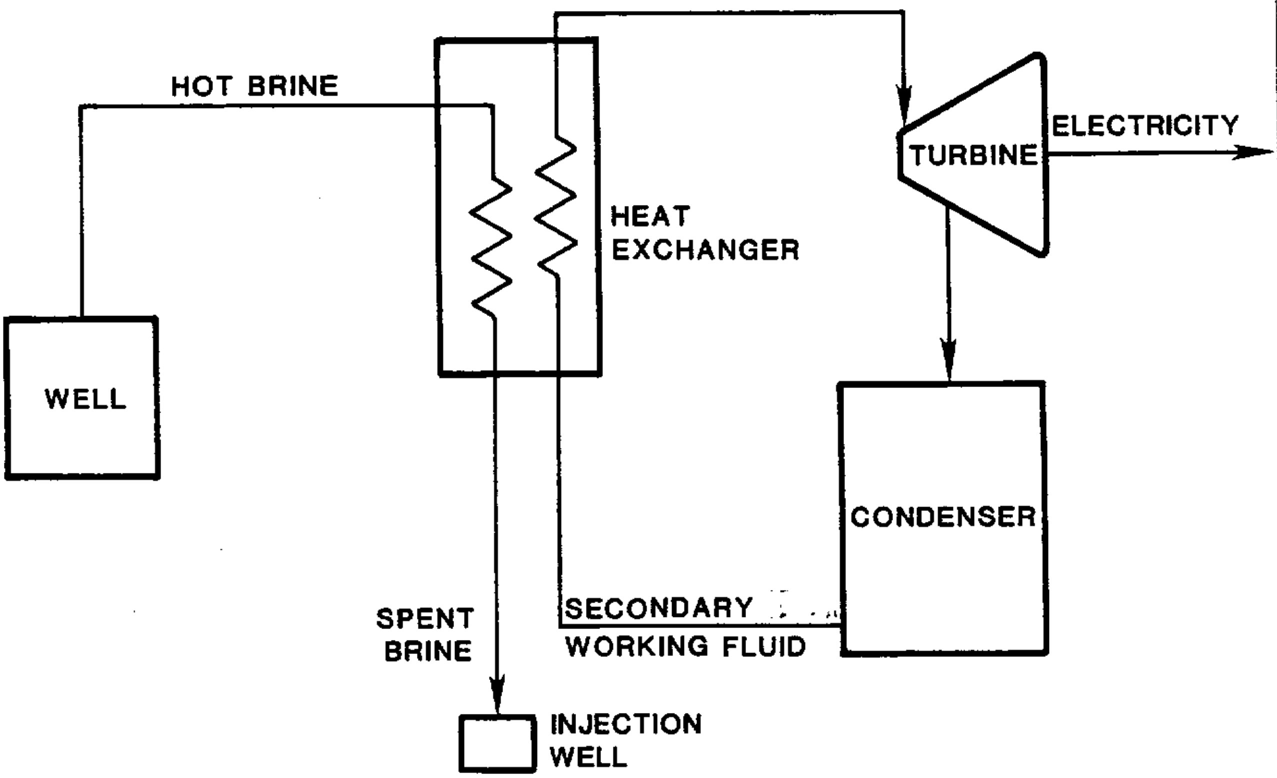
Because of the higher temperatures and salinity levels found in the liquid-dominated geothermal resource within the Salton Sea KGRA, the flash, rather than the binary cycle has been found to be more suitable as the basic conversion technology for use in this area. Therefore, it is assumed for purposes of this MEIR that the flash cycle will constitute the basic technology for the power plants that will be built within the study area over the next 30 years.



Source: Department of Energy, 1980

Simplified Flashed -Steam Conversion Cycle

FIGURE 2.6-2



Source: Department of Energy, 1980

Simplified Binary Conversion Cycle	FIGURE 2.6-3

As mentioned above, however, a number of permutations to the basic flash cycle do exist and will probably be utilized at different plants throughout the Salton Sea Anomaly, depending on the conditions existing at each plant site and on the design criteria used by individual developers. To illustrate this, Appendix 2.6-2 provides a description of the design criteria dictated by test results for four different situations within the KGRA: 1) the Geothermal Loop Experimental Facility (GLEF) (SDG&E, 1980); 2) Union/SCE's recently approved 10 MW power plant (Imperial County, 1980); 3) Magma's approved 28 MW power plant (Imperial County, 1979; Magma, 1980); and 4) Magma's proposed 49 MW power plant (see Section VIII of this MEIR).

2.6.6.2 System Operation

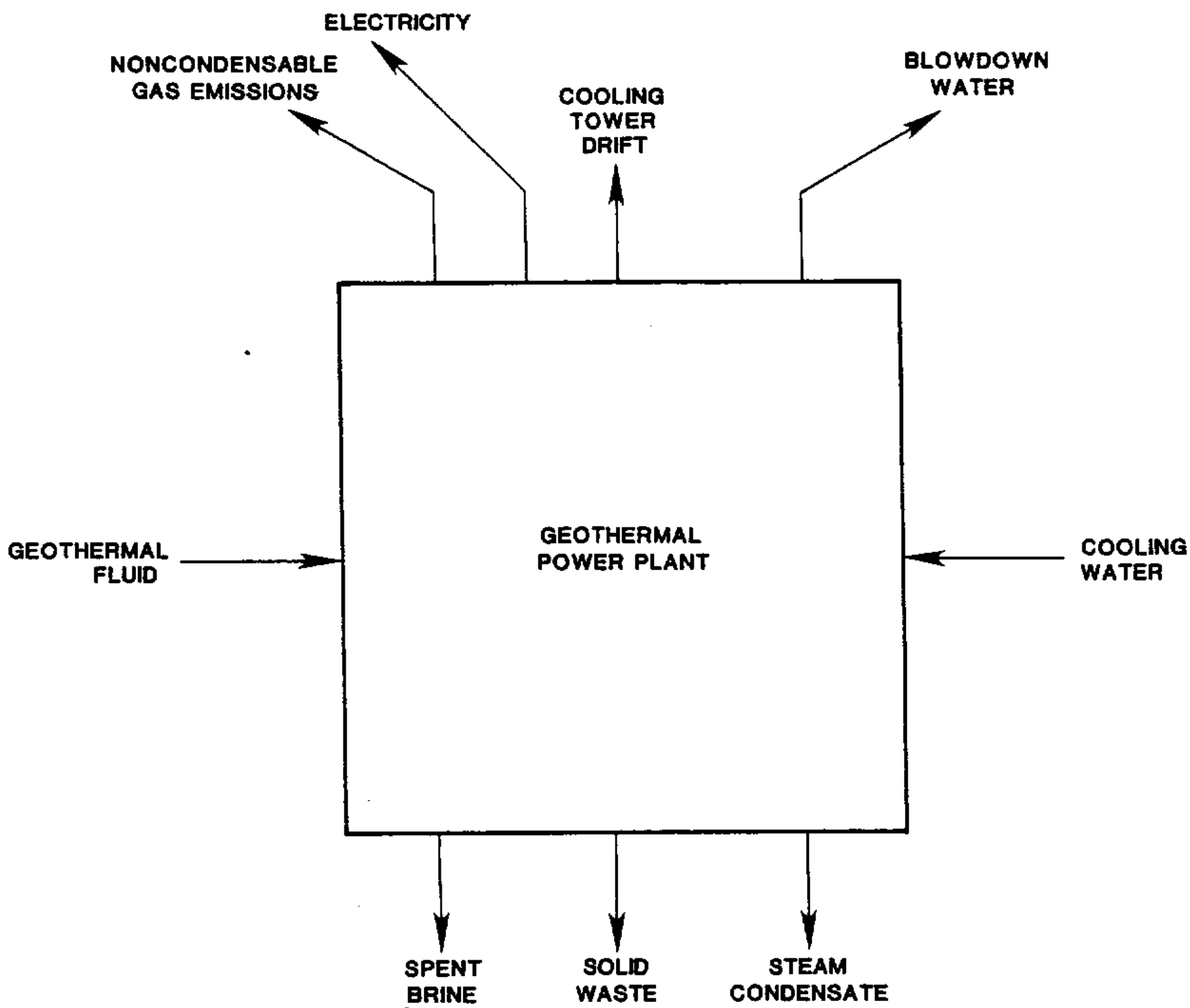
a. Power Generation

Figure 2.6-4 provides a simplified overview of a typical geothermal power plant operation from a resource use and waste disposal viewpoint and will contribute to a basic understanding of the process described in the following paragraphs. Because of its applicability to the geothermal resource found within the Salton Sea Anomaly, a two-stage flash cycle is described in general terms below (also see Figure 2.6-5).

Geothermal brine is extracted from the reservoir via production wells (see (1) in Figure 2.6-5). One million pounds per hour of steam must be supplied to operate a 50 MW power plant using the reservoir characteristic assumptions described earlier.

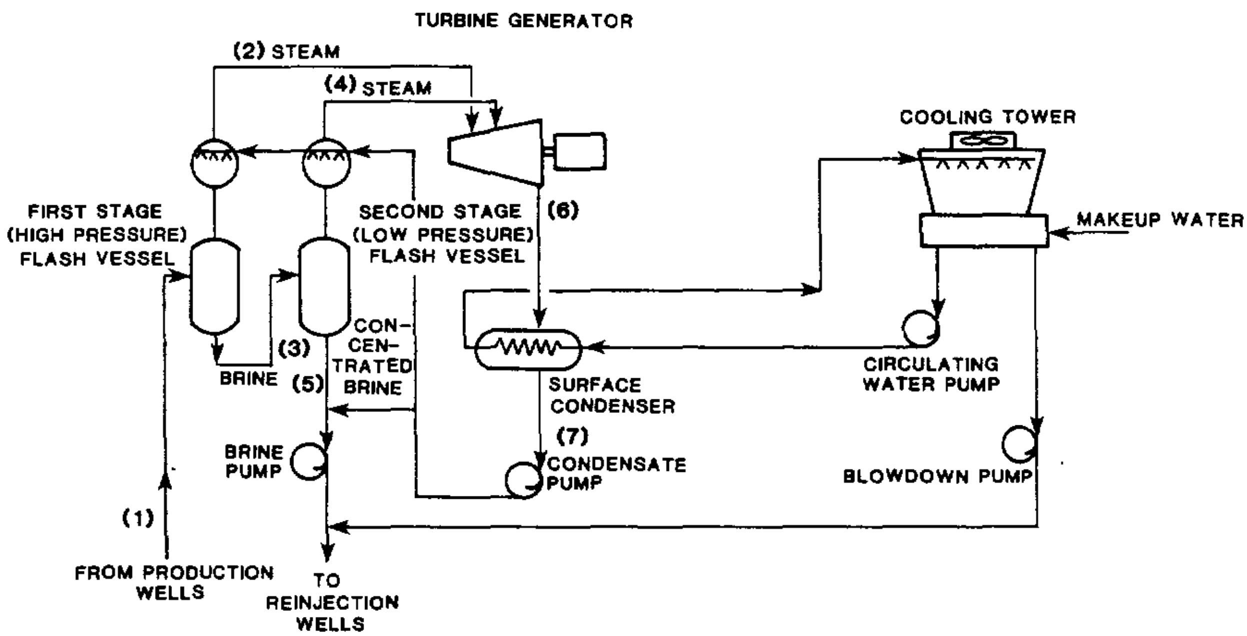
Hot brine would enter the first stage (high pressure) flash vessel shown in Figure 2.6-5. Steam released in this first stage flashing process would flow to (102)
a scrubber utilizing condensate from the surface condenser, and to the high pressure inlet of the turbine (point (2) in Figure 2.6-5). The unflashed portion of the brine flows to the second stage (low pressure) flash vessel (3) and is flashed at a lower pressure. Following its passage through a second scrubber, this lower pressure steam flows to the low pressure inlet of the turbine (4). It should be noted that the two scrubbers are not used for pollution control but only to remove suspended droplets from the steam prior to its entry into the turbines. Residual, concentrated brine from the second stage flash vessel (5) is pumped to the reinjection wells for return to the underground reservoir.

The low pressure flash vessel may also be designed as a crystallizer. A seed bed is provided for the formation of potentially harmful scale thereby preventing scale formation in other parts of the system. Desupersaturation of silica is achieved by recycling a sludge slurry from the brine clarification system discussed in the next subsection.



Simplified Overview of a Typical Power Plant Operation

FIGURE 2.6-4



Schematic of a Two-Stage Flashed Steam Energy Conversion Process

FIGURE 2.6-5

Following passage through the turbine, the exhausted steam (6) flows to a surface condenser which utilizes water from the cooling tower to condense the steam. A portion of the condensate is returned to the scrubbers and the remainder of the condensate (7) joins the blowdown brine for reinjection into the geothermal reservoir.

Coolant which flows through the tubes of the surface condenser is returned to a mechanical draft evaporative cooling tower, which receives makeup water from an approved source of supply (such as irrigation canals, the New or Alamo Rivers, the Salton Sea or elsewhere), as discussed in Section 3.2. In order to meet the requirements for injection (normally 100 percent unless otherwise authorized), cooling tower blowdown may also be used to augment the reinjected brine.

b. Brine Clarification System

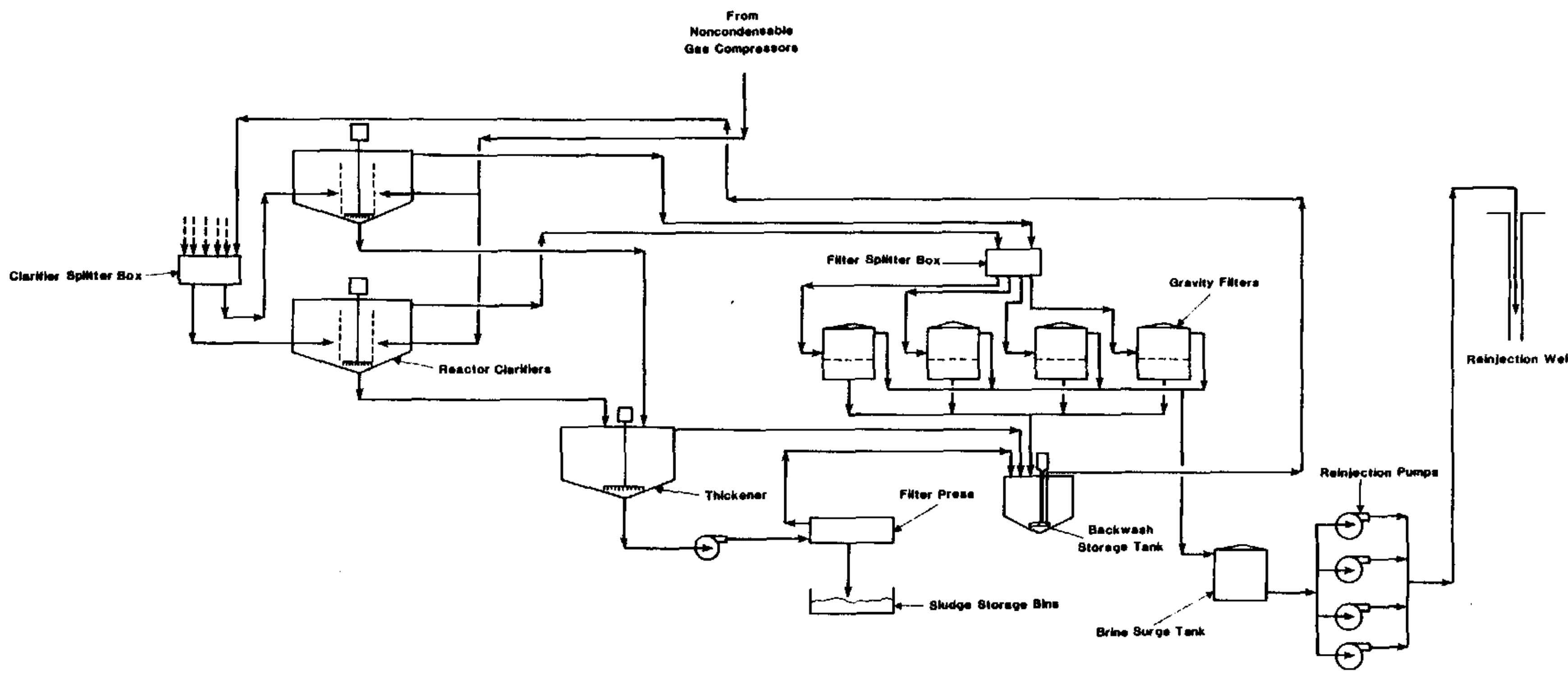
Without proper treatment, the suspended solids in the supersaturated brine from the atmospheric flash tank would quickly plug the reinjection reservoir formation. A brine clarification system was developed to overcome this problem and is
101 likely to be commonly used in the Salton Sea Anomaly. Two reactor-clarifiers and a media filter system are used in the brine treatment process. A schematic diagram of the system is shown in Figure 2.6-6.

Brine from the low pressure flash system is pumped to a splitter box which distributes the flow between two reactor-clarifiers. Dissolved solids are precipitated out with liquids being separated from solids by gravity. Clarifier overflow is directed to four media filters. Filtrate goes to the brine surge tank and is then reinjected. Solids from the reactor-clarifiers are drawn into a thickener before being passed to a pressure filter for dewatering and subsequent discharge to sludge storage bins. Besides performing the important function of preparing brine for injection, the reactor-clarifiers also may serve the purpose of controlling the release of noncondensable gases. These gases collect in the condenser after the steam has passed through the turbines. The noncondensable gases, which include hydrogen sulfide, are then exhausted into the reactor-clarifiers where they can be reabsorbed and later injected with clarified brine.

2.6.7 Ancillary Systems

2.6.7.1 Access Roads

The extensive existing network of paved and unpaved roadways throughout much of the study area will minimize the need for major construction involving new roadways as geothermal development proceeds throughout the study area.



SOURCE: Morrison Knudsen, 1979

Brine Clarification System

FIGURE 2.6-6

Some new access roads will, of course, be required to reach new well sites or power plant locations, and these roadways will have to be constructed in such a way as to accommodate heavy trucks and equipment.

The major demand that will be placed on roadways by geothermal development within the study area will result from the following:

a. Construction activities, including the movement of trucks and heavy equipment.

b. Routine maintenance activities during the life of a given project.

c. Removal of solids to acceptable disposal sites.

The potential effect of these activities on the roadway system in the area is addressed in Section 3.8 of this MEIR.

2.6.7.2 Water Supply and Treatment

Large quantities of water will be needed for use in evaporative cooling towers in order to reject waste heat from the power plant. The total water requirement is the sum of evaporative losses in the cooling tower plus blowdown water. Both Ermak (1977) and U.S. DOE (1980) provide extensive discussions of the need for cooling water to operate geothermal power plants. Using Ermak's estimate of 60 acre-feet per megawatt per year, and assuming that the same relationship can be applied to a development scenario utilizing 50 MW power plants rather than 100 MW, the water needs shown in Table 2.6-4 can be developed. These estimates are based on the probable development scenario shown earlier in Table 2.5-2.

The implications of this demand for water and potential sources, as well as the effects of discharging heated water to local watercourses, are discussed in U.S. DOE (1980). The effects of geothermal development over the next 30 years within the Salton Sea Anomaly as regards water needs and potentially adverse impacts are discussed in detail in Section 3.2 of this MEIR.

2.6.7.3 Waste Disposal

Liquid and solid wastes will be generated during all phases of geothermal development. The primary liquid wastes will be residual geothermal fluids and saline blowdown water from evaporative cooling systems. Solid wastes will be generated during drilling operations, during preinjection treatment of geothermal fluids within the reactor-clarifiers, during the removal of scale from pipelines and equipment, and through the operation of hydrogen sulfide control systems (U.S. DOE, 1980).

The principal method of disposing of spent brine is through subsurface injection. Blowdown fluid may also be reinjected or discharged to surface waters if it meets RWQCB criteria. Surface disposal at approved sites is preferred for solid wastes.

Table 2.6-4

ESTIMATED COOLING WATER REQUIREMENTS

Year	Cooling Water Required for the Time Period Indicated (ac-ft)[1]
1982-83	4,560
1984	5,220
1985	11,220
1986	23,220
1987	38,220
1988	50,220
1989-91	177,660
1992-94	186,660
1995	65,220
1996	71,220
1997-98	154,440
1999-2000	160,440
2001-2010	840,000
Total for 30 years	1,788,300

[1]Based on the development scenario shown in Table 2.5-2 and a requirement of 60 ac-ft per MW per year.

Table 2.6-5 provides an estimate of the volumes of liquid wastes that would require disposal from geothermal development within the Salton Sea Anomaly between now and the year 2010. About 13,800 x 10^6 m^3 would be disposed of over the 30 year period. Most will be reinjected as a disposal method. Likewise, Table 2.6-6 provides an estimate of the amount of solid waste that will require disposal from development within the study area over this same period (about 5.8 x 10^6 m^3). Sections 3.2, 3.8 and 3.11.7 of this MEIR address the environmental effects of disposing of these
89 liquid and solid wastes.

2.6.7.4 Electrical Transmission

As a basis for creating a transmission line development scenario to serve the series of geothermal power plants shown earlier in Figure 2.5-3, two starting points were used: 1) Imperial Irrigation District's (IID) existing and planned facilities; and 2) the County's adopted Transmission Corridor Element.

a. Existing Facilities

IID owns and operates a number of transmission lines and switching yards in the project area. These existing facilities are depicted in Figures 2.6-7, 2.6-8, and 2.6-9, and are described in the following paragraphs.

Only one set of transmission lines extends into the study area west of the Alamo River. This 34.5 kV line terminates at SDG&E's old Geothermal Loop Experimental Facility (GLEF) which is also the site of Magma's approved 28 MW power plant (Site 2 on Figure 2.6-7). From the GLEF site it extends for a short distance to the east, then turns south along Gentry Road. At Young Road it turns due east and terminates at IID's Calipatria Substation.

A second 34.5 kV transmission line extends northward from the line described above, along English Road for a distance of roughly six miles (9.7 km). At Noffsinger Road, it turns due east and passes through the community of Niland to terminate at the Niland Substation.

Other larger north-south transmission lines also exist within the project area. IID's "J" line (92 kV) heads north from the District's generation plant near El Centro (not shown in Figures 2.6-8 or 2.6-9), and enters the study area just east of Calipatria and the Calipatria Substation. It continues northward parallel to and just west of Blair Road, supported by a series of wooden H-frame towers, and terminates at the Niland Substation.

Another larger capacity line ("M" line, 161 kV) extends in a north-south direction along Wiest Road well to the east of the study area. Only a portion of

Table 2.6-5

ESTIMATED LIQUID WASTE DISPOSAL REQUIREMENTS[1]

Year	Residual Geothermal Fluids ($10^6 m^3$)	Blowdown Fluids ($10^6 m^3$)		Total ($10^6 m^3$)
		Using Irrigation Water[2]	Using Condensate[3]	
1982-83	34	2	1	35-36
1984	39	2-3	1	40-43
1985	83	4-6	1-2	84-89
1986	172	8-12	2-4	174-184
1987	282	13-20	4-6	286-302
1988	371	18-26	5-8	376-397
1989-91	1,312	62-92	18-30	1,330-1,404
1992-94	1,445	65-96	19-31	1,464-1,541
1995	482	23-34	7-11	489-516
1996	526	25-37	7-12	533-563
1997-98	1,140	54-80	15-26	1,155-1,220
1999-2000	1,185	56-83	16-27	1,201-1,268
2001-2010	6,203	294-434	84-140	6,287-6,637
TOTAL	13,274	626-925	180-299	13,454-14,200

[1]Based on the development scenario shown in Table 2.5-2, resource characteristics shown in Table 2.4-2, and brine density of 1,148 kg/m^3 (U.S. DOE, 1980). These assumptions result in an estimate of 443,039 m^3 of residual geothermal fluids per MW per year.

[2]Assumes four concentration cycles (U.S. DOE, 1980).

[3]Assumes ten concentration cycles (U.S. DOE, 1980).

Table 2.6-6

ESTIMATED SOLID WASTE DISPOSAL REQUIREMENTS[1]

Year	Well[2] Drilling	Source of Solid Waste ($10^3 m^3$) Brine[3] Clarification	Removal[4] of Scale	H_2S Abatement[5] Systems	Total
1982-83	6	13	1	<1	20
1984	8	15	1	<1	24
1985	15	32	2	<1	49
1986	31	67	4	1	103
1987	39	110	7	1	157
1988	33	144	9	1	187
1989-91	36	509	33	5	583
1992-94	22	535	34	5	596
1995	12	187	12	2	213
1996	20	204	13	2	239
1997-98	27	443	28	5	503
1999-2000	28	426	29	5	488
2001-2010	82	2,408	154	25	2,669
TOTAL	359	5,093	327	53	5,831

[1]Based on the development scenario shown in Table 2.5-2.

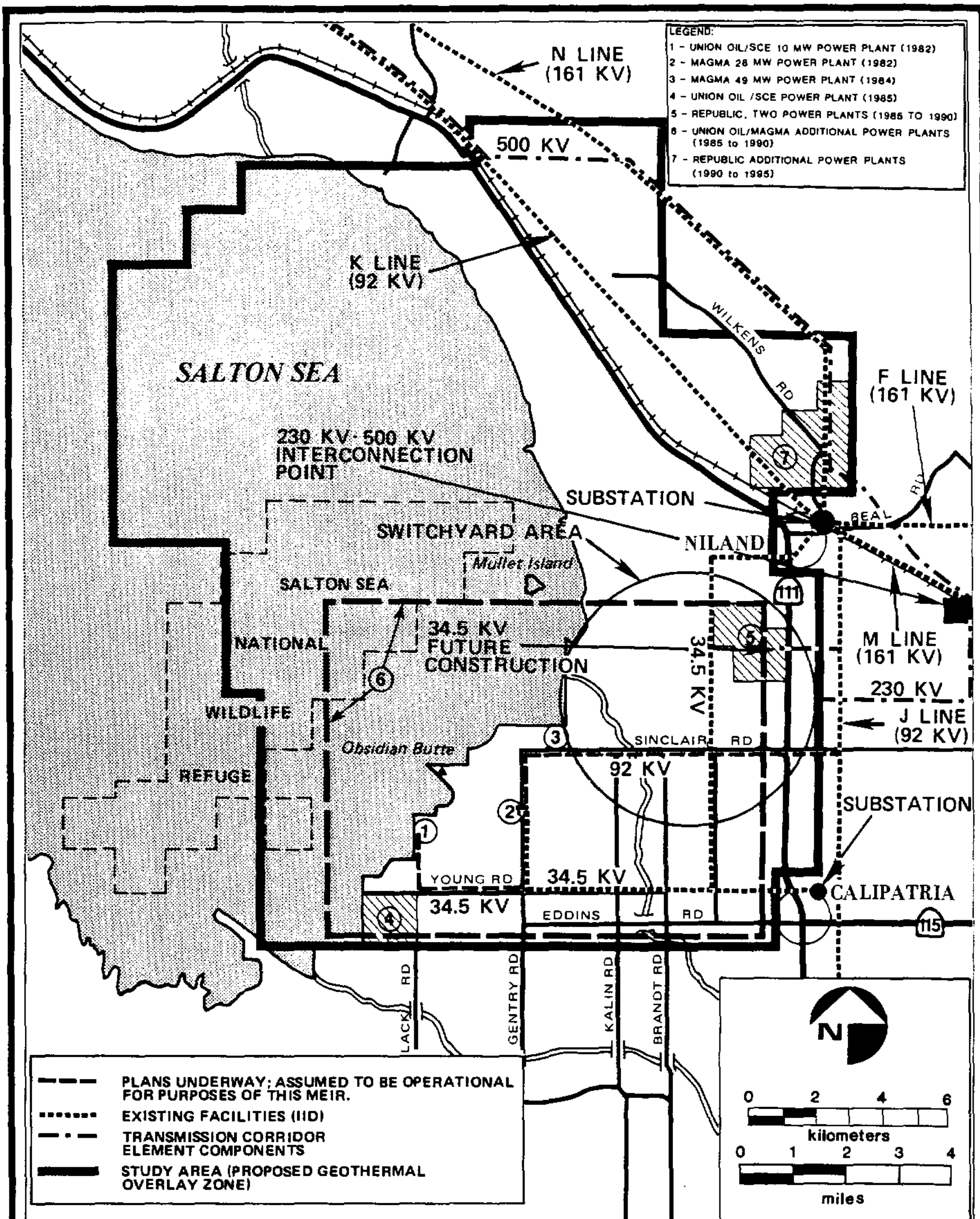
[2]Assumes 30 m^3 waste per 100 m of drilling (U.S. DOE, 1980), average 1000 m well depth and well development scenario of Table 2.6-2.

[3]Assumes 0.04 percent of brine is recoverable as solids (SDG&E, 1980), suspended solids in the filter cake are 65 percent by weight (SDG&E, 1980), and density of the filtered and pressed cake is 1600 kg/m^3 (U.S. DOE, 1980). Therefore, 275,223 kg/MW/year are produced or 172 m^3/MW/year if the resource characteristics in Table 2.4-2 are used. Other sources indicate that 0.02 percent of brine rather than 0.04 percent used herein is a better estimate (Robinson, 1981). Therefore, this analysis will represent worst case conditions.

[4]11 m^3/MW/year (U.S. DOE, 1980).

[5]1.76 m^3/MW/year derived from data in U.S. DOE (1980) (EIC copper sulfate process).

WESTEC Services, Inc.



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Transmission Line Development Scenario

FIGURE 2.6-7

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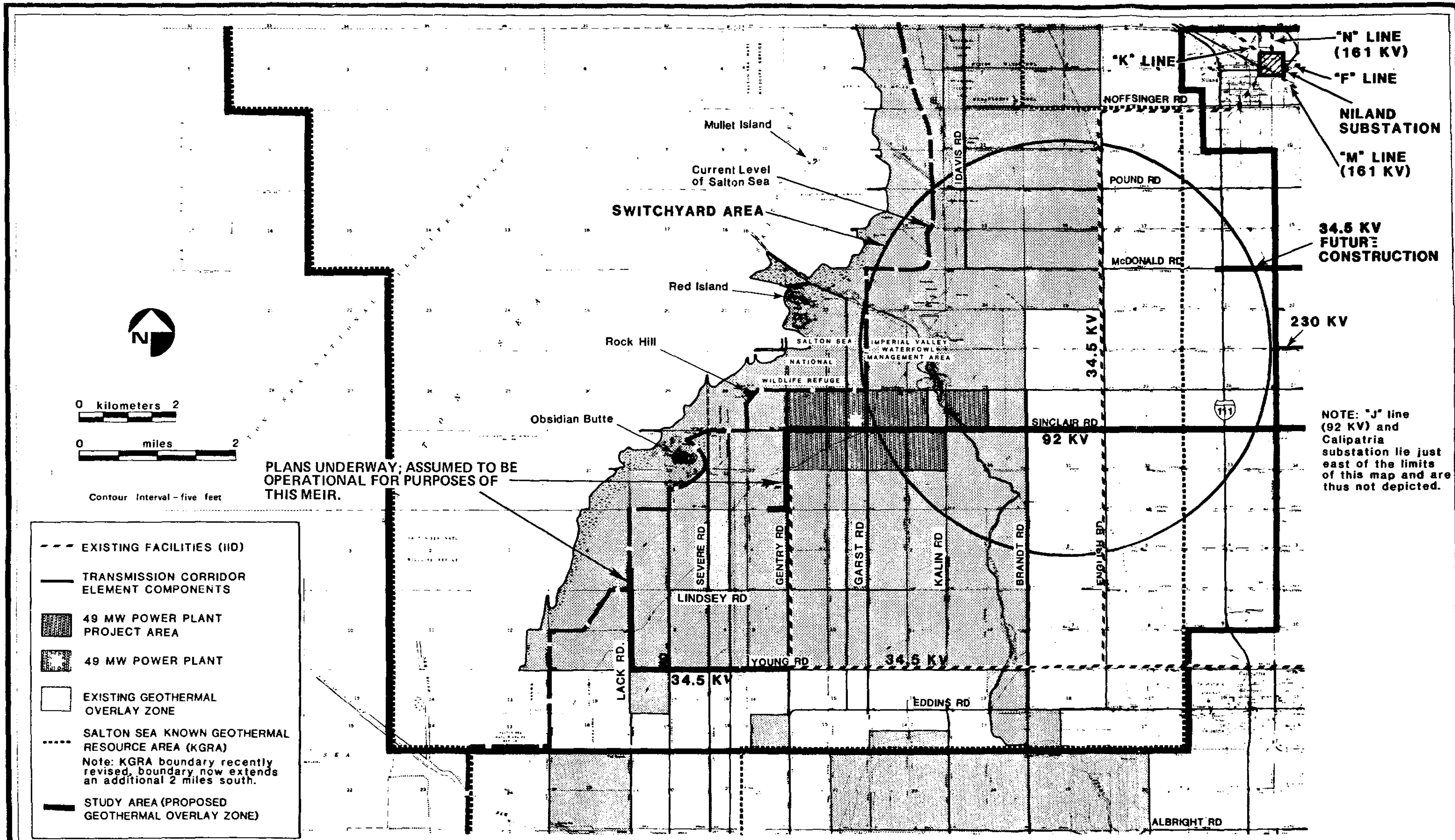
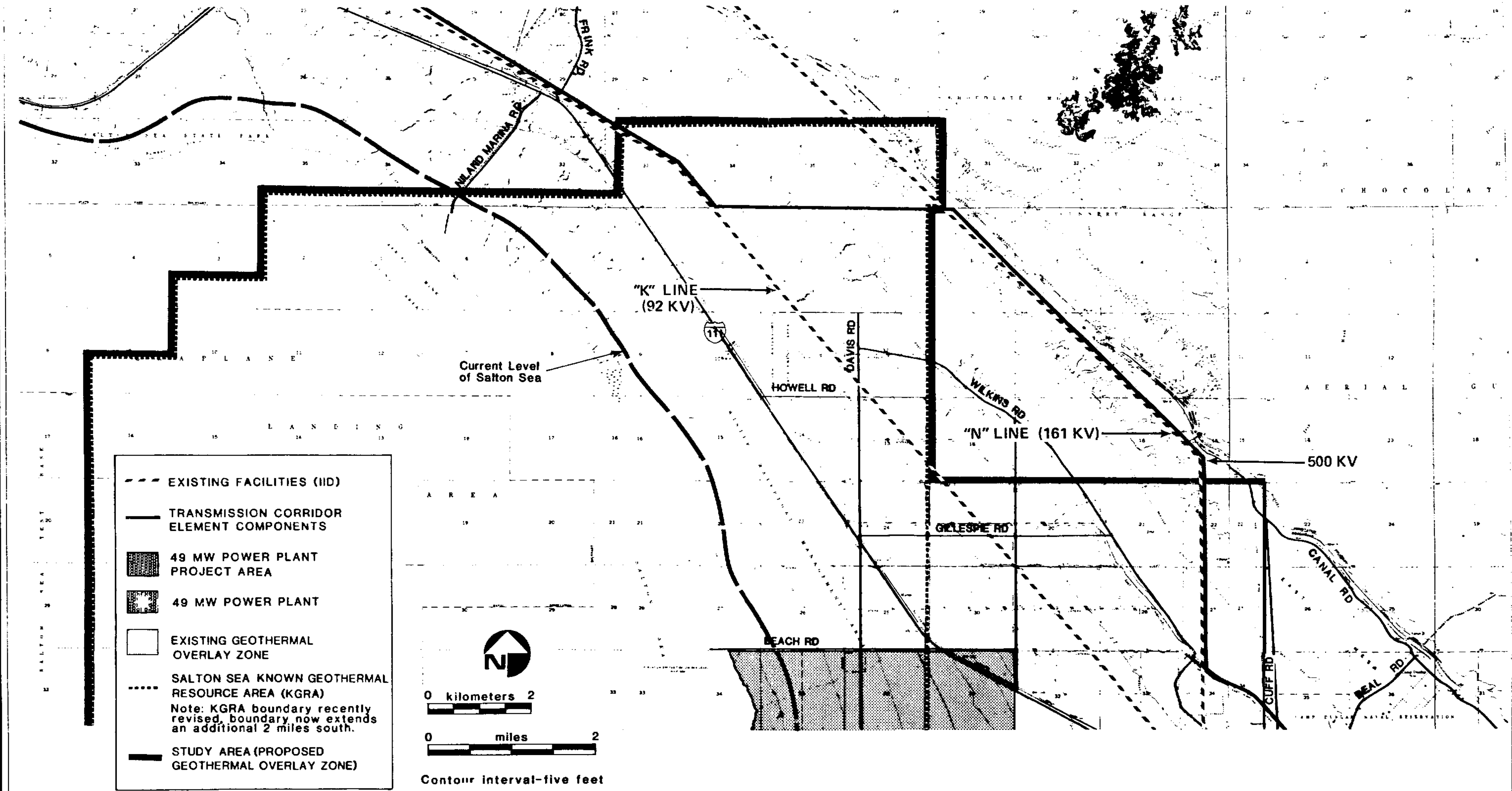


Transmission Line Development - Part I

FIGURE 2.6-8



Transmission Line Development - Part 2

FIGURE 2.6-9

this line is shown in Figures 2.6-7, 2.6-8 and 2.6-9; however, its relationship to the project area can be seen in Figures 2.6-10 and 2.6-11, inasmuch as it (the "M" line) forms the centerline for a portion of the Geothermal Collector System adopted as part of the County's Transmission Corridor Element. The "M" line in this area parallels the Southern Pacific Railroad lines from Yuma for a short distance and terminates at the Niland Substation.

Three additional transmission lines emerge from the Niland Substation and travel generally toward the north. IID's "F" line (161 kV) heads due east from the Niland Substation through the Chocolate Mountains and terminates at Blythe, well to the northeast of the study area. The "N" line (161 kV) heads due north from the Niland Substation until it reaches the Coachella Canal where it turns to the northwest and generally follows the Canal into Riverside County, terminating at a substation near Coachella. The "K" line (92 kV) travels to the northwest from Niland and remains generally parallel to and just east of Highway 111 and the Southern Pacific Railroad tracks. It passes through the Bombay and Mortmar Substations and terminates at Coachella.

b. Transmission Corridor Element

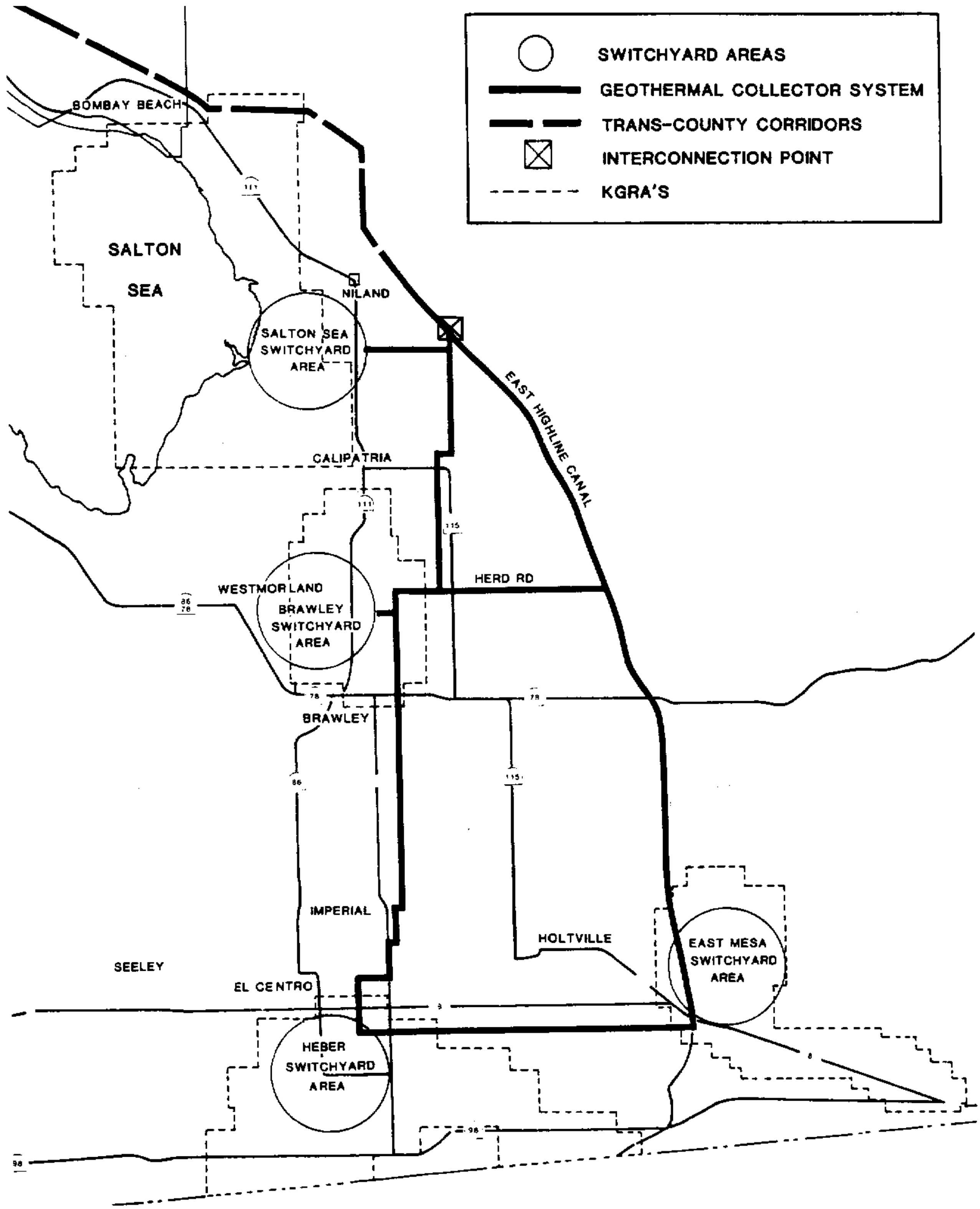
Recently, the County of Imperial adopted a Transmission Corridor Element of the General Plan. It provided for three basic 1 mile (1.6 km) wide planning corridor systems:

1. A 230 kV Geothermal Collector System to gather and transmit power from four KGRAs, including the Salton Sea;

2. A 500 kV north-south corridor to transmit power to and from Riverside, San Bernardino, Orange and Los Angeles Counties, and possibly elsewhere; and

3. An east-west corridor which "in concept" would avoid irrigated agricultural lands. California Public Utilities Commission (CPUC) hearings on SDG&E's application for an east-west 500 kV transmission line between San Diego and Arizona that would pass through the southern part of Imperial County are currently underway.

A portion of the Collector System and part of the north-south 500 kV corridor lie within the Salton Sea MEIR study area. The involved segments are described below and depicted in Figures 2.6-7 through 2.6-11. It should be noted that the starting point for designing the configuration of the Geothermal Collector System was a somewhat arbitrarily defined five-mile diameter "switchyard area," for each of 13

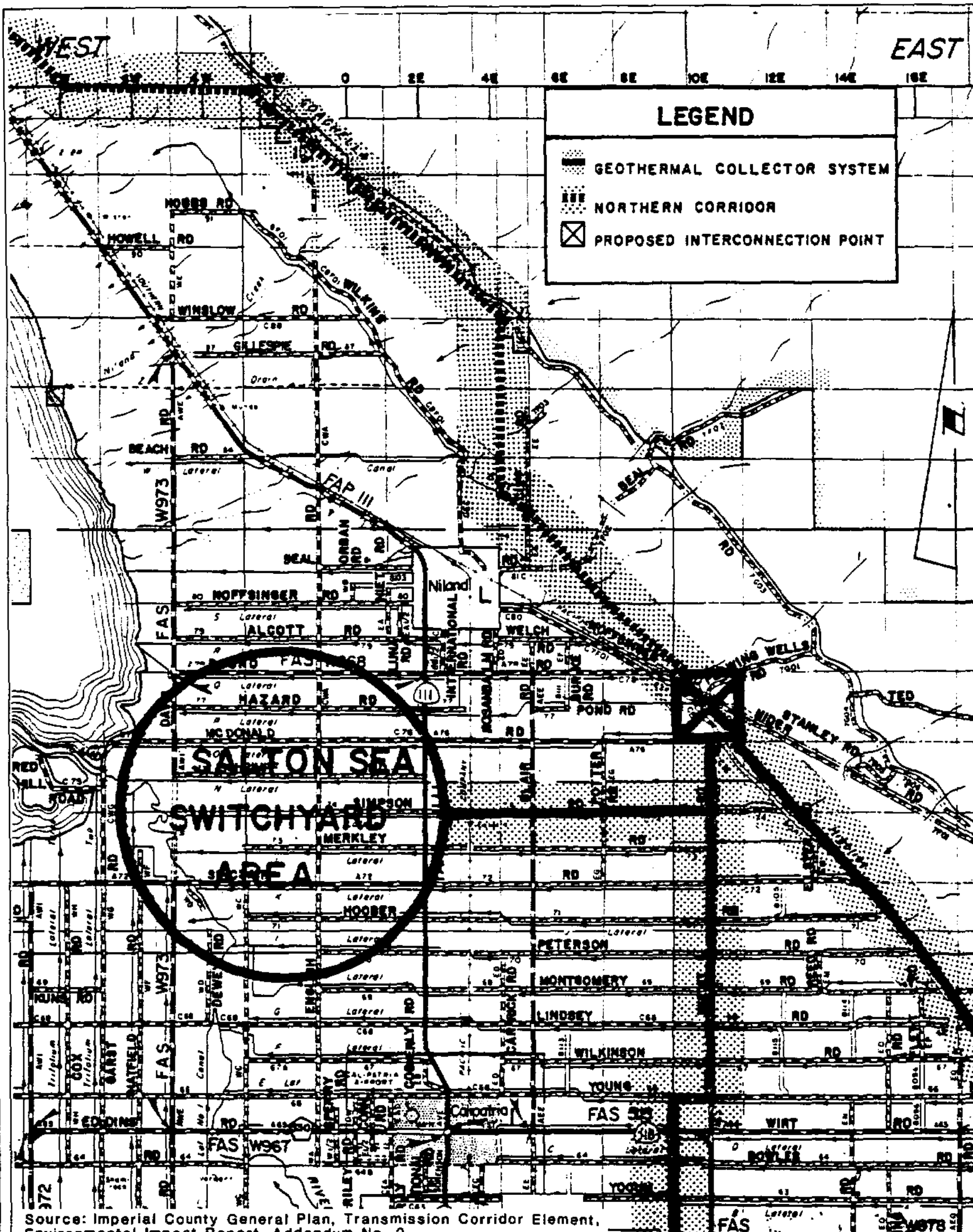


Source: Imperial County, 1980a

Geothermal Collector System

FIGURE 2.6-10

WESTEC Services, Inc.



Source: Imperial County General Plan, Transmission Corridor Element, Environmental Impact Report, Addendum No. 2

Adopted Transmission Corridors in the Vicinity of the Study Area

FIGURE 2.6-11

the four KGRAs. It was anticipated that a centrally located switchyard would be needed at some point in time within each KRGA to step the voltage of power collected from individual plants up to 230 kV for introduction into the Collector System. The need for and location of such a switchyard would be based on the evolution and location of geothermal power plants within each KGRA, as well as on other factors. The switchyard area originally identified for the Salton Sea KGRA is shown in Figures 2.6-7 through 2.6-11.

The Transmission Corridor Element and its related EIR, including Addenda 1 and 2, describe various segments of the adopted Collector System and the north-south corridor. These descriptions, as they relate to the Salton Sea MEIR study area, form the basis for the following paragraphs.

It was visualized that a linkage between the Salton Sea Switchyard Area (SWA) and the backbone collector system "would emerge from the SWA and run due east... along Simpson Road to Wiest Road where it would intercept IID's existing "M" line." The voltage of this linkage was anticipated to be 230 kV with either steel lattice, wooden H-frame, or tall single pole towers used for support. It should be noted that the Transmission Corridor Element EIR identified Simpson Road as a potential centerline for the corridor along this segment of the system for planning purposes only, and went on to state that "any east-west segment from about Pound Road on the north ("Q" lateral and drain) to Lindsey Road on the south ("I" lateral and drain) which could run eastward (to intercept IID's "M" line) would be equally acceptable as an alternate access segment between the Salton Sea Switchyard Area and the backbone routes." Upon reaching IID's existing "M" line at Wiest Road, the Collector System corridor would turn northward for roughly 1.7 miles (2.7 km) until it reached the Southern Pacific Railroad tracks at Flowing Wells, where it would enter a potential 230 kV-500 kV interconnection point planning area. This location and its one-mile square size (somewhat arbitrarily defined around three potential sites) were established for future planning purposes as a potential northern interconnect point between the 230 kV Geothermal Collector System and the 500 kV Trans-County Corridor to the north. From this point, one leg of the Salton Sea KGRA to East Mesa KGRA Collector System Corridor would extend southerly along the East Highline Canal. The first leg of the 500 kV North-South Trans-County Corridor would emerge from the proposed interconnect point and follow IID's "M" line to the north along the East Highline Canal for roughly four miles, to the point where IID's "N" line crosses the Canal. At this intersection, the Trans-County Corridor would turn due north, following the route of the "N" line to and along the Coachella Canal. It was noted in the Transmission Corridor Element EIR that a four mile stretch of "open, relatively barren and unconstrained land between Siphons 13 and 15 of the Coachella Canal" could be used to connect the 500 kV line with the remainder of the adopted Trans-County Corridor, but that for planning purposes only, it would be plotted along "the section line just south of Siphon 14 (northern border of Section 6, T10S, R14E)."

The remainder of the 500 kV corridor would follow IID's "K" line to the northwest into Riverside County.

c. Probable Transmission Line Development Scenario

Plans to accommodate the first three power plants listed in Table 2.5-2 are generally known. Power from Union's 10 MW plant near Lack Road will be accommodated by constructing a new 34.5 kV line from the existing 34.5 kV line at the intersection of Young and Gentry Roads about 2 miles (3.2 km) west along Young Road, then north on Lack Road to the power plant (see Figures 2.6-7 through 2.6-9). Construction plans for this line are currently underway and, for purposes of developing a future scenario within this MEIR, it will be assumed that this line is fully operational.

Magma's 28 MW plant at the old GLEF site will be accommodated by constructing a new 92 kV transmission line from the plant northward along Gentry Road to Sinclair Road, then eastward along Sinclair to tie in with IID's existing "J" line. Again, design and construction activities are already underway on this line within IID and, for purposes of this MEIR, it too will be assumed to be fully operational in developing a future transmission line scenario. This 92 kV line could accommodate Magma's 49 MW power plant which is scheduled for 1984 service and is addressed in Section VIII of this document. However, to the best of our knowledge, no firm plans have been established to transmit power from the 49 MW facility.

As shown in Table 2.5-2, several 50 MW power plants are optimistically scheduled for service in 1985-1987. By the end of 1987, transmission facilities for up to ten 50 MW plants (500 MW total) within Area 6 (Figures 2.6-7 through 2.6-9) could be required. It is possible that one or two of these units could utilize some of the facilities currently being designed or in the construction phase. This rapid development phase of geothermal power, however, would probably require the development of a centrally located switchyard in the Salton Sea KGRA with a fully integrated transmission network from the units to the switchyard and then to the Geothermal Collector System (Figure 2.6-10).

At least three different concepts can be developed for transmitting power from individual power plants to the 230 kV geothermal collector system:

1. Direct transmission via relatively small conductors (34.5 kV) to a 230 kV geothermal collector system substation such as Niland. (Use of the substation in Niland for the 230 kV-500 kV interconnection is in conflict with the County's Transmission Corridor Element.)

2. Transmission from individual power plants over smaller lines (34.5 kV) to interconnect with new mid-size lines (92 kV).

3. Transmission via several small (34.5 kV) lines and/or mid-size lines (92 kV) into a new switchyard which would step up the power from 34.5 kV or 92 kV to 230 kV. This switchyard would then be connected to the Geothermal Collector System via a single or double circuit 230 kV transmission line. If this concept were to be adopted, the location of the switchyard would be influenced by at least two major factors: a) the need to have it near the center of the heat source, and therefore presumably near the densest concentration of power plants, and b) waterfowl impacts related to crossing the Alamo River with a single or double circuit 230 kV line supported by lattice or H-frame towers or a single pole, or by a larger number of lower capacity (34.5 kV or 92 kV) transmission lines.

The first two transmission concepts are already being used by the utilities to some degree to provide for the export of power from the first three geothermal units between 1982 and 1984. Continued development of these systems for the projected rapid development phase (1985-87) would require a substantial number of transmission lines which would not be cost effective or environmentally desirable. Therefore, it is likely that the third concept will be used when rapid development of geothermal units begins to occur.

As stated earlier, it is not the purpose of this MEIR to develop or fully define a transmission line network for the Salton Sea KGRA, nor to precisely
14 locate a centralized switchyear within the study area. However, based on the foregoing
75 discussion and on the evaluation of alternate transmission facility option contained in Section 7.4, certain general parameters for transmission line facilities can be established. These parameters, which are listed below, form the basis for identifying three possible centralized switchyard/transmission line configurations. Underlying parameters include the following:

1. Minimum intrusion onto agricultural land and minimal disruption of agricultural activities should occur.

2. Where possible, existing transmission line rights-of-way should be followed in order to avoid a proliferation of lines throughout the KGRA.

3. The measures contained in the County's Transmission Corridor Element and its related EIR which are aimed at minimizing impacts to agricultures should be employed, e.g., placement of rights-of-way along the edge of fields or roadways, avoidance of diagonal alignments through agricultural fields, etc.

4. Minimal intrusion should be made into areas which have been identified as having high degrees of biological sensitivity (see Section 3.6).

5. The number of transmission line crossings over the Alamo River should be minimized.

6. Populated or high use areas should be avoided to the maximum extent possible.

Based on these parameters, it is felt that the least disruptive transmission facility system would involve the following:

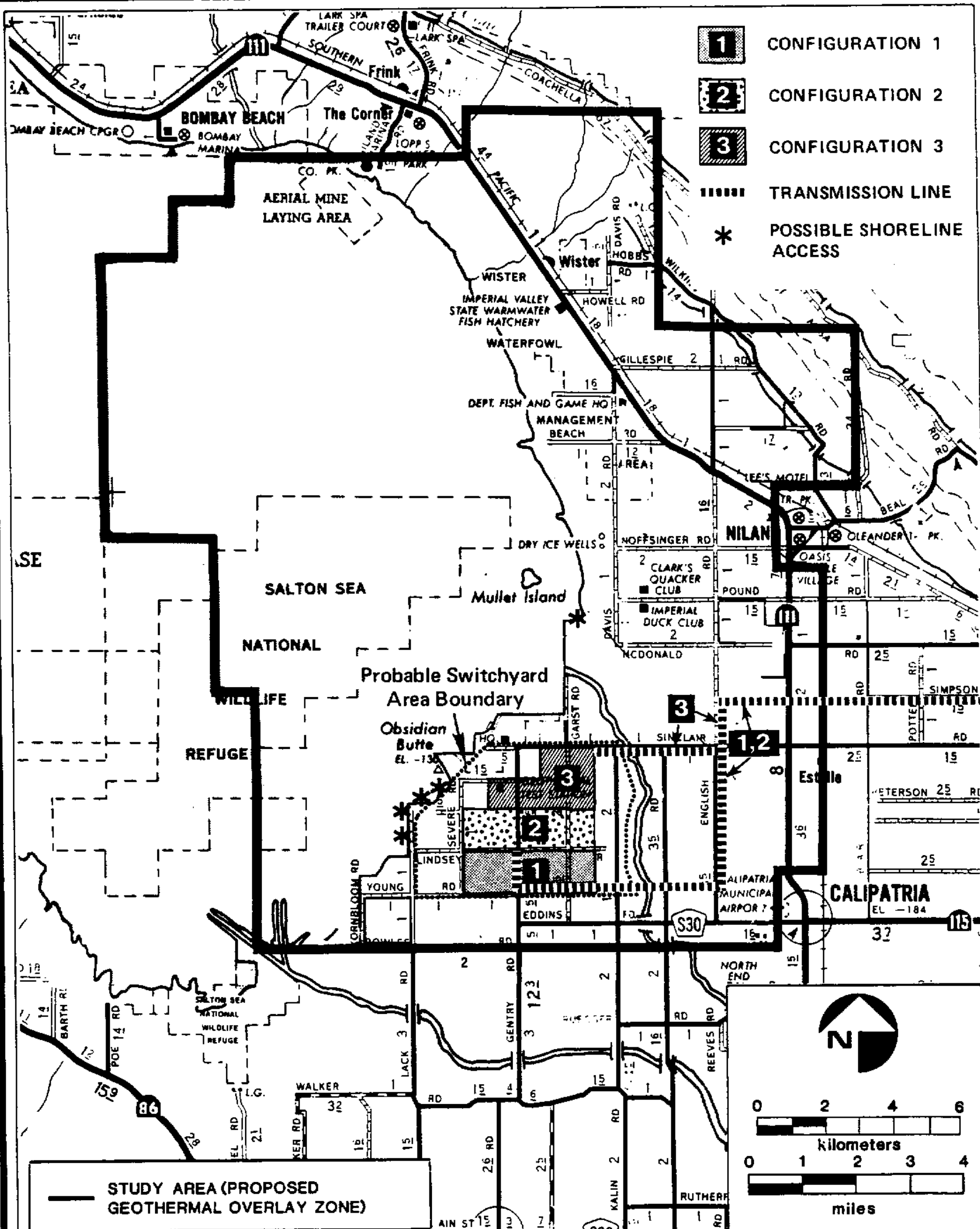
1. A 10 to 20 acre (4-8 ha) centralized switchyard somewhere in the area bounded by Sinclair Road on the north, the Alamo River on the east (with an appropriate buffer), Young Road on the south and Lake Road or the Salton Sea (again with an appropriate buffer) on the west (see Figure 2.6-12). The purpose of this switchyard would be to collect power from individual power plants via 34.5 kV to 230 kV and transmit it eastward to interconnect with the County's adopted Geothermal Collector System.

2. A series of lattice or H-frame towers or single poles to carry the transmission lines eastward to the Collector System. Probable characteristics of such a system are shown in Table 2.6-7.

Based on the foregoing paragraphs and on the impact discussions throughout Sections III and 7.4, three possible switchyard/transmission line configurations have been identified. Others may of course exist, but the following seem to be reasonable, based on the information available today.

Configuration 1

This configuration would call for the creation of a centralized switchyard somewhere within Sections 8, 9, 10 or 11 plus the western half of Section 12, Township 12 South, Range 13 East (Figure 2.6-12). This location would be reasonably close to the first four power plants being planned. Impacts would be essentially the same regardless of where the switchyard would be located within these sections, except that the avian flight corridors near the Salton Sea would have a wider buffer if Section 8 were avoided; likewise, a wider buffer between the switchyard and the flight corridor along the Alamo River could be provided if the eastern half of Section 11 plus



Centralized Switchyard/Transmission Facility Options

FIGURE 2.6-12

Table 2.6-7

PHYSICAL CHARACTERISTICS OF 230 kV
TRANSMISSION LINE SYSTEM

Right-of-way with one set of towers or poles:	
Width of right-of-way	120 ft (37 m)
Distance between tower and edge of right-of-way	60 ft (18 m)
Right-of-way with two sets of towers or poles:	
Width of right-of-way	200 ft (61 m)
Distance between tower and edge of right-of-way	60 ft (18 m)
Distance between parallel towers	80 ft (24 m)
Lattice tower dimensions (if towers are utilized):	
Height	120-123 ft (37-40 m)
Base - side	20-30 ft (6-9 m)
- area	400-900 ft^2 (37-84 ca)
Optimal distance between towers in agricultural areas	1320 ft (402 m)
Height clearance for conductors from ground at mid-point between towers:	
Minimal	30 ft (9 m)
Typical	35-36 ft (11 m)

Section 12 were avoided. Thus the optimal location for a switchyard for this configuration would be somewhere in Sections 9 or 10 or the western half of Section 11, as depicted in Figure 2.6-12. It was not within the scope of work for this MEIR to conduct detailed site specific surveys for potential switchyard sites, therefore a specific, optimal location within these sections cannot be derived based on current data. As discussed elsewhere within this document, it seems reasonable to expect that IID or the Imperial Valley Action Plan Utility Technical Committee would consider the evaluations and suggestions made within this document, and conduct the necessary surveys to more precisely define a preferred site and, if appropriate, to propose its use for a centralized switchyard.

Regarding transmission lines under this configuration, power from individual power plants could be transmitted via smaller lines (34.5 kV or 92 kV) to the switchyard. Larger lines (230 kV) would then emerge from the switchyard headling eastward, probably along Young Road, following the existing right-of-way of one of IID's 34.5 kV lines. It was suggested in Section 3.6.3 that any transmission line crossings of the Alamo River avian flight corridor should be accomplished via underground cable or conduit, or that more detailed studies be conducted to fully determine if in fact a significant increase in avaian mortality is probable if crossings were to be made at certain locations, or if the river could be spanned without significant disruption. In any event, this 230 kV line would continue eastward after crossing the river and intercept another 34.5 kV line at English Road. The 230 kV line would then follow the right-of-way of this second line northward to Simpson Road, where it would again turn to the east. The stretch of right-of-way along Simpson Road and the M Lateral and Drain from English Road eastward to Wiest Road would require the creation of a new right-of-way where none exists today.

Two other possibilities exist for transmitting electricity from this switchyard location into IID's grid or to the Collector System. (Neither is shown in Figure 2.6-12 to avoid clutter.) The first option would call for 230 kV lines running eastward along Lindsey Road rather than Young Road. Little significant difference appears to exist between the two routes, except for the fact that no transmission facilities currently exist along Lindsey Road as they do along Young. Other issues such as the river crossing, towers versus poles, etc. are essentially the same as the Young Road alignment. If the Lindsey Road route were used, it would turn northward at English Road and follow the remainder of the alignment described above.

The second transmission line option under this configuration involves the possibility of continuing northward along English Road following the existing 34.5 kV right-of-way rather than turning to the east at Simpson Road. This option which would terminate at the Niland Substation is inconsistent with the Imperial County Transmission Corridor Element, but, as noted in Section 7.4, is currently being considered by IID.

