GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION
IMPERIAL VALLEY, CALIFORNIA

ENVIRONMENTAL BASELINE DATA ACQUISITION

EPRI ER-352
(Research Project 556)

Final Report

February 1977

Prepared by

SAN DIEGO GAS & ELECTRIC COMPANY
P. O. Box 1831
San Diego, California 92112

PROJECT MANAGER
J. F. Dietz

Prepared for

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
P. N. La Mori

DISCLAIMER

ABSTRACT

The Electric Power Research Institute (EPRI) has been studying the feasibility of a Low Salinity Hydrothermal Demonstration Plant as part of its Geothermal Energy Program. The Heber area of the Imperial Valley was selected as one of the candidate geothermal reservoirs to be considered as a site for the demonstration plant. Documentation of the environmental conditions presently existing in the Heber area is required for assessment of environmental impacts of future development by design engineers and to meet regulatory requirements.

San Diego Gas & Electric Company has managed an environmental baseline data acquisition program to compile available data on the environment of the Heber area. The program included a review of pertinent existing literature, interviews with academic, governmental and private entities, combined with field investigations and meteorological monitoring to collect primary data. Results of the data acquisition program are compiled in this report in terms of three elements: the physical, the biological and socioeconomic settings.

Primary conclusions drawn from the investigation suggest that sufficient data are available to make preliminary assessments of environmental impact of a geothermal project on the site.

CONTENTS

SUMMARY

The Imperial Valley of California is considered an area having great potential for the development of geothermal energy. Because of this potential, geothermal exploration and development are currently being performed by governmental and private entities at several known geothermal resource areas (KGRA) within the Valley.

The Electric Power Research Institute (EPRI) has been studying the feasibility of a Low Salinity Hydrothermal Demonstration Plant as part of its Geothermal Energy Program. The Heber area of the Imperial Valley was selected as one of the candidate geothermal reservoirs to be considered as a site for the demonstration plant. If this geothermal resource is to be beneficially utilized as an economic energy source, environmentally acceptable recovery and conversion methods must be applied. This requires documentation of the environmental conditions presently existing in the Heber area for assessment of environmental impacts of subsequent development.

In December, 1975, the Electric Power Research Institute (EPRI) awarded a contract to the San Deigo Gas & Electric Company (SDG&E) to manage an Environmental Baseline Data Acquisition Study of the Heber area. The Environmental Baseline Data Acquisition (EBDA) project has as its primary goal the collection and compilation of available data on the environment of the Heber KGRA. The results of this study program will establish a foundation for environmental assessment of future geothermal development.

This report summarizes the results of the EBDA program and describes the environment of the Heber region as it now exists in terms of three elements: the physical, the biological, and the socioeconomic settings. The descriptions of these environmental elements have been based on a search of existing literature, interviews with academic, governmental, and private entities, field investigations and monitoring of specific environmental parameters. Certain parameters, such as meteorology and biological setting, have required the collection of data for a full calendar year to obtain seasonal and annual information.

PHYSICAL SETTING

The Physical Setting element of this report provides a description of the Geothermal aspects of the Heber region based on available topographic, geographical, geologic, seismic, and subsidence data. Hydrology, climatology and air quality study components provide coverage broader than the Heber area, whereas the ambient sound levels, meteorology and soils components are specific to the primary eleven square mile study area. The potential geothermal plant site is approximately centered within the study area.

BIOLOGICAL SETTING

The Biological Setting describes the vegetation and vertebrate fauna communities of the Heber region. The description of the ecological communities and changes resulting from man's development of the region have been accomplished through literature reviews, agency interviews, and limited reconnaissance field studies. The presence of rare and endangered species has been evaluated and discussed in the text as well as other significant ecological characteristics of the site.

SOCIOECONOMIC SETTING

Data acquisition for the description of the Socioeconomic Setting consisted principally of a review of existing literature and personal contacts with local governmental and private entities. Imperial County has served as the geographical area for this study element. Societal parameters described in this study component include population characteristics, demographic variables, employment and income, housing, regional economics, land use and ownership, and educational/social services.

A description of the relative importance and abundance of archaeological and historical sites in the Heber region has been provided.

The following list identifies the consultants and principal investigators for the report components of the three environmental elements:

PHYSICAL SETTING

1.1	Physiography Topography	Geonomics, Inc. Berkeley, CA	Tsvi Meidav, PhD
1.2	Seismicity	Geonomics, Inc. Berkeley, CA	Tsvi Meidav, PhD

1.3 Subsidence	Geonomics, Inc. Berkeley, CA	Tsvi Meidav, PhD
1.4 Geology Geophysics	Geonomics, Inc. Berkeley, CA	Tsvi Meidav, PhD
1.5 Soils	Dames & Moore Los Angeles, CA	L. T. Murdock
1.6 Hydrology	Lowry & Associates San Diego, CA	D. A. O'Leary
1.7 Climatology	VTN Irvine, CA	J. P. Tomany
1.8 Meteorology	San Diego Gas & Electric Company, San Diego, CA	T. E. Perry
1.9 Air Quality	VTN Irvine, CA	J. P. Tomany
1.10 Ambient Sound Levels	Westec Services San Diego, CA	Marshall Long, PhD
BIOLOGICAL SETTING		
2.1 Terrestial Vegetation	Woodward-Clyde San Diego, CA	W. Odening, PhD J. Merino
2.2 Terrestial Wildlife	Woodward-Clyde San Diego, CA	W. Odening, PhD J. Merino
2.3 Aquatic Biology	Woodward-Clyde San Diego, CA	W. Odening, PhD J. Merino
SOCIOECONOMIC SETTING		
3.1 Socioeconomics Parameters	Geonomics, Inc. Berkeley, CA	Mae Meidav, PhD
3.2 Archaeology	David Smith Associates San Diego, CA	David Smith, PhD
3.3 History	David Smith Associates San Diego, CA	John Polich, PhD

1.0 PHYSICAL SETTING

1.1 PHYSIOGRAPHY AND TOPOGRAPHY

The Salton Trough, which includes the Imperial Valley, is an elongated northwest trending depression in southeastern California and northern Mexico (Figure 1.1-1). The trough, some 250 km long and 30 to 70 km wide, is surrounded by the Peninsular Ranges 1.5 km high to the west and the Chocolate and Orocopia Mountains 0.5 to 1.5 km high to the east. The Gulf of California to the south and the Transverse Ranges to the north form the other geographic boundaries.

The Imperial Valley segment of the Salton Trough north of the Mexican border and south of the Salton Sea (Figure 1.1-1) is the lowest part of the depression. The lowest part of the valley is at the Salton Sea (-246 feet) and the majority of the valley lies below sea level. The valley is predominantly an agricultural area which was transformed at the turn of the century from an arid desert by the influx of Colorado River water through a system of irrigation canals. The Salton Sea in the north valley is an unintentional man-made lake that resulted from a break in the levee near Imperial Dam in 1906. The waters were diverted into the valley for two years until they were finally controlled in 1908.

Figure 1.1-2 is a geological map of the southern part of the Imperial Valley, showing some of the physiographic features of the valley.

Figure 1.1-3 is a topographic map highlighting the topographic coutours.

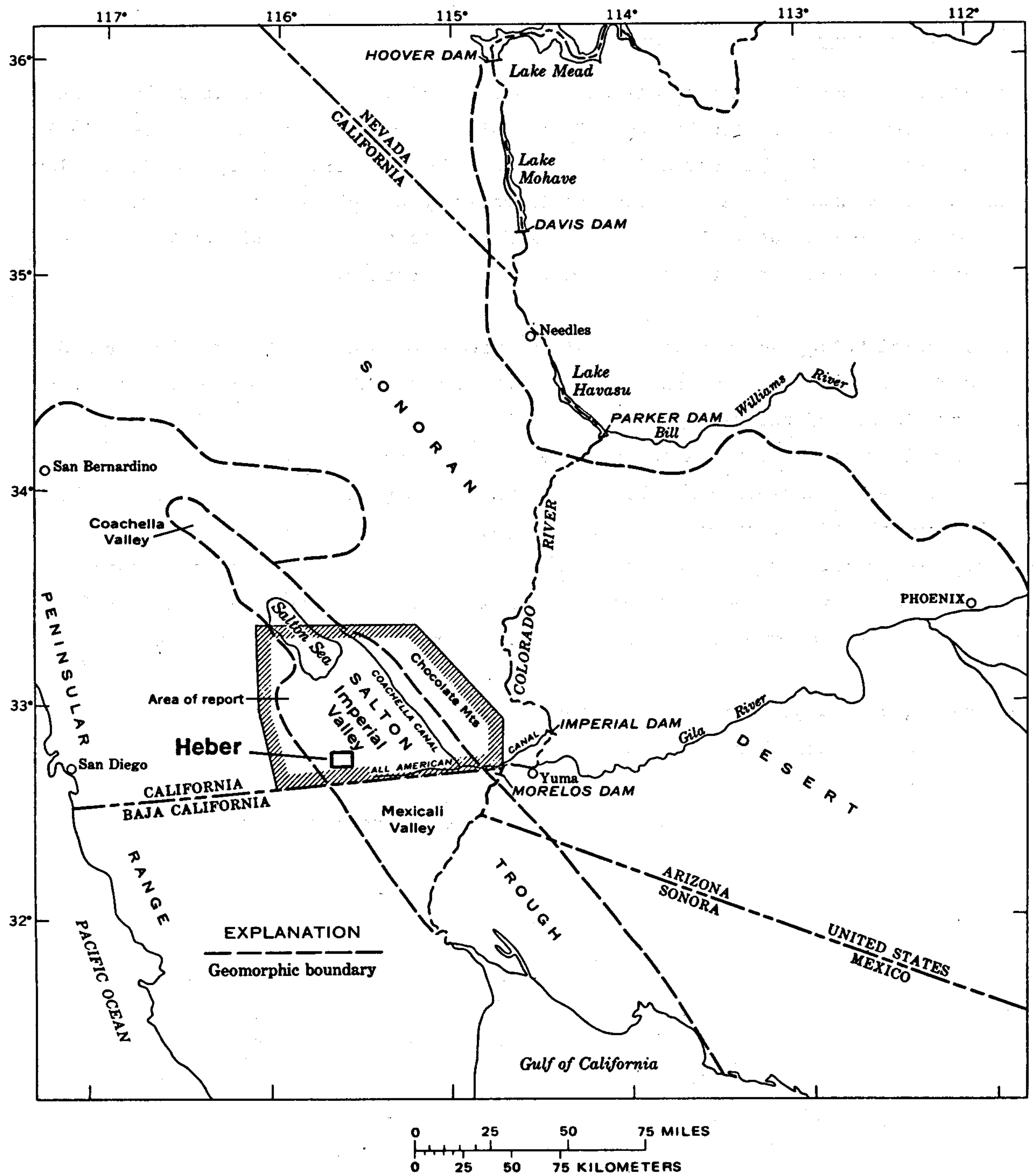
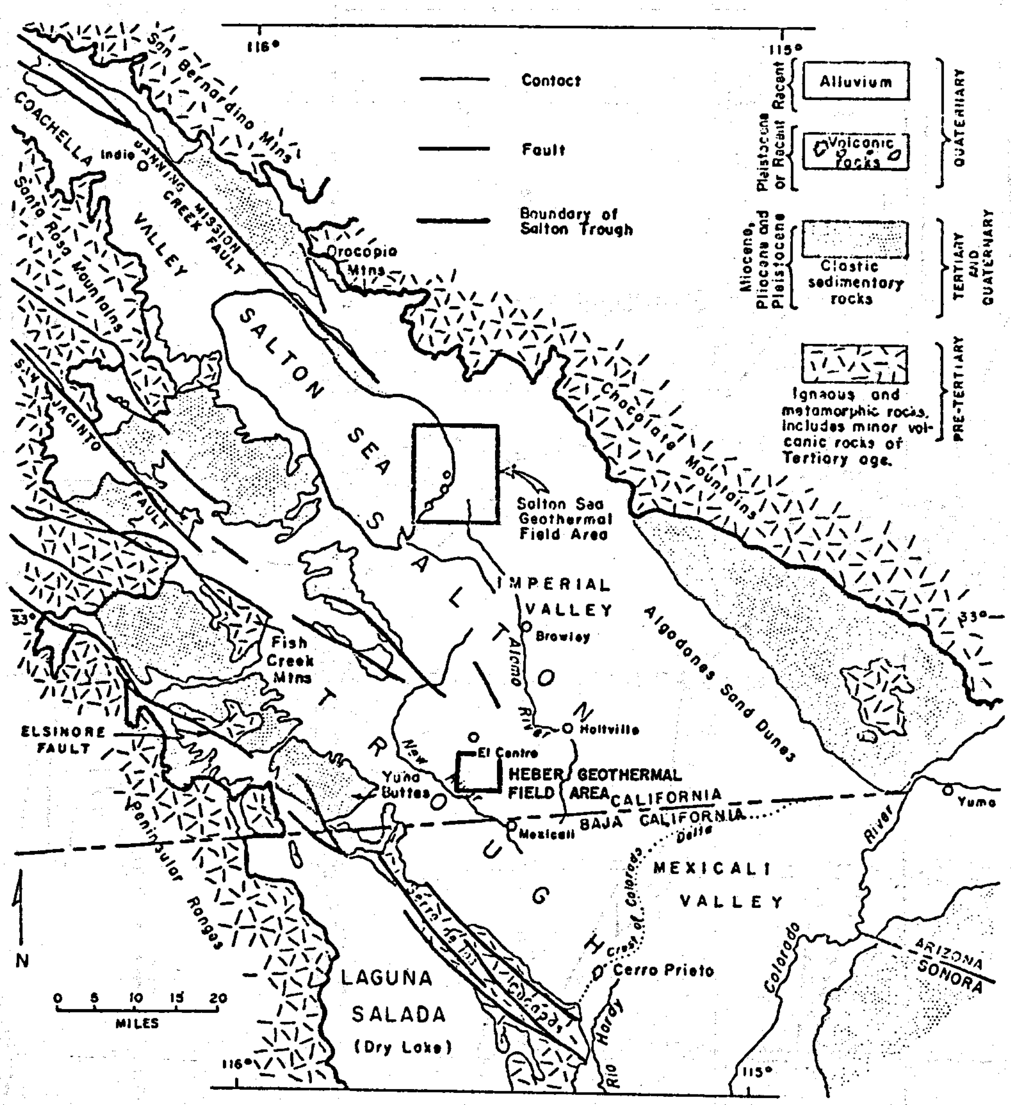
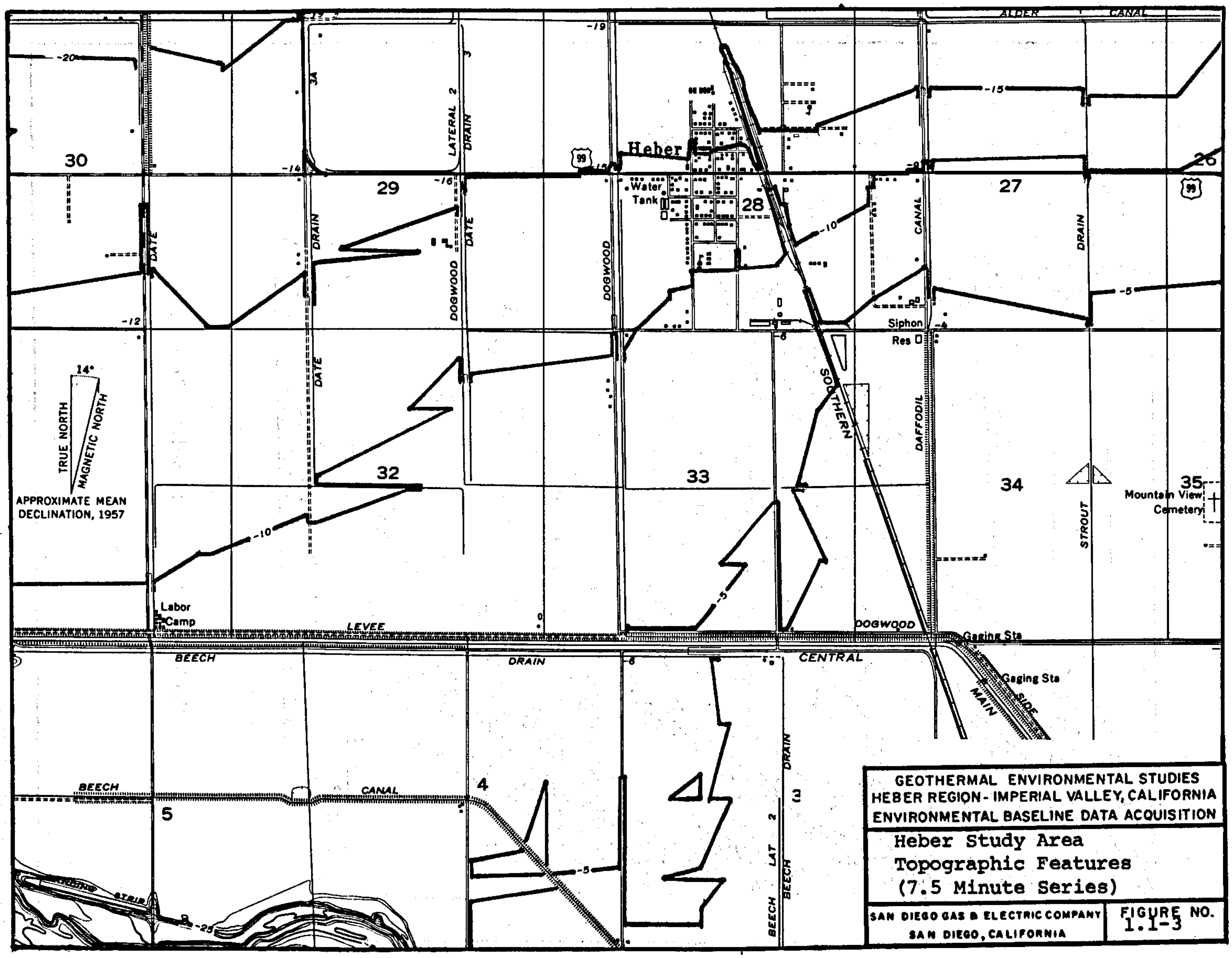