Configuration 2

This configuration would call for the creation of a centralized switchyard somewhere within Sections 2, 3, 4 or 5 plus the western half of Section 1, Township 12 South, Range 13 East. Again avian flight corridors could be more widely buffered by avoiding Section 1 and the eastern half of Section 2 plus Section 5, despite the fact that Union's 10 MW plant is located at the western edge of Section 5 (see Figure 2.6-12). As with Configuration 1, this option would be reasonably accessible to the first four power plants planned as well as to many of those anticipated for future years. Little differences in potential impacts are currently apparent regardless where within this area the switchyard would be located, however, this would be dependent on the results of more detailed site specific surveys in the future.

Transmission lines emerging from a switchyard in this locale could travel in a number of ways. If one were to follow existing rights-of-way, it would be possible to head south along Gentry Road following an existing 34.5 kV line. At Young Road, this alignment would turn east and follow the same route (including the same optional alignments) at that described for Configuration 1.

As discussed earlier, IID is currently planning a 92 kV line from the 28 MW power plant site (Location No. 2 on Figure 2.6-12) which would run northward along Gentry Road then east along Sinclair to intercept the 34.5 kV right-of-way along English Road. If this line is in existence by the time the switchyard is built it would be possible to follow the same alignment with a set of 230 kV circuits. However, this route would pass next to the wildlife refuge and, based on the analyses contained in Section 3.6, would probably impose significant impacts on the wildlife resources of the area. For this reason, it is seen as being less preferable than the alignment described first and shown in Figure 2.6-12. A third possibility would call for 230 kV lines along Lindsey Road, and across the Alamo River to English Road where the lines would intercept the route described under Configuration 1. As noted above, this optional alignment would require the acquisition of new right-of-way and the construction of transmission lines along Lindsay Road where none exist today.

Configuration 3

The last configuration would involve locating a switchyard somewhere within the southeast quarter of Section 33, the southern half or northeast quarter of Section 34 and the western half of Section 35. These somewhat disjointed boundaries are aimed at providing adequate buffer areas between a potential switchyard location in this area and known avian flyways as well as between the transmission lines and the wildlife management area. Within the areas indicated, little if any differences in environmental impact is foreseen between one site and another based on the rather generalized surveys completed to date, although any additional distance that could be placed between the switchyard and the refuge areas would probably be beneficial.

Regarding 230 kV transmission lines, the most direct route would be along Sinclair Road heading due east, across the Alamo River to English Road, where it would intercept the route described earlier under Configuration 1. It seems reasonable that any crossing of the Alamo River near Sinclair Road would incur greater impacts on avian mortality than if the crossing were made farther south, away from the Salton Sea (such as at Young Road). However, no evidence has yet been generated to indicate that this is the case, i.e., the number and elevations of avian flights along the Alamo River corridor do not appear to be significantly different here or farther south, based on current knowledge. If a switchyard were to be located somewhere within the Configuration 3 area, every effort should be made to keep the 230 kV and other lines as far away from the refuge areas as possible. Because of its proximity to the refuge, this final configuration appears to be less preferable than the other two although its proximity to the planned plants and the center of the heat source is somewhat better.

The three switchyard/transmission line configurations discussed above and shown in Figure 2.6-12 were drawn from the evaluation contained in this MEIR and from the provisions of the County's Transmission Corridor Element. As stated earlier, other possible locations for a centralized switchyard may certainly exist. It is felt the information contained herein should be utilized by IID, the County, the IVAP Utility Technical Committee and others as input to both short and long-range planning for transmission facilities within the Salton Sea KGRA.

Regarding the transmission of electricity from power plants offshore in the Salton Sea, it is probable that such facilities will not occur until late in the 1985-90 time period, if not beyond. Alternatives other than aerial lines exist for bringing power from offshore areas onto land, such as underground cables in an earthen causeway or dike, underground cable suspended from an open causeway or pier, or submarine cables. However, indications are that these alternatives would have significantly higher costs compared to aerial lines. The environmental advantages and disadvantages of these various methods and their potential application to this project are addressed throughout Section III as well as in the Alternatives section of this MEIR (Section VII).

Access from the sea via submarine cable or conduit and the transition to aerial transmission lines on land will probably be a rather complicated, and potentially controversial undertaking. If the sea to shore transition is to be made without directly impacting wildlife refuges or duck clubs only two relatively unimpeded areas exist within the study area (see Figure 2.6-12 plus Section 3.6, Figure 3.6-2). One lies between McDonald Road and the westward extension of Hazard Road, several miles southwest of Niland. The other consists of a 2.5 mile stretch that extends from just south of Obsidian Butte near the westward extension of McKendry Road southwestward to about Lindsey Road. Of the two, the southernmost access area would likely be nearer any centralized switchyard that would be built. At the same time, a fairly direct interconnection could be gained via the northern access area to IID's J line by extending transmission facilities eastward from the shoreline along either McDonald or Hazard Roads. This route would also pass directly through plant siting area 5 (Figure 2.6-12). By identifying these two possible shoreline access areas it is not intended to imply constraining influences do not exist. As discussed at length in Section 3.6 and as hown on Figures 3.6-3 and 3.6-6, the entire shoreline in these areas has been identified as a major avaian flyway of some sensitivity. Ideally therefore, transmission line access from the sea might utilize one or both of the areas shown in Figure 2.6-12 but should remain underground or in conduits until the major flight areas have been passed. As with the river crossings, however, if subsequent studies show that avian mortality increases can be avoided or will not be significant in certain specific areas as a result of transmission lines, the transition from undersea cable or conduit to aerial lines might occur nearer the shore.

2.6.7.5 Noise Abatement

It is probable that each geothermal power plant will be equipped with a variety of noise abatement equipment to minimize the impacts of noise on the surrounding community as well as on biological resources in the vicinity. Examples of such noise abatement equipment would include the following:

a. Portable well blowoff silencers
b. Truck mounted well blowoff silencers
c. Permanent steam and gas vent stack blowoff silencers
d. Sound attenuating blankets for drill rigs
e. Control valve modifications
f. Rock mufflers

Section 3.5 of this MEIR describes these abatement systems in more detail and provides an assessment of the probable impacts of geothermal development on the existing acoustical environment of the area.

2.6.7.6 Emission Controls

Table 2.6-8 was drawn from Ermak *et al.* (1979) and provides an estimate of the unabated emissions rates within the Salton Sea KGRA. U.S. DOE (1980) provides a further discussion of potential emissions problems, and Section 3.4 of this MEIR addresses the controls that will probably be utilized within the study area to mitigate the potential adverse air quality effects of long-term geothermal development within the Salton Sea KGRA.

2.6.8 System Shutdown

In compliance with the requirements of Imperial County, each of the power
41 plants and related facilities, at such time as the resource is expended, will be required to dismantle the power production facilities, cap the wells, and rehabilitate the involved area to its prior condition.

2.6.9 Direct Use Applications

It is assumed that the vast majority of the energy extracted from the Salton Sea Anomaly will be utilized in the production of electricity. However, it should be recognized that direct use applications of the heat from the geothermal reservoir are also possible. The agricultural nature of the Salton Sea Anomaly area indicates that the most likely applications would be associated with that industry or the related food and kindred products standard industrial classification. Activities that might use geothermal energy include: drying (e.g., alfalfa and cotton); food processing (e.g., cooking, blanching, peeling, vegetable dehydration, freeze drying, canning, beet sugar refining, milk pasteurization); greenhouses (to provide optimum growing conditions); animal husbandry (heating, cleaning, sanitizing); aquaculture (to provide an optimal environment to enhance growth); and organic waste conversion to fertilizer. The study area does not offer many opportunities for large scale space heating and cooling projects.

Table 2.6-8

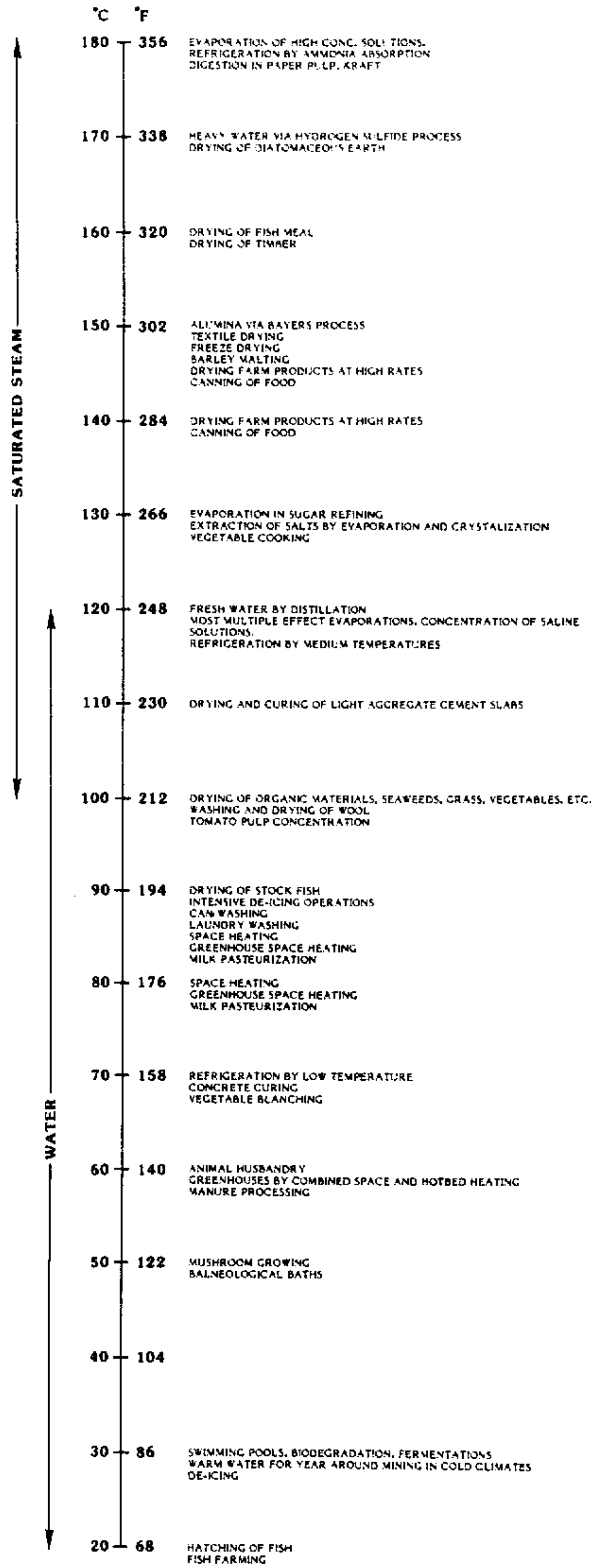
UNABATED EMISSION RATES
SALTON SEA KGRA

Gas	Emissions (g/mwh)
Hydrogen Sulfide (H_2S)	160
Ammonia (NH_3)	1,750
Carbon Dioxide (CO_2)	8.5×10^4
Methane (CH_4)	300
Mercury (Hg)	0.090
Radon 222 (Rn 222)	41[1]
Benzene (C_6H_6)	—

[1] Radon emission rate is μCi/mwh.

Source: Ermak et al., 1979.

Direct use applications are dependent on the temperature of the resource. Figure 2.6-13 relates temperature to potential uses. The Salton Sea Anomaly is sufficiently hot to be adopted for any of the uses listed.



SOURCE:

LINDAL, B., 1973

Direct Use Applications Related to Resource Temperature

FIGURE 2.6-13

SECTION III

EXISTING CONDITIONS/IMPACTS/MITIGATION MEASURES

3.0 INTRODUCTION

In order to make the impact analysis as useful as possible, areas in the proposed G-Overlay Zone have been classified by sensitivity levels related to several environmental parameters discussed in this section. The definitions of sensitivity levels link 16
the magnitude of expected impacts to the degree of mitigation likely to be required. Five categories of sensitivity are used and are defined as follows:

Maximum Sensitivity: A maximum level of sensitivity to or conflict with potential geothermal development occurs in those areas where the environment appears 1a
sensitive to the extent that significant impacts would result that cannot be fully mitigated by any practical means. The preferred mitigation measure would be avoidance of the area.

Conditional Maximum Sensitivity: A conditional maximum level of sensitivity occurs in those areas where a maximum sensitivity appears to exist but there is a lack of sufficient data to definitively classify the area as such. Additional studies would be necessary to determine appropriate mitigation measures.

Major Sensitivity: A major level of sensitivity occurs in those areas where development would result in a high level of potential impact. Substantial mitigation would be necessary in these areas or they should be avoided.

Moderate Sensitivity: A moderate level of sensitivity occurs in those areas where development would result in a low to medium magnitude of impact. Development in these areas would require moderate to minimal mitigation.

Minimal Sensitivity: A minimal level of sensitivity occurs in those areas which, due to a lack of resource value and/or susceptibility to change, indicates that potential development would result in a low degree of impact. These areas would be 15
most suitable for geothermal development. Only minimal mitigation would be necessary.

It should be emphasized that the classification of an area as having "maximum sensitivity" according to a single or even several environmental criteria (e.g., biology and/or visual resources) should not imply that geothermal development cannot be allowed in those areas. It does imply that if development is allowed, impacts on those environmental parameters should be expected but other considerations may make these impacts acceptable from an overall perspective.

3.1 GEOLOGY

3.1.1 Existing Conditions

3.1.1.1 Landform and Topography

The project is situated at the northern end of the Imperial Valley, a broad, flat depression, flanked by mountains of granitic and metamorphic rock, in the central part of the Salton Trough. The Salton Trough comprises the northern landlocked extension of the Gulf of California, which has been isolated by the low divide formed by the present delta of the Colorado River. The divide marks the separation of the Imperial Valley in California and the Mexicali Valley in Mexico. Most of the Imperial Valley north of the divide is below mean sea level (MSL). Elevations range from +47 feet MSL to -278 feet MSL at the bottom of the Salton Sea.

During recent geologic time, the Colorado River would periodically flow directly into the Imperial Valley, creating a lake. The last of these lakes dried up between 300 and 1600 years ago. The present Salton Sea was created initially between 1905 and 1907 by runoff from a break in an irrigation canal during a flood stage of the Colorado River. The Sea persists today primarily because it is fed by inputs from imported irrigation water.

The topography of the Imperial Valley is very subdued as a result of the continuous deposition of sediments from the Colorado River and enclosing mountain ranges. The level expanse of plain is incised by the channels of the Alamo and New Rivers, which originate to the east and south of Mexicali, respectively, in Estado de Baja California, Mexico. These channels were carved to a depth of as much as 40 feet between 1905 to 1907 when the Colorado River contributed its entire flow to the Salton Sink.

The project area occupies the lowest portion of the Salton Trough on the southeast periphery of the Salton Sea. Elevations range between -200 feet MSL and
-278 feet MSL at the bottom of the Salton Sea. The relatively featureless terrain is 76
interrupted by the five small, extinct, volcanic domes which form topographic highs rising to a maximum of 100 feet (30 m) above the surrounding plain. Obsidian Butte and Red Hill are the largest of the volcanic domes, each covering approximately 160 acres (65 ha).

3.1.1.2 Regional Stratigraphic and Structural Geology

The geologic structure of the Salton Trough was formed several million years ago as a result of the rift in the earth's crustal plates (Larson et al., 1968; Atwater, 1970; Moore, 1973). The rift appears to be continuing to widen, with the

Pacific Plate "drifting" northwesterly relative to the continental North American Plate at a rate of approximately 6 centimeters per year (Larson, 1972). Sites of high heat flow in the Imperial Valley have been interpreted as indicating that the East Pacific Rise (a spreading center) extends up the Gulf of California by a series of seismically active "en echelon" strike slip, transform fault offsets to the northern end of the Imperial Valley, where it is offset again by the San Andreas Fault (Figure 3.1-1) (Elders, et al., 1972). Tension faults have developed at the ends of the "en echelon" fault pairs. The crustal thinning associated from the gradual but continuous widening of the Salton Trough has resulted in abnormally high heat flow.

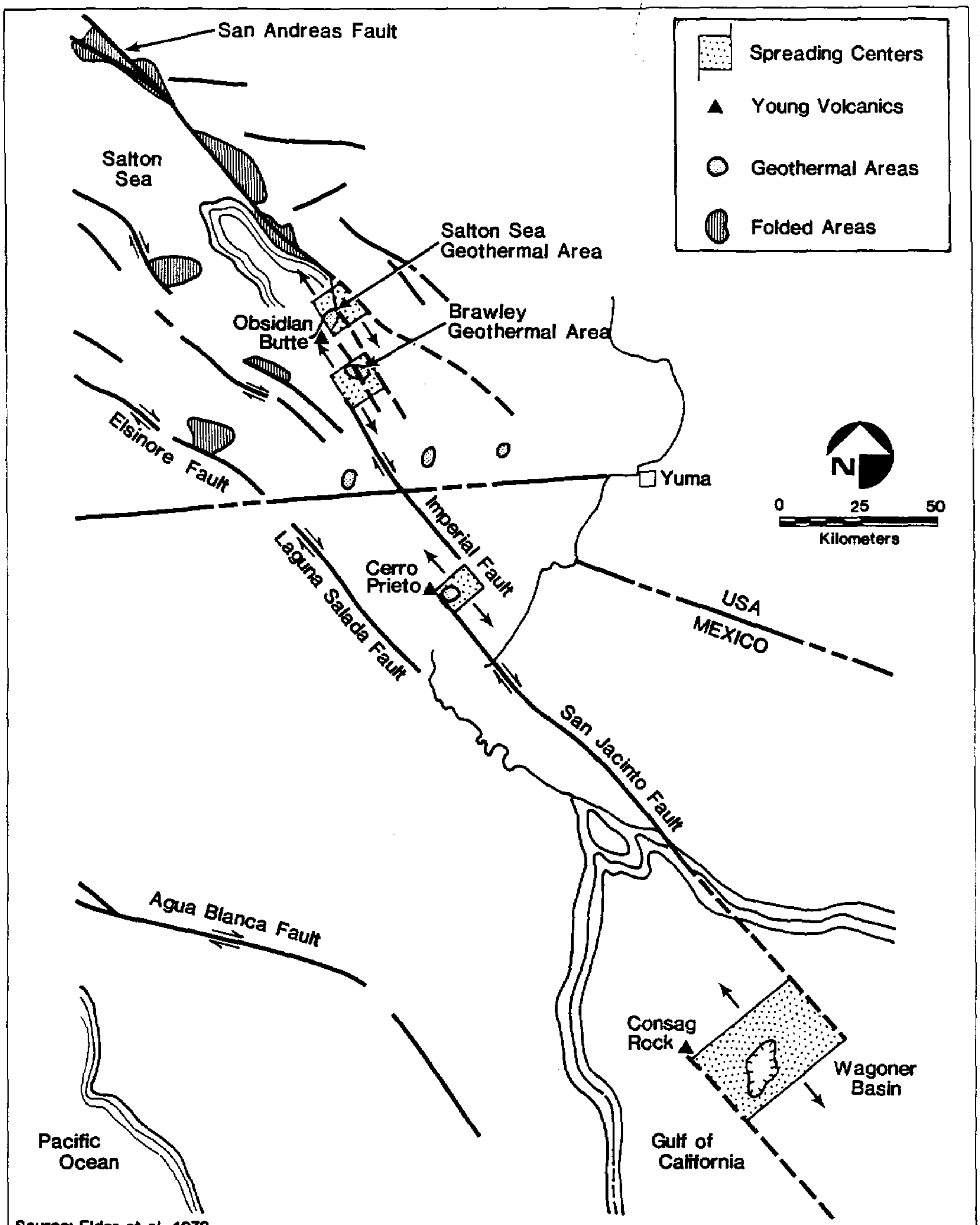
Major active faults associated with the "en echelon" series within the Salton Trough are shown in Figure 3.1-2. These include the Banning-Mission Creek (a branch of the San Andreas), Imperial, Brawley, Calipatria, Superstition Hills, Superstition Mountain, Cucapa, Elsinore-Laguna Salada, and San Jacinto faults.

The Salton Trough is filled with lacustrine and deltaic sands and shales of Tertiary age overlain by Quaternary alluvial, lacustrine and, to a lesser extent, volcanic materials (Figure 3.1-2). The trough is bordered by mountains of late Mesozoic and older granitic rocks and metasediments underlying a thick sedimentary sequence. The major rock units are the Split Mountain (Miocene), Imperial (Upper Miocene-Pliocene), Palm Springs (Pliocene), and Borrego-Brawley (Plio-Pleistocene) Formations (Dibblee, 1954). The total depth to bedrock in the project area is approximately 22,000 feet (Elders, et al., 1972).

3.1.1.3 Salton Sea Anomaly Geologic Setting

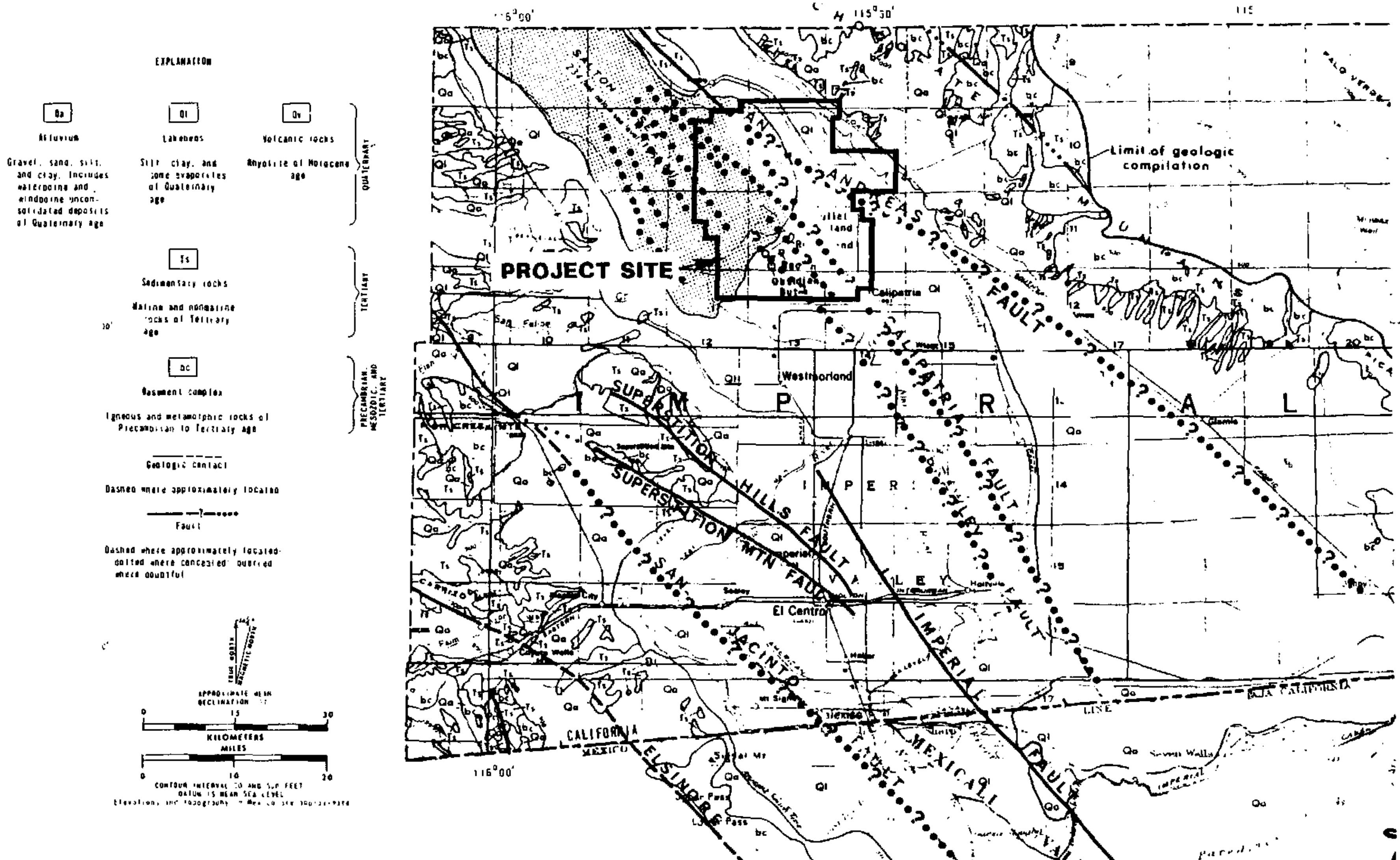
The proposed Geothermal Overlay Zone is centered on a closed Bouguer gravity anomaly (the Salton Sea Anomaly), one of several areas of abnormally high heat flow in the Salton Trough believed to be associated with spreading centers of the East Pacific Rise. The Salton Sea Anomaly lies at the southeast shore area of the Salton Sea and is a structurally complex area containing a number of faults, volcanic domes, mudpots and hot springs. The subsurface geology beneath the project area consists of a thick sedimentary sequence characterized by deltaic and lacustrine deposition. The Salton Trough has undergone a relatively rapid and continuous period of subsidence throughout the Cenozoic Era.

During recent geologic history, including the present, subsidence has been greatest at the Salton Sea area. During Cenozoic time, the Valley has been filled by sediments from the Colorado River. In more recent geologic time, sediments were deposited in ancient Lake Cahuilla. Sediments in the total stratigraphic column that



Sea Floor Spreading in the Salton Trough

FIGURE 3.1-1



SOURCE: DUTCHER et al., 1972 JENNINGS, 1975

Geologic Map of the Southern Salton Trough Showing Proximity of Known Faults to the Project Site

FIGURE 3.1-2

have been penetrated to date have been classified as follows (after Wilson and Mulliner, 1980).

Depth (ft.)	Sedimentary Sequency
0 to 1066	Caprock (Lake Cahuilla Sediments)
1066 to 2953-3609	Hydrothermally altered reservoir rock with relatively high interstitial porosity (15-30%)
2953-3609 to 4368	Hydrothermally altered reservoir rock with relatively low interstitial porosity (15%)

The caprock is a thick layer of low permeability rock that overlies the more permeable reservoir rock. The caprock prevents upward movement of geothermal fluids by convection except where faults in the reservoir rocks extend to the surface. (Leaks along faults occur at the surface as mudpots and fumaroles.) The caprock also acts as a thermal insulator preventing the loss of heat from the reservoir by conduction or radiation. This is evidenced by the very sharp increase of temperature with depth in the caprock.

Underlying the clay-dominated layer is the geothermal reservoir rock consisting of deltaic sandstones, siltstones and shales, metamorphosed to varying degrees by interaction with hydrothermal fluids, considered to be a facies of the Palm Springs Formation (Helgeson, 1968).

Five small rhyolite domes were extruded through the lake and deltaic sediments 16,000 to 50,000 years ago. Within the deltaic sediments there are numerous dikes and sills related to the extrusion of the Salton Buttes. The subsurface volcanics consist of light gray altered silicic rock and dark gray to black altered porphyritic basalt (Robinson, et al., 1974).

The complex structure of the Imperial Valley is characterized by strike slip faults. Surface traces of several faults have been identified south of the project area (Figure 3.1-2). In the project area, however, no surface traces have been identified. Nevertheless, the area is postulated to be underlain by a complex faulting structure. Numerous inferred faults, as shown in Figure 3.1-2, have been deduced beneath the proposed G-Overlay Zone on the basis of aerial photographs (Babcock, 1971), seismic reflections (Sigurdson et al., 1971), electrical resistivity (Randall, 1974), and microearthquake studies (Combs and Hadley, 1974; Hill et al., 1975).

3.1.1.4 Geologic Hazards

Potential geologic hazards within the proposed project area include:

a. Severe groundshaking induced by seismic activity.

b. Ground surface rupture along active and potentially active faults.

c. Liquefaction and differential settlement conditions.

d. Subsidence of the ground surface.

e. Erosion and slope stability hazards.

a. Seismic Ground Shaking

The Imperial Valley region is one of the most seismically active areas in the United States. As shown in Figure 3.1-2, several faults occur within a 25 mile (40 km) radius. Some of these faults have been the source of intense seismic activity within the past few decades (Real, et al., 1979). Recent activity includes a magnitude 6.6 earthquake in October 1979 which produced approximately 30 km of surface rupture on the Imperial and Brawley Faults. A magnitude 5.0 earthquake on April 26, 1981, also on the Imperial Fault, caused a considerable amount of damage to the City of Westmorland, located 10 miles southwest of the southern project area boundary. Faults considered capable of causing significant groundshaking are listed in Table 3.1-1. Also shown are the distances to the faults from the 49 MW power plant which is the subject of Section VIII of this report, the estimated maximum credible earthquakes, and estimated maximum credible rock accelerations expected at the project site from earthquakes on these faults. Since the proposed 49 MW power plant is near the center of the thermal anomaly and many of the power plants planned for the future would be in that area, it serves as a good example for these calculations.

Expansion of the United States Geological Survey-California Institute of Technology seismic monitoring network early in 1973 has led to an accumulation of data concerning small magnitude earthquakes, earthquake swarms and microearthquake activity in the Imperial Valley. Information from this monitoring network resulted in the addition of the Brawley and Calipatria faults to the list of known faults in the Imperial Valley. Both of these newly discovered active faults are believed to traverse the project area. In January 1975, a series of frequent, low magnitude earthquakes occurred along the Brawley fault, primarily south of the project area. Occurrences such as the Brawley swarm are believed to result in a strain release which may avert a very large magnitude event. Previous studies (Lomnitz, et al., 1970; Elders, et al., 1972) have postulated the existence of a chain of offset ridge segments and

Table 3.1-1

ANTICIPATED BEDROCK ACCELERATIONS DUE TO MAXIMUM CREDIBLE EARTHQUAKES ON PERTINENT LOCAL AND REGIONAL FAULTS

Fault	Minimum Distance to 49 MW Facility Project Site (mi)	Maximum Credible Earthquake Magnitude[1]	Maximum Credible Bedrock Acceleration at Minimum Distance[2]
Brawley	1.5	6	0.60g
Imperial	3.5	7	0.60g
Calipatria	—	6	0.60g
Superstition Hills	9.0	7	0.38g
Superstition Mountain	12.0	7	0.30g
San Andreas/Sand Hills	7.0	7.5	0.50g
San Jacinto	18.0	7.5	0.28g
Elsinore-Laguna Salada	28.0	7-7.3	0.15-0.18g
Cucapa	35.0	6	0.05g

[1]Primarily from Greensfelder (1974). Those not listed by Greensfelder assumed to be consistent with other faults, i.e., Richter Magnitude 6.

[2]From Greensfelder (1974, Figure 3).

transform faults connecting similar structures in the Gulf of California with the Banning-Mission Creek branch of the San Andreas fault. Evidence from the Brawley swarm supports the conclusion of Hill et al. (1975) that the Brawley, Calipatria, and Imperial faults are important links in this chain.

b. Fault Displacement

Movement along a fault plane can result in the displacement of a portion of the earth's crust at the ground surface and/or at depth. Such displacement can be either rapid, as occurs during an earthquake, or relatively slow and gradual, as associated with fault "creep." Fault displacement involves such great forces that the only means of avoiding damage to man-made structures is to abstain from building over active fault traces or to design structures to accommodate or withstand the expected displacement.

Large amounts of offset have been observed on the Imperial and San Jacinto faults, and to a lesser extent on the Brawley fault, south of the project area (Sharp, 1976). Although several potentially active fault traces are inferred to traverse the project area, there is no evidence of recent offset. However, because of the recent history of microseismic activity, these faults are considered capable of future displacement. It should be noted that the traces of these faults through the project area have not been exactly located.

c. Liquefaction and Differential Settlement

Data from drilling logs in the project area indicate that soil beneath the subareal portions of the project area contain shallow water tables within 30 feet of the ground surface and layers of loosely compacted sands. This combination of conditions creates a potential for liquefaction (the loss of soil strength caused by the strong shaking that accompanies an earthquake). Soft, compressible clay layers may also occur throughout the project area. Because of the great variability in thickness and characteristics of near surface sediment in the project area, structures placed in areas where compressible clays occur could be susceptible to differential settlement.

d. Subsidence

Subsidence of the ground surface due to natural causes in the Imperial Valley has been a concern to the agricultural industry for many years. Proper operation of the gravity-flow irrigation system in the Valley is dependent on the maintenance of existing ground surface elevations. As these elevations have subsided to varying degrees across the Valley, farmers have had to re-level their lands to keep the irrigation system functioning.

As the possibility of geothermal development in the Imperial Valley increased, government agencies and private industry have initiated monitoring programs to gather baseline data on natural subsidence. Figure 3.1-3 shows the results of a leveling survey sponsored by the Imperial Valley Subsidence Detection Committee (Crow, 1976). Over the two-year period from 1972 to 1974, natural subsidence appears to be relatively large in the area of the Salton Sea (up to -13 cm) and nearly nonexistent near the International Border (Lofgren, 1974).

According to a survey completed by the National Geodetic Survey (NGS) in 1976-77, natural subsidence in the Imperial Valley is increasing (Reese, 1977). This is shown in Figure 3.1-4, using NGS data for the 1974 to 1976-77 period. As evident in Figure 3.1-4, the northern part of the Valley is not subsiding as fast as in the previous two-year period, but the central portion of the Valley south of Niland is experiencing an increasing subsidence rate (the actual subsidence, however, is still greater in the north). Subsidence rates for the three-year period varied from -12.2 cm near Westmorland area to -1 cm southeast of Holtville.

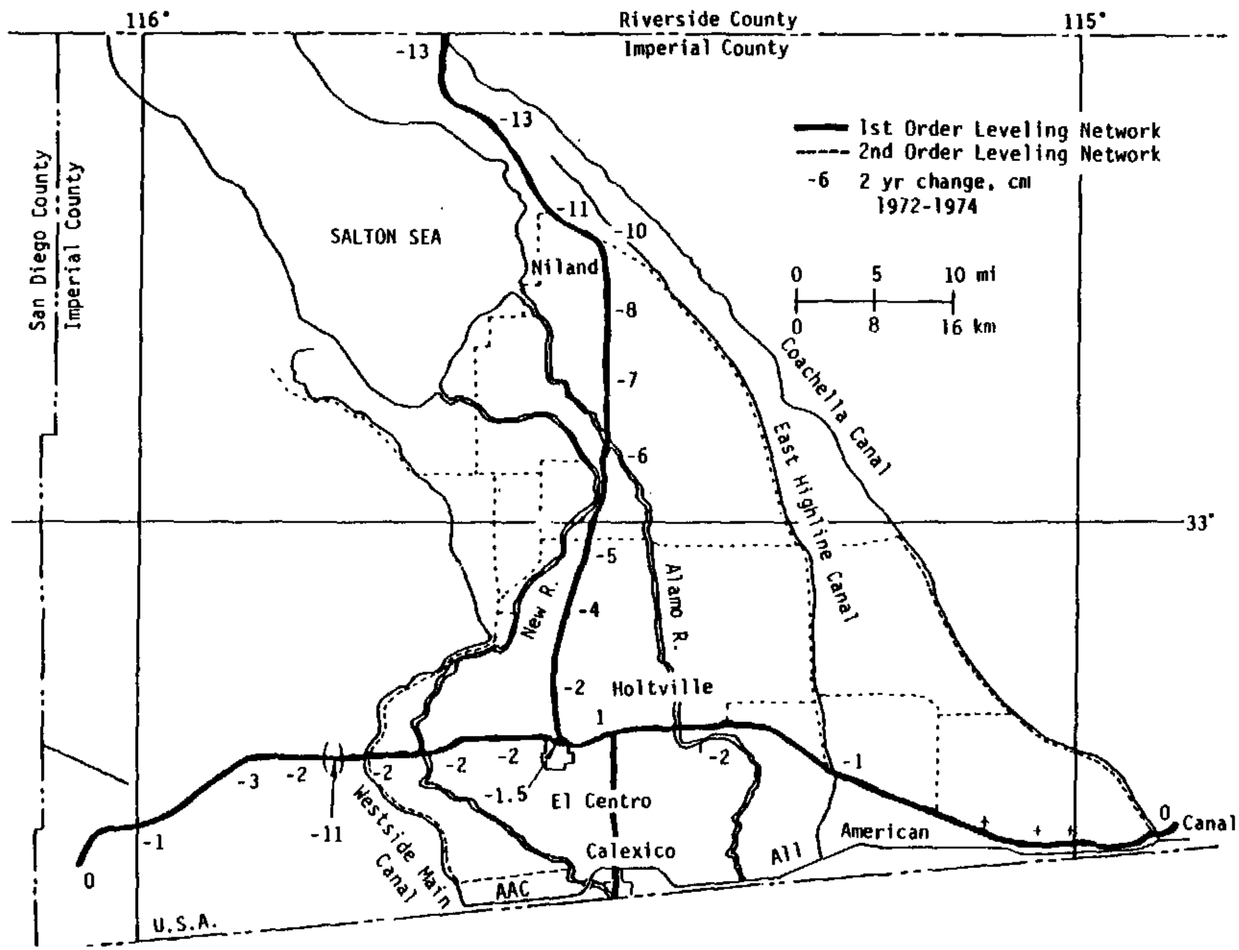
From the results of the above surveys, it is apparent that natural subsidence does occur over a widespread area in the Imperial Valley. A more intensive monitoring network has recently been installed in the north Brawley area on one-quarter section spacing to establish a baseline that will allow a more detailed determination of the subsidence rate due to natural causes, and help distinguish natural subsidence from subsidence related to future geothermal development.

e. Erosion and Slope Stability

The project area has a very low erosion potential. The dominant form of erosion in the project area is due to aeolian action on soils disturbed by farming or vehicular activity. In addition, the banks of earthen irrigation canals and drainage ditches are often eroded during the few periods of heavy rainfall in the Valley. The channel walls of the Alamo River are also subject to erosion and slope instabilities during times of high stream flow. Steep-sided channel slopes, particularly along the outsides of meanders or bends in the river, are known to be unstable, with massive blocks sometimes sloughing into the riverbed. The headward erosion of gullies into adjacent farmland caused by rainfall runoff was also noted in the area.

3.1.1.5 Soils

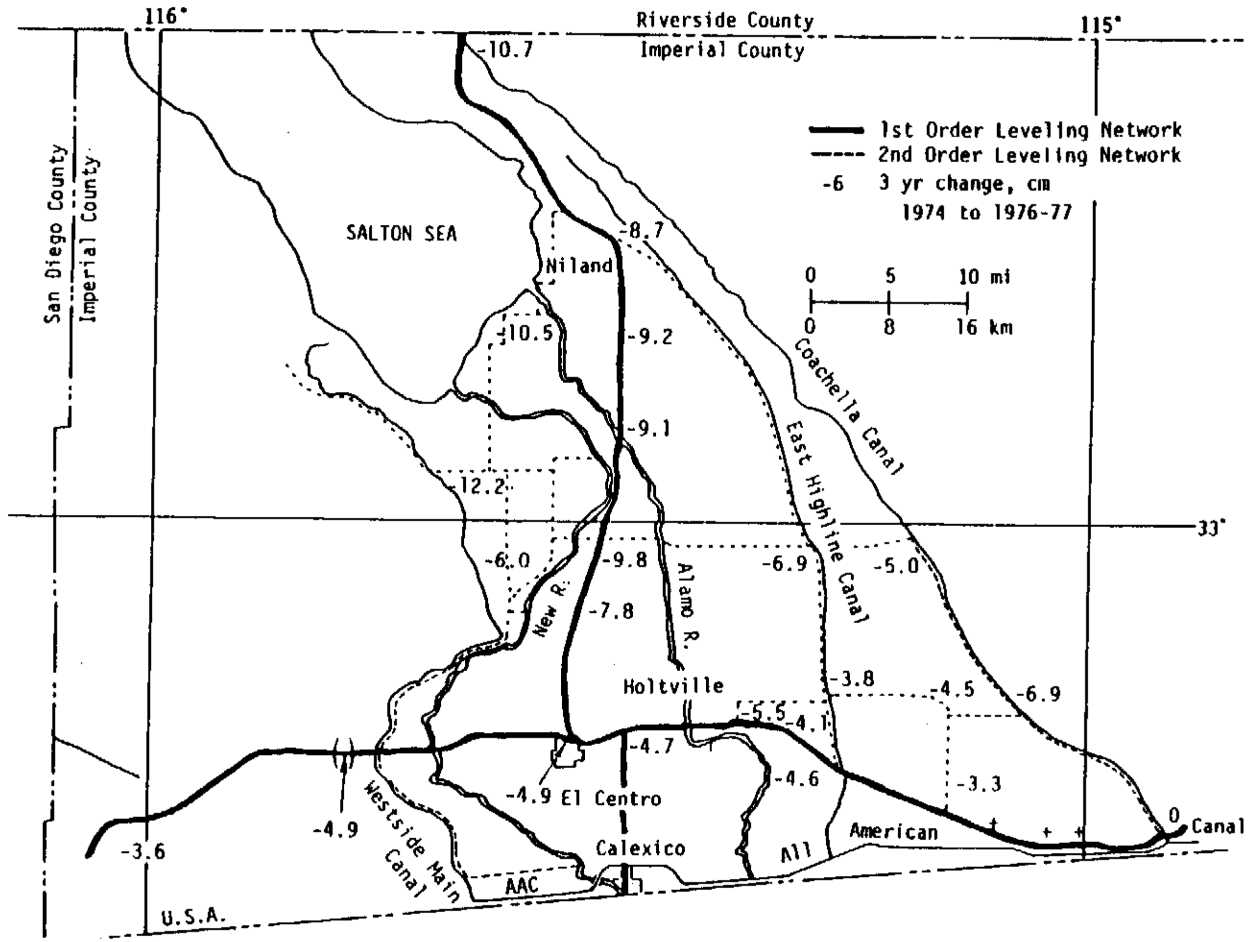
The soil of the project area consists of silty clays, silty clay loams, and clay loams which have formed on nearly level old lake beds and floodplain deposits. The soils are generally deep, highly calcareous and usually contain gypsum and soluble salts.



SOURCE: Lofgren (1974), as presented in Crow (1976, pg. 87)

Imperial Valley Subsidence Detection Network and Measured Differences in Elevation Over a Two-Year Period from 1972 to 1974

FIGURE 3.1-3



SOURCE: REESE (1977)

Vertical Movement in the Imperial Valley Over Three-Year Period from 1974 to 1976-77

FIGURE 3.1-4

Surface soils generally consist of blocky, hard, sticky plastic, silty clay layers. Subsurface strata are usually similar but may contain some sandy layers. The soils have a very slow infiltration rate when wetted, a high to moderate shrink/swell potential, and are considered to be unsuitable for foundation support or engineering use. There is little erosion hazard (United States Department of Agriculture, 1967).

A drainage problem exists due to high water tables and somewhat poor drainage under irrigation. As a result, the soils have been given a Land Capability Classification of IIw5 to IVw5 (see Figure 3.8-4, Section 3.8), which designates a fine texture soil group that has moderate to very severe limitations associated with drainage problems that restrict the choice of crops, and requires careful management (United States Department of Agriculture, 1967). Nevertheless, the soils have a high fertility and most of the soils in the project area are currently under irrigated cultivation. Soils unsuitable for agricultural use in the project area occur in the low, water saturated areas adjacent to the Salton Sea and in localized areas of rough, barren land containing coarse material on the study area's eastern boundary.

3.1.1.6 Geologic Resources

a. Potential Commercial Mineral Extraction

The only known mineral resources within the project area are pumice in the Red Island dome area and sand and gravel deposits on the eastern and northern margins of the proposed G-Overlay Zone. Pumice was formerly extracted from Red Island, but mining operations were discontinued when the area was inundated by rising sea levels. Sand and gravel deposits in the project area have not been commercially exploited.

b. Mineral or Fossil Collecting Localities

Minerals which could be of interest to rock and mineral collectors in the project area include obsidian and pumice from the Obsidian Butte and Rock Hill. These volcanic rocks, though unusual, are not rare or unique and occur at numerous volcanic localities throughout California. There are no notable fossil deposits in the project area.

c. Unique Geomorphic Features

The entire area within a roughly northeast-trending arc along the southeast edge of the Salton Sea is of considerable geologic interest. This arc, which contains four volcanic domes, several clusters of hot springs, mudpots (mud volcanos), and small geysers, appears to be an on-land manifestation of the East Pacific Rise, a crustal spreading center that has been overridden by the North American continent.

The four volcanic domes, from north to south, are Mullet Island, Red Island, Rock Hill, and Obsidian Butte. Although all are the result of late Pleistocene volcanism, they differ from one another in form and composition. Obsidian Butte is composed of pumice and obsidian, while Rock Hill consists of dense rhyolite, Red Island is composed of pumice, and Mullet Island consists of metamorphosed rhyolitic material. A trace of wave-cut terraces formed during the ancient Lake Cahuilla era is visible on several of the domes.

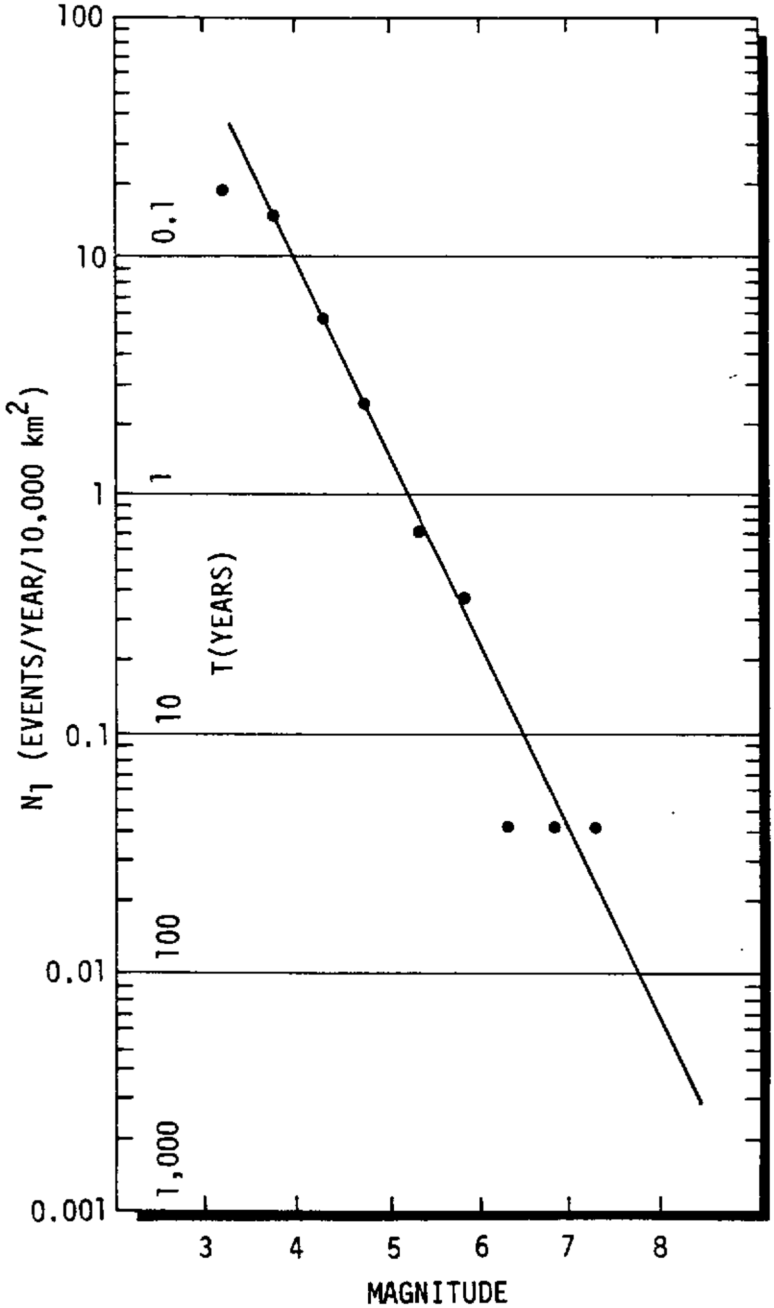
3.1.2 Geology and Soil Impacts

3.1.2.1 Seismicity 39

a. Groundshaking

Table 3.1-1 in Section 3.1.1.4.a. lists the anticipated bedrock accelerations at the project area that would occur during the maximum credible earthquakes in the Imperial Valley region. The Brawley and Calipatria faults which traverse the area and the Imperial fault 3.5 miles (5.6 km) to the south are considered capable of generating peak horizontal bedrock accelerations of 0.6 g at the project area. There are five additional faults in the region that are considered capable of generating peak accelerations from 0.28 g to 0.38 g in the study area. It should be noted that the peak bedrock accelerations given in Column 4 of Table 3.1-1 may be slightly magnified by the soils of the project area (Seed et al., 1968). Conversely, it is the "repeatable high ground acceleration", as opposed to the peak ground acceleration, that is a key data point in designing structures that are safe from groundshaking impacts. Ploessel and Slosson (1974) have shown that the repeatable high ground acceleration is about 65 percent of the peak acceleration.

Numerous earthquakes of Richter Magnitude 6 to 7 have occurred in the Imperial Valley within historic time. Based on these recorded seismic events, the frequency of occurrence of large earthquakes in the Imperial Valley has been plotted by Evernden (1970) to reflect the repeat interval for earthquakes in a 10,000 km^2 area (see Figure 3.1-5). As shown, a Magnitude 7 seismic event would be predicted to occur an average of 0.025 times per year, or once every 40 years. A Magnitude 6 event is expected an average of 0.17 times per year, or once every 6 years. Within the 10,000 km^2 area, the probability of a large magnitude event occurring at or near the proposed G-Overlay Zone is relatively low; hence, the repeat intervals cited above represent worst-case assumptions. Nevertheless, it is reasonable to believe that the proposed overlay area will be subjected to at least one occurrence of significant seismic groundshaking during the predicted 30-year life of the project. Further, the evidence



Source: Evernden, 1970.

Recurrence Intervals for Large Earthquakes in Imperial Valley Region, Based on Seismic Record for the Period from 1934 to 1963

FIGURE 3.1-5

suggests that the peak bedrock acceleration could exceed 50 percent of gravity. It is estimated that such an event would have a predominant period of 0.35 seconds (Seed et al., 1968), and a duration of strong shaking of approximately 24 seconds (Housner, 1970). Because of the proximity of the site to major active faults and the unconsolidated, water-saturated character of underlying soils which amplify ground motion (Seed et al., 1968), geothermal plant facilities in the proposed G-Overlay Zone would be more susceptible to structural damage than structures built on firmer ground. Nevertheless, the effects of groundshaking activity can be mitigated by proper design and construction.

The County of Imperial has adopted the 1979 edition of the Uniform Building Code (UBC) as the County Building Code. The UBC places the proposed G-Overlay Zone in Seismic Zone 4, which requires the use of design criteria that provides reasonable assurance that structures and facilities would safely withstand the most severe earthquake predicted.

b. Induced Seismicity

Appendix 3.1 provides a discussion of the state-of-the-art and theoretical considerations for predicting the frequency of seismic events which may be caused by geothermal activities in the Salton Sea Anomaly. Model and data limitations preclude a quantitative assessment of this phenomenon but sufficient information is available to offer the following conclusions.

Increases in pore pressure could lead to increased seismicity. However, results of the calculations indicate that the high porosity and permeability of the Salton Sea reservoir formation prevent the build-up of high pore pressure even with 100 percent injection. In addition, the reservoir basement is at a depth of approximately 6000 feet (1829 m) which is the minimum hypocenter depth for microearthquakes in geothermal anomalies in the deepest portion of the Salton Trough basin. In view of the unlikelihood of significant pressure increases accompanying fluid injection and the relatively shallow depth of reservoir, there is little reason to expect that fluid injection will cause significant expansion of seismic activity in the Salton Sea area.

Some concern has been expressed that production-level withdrawal of fluids and heat from the reservoir may alter seismic activity. However, calculations attempting to investigate this possibility are still only theoretical and the subject of extensive conjecture. Thus only long term seismic monitoring can resolve this issue.

The Salton Sea Anomaly is characterized by high frequency, low magnitude shallow hypocenter earthquakes and literally continuous microseismic activity. The seismic characteristics of the Anomaly lead to the conclusion that earthquakes induced by geothermal production and injection practices on a commercial scale are not a major concern although ongoing monitoring will be needed to verify this conclusion.

3.1.2.2 Fault Displacement

Several potentially active faults inferred to traverse the project site were shown earlier in Figure 3.1-2. Although no occurrences of ground rupture along these faults are known in the project area, the potential for ground rupture does exist. If ground rupture resulting from displacement during an earthquake would occur, any proposed project facilities constructed over the fault trace could experience moderate to severe damage.

Since the inferred active fault traces have not been located exactly, iden-
tification and evaluation of the most hazardous areas was not possible. Furthermore,
44 there is a potential for project damage due to displacement along currently unknown
45 faults in the project area.

3.1.2.3 Induced Subsidence

Land subsidence can be caused by the compaction of the semi-consoli-
85 dated strata of the reservoir as the effective overburden stress is increased due to fluid
86 withdrawal. Extensive ground surface subsidence caused by geothermal development of
87 the Salton Sea Anomaly would disrupt the gravity flow irrigation system which is essen-
tial for agricultural operations of the area. Appendix 3.1 presents a detailed analysis of
155 the potential magnitude of subsidence which might be induced by geothermal activity.

The analysis includes using a one-dimensional consolidation model to quantify expected reservoir compaction (not to be confused with surface subsidence) for the four cases shown in Table 3.1-2. These cases represent two reinjection scenarios (80 percent and 100 percent) with two assumptions about the compressibility parameters applied to each scenario. Results which should represent maximum and minimum expected amounts of reservoir compaction are shown in Table 3.1-3. The model indicates that the 80 percent reinjection scenario would result in 6.2 to 35 feet (1.9 to 10.7 m) of reservoir compaction after 30 years and the 100 percent reinjection scenario would result in 4.5 to 12 feet (1.4 to 3.7 m). This compaction would take place within distinct contours as shown in Appendix 3.1, not uniformly over the entire study area.

Table 3.1-2

COMPACTION COEFFICIENTS AND REINJECTION PERCENTAGES

	Compressibility	Uplift Compressibility	Reinjection Percentage
Case 1	10^{-6} psi^{-1}	10^{-7} psi^{-1}	80
Case 2	10^{-5} psi^{-1}	10^{-6} psi^{-1}	80
Case 3	10^{-6} psi^{-1}	10^{-7} psi^{-1}	100
Case 4	10^{-5} psi^{-1}	10^{-6} psi^{-1}	100

Table 3.1-3

RESERVOIR COMPACTION (FEET) AS A FUNCTION OF TIME

Time (Years)	Case 1	Case 2	Case 3	Case 4
	80 Percent Reinjection		100 Percent Reinjection	
5	0.5	3.5	0.35	2
10	2.5	12.0	1.0	6
20	6.0	25.0	2.7	9
30	6.2	35.0	4.5	12

Formation compaction can also be caused by thermal contraction resulting from reinjection of colder waste fluids into the reservoir. As shown in Appendix 3.1, one foot of reservoir compaction would be expected for each drop of $10^{o}C$ ($50^{o}F$). This is likely to occur in the vicinity of reinjection zones.

Additional analysis translated reservoir compaction due to pressure and temperature drop into surface subsidence. The model utilized resulted in the following conclusions: practically none of the thermal compaction will appear at the surface; however, essentially all the compaction due to pressure drop will appear as surface subsidence; and surface subsidence, while less than the total reservoir compaction, will occur over a wider area than that encompassed by the geothermal overlay zone. Ongoing monitoring efforts are required to document these conclusions.

The conclusion that all pressure drop compaction will appear as surface subsidence implies that Table 3.1-3 can be interpreted as representing surface subsidence. As discussed above, this table thus indicates that surface subsidence could range from 6.2 to 35 feet (1.9 to 10.7 m) above that naturally occurring if 80 percent reinjection is required, and 4.5 to 12 feet (1.4 to 3.7 m) if 100 percent reinjection is utilized.

It is essential to emphasize strongly that the magnitude of expected induced subsidence reported above represents a rough or order-of-magnitude estimate only. The calculations are based on theoretical models with existing data limitations and therefore several important assumptions has to be made. The predictions for compaction due to pressure drop are likely to be pessimistic because of to the assumption that the reservoir has a closed boundary and receives no recharge. Any recharge (which is probable but currently unquantifiable) will tend to reduce the estimated reservoir compaction shown in Table 3.1-3. Despite the uncertainties involved in the predictions, it is clear that full field geothermal development of the Salton Sea Anomaly over the next 30 years has the potential to induce subsidence by a significant amount over the rate which is occurring naturally. Also, partial reinjection will substantially increase the risk (up to 3 times) of this accelerated rate of subsidence occurring.

3.1.2.4 Soil Liquefaction and Differential Settlement

Potential liquefaction and differential settlement conditions exist throughout the project area. While it is possible to safely and economically build structures on sites where these conditions are present, remedial engineering measures will be necessary to obtain a suitable and stable foundation.

Liquefaction beneath the foundation of the dikes that are stabilizing the Salton Sea shoreline is a potential geotechnical hazard for part of the study area. The occurrence of sudden differential settlement below these dikes of sufficient magnitude to cause rupture and failure could result in the inundation of any power plant facilities below the level of the Salton Sea. However, the dikes are composed of highly plastic, silty clays which are able to withstand a considerable amount of strain. The existing dikes have withstood major seismic events in the recent past without sustaining damage. The additional size improvements to the dikes that will be necessary if the elevation of the Salton Sea continues to rise should increase the strength of the dikes.

Differential settlement would be a major geotechnical problem for offshore power plant facilities. The settlement would result from slow compression of the soft, highly plastic, water saturated, silty clays on the lake bottom under the superimposed weight of the newly placed fill. The ground settlement resulting from compression of the clays would progress gradually over a number of years. Sudden differential ground settlement resulting from liquefaction of loose sand layers below the fill islands would also be a potential geotechnical hazard in offshore areas where the thicknes of fill is less than 25 feet (7.6 m).

3.1.2.5 Erosion and Slope Stability

Site clearing and grading to prepare power plant facilities for construction would disturb some existing ground cover. As most of the site is farm land and is plowed regularly in any case, this impact is viewed as being extremely minor. Following construction of the plant, rainfall runoff from impervious surfaces would tend to increase erosion at the point(s) of concentration. This, also, would be a very minor impact, and proper drainage planning for the project would avoid any problems.

Erosion by wind action would be a minor problem and could be prevented by paving the roads that receive heavy use and oiling or placing gravel over minor roads and yard areas.

Significant slope stability and erosion problems in the area occur primarily along the banks of the Alamo River. This hazard can be easily avoided with proper engineering design.

3.1.3 Mitigation Measures

3.1.3.1 Seismicity

a. Groundshaking

In essence, the County Building Code (the UBC) incorporates the Recommended Lateral Force Requirements published by the Structural Engineers Association of California (SEAOC, 1975). In the commentary on the SEAOC recommendations, the philosophy behind these criteria is stated as follows:

> More specifically with regard to earthquakes, structures designed in conformance with the provisions and principles set forth therein should, in general, be able to:
>
> 1. Resist minor earthquakes without damage.
>
> 2. Resist moderate earthquakes without structural damage, but with some non-structural damage.
>
> 3. Resist major earthquakes, of the intensity of severity of the strongest experienced in California, without collapse, but with some structural as well as non-structural damage.

In most earthquakes, it is expected that structural damage, even in a major earthquake, could be limited to repairable damage. This, however, depends upon a number of factors, including the type of construction selected.

In the same SEAOC commentary is a discussion of the method used to establish the boundaries between UBC Seismic Zones 3 and 4. This involved plotting the major fault systems within California, and locating the boundary of Zone 4 25 miles (40 km) from fault systems considered to have the potential for generating a Richter magnitude event of 7 or greater, and 15 miles (24 km) from those systems with a potential from magnitude 6 to less than 7. The above was based on studies from California Mines and Geology Bulletin 198 (Alfors, et al., 1973) and usage of an arbitrary 0.3 g bedrock acceleration as the boundary between Zones 3 and 4. A study of this part of the commentary indicates bedrock accelerations in Seismic Zone 4 as high as 0.75 g are contemplated by the SEAOC recommendations. As indicated earlier herein, 0.6 g is the maximum bedrock acceleration projected in the vicinity of the proposed 49 MW project used as an example for this calculation in the study area (Table 3.1-1 and Section VIII).

In view of the above, it is considered that design of power plant facilities in accordance with provisions of the County Building Code or the UBC (Seismic Zone 4) would result in structures and plant components which would be adequate to safely resist the strongest earthquake anticipated. Further, since neither the proposed structures nor the project area present unusual features or complex structural problems, a site-specific response analysis should not be necessary. It is recommended, however, that project design be carried out by a structural engineer experienced in seismic design.

b. Induced Seismicity

Detailed seismic and microseismic data for Imperial Valley KGRAs are currently being accumulated by the Lawrence Livermore Laboratory (Fuis, 1977). As geothermal development proceeds, the LLL seismic data will serve as a baseline against which induced seismicity due to fluid withdrawal or reinjection can be measured. Any statistically significant changes in the baseline seismic regime (an increase in seismic event frequency, magnitude or depth, for example) should be apparent. In addition, Imperial County requires the submission of an acceptable seismic monitoring program.

If during the period of geothermal operations any statistically significant changes in seismic activity do occur, then mitigation programs such as those utilized at the Rocky Mountain Arsenal and the Rangely Oil Field in Colorado may be considered. These programs consisted of alternate periods of shutdown and full operation until a statistical relationship between earthquake activity and production-injection was obtained. In practice, these extreme measures will probably never be required because the volume of engineering data for the Salton Sea Anomaly will have expanded to the point where computer modeling will very likely be able to account for any pressure or thermal factors responsible for increased seismic activity.

3.1.3.2 Fault Displacement

Displacement along known faults in the project area could occur during the life of the proposed development. As geological and geophysical exploration continues, the subsurface structure and the location of the currently inferred fault traces will become better known. Prior to the final determination of specific locations for proposed power plants in the vicinity of inferred faults, a geotechnical investigation including a trenching operation should be conducted on the proposed sites. Should any faults be discovered, field development should be planned to avoid placing structures on or across fault traces. Minimum setback distances from identified fault traces should be established by a licensed engineering geologist experienced with mitigating the 106
effects of fault displacement. Likewise, the placement of drilling sites should be such that the possibility of drilling through a fault plane is minimized.

Should fault displacement disrupt a well casing, corrective measures must be undertaken immediately. Two to three foot berms around individual wellpads are generally required by the County. Complete casing washout may necessitate the berming of a relatively large area in order to contain the flow while equipment is procured to redrill into the hole and plug it with cement. Section 3.2.3 under Hydrology further explores the need for adequate mitigation for spills, including berms.

3.1.3.3 Induced Subsidence

In recent years, government agencies, and the private sector have initiated monitoring programs to gather data on natural subsidence. The County requires participation by geothermal developers in the existing subsidence monitoring network.
107 These baseline data together with future regional leveling surveys and the subsidence monitoring results should be sufficient to differentiate between regional subsidence/uplift caused by tectonic forces and geothermal development activities.

Geothermal related subsidence would not appear uniformly over the 30 year period. In the early years when only a few of the plants would be operational, subsidence due to goethermal operations would be relatively small. The subsidence could, however, accelerate in later years as more and more geothermal plants come on line. This should provide sufficient lead time for mitigation measures to take effect.

If geothermal related subsidence is detected there are several mitigation
56 measures that may be instituted. If less than 100 percent reinjection is being permitted anywhere, that practice should be stopped in favor of 100 percent reinjection. A requirement of over 100 percent reinjection to compensate for thermal contraction of reinjected fluids may also be warranted. Canal and drain gradients should be maintained periodically. If a serious problem persists then geothermal activity can be stopped completely and the land surface returned to natural levels by the geothermal industry.

3.1.3.4 Soil Liquefaction/Differential Settlement

It is recommended that detailed foundation investigations be completed for individual power plant or production facilities. If a potential for liquefaction or settlement is identified, appropriate soil preparation and foundation design measures should be incorporated into project design to avoid adverse effects.

3.1.3.5 Erosion and Slope Stability

No potential for significant erosion or slope stability impacts have been identified, with the exception of possible headward erosion along gullies on the banks of the Alamo River. To avoid adverse impacts, drainage should be controlled to avoid concentrating runoff into these gullies. Alternatively, if proposed facilities cannot be located away from river channels, the gullies could be lined with gunite to prevent further erosion, or energy dissipators provided to reduce runoff velocities below erosive levels.

3.2 HYDROLOGY

3.2.1 Existing Conditions

3.2.1.1 Groundwater

(42)

The California Department of Water Resources (1970), Dutcher, Hardt, and Moyle (1972) and Loeltz et al., (1975) presented information on groundwater of the Imperial Valley. Hardt and French (1976) discussed selected information on wells, including drillers' logs, construction data, water level measurements, and chemical analyses. Much of the data available is from four small-diameter test wells which were drilled in or near the Salton Sea Anomaly by the U.S. Geological Survey in 1961-62. A few shallow test holes have also been drilled in the area. The location of the wells is shown in Figure 3.2-1. Each test well was drilled to a depth between 100 and 200 feet (30 and 61 m) and 1¼ inch (3.18 cm) diameter casing was installed. Drillers' logs, water level measurements, and chemical analyses of water are available for all of these wells. Figure 3.2-1 also shows the direction of groundwater movement in the study area.

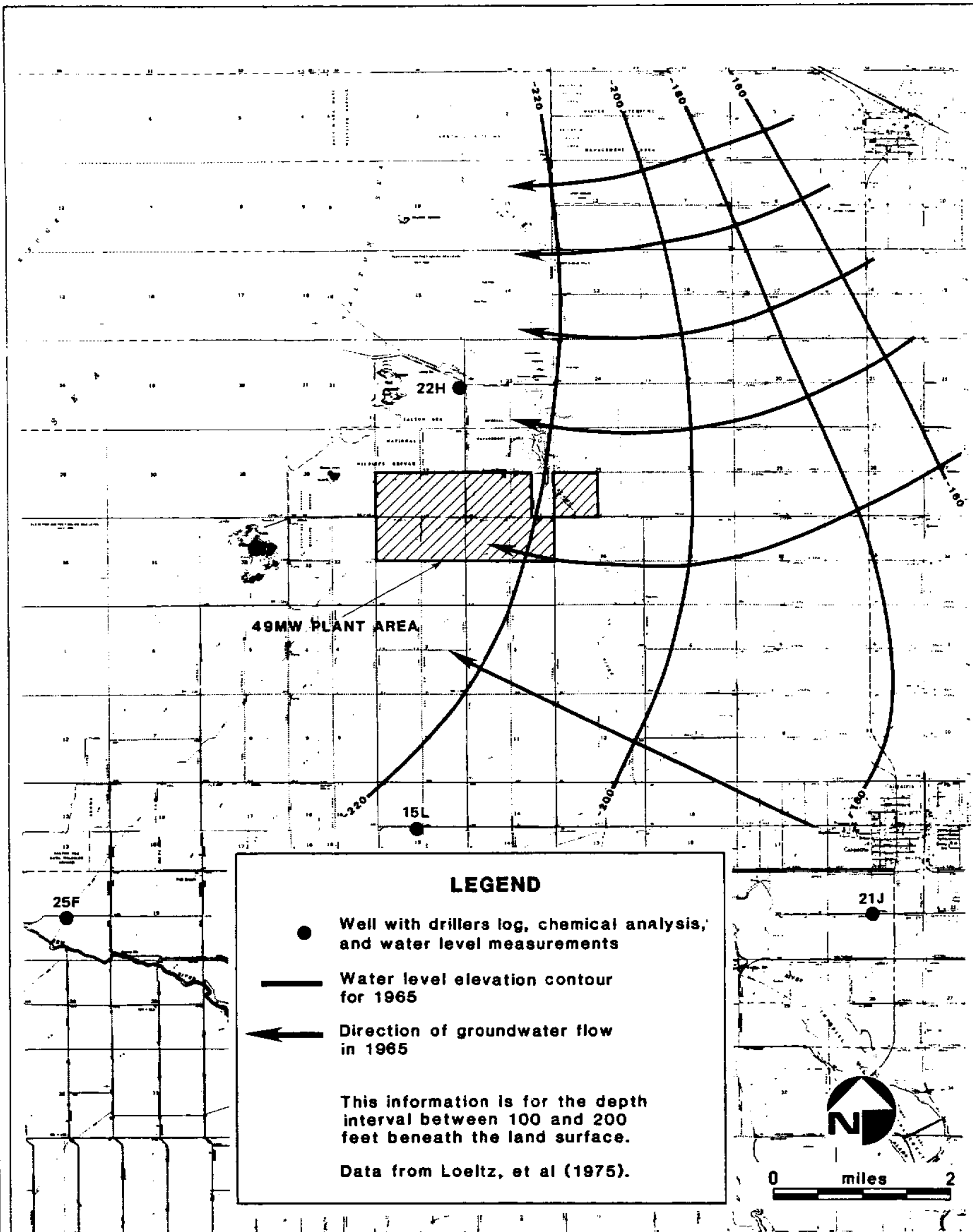
a. Groundwater Aquifers

A thick sequence of dominantly nonmarine sedimentary rocks overlie the pre-Tertiary basement complex. The total thickness of Cenozoic deposits exceeds 20,000 feet, and most of this sequence is Pliocene or younger in age. Loeltz et al., (1975) grouped the Cenozoic deposits into three categories:

1. a lower sequence composed mainly of nonmarine sedimentary rocks of Tertiary age,
2. a middle marine unit, the Imperial Formation, of Miocene or Pliocene age,
3. an upper sequence composed mainly of nonmarine deposits of Pliocene or Quaternary age.

The upper sequence is generally thousands of feet thick and comprises the major aquifer beneath the Imperial Valley. Most of the sediments of the upper sequence are fine-grained, consisting primarily of clay, silt, and some sand. Deposits overlying the Imperial Formation have been subdivided into several formations and units. The Borrego Formation and Brawley Formation are primarily lacustrine deposits of silt and clay. The deposits of Lake Cahuilla are the uppermost lacustrine silts, sands, and clays in the central part of the Valley. A groundwater aquifer description specific to the project area can best be obtained from data on the test wells drilled there and reported below.

Well T11S/R13E-22H is located east of Red Island, near the Alamo River. Land surface elevation at the well is 229 feet (70 m) below mean sea



Location of Water Wells and Direction of Groundwater Flow in the Niland Anomaly

FIGURE 3.2-1

level. A hole was augered to a depth of 152 feet (46 m), and unperforated casing was installed to a depth of 145 feet (44 m), with a well point extending from 145 to 147 feet (44 to 45 m). Sandy clay was encountered at all depths below two feet (.6 m) at this hole.

Well T12S/R12E-25F is located near the southwest corner of the Salton Sea Anomaly, about one-half mile (.8 km) south of the New River. Land surface elevation at the well is 219 feet (67 m) below mean sea level. The hole was augered to a depth of 132 feet (40 m). Clay was found from 17 to 19 feet (5.2 to 5.8 m), from 48 to 51 feet (14.6 to 15.5 m), from 111 to 112 feet (34 m), and from 118 feet (36 m) to the bottom of the hole. Fine sand and silt comprised most of the remaining material. Unperforated casing was installed to a depth of 103 feet (31 m), with a well point extending from 103 to 105 feet (31 to 32 m).

Well T12S/R13E-15L is located five and one-half miles (8.8 km) west of Calipatria, about five miles (8.1 km) south of Red Island. Land surface elevation at the well is 202 feet (62 m) below mean sea level. The hole was augered to a depth of 127 feet (39 m). Clay was encountered from the land surface to seven feet (2.1 m) in depth. Sandy clay was present from 7 to 12 feet (2.1 to 3.7 m) and from 122 to 127 feet (37 to 39 m). Fine to medium sand was present from 12 to 32 feet (3.7 to 9.8 m), and silty sand from 32 to 117 feet (9.8 to 35.6 m). Unperforated casing was installed to a depth of 113 feet (34 m), with a well point extending from 113 to 115 feet (34 to 35 m).

Well T12S/R14E-21J is located about one mile (1.6 km) south of Calipatria. Land surface elevation at the well is 176 feet (54 m) below mean sea level. The hole was augered to a depth of 152 feet (46 m). Clay was found from the land surface to 22 feet (6.7 m) in depth and from 62 to 102 feet (18.9 to 31 m). Sandy clay was present from 22 to 62 feet (6.7 to 18.9 m) and from 102 to 142 feet (31 to 43 m). Clayey sand was present between 142 and 152 feet (43 and 46 m). Unperforated casing was installed to 145 feet (44 m), with a well point extending from 145 to 147 feet (44 to 45 m).

Southern California Edison drilled four test holes at the site of the proposed 10 MW power plant, in the northwest quarter of section 5, T12S/R13E (County of Imperial, 1980). Silty fine sand was found from 5 to 20 feet (1.5 to 6.1 m) and from 45 to 75 feet (13.7 to 22.9 m) in depth. The remaining strata were primarily clay or silty clay.

b. Groundwater Movement

Groundwater within the study area generally moves toward the axis of the Imperial Valley, and thence northwestward toward the Salton Sea. The U.S. Department of Interior and Resources Agency of California (1974) indicated that groundwater inflow to the sea from the Imperial Valley was about 2000 acre-feet per year. The major sources of groundwater recharge at present are seepage of excess applied irrigation water and canal seepage, both of which are derived from the Colorado River. The principal area of groundwater discharge is the central cultivated part of the Valley. Here groundwater moves into the Alamo and New Rivers, as well as into numerous agricultural drains. The ultimate discharge point is thus primarily the Salton Sea. Networks of ditch and tile drains extending throughout the cultivated area have been constructed to alleviate waterlogging due to shallow groundwater. Shallow groundwater levels in the uppermost materials are now stabilized at depths ranging from 5 to 20 feet (1.5 to 6.1 m) below the land surface.

Although the exact amount of usable groundwater in the central Imperial Valley is unknown, the exploitation of this resource has been insignificant because of low well yields and poor chemical quality. In the central part of Imperial Valley, the transmissivity of the fine-grained deposits within the upper 500 feet (152 m) is probably less than 10,000 gallons per day per foot. Geologic data indicate that at greater depths, the materials are of even lower permeability (Dutcher, Hardt, and Moyle, 1972).

Figure 3.2-1 showed the regional direction of groundwater flow in zone between 100 and 200 feet (30 and 61 m) deep. The direction of flow is variable beneath the study area. For example, groundwater flow near Niland is predominantly to the west and the major source of recharge is probably seepage from the East Highline and Coachella Canals. The average slope of the piezometric surface is about 28 feet (8.5 m) per mile. Groundwater flows to the northwest near Calipatria and the predominant source of recharge may also be seepage from the East Highline and Coachella Canals. In that area the slope of the piezometric surface averages about nine feet (2.7 m) per mile.

Groundwater flows to the north near the southwest corner of the Salton Sea Anomaly. The predominant source of recharge is probably seepage of runoff from the Superstition Hills and the mountains to the southwest. The average slope of the piezometric surface is about 25 feet (7.6 m) per mile. Most groundwater in the Valley eventually discharges to the shallow zone (upper 30 feet; 9.1 m), to drains, or to the Salton Sea.

c. Water Levels

The water level was about two feet above land surface in wells T11S/R13E-22H and T12S/R12E-25F in 1961-62. The water level in well T12S/R14E-21J was near the land surface in 1962. When water levels in these wells are at or near the land surface, the hydraulic head in the deep zone (100 to 200 feet; 30 to 61 m) is higher than that in the shallow zone (upper 30 feet; 9.1 m), which is controlled by the drainage system. Groundwater in the deep zone would thus tend to move upward into the shallow zone. The water level was about 10 feet (3 m) below land surface in well T12S/R13E-15L in 1962. When the water level is at this depth, there is probably little vertical groundwater flow within the upper 200 feet (61 m), as this level is near that expected for the shallow zone controlled by the drainage system. The water levels in the four borings at SCE's 10 MW plant site were all about five feet (1.5 m) below ground surface, or ten feet (3 m) below the level of the Salton Sea. As noted by the County of Imperial (1980), this raises the possibility that water from the Salton Sea may now be recharging the aquifer at this site.

d. Chemical Quality

Deep exploration holes in the central part of the Valley have shown that the upper sequence may contain groundwater of high salinity in some zones and fresh water in others. Low vertical permeabilities inhibit the mixing of water present at various depths. The extent of good quality groundwater in the central Imperial Valley is limited. Records indicate that wells west of the Alamo River usually have water of very poor chemical quality. However, artesian wells east of the Alamo River often yield water with a total dissolved solids content between 1000 and 2000 mg/l.

Table 3.2-1 contains the results of chemical analyses of water from the wells shown earlier in Figure 3.2-1. For comparison, an analysis is included for water from the shallow zone, which is tapped by drains. Water from shallow well T12S/R12E-25F2 was of the sodium chloride type, with a total dissolved solids content of 15,700 mg/l. This water had the highest salinity for groundwater sampled in the Imperial Valley in the 1960s, according to Loeltz et al., (1975). The high salinity of this water is ascribed to evaporation of shallow groundwater. Water from the four wells tapping the deep zone was also of the sodium chloride type, but of much lower salinity. Water from wells T11S/R13E-22H and T12S/R12E-25F1 had total dissolved solids contents of about 1600 and 1500 mg/l, respectively. These values are very low compared to groundwater in other parts of the central Imperial Valley. The water is still of marginal chemical quality for most uses. The high hardness (535-620 mg/l

Table 3.2-1

CHEMICAL ANALYSES OF WATER FROM WELLS IN OR NEAR THE SALTON SEA ANOMALY

Constituent (mg/l)	T11S/R13E -22H	T12S/R12E -25F1	T12S/R12E -25F2	T12S/R13E -15L	T12S/R14E -21J
Calcium	134	107	944	476	810
Magnesium	49	86	242	202	822
Sodium + Potassium	384	295	4570	1300	3400
Bicarbonate	100	79	20	40	408
Sulfate	275	425	1200	700	4050
Chloride	710	535	8530	2900	5850
Silica	3	2	1	2	18
Hardness ($CaCO_3$)	535	620	3350	2020	5400
pH	7.4	7.4	6.9	7.2	7.4
Electrical Conductivity (micromhos/cm @ 25°C)	3120	2710	24700	9370	19800
Total Dissolved Solids (mg/l)[1]	1600	1490	15700	5600	15200
Date	5/10/62	2/1/62	2/1/62	7/10/62	7/10/62
Perforated Interval (feet)	145-147	103-105	14-16	113-115	145-147

[1] mg/l = ppm x specific gravity

Analyses from Loeltz, Irelan, Robison, and Olmsted (1975).

calcium carbonate) would be a limiting factor for industrial and domestic use. The reason for the low salinity of groundwater at these locations is not clearly understood. However, the water level information suggests that upward movement of groundwater is predominant. These wells are close to the Salton Sea and the point of groundwater discharge.

The total dissolved solids content of water from well T12S/R13E-15L was 5600 mg/l, and this water would be of unsuitable chemical quality for most uses. Water from well T12S/R14E-21J near Calipatria is of a salinity nearly as high as that of water from well T12S/R12E-25F2, which taps the shallow zone.

e. Regulatory Aspects

There are no specific standards for groundwater quality in the Imperial Valley, except for the EPA drinking water standards. These standards would apply to groundwater used for public supply. However, waste discharges that could significantly impact groundwater quality are covered under the Porter-Cologne Act permit system. The California Regional Water Quality Control Board (RWQCB), Colorado River Basin Region, is the agency with primary regulatory responsibility. Permits issued by this agency generally contain limitations on types of wastes to be disposed, composition of wastes, and methods of waste disposal. Also, monitoring programs can be required to verify impacts on groundwater. The California State Division of Oil and Gas has additional regulatory responsibility specifically related to injection wells.

3.2.1.2 Surface Water

a. Climatological Information

Section 3.3 provides extensive data on the climate of the Imperial Valley. However, two parameters important for surface water are precipitation and pan evaporation. These have been measured since 1948 at an Imperial Irrigation District Station at the southeast shore of the Salton Sea. The average annual precipitation at the Salt Farm Station from 1948 through 1971 was 1.5 inches. The average annual pan evaporation during this period was 91 inches.

b. Streams

The New and Alamo Rivers are the main streams in the Imperial Valley. They carry storm runoff, irrigation drainage water from lands in the Imperial Valley and Mexico, and some wastewater to the Salton Sea. The New River drains the west side of the Imperial Valley. The Alamo River drains the east side.

The U.S. Geological Survey has maintained gaging stations on the New River near the southwest corner of the Salton Sea Anomaly (SW¼ SW¼ SW¼ of

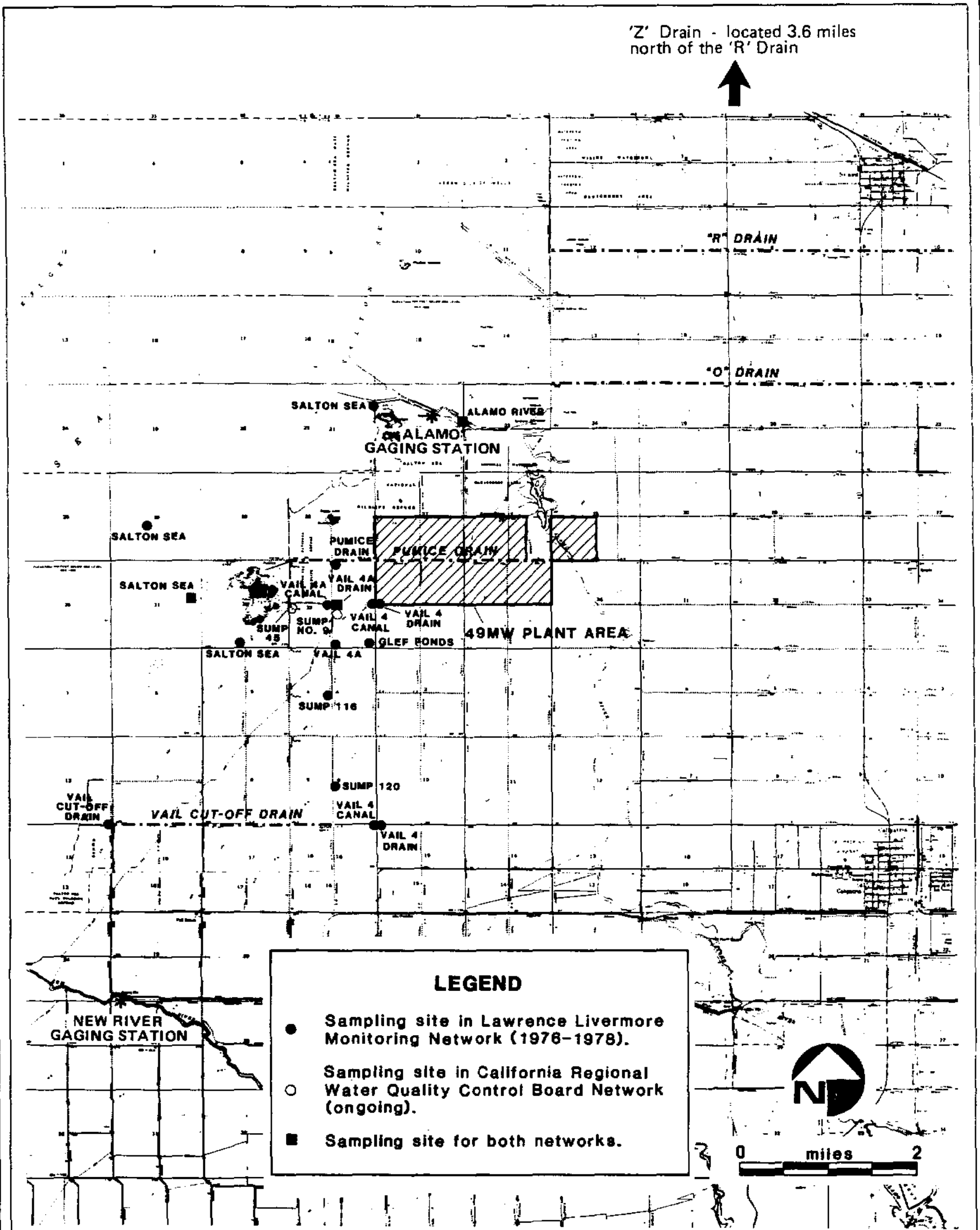
Section 19, T12S/R13E) and the Alamo River near Red Island (NE¼ SW¼ NE¼ of Section 22, T11S/R13E) since 1943. The locations of the gaging stations are shown in Figure 3.2-2. Table 3.2-2 shows annual runoff in these streams for the period of record. Between 1970 and 1979, annual flow averaged 423,000 acre-feet in the New River and 642,000 acre-feet in the Alamo River. The New River has an average annual flow of about 110,000 acre-feet at the border while the Alamo River averages just 1000 to 1500 acre-feet. The large increases in flow in the downstream direction are largely due to irrigation drainage water. Table 3.2-3 shows minimum monthly flows for water years 1975-79. Minimum values are shown, because of their importance in considering of the potential use of this water for power plant cooling. It can be seen from Table 3.2-3 that flows in both the New and Alamo Rivers are lowest from November through February. In recent years, the lowest monthly flow has been 352 cubic feet per second (cfs) in the New River and 307 cfs in the Alamo River. Minimum monthly flows in the New River have ranged from an average of 428 cfs in January to 631 cfs in April. Minimum monthly flows in the Alamo River have ranged from an average of 440 cfs in January to 983 cfs in April.

c. Canals

The water supply facilities of the Imperial Irrigation District (IID) are extensive. Some three million acre-feet of water per year are imported into the Valley and distributed throughout the one million acre district. In 1901 the Alamo Canal was constructed to supply Colorado River water to both the Mexicali and Imperial Valleys. In 1941, diversions of Colorado River water began from Imperial Dam, through the All-American Canal, directly to the Imperial Valley. Within the Imperial Valley, the All-American Canal feeds three main irrigation supply canals, each of which begins at the border and flows northerly toward the Salton Sea. The East Highline Canal extends through the east part of the IID. The Central Main Canal traverses the center of the Imperial Valley, beginning near Calexico and passing west of El Centro and Imperial, then east of Brawley to a terminus near Calipatria. The West Side Main Canal begins at the west end of the All-American Canal and follows the western edge of the Imperial Valley. A network of smaller irrigation canals extends from the three main canals, and these smaller canals cross the Valley at intervals of one mile or less.

d. Drainage Facilities

Salinity problems due to shallow groundwater were recognized early in the century, leading to construction of an irrigation drainage system beginning in 1922. Drainage water was conveyed to the New and Alamo Rivers, and thence to the



Location of Water Quality Monitoring Networks in the Niland Anomaly

FIGURE 3.2-2

Table 3.2-2

ANNUAL RUNOFF FOR THE NEW AND ALAMO RIVERS

Calendar Year	New River (A.F.)	Alamo River (A.F.)
1943	490,030	491,400
1944	504,500	505,900
1945	485,200	519,500
1946	475,800	578,400
1947	442,500	564,300
1948	441,400	539,200
1949	450,200	610,000
1950	460,700	606,800
1951	490,000	642,000
1952	524,100	697,400
1953	540,600	757,000
1954	492,800	732,700
1955	395,900	654,500
1956	429,600	684,100
1957	402,600	622,800
1958	405,200	614,400
1959	434,200	651,700
1960	445,000	682,400
1961	437,000	675,500
1962	455,300	681,300
1963	477,500	723,700
1964	365,900	563,500
1965	357,800	535,100
1966	383,500	610,700
1967	383,300	620,100
1968	384,100	563,300
1969	375,500	592,500
1970	390,500	619,000
1971	423,000	671,700
1972	418,100	638,800
1973	428,600	632,800
1974	436,600	682,300
1975	434,500	682,200
1976	435,100	638,900
1977	413,000	615,100
1978	393,000	603,200
1979	457,700	635,100
Average	423,000	642,000

Data from California Department of Water Resources (1970), U.S. Geological Survey files, and Imperial Irrigation District (1979). Station for New River is located in SW¼ SW¼ SW¼ Section 19, T12S/R13E. Station for Alamo River is located in NE¼ SW¼ NE¼ Section 22, T11S/R13E.

Table 3.2-3

MONTHLY RUNOFF AT OUTLETS FOR THE NEW AND ALAMO RIVERS FOR THE FIVE YEAR PERIOD FROM 1974 TO 1979

	New River (cfs)			Alamo River (cfs)		
	High	Low	Ave.	High	Low	Ave.
January	532	352	428	539	307	440
February	540	404	469	805	379	566
March	706	451	570	871	445	635
April	706	553	631	1120	766	983
May	615	536	578	979	794	878
June	566	463	493	762	666	713
July	706	426	521	858	719	739
August	597	459	508	783	677	733
September	581	427	505	907	653	775
October	543	411	485	856	613	730
November	487	396	438	719	433	566
December	472	396	431	530	412	455

Records from U.S. Geological Survey.

Salton Sea. Tile drainage systems, installed beneath most of the Valley's irrigated fields, capture irrigation drainage below the ground surface and this is discharged to nearby drainage ditches. Most drainage ditches in the western part of the Valley dump into the New River, while those in the eastern part discharge to the Alamo River. Approximately one-third of the water imported into the valley by the IID becomes drainage water, which enters the Salton Sea.

Figure 3.2-2 shows the location of the drainage system operated by the Imperial Irrigation District within the southern part of the Salton Sea Anomaly. Most of the land west of the Alamo River is drained by the Vail Cut-Off and the Pumice Drains, both of which flow directly to the Salton Sea. Lands east of the Alamo River and south of Red Island drain westerly to the Alamo River. Lands north and east of Red Island drain westerly directly to the Salton Sea. In terms of flow, the five most significant drains are the Pumice, the Vail Cut-Off, the "O," the "R," and the "Z". In 1980, flows for five selected months were as follows:

Drain	Monthly Flow (Acre-Feet)				
	Feb	April	June	Aug	Nov
Pumice	470	1,740	1,000	1,120	740
Vail Cut-Off	170	800	380	720	200
"O"	330	840	720	770	310
"R"	390	750	630	700	280
"Z"	680	720	81	290	360

Source: IID data sheets, 1980.

Thus relatively high flows are present in the spring and summer, and low flows are present during the winter. For these months, minimum daily flow was 3.0 cfs for the Pumice Drain, 1.0 cfs for the Vail Cut-Off Drain, 1.3 cfs for the "O" Drain, 1.1 cfs for the "R" Drain, and 0.1 cfs for the "Z" Drain.

e. Salton Sea

The total volume of water in the Salton Sea exceeds six million
59 acre-feet. The deepest point is less than 50 feet (15 m) deep, and in most places the sea is less than 30 feet (9 m) deep.

About 1,200,000 acre-feet of water entered the Salton Sea in 1979 from the New and Alamo Rivers as well as via drains that flow directly to the sea. About 635,000 acre-feet of this water was in the Alamo River, almost all of which originated as agricultural drainage in the U.S. About 460,000 acre-feet of water came from the New River, of which two-thirds originated as agricultural drainage in the U.S.

Most of the remaining water crossed the international boundary from Mexico. About 110,000 acre-feet of water entered the Salton Sea directly from IID drains. Because the inflow to the Salton Sea has exceeded the evaporation since about 1935, the level has gradually risen. Table 3.2-4 shows elevations of the Salton Sea from 1930 to 1979. Highest sea levels are during April through June, and lowest sea levels are in October or November.

f. Water Quality

Phelps and Anspaugh (1976) reported on the Lawrence Livermore
Laboratory (LLL) Imperial Valley Environmental Project. The water quality portion of 96
the project concerned potential contamination of surface water by geothermal brines. In order to evaluate this problem, water samples were collected to establish baseline levels of specific constituents. A monitoring network was established in the Salton Sea KGRA in January 1976. Figure 3.2-2 showed the location of the LLL and Regional Water Quality Control Board monitoring stations in the Salton Sea Anomaly. Water was sampled from the New and Alamo Rivers, the Salton Sea, the Vail 4 and 4A Canals, the Vail 4, 4A, and Pumice Drains, numerous drainage sumps, and several ponds near the GLEF site. Data from these monitoring efforts and other pertinent sources are shown in numerous tables provided as Appendix 3.2. The information is summarized below.

1. Streams

Water quality in streams of the Imperial Valley is poor, since flow is made up of irrigation drainage and municipal and industrial wastewaters. Irrigation drainage predominates, amounting to more than ten times the flow from other sources. The prevalent characteristics of the stream water are high salinity and pollutants from sources such as fertilizers and pesticides.

Water in the New River is of the sodium chloride type, with an average total dissolved solids content ranging from 3900 to 4900 mg/l. There is a decrease in salinity as water flows toward the Salton Sea. Water in the New River had a mean salinity almost 25 percent greater than that of water in the Alamo River. Most of this was due to higher levels of sodium and chloride. Trace elements that are considered to be useful as potential indicators of geothermal brine contamination have been analyzed to establish a baseline to monitor any impacts of geothermal development. Nutrient concentrations for the two rivers have also been measured. Results of these analyses are included in Appendix 3.2 (Pimentel, Irelan, and Tompkins, 1978).

Table 3.2-4

ELEVATION OF SALTON SEA (T8S/R9E-23)

Year	Elevation End of Year	Year	Elevation End of Year
1930	244.3	1955	234.4
1931	244.2	1956	234.5
1932	244.0	1957	234.5
1933	244.6	1958	234.6
1934	247.8	1959	234.3
1935	248.3	1960	233.8
1936	247.7	1961	233.4
1937	246.4	1962	232.7
1938	244.7	1963	231.2
1939	242.2	1964	231.9
1940	242.5	1965	232.0
1941	241.0	1966	232.0
1942	241.3	1967	231.8
1943	241.1	1968	231.8
1944	240.8	1969	232.0
1945	240.4	1970	231.9
1946	240.5	1971	231.7
1947	240.5	1972	231.3
1948	240.8	1973	231.3
1949	240.2	1974	230.7
1950	239.6	1975	230.1
1951	238.3	1976	228.6
1952	236.6	1977	228.3
1953	235.8	1978	228.2
1954	234.8	1979	227.8

Data from Imperial Irrigation District (1979) in feet below mean sea level.

2. Canals

In general, canal water is similar in composition to Colorado River water at Imperial Dam (shown in Appendix 3.2). Pimentel (1980) noted that canal water in the Salton Sea KGRA was of slightly higher salinity than that of canal water in the Heber area. The trimmed mean (highest and lowest 10 percent of the data is not utilized) of total dissolved solids content for all canal samples taken by LLL in the Salton Sea KGRA was about 970 mg/l. Chemical quality of water in the Vail 4 and 4A canals is provided in Appendix 3.2.

3. Drains

The chemical quality of water in the Vail 4, Vail 4A, and Pumice Drains is shown in Appendix 3.2. Water in the Vail 4 and Pumice Drains had a mean salinity similar to that of water in the New River near the outlet. The trimmed mean of total dissolved solids content for all samples taken by LLL from agricultural drains in the Salton Sea KGRA was about 4440 mg/l. This can be compared to a trimmed mean of 3790 mg/l for water in the New River at the outlet. On the other hand, water in the Vail 4A Drain had a trimmed mean of total dissolved solids content of about 5600 mg/l.

4. Salton Sea

Salton Sea water is of the sodium chloride type, similar to ocean water. The salinity of Salton Sea water has gradually increased in recent decades, as shown in Table 3.2-5. Since about 1963, the salinity of water in the Salton Sea has been greater than that of ocean water. The increasing salinity is due to evaporation which results in concentrating the large amounts of salt entering the sea each year. Prior to 1972, information on the salinity of the Salton Sea was limited to only a few sampling points, primarily at the shoreline. There was a question about the possibility of large differences in salinity at various geographic locations and depths. In July 1972, a comprehensive sampling program was undertaken which indicated general uniformity of salinity levels (U.S. Department of Interior and Resources Agency of California, 1974). Chemical analyses of Salton Sea water is provided in Appendix 3.2. A sodium level of about 9600 mg/l and chloride content of 17,000 mg/l is indicated.

The Salton Sea is characterized by an overabundance of mineral nutrients, mainly compounds of nitrogen and phosphorus. These produce intensive "blooms" of floating microscopic plants (phytoplankton) in the upper levels of the water body. The visible results are discoloration and reduction of clarity of the water. In addition, death and decomposition of large populations of these algae often result in

Table 3.2-5

SALINITY OF THE SALTON SEA

Year	Total Dissolved Solids (ppm)[1]	Year	Total Dissolved Solids (ppm)[1]
1954	34,000	1967	38,120
1955	33,451	1968	38,540
1956	34,113	1969	40,009
1957	34,573	1970	38,583
1958	35,769	1971	39,150
1959	35,749	1972	39,013
1960	35,355	1973	39,186
1961	35,303	1974	39,183
1962	35,122	1975	38,973
1963	35,998	1976	38,528
1964	36,727	1977	38,461
1965	36,835	1978	38,141
1966	36,339	1979	38,423

Values are the average for samples taken at Bertram Station, Desert Ranch, Sandy Beach, and Salton Sea Beach in May and November of each year. Total dissolved solids are residue at 105°C (221°F) prior to 1970 and residue at 180°C (356°F) thereafter. Data from Imperial Irrigation District (1979).

[1] mg/l = ppm x specific gravity

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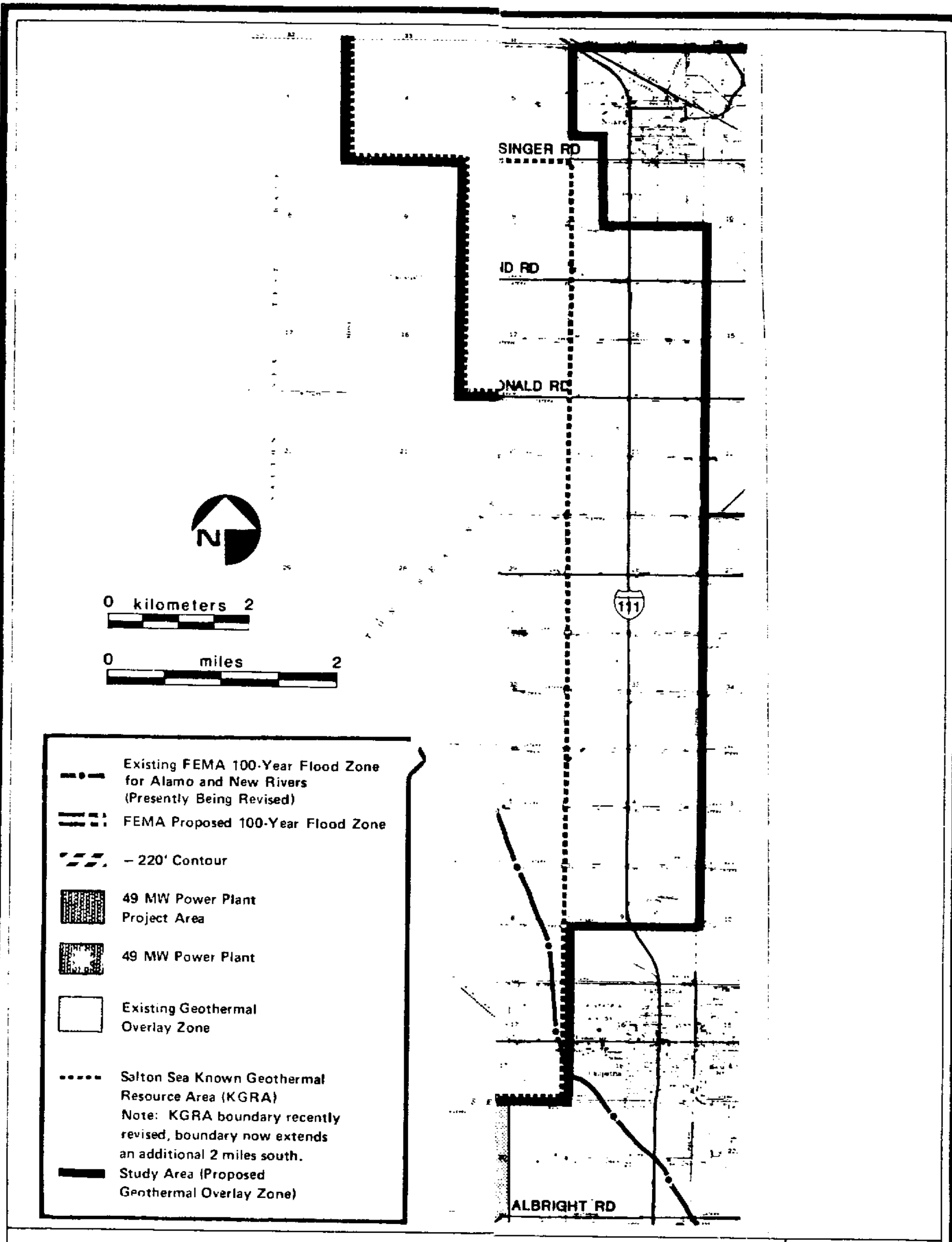


FIGURE 3.2-3

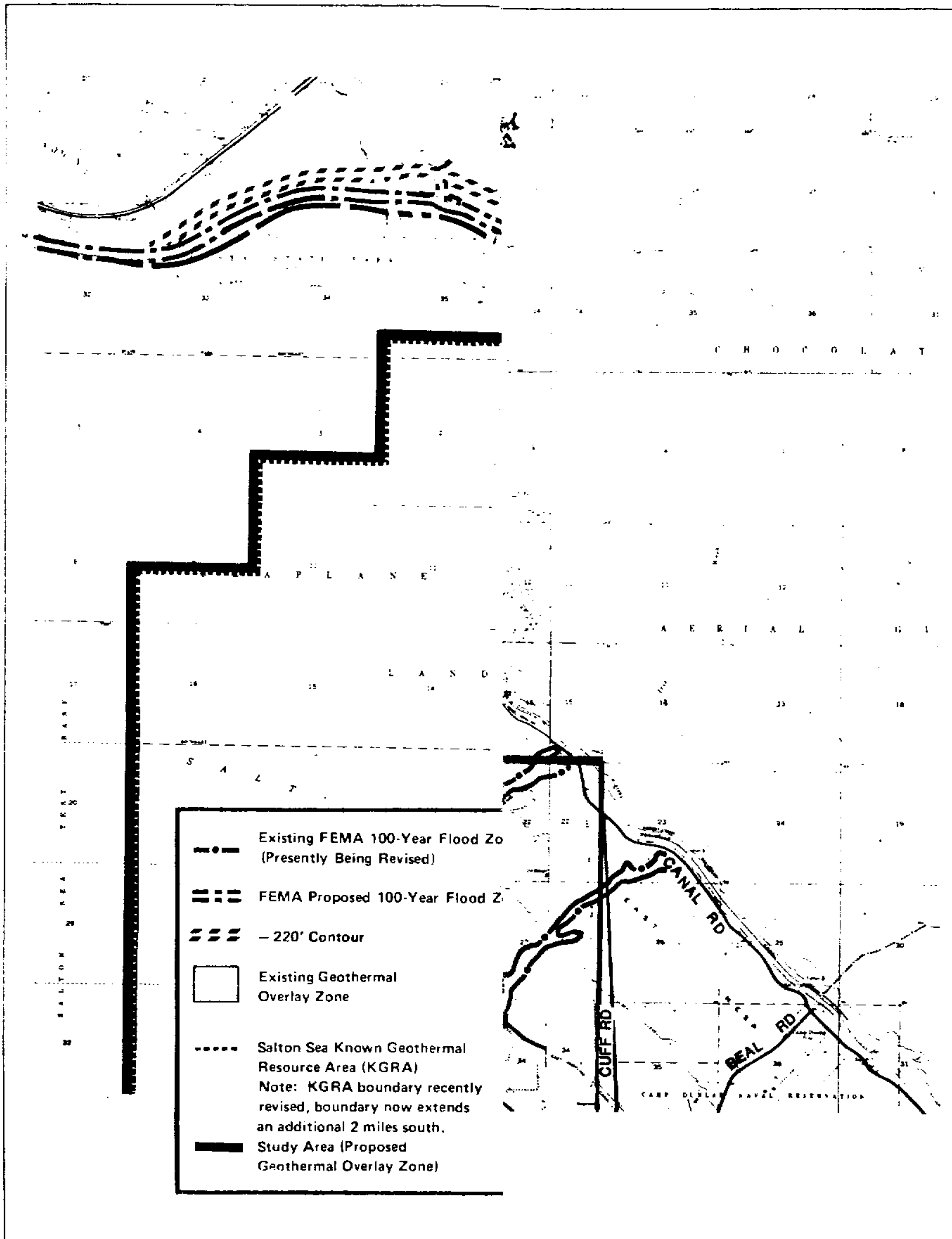

CHOCOLAT
APLANE
AERIAL GI
LAND
SALT
Existing FEMA 100-Year Flood Zo
(Presently Being Revised)
FEMA Proposed 100-Year Flood Z
– 220' Contour
Existing Geothermal
Overlay Zone
Salton Sea Known Geothermal
Resource Area (KGRA)
Note: KGRA boundary recently
revised, boundary now extends
an additional 2 miles south.
Study Area (Proposed
Geothermal Overlay Zone)
CANAL RD
CUFF RD
BEAL RD

FIGURE 3.2-3

temporary anoxic conditions. The mean total phosphorus and total nitrogen concentrations for a 1968-69 study period were 0.10 and 3.30 mg/l, respectively. A 1972 sampling confirmed that the nutrient condition of the sea was essentially unchanged from the condition reflected by the earlier data. Nitrogen forms within the sea are predominantly organic in contrast to the inorganically rich tributaries. Inorganic nutrients entering the sea are converted to organic matter through photosynthetic processes.

g. Flooding Potential

Flooding is a concern in the study area. This concern primarily stems from the Salton Sea and the New and Alamo Rivers.

Currently, the highest short-term water elevation that could be expected to occur in the Salton Sea as a result of 100-year recurrence intensity rainfall over the basin is -225 feet (MSL) (IID datum) or -225.9 test (USGS datum) (HUD 1980). This would be about a 1.4 foot rise. In response to the gradual increase in the level of the Salton Sea, levees have been constructed for flood control between the New and Alamo Rivers in the project area.

Almost all of the water discharge through the New and Alamo Rivers is derived from agricultural drainage. Periodically, these rivers carry large quantities of runoff following severe rainstorms. The channels of both rivers are prone to flooding in their lower reaches near the Salton Sea. Flood Hazard Boundary maps prepared by the Federal Emergency Management Agency (FEMA), indicate that the entire project area between the New and Alamo Rivers, and east of the Alamo River channel for a distance of two to three miles, would be inundated during a 100-year recurrence flood in the watercourses.

Figure 3.2-3 depicts the 100-year flood hazard area utilized by FEMA. If insurance is purchased for buildings in this hazard area, certain design and construction criteria must be met. Also shown on Figure 3.2-3 is the minus 220 foot contour line, below which the County requires a flooding easement in order to receive a building permit. This easement releases the County from liability if flood damage occurs.

3.2.2 Impacts

3.2.2.1 Groundwater

a. Quantity

Unless groundwater beneath East Mesa is developed for direct use or as an exchange for canal water in cooling power plants, there would be no impact on groundwater quantity due to geothermal development of the Salton Sea Anomaly. Water use for full development of 1400 MW of geothermal energy at the Salton Sea Anomaly would be about 84,000 acre-feet per year. If steam condensate, canal water, river water, and drain water are not used for cooling, groundwater may be the only remaining source. The exact amount of low salinity groundwater in storage beneath East Mesa is presently unknown, although there had been more than seven million acre-feet of groundwater recharge in this area from canal seepage through 1967 (Loeltz et al., 1975).

Presently, there is little beneficial use of groundwater beneath East Mesa. Most of this water moves slowly downgradient toward the Salton Sea. Much of it becomes unusable for most purposes due to mixing with poor quality groundwater beneath the Imperial Valley. Discharge of this water is to some wells and eventually the Salton Sea. Shallow groundwater in the Valley discharges to drains, the New and Alamo Rivers, and directly to the sea itself. To a large extent, development of groundwater beneath East Mesa could be considered advantageous, because the water would be put to beneficial use. Use of this water would also mitigate some potential adverse impacts due to use of other sources of water for power plants, including the impacts of waste disposal. There are numerous flowing wells east of the Alamo River in the Imperial Valley that yield water of relatively low salinity (Loeltz et al., 1975). These wells generally extend from near Holtville to Calipatria. Water level contours indicate a westerly direction of flow. Development of groundwater beneath East Mesa could eventually decrease recharge to strata tapped by these flowing wells. However, such wells were present before the canals were built. Also, canal lining projects for these canals will substantially reduce recharge from canal seepage.

b. Quality

The major potential sources of groundwater pollution due to geothermal development of the Salton Sea Anomaly are:

1. Injected geothermal fluids.
2. Geothermal fluids spilled at the land surface.
3. Brine holding ponds.
4. Drilling fluid sumps.
5. Solid waste disposal.

A total of about 450 production wells, 225 injection wells, and 540 replacement wells would be necessary to the year 2010 in the Salton Sea Anomaly if the 1400 MW development scenario were realized. In general, operational procedures are designed to avoid or mitigate potential adverse impacts to groundwater, as described below.

1. Injected Fluids

A discussion of well drilling is presented in Appendix 2.6-1 of this report. Under full development of the Salton Sea Anomaly, over 500,000 acre-feet of geothermal fluids would have to be disposed each year. In general, clay deposits underlying the surface area of the Anomaly extend to a depth of about 1300 feet (396 m) and would be grouted off in production and injection wells. Sand and shale are present below this level but above the geothermal reservoir, between 1300 and 2000 feet (396 and 610 m) in depth. Sand and shale deposits would also be grouted off. However, present plans indicate that some injection wells would be completed in the sand and shale unit above the geothermal reservoir. The chemical quality of fluids in the geothermal reservoir and in water in shallow strata of the clay deposits is known to some extent. Available information indicates that groundwater in the upper part of the clay deposits is of relatively low salinity in part of the Anomaly. However, little is known about the chemical quality of groundwater in the depth interval between 200 and 2000 feet (61 and 610 m). There could be upward movement of reinjected fluids from (108)
the injection zone due to upward head gradients. These fluids could also move upward along the well if the grout seal was ineffective. Geothermal fluids contain a number of pollutants that could degrade groundwater quality. Currently, no known use of groundwater above the geothermal reservoir is occurring in the Salton Sea Anomaly.

2. Spilled Geothermal Fluids

Groundwater within the upper 10 to 20 feet (3 to 6 m) of (88)
the surface is generally of very poor quality. If geothermal fluids are spilled at the land surface, long-term impacts on groundwater would be minimal. Polluted shallow groundwater would likely enter the subsurface drainage system and be discharged to surface water bodies. Water levels in wells tapping aquifer materials between 100 and 200 feet in depth (30 to 61 m) appear to be at or above the land surface in most of the Salton Sea Anomaly. This effectively precludes the downward movement of polluted water near the land surface into the depth interval between 100 and 200 feet (30 and 61 m). However, in the southwest part of the Salton Sea Anomaly, water levels in wells tapping aquifer materials between 100 and 200 feet (30 and 61 m) in depth are from 5 to 10 feet (1.5 to 3 m) below the land surface. This could allow downward movement of polluted water near the land surface. The low vertical permeabilities of the clay deposits would greatly limit any downward flow of polluted water, however.

3. Brine Ponds

Ponds containing geothermal fluids are more likely sources of groundwater pollution than spills, because they may represent a continuous source of seepage. Pimentel, Irelan, and Tompkins (1978) documented pollution of sump and drain water near the Sinclair 4 geothermal well. Holding ponds for this well were found to have allowed seepage of brine into the shallow groundwater. This water then entered the tile drainage system beneath a nearby field, then a drainage collection sump, and thence the Vail 4A Drain. The chemical composition of water in the sump indicated that there was some dilution due to mixing with native groundwater and irrigation return flow. Sump water contained high levels of salinity, boron, lithium, manganese, strontium, and zinc.

Permeability values for pond lining materials are sometimes determined from laboratory tests utilizing distilled water. This information should not be used alone to evaluate the potential seepage from ponds. Permeability depends on both the character of the materials and the liquid involved. Many natural materials have a much greater permeability to fluids of high temperature or high salinity. As in the case of spills, vertical head gradients and low vertical permeability will minimize the downward movement of polluted water to depths of several hundred feet, where relatively low salinity groundwater may be present.

4. Drilling Fluid Sump

A small sump is used to contain the drilling fluid and well cuttings during drilling. There are numerous potential pollutants in the drilling fluid,
109 including arsenic, barium, lead, manganese, zinc, and organic chemicals. Ordinarily, materials accumulating in the sump would be periodically removed and trucked to an approved disposal site. Adverse impacts on groundwater due to the sump are limited by low vertical permeability requirements, vertical head gradients, and the transitory nature of the sump.

5. Solid Waste Disposal

Substantial amounts of solid wastes would be generated at full development of the Salton Sea Anomaly. Any impacts on groundwater from these wastes would primarily occur at offsite landfills. In general, disposal at landfills and hazardous waste disposal sites should not result in groundwater impacts because standards and requirements are in effect at these sites which should prevent contamination. Potential impacts of waste disposal at the IT Corporation Class II-1 disposal site have been evaluated in a previous EIR (WESTEC Services, Inc., 1979a).

3.2.2.2 Surface Water

a. Water Use and Availability

1. Water Requirements

The amount of water required for cooling depends on the type of conversion technology used, the thermal efficiency of the generating facility, the cooling system used, and the amount of blowdown needed. Wet cooling towers are expected to be the primary method of heat rejection from power plants in the Valley. The total consumptive use of water required for wet towers is equal to the amount of water lost to evaporation, discharged as blowdown, and emitted to the atmosphere as drift. Layton (1978) estimated evaporative cooling losses for plants in the Salton Sea KGRA to be 50 acre-feet per year per MW. The blowdown rate depends upon the quality of the source cooling water and the number of times that it is recycled. As the number of cycles increases, the volume of the discharged blowdown decreases, but its salinity increases. As salinity increases, disposal of the blowdown becomes more difficult. In general the salinity of the effluent cannot exceed that of the receiving water. Thus to discharge to rivers or drains in the study area, salinity of the effluent cannot exceed about 4000 mg/l. Losses due to drift are less than 0.01 percent of the circulating flow and thus can be ignored for the water supply question.

Table 3.2-6 shows the cooling water requirements and how they depend on the source of water and number of concentration cycles. Table 2.6-4 in Section II showed the cooling water needs as the Anomaly was developed over time. Annual values increase from about 11,000 acre-feet in 1985, to 60,000 acre-feet in 1990, and to 84,000 acre-feet in 2010. These calculations assume 50 acre-feet of evaporative losses and 10 acre-feet of blowdown per MW per year.

Layton (1978) evaluated the availability of water for the Heber, East Mesa, Brawley, and Salton Sea KGRAs. He used several different water policy combinations because of the importance of institutional constraints. Obviously, development of water from an external source other than the Salton Sea or groundwater for the Heber, East Mesa, and Brawley KGRAs would have an impact on water availability for the Salton Sea KRGA. This is because water from canals, drains, or the New and Alamo Rivers would be consumed before it flowed into the Salton Sea KGRA. Layton found that there was no water supply deficit in the Salton Sea KGRA under any of the water policy combinations he evaluated, even for a high energy growth scenario. This is because of the optimal location of this KGRA, near the outlets of the New and Alamo Rivers.

Table 3.2-6

COOLING WATER REQUIREMENTS FROM VARIOUS SOURCES
FOR SALTON SEA KGRA POWER PLANT DEVELOPMENT

Cooling Water Source	Cycles of Concentration	Water Requirement (AF/yr per MW) Evaporative	Blowdown	Total
Canal Water	4	50	17	67
East Mesa Groundwater	4	50	17	67
Drain or River Water	5	50	12	62
Steam Condensate	10	50	5	55
Salton Sea Water	2	50	50	100

The number of cycles shown assumes disposal of blowdown from canal water, East Mesa groundwater, or steam condensate to streams and drains, assuming that the concentration cycles do not produce salinities in excess of about 4000 mg/l and that all RWQCB discharge requirements can be met. If not, the number of cycles would have to be reduced or the blowdown water disposed of via subsurface injection or evaporation ponds. Drain or river water could probably not be returned to streams or drains if more than one concentration cycle were utilized, if then. Likewise, Salton Sea water could only be returned to the sea if once-through cooling were utilized. Therefore, for purposes of this table, it has been assumed that water from drains, rivers, or the Salton Sea would be disposed via subsurface injection or evaporation ponds following the number of cycles indicated. Modified from Layton (1978).

2. Alternative Water Supplies

a) Canal Water

Use of canal water whenever it is available would be advantageous because the treatment and disposal costs would be less than those for river or drain water. Canal water can be concentrated up to four times and still be discharged to a river or drain without exceeding discharge standards. However, the IID must allocate canal water for this purpose. Imperial County may also be in a position to affect the use of canal water, because of its authority to establish regulations for geothermal operations. The county's policy, as stated in the Geothermal Element, is to limit canal water to demonstration or experimental plants generating a maximum of 75 MW in each geothermal anomaly for the first five years of operation. Layton (1978) concluded that until other sources of cooling water for geothermal facilities are shown to be infeasible, use of canal water for a long-term supply appears unlikely. However, new agricultural irrigation methods in the future may change the situation. According to Layton (1978), if new water conservation practices are developed, then a range of 180,000 to 420,000 acre-feet per year of canal water could become available in the Imperial Valley for cooling, if this water is not used elsewhere. Likewise, a recent (16)
state study estimates that as much as 489,000 acre-feet per year could be saved if certain water conservation measures were implemented.

b) Steam Condensate

To prevent or reduce potential impacts of subsidence on irrigation and drainage systems, the County of Imperial requires the full injection of all fluids withdrawn for geothermal operations in the irrigated portion of the Valley. Deviations from this policy are considered only after the California Division of Oil and Gas approves a less than 100 percent injection program. A full injection policy requires external water supplies to support the operation of a geothermal power plant. One option is to use an external supply for cooling. Another option is to use condensate as cooling water and an external water supply such as Salton Sea water for injection. If partial injection were allowed, then condensate could be used as cooling water and no external supplies would be necessary. Steam condensate can be concentrated up to ten times and still meet the salinity discharge requirements. However, the presence of boron, arsenic, mercury, or other toxic constituents in the condensate could require more frequent blowdown or treatment prior to discharge.

c) River and Drain Water

94 In terms of volume, water in the New and Alamo Rivers and drains is a significant potential source of cooling water. Imperial County water policy favors the use of this water over canal water. The California State Water Resources Control Board also supports the use of agricultural wastewater for power plant cooling. However, use of such water poses several problems. Saline blowdown resulting from use of these waters cannot be discharged to rivers or drains if it is concentrated two or more times. Thus it must be disposed by subsurface injection or evaporation ponds. (It should be noted that Table 3.2-6 assumes five concentration cycles but also states that this water cannot be disposed to streams or drains if this number of cycles occurs.) Disposal to evaporation ponds would require about 120 acres (49 ha) of land for a 100 MW plant discharging 700 acre-feet per year of blowdown. The nutrient-rich river and drain water is an excellent growth medium for organisms that can foul heat transfer surfaces. Water taken from the New and Alamo Rivers or drains would require extensive treatment to mitigate problems of corrosion, scaling, and fouling. This could increase the amount of toxic chemicals contained in the cooling tower drift. Large-scale consumption of river or drain water could cause the level of the Salton Sea to fall and its salinity to rise. Waste flows are somewhat unevenly distributed in space and time, which complicates the use of this source. Future long-term water conservation efforts by irrigators and the IID could mean that smaller volumes of wastewater will be available for cooling. Also, ownership of wastewater
140 flowing in the New and Alamo Rivers may have to be determined. Lastly, consumption of agricultural wastewater will alter flows in the New and Alamo Rivers, which could have adverse environmental (primarily biological) effects. If these problems could be solved, once-through cooling (i.e. one cycle) might be possible for part of the development using New or Alamo River water. This possibility could be considered as appropriate on a case-by-case basis.

Water in the New and Alamo Rivers available in the Salton Sea KGRA was determined by multiplying the predicted annual discharge by 0.047 (Layton, 1978). This factor represents the smallest ratio of monthly discharges from the two rivers to their annual discharge for the years 1965 to 1976. This multiplication gives the minimum monthly discharge, which was multiplied by 12 to get the annual equivalent volume. Table 3.2-7 summarizes amounts of water available. Water in the New or Alamo River could supply the ultimate requirement of 84,000 acre-feet per year for the Salton Sea Anomaly. It should be noted that 50,000 acre-feet of New River water has already been allocated to the Heber Anomaly, and an additional

Table 3.2-7

AMOUNTS OF WATER IN THE NEW AND ALAMO RIVERS AVAILABLE FOR COOLING IN THE SALTON SEA KGRA (ACRE-FEET PER YEAR)

Year	Existing Irrigation Practice		New Water Conservation	
	Maximum	Minimum	Maximum	Minimum
1980	720,000	630,000	720,000	630,000
1990	720,000	630,000	640,000	570,000
2000	720,000	630,000	550,000	480,000
2010	720,000	630,000	480,000	420,000

Modified from Layton (1978). These values assume no other consumption of water in the other KGRAs in the Imperial Valley. However, 50,000 acre-feet per year of New River water has already been allocated to the Heber Anomaly, and a request for an additional 45,000 acre-feet per year of New River water and 45,000 acre-feet of Alamo River water was recently submitted for use in the Brawley Resource Area.

application for 45,000 acre-foot per year of New River water plus 45,000 acre-feet per
141 year of Alamo River water for development of the Brawley Resource Area has been received.

There are two large areas where drains empty directly to the Salton Sea. Most of the land west of the Alamo River in the Salton Sea Anomaly is drained by the Vail Cut-Off and the Pumice Drain, which flow directly to the sea. Lands north and east of Red Island also drain directly to the sea. The greatest limitation in using water from these drains is the minimum flows available. Except for the Pumice Drain, minimum daily flows in 1980 were less than 1.5 cfs. The minimum daily flow in the Pumice Drain was 3.0 cfs.

d) East Mesa Groundwater

Millions of acre-feet of water have been recharged to groundwater beneath East Mesa from Coachella and East Highland Canal seepage. The quality of groundwater beneath East Mesa varies substantially, but in some areas it approaches the composition of canal water (Loeltz, Irelan, and Robison, 1975). In order to be used, this water must first be obtained and then transported to the Salton Sea KGRA. If the groundwater was of suitable quality, it could possibly be placed in an existing canal and water exchanges developed. A groundwater exploration program is necessary to fully evaluate this potential source of water. Some institutional constraints to acquiring water rights must also be resolved.

e) Salton Sea Water

The Salton Sea Anomaly includes part of the Salton Sea. Due to the sea's proximity, it is a potential source of cooling water. Removal of water from the sea could counterbalance the rising sea level, which is now a problem. If salt were also permanently removed from the sea, this could aid in maintaining salinity at an acceptable level. Constraints on the use of this water, however, are extensive.

The high salinity would result in scaling and corrosion. Special salt-water cooling towers would be necessary and extensive treatment of the sea water would be required. Large amounts of saline blowdown would have to be disposed. This could be difficult because subsurface injection has several technical uncertainties. Surface disposal by evaporation requires a substantial amount of land.

Some research has been done to solve the injection problem for Salton Sea water at the GLEF. Untreated, the water is chemically incompatible with brine, causing precipitation of salts and clogging of the injection formation. However, treating the water before injection by passing it through a reactor-clarifier shows promise. This would, however, nearly double the amount of solids requiring disposal from 24 tons per day to roughly 48 tons for a 50 MW power plant (SDG&E, 1980).

Once-through cooling using Salton Sea water with discharge back to the sea might be possible if certain technical problems could be overcome and discharge requirements satisfied. This option would probably only be considered for power plants located in close proximity to the Salton Sea. Technical problems would involve the consistency and high salinity of the sea water and the need to provide a certain level of treatment to minimize scaling and corrosion, not to mention specialized equipment to accommodate once-through cooling from the sea. It appears likely that these technical problems could be overcome, but the question of meeting discharge requirements to the satisfaction of the RWQCB remains largely unanswered. It is not fully known what treatment will have to be applied to the Salton Sea water to use it for once-through cooling, thus its chemical composition at its point of reentry to the sea also cannot be determined at this time. In passing through the heat exchanger, the sea water will also absorb heat and would be returned to the sea at an incrementally higher temperature. Currently, is does not appear that this factor would constitute a major deterrent to using this option; however, this would be dependent on the number of plants employing once-through cooling, the relative locations of their intake and outlet facilities, the volumes of water to be used, and the requirements of the RWQCB and possibly others. At this point in time, no specific applications have been made to employ Salton Sea water for once-through cooling; therefore, the above concerns remain unanswered. This water source option does have the advantage of having access to large quantities of available water and would appear worthy of further consideration.