Figure 1.1-1 Regional Setting of the Imperial Valley (modified from Loeltz et al, 1973).(1)



Geologic map of the Salton Trough.

Figure 1.1-2 General geologic map of the Imperial Valley (modified from Randall et al, 1974).(2)



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY, CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

Heber Study Area
Topographic Features
(7.5 Minute Series)

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.1-3

REFERENCES - Physiography and Topography

1. Loeltz, O. J., et al., Geohydrologic Reconnaissance of the Imperial Valley, California, Geological Survey Professional Paper 486-K, 1975.

2. Randall, W. An Analysis of the Subsurface Structure and Stratigraphy of the Salton Sea Geothermal Anomaly, Imperial Valley, California, Ph.D. Dissertation, University of California, Riverside, December 1974.

1.2 SEISMICITY

1.2.1 Introduction

The historical pattern of seismicity and subsidence activity in the Imperial Valley is presented in this section. The extent of this activity at Heber is included. Current programs for monitoring the Imperial Valley, and the Heber area in particular, for seismicity and ground motion are also briefly mentioned.

1.2.2 Sources of Data

Earthquake data in the Imperial Valley have been extensively recorded since 1927. In 1934 a seismic station was established in the valley as part of the California Institute of Technology (Cal Tech) permanent southern California seismic net. The pattern of seismic recording was to move in portable seismic stations to an area after a large magnitude event, such as the Imperial earthquake of 1940 (6.7 magnitude on the Richter Scale), to record the sequence of aftershocks. Since 1973, however, the United States Geological Survey (U.S.G.S.) in cooperation with Cal Tech has established a sixteen-station telemetered network in the Imperial Valley (Figure 1.2-1) capable of locating earthquake hypocenters and determining magnitudes of events throughout the Valley to a magnitude (level) of 2 or greater. Below this level the net is only capable of consistently locating earthquakes in the central and eastern parts of the Valley. The purpose of the net is to record and interpret earthquakes related to the geothermal phenomenon.[1] Figure 1.2-2 is a typical set of data showing the vertical distribution of hypocenters for earthquakes occurring along the Brawley Fault. In the Heber area Chevron Oil Company plans to establish a closely spaced seismic net to gather information on background seismicity and the relationship the proposed geothermal production might have on seismic activity. The above project is slated for implementation in 1976 and will run continuously throughout the period of power production. Details on the forthcoming project are expected to be released shortly.[2]

Ground motion data (both horizontal and vertical) have been available in the valley since 1934 when the Coast and Geodetic Survey established the first triangulation and leveling network there. Since then the network has been remeasured in 1941, 1954, 1967 and 1972 (Figure 1.3-1). In 1970, as part of the Imperial Valley Project,[3] an array of 141 benchmarks was established in the southern Imperial Valley to monitor fault motion (Figure 1.2-3). In 1971 the

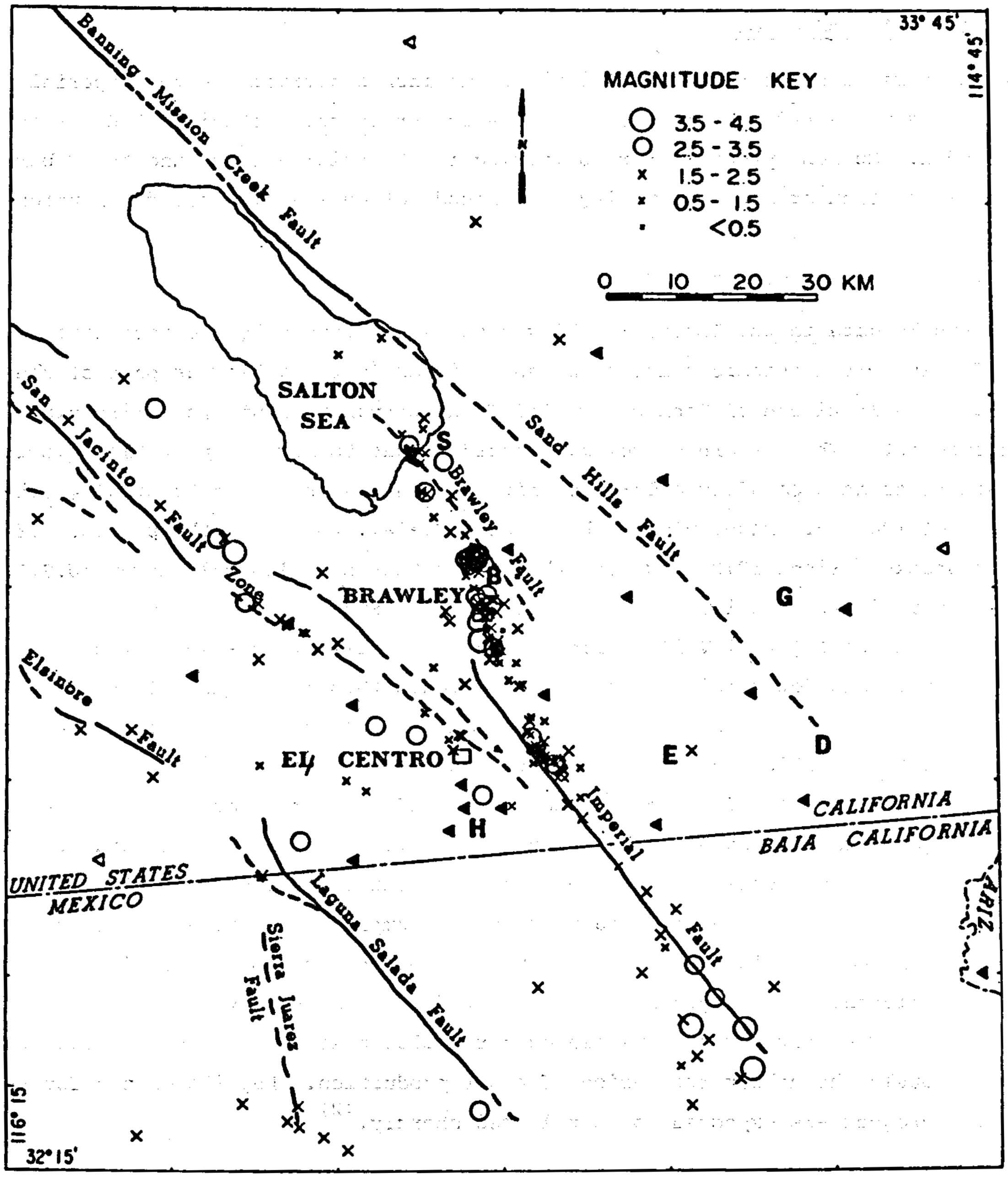


Figure 1.2-1 Location of earthquake epicenters in the Imperial Valley for the period June 1, 1973 through May 31, 1974. Solid triangles are U.S.G.S. seismograph stations, open triangles are Cal Tech stations. Known geothermal areas are indicated by capital letters as follows: (B) North Brawley, (D) Dunes, (E) East Mesa, (G) Glamis, (S) Salton Buttes, (H) Heber (modified from Hill et al, 1975a).[5]