3. Surface Level and Salinity of the Salton Sea

Layton (1978) stated that the most important water-related impacts of geothermal development in the Imperial Valley involve changes in the level and salinity of the Salton Sea. Future changes in the sea will largely depend on the magnitude of water and salt inflows. These inflows will be affected by runoff and salinity of the Colorado River, agricultural water use practices, and diversions of water for geothermal operations. Increased efficiency in the use of water in agriculture coupled with such diversions would lower the level and increase the salinity of the sea. Of these factors, improved efficiencies in agricultural irrigation practices would have by far the greatest long-term potential for affecting both the salinity and the surface level of the Salton Sea. Quite recently (May 1981), IID's Board of Directors approved a $2.8 million water conservation plan involving a number of different measures. Major elements of this program include an increase in the dollar commitment for concrete lateral lining, additional reservoirs, increased staffing and equipment for water conservation programs, continuation of the East Highline water recovery program, and others. To the extent possible, the implications of this increased commitment by IID to water conservation have been considered throughout the following pages.

Impacts due to water use in the Salton Sea Anomaly will depend on the source of water used for cooling purposes. In some cases, flows to the Salton Sea would actually be increased, because amounts of waste discharges would exceed water removed from streams and drains.

Assuming blowdown rates of 240 to 400 acre-feet per year when steam condensate is used for 50 MW plants, then 6700 to 11,200 acre-feet per year of blowdown would be discharged at full development. Net inflows to the sea would not be significantly changed under this alternative. However, if condensate is used and the 100 percent injection policy is enforced, makeup water for injection would likely come from rivers, drains, or the Salton Sea, in which case there would be a net decrease in water in the sea of about 70,000 acre-feet per year.

Assuming blowdown rates of 800 to 1300 acre-feet per year when canal water or groundwater is used for 50 MW plants, then there would be about 20,000 to 35,000 acre-feet per year of blowdown at full development. In the case of groundwater as the source, flows to the Salton Sea would be increased by this amount. However, in the case of canal water, the overall impact is hard to determine, because it would depend on the prior disposition of canal water (i.e., lost to evapotranspiration, drainage, etc.). Net reduction of flows to the sea would probably be less than 60,000 acre-feet per year.

If river or drain water is used for cooling, it would probably not be discharged to surface water and would likely be either injected or evaporated in ponds at the land surface. The net change under full development would be a reduction in flow to the sea of 84,000 acre-feet per year.

In judging the significance of these reductions or increases in flows to the Salton Sea it should be noted that presently the rising level of the sea is due to a net increase of 70,000-100,000 acre-feet per year. Thus, if one could assume that other factors affecting water flows will remain constant (e.g., irrigation practices) then reducing flows by that amount could also have positive impacts by preventing inundation and property losses. However, in light of the recently enacted water conservation program by IID, it appears likely that drainage water volumes may be significantly reduced in future years.

Layton (1978) determined the response of the level of the Salton Sea to reduced inflows of water from the IID. This was based on the assumption that inflows from Mexico and the Coachella Valley would continue at previous rates. Changes in the volume of the sea resulting from historic inflows, precipitation, and evaporation were determined for 1957 through 1971. These were then related to changes in sea levels. Layton (1978) then predicted future sea levels based on alternative future irrigation efficiencies (assuming no geothermal development). His evaluation indicated that if existing irrigation efficiencies are used in the future, sea levels will likely continue to rise. This rise would probably be about four feet by the year 2010. However, flooding of lands near the sea has already forced changes in irrigation practices. Increased irrigation efficiencies, particularly those recently enacted by IID, could have a substantial effect on the level of the sea, which could fall about four to five feet (1.2 to 1.5 m) or more by the year 2000, depending on the timing and effectiveness of the various measures. These values indicate the profound influence irrigation practices can have on levels of the Salton Sea.

Layton (1978) specifically evaluated the use of drain or river water for geothermal development, primarily because of the constraints on use of other potential sources. He considered three levels of development in the Imperial Valley:

a) Low: 1000 MW by the year 2010 with 400 MW in 1994 and growth at 40 MW per year thereafter.

b) Moderate: 3000 MW by 2010 with 400 MW in 1985 and growth of 100 MW per year thereafter.

c) High: 8000 MW by 2010 with 400 MW in 1982 and growth of 250 MW per year thereafter.

The low growth rate would require 24,000 acre-feet per year of water in 1994, 36,000 acre-feet in 2000, and 70,000 acre-feet in 2010. The medium growth rate would require 54,000 acre-feet of water per year in 1990, 114,000 acre-feet in 2000, and 174,000 acre-feet in 2010. The high growth rate would require 144,000 acre-feet of water per year in 1990, 294,000 acre-feet in 2000, and 444,000 acre-feet in 2010.

Conclusions regarding the low growth rate are most applicable in trying to isolate the effects of developing just the Salton Sea Anomaly.

Layton's low growth rate is 1000 MW by 2010 using 70,000 acre-feet a year at full development, while the scenario for the Salton Sea Anomaly being addressed within this MEIR is a comparable 1400 MW by 2010 needing 84,000 acre-feet per year.

If existing irrigation efficiencies are used in the future, there would likely be little change in sea level by the year 2010 at the low geothermal growth rate. That is, the increased water consumption for power plants would tend to offset the rising levels that are now occurring. At the moderate growth rate, levels would probably decline about three to four feet by the year 2010. At the high growth rate, sea levels would fall substantially, almost eight feet by the year 2000.

Of course, the greatest declines would occur with both increased irrigation efficiencies (which are likely to occur) and accelerated geothermal development. Assuming implementation of increased irrigation efficiencies, sea levels could fall about seven feet (2.1 m) by the year 2000 under the low growth rate, almost ten feet (3 m) under the moderate growth rate, and much more under the high growth rate (Layton, 1978).

Layton (1978) also evaluated changes in the salinity of the Salton Sea. His model was calibrated based on chemical quality data for the years 1957 through 1971. Predictions were then made for various alternative irrigation efficiencies in the future without considering geothermal development. If it could be assumed that existing irrigation efficiencies are used in the future, the salinity of the sea water would increase to about 47,000 ppm by the year 2010. However, if increased irrigation efficiencies are used as proposed, the salinity of the sea could increase substantially. In this case, the salinity would approach 55,000 ppm in the year 2000 and 83,000 ppm in the year 2010.

Taking into consideration geothermal development and if no change in irrigation efficiency were to occur, the low growth rate would produce a negligible change in salinity of the Salton Sea compared to that occurring without geothermal development. At the moderate growth rate of geothermal development, the salinity would be about 58,000 ppm by the year 2010. The salinity of sea water could exceed 90,000 ppm by the year 2010 under the high level of geothermal development.

The greatest increases in salinity of the sea would obviously occur with the high growth rate of geothermal development and the increased irrigation efficiencies being planned. Under this alternative, salinity of the sea could increase to 50,000 ppm by 1990 and 90,000 ppm by 2000.

The exact impact due to water development for the Salton Sea Anomaly is difficult to predict because of the importance of other major factors, which cannot be precisely evaluated at present. Increases in flows to the sea would be beneficial if development in other geothermal KGRAs in the Imperial Valley served to decrease inflows to the sea and water conservation practices are implemented as currently planned. However, if for some reason agricultural water conservation practices are not implemented and other geothermal development produced an increase of inflow to the Salton Sea, then decreases in flow to the sea from development of the Anomaly would be beneficial. In a broader context, however, it is apparent that levels and salinity of the Salton Sea will be difficult to control unless a specific water management plan is formulated and implemented. Such a plan would have to include the Coachella and Imperial Valleys as well as the Salton Sea. Both agricultural and geothermal water use would have to be included.

b. Spills

Until more experience has been gained in the extraction, processing, and disposal of large quantities of fluids for actual power plants, the frequency and magnitude of accidental fluid releases will be difficult to predict. Nevertheless, accidental spills are possible. An inadvertent release could amount to more than 1 acre-foot of geothermal fluids, if the entire fluid flow for a 50 MW power plant (processing about 7900 gpm) was spilled for 45 minutes (Layton and Morris, 1980).

Sung et al., (1980) discussed the surface containment of geothermal brines, and specifically evaluated spills. The overall probability of a large spill during 40 years of operation of a 50 MW plant is about 1 in 500. The primary causes of spills noted by these authors are blowouts, corrosion, abrasion, scaling, and miscellaneous accidents. Some methods of failure result in releases of only trickles of fluid. Release from a burst pipe depends on the location and size of the break. A large split on the bottom of a sloping pipe may release the entire flow.

Accidental releases have the potential of polluting water in drains, the New and Alamo Rivers, and the Salton Sea. The severity of a spill depends on the chemical quality of the geothermal fluids and the receiving water, the quantity of the spilled fluids, and the rate of flow in a drain or river. A spill would generally have only a temporary impact on water quality. However, if wastes are spilled onto the land surface overlying a surface drainage system, percolation of these wastes to tile drains could take months or years. Thus the resulting impact on surface water could be substantially delayed.

High temperature, salinity, and high levels of boron, ammonia, and many trace elements would be a major concern in the event of a spill. Information on the chemical quality of geothermal brine shown earlier in Table 2.4-3 indicated that levels of manganese, boron, ammonia, iron, lithium, zinc, bromide, lead, barium, arsenic, and copper are relatively high in the Salton Sea Anomaly.

Spills of geothermal fluids may occur at offshore power plants as well. Substantial dilution of spilled material would occur with distance. A spill from a 50 MW plant, as envisioned by Layton and Morris (1980), could amount to more than one acre-foot. Assuming a depth of water of about ten feet (3 m) near the plants, a dilution of about ten times would occur within an area of one acre near the plant. Such a dilution would lower the salinity to near that of Salton Sea water; however, temperature and contents of selected constituents could still be very high. The high density of geothermal brine would likely result in spilled fluid sinking to the bottom. The sea water appears to be relatively well mixed, based on measurements of electrical conductivity at numerous sites. Assuming a wellhead temperature of 190°C (374°F) and a mean sea temperature of 23°C (73°F) based on LLL monitoring, a tenfold dilution of spilled fluid would result in a temperature of 87°C in a one-acre area of the sea. Water in the sea near the spill could temporarily boil. This phenomenon could only occur if the spill was the result of a break in a pipe under water. In this case heat would not be lost to the atmosphere as the brine flashes but rather the water would receive all the heat. In spills from pipes above water most heat would be lost to the atmosphere before contact with the sea. Therefore, this brine would be at about the boiling point if it reaches the sea and would result in a slight temperature rise in the immediate area.

If the spill entered a river or drain unabated, a flow rate of about 15 to 20 cfs of geothermal brine would result. This would normally be a large flow for most drains, and there would be only a small amount of dilution. Thus a spill to a small drain, or during low flow conditions in all drains, could result in little dilution in the drain and discharge of almost undiluted wastewater to the Salton Sea. However, for the New and Alamo Rivers, low flows normally exceed 300 cfs, and thus an immediate dilution of 15 to 20 times would occur even under minimum flow conditions. Assuming an average river water temperature of about 21°C (70°F) based on LLL monitoring, a 20-fold dilution of spilled geothermal fluid at 100°C (212°F) would result in a temperature of about 25°C (77°F) in the river water below the point of discharge (assuming most heat is lost to the atmosphere before contact with the river). Some cooling would also be expected due to loss of heat to the atmosphere as water flows downstream.

If more than one spill were to occur at once, a substantial impact could result. This is a remote possibility, but in the case of a severe earthquake, for example, it could occur. Flow rates of about 400 to 550 cfs would be possible. If these spills were not contained on the land within the plant sites, they would comprise a major flow into the Salton Sea for a short time. Adverse impacts to water quality and biological resources would occur.

c. Blowdown

The chemical composition of blowdown will depend upon the source of cooling water and the number of times water is recycled. For surface discharge, canal water and condensate are the only two sources considered. If groundwater beneath the East Mesa is used, it would probably be of similar quality to canal water, and thus is not discussed separately.

The following amounts of blowdown would be disposed for the development scenario if canal water was the source of cooling water and four concentration cycles were used:

Year	Acre-Feet
1984	1,500-2,200
1986	6,600-9,700
1995	18,500-27,300
2001-2010	23,800-35,200

It should be noted that under current policies, canal water could not be used as a long-term water supply. If condensate was used with ten concentration cycles, the following amounts of blowdown would be generated:

Year	Acre-Feet
1984	420-700
1986	1,900-3,100
1995	5,300-8,800
2001-2010	6,800-11,300

If no toxic substances are present and the total dissolved solids level is kept below about 4000 ppm, then blowdown from both canal water and steam condensate could possibly be discharged to drains and the New and Alamo Rivers. However, this point in time it is not known with any degree of certainty whether this would be proposed or even allowed. For example, it has been stated that "it is unlikely that we would ever want to or be permitted to discharge geothermal condensate to surface waters" (Robinson, 1981).

The exact chemical composition of blowdown to be produced in the Salton Sea Anomaly is unknown. Besides high temperature and salinity, constituents
121 of concern include boron, ammonia, arsenic, barium, lithium, and manganese. The water quality objectives of the Regional Water Quality Control Board would limit the salinity of wastewater discharged to streams or drains on an average annual basis. Besides these constituents, organic chemical constituents and possibly other inorganic chemical constituents could present problems.

There are two types of impacts to be considered. First is the impact of an individual plant on a specific drain, reach of a stream, or the Salton Sea. The second is the cumulative impact of blowdown from all plants. For an individual 50 MW plant in the Salton Sea Anomaly, the amount of blowdown is about 800 to 1300 acre-feet per year when canal water is used and 240 to 400 acre-feet per year when condensate is used. These amounts are very small compared to the annual flows in the New and Alamo Rivers. All of these amounts are less than one percent of the annual flow in each river at the outlet. There would be substantial dilution of blowdown in these streams. Therefore, impacts would be confined to short reaches of the streams in close proximity to the point of discharge. The limitation on salinity of blowdown will also control to an extent the buildup of concentrations of specific constituents due to recycling. The location of impacted reaches of streams can be determined by monitoring during operation.

These volumes of blowdown are more significant in terms of flow in individual drains, particularly during the winter when such flows are the smallest. Average flows of blowdown from a 50 MW plant would range from 1.1 to 1.8 cfs when canal water is used and from 0.3 to 0.6 cfs when condensate is used. Minimum daily flows in all drains except the Pumice Drain were less than 1.5 cfs in 1980. Thus blowdown from canal water could often comprise more than 50 percent of the flow in an individual drain. During winter months the blowdown from canal water would often comprise more than 90 percent of the flow in drains other than the Pumice Drain. Little dilution of blowdown would occur at this time. However, during summer months flows in the drains are much higher and there would be more dilution. There would be substantial dilution in drains with high flows, such as the Pumice, Vail Cut-Off, "O," "R," and "Z" Drains. The rates of blowdown for condensate are about one-third of that for canal water, and thus impacts are correspondingly less.

At full development of 1400 MW, the total amount of blowdown would be significant, particularly when canal water is used. Many of the power plants would be located near drains that flow directly to the Salton Sea. The total amount of blowdown when steam condensate is used could range from 6800 to 11,300 acre-feet per year. Assuming that two-thirds of this blowdown was discharged to drains flowing directly to the sea, about 4600 to 7500 acre-feet per year of blowdown would be involved. About two-thirds of the land served by drains that flow directly to the sea from IID are in the Salton Sea Anomaly. An estimated 110,000 acre-feet per year of agricultural drainage currently flows in these drains, 70,000 acre-feet of which thus originates within the Salton Sea Anomaly. Blowdown would therefore usually comprise less than 10 percent of the water flowing in drains going directly to the Salton Sea under full development. Likewise, the volume of blowdown would represent less than one percent of the total flow entering the sea from IID in the New and Alamo Rivers plus all drains. There would thus be at least a 100-fold dilution of blowdown water entering the sea.

If canal water or groundwater was used as the source, there would be about 24,000 to 35,000 acre-feet per year of blowdown. Blowdown could comprise almost one-third of the water flowing in drains going directly to the Salton Sea under full development. However, the volume of blowdown would still be less than three percent of the total flow entering the sea from the IID.

d. Flooding

The entire portion of the project area between the New River and approximately two miles east of the Alamo River is in a significant flood hazard area. Flooding could cause major damage to the proposed plant facilities. Plant operations could be interrupted and wells and pipelines delivering steam could be inundated, resulting in significant damage to the steam production system and generating facilities. Any drilling sumps, brine storage ponds, and evaporation ponds could be washed out, thus contamination of the floodwaters by the materials in these containment areas would result. In addition, the steadily rising water levels of the Salton Sea could pose a flood problem to the project area in the future. Currently, onshore portions of the project area below an elevation of -227.3 feet (USGS datum) are protected from flooding by levees. Continued rise of water levels and wave action could result in the breeching of some sections of levees and inundation of large portions of the project area.

Inasmuch as the County currently participates in the FEMA flood insurance program, in order to obtain a permit to construct from the County, geothermal developers would also be required to participate in the FEMA program. A variance to this process is available for developers not interested in participating in the FEMA program, but FEMA would have to approve such a variance.

3.2.3 Mitigation Measures

3.2.3.1 Groundwater

The most important potential impacts of geothermal development at the Salton Sea Anomaly on groundwater would involve the use of groundwater beneath the East Mesa and subsurface injection of geothermal fluid and blowdown. Brine ponds, drilling fluid sumps, and spills near power plants could also impact groundwater. Because of vertical head gradients and low vertical permeabilities in the shallow clay deposits of the Salton Sea Anomaly, groundwater pollution due to sources other than injection would normally be confined to the upper few tens of feet of the surface. Tile drainage systems underlie much of the area and discharge to drains or streams. If shallow groundwater is polluted, surface water may be subsequently impacted. Methods of mitigating these potential impacts are discussed below.

a. Non-Injection Sources

Ponds with a permeability of 1×10^{-6} cm/sec must be used for temporary storage of geothermal fluids, spilled material, and drilling fluids. Native materials could likely be used for liners in many cases. Blowdown, if not discharged to surface waters, could possibly be disposed on land by evaporation. Artificial liners may be necessary in this case because of the high temperature and chemical composition of the wastes. Percolation of brine from ponds near Sinclair Well No. 4 has been documented (Pimentel, Irelan, and Tompkins, 1978). The chemical quality of shallow groundwater can be partly monitored by collecting water samples from agricultural drainage sumps, as recommended in Section 3.2.3.2e.

b. Injection

At full development both geothermal fluids and blowdown may be injected in about 225 injection wells at the Salton Sea Anomaly. Presently, the quality
58 of groundwater below a depth of 200 feet (61 m) and above the geothermal reservoir is poorly known. Thus, the compatibility of injected fluids and groundwater in the zone above the geothermal reservoir cannot precisely be evaluated. Generally, the Environmental Protection Agency recommends protection of any water with a total dissolved solids content of less than 10,000 mg/l. One mitigating measure in this regard would be to drill wells into the zone above the geothermal reservoir. Water samples could be collected at specific depths during the drilling and analyzed. In this manner, substantial information on the chemical quality of groundwater above the geothermal reservoir

could be obtained in the Salton Sea Anomaly. Also, special monitor wells should be installed near injection wells to monitor the quality of groundwater in strata above the injection zone. Details of such testing and monitoring are provided in Section 8.3 for the site specific study of MAGMA's proposed 49 MW plant.

c. East Mesa

If the potential for using groundwater from the East Mesa area is to be explored, a hydrogeologic investigation should be conducted in the East Mesa to more thoroughly determine the amount of low salinity water in storage in that area. This investigation would supplement information available from previous studies, such as those by the U.S. Geological Survey and U.S. Bureau of Reclamation. Numerous wells would be necessary to obtain water samples at various depths. Many of these wells would extend to depths ranging from 1000 (305 m) to more than 2000 feet (610 m). These wells would allow delineation of the vertical and horizontal extent of low salinity water beneath East Mesa. About six large-capacity test wells (minimum 12-inch diameter casing) should also be constructed to allow aquifer testing and water sampling. Pump tests should be conducted to define specific capacities, well losses, and aquifer characteristics. Also, investigations should be made of institutional problems that might make this option unlikely. Potential exchanges of this groundwater with water in canals, and the costs of using this source for cooling water in the Salton Sea Anomaly should also be analyzed.

3.2.3.2 Surface Water

One of the most important potential impacts of development of geothermal resources at the Salton Sea Anomaly involve the level and quality of water in the Salton Sea. There could be substantial impacts from water use alone for the 29 projected power plants. Spills of geothermal fluids and disposal of cooling tower blowdown could affect the quality of water in drains, canals, rivers, and the Salton Sea. Flooding could also cause adverse impacts. Mitigating measures for these potential impacts include the use of specific sources of water and specific methods of waste disposal, coordination of water development with other water management activities in the area, and flood control measures.

a. Water Use

Future levels and water quality of the Salton Sea depend on future agricultural practices in the Imperial and Coachella Valleys, the rate of development of geothermal resources in the Imperial Valley, and stream flows in the New River crossing the border from Mexico. For example, if agricultural efficiencies remain the same in the Imperial Valley, sea levels will likely continue to rise. If drain or river water is tapped for geothermal power plants, then less inflow would enter the sea, which could result in beneficial impacts on its surface levels and adverse effects with regards to salinity. On the other hand, if new water conservation practices are implemented in the Valley as it appears they will be, sea levels could start falling within a decade. If drain or river water is tapped for geothermal development, then even less inflow would enter the sea, and the cumulative impact could be quite adverse.

Because of the multitude of factors that affect water levels and water quality of the Salton Sea, it appears unlikely that potential impacts due solely to development of geothermal energy in the Salton Sea Anomaly can be adequately mitigated unless a comprehensive water management plan is undertaken. This plan would have to include both the Coachella and Imperial Valleys, the Salton Sea, the Colorado River, and the New River in Mexico. The purpose of such a plan would be the stabilization of both water levels and salinity of the Salton Sea. Development of water for geothermal power plants could be coordinated with agricultural water conservation efforts to help achieve this goal. Additional management techniques would likely be necessary for control of salinity of the Salton Sea. Numerous institutional problems would have to be overcome in order for such a plan to be developed because of the multitude of decision-making bodies which control and influence the water systems of the area. These decision-making bodies include those in Arizona, Mexico, the U.S. and State governments, as well as several in the Valley itself, thus their efforts must be coordinated in order to be successful.

If agricultural efficiencies remain as they are today, it would be beneficial to tap drain and river water for development of the Salton Sea Anomaly, to the extent that the sea level is stabilized. On the other hand, if increased agricultural water conservation practices are implemented, which seems probable, they would serve to stabilize and even reverse the rising sea levels. In this case it would seem preferable to tap steam condensate or East Mesa groundwater for use within the Salton Sea Anomaly.

b. <u>Spills</u>

Spills of geothermal fluid can adversely impact the quality of groundwater as well as surface water in rivers, canals, drains, and the Salton Sea. Morris and Armantrout (1980) discussed methods of liquid waste control for geothermal development. Berms can be used at the power plant as a means of containment for spilled geothermal fluids. Evaporation in specially lined ponds is probably the most effective method of disposal for spilled geothermal fluids. Lined ditches beneath pipelines could possibly be used for some containment of some pipeline spills; however, concerns have been raised regarding the applicability of this method in all situations. If utilized, they could lead to specially lined ponds for disposal by evaporation. Special precautions should be taken at power plants located offshore and where pipelines cross small drains or canals near the Salton Sea. These precautions might include heavier casing for pipes or use of a pipe within a pipe to provide double protection.

c. Blowdown Disposal

Disposal of blowdown from cooling towers could adversely affect the quality of water in streams, drains, and the Salton Sea. Blowdown from the use of cooling water from canals or from steam condensate could probably be discharged to surface waters. Blowdown could also be disposed by evaporation in ponds, which could serve to mitigate potential surface water pollution problems. However, about 90 acres of land would be necessary for evaporation ponds to serve a 50 MW power plant. It would be difficult to site ponds of this size in much of the Salton Sea Anomaly without affecting irrigated land; additionally, such ponds may be hazardous to waterfowl that might be attracted to them.

Subsurface injection of blowdown may be a viable alternative. Blowdown could be injected into the geothermal reservoir or into an overlying aquifer that is isolated from aquifers containing good quality water. Blowdown may have to be filtered prior to injection to remove suspended solids that could clog a receiving aquifer. Also, sulfate could precipitate when blowdown, which has a high sulfate content, mixes with geothermal fluid containing high barium and calcium concentrations. To prevent this precipitation, it may be necessary to chemically bind sulfate so that it would not react with reservoir fluids, or pre-treat the blowdown to remove sulfate. Additionally, it may be possible to inject blowdown into an aquifer having low calcium and barium contents (Layton and Morris, 1980). Unfortunately, there is little information available on the chemical quality of water in aquifers overlying the geothermal reservoir in the Salton Sea Anomaly.

If steam condensate is used as the source of cooling water, blowdown could be discharged to streams or drains, if toxic substances are not present. Layton and Morris (1980) concluded that removal of both ammonia and boron may be necessary. Additional research is needed on both the injectability of blowdown and treatment that would be necessary prior to discharge to surface water. Experience at the first few plants operated in the Salton Sea Anomaly can be used to design mitigation measures necessary for full development.

d. Water Quality Monitoring

The California Regional Water Quality Control Board and
(97) U.S. Geological Survey are presently conducting a water quality monitoring program at 38 sites in the Imperial Valley. Figure 3.2-2 previously showed the location of the monitoring sites. Basically, this program involves a continuation of part of the Lawrence Livermore Laboratory monitoring program which was conducted in the late 1970s and was focused on specific KGRAs. Both the New and Alamo Rivers are sampled near the outlets as part of the Valley-wide network. The Salton Sea is sampled near Lack Road. The Vail Cut-Off and Vail 4A Drains and two agricultural drainage sumps in the Salton Sea Anomaly are also sampled. Sampling is conducted quarterly, and electrical conductivity, temperature, and pH are measured in the field. The major inorganic chemical constituents, boron, cadmium, lithium, manganese, strontium, and zinc, are determined in the laboratory.

A monitoring network specifically designed for each power plant should be implemented prior to plant start-up. An example of such a network is discussed for the 49 MW plant in Section VIII of this document.

e. Flooding

Damage to the proposed power plant facilities as a result of flooding on the New or Alamo Rivers can be prevented by surrounding all plant facilities which could sustain damage with levees. There must be adequate freeboard above the 100-year flood elevation. The Federal Insurance Administration (FIA) through the Federal Emergency Management Agency (FEMA) specifies levee design specifications which are considered to offer adequate protection.

> FIA will require a minimum levee freeboard of three feet, with an additional foot within 100 feet either side of structures within the levee or where ever the flow is constricted, such as at bridges. An additional half-foot above this minimum is also required at the upstream end, tapering to the minimum at the downstream end of the levee. This standard has been generally utilized by the Corps for levees protecting populated areas, and is based on long term experience with the success and failure of levee systems (Krimm, 1981).

Another method would be the placement of fill beneath all facilities susceptible to damage in order to raise them above the 100-year flood elevation. Future flood problems associated with the continued or sudden rise of the Salton Sea water level can be mitigated by ensuring that adequate freeboard (as defined by FEMA and Imperial County) is provided on existing levees and by placing riprap on those sections of levees exposed to unimpeded wave action. Imperial County standards (1971) currently require three feet of freeboard for dikes.

3.3 CLIMATOLOGY

3.3.1 Existing Conditions

3.3.1.1 General Climate

Climatic conditions in the Salton Sea study area are governed by the large-scale sinking and warming of air in the semi-permanent subtropical high pressure center over the Pacific Ocean. The high pressure ridge blocks out most mid-latitude storms except in winter when the high is weakest and farthest south. Similarly, the coastal mountains prevent the intrusion of any cool, damp marine air found in California coastal environs. Because of the weakened storms and the orographic barrier, the Imperial Valley experiences clear skies, very low humidities, extremely hot summers, mild winters, and little rainfall. The flat terrain of the Valley and the strong temperature differentials created by intense solar heating produce moderate winds and deep thermal convection. Thus, while the climate is often uncomfortably hot in the summer, it does create much better air pollution dispersal than in the polluted metropolitan areas near the ocean.

3.3.1.2 Temperature

Clear skies and rapid thermal response of dry desert soils creates rapid heating by day and cooling at night. Daily and seasonal temperature oscillations (NOAA, 1972) are extremely large with summer maxima averaging 108°F (42°C) and winter minima of 38°F (3°C). The average annual temperature is 74°F (23°C) ranging from 55° (13°C) in winter to 93°F (34°C) in summer. The highest temperature recorded in 50 years of observations in Niland was 122°F (50°C) and the lowest 19°F (-7°C). Half of all days have temperatures that reach 90°F (32°C) and seven days per year drop to freezing.

3.3.1.3 Precipitation

The combination of subsiding air, protective mountains and distance from the ocean all combine to severely limit precipitation. The Imperial Valley and the eastern Majove Desert have the lowest rainfall in the United States. In California, only one of the Death Valley measurement sites has less rainfall than Niland's annual average of 1.88 inches. Niland averages three occurrences with significant rain (more than 0.1 inch in 24 hours) in winter and one summer rainfall from convective thunderstorms. Rainfall is highly variable with precipitation from a single heavy storm (often causing flash-flooding) exceeding the entire annual total during a later drought condition. By coastal standards, an Imperial Valley "wet" year of 4.50 inches of rain is still a very dry year, but drought conditions of 0.02 inches of rain for the entire year and 15 months of no measurable precipitation have actually been observed in Niland.

3.3.1.4 Humidity

Humidities are low throughout the year, ranging from 28 percent in summer to 52 percent in winter. The large daily oscillation of temperature produces a corresponding large variation in the relative humidity. Nocturnal humidities rise to 50-60 percent, but drop to about 10 percent during the day. Low humidities are beneficial to geothermal development because cooling towers that depend on evaporative cooling are quite effective and the plumes they produce from condensed vapor soon dissipate in dry air lessening the possibility of a significant adverse aesthetic impact.

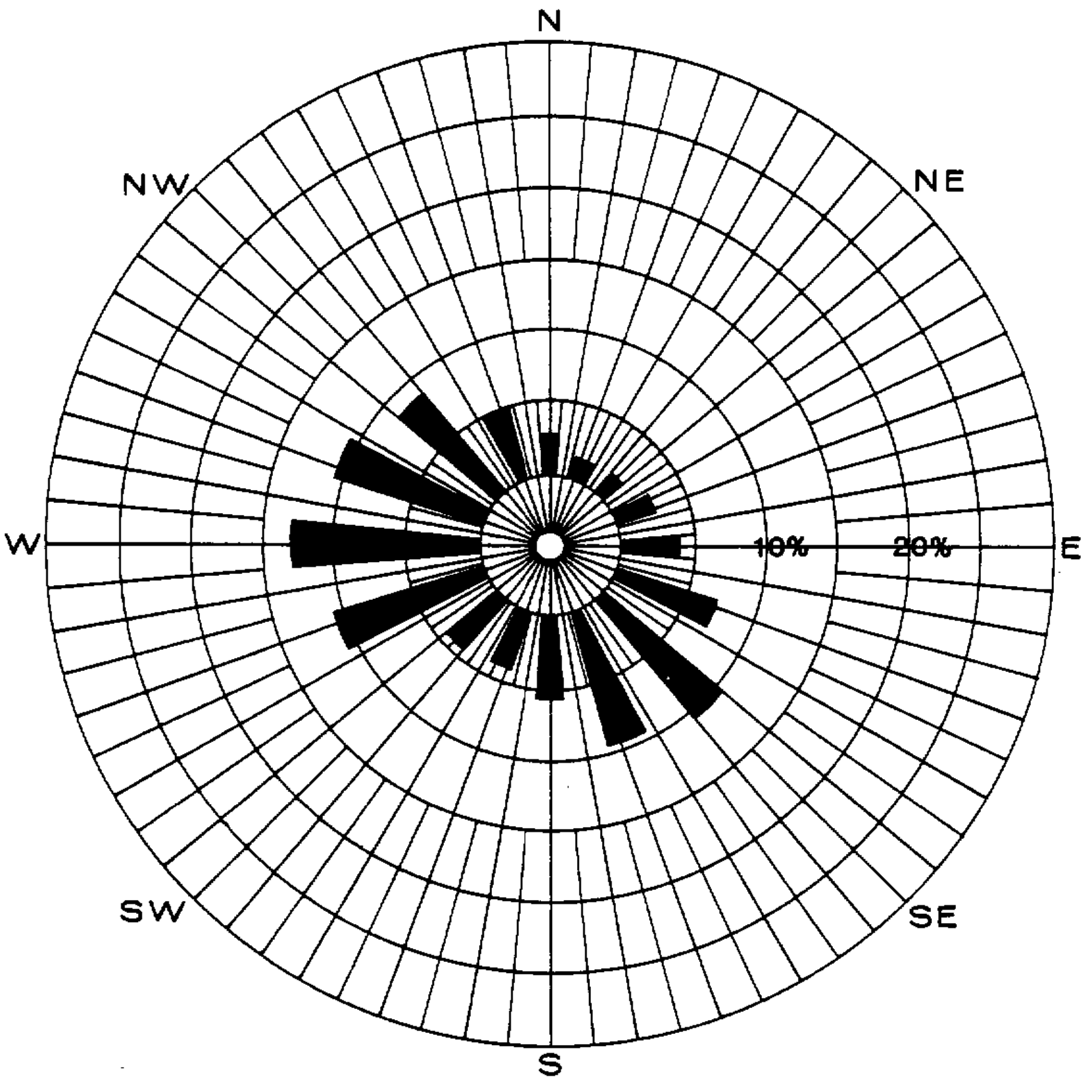
3.3.1.5 Dispersion Climatology

The factors that govern the rate of atmospheric dilution of airborne contaminants are generally quite favorable for good air quality in the Imperial Valley. The winds which govern the horizontal transport are brisk and rarely calm. Vertical and cross-wind dispersions, which are governed by the size of turbulent eddies, are excellent because the strong insolation and rapid soil-thermal response produce large convection cells. The combination of good transport and mixing conditions reduces the probability of adverse air quality impacts from limited Valley air pollution sources. Although there are only limited data resources by which to characterize specific dispersion elements within the study area, the flat valley floor and the uniformity of atmospheric driving mechanisms allows one to extrapolate meteorological patterns throughout the area with reasonable certainty.

a. Winds

Winds across the Salton Sea Anomaly are driven by a complex interaction of several scales of motion. Cultivated/natural soil, Salton Sea/surrounding land, Gulf of California/Pacific Ocean/Mojave Desert and global scale pressure fields all determine the windfield orientation. However, the flat terrain of the Valley does not introduce rapid horizontal variations that would further complicate the wind distribution.

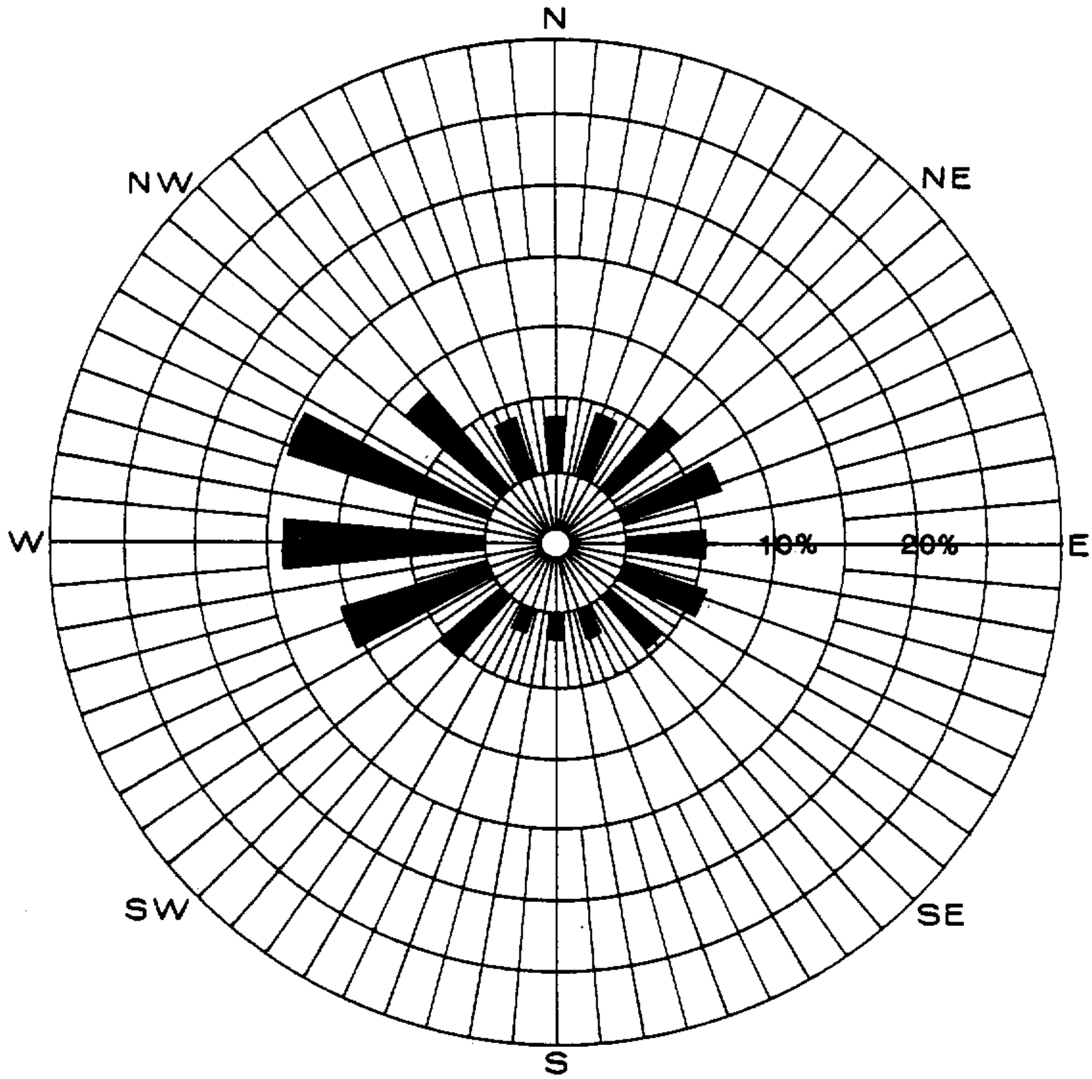
Wind data resources, though limited, are available from a number of monitoring efforts. The National Weather Service at Imperial County Airport and the Naval Sea Test Base, the U.S. Navy at El Centro and Salton City, Lawrence Livermore Laboratory at six sites during a two-year baseline data acquisition program, the National Parachute Test Facility, private consultants at Brawley, Heber, Niland and elsewhere and the County Air Pollution Control District have all been involved in countywide atmospheric data gathering programs. Wind directional frequency distributions (wind roses) from three wind monitoring sites near the Salton Sea study area are shown in Figures 3.3-1 through 3.3-3.



NILAND-SDG&E

Wind Directional Frequency Distribution

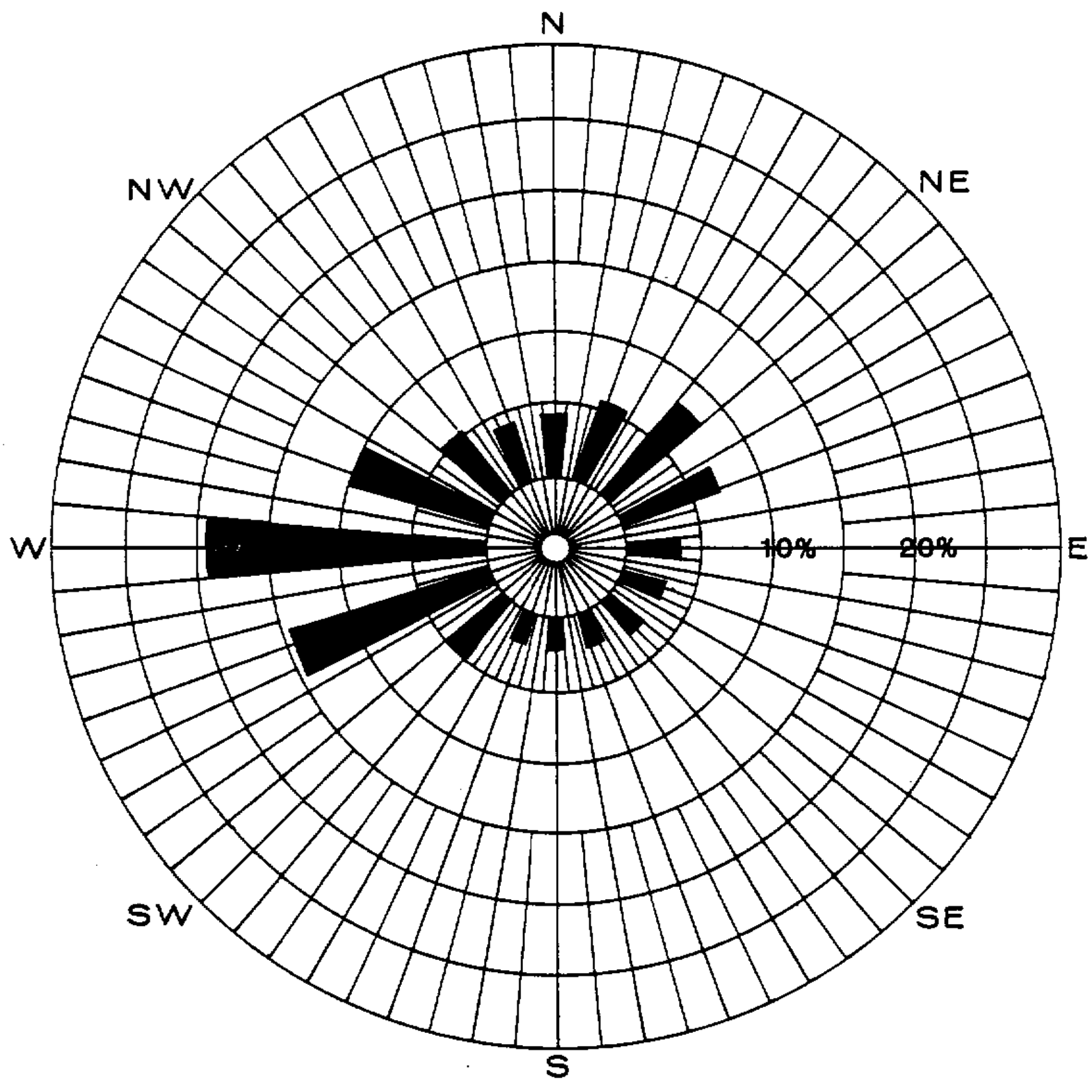
FIGURE 3.3-1



SALTON SEA TEST BASE

Wind Directional Frequency Distribution

FIGURE 3.3-2



WESTMORLAND-ELMORE

Wind Directional Frequency Distribution

FIGURE 3.3-3

At all three sites, the dominant wind direction is from sea to land by day and land to sea at night. The daytime onshore and nocturnal offshore components are especially prevalent during summer afternoons (onshore) and winter nights (offshore). A larger scale ocean-desert circulation that blows west-to-east most of the year and reverses into a "gulf breeze" from the southeast in summer is also often seen in Imperial County, but this circulation pattern is not as dominant close to the Salton Sea where the small-scale land/sea breezes are the dominant flow mechanism. The strongly bimodal wind distribution suggests that daytime emissions from KGRA development will blow predominantly toward the east-southeast or southeast toward the Chocolate Mountain Bombing Range or East Mesa. Brisk daytime winds averaging 8-12 mph and strong thermal convection will help to minimize daytime pollution levels near the Salton Sea KGRA.

At night, as the winds diminish to 3.5 mph and drift out over the Salton Sea, geothermal power plant plumes will retain their integrity longer with associated higher concentrations of noncondensable gaseous plant emissions. As long as these buoyant emissions remain aloft, they will cause little adverse ambient impact. If, however, they mix down to the surface, these high concentrations of pollutants could cause corresponding elevated pollution levels at the surface. If this downward mixing occurs during the morning hours when the plumes that drifted seaward at night reverse their direction and blow onshore, then the "old" nocturnal emissions and the "fresh" daytime emissions may both start moving across the KGRA. The combined noctural/ morning emissions and the onset of daytime convective instability represents a worst case dispersion pattern that forms the basis for predicting the worst air quality impact that may be expected from Salton Sea KGRA geothermal resource development.

b. <u>Atmospheric Stability</u>

The rate of dilution of a polluted air parcel depends critically on how fast it is mixed with relatively clean ambient air. Across rough terrain, much of this mixing is a result of mechanical turbulence. In the relatively flat terrain of the Imperial Valley, most of this turbulence results from thermal convection and from wind speed and directional shears introduced by differing surface characteristics.

Atmospheric stability is usually described in terms of six discrete stability categories in a typing scheme developed by Pasquill in England and Gifford in the United States. Experience has also shown that meteorological conditions of wind speed, solar insolation, and cloud cover are directly related to these six stability categories. Table 3.3-1 shows the results of an analysis of five years of Imperial Valley

Table 3.3-1

IMPERIAL VALLEY ATMOSPHERIC STABILITY DISTRIBUTION

Stability Class	Annual Frequency of Occurrence (%)
Extremely Unstable	3.73
Moderately Unstable	14.42
Slightly Unstable	13.72
Neutral - Daytime	10.49
Neutral - Night	15.92
Stable	41.72

Source: National Oceanic and Atmospheric Administration (NOAA) STability ARray (STAR) computer program, El Centro, California (1/54-12/58), run July 24, 1975.

weather observations showing the stability categories predicted by meteorological parameters. Almost one-half of all observations are stable with only a small frequency of very unstable conditions. It should be noted that the results in Table 3.3-1 represent the stability conditions through a deep layer of the atmosphere (usually several thousand feet) and do not necessarily show the highly unstable conditions found near the ground on most days with strong sunshine. It should also be noted that the Pasquill-Gifford system was developed from dispersion data in England and the eastern United States and may not necessarily reflect turbulence patterns over the southwestern United States deserts.

Table 3.3-1 also does not take into account the transition in turbulence structure that occurs when there are definite layers of thermal stratification that affect dispersion conditions. Most notably among these is the phenomenon of temperature inversions. An inversion is a reversal of the normal decrease of temperature with height to an increase with height. Since a polluted parcel of air cools by expansion as it rises, inversions suppress vertical motion and restrict dispersion. When an inversion forms above the surface, it forms a lid above the surface and prevents the vertical escape of pollutants. When the inversion forms at the surface itself, it confines surface-based-emissions within that shallow layer and prevents any intrusion of buoyant emissions back down to the surface.

Elevated inversions over the desert, if and when they do form, usually occur at 6000 to 8000 feet (1829 to 2439 m) above the surface (Bennett 1975), and therefore do not significantly affect air quality. Surface-based inversions, on the other hand form almost every night (90 percent of all observations) as cool air settles near the ground in lower elevations. They restrict localized dispersion and cause local pollution "hot spots." For the elevated steam plumes from geothermal development, these nocturnal inversions protect ground-level receptors. However, when these inversions are destroyed by surface heating, the pollution accumulations above the surface inversion are readily mixed to the ground and can lead to high pollution concentrations (fumigation). Except during fumigation during the morning hours and the transition from unstable daytime to stable nocturnal conditions where daytime instability mixes pollutants to the ground and nocturnal stability traps them, Imperial Valley wind and stability conditions are usually favorable for minimizing the air quality impact of Salton Sea KGRA development.

3.3.2 Impacts

Relative humidity increases may occur during light winds when the approximately 775,000 pounds (351,500 kg) of moisture released per hour by a 50 MW plant stagnate near the source. Within 0.6 miles (1 km) of the plant a cylinder 984 feet (300 m) high contains 2.4 billion pounds of air (1.1×10^9 kg), of which 6 million pounds (2.7×10^6 kg) may be water vapor (25 percent relative humidity, about 75°F; 24°C). If winds are calm and the cooling tower moisture emissions are injected into that limited volume surrounding the plant, it could cause localized relative humidity increases of up to 4 percent. Given the typically dry conditions of the Valley, such an increase may have a slightly beneficial effect on plant response by decreasing the transpiration stress introduced on plants by such a dry climate. By way of comparison, the moisture emitted as a result of plant operation is equivalent to the moisture evaporated from 315 acres (128 ha) of water surface at the annual average Imperial Valley evaporation rate of about 100 inches (254 cm) per year. The net moisture increase effect from a 50 MW power plant would thus be about the same as building a fresh water lake covering about one-half section.

The second humidity consideration relates to the formation of visible plumes. Measurements at the Oak Ridge Gaseous Diffusion Plant (ORGDP) (LaVerne, 1977) cooling tower have led to semi-empirical equations by which one can estimate the typical plume length or height under already cool, moist conditions. The ORGDP equations were applied to a 50 MW power plant bank of cooling towers on a cool morning (50°F; 10°C) with a 50 percent relative humidity. The model predicted a tall but not very long plume rising to 1150 feet (350 m) during near calm wind conditions and a long but low plume of 3870 feet (1180 m) under moderate wind conditions. A plume of 1150 feet (350 m) would be visible throughout much of the Imperial Valley on days with good visibility.

Another aspect of plume rise from cooling towers is the phenomenon known as "downwash." This occurs when strong winds (generally above 15 mph) impact a bank of cooling towers nearly perpendicularly and form a cavity vortex on the lee side of the structure. The vacuum may draw the plume almost to the ground with resulting fogging and high H_2S concentrations close to the site.

3.3.3 Mitigation Measures

"Downwash" may be minimized by aligning the axis of the cooling tower with the direction of the highest winds. This will decrease the size of any resulting vacuum. A good knowledge of the wind distribution pattern at each plant site would be necessary.

3.4 AIR QUALITY

3.4.1 Existing Conditions

3.4.1.1 Ambient Air Quality Standards

In order to assess the significance of the impact of a proposed development, that impact, together with baseline air quality levels, must be compared to the applicable ambient air quality standards (AAQS). These standards are the levels of air quality necessary, with an adequate margin of safety, to protect the public health and welfare from any adverse effects. They are designed to protect those people most sensitive to further respiratory distress such as asthmatics, young children, the elderly, hospital patients or people engaged in heavy work or exercises. National AAQS were established for six (now seven) pollution species with states retaining the right to set their own standards for other species or other exposure periods. Since California air standards preceded the federal standards, there is considerable diversity between state and federal clean air standards. The standards currently applicable in California are presented in Table 3.4-1.

Geothermal development releases very few (regulated) pollutants in appreciable quantities except for hydrogen sulfide (H_2S). The hourly air quality standard for H_2S of 0.03 ppm by volume is designed to reduce the odor nuisance from the characteristic rotten-egg odor of H_2S. Unlike other standards, the H_2S standard is not based on adverse effects on human health. Since adverse health effects or destruction of vegetation are not noted until somewhat higher concentrations of H_2S are observed, 46
there have been efforts to raise the standard to a level of perhaps 0.08 ppm where it is accepted that health effects may occur (see Table 2 in Appendix 3.4). Conversely, it has also been demonstrated that the 0.03 ppm odor threshhold standard may be too high in that many people can detect H_2S below the 0.03 ppm level (see Table 2 in Appendix 3.4). Furthermore, one inhalation of a high concentration of H_2S can make one nauseous, instead of a one hour exposure at the 0.03 ppm level. For those reasons some have suggested the need for a lower standard. With competing pressures to modify the standard, it is not clear what changes to the standard, if any, may be made in the future.

3.4.1.2 Air Quality Rules and Regulations

In addition to the overriding constraint of the state H_2S standard, there are several rules and regulations that could impact large-scale regional geothermal development. Because there is no federal standard for H_2S, these rules and regulations are primarily state and/or local APCD considerations. There are federal requirements

Table 3.4-1

AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	California Standards		National Standards		
		Concentration	Method	Primary	Secondary	Method
Oxidant	1 hour	0.10 ppm (200 ug/m^3)	Ultraviolet Photometry	—	—	—
Ozone	1 hour	—	—	240 ug/m^3 (0.12 ppm)	Same as Primary Standard	Chemiluminescent Method
Carbon Monoxide	12 hour	10 ppm (11 mg/m^3)	Non-Dispersive Infrared Spectroscopy	—	Same as Primary Standards	Non-Dispersive Infrared Spectroscopy
	8 hour	—		10 mg/m^3 (9 ppm)		
	1 hour	40 ppm (46 mg/m^3)		40 mg/m^3 (35 ppm)		
Nitrogen Dioxide	Annual Average	—	Saltzman Method	100 ug/m^3 (0.05 ppm)	Same as Primary Standards	Gas Phase Chemiluminescence
	1 hour	0.25 ppm (470 ug/m^3)		—		
Sulfur Dioxide	Annual Average	—	Conductimetric Method	80 ug/m^3 (0.03 ppm)	—	Pararosaniline Method
	24 hour	0.05 ppm (131 ug/m^3)		365 ug/m^3 (0.14 ppm)	—	
	3 hour	—		—	1300 ug/m^3 (0.5 ppm)	
	1 hour	0.5 ppm (1310 ug/m^3)		—	—	
Suspended Particulate Matter	Annual Geometric Mean	60 ug/m^3	High Volume Sampling	75 ug/m^3	60 ug/m^3	High Volume Sampling
	24 hour	100 ug/m^3		260 ug/m^3	150 ug/m^3	
Sulfates	24 hour	25 ug/m^3	AIHL Method No. 61	—	—	—
Lead	30 day Average	1.5 ug/m^3	AIHL Method No. 54	—	—	—
	Calendar Quarter	—	—	1.5 ug/m^3	1.5 ug/m^3	Atomic Absorption
Hydrogen Sulfide	1 hour	0.03 ppm (42 ug/m^3)	Cadmium Hydroxide Stractan Method	—	—	—
Hydrocarbons (Corrected for Methane)	3 hour (6-9 a.m.)	—	—	160 ug/m^3 (0.24 ppm)	Same as Primary Standards	Flame Ionization Detection Using Gas Chromatography
Vinyl Chloride (Chloroethene)	24 hour	0.010 ppm (26 ug/m^3)	Gas Chromatography (ARB staff report 78-8-3)			
Ethylene	8 hour	0.1 ppm	—	—	—	—
	1 hour	0.5 ppm				
Visibility Reducing Particles	1 observation	In sufficient amount to reduce the prevailing visibility to less than 10 miles when the relative humidity is less than 70%		—	—	—
APPLICABLE ONLY IN THE LAKE TAHOE AIR BASIN:						
Carbon Monoxide	8 hour	6 ppm (7 mg/m^3)	NDIR	—	—	—
Visibility Reducing Particles	1 observation	In sufficient amount to reduce the prevailing visibility to less than 30 miles when the relative humidity is less than 70%		—	—	—

that all national AAQS be met by 1987 and the development of geothermal power generation may not interfere with that attainment process. Except for the small amount of particulate emissions from cooling tower drift, however, there are no anticipated pollution sources in the development scenario that would be affected by the federally mandated air quality planning process.

In California, control and enforcement of vehicular pollution sources is the responsibility of the Air Resources Board (ARB) and stationary sources are controlled by the local air pollution control district (APCD). As dictated by the California Health and Safety Code, the ARB maintains an oversight responsibility for stationary source controls and develops model rules for district-wide adoption to insure statewide compliance with air pollution control legislation.

The foremost air quality constraint is the New Source Review Rule which is embodied in Imperial County APCD Rules 201-212 (Regulation II-Permits). Currently, this rule applies only to pollutants for which there is a NAAQS. In the Geysers area of Northern California, the New Source Review process has been expanded to include H_2S limitations as well. The ARB's position regarding Imperial County geothermal development is that they would prefer to control Imperial Valley H_2S emissions
before they become a problem. If such a control philosophy is adopted, it will probably 146
be incorporated within the New Source Review process of obtaining "authorities to construct" and "permits to operate."

In addition to possible New Source Review considerations, there are other prohibitons within APCD Regulation IV that may be applicable to the construction of a single power plant or the development of the whole KGRA. These include:

- Rule 401 - Opacity of Emissions (limits opacity of any airborne plant effluent discharge to 20 percent opacity except for condensed vapor plumes)
- Rule 403 - Quantity of Emissions (limits particulate loading of emissions to 0.2 grains per cubic foot of gas emitted)
- Rule 405 - Sulfur compounds (limits sulfur compound emissions to 0.2 percent by volume (2000 ppm) at the point of discharge)
- Rule 407 - Nuisance (prohibits emissions that may cause injury, detriment, nuisance or annoyance to any considerable number of people).

Geothermal-related emissions are typically much less than the limitations imposed because they are usually diluted with large quantities of clean air prior to discharge. The prohibition against causing a nuisance could be applied to a power plant emitting considerable quantities of H_2S. This rule has not been invoked to abate H_2S emissions, but is an important consideration in maintaining a reasonable separation between power plants and any centers of population in the KGRA.

3.4.1.3 Ambient Air Quality

Imperial County is located within the Southeast Desert Air Basin (SEDAB) covering the Imperial, Coachella and Antelope Valleys eastward to the California border. Although the air basin concept suggests that air quality conditions are somewhat uniform within each basin, that is certainly not true within the SEDAB. Close to the Los Angeles urban complex, photochemical smog blowing into the desert is the major air quality problem. In Imperial County, particulate matter especially emissions from agricultural activities including dust generated from disturbed soils, is the primary air quality concern. Air quality for regulated gaseous emissions is recognized as being excellent.

In addition to the parameters monitored or controlled by rule or standards, there are additional considerations that affect people's perception of air quality. In Imperial County these concerns typically include fumes, dusts, odors or gaseous emissions either exempt from air pollution rules or for which no standard has been promulgated. Examples of such emissions include odors from agricultural operations (feed lots, manure compost, alfalfa drying, etc.) or ammonia fumes from fertilizer processing and application. Agricultural odors are specifically exempt from air quality rules, while others, if they impact a significant population, may be abated under air pollution district odor nuisance abatement authority.

The clean gaseous pollution levels and extremely high particulate levels are evidenced in Table 3.4-2, a summary of the last three years of published data (1980 data are not yet completed). Ozone has not exceeded federal standards in three
147 years and, according to EPA guidelines, Imperial County should be designated as an "attainment area" for ozone. However, there have been violations of California ozone standards. Sulfur compounds in the form of sulfur dioxide or sulfate particulates are very low. Lead, an indicator of vehicular activity levels, is also well below the standard and improving every year.

Particulate matter, on the other hand, is among the highest in all of California. In 1979, dust levels exceeded the state standard on nearly every day that they were measured. These high dust concentrations were observed in El Centro and to an even greater extent in Brawley and Calexico. The low sulfate and lead levels in

Table 3.4-2

IMPERIAL VALLEY
AIR QUALITY SUMMARY

	1977	1978	1979
Ozone - El Centro			
Days with 1 Hour ≥ 0.10 ppm	0	6	10
Days with 1 Hour > 0.12 ppm	0	0	0
Maximum Hourly Concentration	0.090 ppm	0.120 ppm	0.120 ppm
Sulfur Dioxide - El Centro			
Days with 1 Hour ≥ 0.50 ppm	0	0	0
Days when 24 Hours ≥ 0.05 ppm	0	0	0
Maximum Hourly Concentration	0.090 ppm	0.090 ppm	0.060 ppm
Maximum Daily Concentration	0.013 ppm	0.009 ppm	0.009 ppm
Particulate Sulfate - El Centro			
24 Hours > 25 μg/m^3*	0/57	0/60	0/57
Maximum Daily Concentration	8.7 μg/m^3	8.4 μg/m^3	10.8 μg/m^3
Particulate Lead - El Centro			
Months ≥ 1.5 μg/m^3*	0/12	0/12	0/12
Maximum Monthly Concentration	1.06 μg/m^3	1.02 μg/m^3	0.59 μg/m^3
Total Particulates - El Centro			
24 Hours ≥ 100 μg/m^3*	37/56	30/61	36/58
Maximum Daily Concentration	328 μg/m^3	303 μg/m^3	406 μg/m^3
Total Particulates - Brawley			
24 Hours ≥ 100 μg/m^3*	52/59	49/59	56/57
Maximum Daily Concentration	491 μg/m^3	602 μg/m^3	645 μg/m^3
Total Particulates - Calexico			
24 Hours ≥ 100 μg/m^3*	55/60	48/58	56/58
Maximum Daily Concentration	503 μg/m^3	550 μg/m^3	520 μg/m^3

*Expressed as number of violations per number of days or months tested.

Source: California ARB, 1977-79.

these particulates suggests that the dust is primarily inorganic silicates from cultivated land or disturbed desert soils. Fortunately, such dust tends to be of a larger diameter more readily filtered by the human breathing passages and is therefore not as closely associated with the adverse health effects resulting from the very small aerosols in urban smog. Since the Valley is expected to continue as a major agricultural producer well into the future, it is similarly anticipated that it will continue to be in violation of state and federal particulate standards. Standards to separate the total dust burden into an inhalable and non-respirable fraction have been proposed. At this time, however, the equipment to separate and measure microscopic dusts is still under development. If and when such equipment is developed, a better definition of Imperial Valley particulate matter/health implications and future dust levels can be formulated.

While the areal extent of air quality measurements is limited to El Centro
148 and particulate data from Brawley and Calexico, these data should be quite representative of the Salton Sea KGRA as well. An extensive air quality and meteorological baseline study by Lawrence Livermore Laboratories from 1976-1978 throughout the Valley demonstrated a fairly homogeneous air quality distribution. Ozone levels in the Salton Sea KGRA were slightly higher and particulate levels were somewhat variable depending on the intensity of agricultural activity near the site. Otherwise, the general conclusion of low gaseous pollutants and high dust levels is a county-wide phenomenon well characterized by the El Centro data.

This baseline study did show some violation of the H_2S standard. On 4 percent of all days (or 14 days between December 1976 and April 1978) the one-hour standard was violated at the Niland monitoring station (Gudikson et al., 1979). However, the validity of these data has been questioned because of quality control of the monitoring program (Air Resources Board, 1980).