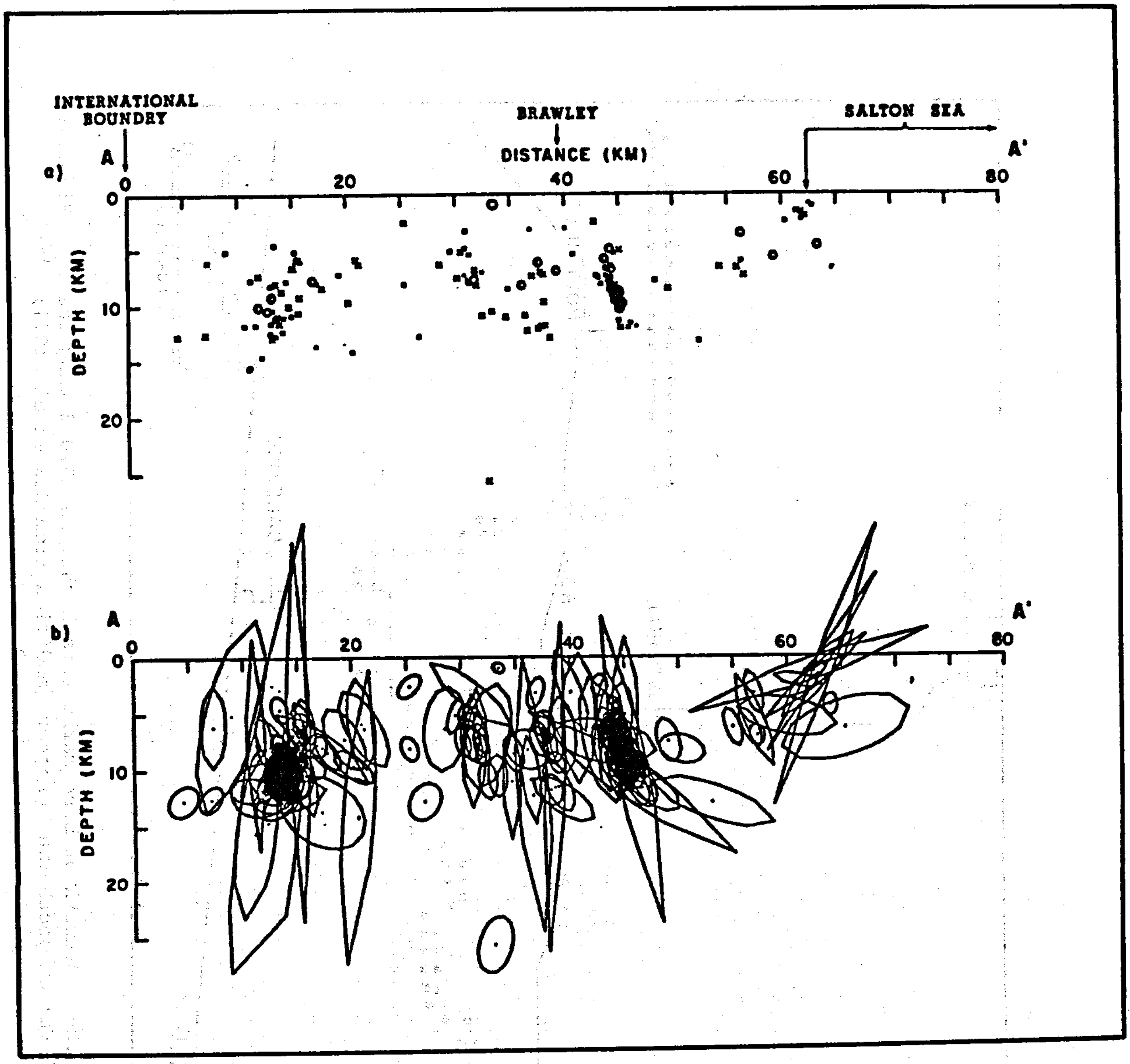


Figure 1.2-2

Vertical Distribution of Hypocenters for Earthquakes Occurring Within the Brawley and Imperial Fault Zones, for the Period June 1, 1973 Through May 31, 1974

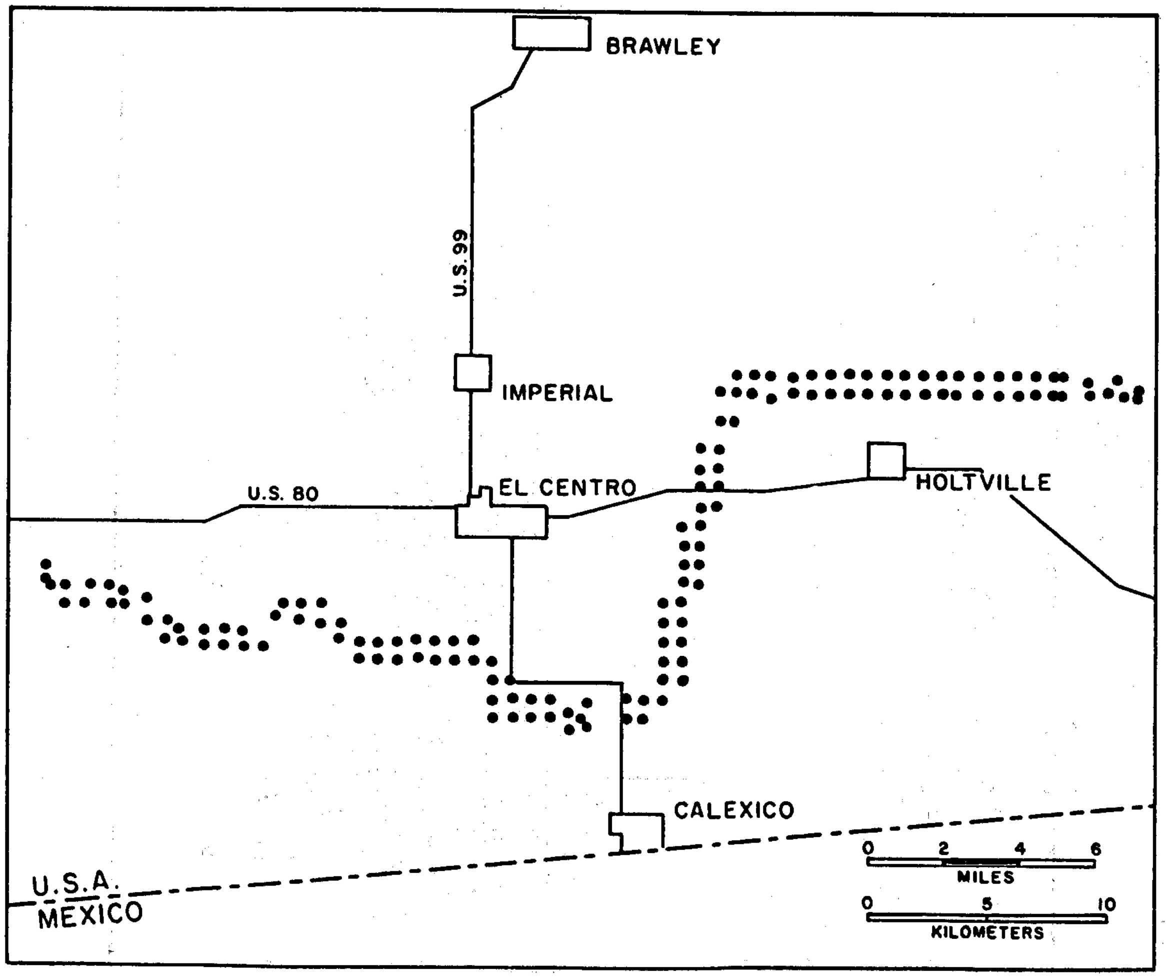


Figure 1.2-3 Network of benchmarks established in 1970 during the U.S. Riverside Imperial Valley geothermal project (modified from Rex et al, 1971).[3]

Coast and Geodetic Survey, in cooperation with the U.S.G.S., undertook an extensive program to monitor ground motion in the Imperial Valley. This program recommended triangulation and leveling surveys throughout the valley every two years and more frequently if geothermal production becomes a reality in the valley.[4] In addition, a system of tiltmeter, extensometers and level nets was established at Salton Buttes, East Mesa and Heber (Figures 1.2-4 and 1.2-5). These instruments measure vertical movements (level net), horizontal movement (extensometer) and ground level tilt (tiltmeter). The purpose of these surveys is to collect and interpret ground motion data related to the proposed geothermal development. Added to the above data was a private leveling survey done by Chevron Oil Company in the Heber area. This 1974-1975 survey measured the relative vertical ground motion in the Heber area. This data is proprietary but its existence and survey results are reported (see Section 1.3).

1.2.3 Regional Seismicity and Strain Release

Since 1927, when the first earthquake monitoring was done in the Imperial Valley, the records indicate the area is characterized by high regional seismicity. Earthquakes of magnitude 4.5 or less are common (Figure 1.2-6) and 12 earthquakes of magnitude 6.0 or greater have been observed since 1890[5] (Figure 1.2-7). Earthquakes have occurred both in swarms, such as the Brawley swarm of 1975[6] (Figures 1.2-8 and 1.2-9), and classical main shock-aftershock sequences such as the Imperial earthquake of 1940.[7] Figure 1.2-1 shows a map of earthquake epicenters in the valley for the period June 1, 1973--May 31, 1974. The diagram gives a picture of the seismicity of the region, although it must be used with caution because coverage was not uniform for earthquakes of magnitude 2 and below. Figure 1.2-2 gives focal depths for those of the earthquakes that occurred on the Brawley and Imperial fault zones and the relative location error.

The San Andreas Fault System which traverses the axis of the trough accounts for most of the regional fault movement. The system which includes the Banning-Mission Creek, Imperial, Brawley, Elsinore and San Jacinto Faults, among others, is moving right laterally at the cumulative rate of approximately 8.0 cm/yr.[8] This figure is a 20 year average of cumulative shear taken from the Peninsular Ranges to the west of the valley to the Chocolate Mountains to the east.[9] The actual movement is by no means constant but has varied greatly with time[10] and location in the valley.[8]

Earthquakes occurring along the San Andreas Fault system typically have focal depths of 5-8 km, which is approximately the basement-sediment interface.

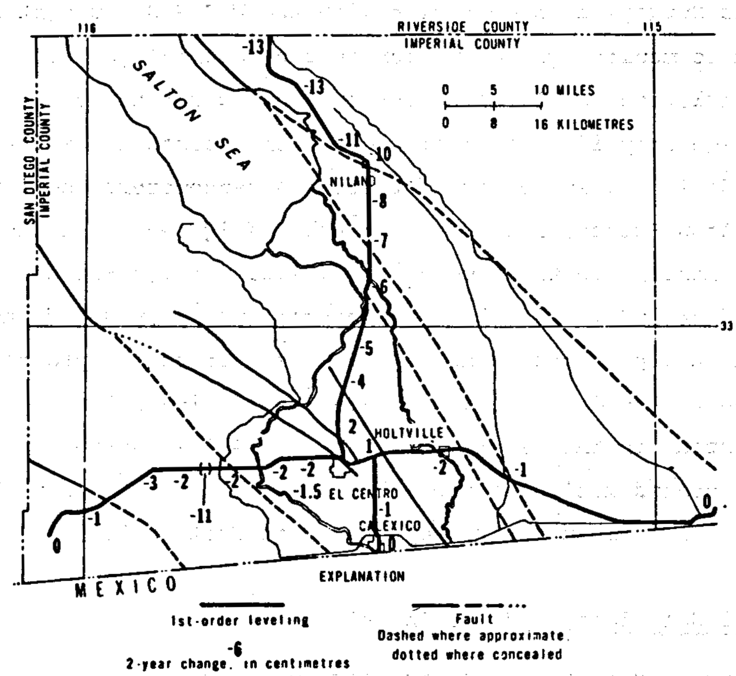


Figure 1.2-4 Network of first order vertical control and 2-year change in elevation, 1972-1974 (modified from Lofgren, 1974).(4)

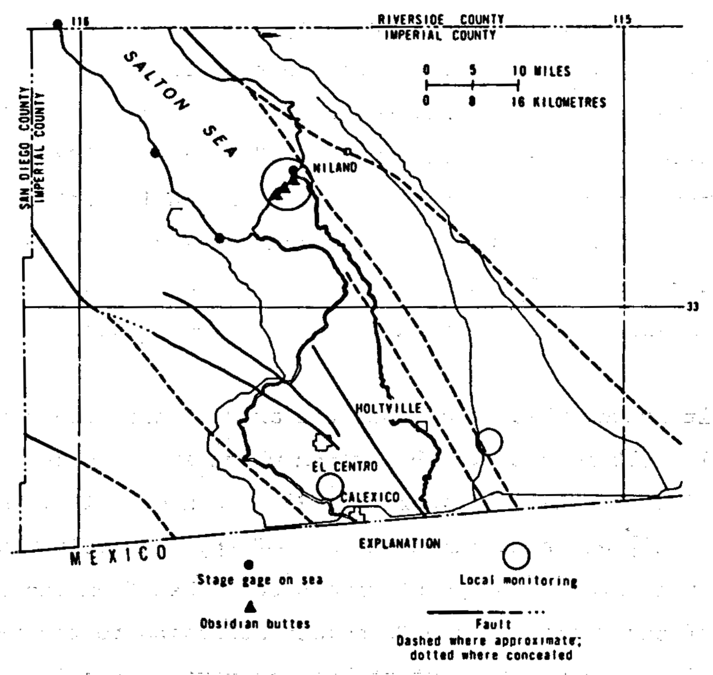


Figure 1.2-5 Geothermal areas of local vertical and horizontal control (modified from Lofgren, 1974).(4)