3.4.2 Impacts

Air quality impacts from geothermal development center primarily on the emissions of noncondensable materials related from flashed steam geothermal power plants. There are secondary concerns related to development of the geothermal resource itself (drilling, testing, construction, etc.) and some release of material from the power plant cooling systems, but these atmospheric pathways are generally not as significant as the noncondensable gases. For purposes of analysis, certain assumptions regarding levels of H_2S emitted, levels of technology used to generate electricity and potential control of H_2S emissions had to be made. To provide a conservative estimate of these emissions, maximum emissions consistent with supporting data and negligible controls have been assumed. This will, in general, provide a "realistic worst-case" set of assumptions by which to gauge the impact of future development of 1400 MW of geothermal electrical production within the KGRA. Any level of production less than 1400 MW, and H_2S release rates below the high levels assumed (which were found within a few wells to date) or any future H_2S abatement will all serve to reduce the impact predicted in the following discussions.

The air quality impact models require a specific development scenario with locations for all emission sources. The scenario developed for modeling purposes was built upon that described in Section II. No rigorous siting criteria were applied to this distribution of power plants except to concentrate plants near the center of the Anomaly, to maintain one mile separation between two adjacent plants, to maintain reasonable separation from population centers in Niland and Calipatria, and to maintain nominal separation from recreational uses at the Red Hill Marina Campground and County Park. A typical plant size of 50 MW was selected for each generating unit because that currently appears to be the optimum size. By using 50 MW, it was possible to predict the impact from one generating facility and then create a cumulative impact from a number of such units. The initial development of 10 and 28 MW power plants was considered separately. After that, each unit was essentially identical.

Impacts from the development of each power plant have been considered separately, and then combined into a cumulative impact. Areas of analysis include construction and other preoperational impacts, operational impacts of H_2S emissions, and operational non-H_2S air quality impacts. Except for the regional dispersion of H_2S, most impacts are sufficiently localized such that there is minimal interaction between the emissions at one power plant site and those from another site.

3.4.2.1 Preoperational Impacts

a. Single Plant (49-50 MW)

During resource development, there will be temporary emissions from site preparation, combustion emissions from heavy onsite equipment and mobile sources and from testing of the resource during cleanout, flow testing and other preoperational emissions. Construction and preoperational emissions are difficult to quantify because they depend on a large number of variables not precisely known. These parameters include soil characteristics, H_2S content and volume of brine flashed/steam released, location and date of activity, etc. One can therefore only make some general approximations to these multiple unknown factors and thus obtain a corresponding approximate impact assessment. Because the resource development impacts are temporary and confined to a limited area, their effects are minimal on a regional basis. However, these impacts could have a significant effect on the local environs.

103 Fugitive dust from soil disturbance to prepare the power plant site, clear the well pads, dig the sumps, and grade access roads will cause a significantly adverse air quality impact because the Imperial Valley already has a significant dust problem. Based on an estimated 15 acres (6 ha) per plant site, 35 acres (14 ha) for all well sites (later reduced to 14 acres (5.7 ha) as the disturbed land is reclaimed), and 10 acres (4 ha) for pipeline and access roads, about 60 acres (24 ha) will be disturbed per plant during construction. According to EPA estimates, each acre disturbed lofts about 80 pounds (36 kg) of dust into the air each day. If one-half the total acreage for the plant is experiencing construction disturbance at any one time, about 2400 pounds (1089 kg) of dust will be released each day for each plant in construction. If routine watering and other dust stabilization techniques are applied, the dust generation can be reduced to about 1200 pounds (544 kg) of dust per day per plant under construction. Compared to the regional emissions level of 50+ tons (45 Mt) of fugitive dust per day, the KGRA development contribution is small. On a local basis, however, the additional dust emissions may soil vehicles and clothing, settle on nearby plant material and retard photosynthetic activity, and increase the possibility of adverse health effects to nearby residents. Fortunately, construction and soil dusts are usually of a large diameter particle more readily filtered by the human breathing passage. If, though, one is exposed to high dust levels for too often and too long a time, then the protective action of the breathing passages may be hampered with a potential increase of secondary pulmonary infection.

A second impact during preoperational activities results from the diesel drives powering the drill rigs. During drilling, the rigs consume about 550 gallons (208 dal) of fuel per day. Each gallon of fuel burned produces slightly over one-half pound of air pollution. Daily emissions from the drilling operations producing air pollutants are therefore as follows:

Particulates -	18 pounds/day (8 kg/d)
Carbon monoxide -	56 pounds/day (25 kg/d)
Hydrocarbons -	21 pounds/day (10 kg/d)
Oxides of Nitrogen -	258 pounds/day (117 kg/d)
Oxides of Sulfur -	17 pounds/day (8 kg/d)

Daily drilling emissions of hundreds of pounds/day compared to regional emissions of tons/day and any air quality impact from drilling will not be discernible far from the source. While drilling equipment emissions will not result in significant health hazards, diesel exhaust has a very characteristic odor that will tend to linger near the drilling site during the night as winds become light and the atmosphere forms low-level, stable temperature inversions.

Another source of pre-operational air pollution results from various mobile sources used during construction (onsite construction equipment, delivery trucks, concrete trucks, employee commuting vehicles, subcontractor work vehicles, etc.). As with the diesel drive emissions, these emissions are nominal compared to basinwide levels. Because these emissions are temporary and are widely dispersed, their air quality impact would not of itself threaten any ambient air quality standard. Such impacts are therefore a minor air quality effect.

The one area where pre-operational emissions could create a threat to clean air standards occurs when possible concentrated pockets of hydrogen sulfide are encountered during drilling or when the well is completed and the brine is flashed to test the well's production capabilities. Depending on the H_2S content of the noncondensable gases, volume of fluid produced and the dispersion conditions during the release period, the H_2S standard could be violated near the well site.

To test this potential, a mathematical model was utilized in which an H_2S-laden steam plume was allowed to rise under positive buoyancy, and then undergo horizontal transport and dispersion by the prevailing winds. Input parameters for flow testing emissions were derived from the SCE Salton Sea 10 MW plant environmental documents. H_2S, the noncondensable constituent that could potentially cause a downwind odor nuisance, was assumed to be contained in the one percent of the noncondensable gases. For purposes of analysis, the H_2S content of the steam was taken at 0.25 percent of the noncondensables, or 25 ppm in the steam. During flow testing, 400,000 pounds (181,439 kg) of brine per hour were assumed produced from a well with 60,000 pounds (27,273 kg) of the fluid flashing to steam.

These input characteristics were used to initialize the Texas Episodic Model (TEM), (Christiansen, 1975) an EPA-approved short term computer dispersion model. Physical parameters of the release process included the following:

H_2S Emission Rate - 0.189 grams/second
Physical Stack Height - 6.1 meters
Steam Temperature - 148°C

Steam Volume - 26.3 m^3/sec

Ambient Temperature - 20°C

These input characteristics were used to determine the height at which the plume loses its buoyancy and stabilizes using plume rise formulas developed by Briggs (1975). The height of plume rise plus the physical stack height were then used in the TEM model to predict the location and concentration at maximum impact and at selected distances downwind from the well.

Results from these dispersion simulations are shown in Tables 3.4-3 and 3.4-4. The maximum hourly impact from a single well is predicted to be 14.3 $\mu g/m^3$, or 34 percent of the hourly standard. For shorter exposure periods, the H_2S concentration comes closer to the hourly standard of 42 $\mu g/m^3$. Over shorter time periods of a few minutes, the TEM model results suggest H_2S odor may be faintly detectable during testing, but that the hourly H_2S will not be violated or even approached. Table 3.4-4 shows that beyond about one-half mile (800 m), even the short term exposure is much less than the standard such that noticeable air quality effects from well testing are confined to considerably less than 0.5 miles (800 m) from the well site.

These H_2S impacts are superimposed on any other H_2S that may be present in the upwind airstream. These background levels take the form of a very low concentration, highly dispersed overall H_2S background and discrete "spikes" of higher H_2S concentrations from individual sources. The overall average H_2S concentration at full field development was calculated to be around 2 ppb in regional modeling analyses (Section 3.4.2.2.b), but the individual plumes may be much higher. Thus, if the well testing impact is superimposed on the general background, there is little change in the results in Tables 3.4-3 and 3.4-4. If, however, a power plant is directly upwind of a well being tested, their combined effects could possibly threaten the ambient air quality standard for H_2S depending on the proximity of the power plant.

b. Cumulative Impacts

Full field development will require a total of around 1200 wells drilled in the next 30 years, averaging 40 per year. Since testing covers a few days, there may be some simultaneous activities from several well operations in the KGRA. These simultaneous activities may include fugitive dust generation from dirt road travel to several well pads, combustion emissions from several drill rigs operating simultaneously and possibly from two wells flow testing on the same day. Except perhaps for the

Table 3.4-3

WELL TESTING H_2S IMPACT AT MAXIMUM IMPACT LOCATION

Stability Class	Distance (m)	Wind Speed (m Sec^{1})	Equilibrium Height (m)	10 Minute Concentration (μg/m^3)	Hourly* Concentration (μg/m^3)
A	82	5	14.0	20.8	6.2
B	83	6	12.7	25.6	9.6
C	124	6	12.7	26.3	12.3
D	213	6	12.7	24.4	14.3
E	1,471	1	39.5	9.7	7.1
F	2,327	1	33.8	11.1	8.1

*Standard = 42 μg/m^3

Table 3.4-4

WELL TESTING H_2S IMPACT AT VARIOUS DOWNWIND LOCATIONS

Stability Class	Distance (m)	Wind Speed (m Sec^{1})	Equilibrium Height (m)	10 Minute Concentration ($\mu g/m^3$)	Hourly* Concentration ($\mu g/m^3$)
A	400	1	45.8	2.3	0.7
B	400	1	45.8	7.0	2.6
C	400	1	45.8	11.2	5.2
D	400	2	26.0	15.0	8.8
E	400	3	29.3	5.8	4.2
F	400	8	20.0	4.2	3.1
A	800	1	45.8	0.3	0.1
B	800	1	45.8	2.1	0.8
C	800	1	45.8	5.1	2.4
D	800	1	45.8	8.6	5.0
E	800	1	39.5	9.6	7.0
F	800	2	28.1	8.0	5.9
A	1,600	1	45.8	0.04	0.01
B	1,600	1	45.8	0.6	0.2
C	1,600	1	45.8	1.6	0.8
D	1,600	1	45.8	4.7	2.8
E	1,600	1	39.5	7.6	5.6
F	1,600	1	33.8	11.0	8.0

*Standard = 42 $\mu g/m^3$

cumulative effects of multiple dust sources degrading visibility, the full field development pre-operational impacts will not be noticeable on a regional scale, but will remain confined to the immediate environs of the wells or power plants under development and construction. Since H_2S impacts occur principally within one-half mile of a well during flow testing, there will be negligible interaction between scattered wells around the KGRA unless the wells undergoing testing are located within one-half mile (800 m) of each other or less. At any given receptor site within the Salton Sea KGRA, the cumulative impact of multiple facility development is almost identical to the impact of any single facility development.

3.4.2.2 Hydrogen Sulfide Operational Emissions Impact

a. Single Plant (49-50 MW) Impact

By far, the most significant operational air quality concern is that the H_2S emissions from a large power plant may create an adverse odor nuisance downwind from the power plant. Assessing the air quality impact from power plant emissions is difficult because the height at which these normally buoyant emissions reach an equilibrium with their environment is a critical factor in estimating the downwind ambient pollutant concentration. Most models of plume rise are based on hot stack emissions from combustion sources and may not necessarily be applicable to a geothermal power plant. Since, however, the standardized models suggested by the EPA in their Guideline on Air Quality Models (U.S. EPA, 1978) use the combustion source plume rise formulas, there is little choice in applying differing plume rise formulations short of developing and justifying a new set of models. Rather than developing a new set of models, the impact analysis for the 49 MW prototype power plant (and the future assemblage of many such plants) was based on these established models with the understanding that there may be certain shortcomings in the modeling methodology that create some uncertainty in the absolute accuracy of the impact assessments.

H_2S emissions from the 49 MW power plant were assumed manifolded into the cooling towers to benefit from the increased buoyancy by fan-assist from the towers. As with the individual wells, the noncondensable fraction of the steam was assumed one percent by weight and the H_2S content of the noncondensables was taken at 0.25 percent. Each 1 million pounds of steam (necessary to generate 50 MW/hr) thus produces 25 pounds (11 kg) of H_2S released into the atmosphere. These H_2S emissions are released through a multiple cell cooling tower with the following characteristics: 149

H_2S Release Rate (49 MW) = 3.12 grams/second

Tower Height = 15.1 meters

Exit Velocity = 10 meter/second
Cell Diameter = 7.7 meters
Number of Cells = 8 cells
Exit Temperature = 303°Kelvin
Ambient Temperature = 283°Kelvin

To evaluate the ambient H_2S level resulting from this single power plant the above source conditions were used to initialize the TEM (Texas Episodic Model) for a wide variety of possible meteorological conditions to determine both the (17) typical and worst-case H_2S impacts that might result from the plant. The model uses a "dry" plume assumption about plume rise and may therefore underestimate the plume rise when both thermal buoyancy, moisture and multiple plumes from closely spaced sources are involved. If, as suspected, the model underestimates plume rise, then the predicted H_2S levels will be in error on the high side. Such overprediction of project impact is obviously preferable to any underprediction.

As with the single well emissions, the model uses a Brigg's Plume Rise Model to estimate equilibrium plume heights. For various wind and stability conditions, the height of the power plant cooling tower plumes are predicted to be as shown in Table 3.4-5. Light wind conditions will allow plumes to rise from 300-670 feet (90-205 m) above the surface. Under very windy conditions, the plume will turn over rapidly and will not rise much more than 125-260 feet (40-80 m) above the surface. For the rapid diffusion that occurs during the daytime, highest ground level concentrations will result near the plant under windy conditions. For the slower diffusion process at night, highest concentrations will result farther away from the plant under light windy conditions.

When the plume rise estimates are applied to the TEM dispersion model, the qualitative thoughts about impact magnitude and location are borne out by the calculations. Table 3.4-6 shows that the highest hourly predicted project impact is 33.5 $\mu g/m^3$ (compared to the standard of 42 $\mu g/^3$) under Pasquill "C" stability and very strong (10 m/sec) winds at a distance of 1200 feet (366 m) from the plant. These calculations assume a completely clean (zero H_2S) background. If there is a significant H_2S level from other sources or for time periods of much less than one hour, the ambient concentration may be above the standard of 42 $\mu g/m^3$ level. All significant hourly concentrations (>10 $\mu g/m^3$) occur within about one mile (1600 m) of the source, with most noticeable impacts predicted even closer (within about one-half mile). With the major power plant pollution confined close to the plant and minimum plant spacing of

Table 3.4-5

PLUME RISE ESTIMATES (METERS ABOVE SURFACE) FOR SALTON SEA KGRA

Cooling Tower Plumes - 49 MW Power Plants

	WIND SPEED (m/sec)							
	1	2	3	4	5	6	8	10
Unstable + Neutral Conditions	204.7	109.9	78.3	62.5	53.0	46.7	38.8	34.1
Slightly Stable Conditions	129.4	105.8	94.4	87.1	82.0	78.0	72.3	68.2
Very Stable Conditions	109.9	90.4	80.9	74.9	70.6	67.3	62.5	59.1

Table 3.4-6

MAXIMUM H_2S AMBIENT AIR QUALITY IMPACT (49 MW)

Hourly H_2S Concentrations ($\mu g/m^3$)

Stability Class	Wind Speed (m/sec) 1	2	3	4	5	6	8	10
A	12.41	15.83	18.67	20.45	21.58	22.26	22.80	22.70
B	9.77	15.01	18.45	21.01	23.15	24.70	26.58	27.41
C	9.51	16.30	21.27	24.93	27.63	29.60	32.26	33.48
D	3.14	7.43	10.88	13.77	16.14	18.06	20.83	22.55
E	10.92	9.78	9.09	8.60	7.86	7.39	6.68	6.16
F	9.34	9.02	7.26	7.13	7.01	6.89	6.68	6.49

Distance of Maximum Impact (meters)

Stability Class	1	2	3	4	5	6	8	10
A	618	408	314	263	231	209	181	164
B	1,356	776	572	445	374	327	269	234
C	2,575	1,316	912	715	599	522	422	366
D	9,149	3,606	2,202	1,586	1,248	1,037	792	655
E	9,760	6,421	5,527	4,991	4,633	4,288	3,801	3,468
F	23,479	13,748	9,639	7,806	6,646	5,838	4,775	4,099

perhaps one mile or more, high concentrations from several plants will not overlap during full field development. Upwind sources (power plants, wells, fugitive and natural sources) may raise the background level and eventually cause a downwind plant to exceed the clean air standard, but the data in Table 3.4-6 suggests that any single plant will not of itself cause the California H_2S air quality standard to be exceeded.

The maximum hourly impacts, in addition to assuming no significant plume superposition, are also applicable only to a 50 MW source emitting 25 pounds (11 kg) of H_2S per hour. Any plant complex of greater capacity or utilizing "dirtier" steam would create higher concentrations in direct proportion to the H_2S emission rate. With somewhat greater H_2S emissions, a single unit could by itself cause the 42 $\mu g/m^3$ standard to be exceeded, while any abatement, cleaner steam, or a smaller unit would create a correspondingly lower ambient H_2S impact. (18)

b. Cumulative Development (1400 MW)

The siting of multiple power plants within the Salton Sea KGRA is indeed the mechanism by which general background pollution levels can be sufficiently elevated to cause isolated violations of the air quality standard. If each power plant producing 50 MW adds 25 pounds (11 kg) of H_2S to the air each hour, areawide release rates could reach 700 pounds (318 kg) per hour. If all plants are not operating at full capacity at any given time the areawide emission rate would be correspondingly less.

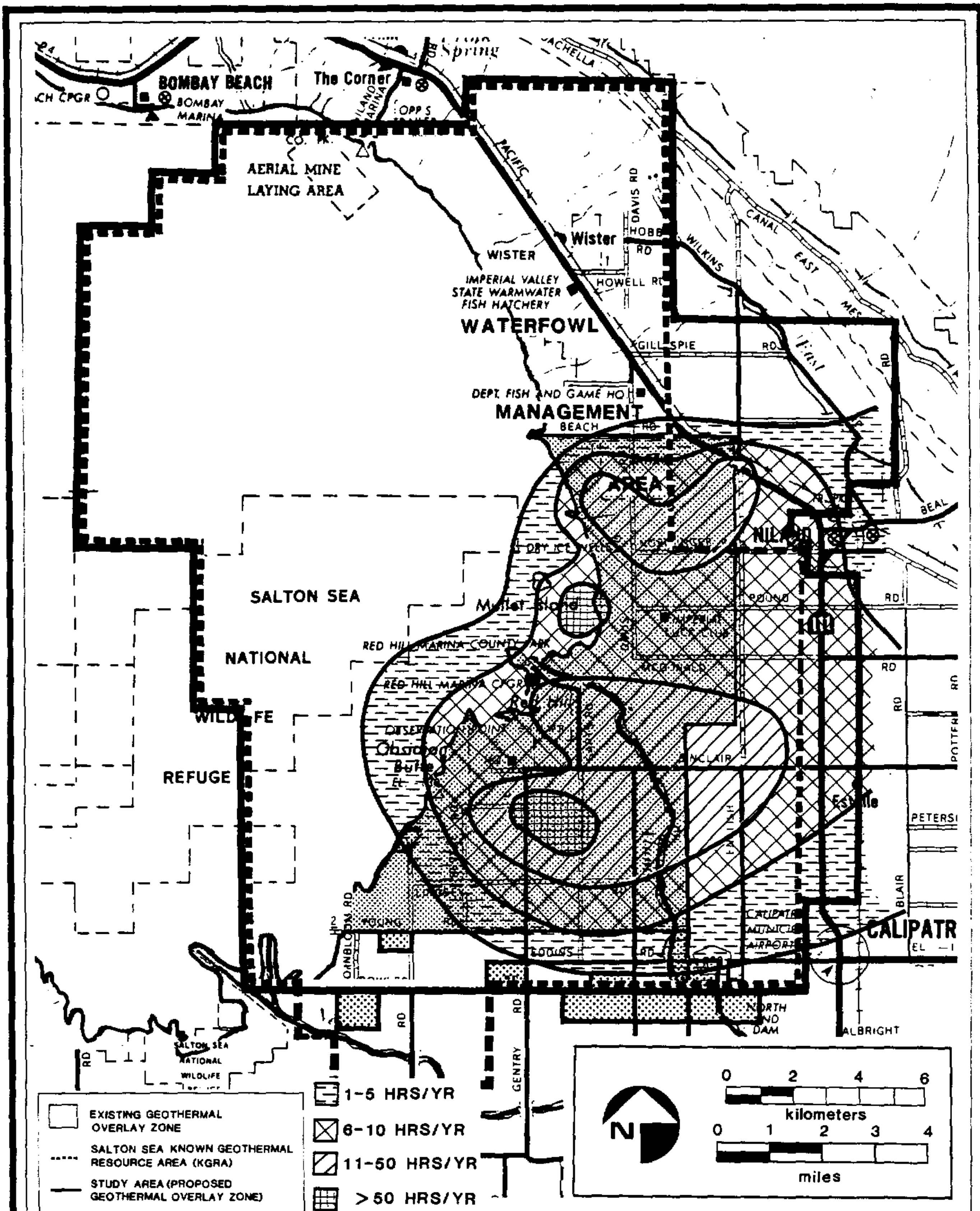
A simple air quality model developed by Hanna (1971) allows one to approximately determine the long-term areawide background level from multiple sources. The Hanna Model is expressed by:

$$\chi(H_2S \text{ Conc.}) = C \frac{Q(\text{area source strength})}{U(\text{mean wind speed})}$$

where C is an empirical constant. Using Hanna's value of C=50, an average wind speed of 7.5 knots and 700 pounds (318 kg) of H_2S released over about 100 square miles (259 sq km) of the KGRA each hour the Hanna Model predicts a long-term (annual) average of 3 $\mu g/m^3$. Since the winds will be blowing H_2S away from pollution sources in other directions besides toward any given receptor, the daily or hourly background concentration will be much higher.

To better define the annual composite background level estimates, a more sophisticated modeling approach was applied using the EPA's Climatological Dispersion Model (CDM) (Busse and Zimmerman, 1973). CDM was used to calculate annual H_2S concentrations at 200 specific receptors from 29 separate power plants. As previously noted, these plants were geographically distributed quasi-randomly except for the first three sites (10, 28 and 49 MW) for which precise locations are known. CDM predicts the annual average using information of wind frequencies for 16 directions, 6 wind speed groups and 6 stability classes (576 data entries) based on the National Oceanic and Atmospheric Administration (NOAA) STability ARray (STAR) structuring of available meteorological data. The STAR data for El Centro was used since this was the nearest data resource representative of the Salton Sea KGRA. Information on inversions, diurnal emissions behavior, diffuse area source contributions and other input parameters were selected to give a realistic, but still conservative impact assessment. The final result from this very involved modeling exercise was that the mean annual average background H_2S concentration ranged from a peak of 3.6 $\mu g/m^3$ near the center of the KGRA to a low of $0.5 \mu/m^3$ over the Salton Sea itself away from development. The close agreement between the simple Hanna Model and the detailed CDM computer simulation helps to verify the calculations since both predicted values near $3 \mu g/m^3$.

With an annual average of almost 10 percent of the hourly standard, one can be relatively sure that hourly concentrations are going to be much higher. To try to extend the utility of the CDM results, a peak to mean ratio of H_2S measurements from the Geysers was applied to the Salton Sea KGRA data as well. It should be noted that this procedure overstates the impacts because the data from the Geysers was gathered to determine maximum concentration at specific sites rather than general average concentrations. By assuming that this ratio will be approximately valid and that extreme value distributions are log-normally distributed, one can then use the annual average data to extrapolate an estimated frequency of violations of the H_2S standard and an approximate hourly maximum concentration for the year. The resulting distribution is shown in Figure 3.4-1. In the area of heaviest concentration of power plants, the standard may be exceeded for slightly more than 50 hours per year (or 0.6 percent of all hours). Within much of the area of probable extensive geothermal development, the standard may be exceeded between 10 and 50 hours with a decreasing violation frequency of about 5 hours per year in Niland and 1 hour in Calipatria. As noted previously, the number of standard violations is not necessarily the same as the number hours when odors may be detected. Odor may be noticeable more frequently because higher concentrations may exist for short periods of time but when averaged



Predicted Frequency of H_2S Standard Violations At Salton Sea KGRA Full - Field Development (Hrs / Year) (Assuming no Abatement)

FIGURE 3.4-1

over one hour no violation will have occurred. In terms of annual maxima, the contours in Figure 3.4-1 translate into projected hourly maximum concentrations as follows:

1 HR/YEAR => 30 ppb Maximum Concentration
5 HRS/YEAR => 42 ppb Maximum Concentration
10 HRS/YEAR => 55 ppb Maximum Concentration
50 HRS/YEAR => 90 ppb Maximum Concentration

At this point, it is difficult to predict with confidence what degree of abatement, if any, may be necessary to eliminate the predicted problem of H_2S odor nuisance. In each case above, the higher concentrations are directly attributable to one or two individual power plants near a given receptor. The model indicates that for these few plants 70 percent abatement is the maximum that would be necessary to eliminate all predicted violations. For the rest of the power plants, especially those on the periphery of the study area, modeling efforts suggest that less than 50 percent abatement would be necessary. It should be noted that the projected maxima were derived from a model that tends to underpredict plume rise and thus overpredict H_2S concentrations. It should also be stressed that pessimistic assumptions were made about the resource that may turn out to be very inaccurate. When more data and experience is gained from the first few power plants, more precise modeling can be done that might serve as the basis for future decisions about the degree of abatement necessary. As plants are built, baseline H_2S monitoring will be necessary to confirm the relationship between H_2S emissions and ambient air quality. It can be said that even at full field development, the H_2S problem in the Salton Sea KGRA will not be as
150 severe as at the Geysers KGRA. With regard to the Geysers, current predictions are that H_2S air quality standards at locations outside the immediate area of geothermal development will meet the ambient air standard when regional emissions reach around the same value used in the Salton Sea H_2S impact analysis (700 lbs/hour). Standards near the plants may sometimes still be exceeded. It should also be noted that the above estimates of about 50 hours per year of violations are much lower than the Lawrence Livermore Laboratory (LLL) estimates of hundreds of hours (Layton, 1980). This disparity is probably attributable to LLL's exclusive use of 100 MW power plants instead of dispersing some of the emissions into 50 MW sources. If the maximum hourly impact were doubled, then the maximum ground level concentration would also almost double (depending on any background from other sources). Based on a worst-case assumption of two 100 MW power plants in close proximity, a maximum impact of almost 180 ppb H_2S would be expected. Extreme value plots of the impact data predict over 400 hours of violations of the state H_2S standard which is consistent with the LLL study.

Based on the above findings, it appears likely that multiple power
plant development could lead to future violations of the H_2S standard. The degree of
abatement needed to reduce that impact is not precisely known at this time, but is 105
probably not as stringent as the abatement efficiency requirements placed on new plants in the Geysers with its higher H_2S steam content. While some future violations appear possible the predicted small area and small magnitude of these violations suggest that reasonable control efforts and abatement would suffice to allow full field development with little or no threat to maintenance of the H_2S ambient air quality standard.

3.4.2.3 Non-H_2S Air Quality Impacts

Because the nature of the geothermal resource and the potential effects of small amounts of various elements in the effluent were not well understood, there has been a considerable concern at times about other pollutant emissions besides H_2S. Subsequent research has usually shown the problem to not be as significant as was often initially anticipated. Some of these problems included radioactive radon emissions, acid rain formation from the oxidation of H_2S to sulfuric acid, trace elements in the cooling tower drift, and salt deposition from concentrated saline cooling water.

a. Single Plant (49-50 MW) Impact

1. Gaseous Emissions

Layton (1980) has performed a detailed analysis of non-H_2S gaseous emissions from a prototype 100 MW Salton Sea KGRA power plant and found the air quality impact from such a source to have no potential for adverse health effects. Gaseous elements in the noncondensable portion of the steam included ammonia, carbon dioxide, methane, mercury vapor, radon and benzene. The results of these dispersion estimates, modified for a 50 MW unit considered in this study, were as follows:

Species	Standard	Predicted Concentration (% of Standard)
Ammonia	3.5×10^4 µg/m^3 (8 Hours)	< 5 %
Mercury	100 µg/m^3 (8 Hours)	< .25%
$Radon_{222}$	10 pCi/m^3	< .5%
Benzene	3200 µg/m^3 (proposed)	< 2%

Increases in carbon dioxide (there is no CO_2 standard) were predicted to be within the standard deviation of baseline levels measured in the Imperial Valley. Since none of the pollutant increases remotely approached the health standard, the effects of these non-condensable gases were assumed minimal. While this argument is probably valid, considering the large difference between the impact and the standard, it should be noted that the standards are occupational health standards (for all except radon), and are not ambient air quality standards. The occupational health standards are designed to protect a healthy adult worker, not necessarily somebody whose condition might be aggravated by the additional exposure to small amounts of airborne chemical irritants. Nevertheless, the fact that the predicted concentrations are so far below the health standard should insure that impacts from the non-H_2S gaseous emissions will be negligible.

Appendix 3.4 contains a health effects analysis prepared for a Geysers power plant that better discusses the safe levels of exposure to geothermal pollutants (CEC, 1979). The discussion on health effects should be appropriate for the Salton Sea development concerns.

2. Solid Emissions

Solid materials may enter the atmosphere via drift droplets (liquid material escaping from the cooling towers). Depending on the chemistry of the cooling water, small amounts of undesirable materials may become airborne by this pathway. Because the evaporative cooling process leaves behind a concentrated brine solution that evaporates even more after entering the atmosphere, the subsequent deposition of such material on downwind surfaces could have corrosive or toxic effects. If such material evaporates completely, the solids in the drift form microscopic crystals that remain suspended in the air for long periods. They thus contribute to the already high TSP (total suspended particulate) levels of the Imperial Valley and are furthermore of such a small diameter that they are readily inhaled and absorbed by sensitive tissues in the deep lung area. These particulates, because they contain hygroscopic salts, may acquire a liquid coating at humidities of much less than 100 percent and contribute to the formation of a marine-type haze found in salty coastal environments.

There are four primary concerns related to the release of solid materials. In addition to the increased TSP levels, these concerns include the deposition of concentrated saline droplets on nearby surfaces, the deposition of inhibitors and biocides added to the cooling water to control scale and biological growth and the possible release of boron. Boron may be carried over from the geothermal fluids into the cooling water if steam condensate is used for cooling water. Estimating the impacts from these release pathways is difficult because cooling water make-up sources have not been selected, cooling tower suppliers have not been contracted and chemical additives cannot be selected until the cooling water chemistry is known. Even if these parameters are known, the models that might translate the drift release from the cooling towers into a downwind environmental impact are not well established. The assessment of the impact from the release of solid materials is thus very approximate.

In order to estimate the impact from the drift droplet release, certain assumptions relative to cooling tower operations were made. These include assumptions about circulation rates, cooling tower performance specifications, drift droplet size distributions and drift eliminator efficiencies. As with other elements of this analysis, the most representative data were used when available, and reasonably conservative assumptions were made when there were no data available. The cooling tower for a typical 50 MW plant was assumed to circulate 60,000 gallons per minute in an 8 cell mechanical draft cooling tower. The drift eliminator efficiency was rated at 99.995 percent, which is readily available by current technology. Based on a design total dissolved solids (TDS) level of 4000 ppm, the following is an estimate of the net particulate burden from the cooling system:

60,000 gallons/minute x 1440 min/day x 8 lbs/gallon x 0.004 TDS
x 0.00005 drift elimination = 138.2 pounds of salt per day

Part of this salt will remain suspended in the air and part will fall to the ground near the cooling tower.

To define how the total salt release is allocated between the suspended and deposited fraction, the salt deposition model developed by Hosler, Pena and Pena (1972) was used to determine how large a particle needs to be to survive passage through the Imperial Valley's dry air to be deposited on surrounding surfaces. Their model predicts that droplets of 280 microns or smaller diameter, under average Imperial Valley wind and relative humidity conditions, will evaporate. If one therefore had some breakdown of the drift droplet size distribution, then the evaporation/deposition split could be quantified.

The distribution selected was supplied by Marly Corporation, a commercial supplier of similarly sized mechanical draft cooling towers. Table 3.4-7 shows that while most of the droplets are very small (92 percent are smaller than 50 microns in diameter), most of the mass is concentrated in the large droplets. Using the Hosler model cut-off of 280 microns, 33 percent of the droplet's

Table 3.4.-7

TYPICAL SIZE AND MASS
DISTRIBUTION OF DRIFT PARTICLES

(Hosler Model Cut-off Evaporation/Deposition
Split Shown With Associated Mass Fractions)

Droplet Diameter (μm)	% of sample By Number	% Mass By Droplet Size
50	92.153	9.189
90	2.150	1.250
110	0.691	0.733
140	1.044	2.286
180	0.829	3.858
220	0.767	6.523
260	0.675	9.474
300	0.583	12.570
340	0.460	14.447
380	0.291	12.773
420	0.175	10.349
460	0.098	7.633
500	0.049	4.902
540	0.018	2.315
580	0.007	1.099
620	0.002	0.408
660	0.001	0.141
700	0.001	0.050

Source: Marley Corporation, 1975.

mass evaporates and 67 percent deposits out. At 138 pounds (63 kg) per day, 46 pounds (21 kg) per day per 50 MW plant are added to the basin particulate burden and 92 pounds (42 kg) are deposited out. The 46 pounds/day (21 kg/d) are nominal compared to basinwide TSP emissions, but as previously noted, the salt crystals are very small and easily inhaled. A 10 μm drift droplet evaporates down to a 1 μm salt crystal. If the cooling water were to contain any harmful solids, the salt crystallization process provides a pathway into human and animal lung tissue. While significant amounts of harmful constituents are not anticipated, reasonable precautions and periodic testing are needed to confirm this assumption.

In addition to the respirable fraction, the deposition of 92 pounds (42 kg) of salt per hour represents a possible adverse impact on surrounding plant communities. Much of this material will be deposited close to the cooling tower distributed according to the prevailing winds. The highest deposition rates will usually occur along the east side of the plant boundary because of the dominant west winds. Assuming that half of the salt is deposited within 500 feet (152 m) and a 20 percent annual frequency of occurrence of winds from the west (an overestimate), the downwind salt deposition is almost 200 pounds/acre/year (91 kg/ac/yr). This is about the same rate of salt supplied by 1 acre-inch of irrigation water containing 1000 ppm TDS. Covering a field with 1 inch (2.54 cm) of water supplies the same salt as the maximum annual cooling tower impact. 200 pounds/acre/year is also about the same rate as natural deposition of sea salt at a distance of 1.5 miles (2.4 km) from the ocean. Since there is typically little evidence of leaf mottling from ocean salt at 1.5 miles (2.4 km) from the beach, one would anticipate that cooling tower drift droplet deposition would have similarly nominal effects unless the drift contained substances of higher toxicity than the chlorides and sulfates normally found in the cooling water.

Higher toxicity would come from borates or biocides that could be present in the cooling water. If the initial demonstration plants are found to contain large fractions of boron or require potent biocides, then more detailed computer modeling of actual deposition patterns may be required to demonstrate the magnitude of such impacts. With considerable boron emissions and drift elimination efficiencies below those considered for the Salton Sea KGRA, Geysers cooling tower drift emissions impacts have been shown to be limited to only the most sensitive species within a few hundred feet from the towers. While one would therefore expect similarly minimal impacts at the Salton Sea, particularly since toxicity decreases with decreasing relative humidity, a final assessment of boron/biocide impacts will require a better definition of the source strength of such emissions derived from actual operational requirements and measurements.

b. Cumulative Development (1400 MW)

Gaseous dispersion theory has shown that maximum impacts occur within one mile (1600 m) of a plant. Since plants are assumed to be spaced one mile apart or more, there is little potential for multiple plant interaction. Since the ambient air quality impact from any single plant is so low compared to any health standards for non-H_2S gaseous emissions, even when one upwind plant causes a rise of background levels at the downwind plant, there is little or no potential for causing significantly high ambient concentrations.

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Because solids such as drift droplets are heavier than air, they fall even closer to the plant site than where the gaseous pollutants mix by turbulent processes. Thus, as with the gaseous material, there is no potential for plant overlap. Salt deposition rates from one tower near a downwind tower average 1-2 pounds/acre/year (0.5-1 kg/ac/yr). The overlap of this small amount on the several hundred pounds/acre/year single plant maximum is insignificant considering the uncertainty in the deposition prediction technique. Total suspended salt emissions average about 1 pound/day/MW capacity; full field development thus will add about 1400 pounds (635 kg) to the Valley dust burden. Such an increase is significant because of the current nonattainment status of the Valley for particulates and may also contribute to a general haze on damp mornings or evenings.

3.4.3 Mitigation Measures

For each of the three major impact areas - fugitive dust, hydrogen sulfide and cooling tower drift - there are possible mitigation measures to reduce the impact of geothermal resource development. These measures may require some modification on a site-by-site basis, but should in general prove effective throughout the resource development process. These measures include:

Fugitive Dust

- Apply dust control measures (watering, clean gravel, soil stabilizers or oil) to access roads, well pads and plant site areas.
- Where feasible, construct gravel or paved parking lots and entrances.
- Enforce reduced speed travel by drilling and maintenance personnel on unpaved roadways.
- Limit public access to well sites and on access roads through gates or fences.

Hydrogen Sulfide	-	Future siting efforts should avoid lining up power plants along major wind axes. This will help prevent overlap of pollution plumes and thus reduce the possibility of standard violations. (104)
	-	Site all power plants at least .6 mile (1 km) from populated areas and other sensitive areas.
	-	Monitor ambient H_2S levels near plants to determine if air standards are being violated and thus require supplemental abatement.
	-	Process noncondensable gases through a supplemental abatement process, if necessary. Potential supplemental abatement includes processing gases through a reactor/clarifier to reabsorb H_2S for injection with spent brine, the EIC copper sulfate process, the Stretford process, the Dow deoxygenation proces, or the iron catalyst method.
	-	Research upstream abatement techniques to change brine chemistry to remove H_2S before flashing.
Drift Droplets	-	utilize cooling towers with high drift elimination efficiency.
	-	Orient cooling towers along axis of maximum wind speeds to reduce downwash potential.
	-	Organize plant layout to site cooling towers away from adjacent fields to prevent deposition of heavy splash droplets where possible.
	-	Monitor cooling water chemistry to determine if excessive levels of boron or biocides are reached.

3.5 ACOUSTICAL ENVIRONMENT

3.5.1 Existing Conditions

3.5.1.1 Introduction

A combination of existing community noise levels, land use sensitivities, and legal guideline restrictions serves to establish what impact the sounds of proposed geothermal development would have on the surrounding areas. Existing high noise levels may tend to mask noise emissions from proposed development, whereas existing lower levels may help highlight noise intrusion from new geothermal development. The existing and/or planned land use in and near the proposed overlay zone and the legal restrictions pertaining thereto will limit noise intrusions into potentially sensitive areas. However, in a practical sense, beyond legal requirements, probable impacts from proposed development can only be assessed through comparisons with existing noise levels. Therefore, as a basis for impact evaluation, this section documents both existing and new community noise survey data for the study area. Data are presented for the area both by geographical location and by typical land use category to provide a basis for determining potential environmental (community) noise conflicts from geothermal development and to establish benchmark, pre-development, community noise levels.

3.5.1.2 Ambient Noise Levels

The ambient noise level is the background or existing noise level from the area surrounding the proposed study area prior to development. Ambient noise benchmark levels must be determined to establish a criterion by which noise levels from the proposed project can be evaluated. Several methods of determining this existing noise environment are available including actual measurement during different times of the day, use of prior noise measurements for the site's area, calculations of the noise levels based on an inventory of noise sources indigenous to the area, and/or a combination of measurements and calculations. All the following methods were used:

- mathematical predictive methods including the generation of railroad right-of-way noise contours for the Southern Pacific Transportation's railroad traffic, and the Federal Highway Administration's Traffic Noise Prediction Model FHWA-RD-77-108 for State Highway 111;
- inductive methods based upon previous data on typical environmental noise sources;

- an environmental noise measurement survey of the project area using community noise analyses equipment calibrated traceable to the National Bureau of Standards; and
- previously published noise measurement data for the study area.

a. Community Noise Survey

A community noise survey was performed in the proposed geothermal overlay zone and in the adjacent communities of Niland and Calipatria. The purpose of this survey was to provide an area-wide characterization of the existing acoustical environment for later comparisons with projected noise levels from proposed geothermal development. In the survey, existing ambient community noise levels and their variation with time of day were determined. Specific noise sources and their relative contribution to the overall existing noise level were also examined and recorded. These ambient noise levels include both normal background, (L_b), environmental sounds from all existing sources, and from specific identifiable local and stronger distant sources. The survey data thus becomes, in effect, both a record of noise levels and an inventory of specific sources and their relative level. This provides the basis for a characterization of the pre-development ambience and an objective documentation for comparison with projected project levels and applicable standards.

Measurement of the ambient noise level is an objective determination of the acoustic environment and as such does not indicate the response of an individual or community to the existing sound environment. Community response evaluations require the consideration of several objective and subjective factors which have resulted in the development of various noise indices or noise environment descriptions. Some of these objective noise indices were used to evaluate the measured data and are presented with the data.

The proposed Salton Sea Geothermal Overlay Zone is located in an area that contains agricultural and open desert land, an inland sea, valuable wetlands that serve as wildlife refuges and recreational hunting/wildlife management areas, rural residences, small towns and some industrial facilities. To accurately depict the acoustical environment, 26 sites were chosen on both a geographical and a land use basis (see Figure 3.5-1 and Appendix 3.5, Figure A3.5-1). These locations include typical open desert, agricultural land, rural residential, school, town, industrial, recreational, and wetland refuge areas. Also included is the proposed construction site for a 49 MW power plant. The survey methods are explicitly described in Appendix 3.5. The survey results are summarized below.

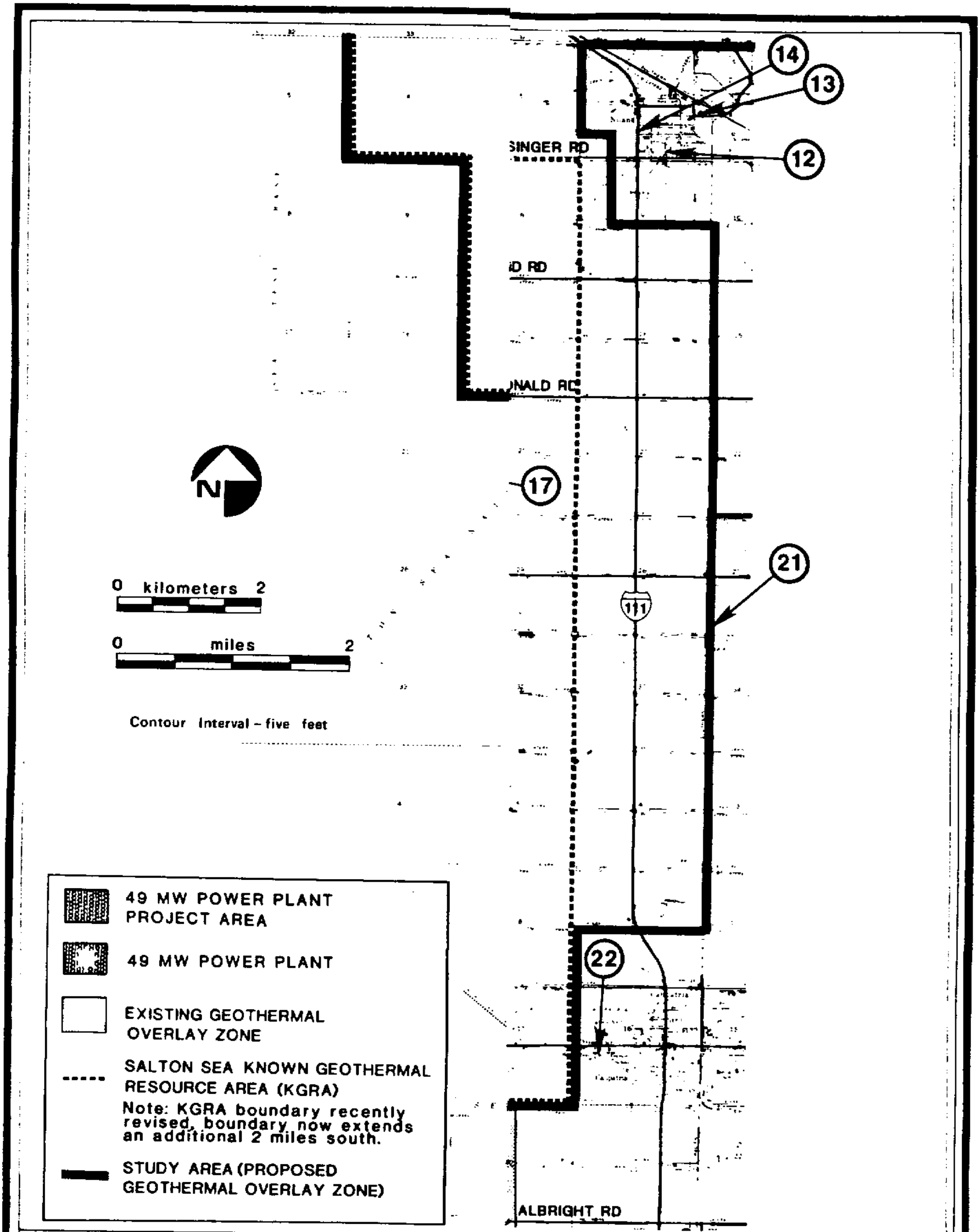

SINGER RD
D RD
NALD RD
ALBRIGHT RD
111
14
13
12
17
21
22
N
0 kilometers 2
0 miles 2
Contour Interval - five feet
49 MW POWER PLANT PROJECT AREA
49 MW POWER PLANT
EXISTING GEOTHERMAL OVERLAY ZONE
SALTON SEA KNOWN GEOTHERMAL RESOURCE AREA (KGRA)
Note: KGRA boundary recently revised, boundary now extends an additional 2 miles south.
STUDY AREA (PROPOSED GEOTHERMAL OVERLAY ZONE)

FIGURE 3.5-1

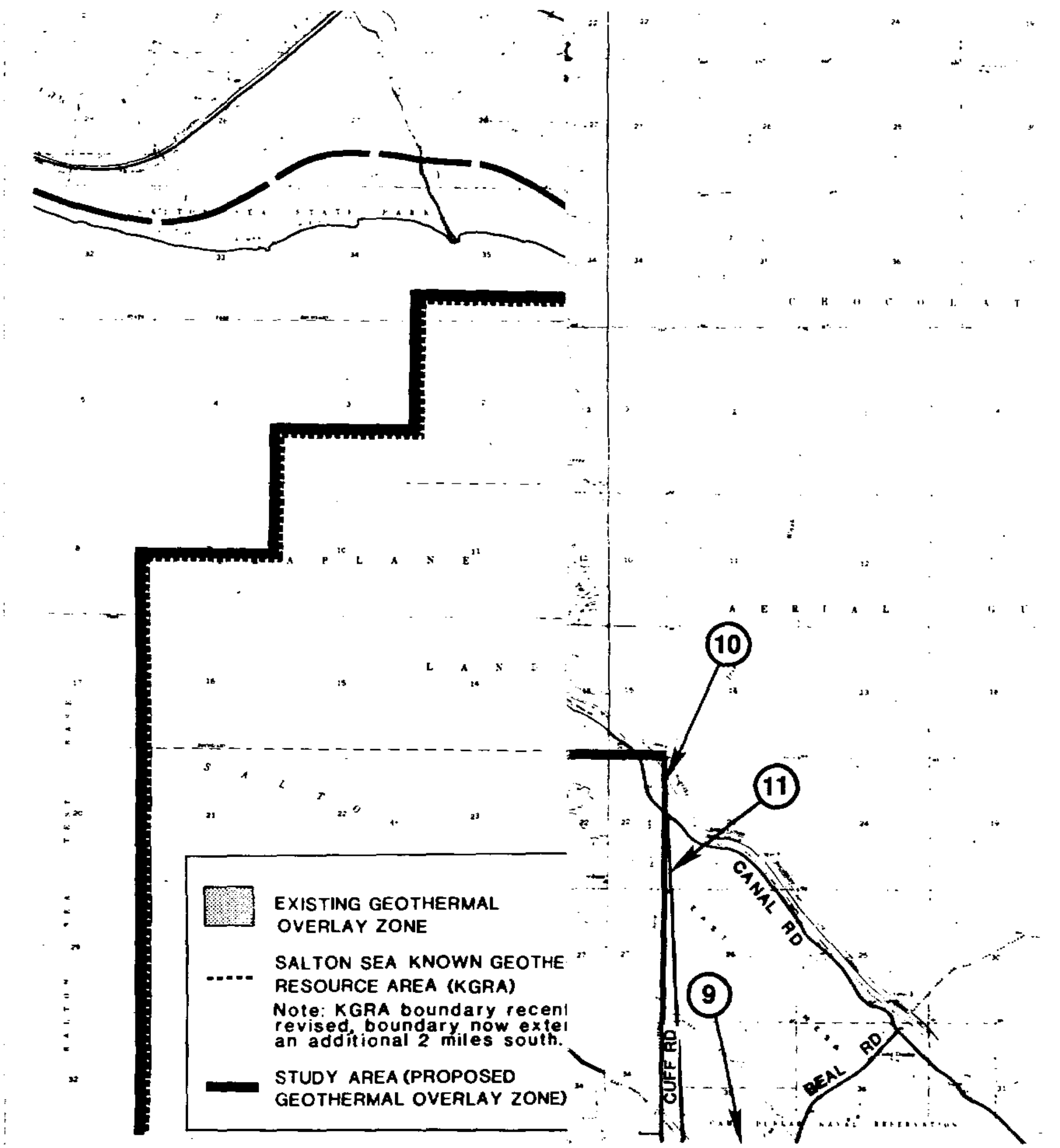

SALTON SEA STATE PARK
CHOCOLAT
APLANE
LAND
AERIAL GU
SALTO
10
11
9
CANAL RD
BEAL RD
CUFF RD
EXISTING GEOTHERMAL OVERLAY ZONE
SALTON SEA KNOWN GEOTHE
RESOURCE AREA (KGRA)
Note: KGRA boundary recent
revised, boundary now exte
an additional 2 miles south.
STUDY AREA (PROPOSED GEOTHERMAL OVERLAY ZONE)

FIGURE 3.5-1

The highest weighted community noise level (L_{dn}/CNEL), calculated in decibels (dB) from the measurement samples, was an L_{dn}/CNEL of 71/72 dB measured near a cotton processing mill. The lowest level was an L_{dn}/CNEL of 32/33 dB for the open desert area near Cuff Road at the Coachella Canal. In Niland, typical noise levels, away from Highway 111, were in the L_{dn}/CNEL range of 60/61 to 58/61 dB. In the main Niland business area, the noise levels were an L_{dn}/CNEL of 68/68 dB, one of the three highest noise levels experienced in the survey. Typical sounds ranged from 23 dB(A) for crickets in agricultural areas to 84 dB(A) peaks for freight train passages along the Southern Pacific Railroad right-of-way. Other sounds were agricultural machinery at 70-73 dB(A), distant hunters' gunfire at 42 dB(A) and children on the playground at school, 74 dB(A). A more complete list on a site specific basis is presented in Appendix 3.5.

The results of the community noise survey show that most of the proposed development area is in open land with relatively low ambient noise levels and that there are few sensitive receivers. As can be expected, Niland and Calipatria, being urbanized areas, and both adjacent to Highway 111 and the Southern Pacific Railroad have higher noise levels. They also incur higher levels of vehicular traffic, one of the major contributors to community noise. Typical noise levels in the northern sensitive wetland wildlife areas range from 36 to 39 dB(A), which was largely from highway traffic on Highway 111. In the southern wetland wildlife areas away from the highway, the levels averaged from 30 to 41 dB(A) and dropped to as low as 28 dB(A). In the offshore locations, traffic noise can be expected to diminish with distance from the transportation corridors and urbanization.

b. Existing Measurement Data

Several locations in the study area have been the subject of prior community noise investigations. The data from these studies is presented in the following material.

Ambient noise levels were measured at several locations in the northern Imperial Valley (Brawley and Salton Sea KGRAs) as part of the Imperial Valley Environmental Project (IVEP) (Nyholm and Anspaugh, 1977; Leitner, unpublished data, 1979). These measurements were made in open-space areas used for agriculture and wildlife habitat. At some locations no man-made noise sources were audible, while at others, distant aircraft, vehicular traffic, or farm machinery contributed to the measured noise levels. Most values were below 40 dB(A), although about one-third (9 out of 26) ranged from 41 to 50 dB(A) (Table 3.5-1) (Leitner, 1979).

Table 3.5-1

AMBIENT NOISE MEASUREMENTS IN OPEN-SPACE AREAS OF IMPERIAL VALLEY

Location	Range in Sound Pressure Level (dB(A))	Number of Measurements
Imperial Wildlife Management Area		
Wister Unit	27-50	8
Finney-Ramer Unit	29-49	8
Salton Sea National Wildlife Refuge		
Headquarters Unit	38-44	6
South Unit	33-37	4

Source: Nyholm and Anspaugh, 1977
Leitner, unpublished, 1979

Table 3.5-2 presents the ambient noise levels measured by Edison personnel in 1980 for the two sites associated with a proposed Salton Sea 10 MW Geothermal Demonstration Facility (County of Imperial, 1980).

Table 3.5-2

AMBIENT NOISE LEVELS[1]

Location[2]	CNEL	L_{dn}	L_{max}	L_1	L_{10}	L_{50}	L_{90}	L_{99}
1	52	50	69	63	48	34	30	24
2	52	50	69	63	44	34	30	28

[1] A-weighted decibels.

[2] At locations shown in Figure 3.5-1.

c. Calculated Noise Levels

Two sets of calculated noise levels, 1) the L_{dn} and CNEL and 2) the Southern Pacific Transportation Company's railroad tracks and Highway 111, are described in detail in Appendix 3.5. Using these noise levels, noise contours were determined and are demonstrated on Figure A3.5-2 in Appendix 3.5.

3.5.1.3 Existing Noise Standards

The proposed Salton Sea Anomaly Geothermal Overlay Zone encompasses a large area of diverse land use including: residential, agricultural, open desert, recreational, inland sea and protected wildlife habitat, commercial, mining, and industrial uses. Although specifically excluded from the overlay zone, the towns of Niland and Calipatria are immediately adjacent to the overlay zone and therefore have a potential of being affected.

Standards or regulations to limit noise pollution are generally imposed with a goal of protecting people and animals from undue health effects, activity interference, and annoyance. Limitations on the community noise emissions from a particular site (source) usually are based on the surrounding uses (and hence sensitivity) and the existing noise environment without the source in question. Federal, state and local noise regulations, standards, and guidelines apply to the proposed geothermal development of the Salton Sea Anomaly. The various noise standards that exist and that are applicable to the proposed development are documented and discussed in detail in Appendix 3.5 and briefly summarized below. It is these standards that, together with the existing noise environment and projected noise levels for the proposed geothermal development, provide for the assessment of possible impacts in the following sections.

This study is concerned only with community noise; the province of worker habitat and relationship to their tools/machinery is not addressed here, but is administered by the Federal Department of Labor under the Occupational Safety and Health Act (OSHA), May 29, 1971. (19)

a. Federal Regulations and Guidelines

The standards and guidelines that are considered in this report that are federally based were issued by the Department of Housing and Urban Development (HUD), the U.S. Environmental Protection Agency (EPA), and the U.S. Geological Survey (USGS). 1) HUD standards dictate that the magnitude of the external noise environment at a site be determined by the value of the day-night average sound level produced as a result of the accumulation of noise from all sources contributing to the external noise environment. This 24-hour day-night average sound level is abbreviated as DNL and symbolized as L_{dn}. 2) EPA has developed noise levels which are requisite to protect public health and welfare with an adequate margin of safety for activity interference and hearing loss. Table 3.5-3 presents these levels and Table 3.5-4 modifies these levels to include corrections for existing predevelopment conditions. 3) The

Table 3.5-3

YEARLY AVERAGE* EQUIVALENT SOUND LEVELS IDENTIFIED AS REQUISITE TO PROTECT THE PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

		Indoor			Outdoor		
	Measure	Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects(b)	Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects (b)
Residential with Outside Space and Farm Residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with No Outside Space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70(a)				
Industrial	$L_{eq(24)(d)}$	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	$L_{eq(24)}$	45		45	55		55
	$L_{eq(24)(d)}$		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farm Land and General Unpopulated Land	$L_{eq(24)}$				(a)	70	70(c)

Code:

a. Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity.

b. Based on lowest level.

c. Based only on hearing loss.

d. An $L_{eq(8)}$ of 75 dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than an L_{eq} of 60 dB.

Note: Explanation of identified level for hearing loss: the exposure period which results in hearing loss at the identified level is a period of 40 years.

* Refers to energy rather than arithmetic average.

Source: U.S. Environmental Protection Agency "Information on Levels of Environmental Noise Results Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," March 1974, 550/9-74-004.

Table 3.5-4

CORRECTIONS TO BE ADDED TO THE MEASURED DAY-NIGHT SOUND LEVEL (L_{dn}) OF INTRUDING NOISE TO OBTAIN NORMALIZED L_{dn} (D-3)

Type of Correction	Description	Amount of Correction to be Added to Measured L_{dn} in dB
Seasonal Correction	Summer (or year-round operation).	0
	Winter only (or windows always closed).	-5
Correction for Outdoor Noise Level Measured in Absence of Intruding Noise	Quiet suburban or rural community (remote from large cities and from industrial activity and trucking).	+10
	Normal suburban community (not located near industrial activity).	+5
	Urban residential community (not immediately adjacent to heavily traveled roads and industrial areas).	0
	Noisy urban residential community (near relatively busy roads or industrial areas).	-5
	Very noisy urban residential community.	-10
Correction for Previous Exposure & Community Attitudes	No prior experience with the intruding noise.	+5
	Community has had some previous exposure to intruding noise but little effort is being made to control the noise. This correction may also be applied in a situation where the community has not been exposed to the noise previously, but the people are aware that bona fide efforts are being made to control the noise.	0
	Community has had considerable previous exposure to the intruding noise and the noise-maker's relations with the community are good.	-5
	Community aware that operation causing noise is very necessary and it will not continue indefinitely. This correction can be applied for an operation of limited duration and under emergency circumstances.	-10
Pure Tone or Impulse	No pure tone or impulsive character.	0
	Pure tone or impulsive character present.	+5

USGS in 1975 set a standard of 65 dB(A) at one-half mile (0.8 km) (applicable to geothermal operations on federal lands at East Mesa). 4) The State of California has established that outdoor noise levels of 65 dB CNEL were not to be exceeded in residential areas impacted by aircraft noise, and that the noise level intrusive to residential buildings should be limited to 45 dB CNEL. However, it was acknowledged that with typical building practices and the likelihood of doors and windows being open, that typical exterior noise levels in residential areas should not exceed 57 dB CNEL.

b. Local - Imperial County Regulations

The Imperial County Noise Element utilized standards given in terms of the Composite Noise Rating (CNR), Noise Exposure Forecast (NEF) and HUD criteria. These standards are not consistent with both the geothermal development standards and federal recommendations. For purposes of this MEIR, the most recent HUD standards and CNR standards (designated CNR_c) will be utilized. The County Geothermal Standards for noise have been established in the "Terms, Conditions, Standards and Application Procedures for Initial Geothermal Development in Imperial County" (Imperial County Planning Department, 1977). These criteria establish two classes, Class I and Class II, of drilling and production noise standards. The Class I standard refers to an applied land use. The Class II standard is subdivided to take various land use categories (i.e., industrial, commercial, dense residential, normal residential and open space) into account. The category which would apply to any particular geothermal project is determined by the County Planning Commission. Because the Class I and Class II standards are in conflict with their underlying federal criteria bases as well as EPA standards, they have been translated into the L_{dn} and CNEL indices. After translation, geothermal standards exceed most of the EPA standards.

3.5.2 Noise Impacts

3.5.2.1 Introduction

In this section, the various phases of geothermal electrical power development that may result in community noise are discussed, and typical noise levels from each phase are presented. The noise levels from each phase of geothermal development are then evaluated in terms of the existing noise standards to determine the legal acceptability of each phase. Since most of the proposed development may occur in open desert or unpopulated farmlands, the potential for noise impact is limited. However, the characteristic flat terrain of the area and the relatively low levels of existing community noise allow some geothermal noises to be audible at relatively long distances, thereby increasing the zone of potential annoyance over that which might be expected for a more developed area.

In addition, some of the major noise generating components of a typical steam generation and power plant are singled out for examination. Both noise measurement and analysis techniques have been used to assess the impact of the identified noise sources and provide a basis for direction in specifying and designing noise mitigation.

This analysis also presents human and animal response and acceptability of potentially unmitigated geothermal development.

3.5.2.2 Noise Levels from Geothermal Development and Operations

The development of a typical geothermal power plant project in a water-dominated geothermal resource area (typified by the Salton Sea Anomaly) may, for noise assessment purposes, be divided into the following phases: 1) drill site preparation, 2) well drilling, 3) well flow testing, 4) well cleanout, 5) power plant installation, and 6) power plant operation. In the following paragraphs, a description of each of these phases is presented and the noise generated by the associated activities is documented.

a. Drill Site Preparation

The noise environment during preparation of a site for geothermal well drilling is dominated by the sounds of a bulldozer and backhoe used to level the site and excavate a sump. The primary remaining noise source is from various heavy-duty trucks going to and from the site. Noise levels associated with this phase of a geothermal development were previously measured at Union Oil Tow 1 drill site preparatory to development of the North Brawley 10 MW geothermal power plant. In that study, bulldozer and backhoe noise levels for site clearing were 53 dB(A) at a distance of 1600 feet (488 m). These data were combined with calculated spectral noise data for diesel tractor/trailer rigs that would typically be involved in site preparation. These combined data, presented in Table 3.5-5 as representative of site preparation at a distance of 100 feet (30 m), were also projected to a distance of 10,000 feet (3049 m), accounting for geometric spreading and atmospheric absorption losses, and are displayed in Figure 3.5-2.

b. Well Drilling

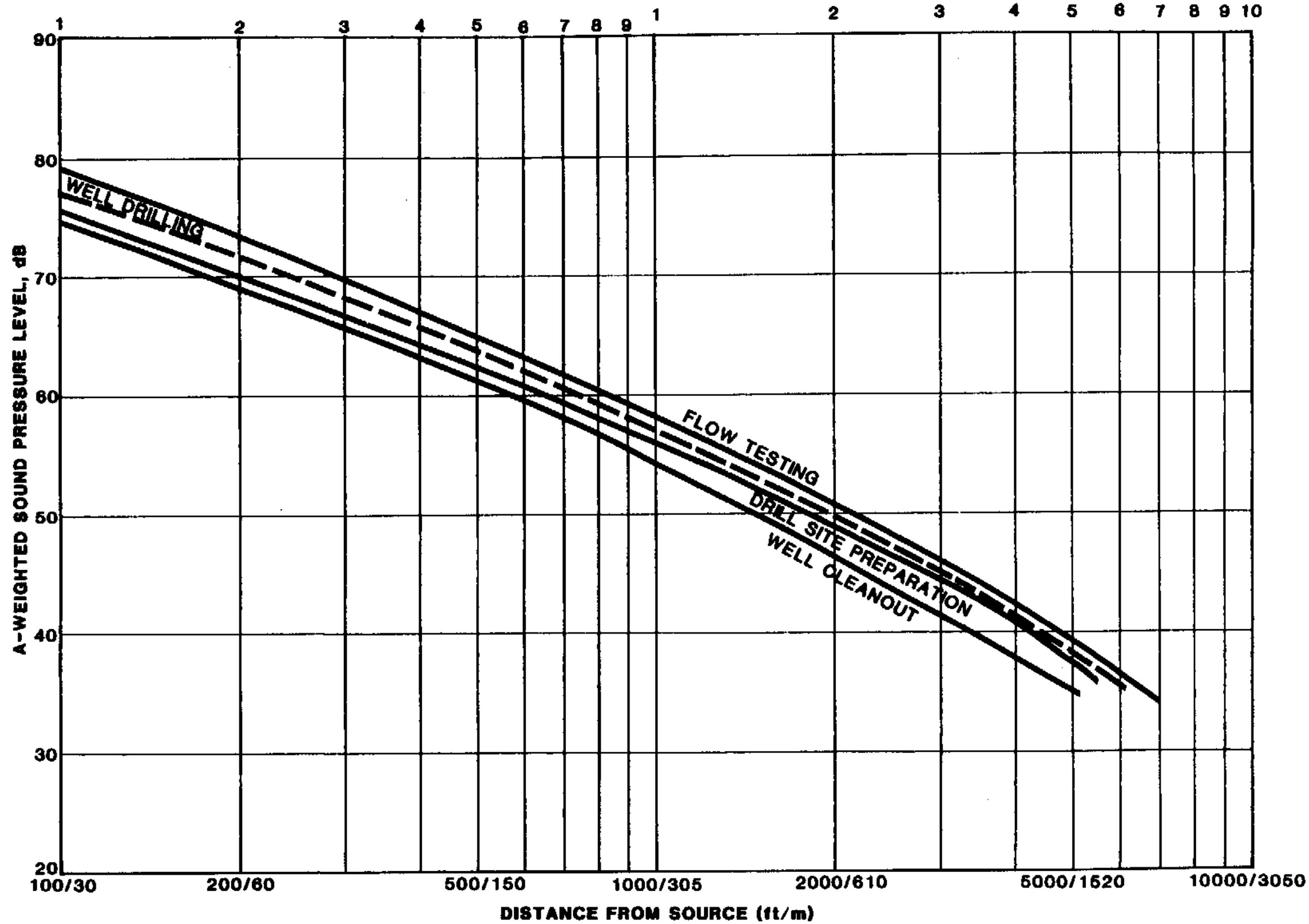
The well drilling operation consists of mud drilling using a rotary rig. Onsite equipment includes the rotary table driven by diesel engines, mud pumps, mud shaker, electric power generator, and draw works engine, and may use a small cooling tower or mud reservoir box. Well drilling is characterized by two distinct noise phases: the rotary table operation and the draw works operation. Noise from the draw works is most likely to include the impact of steel pipe banging together, primarily

Table 3.5-5

OCTAVE BAND SOUND PRESSURE LEVELS (dB)
AT 30 M (100 FT) FOR PREOPERATIONAL PHASES OF
A GEOTHERMAL POWER GENERATION PROJECT

Octave Band	Drill Site Preparation[1]	Well Drilling	Well Cleanout	Flow Testing
63	84/57	80	83	79
125	92/72	85	81	84
250	76/66	78	75	78
500	71/59	73	71	75
1000	74/57	73	68	75
2000	68/55	70	66	68
4000	62/46	63	63	61
8000	54/42	55	61	48
Overall A-weighted Sound Pressure Level	79/64	77	75	79

[1]Excavation equipment/truck noise.



A-Weighted Sound Pressure Levels as a Function of Distance from Noise Source for Preoperational Phases of a Geothermal Power Generation Project

FIGURE 3.5-2

during stacking. In addition, running of casing will also result in pipe impact noise. Drilling is a 24-hour a day operation and drilling operations are expected to require three to five weeks per well.

Since geothermal well drilling noise data are scarce and incomplete, new measurements were made in January, 1981, at a geothermal well site operated by Republic Drilling Company (Figure A3.5-6 in Appendix 3.5). Both rotary table and draw works were in operation during the measurement period. The rig was powered by three Caterpillar Diesel D 379s, and the drilling depth was 8350 feet (2545 m) which is somewhat deeper than what is expected at the Salton Sea Anomaly. Three separate distances and angles around the drill rig were used as noise measurement locations. The spectral noise data from these three locations were corrected for distance to a common reference of 100 feet (30 m) and logarithmically (decibel) averaged to obtain the data presented in Table 3.5.5 for well drilling. These data were also compared for consistency with unpublished oil company data for typical oil wells. The projected A-weighted Sound Pressure Level versus distance for drilling operations is also shown in Figure 3.5-2.

c. Well Cleanout and Flow Testing

After drilling, the wells are flow tested for short periods of time to clean out drilling muds and other debris. Initially, the valve is opened and the flow runs into an open pit or sump. This operation may be slightly noisier than drilling due to the flashing of steam and subsequent venting to the atmosphere at the end of the discharge pipe. More extensive flow or production testing is performed on selected wells by flowing geothermal fluid from the well, separating the steam from the liquid fraction, venting the steam to the atmosphere through a muffler, and reinjecting the liquid into another well. Primary noise comes from steam venting operation of the reinjection pumps. Duration of the flow testing may range from 12 hours to several months.

Well cleanout noise is a function of the flow rate and the method of handling the fluid. Unpublished noise monitoring data on file at WESTEC Services and data reported in USDOE (1978) were used to establish the well cleanout noise level curve given in Figure 3.5-2.

Onsite measurements at the Union Oil Company Jiminez well site indicated noise levels on the order of 46 to 59 dB(A) at 280 feet (85 m). Other data on file at WESTEC Services indicate levels on the order of 51 to 62 dB(A) at 1300 feet (396 m). These latter levels are believed to be more realistic for the entire operational sequence. The Jiminez well site data did not include steam flashing or venting, nor was the mud cooling tower operative. Thus, using available data and applying engineering judgment, the curve shown in Figure 3.5-2 was derived to represent noise from well testing operations. Composite spectra of well cleanout and flow testing were given in Table 3.5-5.

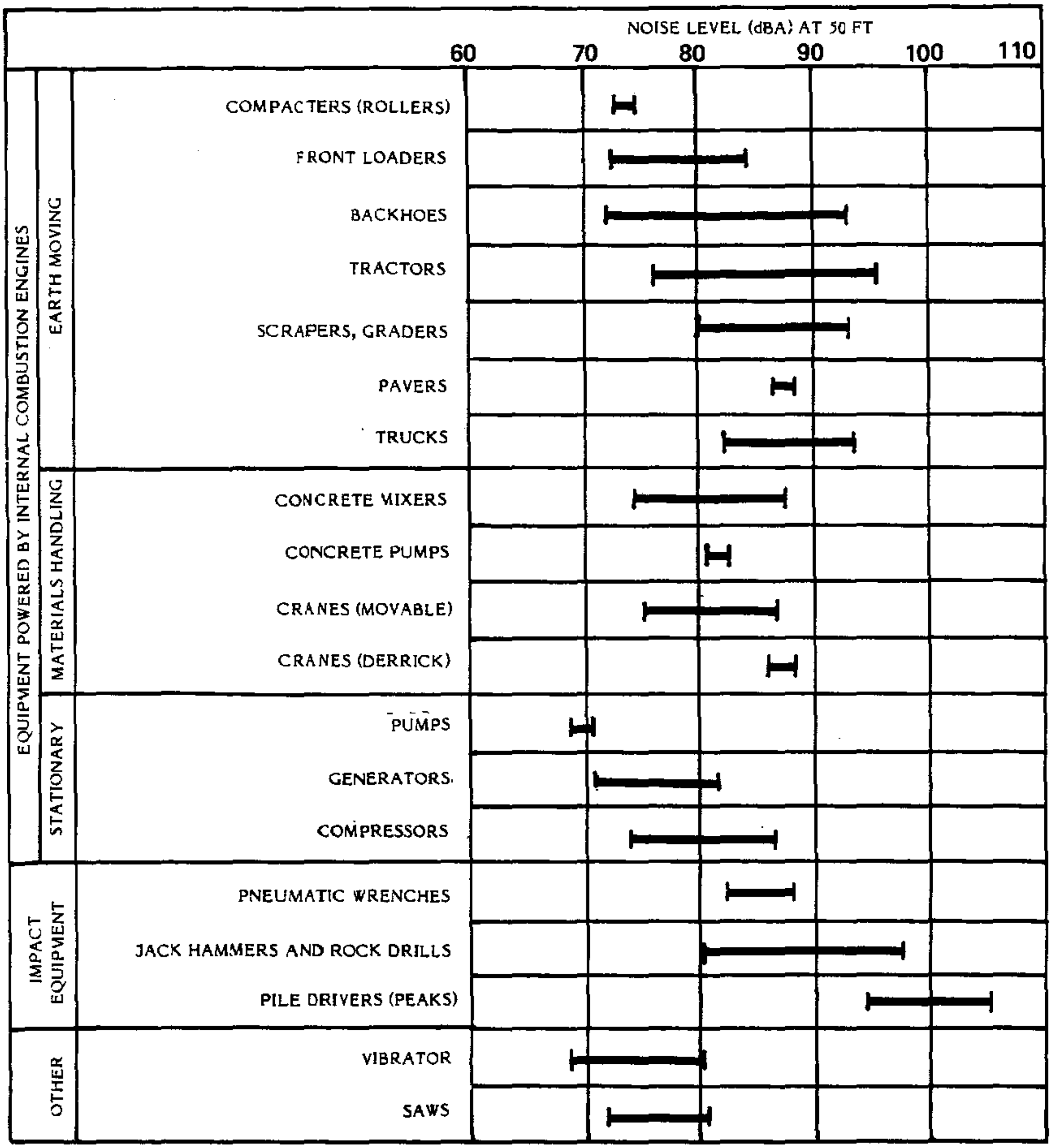
d. Power Plant Construction

Geothermal power plant construction typically requires about 12 months, and takes place concurrently with the installation of steam production and fluid reinjection facilities. The noise level of typical equipment used in this phase is shown in Figure 3.5-3. Noise from this phase of a project will be approximately the same as that produced during drill site preparation (see Figure 3.5-2 and Table 3.5-5).

e. Power Plant Operations

In this subsection much of the analysis is based on noise measurements taken at the North Brawley 10 MW power plant site. Therefore noise data presented is not for completely unmitigated equipment or processes. Those measures which are applied as standard engineering practice were in place.

A geothermal power generation plant may, for purposes of discussion, be separated into two component parts: 1) the steam production facilities and 2) electrical power generation facilities. Typically, in a water dominated resource area such as the Salton Sea Anomaly, production facilities will include production/injection wells, separators, scrubbers, piping and pumps. The major sources of noise are pumps, the flashing of steam at throttle valves or locations where the geothermal fluid is allowed to flash and at vent stacks for noncondensable gases. Field investigation revealed that at the North Brawley 10 MW Geothermal Demonstration Plant the vent stack is a major source of noise in the steam generation side of operations; however, due to the proximity of the vent stack to the cooling tower and site access problems, a set of measurements isolating this noise source was not made. Several sets of far field measurements of the steam generation and injection facilities were made at a distance of 1200 feet (366 m). These measurements were then decibel averaged to provide spatially and temporally corrected data. For the purposes of presentation and comparison, these data were projected back to a 100 foot (30 m) distance and are shown in Table 3.5-6 for a 10 MW facility. The A-weighted Sound Pressure Level as a function of distance is displayed in Figure 3.5-4 for a 10 MW facility. Assuming similar technology, the noise measurements were scaled up on a power basis to model a 50 MW facility. These data are also presented in Table 3.5-6 and Figure 3.5-4.



NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES

EPA PB 206 717
ENVIRONMENTAL PROTECTION AGENCY
31 DEC 1971
NOISE FROM CONSTRUCTION EQUIPMENT AND OPERATIONS

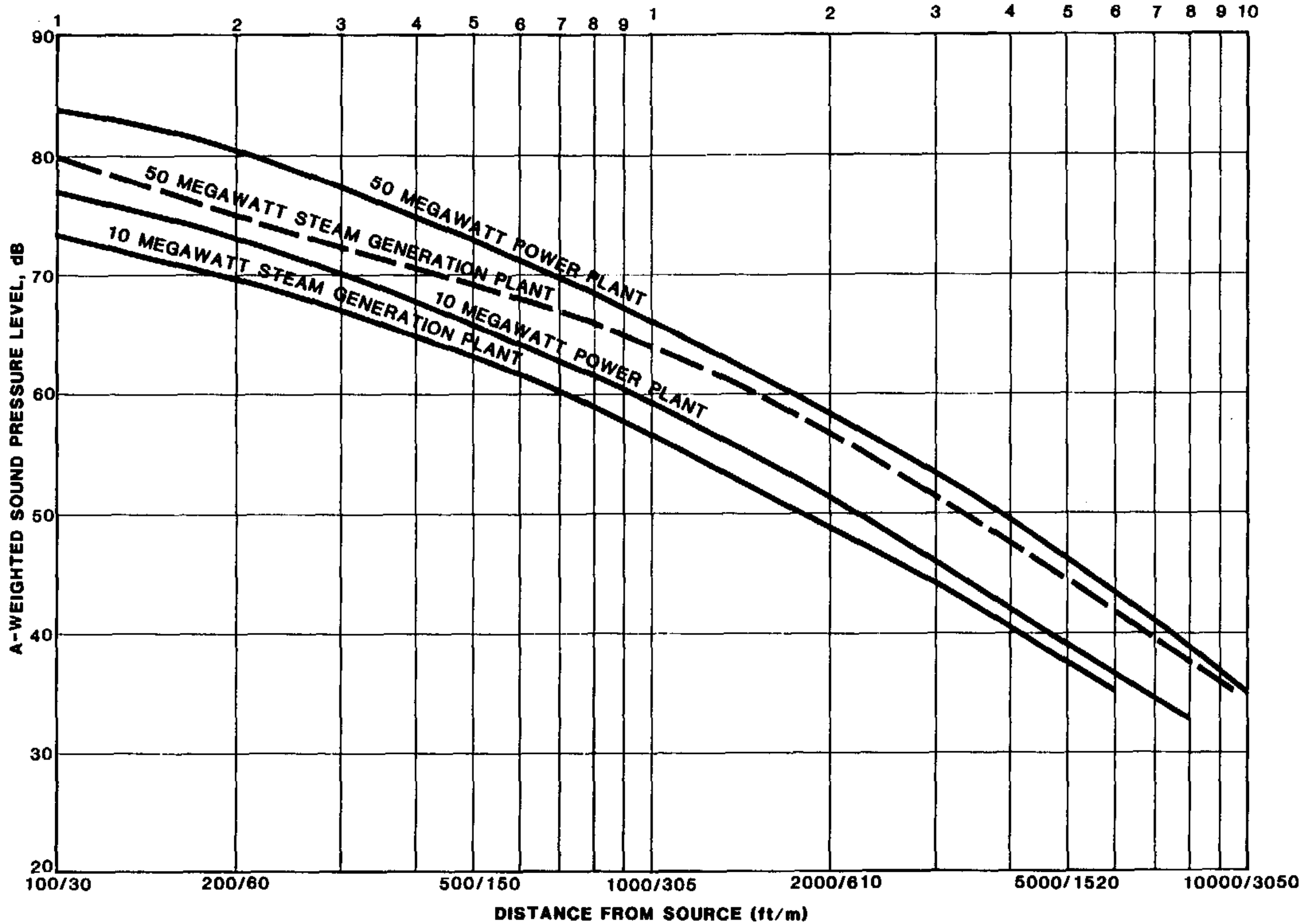
Construction Equipment Noise Ranges

FIGURE 3.5-3

Table 3.5-6

OCTAVE BAND SOUND PRESSURE LEVELS (dB)
AT 30 M (100 FT) FOR OPERATIONAL PHASES

Octave Band	10 MW Steam Generation Plant Operation	50 MW Steam Generation Plant Operation	10 MW Power Plant Operation	50 MW Power Plant Operation	10 MW Combined Facility Operation	50 MW Combined Facility Operation
63	72	79	73	80	73	80
125	73	80	72	79	73	80
250	60	67	64	71	63	69
500	61	68	61	68	61	68
1000	61	68	65	72	63	70
2000	68	75	68	75	68	75
4000	69	76	68	75	69	76
8000	63	70	60	67	62	69
Overall A-weighted Sound Pressure Level	70	80	73	80	73	80



A-Weighted Sound Pressure Level for Operational Phases of a Geothermal Power Generation Plant

FIGURE 3.5-4

The high content of dissolved salts in the Imperial area geothermal fluids results in a severe maintenance problem in the steam generation plant, necessitating descaling of pipes, valves, and pressure vessels on a regular and continuous basis. Because of this, independent contractors work on a 24-hour basis cleaning the interiors of geothermal fluid conduits, valves and vessels. This work is performed with a high pressure, airless water sprayer termed a Hydro Blaster. The noise from these operations is of primary importance in the consideration of impact. A typical Hydro Blaster unit in use was measured at the Mercer Unit of the South Brawley Geothermal Project (Figure A3.5-7 in Appendix 3.5). The Hydro Blaster's Aqua Dyne pump, rated at 12,000 psi, was driven by a Detroit Diesel. The octave band sound pressure level spectrum for this piece of equipment is given in Table 3.5-7. The A-weighted Sound Pressure Level as a function of distance is presented in Figure 3.5-5 for a 10 MW turbine/generator.

Power plant equipment typically includes a turbine-generator unit, a mechanical draft cooling tower, circulating water pumps, a surface contact condenser, air ejectors, condensate and vacuum pumps, step-up transformers and electricity transmission lines. Both near field and far field (1200 feet; 366 m) noise measurements were made on the power plant side of the North Brawley 10 MW Geothermal Demonstration Plant. These data were recorded at many locations, spatially and temporally decibel averaged and then used to determine the characteristic noise level and spectrum of a 10 MW geothermal powered electrical power generation system. It should be noted that the spectral noise levels presented in Table 3.5-6 for comparison purposes at 100 feet (30 m) do not fall off with distance in the near field, as a point source, because of the extended shape (i.e., size) of the noise generating mechanism. The A-weighted Sound Pressure Level as a function of distance is presented in Figure 3.5-5. These data were scaled up on a power basis to model a 50 MW power plant; the equation generally used to model a 50 MW plant is:

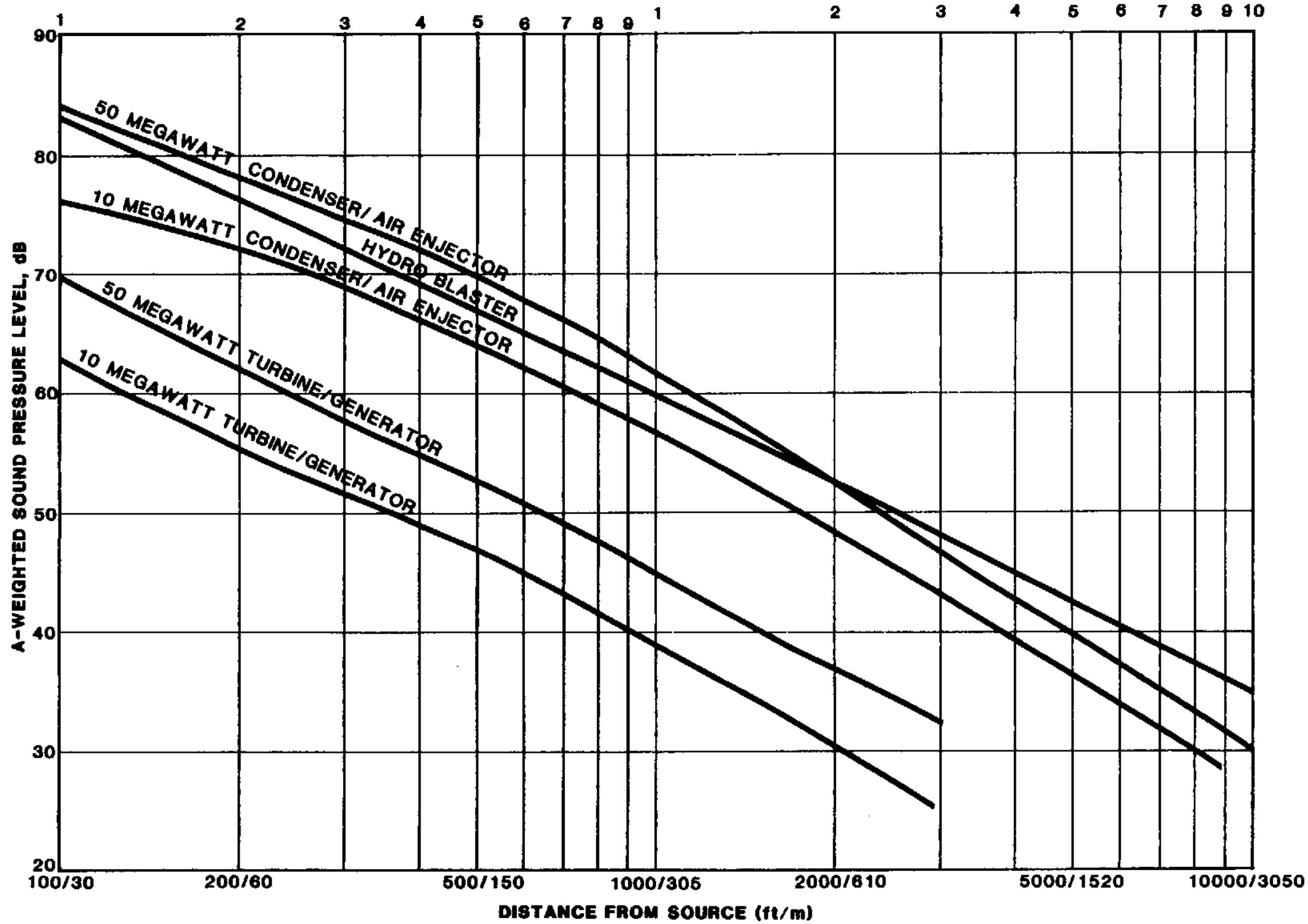
$$\text{Sound Pressure Level (SPL) (A-weighted)}_{50\ \text{MW}} = \text{SPL(A-weighted)}_{10\ \text{MW}} + 10 \log_{10}\left(\frac{50}{10}\right)$$

(Beranek, 1971). This information is also displayed in Table 3.5-6 and Figure 3.5-5. The data for the subcomponents of the steam plant and power plant for the 10 MW facility were averaged to obtain a combined facility level. This was accomplished also for the 50 MW facility. Since plant components could not be placed physically one on top of the other, their noise components could not add directly and would be combined

Table 3.5-7

OCTAVE BAND SOUND PRESSURE LEVELS (dB)
AT 30 M (100 FT) FOR POWER PLANT EQUIPMENT (COMPONENTS)

Octave Band	Hydro Blaster DeScaler	10 MW Turbine/ Generator	50 MW Turbine/ Generator	10 MW Condenser/ Air Ejector	50 MW Condenser/ Air Ejector	10 MW Cooling Tower	50 MW Cooling Tower
63	74	61	68	68	75	66	71
125	92	60	67	68	75	65	69
250	82	54	61	61	68	66	64
500	75	54	61	65	72	62	61
1000	74	55	62	68	75	58	59
2000	75	59	66	76	83	53	56
4000	76	55	62	77	84	45	53
8000	70	45	52	72	79	36	52
Overall A-weighted Sound Pressure Level	82	64	71	81	88	63	64



A-Weighted Sound Pressure Level for Individual Power Plant Components

FIGURE 3.5-5

on the basis of their physical separation. As a first approximation they were averaged. However, as discussed later in the mitigation section, when exact plant layouts are finalized, then, on a plan approval basis, the impacts can be more accurately calculated as a condition of facility approval for building permits.

To provide a basis for determining mitigation measures, individual components of the power plant were measured to determine their contribution to the overall noise environment. Near field noise measurements of the turbine and generator were made at the North Brawley facility. These measurements were combined and projected to a distance of 100 feet (30 m) as presented in Table 3.5-7. The relationship between A-weighted Sound Pressure Level and distance is shown in Figure 3.5-5 for a 10 MW turbine/generator. Also shown is the data for a 50 MW turbine/generator.

The steam condenser and its ancillary air ejector that removes noncondensable gases are a major source of noise in the power plant area. The noise spectrum for both a 10 and 50 MW sized condenser/air ejector, based on the North Brawley plant equipment noise measurements, are shown in Table 3.5-7. The A-weighted level versus distance is plotted in Figure 3.5-5.

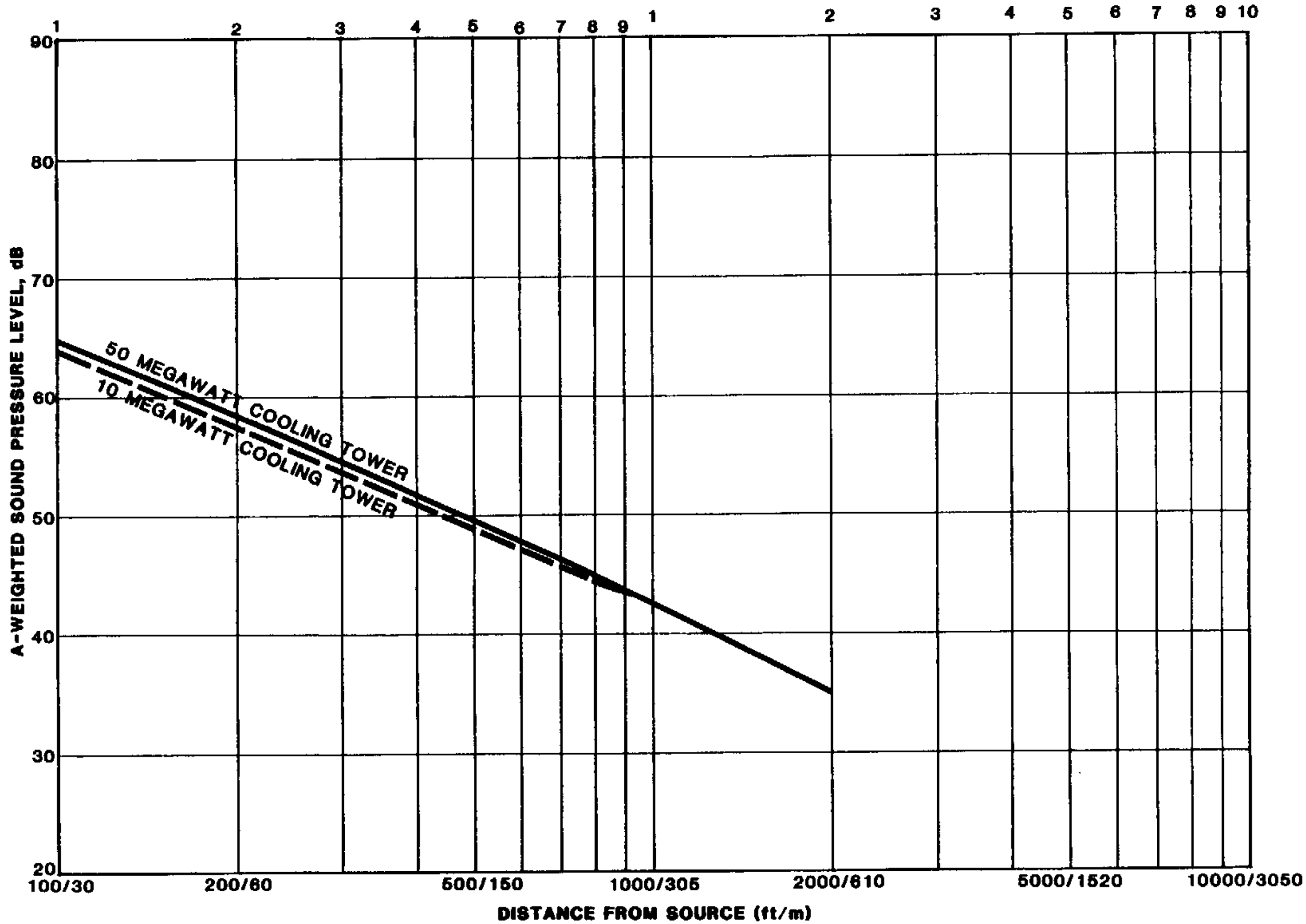
The cooling tower is a major facility component that may be over 50 feet (15 m) tall and several hundered feet long for a 50 MW power plant. Figure A3.5-8 in Appendix 3.5 shows the two-cell 10 MW cooling tower size for the North Brawley demonstration plant. Because of the size of this component, it could not easily be noise mitigated. Therefore, an examination of the cooling tower noise may provide information on the noise levels that will remain when other noises are controlled. The relatively low noise levels of this component precluded field measurement data. Noise data from engineering design data supplied by the Morley Company for a 50 MW power plant cooling tower and scaling information to relate single cell data to a 10 MW cooling tower were used to calculate the A-weighted Sound Pressure Levels versus distance for both size towers as shown in Figure 3.5-6. The representative 100 foot (30 m) spectral data is shown in Table 3.5-7.

3.5.2.3 Statutory Noise Impacts

In the first part of this subsection, the existing noise standards, statutes, and guidelines are used to determine the impact from each identified noise source and development phase. In the second part, noise impact contours are presented for a typical 49 MW power plant and for two 49 MW plants in close proximity.

The octave band (spectral) noise data for each source was analytically projected outward (i.e., to various distances from each source) using both geometric

WESTEC Services, Inc.



A-Weighted Sound Pressure Level for Cooling Towers

FIGURE 3.5-6

spreading losses and atmospheric attenuation to determine far field noise spectra. These spectra were then compared with the Imperial County Noise Standards for Initial Geothermal Development and with the Composite Noise Rating (CNR) scale of the Imperial County Noise Element of the General Plan (see Section 3.5.1 plus Appendix 3.5). Noise spectra calculated for many distances from each source were overlaid on the two standard charts to determine how close (i.e., the nearest distance) each noise source could be brought to the specific land use categories (or in the case of CNR, to determine the resultant complaint level category). In addition, CNEL and L_{dn} noise impacts were calculated based on typical operating scenarios (24 hours per day of operation) to determine the closest point to the source that would meet state and federal requirements. Distances varied according to requirements of each agency, yet were consistently greatest for the 50 MW power and steam generation facilities. A summary of these nearest distances at which the standards can be met is presented in Table 3.5-8.

Statutory noise impact distances which were determined from calculated spectral levels have been plotted in the form of isopleths for a 50 MW plant in terms of the Initial Geothermal Development Standards (Figure 3.5-7); the Noise Element's CNR categories (Figure 3.5-8); and in terms of L_{dn}/CNEL standards (Figure 3.5-9). These impacts are from projected levels for a power plant with only minimal noise mitigation measures which are standardly applied. Since the position of each piece of equipment on a projected 10-acre (4 ha) site may vary, the actual directivity pattern of the noise can be expected to vary from the uniform patterns shown.

The case of two adjacent, identical 50 MW power plants has also been examined to determine statutory impact isopleths. The sound levels near (within several hundred feet of) either plant can be expected to be dominated by the near field levels of the closest facilities. In the far field, beyond 1000 feet (300 m), the effect of each plant will be important. The noise radiation pattern, however, cannot be expected to be uniform. Techniques adapted from Rathe[1] for arrays of point sources were used in a computer model scheme to approximate the far field noise as a function of radial distance and polar angle from a central reference between the two proposed plants. Because of the angular dependence of the data, it is not presented in tabular form as

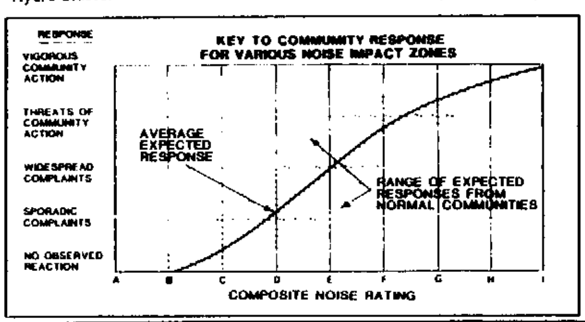
[1]Excerpts from lectures on electroacoustics and habilitation: Methoden und Ergebinsse von Gerauschmessungen an Motorfahrzeugen, by E.J. Rathe, Swiss Federal Institute of Technology published in J. Sound Vibration 10(3), 472-479, 1969.

Table 3.5-8

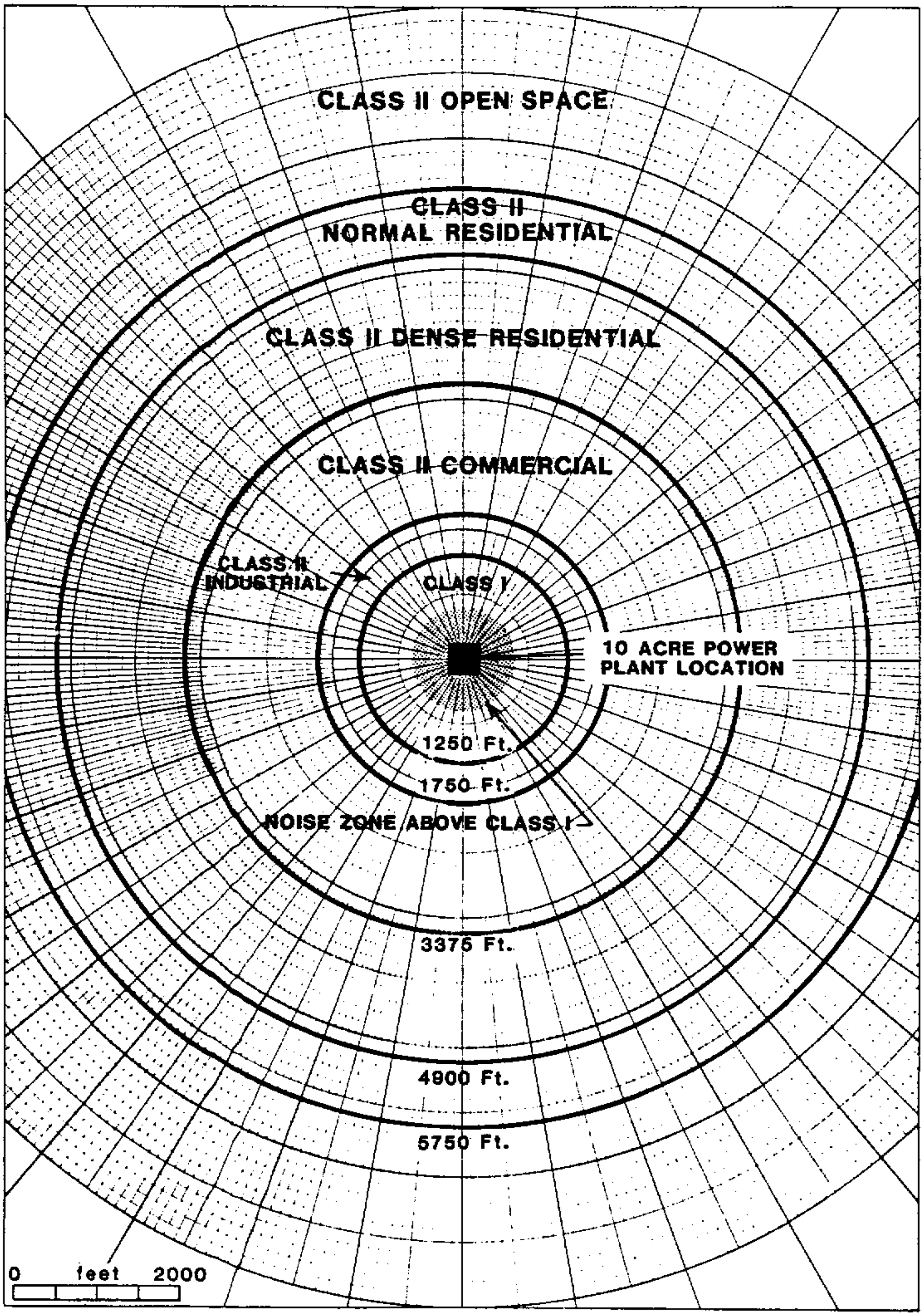
MINIMUM ALLOWABLE SEPARATION BETWEEN GEOTHERMAL DEVELOPMENT AND NOISE SENSITIVE AREAS (FEET)

Noise Source	Imperial County Noise Standards for Initial Geothermal Development: Class I	Class II: Ind.	Class II: Comm.	Class II: Dense Res.	Class II: Normal Res.	Class II: Open Space	Imperial County Noise Element of the General Plan Composite Noise Ratings for the Response of Residents to Community Intruding Noise *: A	B	C	D	E	F	G	H	I	US EPA Recommended Residential Hospital School	US HUD Residential	State of Calif. Airport Community Residential Standards	State of Calif. Airport Multi-Dwelling Standards
Drill Site Preparation	300	500	1,000	2,000	3,000	5,000	12,000	10,000	5,000	3,000	2,000	1,000	600	300	200	1,900	800	800	1,700
Well Drilling	200	400	800	2,000	3,000	4,000	7,500	5,500	3,500	2,000	1,500	800	500	300	150	2,000	800	800	1,800
Well Cleanout	150	300	500	1,000	2,000	3,000	5,000	4,000	2,500	1,500	800	600	800	150	100	1,400	600	600	1,300
Well Flow Testing	300	500	800	2,000	3,000	5,000	7,000	5,000	4,000	2,500	1,500	1,000	600	300	200	2,100	800	800	2,000
10 MW Power Plant	200	600	1,000	2,500	4,000	5,000	7,000	6,000	4,500	3,000	2,000	1,500	800	500	300	2,500	1,100	1,100	2,000
10 MW Turbine Generation	-	100	150	500	800	1,200	2,000	1,500	1,000	600	400	200	150	100	-	400	150	150	350
10 MW Condenser/Air Ejector	200	500	800	2,000	3,500	5,000	7,000	6,000	4,000	2,500	1,500	1,000	700	400	300	2,000	850	850	1,000
10 MW Cooling Tower	50	100	150	500	800	1,500	2,000	1,500	1,000	500	300	200	100	50	-	500	170	170	400
10 MW Steam Generation Plant	300	600	800	2,000	2,500	4,000	8,000	6,000	4,000	2,500	1,700	1,200	800	700	500	2,000	780	780	1,800
50 MW Power Plant	600	1,200	2,000	4,000	6,000	7,000	10,000	8,000	7,000	4,500	3,200	2,200	1,600	800	600	4,000	2,000	2,000	3,500
50 MW Turbine Generation	100	200	300	800	1,500	2,000	3,000	2,500	2,000	1,500	800	600	300	150	100	800	300	300	550
50 MW Condenser/Air Ejector	400	800	1,300	2,600	3,500	5,000	8,000	6,000	4,000	3,000	2,500	1,800	1,300	700	400	2,800	1,350	1,350	2,500
50 MW Cooling Tower	50	100	200	400	700	1,200	2,500	1,500	1,000	500	300	200	100	50	-	600	200	200	450
50 MW Steam Generation Plant	500	1,000	1,500	3,000	5,000	9,000	20,000	15,000	9,000	5,000	3,000	2,000	1,500	800	600	3,500	1,500	1,500	3,000
Hydro Blaster	400	800	1,200	3,000	5,000	7,000	15,000	12,000	7,000	4,000	3,000	1,500	800	350	300	3,000	1,200	1,200	2,000

*



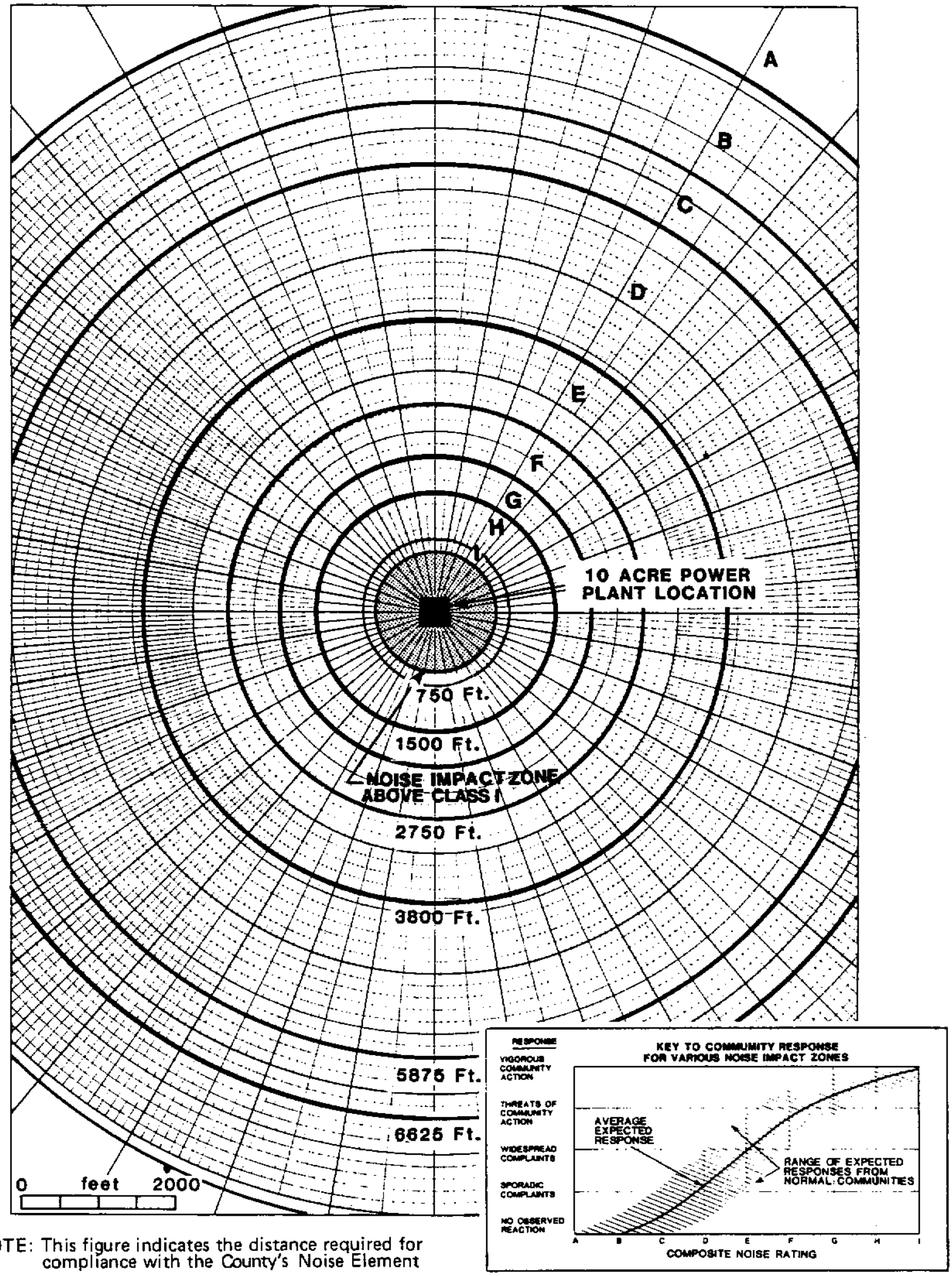
NOTE: This chart indicates the minimum distance needed from each noise source to comply with the above noise standards.



NOTE: This figure indicates the distances required for compliance with the County's standards for Initial Geothermal Development.

Noise Impact Zones for a 50 Megawatt Geothermal Power Plant. County of Imperial Standards for Initial Geothermal Development.

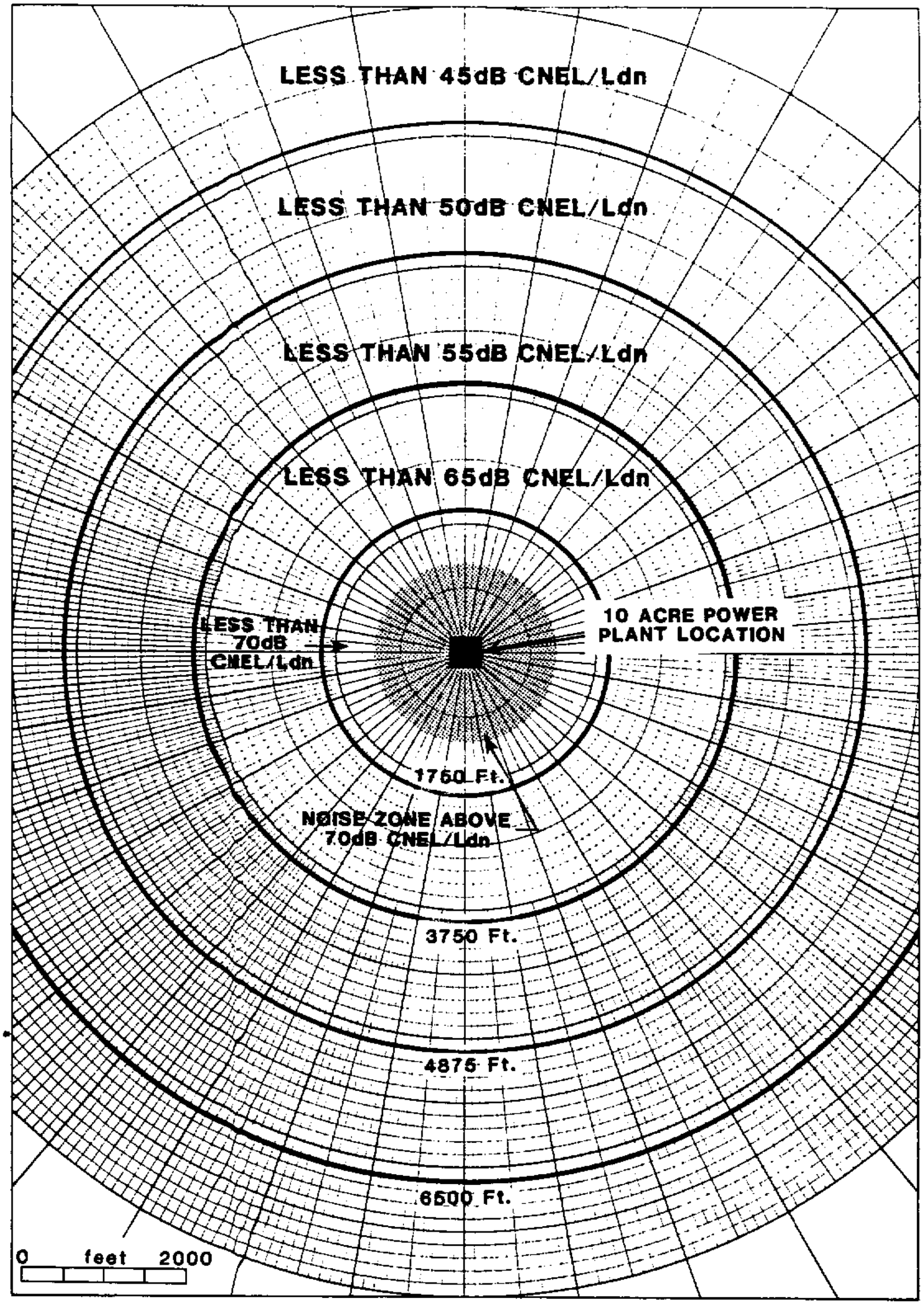
FIGURE 3.5-7



NOTE: This figure indicates the distance required for compliance with the County's Noise Element

Noise Impact Zones for a 50 Megawatt Power Plant in Terms of County of Imperial's Composite Noise Rating Scale (CNR) from the Noise Element of the General Plan.

FIGURE 3.5-8



NOTE: This figure indicates the distance required for compliance with CNEL/LDN Noise Standards.

Noise Impact Zones for a 50 Megawatt Geothermal Power Plant Using the CNEL and Ldn Noise Indicies

FIGURE 3.5-9

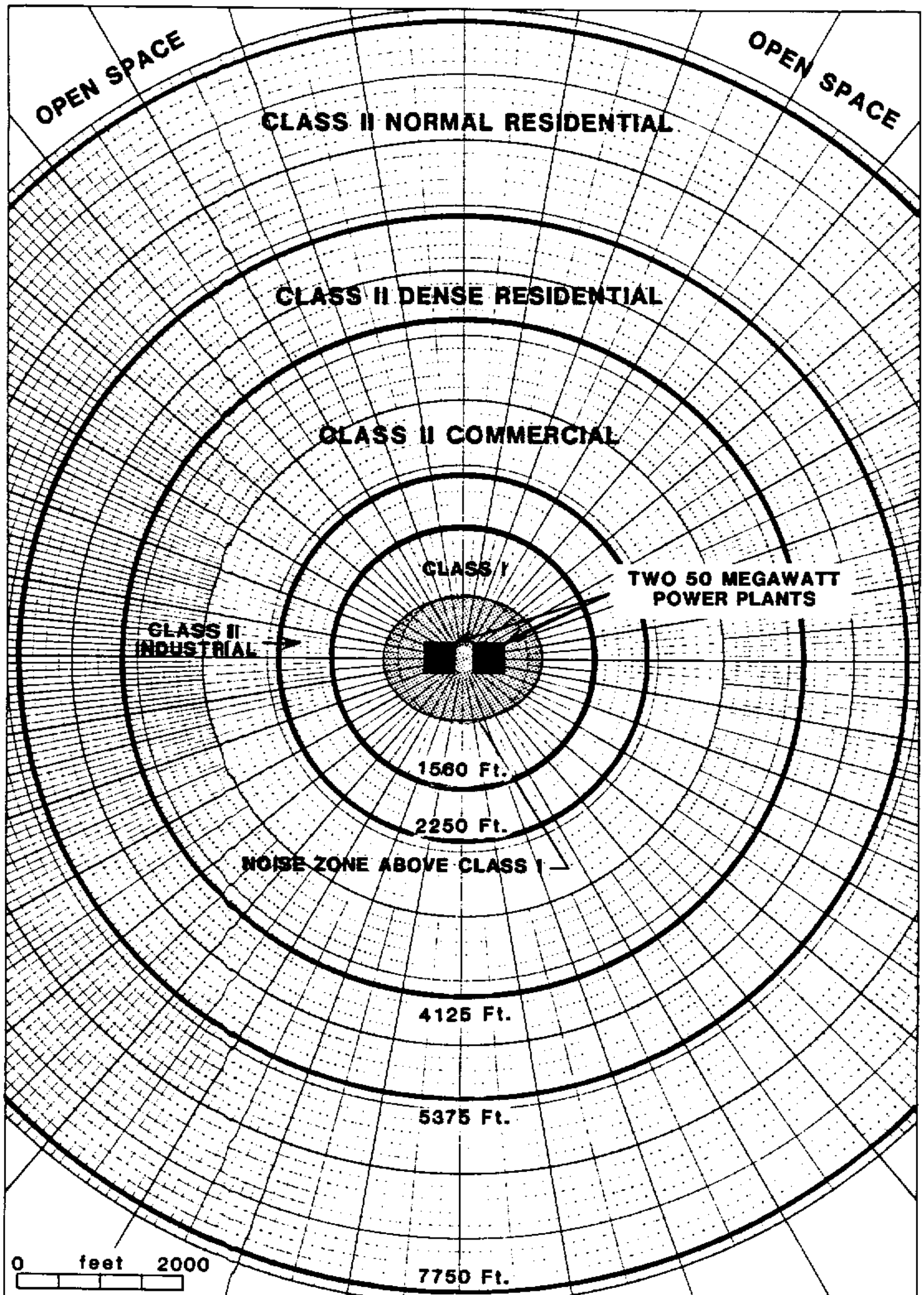
for the other sources studied. However, the spectral levels have been evaluated by means of comparison with the various standards referenced herein and the impacts are displayed in Figures 3.5-10, 3.5-11, and 3.5-12 for Imperial's Initial Geothermal Development Standards, Noise Element Standards, and CNEL/L_{dn} criteria respectively.

Non-statutory impacts relate to "health and welfare" and are not concerned just with meeting legal requirements, but look through the law to examine the intent of the restrictions. The goal of community noise standards is to protect, as far as possible, the complete physical, mental, and social well-being, not just to limit disease and infirmity. This would then include sub-clinical and subjective responses (e.g., annoyance or other adverse psychological reactions) of the individual and the public. Although noise exposure can result in tension that relates to other clinical health effects, the most prevalent problems associated with noise interference involve the ability to hear. Also included are personal comfort and well-being and the absence of mental anguish and annoyance. In fact, a great deal of data on the effects of noise are expressed in terms of annoyance. Annoyance is a subjective reaction to interference with some desired human activity.

The level identified for the protection of speech communication is an L_{eq} (hourly average A-weighted sound level for the period measured) of 45 dB within the home in order to provide for 100 percent intelligibility of speech sounds. Allowing for the 15 dB reduction in sound level between outdoors and indoors (which is an average amount of sound attenuation that assumes partly-open windows), this level becomes an outdoor L_{eq} of 60 dB for residential areas. For outdoor voice communications, the outdoor L_{eq} of 60 dB allows normal conversation at distances up to 6.5 feet (2 m) with 95 percent sentence intelligibility. Table 3.5-9 presents a summary of the effects on speech or communication.

Although speech interference has been identified as the primary interference of noise with human activities and is one of the primary reasons for adverse community reactions to noise and long-term annoyance, the 10 dB nighttime weighting (and, hence, the term L_{dn}) is applied to give adequate weight to all of the other adverse effects on activity interference. For the same reason, a 5 dB margin of safety is applied to the identified outdoor level. Therefore, the outdoor L_{dn} identified for residential areas is 55 dB.

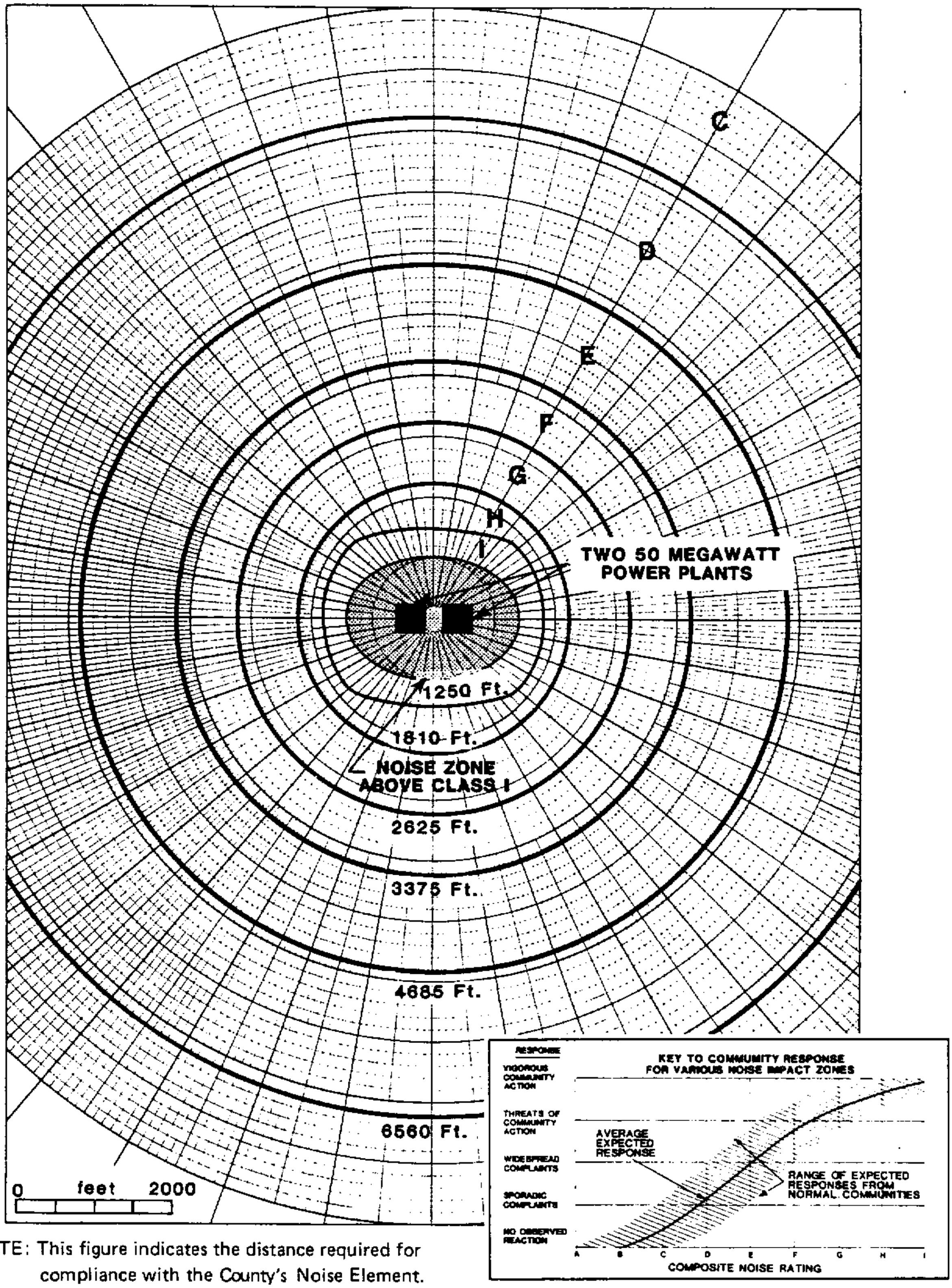
The associated interior day-night sound level within a typical home which results from outdoors is 15 dB less, or 40 dB, due to the attenuation of the structure. The expected indoor daytime level for a typical neighborhood which has an outdoor L_{dn}



NOTE: This figure indicates the distance required for compliance with the County's standards for Initial Geothermal Develpment.

Noise Impact Zones for Two Adjoining 50 Megawatt Geothermal Power Plants. County of Imperial Standards for Initial Geothermal Development.

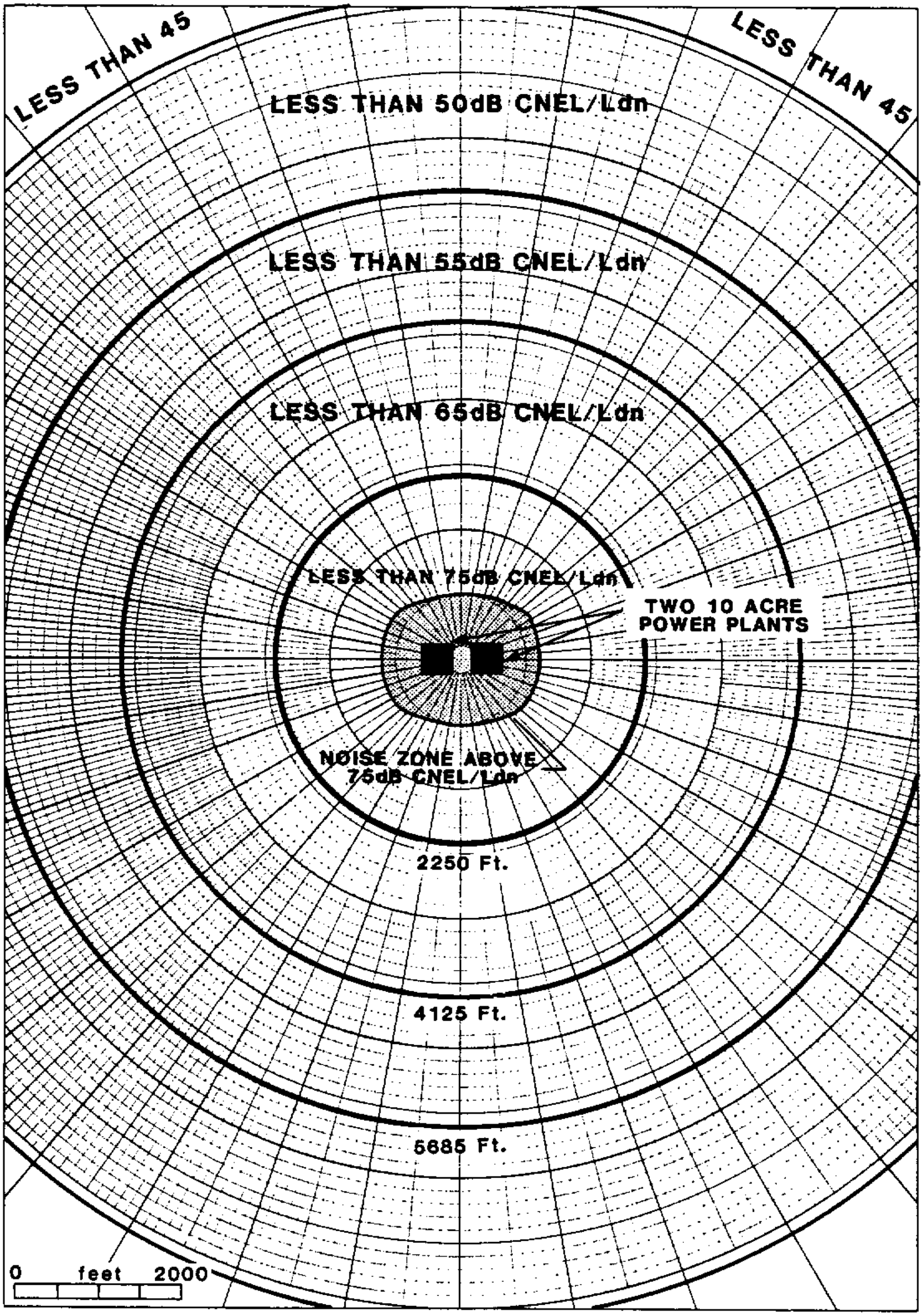
FIGURE 3.5-10



NOTE: This figure indicates the distance required for compliance with the County's Noise Element.