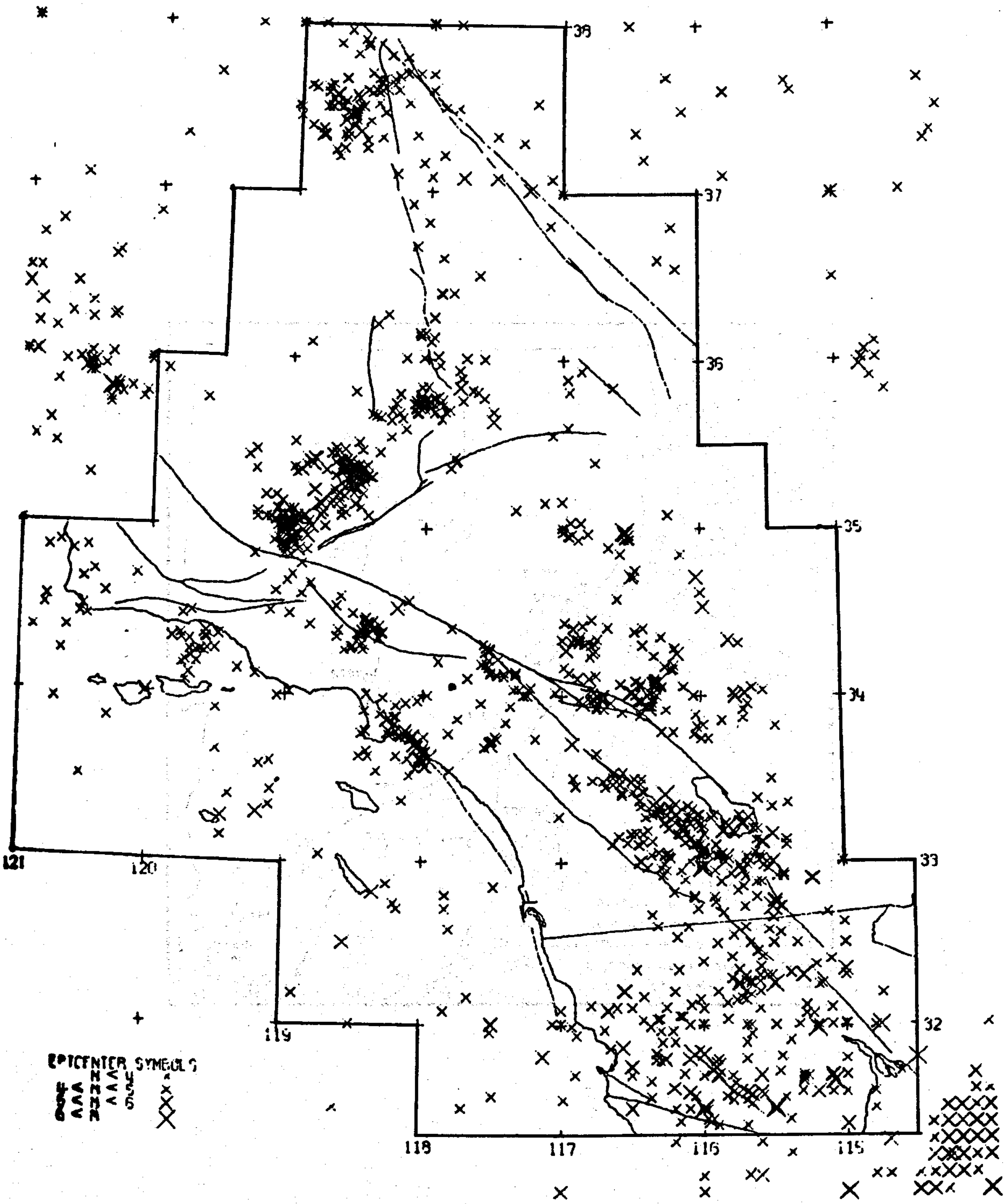


Figure 1.2-6 Epicenters of earthquake events in Southern California of magnitude 4 or greater from 1932 through 1972 (modified from Hileman et al, 1973). (14)

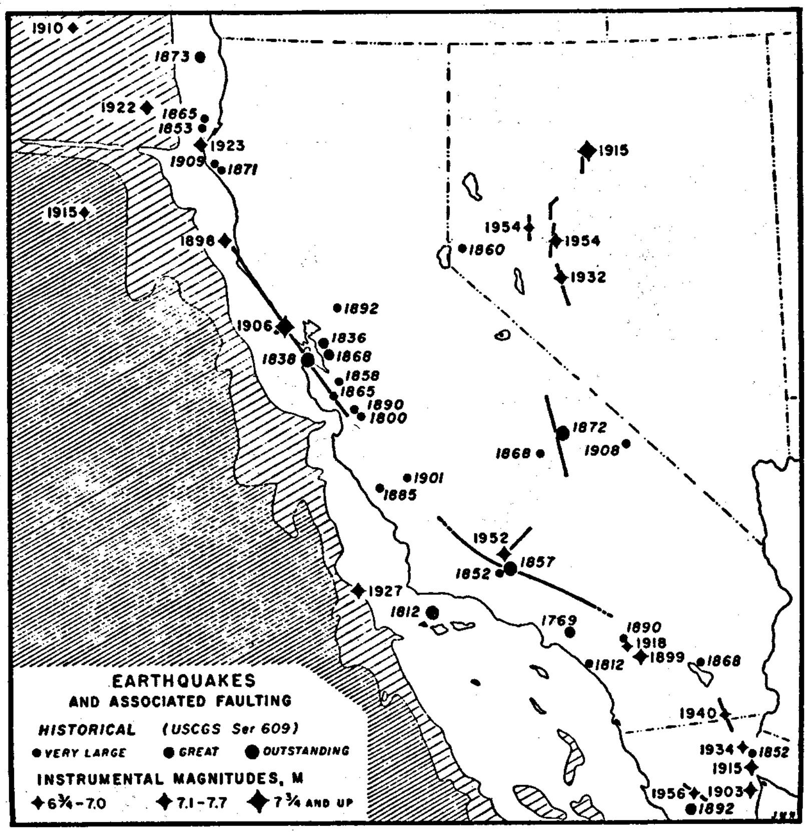


Figure 1.2-7 Large earthquakes in the California region. From ELEMENTARY SEISMOLOGY, by Charles F. Richter. W.H. Freeman and Company. Copyright © 1958.

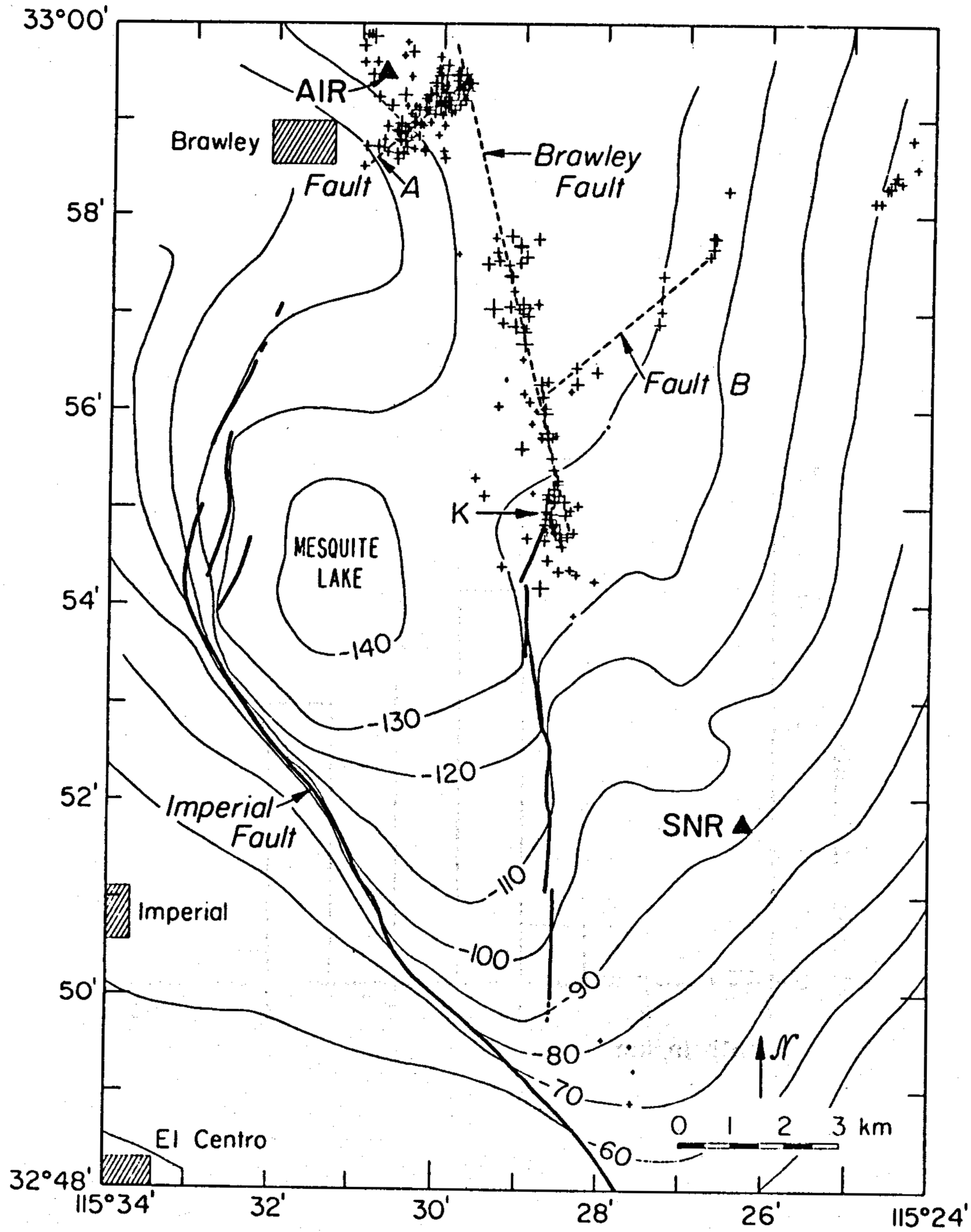


Figure 1.2-8 Earthquakes of the Brawley swarm January, 1975 (modified from Johnson and Hadley, 1975).[6]

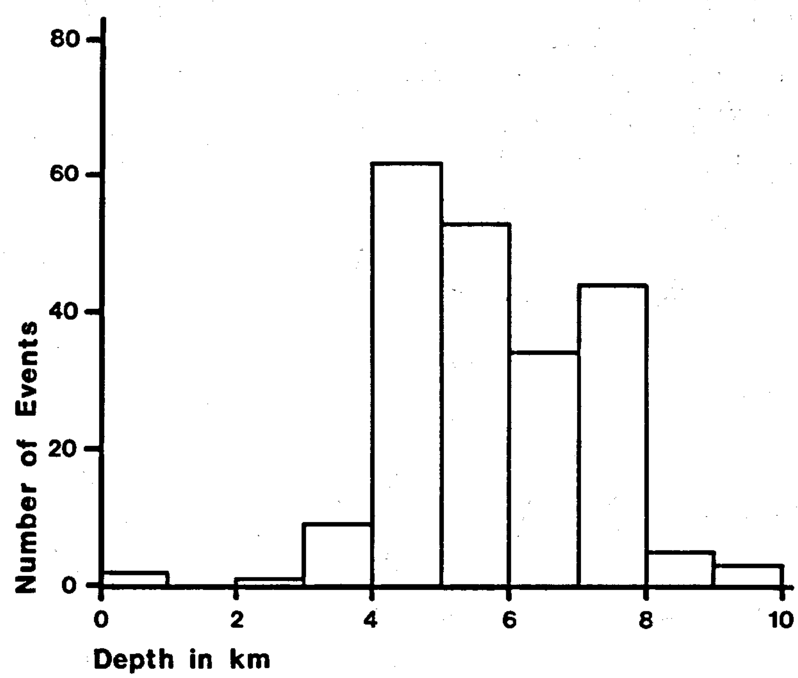


Figure 1.2-9 Depths of Earthquake Hypocenters for Events of the Brawley Swarm January, 1975.