Noise Impact Zones for Two Adjoining 50 Megawatt Geothermal Power Plants. County of Imperial's Noise Element of the General Plan–Composite Noise Rating Scale (CNR).

FIGURE 3.5-11



NOTE: This figure indicates the distance for compliance with CNEL/LDN Noise Standards.

Noise Impact Zones for Two Adjoining 50 Megawatt Geothermal Power Plants Using the CNEL and Ldn Noise Indicies

FIGURE 3.5-12

Table 3.5-9

SUMMARY OF HUMAN EFFECTS IN TERMS OF SPEECH COMMUNICATION, COMMUNITY REACTION, COMPLAINTS, ANNOYANCE, AND ATTITUDE TOWARDS AREAS ASSOCIATED WITH AN OUTDOOR DAY/NIGHT SOUND LEVEL OF 55 dB RE 20 MICROPASONS[1]

TYPE OF EFFECT	MAGNITUDE OF EFFECT
Speech - Indoors	100 percent intelligibility (average) with a 5 dB margin of safety.
- Outdoors	100 percent sentence intelligibility (average) at 0.35 meters.
	99 percent sentence intelligibility (average) at 1.0 meters.
	95 percent sentence intelligibility (average) at 3.5 meters.
Average Community Reaction	None evident; 7 dB below level of significant "complaints and threats of legal action" and at least 16 dB below "vigorous action" (attitudes and other non-level related factors may affect this result).
Complaints	1 percent dependent on attitude and other non-level related factors.
Annoyance	17 percent dependent on attitude and other non-level related factors.
Attitudes Towards Area	Noise essentially the least important of various factors.

[1]USEPA, 1974, "Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety," 550/9-74-004, March.

of 55 dB is approximately 40 dB, whereas the nighttime level is approximately 32 dB. These indoor levels of 40 dB during the day and approximately 32 dB at night are consistent with the background levels inside the home which have been recommended by acoustical consultants as acceptable for many years.

3.5.2.4 Startle and Awakening

Impulsive noises which are novel, unheralded, or unexpectedly loud can startle people and animals. Even very mild impulsive noises can awaken sleepers. In some circumstances (e.g., when a person is handling delicate or dangerous objects or materials), startle can be hazardous. Because startle and alerting responses depend very largely upon individual circumstances and psychological factors unrelated to the intensity of the sound, it is difficult to make any generalization about acceptable values of Sound Pressure Level (SPL) in this connection. A high degree of behavioral habituation, even to intense impulse noises, is normally seen in animals and humans when the exposure is repeated, provided that the character of the stimulus is not changed.

3.5.2.5 Comparison With Existing Levels

One of the criteria that can be used to judge impact is the degree of intrusion that a noise source has by comparing its level with the existing community levels. In areas where noise levels are currently quite low, intrusion, even below statutory levels, can be expected to be unacceptable to residents. For example, measurement site 20 shown in Figure 3.5-1, represents a residental use in the project area for the 49 MW power plant (discussed in Section VIII and currently has day, evening and night levels of 38, 35, 26 dBA, respectively, and an L_{dn}/CNEL level of 36/37 dB. Depending upon the actual geothermal equipment locations, the noise environment could be raised by 10 dB, which would represent a doubling in the perceived noise, and still meet the dense residential level classifications for initial geothermal development or the EPA standards for residential use. HUD standards would allow the noise to increase fourfold. However, this increase in noise level, although acceptable in a statutory sense, may not be well received by the residents. These figures assumed a separation of 2000 to 4000 feet (610 to 1220 m) between the unmitigated plant and the residence and, of course, closer spacing would increase noise levels even further. In the case of this residence, there is considerable potential for noise impact.

The current noise levels at the residence located at the Salton Sea National Wildlife Refuge Headquarters Unit are as low as 38 dBA, 36 dBA and 25 dBA in the day, evening and night periods, resulting in an L_{dn}/CNEL of 36/38 dB. Location of a 50 MW plant at Sinclair and Garst roads could raise the continuous environment to

45 dBA, still quiet by urban standards, but a significant increase over existing levels. The L_{dn}/CNEL could be expected to increase to 52/53 dB, more than doubling the perceived noise environment.

In contrast to the above, the noise measurement sites in Niland showed that a 50 MW power plant might be moved as close as 3000 feet (915 m) and not exceed the L_{dn}/CNEL environment, although the nighttime levels could be increased by as much as 8 dB. Moving away 4500 feet (1372 m) could allow the existing nighttime levels to be matched.

In the rural areas, particularly those of the wildlife refuges and game management areas, it may be desirable not to exceed the ambient noise levels. However, as was mentioned earlier, the wildlife tend to exhibit a high degree of habituation even to loud impulsive sounds like gunfire if they are repeated often and with the same characteristics. On the other hand, although information is scarce, non-repetitive impulse or sudden loud sounds may be disruptive. 124

The noise environment varies considerably over the study area and probable impacts may be determined based upon the noise impact data presented herein, an examination of existing land uses, ambient noise levels, and the distance from proposed developments. The information presented in this section, although carefully and accurately prepared and based upon the best information available, including actual measurements, does not constitute a noise prediction analysis for a specific plant (i.e., based on site drawings, capacities etc.), but is rather a generic analysis predicting probable impacts with a high degree of precision. Information presented in the following section will outline available techniques for reducing the noise impacts.

3.5.3 Noise Mitigation Measures

3.5.3.1 General

As discussed in the Impact section the noise from a geothermal power generation facility comes from a number of sources, some of which were identified and discussed. Since a power generation facility is composed of individual sources, there is an opportunity to treat each source separately. On an engineering/economic basis, it makes no sense to treat a number of smaller "noise sources" when there are major noise producing components left untreated (i.e., the noisiest components will always set the environmental level). Therefore, a noise mitigation strategy would involve reducing the major sources first. In the case of a single 50 MW power plant, the unmitigated noise level effects may reach out some two miles (3 km) under normal atmospheric conditions. For the case of dual 50 MW plants, effects could extend out to four miles

(6.5 km). Because of the magnitude of potential impact, noise mitigation measures must be considered to protect existing residential uses and wildlife habitats.

Noise control technology exists that can significantly reduce or control all the noise sources separately, thereby making large reductions in the overall projected plant noise impacts. However, the scope of this study does not include an analysis of detailed final plans as to process temperatures, flow velocities and pipe and equipment layouts for a specific plant. Therefore, only the most probable potential for impacts and mitigations were determined. When final proposed plans are determined for any specific site, both a site specific and equipment/process specific engineering noise analysis should be completed and presented to the County of Imperial.

3.5.3.2 Wildlife Areas

Much of the Salton Sea migratory waterfowl wetlands may be impacted with noise levels above existing ambient noise levels. Since there is little data correlating noise intrusion into this type of area with either immediate response or longer term effects that may slowly encourage changes in migratory patterns or feeding and nesting areas, cautions should be encouraged in allowing noise levels to be increased where "off the shelf" or easily designed noise control measures are available. There are several viable approaches for protection against adverse impacts in the absense of definitive data on the noise sensitivity of wildlife: geothermal development may be situated far enough away to preclude increasing the ambient noise levels in sensitive areas (generally, for a 50 MW power plant, a distance which would result in 10 dB below the ambient noise level away from the sensitive area would preclude increasing noise levels); engineering noise controls may be required to reduce the plant levels, and some noisy activities could be limited to months of the year when migratory waterfowl would not be present. Another alternative would be to design and perform some noise sensitivity experiments to establish a correlation between intruding noise levels typifying geothermal development and the reactions (if any) of the various fauna indigenous to the area. Then environmental noise control strategies could be exercised to assure little or no impact.

In the following paragraphs, noise control technology applicable to a 10 MW, 50 MW and dual 50 MW development will be discussed without distinction.

3.5.3.3 Flow Testing, Well Cleanout, Steam Diversion

Flow testing, well cleanout and power plant steam diversion could all result in the venting of steam to the atmosphere. Sudden and/or continuous release of high pressure geothermal fluids and steam could be potentially disturbing to both people and protected fauna. However, technology exists to virtually eliminate this source of noise. High temperature and pressure geothermal effluent may be discharged underwater in a tank or sump or be reinjected.

Commercial steam operated power plants have been in existence for years. During start-up and certain operational and/or maintenance phases these plants may need to blow off full capacity steam generation at rates up to four million pounds of steam per hour. Commercially available portable blowoff silencers were used at the Commonwealth Edison Company, Collins Station Unit No. 5, Morris, Illinois during plant start-up, discharging four million pounds of steam at 830 psig initial drum pressure. The octave band unsilenced and silenced levels are shown in Figure 3.5-13 showing a 49 dB reduction in levels. Figure A3.5-9 in Appendix 3.5 shows a truck-mounted silencer that could be moved from site to site for individual well testing, thereby obviating the need for expensive permanent installations to serve temporary or intermittent noise control needs. Figure A3.5-10 in Appendix 3.5 shows an exploded view of the internal parts of such a device.

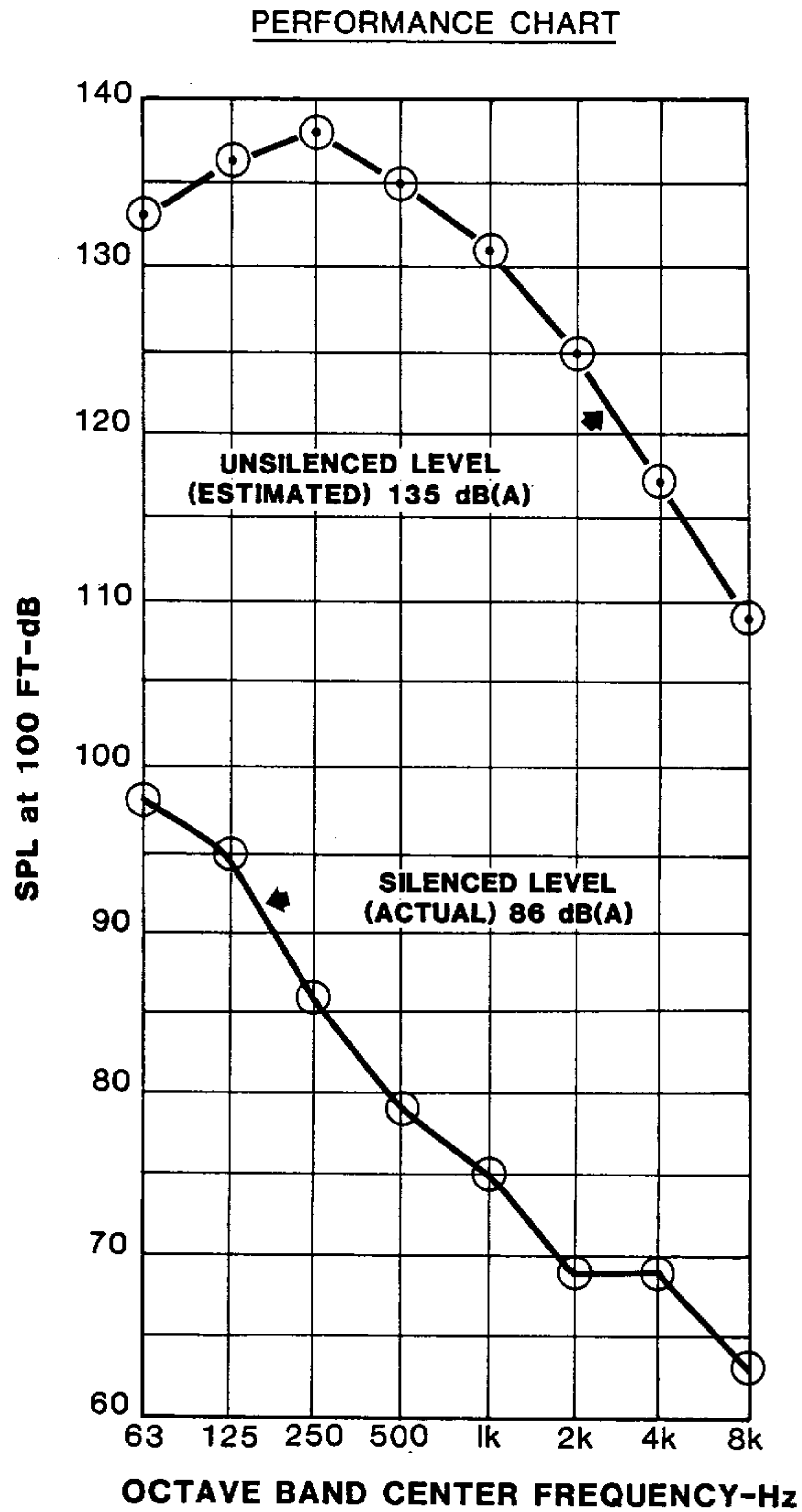
Permanent steam blowoff silencers discharging steam through a manifolding system under a depth of gravel may also be used for power plant locations for sudden diverting of steam; with noise reductions equalling 35 to 40 dB.

3.5.3.4 Drill Site Preparation/Power Plant Construction

The noise generated from drill site preparation is largely from the operation of heavy equipment. Two strategies are available for noise impact mitigation: limitation of the hours of operation and/or limitation of project operation to months of absence of sensitive waterfowl species; and control of noise at the source by using heavily muffled "quiet model" equipment such as that required to be used in noise sensitive zones near hospitals, etc.

3.5.3.5 Well Drilling

The major noise sources during well drilling include diesel engines used to power the draw works, rotary table mud pumps, and power generators for other electrical uses. Also included is the noise from the racking of pipe. Well drilling near wildlife refuges and avian flyways may be restricted to months of low waterfowl activity. Likewise, pipe racking and stacking plus heavy truck traffic may be restricted to months of low waterfowl activity. Likewise, pipe racking and stacking plus heavy truck traffic may be restricted between 7:00 a.m. and 7:00 p.m. if near residential areas or other sensitive receptors. The technology also exists to quiet an entire drill rig where it is necessary to reduce levels because of sensitive adjacent land uses. This is done



Example of Noise Reduction from a Portable Steam Blow-Off Silencer

FIGURE 3.5-13

frequently in sensitive urban drill site areas. The entire tower is wrapped in a sound attenuating blanket, the engines are muffled more heavily and enclosed in shielding enclosures. This technology can does increase hazards to workers as well as costs but reduction in the order of 20 decibels could be attainable.

3.5.3.6 Power Plant/Steam Generation Facility

There are a number of sources of noise in a power plant/steam generation facility as was discussed in the impact section. Each of the various components can be reduced in their noise output to some degree. All internal combustion powered equipment may be quieted using high quality/reduction reactive muffling devices on the exhaust and by enclosing the equipment in noise dissipative enclosures that incorporate opening ports or doors for maintenance and observation.

a. Pipes and Valves

At locations where the geothermal fluid is allowed to flash to steam, the noise impact from this process and from the flow of steam, fluids and other gases, flow rates should be low and the transition between pipe sizes should be gradual. Figure A3.5-11 in Appendix 3.5 illustrates two ways of expanding a single or a two phase fluid flow. Rapid pressure changes produce more noise. Much noise generation and radiation can be reduced by a slow transition from one diameter conduit to another. Otherwise, turbulence forms in a liquid system when the pressure drops rapidly and gas is suddenly released in the form of bubbles, producing a roaring type noise.

If steam is flashed from the working fluid at a valve (letdown valve or throttle valve) the flow can be expected to be more turbulent than at a diffuser (as shown in Figure A3.5-11). However, if a valve is used for flashing of geothermal fluids, then measures should be taken to reduce the turbulence and rapid pressure changes which will result in higher levels of radiated noise. Figure A3.5-12 in Appendix 3.5 illustrates this requirement, showing first a typical control valve in a liquid system with a small valve seat and second a large seat valve. The small seat results in large flow speeds and pressure changes. The twisted flow pathways and sharp edges produce intense turbulence and sound radiation. The improved valve has a larger cone diameter, straighter flow pathways and more rounded edges. This results in less turbulence and noise radiation.

Experience at the North Brawley demonstration plant shows that the pipes and valves where flashing occurs may also need to be enclosed or wrapped with dissipative material to reduce radiated noise. Figure A3.5-13 in Appendix 3.5 shows an example of bad plumbing techniques for a branch steam line with three valves which produces a loud shrieking sound. The branch also has two sharp bends that are the source of considerable noise. The lower drawing in the figures shows a new branch with softer bends and tubing pieces between the valves to reduce or eliminate turbulence before the steam reaches the next valve.

b. Noncondensable Gas Vent Stacks

The main noncondensable gas vent stack at the North Brawley demonstration plant is a major noise source. Scaling up the plant size would also scale up the noise radiated from this part of the plant. The vent stack can be quieted quite effectively with a commercial blowoff silencer. These devices are custom designed to match gas flow rates, temperature and the required noise reduction. Figure A3.5-14 in Appendix 3.5 shows a cross section of a typical silencer that incorporates both dissipative elements (sound absorbing materials) and reactive elements (tuned chambers and tubes). Noise reduction in the order of 30 dBA can be expected from this type of treatment.

c. Turbine/Generator

The turbine/generator set is a significant noise source. Where the propagation of noise is considered important, these elements can be enclosed in a building. Noise reductions in the order of 30 dBA may be attained with proper building design and selection.

d. Condenser/Air Ejector

The condenser and air ejector components receive the steam that has passed through the turbine. Venturi scavenging by the air ejector removes noncondensable gases and produces one of the highest levels of noise from the power generation part of the plant. Change of designs, or enclosure in a building or shielded enclosure, could easily reduce radiated noise from these components by 30 dB and bring the radiated levels down to the ambient environment at a location much closer to the plant than the unmitigated conditions.

e. Cooling Tower

Noise from the cooling tower elements can be changed only with primary design changes. The noise is generated fundamentally by fan blade (air foil) vortex shedding. The noise radiated may be changed by using larger fans with slower tip speeds, more tower cells and lower fan rotational speeds. Because of the large size of the elements and the cooling air flow requirements they could not be enclosed in a building. Noise control requirements would have to be decided upon prior to design and installation since retro-fit is most impractical.

f. Hydro Blaster

The noise radiated from a Hydro Blaster performing descaling operations on encrusted components is primarily from the pump and its diesel engine. This problem has been solved in the air compressor industry for years by enclosing the trailer mounted equipment in a complete housing of damped material lined with a sound absorbent material. Effective mufflers at the intake and exhaust are not sufficient. Inspection and servicing doors must close tightly. Figure A3.5-15 in Appendix 3.5 shows a typical trailer mounted equipment with and without noise suppression treatment. The levels can be expected to be reduced 20 to 30 dB by use of these techniques. An alternative to this type of noise control is to use stationary pumps in a pump house with built-in noise control mufflers and acoustically engineered structures.

3.5.3.7 Summary

For the most part, noise control from a geothermal power generation installation should not be a problem on a long-term basis. The technology exists to control levels once noise environmental goals are set. The design process is not simple and involves an interaction between the acoustical engineers, the process engineers and the machinery and/or component designer/manufacturers. Plant setting and distances will determine just what measures will be reasonable. When actual component and plant layout designs are complete, the acoustical engineer can design and assist in reducing noise levels before construction.

3.6 BIOLOGICAL RESOURCES

3.6.1 Existing Conditions

3.6.1.1 Vegetation

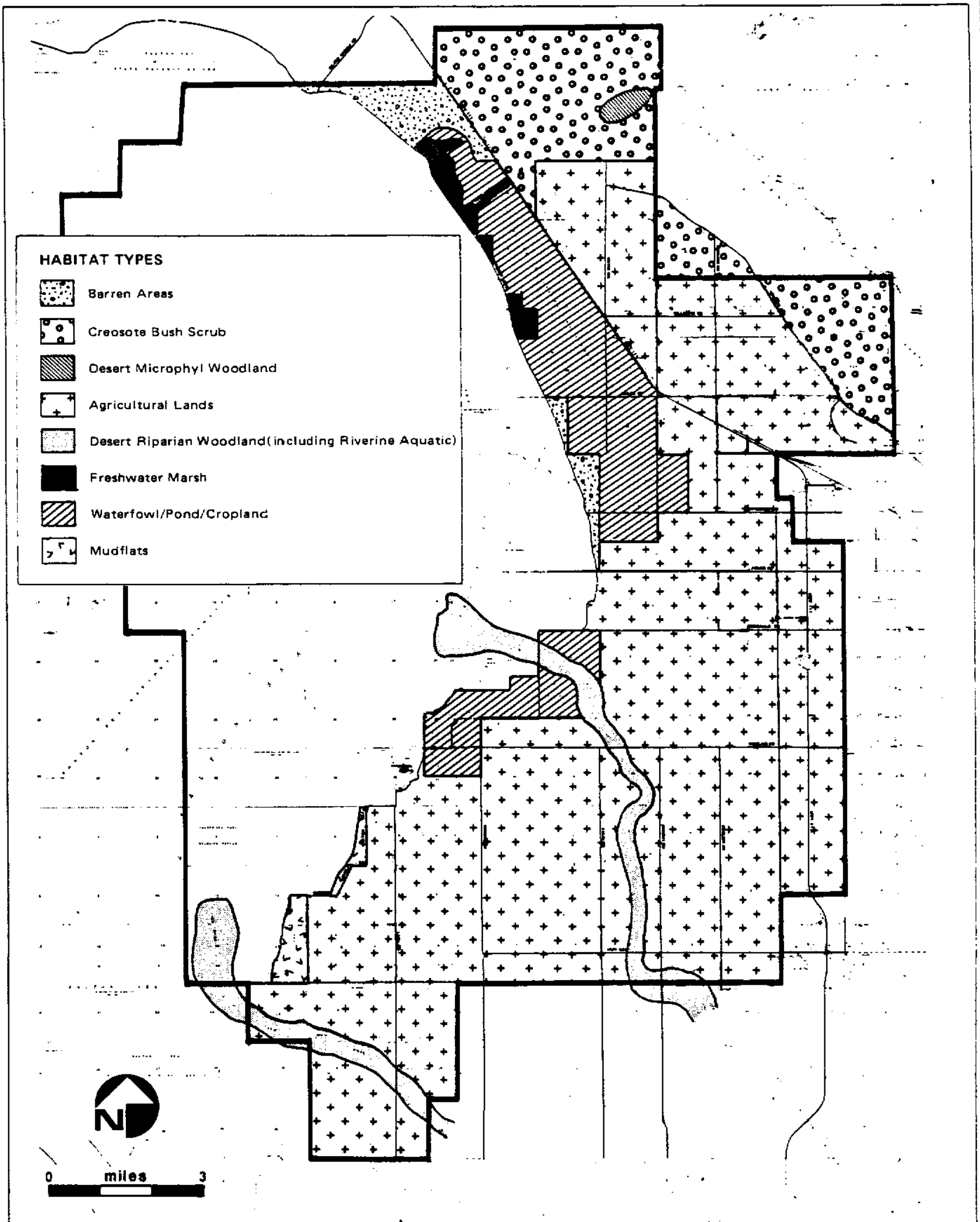
a. Plant Communities

Figure 3.6-1 delineates the major vegetation habitats within the study area. The majority of the area is or has been under cultivation. Major crops within the area include alfalfa, cotton and various truck crops such as lettuce, melons, and tomatoes.

Desert Riparian Woodland (Thorne, 1976) vegetative community exists within the study area along the New and Alamo Rivers, about some of the irrigation canals, and around the dikes and canals associated with Federal, State and private waterfowl management areas. In the study area, this vegetative cover consists of tamarisk or saltcedar (*Tamarix* sp.), common reed (*Phragmites australis*) and arrowweed (*Pulchea sericea*). Cattail (*Typha* sp) marsh is associated with this vegetative habitat and is especially extensive and well developed on the New and Alamo River deltas and at a number of locations along the seaward side of the Wister Unit of the Imperial Waterfowl Management Area.

Desert Microphyll Woodland (Thorne, 1976) or Wash Woodland (127)
(Burk, 1977) vegetation is present in a single location in the northeastern corner of the study area. This vegetation association is situated west of the Coachella Canal between siphons 13 and 14 and east of the northern terminus of the East Highline Canal. This vegetative cover is characterized by arboreal species and contrasts markedly with the surrounding low desert scrub. This particular woodland is visually dominated by desert ironwood (*Olneya tesota*). Common constituents of the association include the arboreal species palo verde (*Cercidium floridum*) and mesquite (*Prosopsis glandulosa* var. *torreyana*) and understory scrub species including saltbush (*Atriplex* spp.), brittlebush (*Encelia farinosa*), boxthorn (*Lycium andersonii*) and creosote bush (*Larrea tridentata*). Small patches of cattail indicates the presence of seeps possibly from the Coachella Canal within the woodland. Another more extensive woodland is present at about the same elevation from just north of the boundary of the study area boundary to the area about Frink Spring.

The area between these two woodlands is less vegetated Creosote Bush Scrub (Thorne, 1976). Below or generally west of the -100 foot elevation, the vegetation gradually becomes sparser to where west of State Highway 111 perennial vegetation is almost nonexistent. Species noted off Niland Marina Road include desert



Habitat Types

FIGURE 3.6-1

fir (Peucephyllum schottii), saltbush (Atriplex spp.), buckwheat (Eriogonum spp.), and honey-sweet (Tidestromia oblongifolia).

A number of small freshwater marshes exist west of the Wister Waterfowl Management Area. These marshes are dominated by cattail and common reed. The Wister Waterfowl Management Area, Salton Sea National Wildlife Refuge, the Hazard Unit of the Imperial Waterfowl Management Area, and numerous private duck clubs are managed for waterfowl. Ponds containing sedges, tules, and cattails as well as areas planted to grain crops are found in these areas. The locations of the ponds and grain crops vary from time to time depending upon waterfowl management practices.

b. Sensitive Species

Table 3.6-1 lists plant species that are considered rare or endangered by the California Native Plant Society (CNPS, 1980), State of California (CDFG, 1979), or the US Department of Interior (USFWS, 1980), and that are known to occur in the Imperial Valley area. Table 3.6-2 is provided so that status codes in Table 3.6-1 can be interpreted. There is a possibility that localized populations of these species could occur within the northeastern portion of the study area where native plant populations have not been eliminated by agricultural development.

None of the species listed in Table 3.6-1 are listed as rare or threatened by the U.S. Fish and Wildlife Service (USFWS, 1979). Ammobroma sonorae is currently under review by the U.S. Fish and Wildlife Service for inclusion as a federally listed species (Wirth, 1980). It is listed as rare and endangered by the California Native Plant Society (CNPS, 1980). Ammobroma sonorae is found primarily within the Algodones Dunes and adjacent sandy areas of the East Mesa of Imperial Valley. It is also found at a single location on West Mesa in the northwestern corner of Imperial County. This species is a root parasite on several perennial shrubs. Host species include Eoldenia plicata, Coldenia palmer, Eriogonum deserticola, and possibly Pluchea sericea (WESTEC Services, 1977). These species could all occur in the northeastern corner of the study area. Ammobroma sonorae prefers very sandy or dune areas, a habitat condition that appears to be lacking in the study area.

Astragalus magdalenae var. peirsonii is listed as an endangered species by the California Department of Fish and Game (CDFG, 1979). This species has been recorded from the Algodones Dunes and a dune system in the Borrego Valley. This species prefers dunes, a feature lacking in the study area.

Table 3.6-1

SENSITIVE PLANTS THAT MAY OCCUR IN THE STUDY AREA

Scientific Name	Common Name	Status[1]	
Ambrosia ilicifolia	Holly-leaved Burbush	None	
Ammobroma sonorae	Sand Food	USFWS CNPS	- under review - rare and endangered, code 2-2-2-2
Astragalus crotalariae	Salton Milkvetch	CNPS	- rare but not endangered
Astragalus insularis var. harwoodii	Harwood's Rattleweed	CNPS	- rare in California, common elsewhere, code 2-2-1-1
Astragalus lentiginosus var. borreganus	Borrego Milkvetch	CNPS	- rare in California, common elsewhere, code 2-2-1-1
Astragalus magdalenae var. peirsonii	Peirson's Milkvetch	CDFG CNPS	- endangered - rare and endangered, code 3-2-1-2
Opuntia munzii	Munz's Cactus	CNPS	- rare and endangered, code 2-1-1-3
Pilostyles thurberi	Thurber's Pilostyles	CNPS	- rare in California, common elsewhere, code 1-1-1-1
Saliva greatai	Orocopia Sage	CNPS	- rare and endangered, code 2-1-1-3

[1]See Table 3,6-2 for explanation of CNPS rarity and endangerment code.

Table 3.6-2

RARITY-ENDANGERMENT CODE
(California Native Plant Society 1980)

Rarity (R)

1. Rare, of limited distribution, but distributed widely enough that potential for extinction or extirpation is apparently low at present.

2. Occurrence confined to several populations or one extended population.

3. Occurs in such small numbers that it is seldom reported; or occurs in one or very few highly restricted populations.

P.E. Possibly extinct or extirpated.

Endangerment (E)

1. Not endangered.

2. Endangered in part.

3. Totally endangered.

Vigor (V)

1. Stable or increasing.

2. Declining.

3. Approaching extinction or extirpation.

General Distribution (D)

1. Not rare outside California.

2. Rare outside California.

3. Endemic to California.

The California Native Plant Society (CNPS, 1980) lists Opuntia munzii and Salvia greatai as rare and endangered. Opuntia munzii is found in dry gravelly places in the Chocolate and Chuckwalla Mountains. It has been recorded from the adjacent Uris Pass 15' USGS quadrangle east of the study area. Salvia greatai is found in dry washes and on fans below 600 feet in elevation in the Orocopia and Chocolate Mountains. It has been recorded from the Frink 15' USGS quadrangle.

Astragalus crotalariae is listed as rare but not endangered by the California Native Plant Society (CNPS, 1980). This species prefers sandy flats and fans. This species has been recorded at a number of locations on the West Mesa of Imperial County and is found in Baja California and adjacent southwest Arizona.

Astragalus insularis var. harwoodii, Astragalus lentiginosus var. borreganus, and Pilostyles thurberi are all listed by the CNPS (1980) as rare in California but common elsewhere. Both Astragalus species prefer dunes and sandy valleys. Both have been recorded in the Colorado Desert, Arizona and Sonora, Mexico. Pilostyles thurberi is a minute stem parasite that grows on Dalea emoryi in San Diego and Imperial Counties, southwest Arizona and Baja California.

A number of additional high interest plant species have been recorded for eastern Imperial County. Croton wigginsii, Helianthus niveus ssp. tephrodes and Palaforxia arida var. gigantea are confined to the Algodones Dunes in the United States although their distribution extends south of the U.S. Mexico border. Dune habitat is not found within the study area. Eriogonum deserticola, desert eriogonum, has been recorded from the general project area. This species was previously listed as a rare and endangered species by the CNPS (1974). Subsequent fieldwork revealed the species did not warrant such status, however, and it has subsequently been removed from the most recent CNPS listing. Ambrosia ilicifolia is not listed by the California Native Plant Society. It is included in this discussion because it has been referred to as a rare species (Mung, 1974; BLM, 1975). It is found in sandy canyons and washes in the Colorado Desert east of the Salton Sea and has been recorded for Imperial and Riverside Counties, western Arizona, and northern Lower California.

3.6.1.2 Wildlife

a. Reptiles and Amphibians

The reptile and amphibian wildlife component of the majority of the proposed study area is typical of the agricultural areas of the Imperial Valley. Bullfrog (Rana catesbeiana) and leopard frogs (Rana pipiens) occur within the rivers, irrigation drains and marshes (duck ponds). The red-spotted toad (Bufo punctatus) may also occur within the more natural areas in the northern portion of the study area.

Reptilian species within agricultural areas would be primarily limited to side-blotched lizard (*Uta stansburiana*), western whiptail (*Cnemidophorus tigris*), gopher snake (*Pituophis melanoleucus*), common kingsnake (*Lampropeltis getulus*), and western diamond rattlesnake (*Crotalus atrox*). The checkered garter snake (*Thamnophis marcianus*) may also occur within irrigation drains and the New and Alamo Rivers. The northern portion of the study area would be expected to contain reptilian species typical of the desert regions of the Imperial Valley. These species would include the leopard lizard (*Gambela wislizenii*), long-tailed brush lizard (*Urosaurus graciosus*), desert horned lizard (*Phrynosoma platyrhinos*), western blind snake (*Leptotyphlops humilus*), coachwhip (*Masticophis flagellum*), western patch-nosed snake (*Salvadora hexalepis*) and sidewinder (*Crotalus cerastes*). There is a slight potential that the flat-tailed horned lizard (*Phrynosoma m'calli*) could occur in this area. The desert spiny lizard (*Sceloporas magister*) may occur within the patches of Ironwood and Palo Verde.

b. Mammals

Based on wildlife studies of the Imperial Irrigation District by Gould (1975) and of the Finney-Ramer Unit of the Imperial Wildlife Area (CDFG, 1978), the agricultural and riparian areas of the study area would be expected to support the deer mouse (*Peromyscus maniculatus*), the desert long-tailed and spiny pocket mouse (*Perognathus penicillatus*, *P. formosus*, and *P. spinatus*), house mouse (*Mus musculus*), botta pocket gopher (*Thomomys bottae*), and round-tailed ground squirrel (*Spermophilus tereticaudus*) as the principal rodent species. Muskrat (*Ondata zibethica*) and possibly beaver (*Castor canadensis*) may occur in the rivers and drains of the study area. 125 Black-tailed jack rabbits (*Lepus californicus*) and desert cottontails (*Sylvilagus audubonii*) are found throughout the area with probable highest densities found within the riparian areas. Carnivores expected to occur within the study area include coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis*), and spotted skunk (*Spilogale putoris*).

The desert scrub areas in the northern portion of the study area would be expected to support more desert-adapted rodents including kangaroo rats (*Dipodomys merriami* and *D. deserti*), pocket mice (*Perognathus* spp.), and cactus mice (*Peromyscus eremicus*).

c. Avian Resources

1. Species Occurrence

The Salton Sea is regarded as an area of high waterfowl activity especially during migration periods and as overwintering habitat. Thousands of shorebirds and waterfowl have been documented as occurring in this region (Jurek, 1974; McCaskie, 1970; Small, 1974).

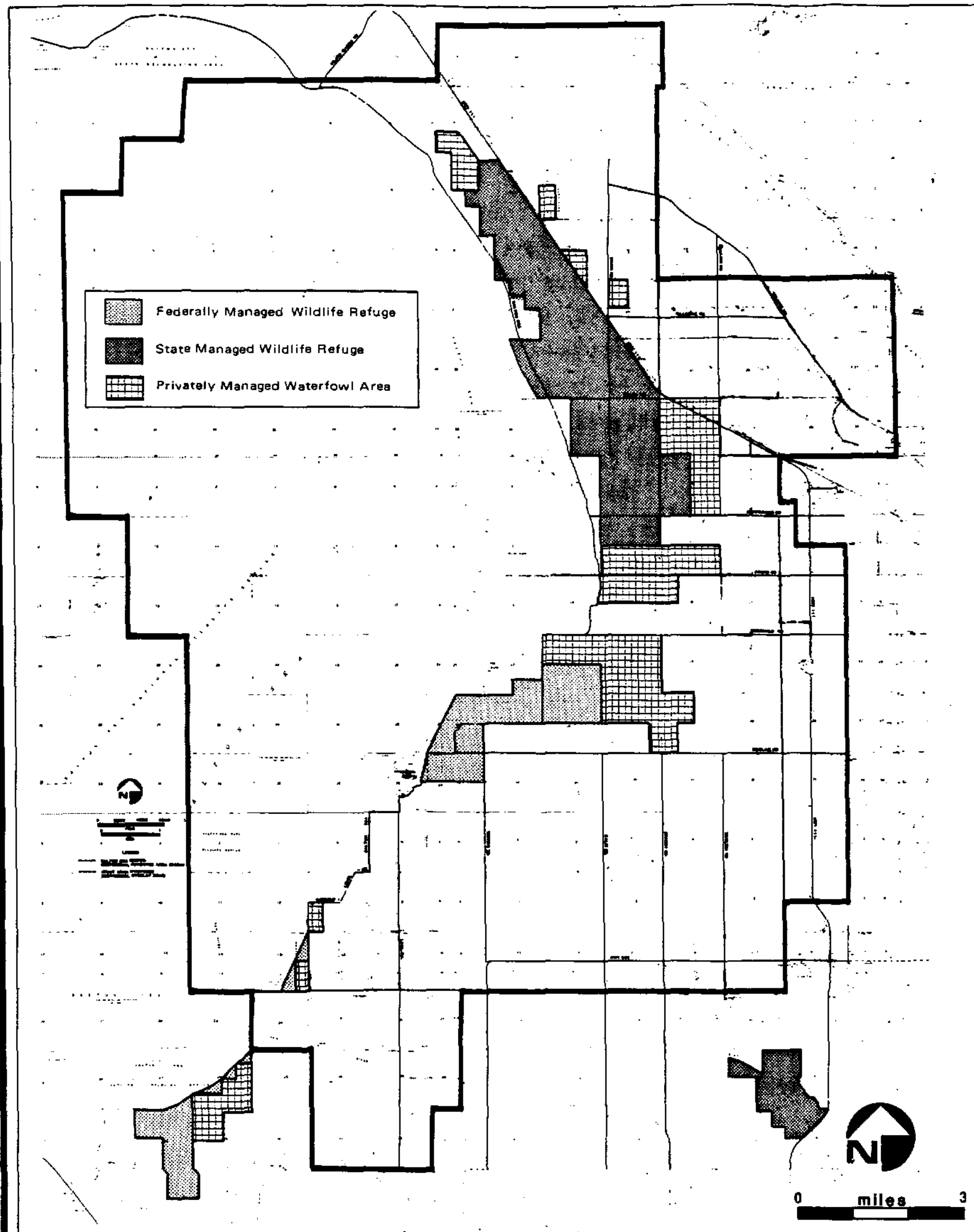
Table A3.6-1 in Appendix 3.6 summarizes documented avian resources which occur with some regularity at the Salton Sea National Wildlife Refuge. Table A3.6-2 also in Appendix 3.6 lists species which are seen irregularly at the refuge and are documented as casual or accidental occurrences. In addition to numerous waterfowl and shorebirds, species occurrence also include those birds frequenting agricultural, mudflats, riparian, and desert habitats.

Snow Goose populations at the Salton Sea National Wildlife Refuge presently average about 12,000 birds and have numbered up to 20,000 in the past. Great Basin Canadian Geese populations reach 5000 birds. Duck populations number into the hundred thousands with the majority of birds consisting of Pintails, Ruddy Ducks, Green-wing Teal, and Shovelers (Dean, 1981). Leitner and Grant (1978) censused nearly 10,000 Cattle Egrets and over 4000 White Pelicans near the study area in 1977.

2. Wildlife Refuges and Duck Clubs

In order to protect the large waterfowl population at the Salton Sea, provide protection from crop depredation, and to manage the waterfowl for hunting, the State of California and the federal government have established wildlife refuges within and adjacent to the study area. In addition, up to approximately 50 private duck clubs are situated within the study area. These refuges and duck hunting clubs are shown in Figure 3.6-2.

The Salton Sea National Wildlife Refuge was established in 1930 for protection of ducks, geese, and shorebirds as well as for agricultural protection from crop depredation. The Refuge's original 35,000 acres (14,165 ha) was inun-
78 dated by the rising Salton Sea. In 1947, the Imperial Irrigation District leased a total of approximately 24,000 acres (9713 ha) to the Fish and Wildlife Service, State of California, and the U.S. Navy. Much of this additional land has been innundated by the Salton Sea, so that the total managed refuge lands consist presently of approximately 1565 acres (633 ha). An additional 363 acres (147 ha) are proposed for acquisition within the south unit. The Salton Sea National Wildlife Refuge is divided into two units (Units I and II). Unit I, consisting of 650.6 acres (263 ha), is located adjacent to the study area west of the New River. Two small mudflat areas of Unit I are located within the study area. Unit II, occupying 379.3 acres (154 ha) is located within the study area. In addition, the 535 acre (217 ha) Hazard Tract, owned by the California Department of



Duck Clubs and Wildlife Refuges

FIGURE 3.6-2

2

126

Fish and Game, is managed as a portion of the Salton Sea National Wildlife Refuge. The Refuge also leases 1,300 acres (526 ha) within the Salton Sea that is not managed for waterfowl.

The Salton Sea National Wildlife Refuge has over 700 acres (283 ha) that are farmed for alfalfa and rye grass. Approximately 800 acres (323 ha) are maintained in marsh and open water habitats.

The California Department of Fish and Game owns the Wister Waterfowl Management Area located in the northern portion of the study area. Consisting of approximately 5255 acres (2127 ha), the Wister area is maintained in both grain pastures and in marshland and open water. The California Department of Fish and Game also manages the 2600 acre (1052 ha) Finney-Ramer Wildlife Management Area located southeast of the study area.

In addition to the formal wildlife refuges, approximately 50 private duck hunting clubs are located within the study area. These duck hunting clubs vary in size and management practices. Many of these duck and gun clubs consist of agricultural fields that are flooded during hunting season. Other duck hunting clubs are more carefully managed with extensive marshlands maintained on a more permanent basis. Figure 3.6-2 delineates the location of duck hunting clubs identified by field inspection and contact with fish and wildlife agencies. It should be noted that the location and activity of these areas vary from year to year.

3. Waterfowl Flight Corridors and Rafting Areas

Waterfowl activity studies within the Salton Sea area have been of narrow scope and short duration. Leitner and Grant (1978) performed somewhat limited studies of general avian movements within the study area. WESTEC Services (1980c) performed more comprehensive activity studies, however these studies were highly localized. Both the U.S. Fish and Wildlife Service and the California Department of Fish and Game have conducted ground and aerial censuses on a frequent basis. However, no comprehensive studies have been conducted, to provide a clear picture of waterfowl movements and use of the area on a long term basis. Another data gap concerns nighttime waterfowl movements within the area.

Although comprehensive data are lacking, some general waterfowl movement patterns can be delineated. For the purposes of this report, two general types of flight patterns are identified. These flight patterns are short duration flights between feeding areas and long duration flights between refuges and separated feeding areas.

The short duration flights generally occur between feeding areas within units of the wildlife refuges and adjacent fields and duck clubs. These flights vary from month to month and year to year depending upon cropping patterns and hunting pressure. Normally these flights are of low altitude and encompass flight paths of less than one mile.

Leitner and Grant (1978) have identified major longer distance flight corridors within the study area. These flight corridors are delineated on Figure 3.6-3. It must be emphasized that these corridors are areas of highest flight use and do not preclude the potential of significant numbers of birds flying within other areas. Based on Leitner and Grant's (1978) analysis, the following major flight corridors have been identified:

a) New and Alamo Rivers

Many flocks of birds follow the New and Alamo River corridors. Leitner and Grant (1978) noted flocks of Cattle Egrets along the Alamo River from the Salton Sea to the Finney-Ramer Wildlife Management Area. It should be noted that the number of egrets observed during the current study were much reduced. Cattle Egrets formerly bred on the Wister Unit and presumably roosted there; however, the majority of the Cattle Egrets in the southern Imperial Valley now roost south of Seeley. The rivers still serve as major flight corridors for a variety of species; most species observed were flying below 100 feet.

b) Salton Sea Shoreline

Leitner and Grant (1978) recorded high waterfowl flights along the Salton Sea shoreline in a corridor radiating approximately one mile offshore and onshore from the coastline. Flocks of White Pelicans, Pintail, Canada Goose, and Snow Goose were regularly recorded flying along the coastline between Units I and II of the Salton Sea National Wildlife Refuge and the Wister Waterfowl Management Area. Flight altitudes were generally no lower than 100 yards (92 m). Birds noted during the current study were observed at a much lower altitude. This may be due to the fact that current surveys were conducted after hunting season has ended. In addition to flights along the coastline, waterfowl frequently feed up to three miles inland from the shoreline. Personnel at the Wister Waterfowl Management Area (Gonzales, personal communication) have documented movement of waterfowl from the management area in a northeasterly direction toward the Chocolate Mountains presumably to pick up gravel. In addition, WESTEC Services (1980c) noted large flocks of gulls flying in an east-west direction across the Salton Sea.

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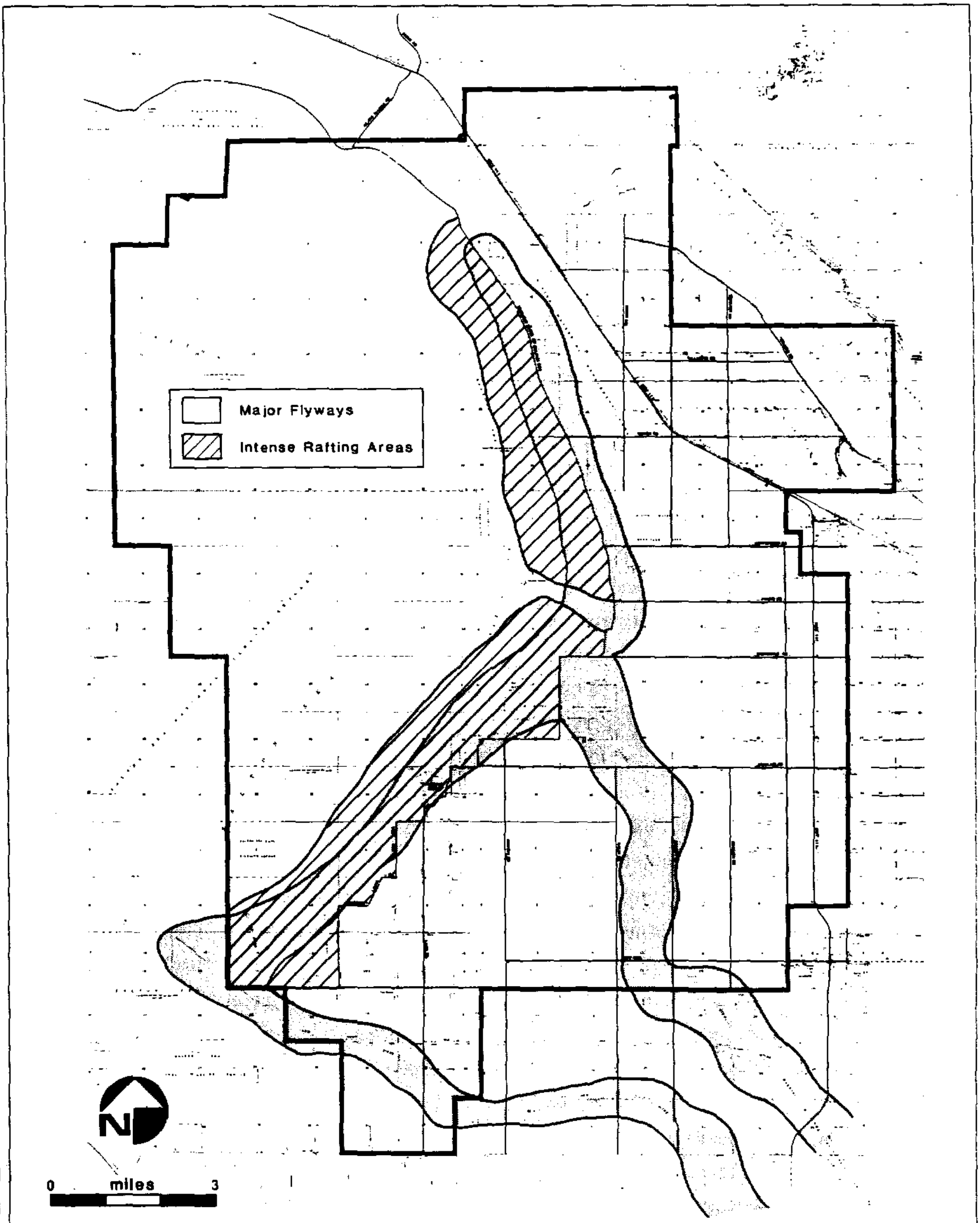


Major Avian Flyways and Rafting Areas

FIGURE 3.6-3

The Salton Sea itself is used extensively as a rafting area for waterfowl. Dean (personal communication) has indicated that the southern and northern ends of the sea are high-use rafting areas. The Salton Sea portion of the study area should be considered a high-use rafting area. As shown in Figure 3.6-3, a majority of the shoreline is a year-round intensive-use rafting area with tens of thousands of ducks and geese concentrated from the shoreline to approximately two miles offshore. The remainder of the Salton Sea also supports significant rafting populations of waterfowl.

4. Hunting and Recreational Use

The Salton Sea region is an important area for waterfowl hunting. Hunting season generally runs from November through January with varying activity both on federal and state refuges and at private duck clubs. Hunting is conducted both within refuge areas as well as throughout the many duck hunting clubs in the area.

In addition to hunting use, the Salton Sea area is a high use area for birdwatching. Universities and private organizations regularly conduct field trips to the area both because of the high avian species diversity and densities. The Salton Sea area supports many uncommon migrating bird species which are of particular interest to birders.

5. Ongoing or Planned Waterfowl Studies

The U.S. Fish and Wildlife Service, California Department of Fish and Game, and other organizations are conducting ongoing biological studies on or adjacent to the study area. The U.S. Fish and Wildlife Service (Dean, personal communication) is currently conducting the more comprehensive studies of the Salton Sea area with emphasis upon the Salton Sea National Wildlife Refuge. These studies include:

a) Waterfowl Aerial Census. This survey is conducted by fixed-wing aircraft throughout the Salton Sea area on a bimonthly basis from mid-October through mid-March. These studies provide information on waterfowl densities, resting areas, and rafting areas.

b) Bi-monthly Wildlife Census. Transects have been conducted throughout the year on a bi-monthly basis throughout the Salton Sea National Wildlife Refuge. The primary goal of this study focuses upon identification of habitat use.

c) Mortality Transects. Mortality transects coordinated with the National Wildlife Health Lab are conducted within the refuge to deter-
20 mine the causes and severity of migratory bird loss from disease, determine the seasonality of these losses over time, determine relationship between occurrence and environmental changes, and evaluate the effectiveness of disease control activities.

d) Powerline Transects. Transects were initiated in October of 1980 in order to determine the extent of wildlife mortality from existing electrical transmission lines.

e) Salton Sea Inventory. The U.S. Fish and Wildlife Service is planning to initiate studies in the spring of 1981 to survey, census and evaluate the bird use in the Salton Sea area. The study is planned to determine species distribution, nesting areas, and year-round population trends and usage. The intensity and duration of these studies are dependent upon funding priorities in the future.

Studies conducted by the California Department of Fish and Game are currently oriented toward surveys within their managed areas and monitoring of hunting activities including private duck hunting clubs. Aquatic studies are also conducted on a frequent basis. These studies are severely limited in scope due to low funding levels.

6. Nesting Habitat

The Salton Sea area has been historically an active nesting area for many species of birds. In particular the study area supports heron rookeries along the New and Alamo Rivers and within the Wister Waterfowl Management Area. The area near the mouth of the New River has been identified as a heron rookery by Engineering Science (1980). Species such as dove and quail also use this area for nesting.

d. Sensitive Species

The Salton Sea area contains wildlife listed by the U.S. Fish and
79 Wildlife Service and/or California Fish and Game Commission as rare, threatened, or endangered. In addition, the area contains other wildlife species considered by land management agencies, wildlife agencies, and private wildlife organizations as sensitive.

1. Species Listed as Threatened, Rare, or Endangered

Yuma Clapper Rail - The Yuma Clapper Rail is considered as endangered by the U.S. Fish and Wildlife Service and as rare by the State of California. This secretive species nests and feeds within wetland habitats containing mature stands of cattail and bulrush (Bennett and Ohmart, 1978). Surveys by Bennett and

Ohmart (1978) found Clapper Rails distributed at the New River delta, Alamo River delta, Wister Wildlife Management Area, and Salton Sea Wildlife Refuge (Unit II) within the study area.

The water level of the Salton Sea has risen since the 1978 survey resulting in loss of some habitat and possible displacement of birds to other areas. Based on discussions with refuge personnel, many portions of the study area could be considered as potential habitat for this species. These habitats could include managed ponds on wildlife refuges and duck clubs, as well as portions of the New and Alamo Rivers, marshes near Wister Waterfowl Management area, and some potential seep areas near the Coachella Canal. Powell (personal communication) also reported that Clapper Rails migrate along the New and Alamo River corridors.

Black Rail - The Black Rail is considered threatened by the U.S. Fish and Wildlife Service and rare by the California Fish and Game Commission. The species has been documented as occurring within the study area in low numbers and may be expected to inhabit similar habitat to the Yuma Clapper Rail.

Southern Bald Eagle - The Southern Bald Eagle is classified as endangered by the U.S. Fish and Wildlife Service and the California Department of Fish and Game. The species is noted as an occasional visitor to the study area. The study area should be considered as foraging and perching habitat for this sensitive species.

American Peregrine Falcon - The American Peregrine Falcon has been spotted occasionally within the study area. This species is listed as endangered by both the USFWS (1979) and the CDFG (1978). The study area should be considered as potential foraging habitat for this endangered species.

Brown Pelican - The Brown Pelican, an endangered species, is an occasional summer and fall visitor to the Salton Sea.

Least Tern - This endangered species is an accidental visitor to the Salton Sea.

Aleutian Canada Goose - This federally endangered subspecies of Canada Goose has been observed infrequently at the Salton Sea (Springer et al, 1978).

Desert Bighorn Sheep - Bighorn Sheep have been observed in the northern portion of the study area (Gonzales, personal communication). The habitat of this species is principally within the Chocolate Mountains and the project area should at most be considered peripheral to that habitat.

Other Sensitive Species - The northern portion of the study area was identified as potential habitat for the flat-tailed horned lizard by Turner et al. (1979). This species is proposed for status review by the U.S. Fish and and Wildlife Service, is fully protected by the CDFG (1980), and is considered a sensitive species by the Bureau of Land Management (1980a). This species is generally restricted to sandy habitats. Habitat for this species has been lost through agricultural development and off-road vehicle use.

In addition to the rare, threatened, or endangered species listed above, the Salton Sea area supports numerous avian species classified as sensitive due to their general population decline within the southwest. These species are listed and described in Appendix 3.6.

3.6.1.3 Aquatic Resources

a. Salton Sea

1. Structure of the Algal Subsystem

The plant life in the Sea is predominantly single-celled algae suspended in the water column or forming thick mats of growth on the bottom, especially nearshore. The algal mat has been found to be composed of numerous species of blue-green algae, their gelatinous matrix and some attached littoral diatoms (Carpelan, 1961). The nature and productivity of this benthic mat suggests that it is probably an active site for decompositional processes and nutrient recycling, although no research has been done in this area. In fact, the whole area of nutrient cycling in the Salton Sea has been largely ignored.

The phytoplankton cycle described by Carpelan (1961) is consistent with eutrophic lake phytoplankton dynamics (Russell-Hunter, 1970). However, there appears to be a succession of phytoplankton blooms within the peak periods as defined by Carpelan, which operate on a 7-20 day production cycle (K. Kline, unpublished data). These "internal cycles" have not been described in the past. There is a need for additional research in this area.

The dominant flora in the phytoplankton are diatoms, dinoflagellates, and green algae. According to Carpelan (1961) phytoplankton densities range from 5000 cells/ml in the late summer and fall to as high as 100,000 cells/ml in the winter and early summer. He did state that different species appeared to make up the maxima at the different seasons.

Primary production has been shown to be dependent upon a number of variables including temperature, depth, nitrogen and phosphorous levels and zooplankton grazing (Riley, 1946). In the Salton Sea, zooplankton levels are high in the spring and summer and appear to coincide with lower phytoplankton levels, with the situation reversing in the winter (Carpelan, 1961).

The diatoms were the dominant phytoplankton form with Pleurosigma sp., Thalassionema nitzchoides, Nitzschia longissima and Cyclotella caspia making up the numerical majority during most parts of the year (Carpelan, 1961). The production of diatoms appears to increase in the fall and winter and to decrease in the summer.

The dinoflagellates (Class-Dinophyceae) were the next most dominant group in the phytoplankton. Two species tend to dominate the production; Glenodinium sp. and Exuviella compressa. Carpelan (1961) found these two species at all times of the year, with highest numbers being found in the winter. Dinoflagellate levels ranged from 6000 cells/ml in the summer to approximately 100,000 cells/ml in the winter months. The dinoflagellate blooms are called "red tides" by local people. However, the algae involved are not known to release toxin upon ingestion by fish or shellfish. Local fish kills associated with these occurrences appear to be caused by oxygen depletion and accumulation of hydrogen sulfide. Levels of hydrogen sulfide subsequent to a bloom has been as high as 15 ppm (Kline, unpublished data).

At times green algae may dominate the phytoplankton, particularly in the summer. One species was identified by Carpelan (1961) as Westella botryoides and was found in high numbers in the early summer. Normally, the green algae do not represent a major element in the phytoplankton dynamics of the sea. The algal subsystem has only recently been used directly by fish for food. Most of the phytoplankton dies and is deposited on the bottom to be used by detritovores such as Neanthes, the Pileworm, which is then utilized by a number of species of fish. The recent introduction of Tilapia into the Sea has altered the feeding web somewhat, since the Tilapia feed directly on algae. The phytoplankton and benthic algal mat was last studied over 20 years ago (Carpelan, 1961).

2. Invertebrates and Zooplankton

In 1961, Linsley and Carpelan examined the invertebrate ecology of the Salton Sea. In their assessment, they documented an extremely low species diversity. They felt that the rigorous environmental constraints in the Sea place extraordinary selection pressure on potential species. The basin-like characteristics of the Sea as well as no "tidal cycle" limits the type of habitats available, with those organisms able to adapt being found in high numbers.

Six phyla of invertebrates are represented in the sea. These include numerous species of ciliates (Phylum-Protozoa) living on the blue-green algal mat. Foraminiferans are also found on the algal mat as well as in sediment deposits (Arnal, 1961).

The Rotifera is represented primarily by one species, Brachionus plicatilis. This species is often found in high numbers in the zooplankton, particularly in the summer. It is a large rotifer that could be utilized as a food source by zooplankton feeding fish; however, it does not appear to be effectively utilized in the Salton Sea. Linsley and Carpelan (1961) felt that the majority of the production became part of the detrital element and was utilized in that manner.

Two colonial species of Bryozoans were identified by Soule (1957) as Ńolella blakei and Victoriella pavida. These colonial animals form a moss-like growth on solid objects and are neither numerous nor important in the ecology of the Sea.

Nematodes occur in the algal mat and have been identified to the genus Spilophorella. They are present in high numbers, but are extremely small, and are probably more important in decompositional processes than as a food source (Linsley and Carpelan, 1961).

One species of annelid worm is present in the Sea and has been shown to be of significant importance in the feeding strategies of several species of fish. Neanthes succinia, occasionally referred to as Nereis succinia, was introduced in 1930 when a few worms were included in material planted by the California Department of Fish and Game (Linsley and Carpelan, 1961). Neanthes is a bottom-dwelling detritus feeding worm, spending most of its life on the bottom in burrows or among masses of barnacles. It is abundant in the Sea and is probably of substantial importance in the decomposition of deposited organic material. Its life history has been described by Carpelan and Linsley (1961). Several subsequent studies have been done to determine its capability of dealing with increasing salinities (Kuhl and Oglesby, 1979; Hanson, 1972). These studies have shown that the worm can withstand salinities as high as 67 parts per thousand (ppt). Reproduction is reduced significantly at salinities over 50 ppt and fertilization and larval development at 45 ppt (Kuhl and Oglesby, 1979). The last invertebrate phylum represented is the Arthopoda-Class Crustacea. Two groups of crustaceans appear to be of importance in the zooplankton and benthic ecology of the Salton Sea. Cyclops dimorphus, a member of the Copepoda, is numerically important in the zooplankton in the summer months, and is probably important as food for larval fishes. It is dominant in the plankton only during the warmest parts of the year and disappears in the early winter. Its biology is discussed by Carpelan (1961) for the Salton Sea population.

Probably one of the major species in the zooplankton as well as the benthic ecosystem is the barnacle, Balanus amphitrite Darwin. The first 112
observation of the species in the sea was in 1944 (Cockerell, 1945). It is probable that the initial stocking was via docks, moved from San Diego Bay to the Naval Facility on the Salton Sea in the early 1940's. The natural history of the barnacle is reviewed and discussed by Carpelan (1961). Two abundance peaks occur: one in the late spring and one in early fall. Planktonic barnacles are found in higher numbers nearshore, where increased attachment surfaces are present. The population is possibly limited by natural attachment surfaces; however, the population takes advantage of any potential site including bottles, outboard motors, boats, pilings, and any other hard surface. The barnacle does not appear to have a predator in the sea, although it is probable that nauplii and cypris zooplankton stages are eaten by larval fishes. Vittor (1968) and Sixtus (1978) have done more recent work on this population. Sixtus (1978), using electrophoretic techniques, determined that the Salton Sea population was contiguous with the San Diego Bay population, though some differences are beginning to appear.

Again, much of the work on the invertebrates of the sea was done over 20 years ago. Changes have occurred and it is no longer easy to accept the facts probably true then, without further study of at least the major and influencing species of zooplankton and benthic invertebrates.

3. Fishes

The historical status of fish introductions into the Salton Sea is well documented and discussed by Walker, Whitney and Barlow (1961). Numerous species were introduced into the sea by personnel from the California Department of Fish and Game in an attempt to find a species or group of species that could survive and maintain themselves in the waters of the Salton Sea. From 1929 to 1956, major stocking efforts were carried out. By 1956, nine species were present in the Sea and several species appeared to be reproducing successfully. The nine species were:

Dorosoma petenense	Threadfin Shad
Cyprinodon macularis	Desert Pupfish

Gambusia affinis	Mosquitofish
Mugil cephalus	Striped Mullet
Anisotremus davidsoni	Sargo
Bairdiella icistius	Bairdiella or White Croaker
Cynoscion xanthulus	Orangemouth Corvina
Cynoscion parvipinnis	Shortfin Corvina
Gillichthys mirabilis	Long-jawed Mudsucker

The biology of the Threadfin Shad (Dorosoma petenense) is well discussed by Hendricks (1961) and Moyle (1976). It is commonly found in the surrounding freshwater sources adjacent to the Salton Sea and can survive in the Salton Sea. It is unlikely that spawning takes place in the sea, and therefore recruitment to the sea is from freshwater sources. Hendricks (1961) suggested that the shad was a fairly important dietary element for corvina. At the present time it does not appear to be as important as it possibly once was to the corvina (Glenn Black, Cal. Fish and Game, Pers. Comm.).

The biology and present distribution of the Desert Pupfish (Cyprinodon macularis) in California is described by Moyle (1976). A more recent study by Black (1980) discusses the present status of the species in and around the Salton Sea. This species is extremely adaptable and has been found in areas of environmental extremes. They have been known to tolerate temperatures from $48^{\circ}F$ to $113^{\circ}F$ ($9^{\circ}C$ to $45^{\circ}C$), salinities from 0 ppt to 68 ppt, and oxygen levels from 0.1 parts per million to
60 saturation (Moyle, 1976). The current status of this species is in question. Apparently
80 its population levels have been reduced in the Sea, probably due to competition with
111 mollies, Tilapia and Mosquitofish (Black, 1980). Black (1980) has requested endangered
145 species status for the Desert Pupfish in and around the Salton Sea, especially in the area around San Felipe Creek, which discharges into the sea just south of the proposed solar pond site.

The biology of the Mosquitofish (Gambusia affinis) is described by Moyle (1976). This fish has been extensively stocked in freshwater habitats for use as a biological control of mosquito larvae and pupae. In nature, however, they have been found to have rather omnivorous dietary habits. In many instances, these fish have been found to be useful in controlling aquatic insects; however, in undisturbed ecosystems they may interact in a negative way with native species such as the Desert Pupfish (Moyle, 1976; Black, 1980). Mosquitofish is commonly found in freshwaters surrounding the sea and at inlets to the sea. It is likely that its role in the ecosystem is minor.

The Striped Mullet (Mugil cephalus) has not been found in the sea for at least 10-20 years and is considered extinct in the sea (Walker et al. 1961; G. Black, Cal. Fish and Game, Pers. Comm.).

The status of the Sargo (Anisotremus davidsoni) is 61
described by Walker, Whitney and Barlow (1961). At that time it was felt that the 114
Sargo population was on the increase and would possibly replace the Bairdiella as a forage species for corvina. Little is known of the biology of the Sargo in the Salton Sea to date. At the present time the population appears to be extremely low (G. Black, Cal. Fish and Game, Pers. Comm.; K.F. Kline, unpublished data). This is possibly due to a competitive interaction with the abundant Bairdiella and possibly with the Tilapia. This species may be very close to extinction in the sea, or at least at very low levels.

The White Croaker (Bairdiella icistius) is extremely abundant in the sea at the present time, though no published data is available from recent studies. An ongoing California Department of Fish and Game Study has found high numbers present in a variety of locations in the sea. They were originally felt to be a major food source for corvina (Walker, Whitney and Barlow, 1961). Whitney (1961) reviewed their biology and studied reproduction and population dynamics for the species in the Salton Sea. It is apparent that this species is a dominant member of the fish ecosystem in the sea.

The Orangemouth Corvina (Cynoscion xanthulus) is the dominant predator and sport fish at the present time in the Salton Sea. The biology of this population was discussed originally by Whitney (1961). At that time the species was undergoing an explosive population increase and growth rates were high. Growth to four inches (100 mm; standard length) is fairly slow then increases sharply reaching nearly 16 inches (400 mm) at two years. This growth spurt is likely to be the result of a major dietary shift, probably from Neanthes to fish.

There was some concern in the past two years by Fish and 113
Game personnel over the fact that few young of the year (less than one year old) and 1+ year old corvina were being found. The present study by Fish and Game is reassessing the growth and reproductive biology of this important species. In the last few months, the capture of good numbers of young of the year and 1+ year fish has increased the optimism of workers in the field that the fish had been in some reproductive stress and is now coming out of the problem period. There is anticipation of a resurgence in the corvina fishery in the next few years (G. Black, Cal. Fish and Game, Pers. Comm.).

The biology of the Long-jawed Mudsucker (Gillichthys mirabilis) is well reviewed by Walker, Whitney and Barlow (1961). It was introduced into the sea in 1930 and is one of the earliest fish introductions in the sea. The original intent was to provide a source of mudsuckers for bait for the Southern California and Colorado River areas. It is an important baitfish in the corvina fishery, but it is unlikely that it is present in large numbers in the sea due to the limitation of appropriate habitat. No recent research has been done on this species in the Salton Sea.

Tilapia (Sarotherodon) are cichlid fishes whose evolutionary origins seem to be the Middle East and the lowlands of Central Africa. The genus Tilapia has recently been divided into the genera Sarotherodon (mouth-brooding forms) and Tilapia (nonmouth-brooding). The only nonmouth-brooding Tilapia is T. zilli; all others in this group in the U.S. are now Sarotherodon sp. This is only a scientific nomenclatural difference and most people continue to use the term Tilapia for all members of this group. The California Department of Fish and Game authorized the introduction of three species for weed control in the Imperial Valley (Pelzman, 1973). These introductions were moderately successful, with T. zilli being commonly found in irrigation canals of the Imperial Irrigation District. Two species have worked their way through the irrigation systems and are now in the waters of the Salton Sea. Sarotherodon mossambica and Sarotherodon aurea are presently reproducing successfully in the Sea and rapidly becoming a dominant member of the fish community. It is presently unknown what impact this addition to the fauna will have; a preliminary study is in consideration by Fish and Game. The Tilapia has been implicated in the decrease of the Desert Pupfish population (Black, 1980) and probably does constitute a source of competitive pressure, possibly in the larval and juvenile stages.

A study on the feeding habits of this group has tentatively shown that fish larger than three inches (75 mm) are feeding on the blue-green algal mat and not on fishes or invertebrates (K.F. Kline, unpublished data). There may be some competitive interaction with other fish species at smaller sizes, though this has not been verified at the present time. The Tilapia in the Sea are apparently hybridizing and a wide variation in morphological characteristics is making species level identification nearly impossible. The "hybrids" are growing extremely fast and are now entering the fishery as 12 to 16 inch (300 to 400 mm) fish. Many fishermen fish specifically for these easy to catch species.

The biology of the Sailfin Molly (Poecilia latipinna) is discussed by Moyle (1976). The irrigation canals around the Sea and the Sea itself constitute the only large population of mollies in California. These fish are related to the Mosquitofish and have very similar reproductive biology and behavior. The molly has been found to feed primarily on detritus and algae as an adult. The fish is found in high numbers in the sea, especially in channels and protected shoreline areas and appears to be highly adaptable to variable environmental conditions (Moyle, 1976). Black (1980) considers them to have had a major impact on the Desert Pupfish population in the sea.

4. Summary

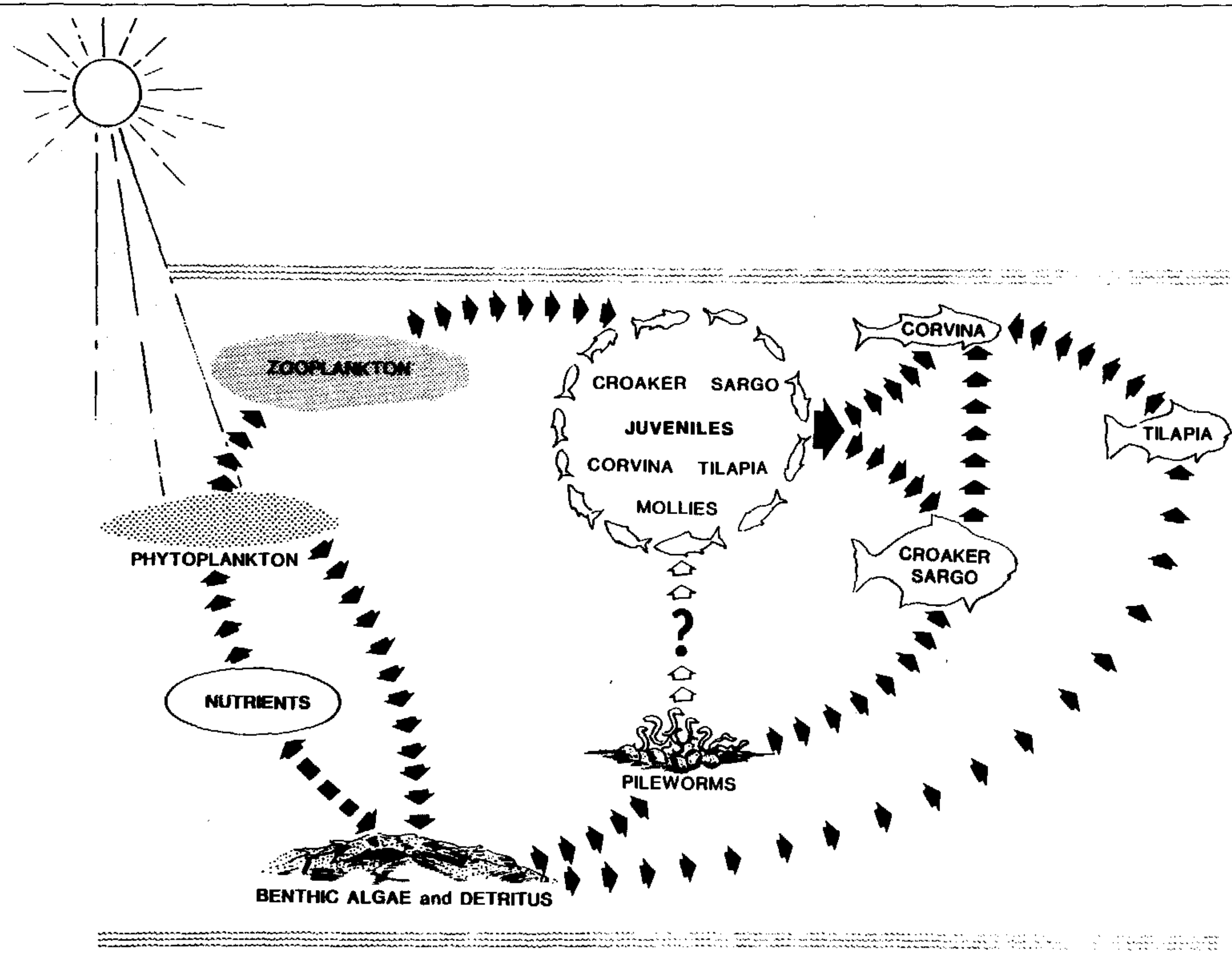
The aquatic ecosystem of the Salton Sea has for 20 years or more been considered to be relatively simple. There are limited species in each trophic level, though production can be extremely high. Ecological theory suggests that simple ecosystems tend toward instability, and this is true in situations where linear food chains exist. The original description of the system by Walker (1961) makes the system seem simpler than it probably is. The most important food chain was: phytoplankton ----->detritus----->Neanthes----->Bairdiella and Sargo----->corvina. This is probably a gross simplification of a much more complex system. This is especially true in light of the added fish species, that are primarily herbivores or detritovores.

The addition of the Sarotherodon complex and the mollies has increased the complexity of the tropic system in the Salton Sea. A graphic representation of the system is shown in Figure 3.6-4. Since all tropic relationships have not been analyzed, this representation is speculative. Larval and juvenile fish ecology is an area of major weakness in terms of available data.

The work of the mid-1950's produced good preliminary studies; since that time, however, little work has been done. The Striped Mullet and Shortfin Corvina are no longer present in the Sea. These two species have been replaced by radically different types of fish. Primary emphasis of more recent work has been to document the effect of increasing salinities on fish and invertebrates (Cal. Fish and Game, 1968; Kuhl and Oglesby, 1979; May, 1976). A great deal of work is needed on this ecosystem to assess its current status and to determine management alternatives.

b. New River

The New River constitutes a well-developed riparian corridor through intensively managed agricultural lands. It receives water from across the International Boundary with Mexico. This water includes sewage effluent, agricultural drainage and overflow waters from the Colorado River. On the American side,



Speculated Food Web of the Salton Sea

FIGURE 3.6-4

agricultural drain waters and seepage constitute the major source of additional flows. Approximately 25 percent of the water in the river at its discharge is of Mexican origin. The flow in the river follows a fairly cyclic pattern, with the lowest flows during the winter, increasing through the spring and then decreasing again through the summer.

Most water quality parameters also tend to range within wide limits. The temperature of the river varies from winter lows of 54 to 55°F (12 to 13°C) to highs of 81 to 84°F (27 to 29°C) in the late summer. Oxygen levels correlated closely with temperature, with winter high levels from 7 ppm to 8.5 ppm and summer lows of 2 ppm to 5 ppm. Turbidity, nitrogen, and phosphorus levels are also quite high in relation to other bodies of water in Imperial County. The salinity of the river is from 3,000 ppm to 6,000 ppm which is also fairly high for freshwater, but is indicative of the source water (Colorado River) and its use as a sewage disposal location. Coliform bacterial levels are extremely high, and are sufficient to be considered a public health hazard (Imperial County Health Department, personnel communication).

1. Aquatic Plants

The dominant algae in the river, particularly near the International Boundry are species of blue-green algae, including Aphanizomenon, Oscillatoria, Spirulina, and Lyngbya. There are few species of diatoms and green algae, with Spirogyra and Cladophora being found in some areas. Rooted aquatic plants probably include bushy pondweed (Najas sp.), sago pondweed (Potamogetum pectinatus), and eurasian milfoil (Myriophyllum sp.). Associated with the edge of the river are dense strands of tules (Scirpus sp.), cattails (Typha sp.), and common reed (Phragmites austratis).

2. Aquatic Invertebrates

There are little data on invertebrate organisms in the New River. However, crayfish (Procambarus clarkii) and Asian clam (Corbicula sp.) are known from the river. Data from the Imperial County Vector Control Office (personal communication) establish a number of aquatic insect species found in the river as well as in its drainages. These include several neotropical mosquitoes including Culex sp. and Aedea sp., plus an obnoxious gnat, Culicoides sp.

3. Fishes

A list of fishes found in the river is seen in Table 3.6-3. The Desert Pupfish, Cyprinodon macularis, was not included due to the fact that Black (1980) does not include the New or Alamo Rivers in its historical or present distribution, and with the large number of predatory fishes found in the river, the Pupfish would not 115

Table 3.6-3

FISH SPECIES FOUND IN THE NEW AND ALAMO RIVERS

63

	Common Name	Scientific Name
1.	Carp	*Cyprinus carpio*
2.	Mosquitofish	*Gambusia affinis*
3.	Sailfin Molly	*Poecilia latipinna*
4.	Channel Catfish	*Ictalurus punctatus*
5.	Flathead Catfish	*Pylodictis olivaris*
6.	Red Shiner	*Notropis lutrensis*
7.	Golden Shiner	*Notemigonus crysoleucas*
8.	Threadfin Shad	*Dorosoma petenense*
9.	Large Mouth Bass	*Micropterus salmoides*
10.	Bluegill Sunfish	*Lepomis macrochirus*
11.	White Crappie	*Pomoxis annularis*
12.	Zill's Cichlid	*Tilapia zilla*
13.	Mozambique Mouthbrooder	*Sarotherodon mossambica*

Note: This list has been compiled from personal observations by Dr. K.F. Kline, data supplied from fishermen, and from Moyle (1976).

compete effectively (Moyle, 1976). The fishes found in the New River are typical species of slow moving rivers with high turbidity and organic loading. They do not constitute a particularly unique species set.

c. Alamo River

The Alamo River also constitues a major, well developed riparian corridor through agricultural lands. The headwaters are in Mexico, east of the City of Mexicali. It drains agricultural lands as it moves through Imperial County and discharges into the Salton Sea. At the mouth of the river, the average volume exceeds that of the New River by approximately 40 percent. There is a substantial increase in flow between Holtville and Niland, attributable to irrigation drains and seepage. The flow in the river follows a cyclic pattern with low flows in the winter, increasing through the spring, and then decreasing again through the late summer and fall.

Water quality parameters again tend to vary within wide ranges, similar to those of the New River. Turbidity can be higher in the Alamo at times, though a yearly average would be nearly the same for both rivers. The salinity of the 64
Alamo is somewhat lower than that of the New River. This is probably attributable to differences in the drainage basins and possibly the lack of sewage discharges into the Alamo River. Overall, the quality of the Alamo is slightly higher than the New River, particularly in the area of coliform bacterial counts.

1. Aquatic Plants

The Alamo River has basically the same aquatic plants as those seen in the New River. The dominance of blue-green algae would not be expected due to the increase in water quality, though seasonal variation could promote blooms of these noxious algal forms.

2. Aquatic Invertebrates

There is little data on the aquatic invertebrates of the Alamo River, but it is expected that based upon the similarities between the New River and Alamo River the organisms would be similar as well. Refer to the preceding section on the New River.

3. Fishes

The fishes of the Alamo River would be generally similar to those found in the New River (Table 3.6-3), though it has not been well-studied. A recent report (Engineering-Science, 1980) has found that the majority of the fish in the river are non-game species, dominated by the carp, Cypienus carpir. The fish popula- 65
tions in the river are self-sustaining and some fishing activity does occur at various locations for channel catfish and bullhead.

There are a number of small dams on the river which control water levels. These structures effectively eliminate the chance of upstream movement of fish population. Recruitment between sections is done by downstream movement (Engineering Science, 1980).

The fishes of these rivers are particularly suited for survival in the slow flowing, organically enriched aquatic system. They all have wide environmental tolerances, particularly with regard to temperature and dissolved oxygen (Moyle, 1976). Since these parameters may vary substantially through the year, the fish species must be able to deal with these fluctuations.

117 3.6.1.4 Analysis of Biological Sensitivity

This section attempts to identify those biological resources in the study area which are sensitive to siting of geothermal facilities. It must be emphasized, however, that future siting of facilities will require site specific studies and formulation of appropriate mitigation measures.

The biological sensitivity of the area was divided into two categories:
47 sensitive habitats and sensitive avian flyways. Although these two categories are inter-
48 related, and many times overlapping, they present potentially different considerations for facility siting. Sensitive habitats are those regions where sensitive biological resources are considerd to be present on a year round or seasonal basis. The presence of these habitats reflects a constraint upon placement of any geothermal facility within or adjacent to these areas. Sensitive avian flyways are those areas where significant numbers of birds have been documented to fly in a specific direction on a seasonal or year-round basis. These areas would present constraints to placement of above ground electrical transmission lines as well as tall structures. The following sections discuss both sensitive habitats and sensitive avian flyways.

a. Sensitive Habitats

Figure 3.6-5 delineates areas of Maximum, Conditional Maximum, Major, Moderate, and Minimal habitat sensitivity for general geothermal development. These classifications were defined in the Introduction to Section III. The numbers next to the following descriptions correspond to areas on Figure 3.6-5.

Areas of maximum habitat sensitivity include:

1. Units of the Salton Sea National Wildlife Refuge and Wister Unit of the Imperial Wildlife Management Area. These areas are actively managed to concentrate waterfowl and also provide suitable habitat for the endangered Yuma Clapper Rail and California Black Rail.

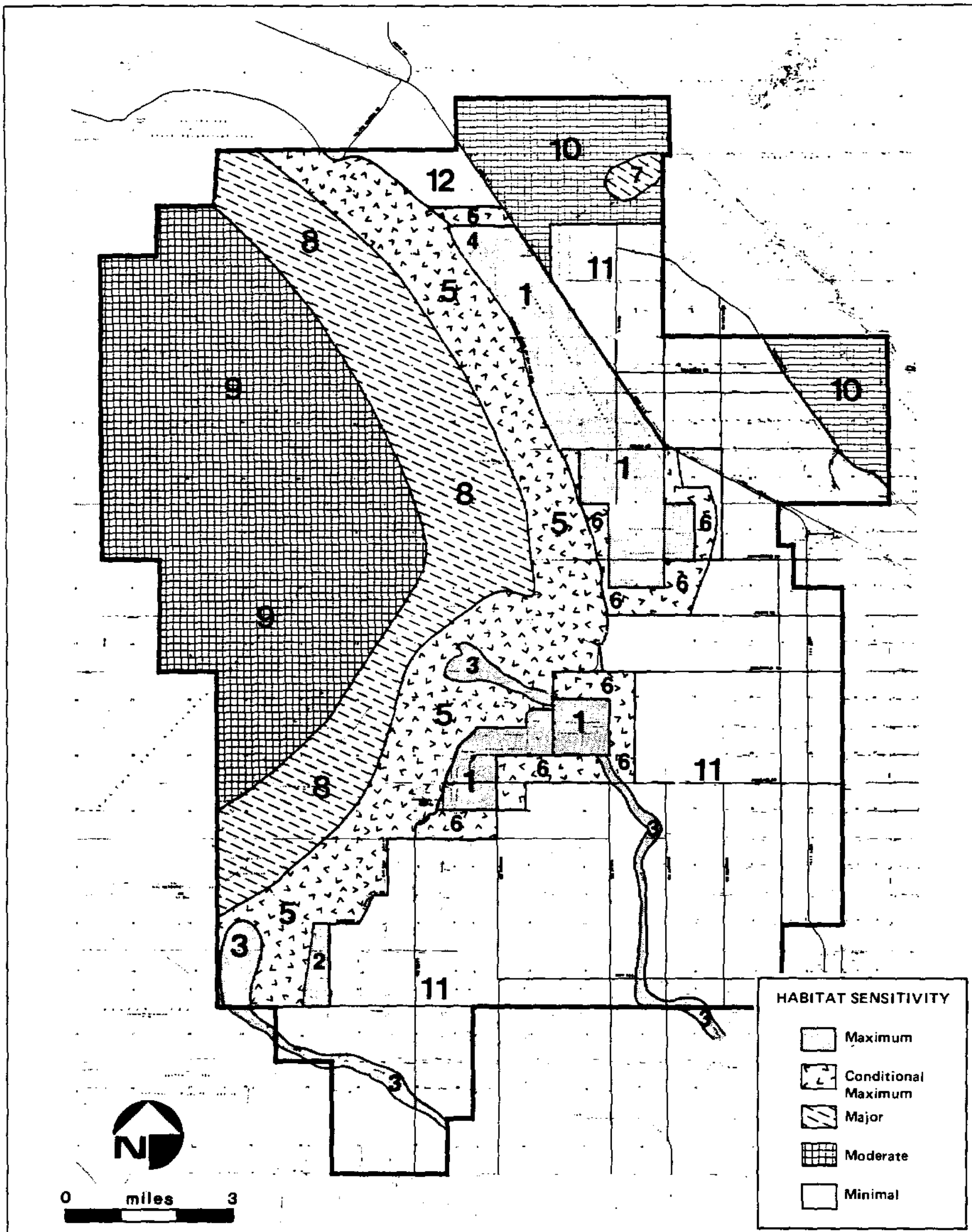


FIGURE 3.6-5

Habitat Sensitivity to Geothermal Development in the Study Area

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2. Mud Flat Area - Because of the increase of sea levels in recent years, mudflat habitat in the Salton Sea area is very limited.

3. Alamo and New River Riparian Corridors and Deltas - The Alamo and New Rivers contain high quality riparian habitat supporting a high diversity and density of avian species. The deltas and potentially marshy areas along the river are habitat for the endangered Yuma Clapper Rail. In addition, these riparian areas should be considered a wildlife movement corridor.

4. Marsh Areas West of Wister Unit Imperial Waterfowl Management Area - These wetlands may be habitat for the endangered Yuma Clapper Rail and California Black Rail.

Areas of Conditional Maximum Sensitivity include:

5. Nearshore Rafting Areas - Nearshore areas have been identified as intensive rafting areas by Dean (personal communication) and Gonzales (personal communication). These areas serve as important feeding and nesting areas and are associated closely with refuge operations. In addition the shoreline is a potential habitat for the desert pupfish. Additional studies within these areas will be required to determine the potential impact of geothermal development.

21

6. Buffer Areas Around Refuges - Ideally, a minimum of a one-half mile buffer around refuges should be maintained. The effectiveness of the buffer requires additional future studies.

Areas of Major Habitat Sensitivity include:

7. Desert Microphyll Woodland and Marsh Areas - Located in the northeastern portion of the study area, this habitat provides high quality wildlife habitat.

8. Offshore Areas of the Salton Sea - These areas serve as a significant rafting area for waterfowl, but are not as intensively used as the nearshore areas.

Areas of Moderate Sensitivity include:

9. Far Offshore Areas of Salton Sea - This area is feeding and rafting habitat for waterfowl.

10. Creosote Bush Scrub - This native desert scrub habitat is located east of Highway 111 in the northeastern corner of the study area. This area may be potential habitat for several sensitive plant species, as well as the sensitive Flat-tailed Horned Lizard.

Areas of Minimal Sensitivity include:

11. Agricultural Areas - Not covered by any of the above categories.
12. Barren Desert Areas - West of Highway 111 in the northeastern aspect of the study area.

The above discussion provides an analysis of impacts associated with general geothermal development. Table 3.6-4 more precisely defines the sensitivity of the area for specific activities.

b. Sensitive Avian Flyways

Figure 3.6-6 delineates areas of Major, Moderate, and Minimal Sensitivity based upon documented or inferred avian flight patterns. No area of maximum sensitivity is designated. These sensitivities are related primarily to the

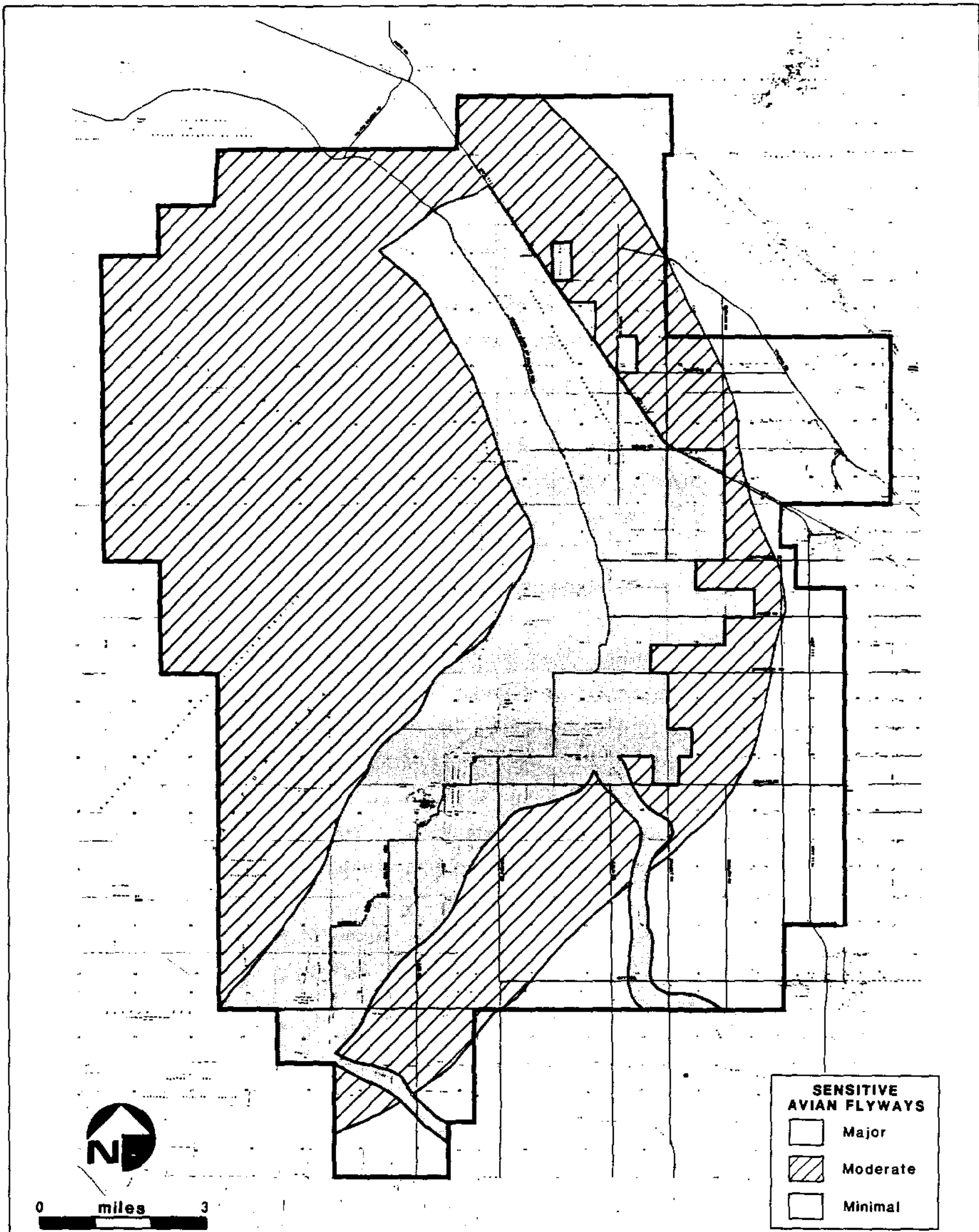
6

Table 3.6-4

BIOLOGICAL CONSTRAINTS

Area	Seismic Testing	Exploratory Drilling	Production Drilling	Power Plant Construction and Operation
1	Mod*	Maj*	CMax	Max
2	Mod	Max	Max	Max
3	Mod	Maj	Max	Max
4	Mod*	Max	Max	Max
5	Mod*	Maj	CMax	CMax
6	Mod*	Maj	CMax	CMax
7	Mod	Maj	Maj	Maj
8	Mod*	Maj	Maj	Maj
9	Min	Mod	Mod	Mod
10	Min	Mod	Mod	Mod
11	Min	Min	Min	Min
12	Min	Min	Min	Min

Max = Maximum Sensitivity
CMax = Conditional Maximum Sensitivity
Maj = Major Sensitivity
Mod = Moderate Sensitivity
Min = Minimal Sensitivity
* = Assumes testing conducted in summer



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Avian Flyway Sensitivity to Geothermal Development in the Study Area

FIGURE 3.6-6

placement of above-ground electrical transmission lines, but would also pertain to placement of tall structures such as drilling rigs or offshore drilling platforms.

Areas of Major avian flyway sensitivity include:

Alamo and New River Corridors - These corridors are major flight corridors for waterfowl, and other avian species. They may also be utilized as migration routes for the Yuma Clapper Rail (Powell, personal communication).

Salton Sea Corridor - A corridor, approximately 1 mile on either side of the Salton Sea shoreline between wildlife refuges, has been identified as a high use area by Leitner and Grant (1978).

Wildlife Refuges and Duck Clubs - These areas have high waterfowl use with most flights at low altitude.

Areas of Moderate Sensitivity include:

Remaining Areas in Salton Sea Study Area - These areas are subjected to a number of avian flights in many directions. Included are low level flights from rafting waterfowl.

Areas within Three Miles of Salton Sea Shoreline - These areas were identified by Leitner and Grant (1978) as areas used as feeding grounds for waterfowl. Flights and routes vary from year to year depending upon such factors as cropping patterns, crop types, etc. Many of these flights are of low altitude.

The remainder of the area is classified as having minimal sensitivity. It must be noted, however, that localized high avian activity may occur if special attractants such as flooded fields are present.

3.6.2 Biological Impact

3.6.2.1 Vegetation

a. Habitat Loss

Geothermal development of the study area will result in loss of vegetation due to development of well pads, power plants, access roads and other geothermal support facilities. The preliminary estimate is about 900 acres (364 ha) of vegetation habitat loss as a result of geothermal development, not counting transmission line impacts.

The degree of impact to vegetation as a result of geothermal development of the study area will depend upon the vegetation type affected. Geothermal development within agricultural areas will not affect natural vegetation; however, agricultural productivity will be affected (see Section 3.8). There is a potential that riparian or marsh habitat may be affected by geothermal development. Because of the relative rarity and sensitivity of these habitats, any major disturbance should be considered a significant adverse impact.

In general, small scale development within the Creosote Bush Scrub would not constitute a significant adverse impact since the community is not generally well-developed and is common within the region. Disturbance of the Desert Microphyll Woodland in the northeastern portion of the study area would be more severe since this vegetation type is less common.

b. Sensitive Species

Development of geothermal facilities within the Creosote Scrub and Desert Microphyll Woodlands would have the potential to disturb populations of the sensitive plants listed in Table 3.6-1. It should be noted that the study area is probably not ideal habitat for these species and that occurrence would most likely be limited to isolated populations. Loss of any population would normally constitute a significant adverse impact.

The location of many sensitive plant species can only be determined after springtime site-specific surveys. If these surveys are conducted early in the facility siting phase, there is a good potential that all or portions of these populations can be preserved.

c. Effects of Geothermal Spills and Cooling Tower Drift

There is a potential that geothermal fluids could be spilled during well drilling and wellfield or power plant operation. Spillage of geothermal brine has two effects on plants: 91

- Scalding of vegetation due to the high temperature of the geothermal fluid.
- Sterilization of the soil due to the high salinity of the geothermal fluid as well as potentially high concentrations of heavy metals and boron.

Because the Salton Sea Anomaly has very high temperature and salinity, spillage of geothermal fluid could be critical and would require extensive leaching efforts to reclaim the land.

The highest potential impact associated with geothermal development is brine spillage into riparian or marsh habitats. If significant spillage were to occur within these habitats, it would constitute a significant adverse effect.

Vegetation damage has been documented as a result of drift of salt particles from cooling towers (Malloch, 1978). Based on air quality studies for this project, any salt deposition would most likely occur within 500 ft (152 m) downwind of a cooling tower. There is a potential that native vegetation could be affected by such salt deposition; however, since native plants in the area are generally salt tolerant, damage to vegetation would more likely affect cultivated plants. Also see Sections 3.4.2.3 and 3.11.5 for further discussion of this issue.

3.6.2.2 General Wildlife Resources

a. Habitat Loss

Geothermal development within the Salton Sea Anomaly will result in loss of wildlife habitat. Based upon current estimates, approximately 900 acres (389 ha) of land will be committed to geothermal development within the study area which would account for something less than one percent of the total habitat of the study area.

The degree of impact will vary depending upon the type of habitat affected. It is probable that at least in the initial years of development, the majority of habitat affected will be farmland. Geothermal development of farmland will result in loss of open space wildlife habitat for species normally occurring within farmland areas. This would also include reduction of foraging habitat for raptors and mammalian carnivores. Additionally, geothermal operations would tend to repell some species from individual sites.

Riparian and marsh habitats are extremely sensitive due to their rather uncommon occurrence, high wildlife species diversity and density, use as wildlife movement corridors, and as a habitat for sensitive species. Disturbance of these habitats by geothermal development would constitute a several magnitude increase of impact greater than disturbance to agricultural habitats.

Geothermal development within the Desert Microphyll Woodland in the northern portion of the study area would constitute an adverse impact to wildlife since this area would support higher wildlife species diversity than the surrounding Creosote Bush habitat.

b. Sensitive Species

- Yuma Clapper Rail

The occurrence of this endangered species has been documented within the study area (Bennet and Ohmart, 1978). Its perferred habitat includes the following: cat-tail marsh which occurs at the Alamo and New River deltas; managed waterfowl marshes within the Wister Waterfowl Management Area; the Salton Sea National Wildlife Refuge; private waterfowl management areas; and natural marshes west of the Wister Waterfowl Management Area. Additionally, riparian areas along the Alamo and New Rivers are migratory routes for this species (Powell, personal communication) and thus may also serve as habitat for these species.

Activities associated with geothermal development that would result in loss of portions of the habitats described above would constitute potential significant adverse impact on this species. The degree of impact as well as the extent of mitigation/compensation required would depend upon site-specific analyses inlcuding tape-response surveys.

In addition to direct habitat loss, other operations associated with geothermal resources may also affect this species. Major geothermal spills could eliminate large areas of aquatic or riparian habitats. Electrical transmission lines crossing the New or Alamo Rivers or passing near marsh habitat could cause mortality in the species through collision of birds with wires, or could alter flight paths of this species (see Section 3.6.2.3 for further discussion). Geothermal facility development and operations could also produce relatively high noise levels (see Section 3.5). Operations near habitats of this secretive species could have an adverse effect on it. However, there are no studies to determine what magnitude or duration noise would be detrimental. Since this species usually lives in dense vegetation, it is probable that only operations very close to its habitat would produce adverse effects.

- Black Rail

The efect upon the Black Rail would be the same as discussed above for the Yuma Clapper Rail.

- Brown Pelican

No specific impacts associated with development of geothermal resources are forseen as regards the Brown Pelican; however on and offshore geothermal development could affect the species through habitat disturbance, creation of high noise levels, and geothermal fluid spills.

- <u>Raptors</u>

The study area contains foraging habitat for the endangered Southern Bald Eagle and Peregrine Falcon as well as for sensitive species such as the Prairie Falcon, Marsh Hawk and Burrowing Owl. Geothermal development of the study area could result in loss of foraging habitat for these species and could disrupt nesting habitat of the Marsh Hawk and Burrowing Owl. The addition of electical transmission lines in the area would also increase the electricution potention for raptors if they are not designed with wire separation greater than raptor wing spans.

- <u>Flat-tailed Horned Lizard</u>

The northern section of the study area contains potential habitat for the Flat-tailed Horned Lizard (Turner, 1978). Although this area is not ideal habitat and has not been identified as a high concentration area for this species, small populations may be affected by geothermal development.

- <u>Big Horn Sheep and Burro Deer</u>

The study area should be considered as marginal habitat for
129 these species and geothermal development within the study area would not result in a significant adverse impact to these species.

3.6.2.3 <u>Impact to Avian Resources</u>

a. <u>Habitat Loss</u>

Geothermal development of the study area will cause a loss of open space wildlife habitat that will result in a concomitant loss of avian habitat. Most of this loss will center around those species adapted to agricultural lands, including raptors.

Loss of mudflat areas would create significant impacts to the shorebird component of the avian resources of the study area. Loss of marshland and waterfowl management areas would result in reduction of feeding habitat for waterfowl and shorebirds and these species could conceivably disperse into adjacent agricultural areas causing crop depredation.

Loss of riparian areas will impact shorebirds and waterfowl as well as species primarily restricted to riparian areas such as the Bell's Viero. This area also serves as nesting habitat for a variety of species including Mourning Doves and Gambel's Quail. The patch of Desert Microphyll Woodland also serves as high density avian habitat and nesting habitat. Loss of this habitat would constitute a significant adverse impact.

Development of geothermal resources adjacent to duck hunting clubs may produce adverse impacts to hunting activities in these areas. These impacts could include alteration of flight patterns as well as creation of high noise impact areas.

b. Effects of Noise on Avian Resources

Development of geothermal resources within the study area will produce generally high noise levels during some phases. As discussed in Section 3.5, the well drilling, well testing, power plant construction and power plant operation phases will produce rather high noise levels which will increase ambient noise levels up to approximately 80 dB(A) at 100 feet (30 m). The effects of high noise levels on wildlife in general and avian resources in particular are variable and not well understood. Based on studies by Leitner, 1979, as well as on field observations at the Geysers Geothermal Field (PG&E, 1978) high noise levels tend to initially repel wildlife from an area; however, most species eventually habituate to constant relatively high noise levels. There is a potential, however, that this noise could affect behavioral patterns (i.e., mating calls) or could cause hearing loss to make the species more prone to predation. It should be noted, however, that comprehensive studies on these aspects have not been conducted.

Of particular concern to the proposed project is the generation of sudden, high intensity noise produced by well venting and other field development procedures. These activities produce instantaneous noise levels exceeding 80 dB(A) and may have a startling effect on wildlife, which could result in mass flight of large numbers of waterfowl. Dean (personal communication) has observed an incident of startling reaction in geese more severe than that produced by gunshot, backfires, etc., as a result of well venting. This startling reaction could be produced by intense noise levels, low frequency sound, or steam clouds. Studies by WESTEC Services (1980c) have noted avoidance of steam clouds by various bird species.

Geothermal operations near high concentrations of birds (e.g., refuges or riparian area) could result in decreased quality of adjacent habitats. Further, each operation could cause disruption of waterfowl feeding or resting habitat and increase the potential of waterfowl dispersing to agricultural fields resulting in greater crop depredation.

c. Impact of Powerlines

Geothermal development within the study area will result in a proliferation of electrical transmission lines, as discussed in Section 2.6.7.4. The 23 25 exact configuration of the power transmission grid will depend upon the number and location of future power plants, however.

Electrical transmission lines have the potential to create the following impacts to avian resources:

1. Potential for collision of birds with electrical transmission lines and structures. This collision potential varies from species to species and is greater at times of poor visibility or at night. Although most major studies have been associated with large transmission structures, smaller transision lines, especially those fitted with a top-mounted static line, may produce significant avian mortality.
2. Electrocution potential of raptors by transmission lines has been found primarily in (ie., distribution) lines where separation of wires is less than the wingspan of some raptors. Distribution lines can be modified with long insulators to minimize electrocution potential to raptors.

Placement of above-ground electrical transmission lines within the study area would create the potential for increased avian mortality within the area. The percentage increase in mortality cannot be estimated at this time since the number and locations of transmission lines are not known. The precise degree of impact of transmission line mortality can only be determined after conducting mortality studies similar to those underway by the U.S. Fish and Wildlife Service. However, avian mortality from transmission lines may constitute a significant adverse impact, especially if the lines are located within principal avian flight corridors which include: the New and Alamo Rivers corridors; areas within one mile (1.6 km) of the Salton Sea shoreline; areas on or adjacent to waterfowl refuges; and offshore areas of the Salton Sea. In general, transmission structures within these areas should be considered an adverse impact unless site specific studies indicate that the particular site is not an area of high avian overflight or that flight height activity exceeds the height of the transmission line. Because the Alamo and New Rivers corridors have been documented as major overflight areas (Leitner and Grant, 1978), any aboveground transmission line crossing these areas may produce significant adverse impacts. These impacts would be more severe if transmission structures were fitted with static lines oriented above the other wires. In addition, transmission lines on or adjacent to wildlife refuges or duck hunting clubs may have a high potential for avian collisions since large flocks of low-flying birds would occur within this area.

Leitner and Grant (1978) documented major overflights of birds along the Salton Sea shoreline between wildlife refuges. Most of these flights are of altitudes over 50 feet (15 m), and as indicated by WESTEC Services (1980c), are somewhat area specific. Transmission structures may produce significant avian mortality in these areas. Any placement of transmission lines should only be made after site-specific studies.

Because offshore areas are major waterfowl rafting areas, low level flights are very frequent. Above-water offshore transmission lines would disrupt avian flight patterns and have the potential to produce significant avian collision mortality.

d. Impact on Refuges and Gun Clubs

Geothermal development on or adjacent to waterfowl refuges or gun clubs would have the potential to create the following impacts:

- Loss of refuge or duck club lands if development occurred onsite.
- Potential alteration of flight paths and decrease of hunting success due to placement of structures or transmission lines. The presence of these structures may increase the angle of ascent or descent or the direction of flight.
- Sharp, loud noise produced by venting or other activities may repel birds from an area for short periods of time. 24
- Geothermal spills could flow onto refuge lands, eliminating aquatic vegetation.

e. Impact of Geothermal Spills

Geothermal fluid contains toxic materials and usually has a high temperature. If the fluid is spilled or otherwise ponded at facilities, waterfowl and shore birds may be attracted to the water. The hot fluids may injure the birds and there is also a potential that birds could ingest toxic materials. Ponding of any water 134
at any geothermal facility would also have a potential of creating an environment for development of avian botulism. This would be especially true if the ponded water were high in organic matter.

f. Offshore Geothermal Facilities

Offshore geothermal facilities would have the potential for creating specific impacts to waterfowl. These potential impacts are discussed below.

- Loss of Rafting Feeding Habitat - Construction of islands
135 and causeways would result in loss of rafting and feeding habitat. Aquatic habitats created as a result of island/causeway construction and creation of sheltered areas may partially mitigate this impact.
- Structures and Powerlines - Above-water powerlines and other structures (e.g., drilling platforms, cooling towers and cranes, etc.) may create a significant collision potential due to the presence of a large number of low-flying birds.
- Noise - Drilling, testing and operating of offshore geothermal facilities will create noise which would have the potential to repel rafting waterfowl from the vicinity of the facility, potentially diminishing the worth of some rafting areas.
- 120 Geothermal Fluid Spills - Major geothermal spills within
118 aquatic habitats would introduce a variety of toxic material to the ecosystem which may have deleterious effects upon waterfowl resources.

119 3.6.2.4 Impact to Aquatic Resources

Geothermal development of the study area will have the potential to create impacts to aquatic resources associated with use of irrigation tail water for cooling (as discussed in Section 3.2) which could result in potential increased salinity of the Salton Sea as well as fluctuation of the water levels of the sea. Additionally, offshore geothermal development may produce impacts concerning loss of habitat and water quality degradation. Each topic is discussed below.

a. Impact of Increasing Salinity on Salton Sea

There has been much speculation and forecasting concerning the potential increase in salinity on the Salton Sea; however, little data has been accumulated to document potential effects. The majority of the research on salinity tolerances has been done on the Salton Sea Pileworm, Nereis succinea. It was felt by Walker, (1961) that this species occupied a unique position in the food web of the Salton Sea. Kuhl and Oglesby (1979) established that salinities near 45 ppt tended to inhibit reproduction and reproductive success, though levels exceeding 60 ppt could be tolerated by adult worms for fairly long periods of time.

There is some evidence that fishes of the sea would react to an increasing salinity regimen in a variety of ways. Fish eggs tend to be quite sensitive to hypersaline conditions, and most likely the first observed impact would be a reduction in spawning success and larval fish survival. As the salinity increased the adult fish would probably reduce reproductive effort due to the increasing metabolic demands for osmoregulation. A stressed fish will rarely have enough available energy to go through the rigors of the reproductive process. At the highest salinities, the older fish would die from osmoregulatory stress. It would be expected that reproductive failure would occur at levels above 40 ppt and increasing adult mortality at levels above 45 ppt (Brockson and Cole, 1972; Lasker, Tenaza and Chamberlain, 1972).

There is no evidence concerning the impact of increasing salinity on algal species. The phytoplankton of the Sea are derived from both freshwater and marine sources. It should be logical that selective pressures would cause the restructuring of the algal system toward those species adaptable to hypersaline conditions.

Spills of geothermal brine, five to ten times the salinity of the Sea, would be expected to eliminate much of the biota from the affected area (California Department of Water Resources 1970; Shinn, 1976). Depending upon the extent of the spill, the impact could be from short to fairly long term. The adverse impacts would be caused by the interaction of the brine, increased temperatures, and the resultant decrease in oxygen levels. The major effect would likely be on sedentary species, such as pileworms and other invertebrates; with fish being able to move from the affected area.

From data available in the literature an increase in the salinity on (27)
the Salton Sea would likely lead to the effects listed in Table 3.6-5.

b. Impact of Fluctuations in the Level of the Sea

The major impact of sea level variation would be to increase (or
decrease) the area of shallow, nearshore environments. This impact would be minimal (8)
in and of itself, due to the fact that most of the invertebrates and fish have sufficient
habitat to satisfy their needs presently. However increasing the level of the sea would (26)
tend to lengthen the time until the sea becomes hypersaline; while decreasing the sea level would have the opposite effect. The impact of increasing salinities has already been discussed.

Table 3.6-5

EFFECTS FROM SALINITY INCREASES

Salinity (ppt)	Effect
36-38	Little or no change from current conditions
38-40	Probably little or no effect; possible osmotic stress on fish eggs, resulting in year-class variation
40-42	Effect on fish eggs; probable significant effect on larval fishes
42-44	Stress in adult fish observed; reduced pileworm reproduction; selection pressure on phytoplankton
44-46	Probably point of major impact on all fishes
46-50	Most, if not all, fish species gone; exception may be desert pupfish; failure of pileworms to reproduce
above 50	For all recreational purposes, the biota would disappear from the sea; probably selection for brine shrimp and hypersaline algae.

28 c. Impact of Offshore Exploratory and Development Programs

Construction of islands and causeways will result in loss of aquatic habitat. Although the percentage of loss of this habitat is small, the degree of impact to spawning areas, sources, etc. is unknown, since these areas have not been defined by comprehensive aquatic studies.

The configuration of the Salton Sea is quite bowl-like, in that there are few areas where there is significant three-dimensional topography. The impact of three-dimensional structures in aquatic systems would be significant in attracting a variety of species of fish and invertebrates. The construction of offshore islands could provide new habitat for that lost to construction.

The impacts of the construction of these islands are both short- and long-term. The temporary displacement of fishes and invertebrates due to construction would be a short-term impact. Some toxic conditions could arise, particularly if substantial dredging were to occur. The bottom muds tend to be high in hydrogen sulfide and ammonia, particularly in the summer months. These two substances are toxic to fish and invertebrates. Also, large amounts of nutrients would be recharged back into the system from the sediments, increasing the already high productivity in the sea. This increase in nutrients would likely have only a local effect and would be rapidly assimilated by algae.

Little data is available on levels of pesticides, heavy metals, and other sedimented substances in the Salton Sea. Since the sea acts as a sink, the matter of pesticides and metals is of some significance. The bottom muds are generally anaerobic during parts of the summer, and their disturbance could create unique problems during those months. This impact may be minimized by dredging in the fall and winter.

Offshore exploratory operations, including drilling of test wells by barge or swamp buggy, would have the potential to create temporary habitat loss, increased turbidity, and potential for geothermal fluid spills. A spill within the Salton Sea would produce localized areas of extremely high salinity, high temperatures, and low oxygen levels. Additionally, significant quantities of toxic materials would be introduced into the aquatic ecosystem. The environmental effects produced by these spills may be quite severe, causing further fluctuations in conditions in near-shore areas and could result in increase in already common fish kills.

Construction of offshore islands would increase turbidity and siltation during the construction phase. Disturbance of bottom muds would also be expected to increase hydrogen sulfide, resulting in a decrease of oxygen levels. Organic nutrients would also be released, resulting in increased local algae production. Fish and invertebrates would be temporarily displaced from the island area. Sedentary invertebrates would be lost during construction.

Use of boats for access would have the lowest potential impact for distrubance; however, there would be a potential for spills. Use of a filled causeway would have the greatest potential for adverse impact, producing impacts similar to those caused by fill islands and would also have the potential for reduction in near-shore circulation patterns which could produce "dead" areas that have increased levels of hydrogen sulfide, lower oxygen, and increased sedimentation. Construction of piers would have temporary sedimentation impacts, but long-term impacts would be much less than construction of a causeway.

d. Impact to New and Alamo Rivers

Use of cooling or make-up water from the New or Alamo Rivers could have the potential for reducing habitat quality for fisheries within the rivers and potential salinity increases in the Salton Sea. Spills of geothermal fluids within the river would introduce hot hypersaline fluids containing toxic constituents to the river system. Depending upon the severity of the spill, short-to long-term major degradation of the streams may occur.

e. Effect of Brine Spill on Aquatic System

The impact of a major geothermal brine spill would be substantial. The overall impact of freshwater and saline (Salton Sea) systems would be similar in form, though the speed of action in a quasi-marine system would be somewhat slower. The components of the geothermal brine have a number of extremely toxic elements including ammonia, hydrogen sulfide and a variety of metals.

Individual effects of toxicity are well established in the literature for these components however synergistic studies are lacking, particularly with regard to the interactive effects of temperatures and hypersalinity on the action of the toxic chemicals. Individual effects of various components of geothermal brine are discussed in Appendix 3.6.

f. Effects of dredging

Dredging and disposal operations can have a direct or an indirect effect on the environment. Direct effects often tend to be short term, and are often lethal in action. Indirect effects are usually long term and sub-lethal in action.

The major impacts of dredging are: 1) Physical disruption of the bottom environment; 2) The generation of suspended sediments; and 3) The disturbance and redistribution of the sediment contaminant load. Due to the limited amount of information concerning Salton Sea sediments, particularly with regard to chemical properties, the above impacts must be assessed in general terms.

1. Physical disruption of the bottom environment

Dredging activity has an immediate localized effect on bottom organisms. It includes the removal of the naturally occuring community. Organisms directly involved with the dredging have varying rates of survival. At the disposal site, the naturally occuring community is usually buried under various depths of dredged material. The dual act of dredging and deposition creates a new bottom substrate which may or may not resemble the original sediments. The major environmental concern, besides the physical disruption effects, is directed toward the process of recovery and the reestablishment of a resident flora and fauna. After disruption, most communities begin the process of colonization fairly quickly. The time frame can vary from days to months to years depending upon the type of environment and the plants and animals involved (Hirsh, et al. 1978).

The more variable the environment, the less effect dredging tends to have (Hirsh, et al. 1978). The Salton Sea has already been shown to be a highly variable physical ecosystem, with wide environmental fluctuations. The bottom of the sea is highly organic, with normally high levels of ammonia and hydrogen sulfide (Walker, 1961). It is common for the waters of the sea to become anaerobic during the summer months and few if any organisms are found in the bottom sediments or waters (Walker, 1961). Most of motile, sediment dwelling organisms are able to move vertically through dredged sediments if the materials are similar to the substrates normally inhabited by the organism. The deposition of mud on a sand bottom, and vice versa can be detrimental (Peddicord and MacFarland, 1978).

As far as can be determined, the dredging activity will be a prelude to the construction of "islands" or levee systems. If this is true, the recolonization of the dredged area would be impossible, though the colonization of the island fill material would take a normal form.

2. Effects of suspended sediments

Most organisms are not seriously affected by the suspended sediment conditions created by dredging and deposition operations. Special examples, such as the deposit of spoils on coral reefs or directly on fish eggs, can be potentially serious. It is generally accepted that concentrations of suspended solids well above those generated by dredging cause mortality (Hirsh, et al. 1978).

Some effects such as the reduction in photosynthetic activity are transitory. Uncontaminated sediments tend to have little or no serious effects while contaminated sediments increase the potential risk.

The most serious form of turbidity is the condition known as "fluid mud". Fluid mud presents a condition of extreme stress to bottom organisms. The muds tend to be low in oxygen and to inhibit the upward movement, and potential escape, for covered organisms. Fluid muds can be most serious in areas of fish spawning or in areas used extensively by larval and small juvenile fishes. If the fluid muds are contaminated, impact on adult macrofauna may be significant (Hirsh, et al. 1978).

Sediment suspensions associated with dredging and disposal are unavoidable. Mitigation measures should be considered where there are reasonable indications that aesthetically or environmentally objectionable sediment suspensions are likely to result. These measures are best applied to each dredging operation by considering the general characteristics of the local environment during the development of work plans. The Salton Sea has a very high turbidity and most associated organisms are likely to be fairly tolerant of an increased load caused by dredging. Spoil areas should be identified, with particular reference to fish spawning areas and deposition should not occur in these areas if possible.

Understanding the biological community existing at the dredge and disposal sites can aid in minimizing habitat disruption. As previously noted, hydrogen sulfide and ammonia are common in the bottom waters and muds. These chemical compounds are extremely toxic to fish and invertebrates and their movement into surface waters could cause localized fish kills in the areas adjacent to the dredging and deposition sites. The kills will likely be limited to juvenile fishes in the area, as well as those territorial species, unwilling to leave their range (Tilapia).

3. Indirect effects of sediment contaminants

Aquatic sediments act as natural depositories for contaminants such as heavy metals, persistant pesticides, polychlorinated biphenals and petroleum hydrocarbons. The major concern in dredging these sediments is the potential that these sediment-associated contaminants could exert a toxic effect on aquatic systems.

While potentially highly variable, the accumulation of heavy metals by aquatic organisms from sediments appears to be minimal. The variable accumulation and release of heavy metals demonstrated by test organisms have not been directly correlated with dredging and disposal operations or with the total amount of heavy metals present in the sediments (Hirsh, et al. 1978). The bio-accumulation of heavy metals appears to depend upon the physical and chemical state of the metal and varies from one sediment and organism to another.

A full analysis of the heavy metals in the sediments of the Salton Sea is not available and sites selected for dredging should be assessed in terms of sediment loading of contaminants.

Most persistent pesticides and related contaminants do not appear to readily desorb from sediment attachment and are thus less toxic than in their free state. The free state phase is usually the chemical tested in bioassay determinations for toxicity. Some sediments are toxic or create subtoxic environmental effects and the uncontrolled disposal of these sediments may cause considerable harm (Hirsh, et al. 1978). The toxic properties of the sediments of the Salton Sea should be analysed by whole-sediment analysis and bioassay prior to major dredging operations, to determine acute and, potentially, long term effects of sediment disturbance.

g. Impact to Sensitive Species

The Desert Pupfish is a sensitive species that is proposed to be (66)
listed as endangered by the State of California. The preferred habitat for the species (29)
within the Salton Sea are shallow pools at the shoreline. Changing water levels, increased salinity, introduction of toxic materials, or oxygen depletion will create adverse impacts on the Salton Sea populations of this species.

3.6.3 Mitigation Measures

3.6.3.1 Vegetation (1a)

a. Facility Sitings

Facilities (e.g., power plants and well sites) should be oriented as (48)
much as possible away from Riparian, Marsh and Desert Microphyll Woodlands. Facili- (49)
ties should also be designed to minimize the extent of loss of agricultural lands and Creosote Scrub.

b. Site Specific Studies

Prior to finalization of geothermal facility designs, site specific botanical surveys should be conducted in order to orient facilities away from sensitive habitats (Riparian, Marsh and Desert Microphyll Woodlands). Site specific springtime surveys should be conducted within the Creosote Scrub and Desert Microphyll Woodlands in order to determine the presence of any sensitive plant species within a proposed project area.

3.6.3.2 Wildlife

a. Habitat Retention and Buffers

Geothermal facilities should be oriented away from refuges and (130)
gunclubs as well as marshlands, riparian areas and Desert Microphyll Woodlands. (133)
Ideally, a one-half mile buffer should be placed between sensitive areas and geothermal facilities. It is apparent, however that full development cannot take place without encroachment into the buffer. If the buffer is encroached upon, specialized measures (e.g., noise attenuation, spill containment structures, etc.) may be required on a site specific basis.

If near term geothermal resource testing results indicate that existing wildlife refuge lands represent a highly valuable geothermal resource base, then developers could consider land swapping agreements. Leaseholds which may be suitable as a wildlife area, and which would not be highly desirable for geothermal
resource development, could be traded appropriately. This measure would, in effect, (132)
move the existing wildlife refuge areas.

b. Noise Attenuation

Where well drilling and testing is contemplated near sensitive habitats, measures should be used to limit the intensity and/or timing of noise emissions. Some methods may include:

- When possible conduct well testing primarily during non-winter months in order to reduce potential impacts on wintering waterfowl.
- (131) Use sound attenuating devices to reduce venting noise.
- Whenever possible, conduct well venting at night in order to prevent frightening of birds due to the presence of steam clouds.

c. Power Transmission Line Siting

- Offshore transmission lines

(9a) Because of the high potential for avian mortality, offshore
(9b) powerlines should be placed within conduits or submarine cables should be used.

- (9c) Onshore Lines

To the greatest extent possible, the number of transmission lines within one mile of the Salton Sea shoreline should be minimized. Site specific studies should be conducted in order to select transmission line alignments through this area that are the least sensitive to waterfowl.

Transmission lines should not be placed within wildlife
(82) refuges or duck clubs. Site specific analysis should be conducted prior to placement of lines near refuges in order to minimize potential impact to the refuges. In the event that duck hunting clubs are severely affected, relocation of the hunting club may be the most feasible mitigation.

Because the New and Alamo Rivers are major flight corridors, it is recommended that crossings of these rivers be minimized. Where crossing must occur it is suggested that transmission wires be placed underground or within conduits within 1000 feet (305 m) of either side of these rivers, in order to reduce the potential for avian mortality. If underground placement of transmission lines is considered to be infeasible, site specific surveys or monitoring programs aimed at determining flight elevations versus vertical height of the lines, tower spacing, tower design, line separation, and the like should be conducted to optimally design the system to
(81) minimize avian mortality to the maximum extent possible. For example, transmission lines should be designed so that wires will be separated sufficiently to prevent raptor

electrocution. Powerlines should also be designed without above-pole static lines in order to minimize avian collision potential. 83

In addition to the above, it is suggested that avian mortality and habitat studies currently being conducted by the Fish and Wildlife Service be continued and expanded to cover areas proposed for transmission line construction. In this manner, adequate data may be available to precisely predict impacts of future facility sitings.

d. Geothermal Fluid Ponding

Reservoirs used for temporary holding of geothermal fluids should be covered or otherwise made non-attractive to waterfowl. In the event of geothermal fluid spills, personnel should be stationed by the spill and use standard methods to drive waterfowl from the ponded material. In order to reduce waterfowl botulism potential, water should not be dumped into shallow ponds. This is especially true for waters rich in organics.

e. Rafting Areas

It is recommended that offshore facilities be oriented away from major rafting areas.

3.6.3.3 Aquatic Resources

a. Geothermal Fluid Spill Potential

Geothermal wells or power plants near the New or Alamo Rivers or near drains leading into the Salton Sea should be diked and fitted with blowout preventers. Facilities on offshore islands must also be fitted with dike systems and blow out preventers.

b. Water Usage

In order to help eliminate potential impacts due to sea level changes and increased salinity, it is recommended that a comprehensive management plan be formulated which coordinates the water use of all interests such that the Salton Sea's level and salinity is controlled.

c. Causeways

If causeways are to be used, it is suggested that piers, rather than filled causeways, be used. Any dredging would best be done in the fall or winter. Before major dredging operations begin, the toxicity of the sediments to be disturbed should be tested.

30 d. Further Studies

Prior to placing offshore facilities, it is recommended that aquatic studies be conducted to clearly outline spawning areas, to determine ecosystem dynamics, and to identify sensitive areas of the Salton Sea.