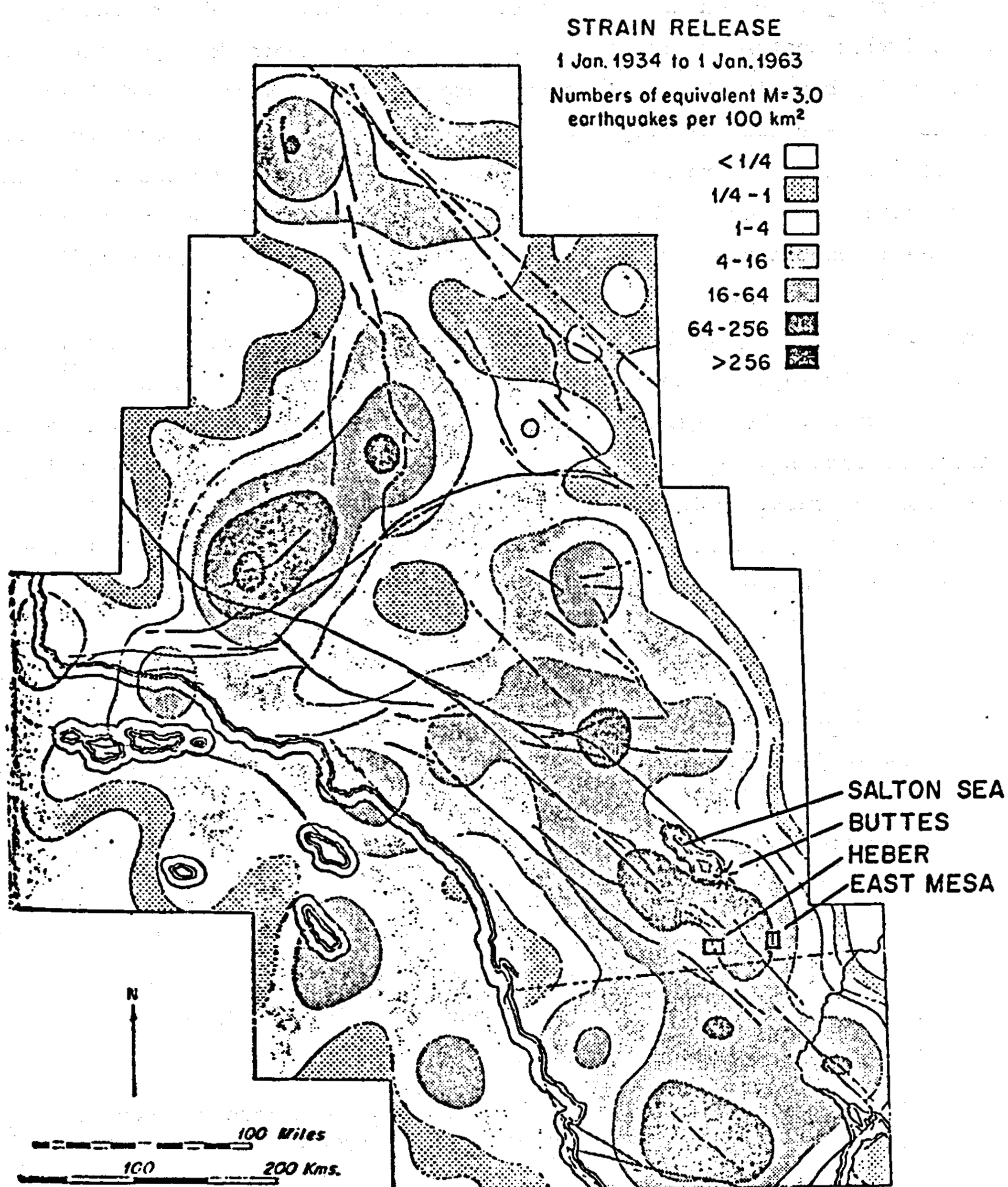
Events generally occur on nearly vertical fault planes and are frequently associated with Quaternary fault scarps. A limiting depth for hypocenters in the valley is about 10-12 km. At depths greater than this the high thermal gradients generate sufficiently high temperatures to cause the rocks to move plastically in response to stress. In the geothermal areas of the valley this 10-12 km figure is probably high.[6] Figure 1.2-9 shows the depth distribution of earthquake epicenters for Events of the Brawley Swarm of January 1975.

Although aseismic creeping has accounted for significant fault movement, most of the regional strain has been released by moderate to large earthquakes[11] or in earthquake swarms. As a general rule a gain of 1 in earthquake magnitude results in strain release six times as great. A smoothed strain release map during a 30 year period for southern California is given in Figure 1.2-10. The figure shows that in the valley, (a) most of the strain was released in the central part, and (b) that most of the geothermal areas fall in the region of highest strain release.

1.2.4 Relation to Geothermal Activity

Several studies have shown that there is a correlation between microearthquake activity and geothermal anomalies.[12, 13] In the Imperial Valley the correlation is unusually high. High levels of microearthquake activity are found at Salton Buttes,[5] North Brawley[6] and East Mesa.[12] To date, it is unknown whether such a relationship also exists at Heber. It is not known whether the high microearthquake levels are the result of the geothermal anomaly or if the geothermal anomaly is related to the earthquake activity. In any case, several remarks can be made about earthquakes in the valley's geothermal areas:

> Shocks are generally smaller in magnitude and more frequent in geothermal areas than other areas in the same tectonic setting.[12]
>
> Faults related to the microearthquakes often serve as plumbing conduits for circulating brines. At the Salton Buttes, for example, it was observed that CO_2 wells began emitting large quantities of gas just after earthquakes in the 1930's.[16]
>
> Earthquake focal depths are usually higher in geothermal areas than in outside areas. This implies that microearthquakes are probably related to the geothermal processes.[17]



$$\text{Log } E = 11.8 + 1.5M$$
$$N_3 = 10^{0.75(M-3.0)}$$

Figure 1.2-10. Smoothed strain release map of Southern California from 1933 through 1963 (modified from Allen et al, 1965).(11)

REFERENCES - Seismicity

1. Hill, D., Mowinckel, P. and Peake, L., "Earthquakes, Active Faults and Geothermal Areas in the Imperial Valley, Science 188, pp. 1306-1308 (1975b).

2. Dobrich, E. Personal communication, March 1976.

3. Rex, R. W., et al. Cooperative Geological-Geophysical-Geochemical Investigations of Geothermal Resources in the Imperial Valley Area of California, University of California, Riverside, 1971.

4. Lofgren, B. E. Measuring Ground Movement in Geothermal Areas of Imperial Valley, California, Proc. Conf. on Research for the Development of Geothermal Energy Resources, Pasadena, California, Sept. 23-25, p. 128-133, (1974).

5. Hill, D., Mowinckel, P., and Lahr, A. Catalog of Earthquakes in the Imperial Valley, California, June 73 - May 74, U.S.G.S. Open File Report, Washington, D.C., 1975 a.

6. Johnson, C. E., and Hadley, D. M. Tectonic Implications of the Brawley Earthquake Swarm, Imperial Valley, California, Seismological Laboratory, California Institute of Technology, Pasadena, California, 1975.

7. Ulrich, F. P., "The Imperial Valley Earthquakes of 1940," Bull. Seism. Soc. of Amer., v. 31, pp. 13-31 (1941).

8. Scholz, C. H., and Fitch, T. J., "Strain Accumulation Along the San Andreas Fault," Journal of Geophysical Research, v. 74, no. 27, p. 6649 (1969).

9. Whitten, C. A., "Crustal Movement in California and Nevada," Amer. Geophysical Union Transactions, v. 37, no. 4, pp. 393-398, (1956).

10. Garfunkel, Z. The Tectonics of the Salton Trough of California, Cooperative Investigations of Geothermal Resources in the Imperial Valley and their Potential Value for Desalting of Water and other Purposes, R.W. Rex, Ed., University of California, Riverside, p. H1-H3, (1972).

11. Allen, C. R., et al, "Relation Between Seismicity and Geologic Structure in the Southern California Region," Bull. Seism. Soc. Am, No. 55, pp. 753-797, (1965).

12. Combs, J., and Hadley, D. M., "Microearthquake Investigations of the Subhir Mesa Geothermal Anomaly, Imperial Valley, California," Geophysics, v. 39, (1974).

13. Lange, A. L., Microearthquakes in Geothermal Prospecting, Amax Exploration Inc., pp. 11, from Annual Meeting of the Society of Economic Geologists, Miami, Florida, Nov. 18, 1974.

14. Hileman, J. A., Allen, C. R., and Nordquist, J. M. Seismicity of the Southern California Region: 1 Jan. 1932 to 31 Dec. 1972, Seismological Lab. Bull., C.I.T., Pasadena, 1973.

15. Richter, C. F. Elementary Seismology, W. H. Freeman & Co., Inc., ed., 1958.

16. Muffler, L.J.P. and White, D.E., "Origin of CO_2 in the Salton Sea Geothermal field, Southeastern California, USA," XXIII International Geological Congress, Prague, 1968, v 17, Symposium II Procedings, Gensis of Mineral and Thermal Waters, pp. 185-194, (1968).

17. Ward, P.L., Palmason, G., and Drake, C., "Microearthquake Survey and the Mid-Atlantic Ridge in Iceland," Journal of Geophysical Research, 74, p. 664, (1969).

1.3 SUBSIDENCE

In the Imperial Valley ground motion and subsidence exist as part of the tectonic background. As shown in Figure 1.3-1 triangulation and leveling data show that the valley is moving horizontally in a complex manner and that the central valley is subsiding at the maximum rate of about 1.5 cm per year relative to the surrounding mountains. It is clear from these figures that the horizontal motion is far more complex than the assumed right-handed shear model[1] and that the northern and central parts of the valley are showing greatest subsidence. The Brawley area has recently been moving downward at the highest rate, which may be related to the large number of recent earthquakes[2,3] and the high strain rate on the Imperial and Brawley faults.[4,5] A recent leveling survey by the Chevron Oil Company[6] suggests that the Heber area is moving up slightly with respect to El Centro but that the dominant motion has been a downward tilting northward and eastward. Data from this survey is considered proprietary.

A subsidence detection committee has been formed in Imperial County. This committee has studied subsidence in connection with agricultural operations. The Imperial Irrigation District surveys and makes profiles of canals and ditches in the county. Monitoring of the leveling in the valley is continuous. The first order lines are scheduled for surveys biennially. The bedrock ties to the west, east, and north of El Centro are considered stable, although, of course, this has not been proven. The surveys made to date disclose a slight regional tilt from south to north. The county surveyor's office knew of no localized subsidence caused by agricultural operations. It was mentioned also that bench marks by law must be established in the areas of geothermal fluid reservoir with local surveys being made periodically. The results are to be related to the major first and second order networks for the purpose of detecting subsidence.

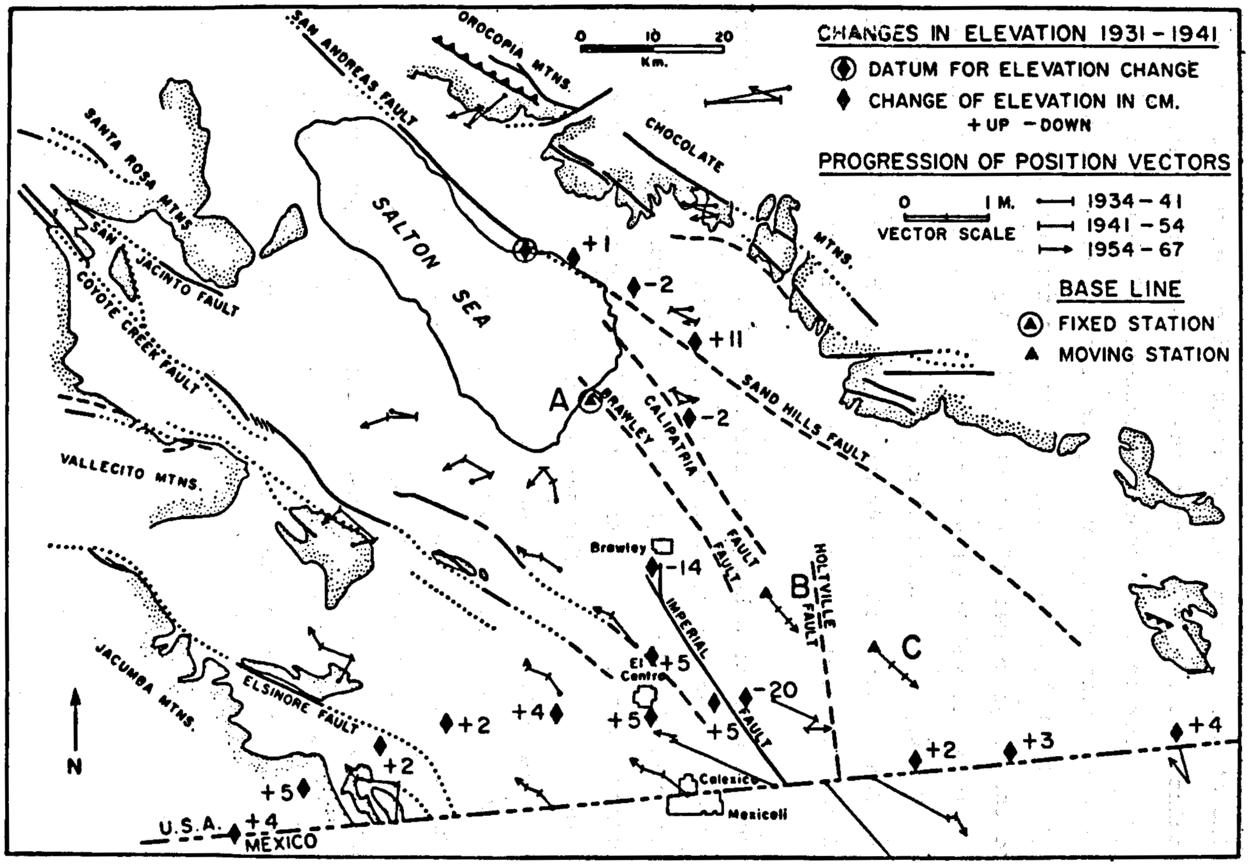


Figure 1.3-1 Geodetic measurement in the Imperial Valley from 1934 to 1967. Station A is assumed fixed (modified from Elders et al, 1972).[5]

REFERENCES - Subsidence

1. Whitten, C. A., "Crustal Movement in California and Nevada," Amer. Geophysical Union Transactions, v. 37, no. 4, pp. 393-398, (1956).

2. Hill, D., Mowinckel, P., and Lahr, A., Catalog of Earthquakes In the Imperial Valley, California, June 73 - May 74, U.S.G.S. Open File Report, Washington, D.C., (1975 a).

3. Hill, D., Mowinckel, P. and Peake, L., "Earthquakes, Active Faults and Geothermal Areas in the Imperial Valley," Science, 188, pp. 1306-1308, (1975 b).

4. Johnson, C. E., and Hadley, D. M. Tectonic Implications of the Brawley Earthquake Swarm, Imperial Valley, California, Seismological Laboratory, California Institute of Technology, Pasadena, California.

5. Elders, W. A., et al., "Crustal Spreading in Southern California," Science, 178, pp. 15-24, (1972). Copyright 1972 by the American Association for the Advancement of Science.

6. Dobrich, E. Personal communication, March 1976.

NOTE: Basic data is in U.S.G.S. governmental files, Mr. B. Lofgren of U.S.G.S. Sacramento office is custodian of the data. Proprietary data in the Heber Area has been collected by the Minerals Staff of Chevron.

1.4 GEOLOGY AND GEOPHYSICS

1.4.1 Salton Trough

The Salton Trough can be characterized as a complex rift valley of Miocene Age[1] filled to great depths with Tertiary and Quaternary sediments (Figure 1.4-1). These deposits are largely fluvial, lacustrine, and marine beds, primarily derived from Colorado River sources and intermittent marine incursions.[2,3,4] The Peninsular Ranges to the west of the trough are composed chiefly of Cretaceous southern California batholith granites[5] while the Chocolate and Orocopia Mountains to the east contain Mesozoic and older granitic and metamorphic rocks.[6]

Unlike most rift valleys, the Salton Trough is bounded by active strike slip faults trending oblique to its axis and the component of fault motion normal to the axis of the trough accounts for the observed rifting.[6] Geophysical studies[7] showed that the trough is 6-7 km deep in the central Imperial Valley, but despite its great thickness of low density sediments, the trough has a positive residual Bouger gravity (Figures 1.4-2 and 1.4-3). This implies that either the crust is thinner or more dense than usual or both. Gravity modeling by Meidav and Rotstein,[8] (Figure 1.4-3) suggests that the crust in the Imperial Valley may be as thin as 14 km.

In a general sense, the existence of the Salton Trough may be explained with plate tectonic models. The observed crustal thinning and basification may be accounted for by noticing that the Salton Trough comprises a part of the active Pacific North American Plate Boundary (Figure 1.4-4). The trough is actually a landward extension of the East Pacific rise, an oceanic spreading center. An evolutionary model for the development of the trough in this framework is given in Figure 1.4-5 which shows how a thinner, denser crust may be forming under the Salton Trough by processes analogous to oceanic crustal spreading.

1.4.2 Imperial Valley

The Imperial Valley is the most tectonically active part of the Salton Trough in the United States. It is an area of high regional heat flow,[9] intensive crustal deformation,[6] high seismicity and subsidence activity,[10,11] and numerous geothermal anomalies.[12]

The Imperial Valley is one of the most seismically active areas of the United States.[13,10,11] The seismic activity has taken the form of both the classical

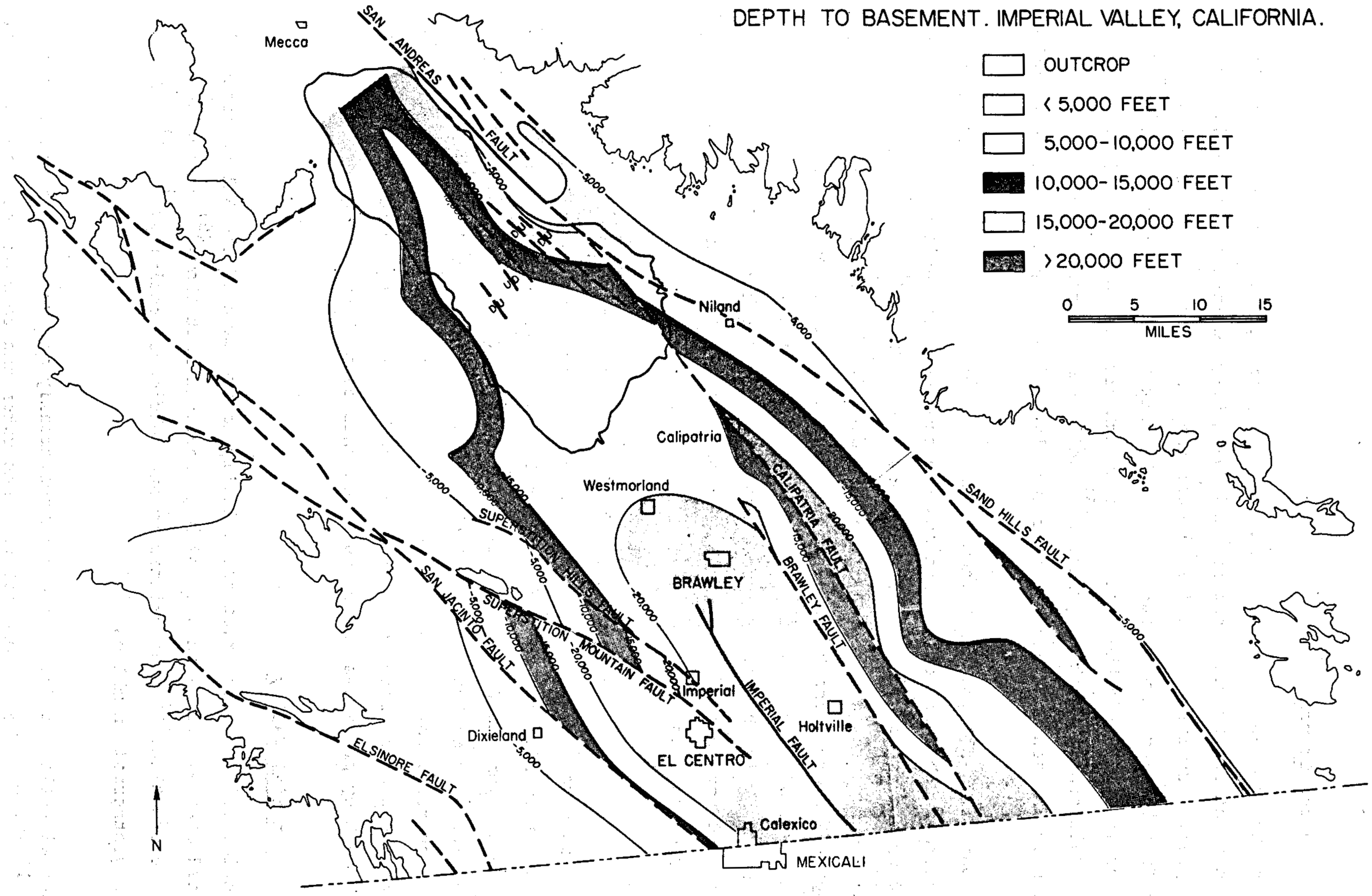


Figure 1.4-1 Depth to basement isopach map (after Bidhler et al. 1964).(7)

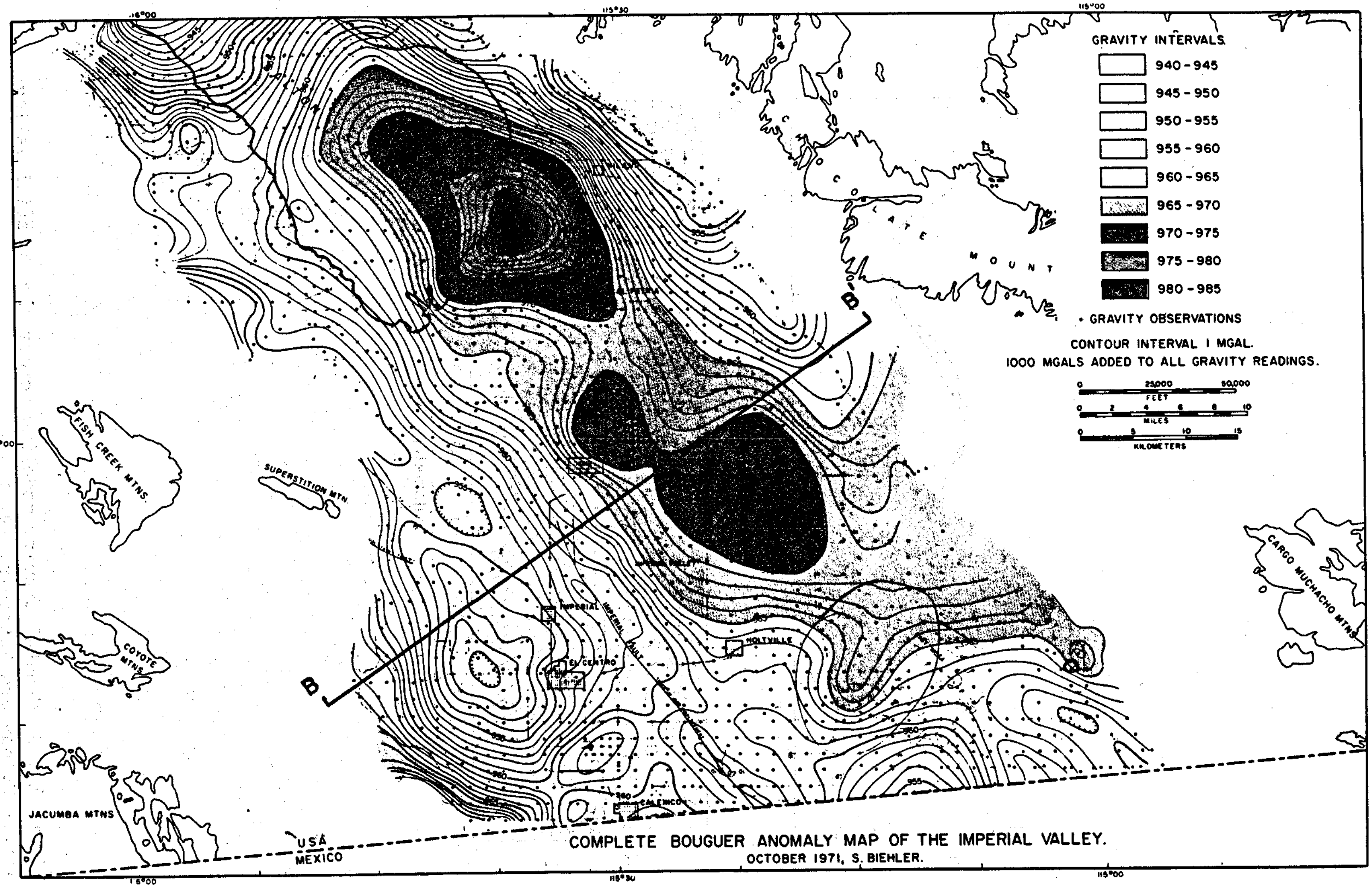


Figure 1.4-2 Bouguer gravity for the Imperial Valley. (after Biehler, 1971).[22]

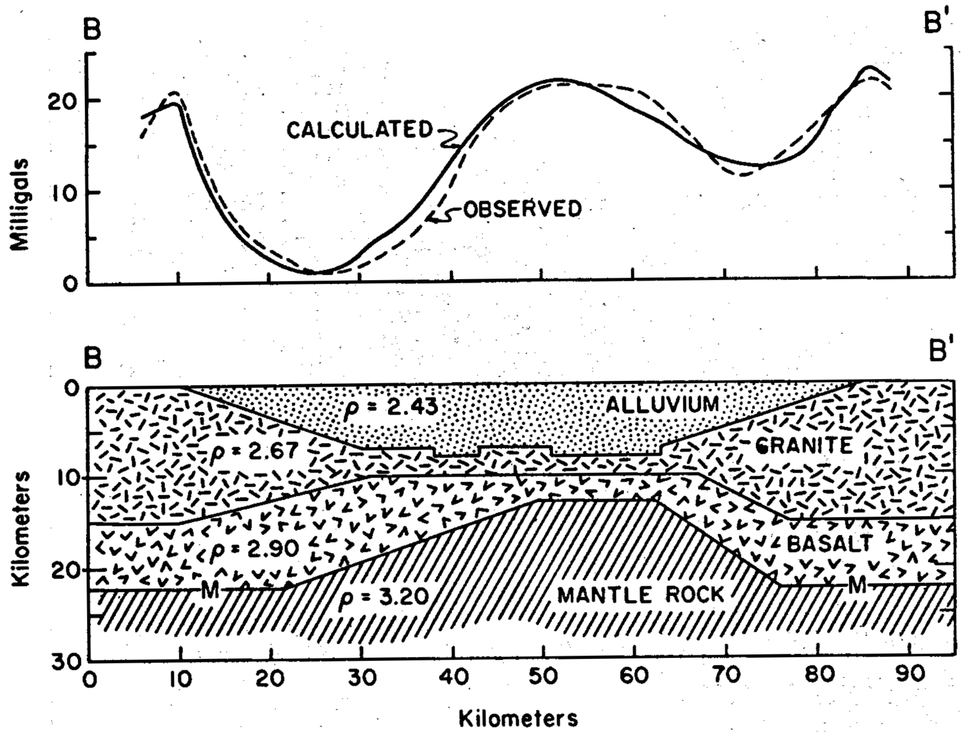


Figure 1.4-3 Crustal gravity modeling across the Imperial Valley (after Meidav and Rotstein, 1971).(8)

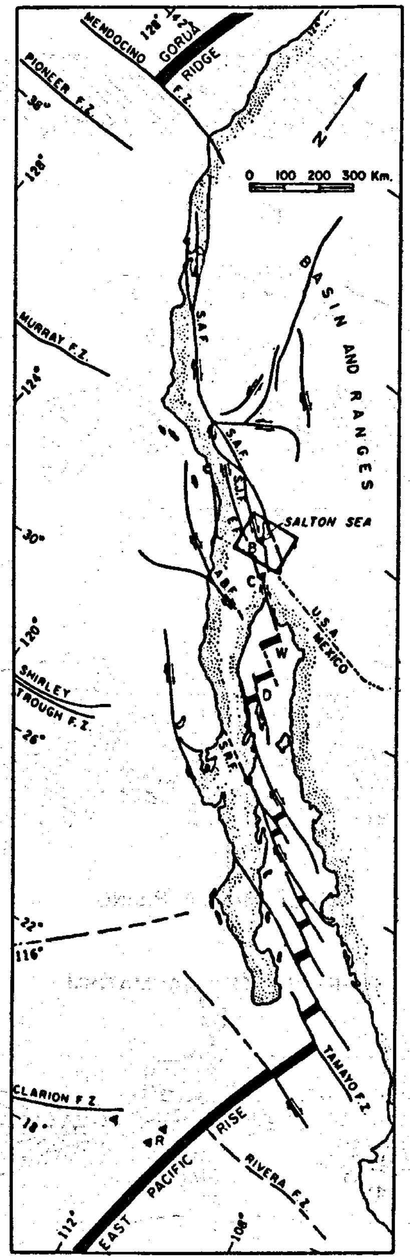


Figure 1.4-4 Tectonic setting of the Salton Trough (after Elders et al, 1972).(1)

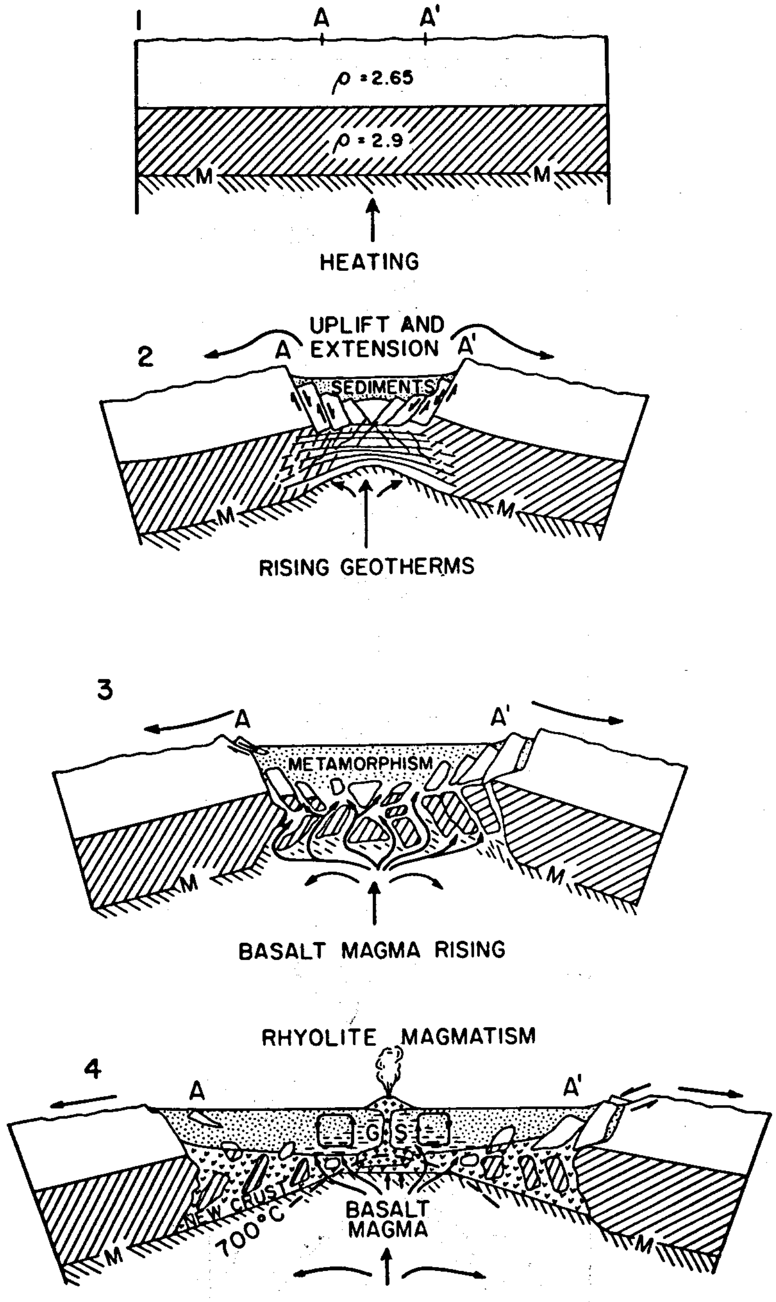


Figure 1.4-5 Schematic model for the evolutionary development of the Salton Trough (modified from Elders et al, 1972).(1)

main shock-aftershock sequences, such as the Imperial earthquake of 1941[14,15] and swarm activity, such as the Brawley swarm of 1975.[16] Numerous strike slip faults of the San Andreas system strike into the valley[7] and most of these are still currently active. The San Andreas Fault which bounds the valley to the east (Figure 1.4-1) and the Elsinore, San Jacinto, and Superstition Hills faults, which lie at the western boundaries of the valley are presently less active than the central valley faults.[10,11,13] These faults, which include the Imperial Fault and Brawley Fault, are sites for most of the observed historical seismicity.[13]

A thermal gradient map and a gravity map of the valley (Figures 1.4-6 and 1.4-2) show a strong correlation between thermal gradient anomalies and positive gravity closures, where each geothermal anomaly has an associated gravity positive. This factor, which has greatly simplified geothermal exploration in the valley, may be explained by assuming a convective mass transfer model. In this model heated subsurface brines cool and precipitate mineral phases while rising up fault conduits. The result is a large amount of intergranular mineralization and near surface densification of country rock; hence positive gravity anomalies occur.[17] An analysis of a more detailed gravity survey of the Heber area by the Chevron Oil Company (the data is proprietary) indicates that the relative gravity high is surrounded by a moderate gravity low. This suggests a selective leaching and deposition process, whereby ascending minerals are dissolved out of the rocks on the periphery and deposited in the central portion of the field, through cooling and decompression. It is noteworthy that six of the seven geothermal systems found in the valley have no surface leakage manifestation. These systems are either stratigraphically sealed (by thick impermeable clay beds, for example) or self-sealed by mineral precipitation from circulating brines.[18] The only exception is the Salton Buttes field.[1]

1.4.3 Heber Anomaly

The Heber Anomaly is located in the south central part of the Imperial Valley (Figure 1.1-2). The area is characterized by very flat topography, low elevations, and the lack of surface rock outcroppings. Sediments are dominantly Quaternary Deltaic sands and shales derived from Colorado river sources.[4] Boreholes show that the Deltaic sediments persist to a depth of at least 2.5 km.[19] The depth to basement at Heber estimated from seismic surveys[7] is 7 km, which is equal to the greatest basement depth thus far encountered in the valley (Figure 1.4-1).

The Heber heat flow anomaly is about 35 square kilometers, based on deep and shallow borehole temperature data,[9] (Figure 1.4-6). Although surficial thermal

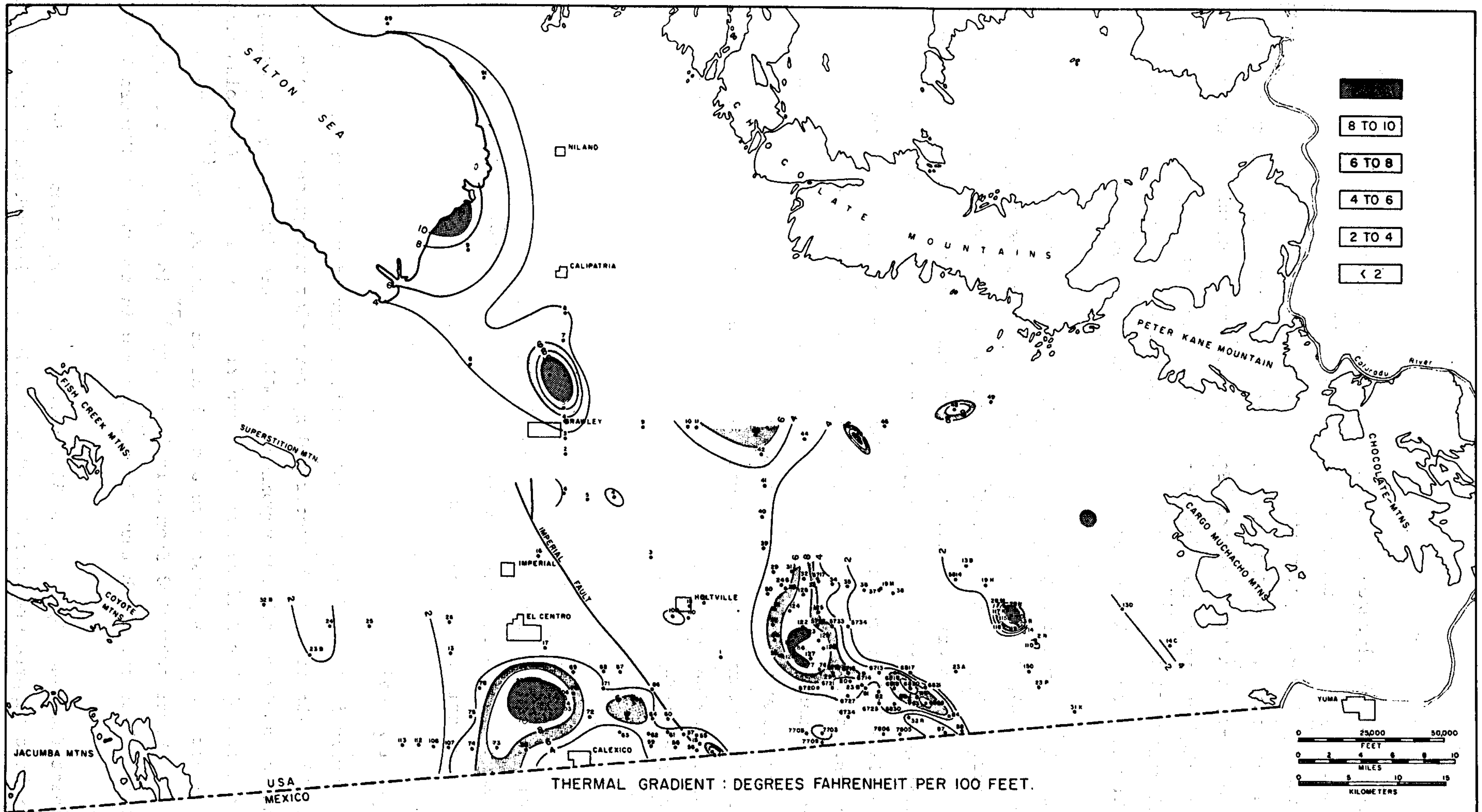


Figure 1.4-6. Thermal gradient map of the Imperial Valley (after Combs, 1971).

gradients were found to exceed 40C/100 m there is no surficial manifestation of the heat source. Numerous geophysical surveys were conducted in the Heber area[20,21,2] and it was found that the Heber area has gravity and electrical resistivity anomalies associated with the heat flow high. Biehler[22] discovered a 2 mgal gravity positive over Heber of approximately the same shape and size as the heat flow high (Figure 1.4-2). This gravity contrasts with much larger positives found over the Salton Buttes, North Brawley and East Mesa geothermal fields. Biehler[22] postulated that the lower gravity pointed to the possible existence of a pure steam phase at the Heber field, but to date drilling has not confirmed his suggestion. Meidav and Furgerson[20] showed that the Heber field has an associated low resistivity anomaly (Figure 1.4-7) although it was noted that the resistivity contrast of the anomaly is small because the background resistivities are also very low (less than 2 ohm-meters). These low background resistivities were explained by increased water salinities because of inadequate mixing and sluggish ground water transport. Meidav and Furgerson[20] also showed that the Imperial Fault serves as an aquitard in the Heber area which separates brackish central valley waters from fresher waters to the east (Figure 1.4-8).

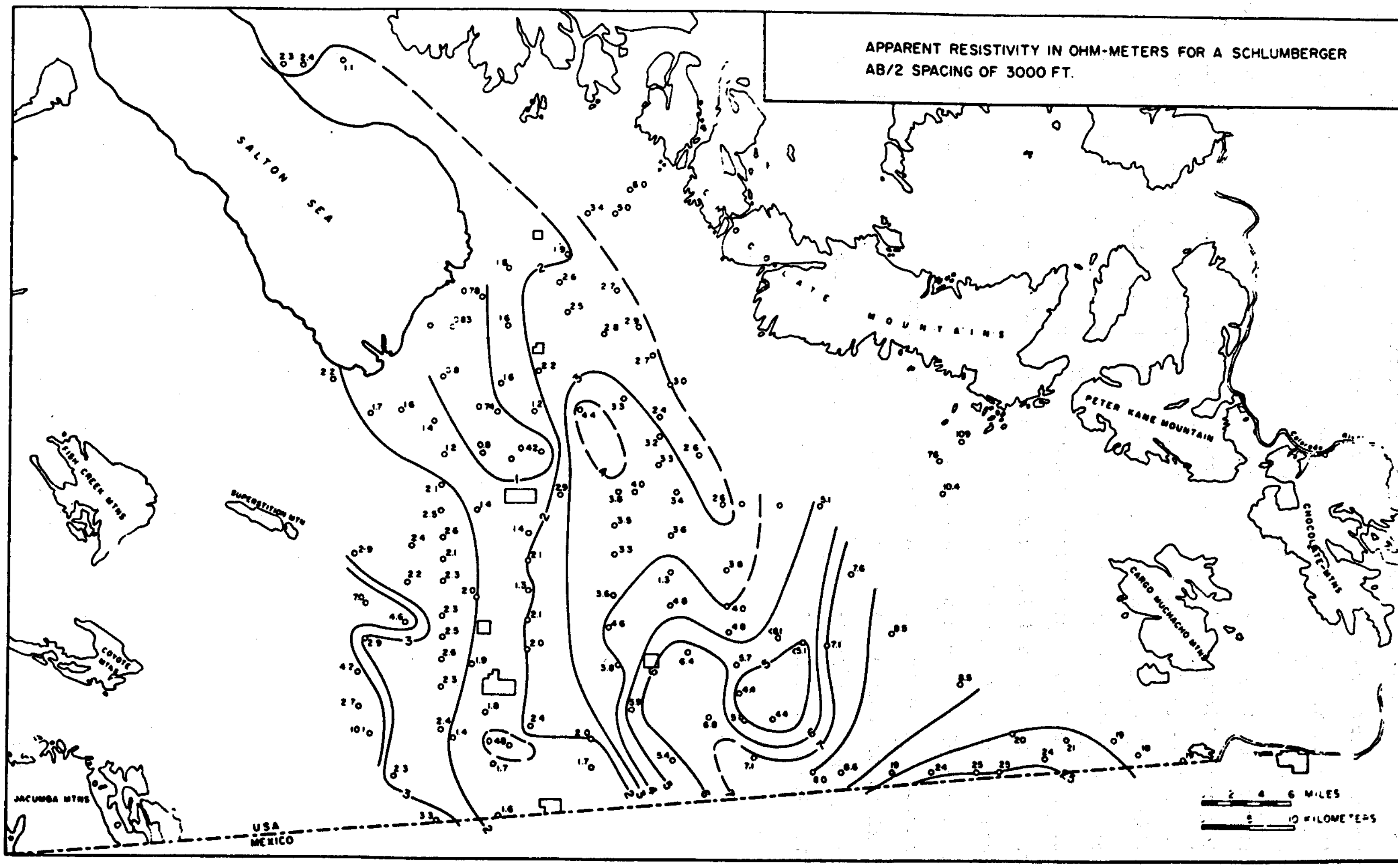


Figure 1.4-7 Electrical resistivity map for the valley (after Meiday and Furgerson, 1972).[20]

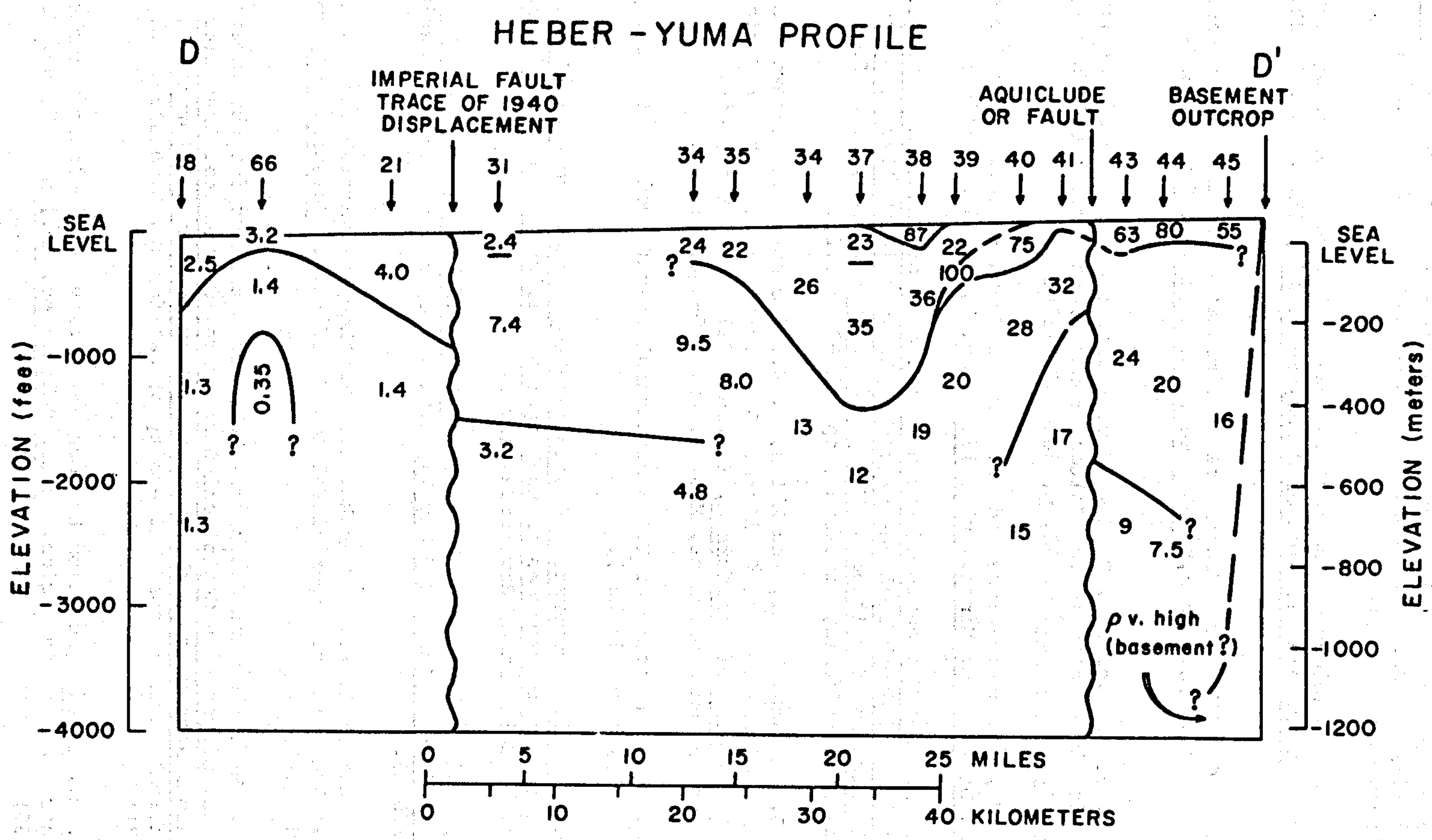


Figure 1.4-8 East-west resistivity cross-section from Heber to Yuma.

REFERENCES - Geology and Geophysics

1. Elders, W. A., et al., "Crustal Spreading in Southern California," Science, 178, pp. 15-24, (1972). Copyright 1972 by the American Association for the Advancement of Science.

2. Dibblee, T. W., "Geology of the Imperial Valley Region, Geology of Southern California," California Division of Mines, Bull. 170, Ch. 2, pp. 21-28, (1954).

3. Van Kamp, P. C., "Holocene Continental Sedimentation in the Salton Basin, California: A Reconnaissance," Geol. Soc. Am. Bull., v. 84, pp. 827-848, (1973).

4. Muffler, L. P. J., and Doe, B. R., "Composition and Mean Age of Detritus of the Colorado River Delta in the Salton Trough, Southeastern California," J. Sedimentary Petrology, v. 38, p. 384-399, (1968).

5. Jahns, R. H., "Investigations and Problems of Southern California Geology," California Division of Mines, Bull. 170, chap. 1, pp. 5-29, (1954).

6. Garfunkel, Z. The Tectonics of the Salton Trough of California, Cooperative Investigations of Geothermal Resources in the Imperial Valley Area and their Potential Value for Desalting of Water and Other Purposes, R. W. Rex, ed., University of California, Riverside, pp. H1-H3, (1972).

7. Biehler, S., Kovach, R. L., and Allen, C. R., "Geophysical Framework of the Northern End of the Gulf of California Structural Province," in: Marine Geology of the Gulf of California, T. Van Andel and G. Shor, eds., Am. Assoc. of Petroleum Geologists, Mem. 3, pp. 126-296, (1964).

8. Meidav, H. T., and Rotstein, Y. A structural Gravity Model for the Imperial Valley, (1971), (unpublished).

9. Rex, R. W., et al. Cooperative Geological-Geophysical-Geochemical Investigations of Geothermal Resources in the Imperial Valley Area of California, University of California, Riverside, (1971).

10. Hill, D., Mowinckel, P., and Lahr, A. Catalog of Earthquakes in the Imperial Valley, California, June 73 - May 74, U.S.G.S. Open File Report, Washington, D.C., (1975 a).

11. Hill, D., Mowinckel, P., and Peake, L., "Earthquakes, Active Faults, and Geothermal Areas in the Imperial Valley, California," Science, 188, pp. 1306-1308, (1975 b).

12. Combs, J., "Heat Flow and Geothermal Resource Estimates for the Imperial Valley," in: Cooperative Geological-Geophysical-Geochemical Investigations of Geothermal Resources in the Imperial Valley Area of California, R. W. Rex, Principal Investigator, University of California, Riverside, pp. 119-124, (1971).

13. Allen, C. R., et al, "Relation Between Seismicity and Geologic Structure in the Southern California Region," Bull. Seism. Soc. Am., no. 55, pp. 753-797, (1965).

14. Ulrich, F. P., "The Imperial Valley Earthquakes of 1940," Bull. Seism. Soc. of Am., v. 31, pp. 13-31, (1941).

15. Richter, C. F. Elementary Seismology, W. H. Freeman & Co., Inc., ed., (1958).

16. Johnson, C. E., and Hadley, D. M. Tectonic Implications of the Brawley Earthquake Swarm, Imperial Valley, California, Seismological Laboratory, California Institute of Technology, Pasadena, California.

17. Meidav, H. T., James, R., and Sanyal, S. K. Utilization of Gravimetric Data for Estimation of Hydrothermal Reservoir Characteristics in the East Mesa Field, Imperial Valley, California, Stanford Geothermal Program (NSF) Workshop on Geothermal Reservoir Engineering, SAP-TR-12, December 15-17, 1975, (1975).

18. Bird, D. Geology and Geochemistry of the Dunes Hydrothermal System, Imperial Valley of California. Master's Thesis, University of California, Riverside, (1975).

19. Randall, W., "Percent Volume Sand Bodies in the Imperial Valley," (Preliminary Report), in: Cooperative Geological-Geophysical-Geochemical Investigations of Geothermal Resources in the Imperial Valley Area of California, R. W. Rex, Principal Investigator, University of California, Riverside, pp. 119-124, (1971).

20. Meidav, H. T., and Furgerson, R., "Resistivity Studies of the Imperial Valley Geothermal Area, California," Geothermics, v. 1, pp. 47-62, (1972).

21. Kovach, R. L., Allen, C. R., and Press, F., "Geophysical Investigations in the Colorado Delta Region," Journal of Geophysical Research, v. 67, pp. 2845-2871, (1962).

22. Biehler, S., "Gravity Studies in the Imperial Valley," in: Cooperative-Geological-Geophysical-Geochemical Investigations of Geothermal Resources in the Imperial Valley of California, R. W. Rex, Principal Investigator, University of California, Riverside, pp. 29-43, (1971).

1.5 SOILS

1.5.1 Introduction

A preliminary soil investigation has been performed in order to evaluate site feasibility and to provide recommendations for site grading and foundation support. The scope of work included:

Drilling of three widely spaced borings to depths of 9 to 30 m (30 to 100 ft), and extraction of undisturbed samples for identification and testing purposes.

Performing laboratory tests to evaluate strength, consolidation, expansion, compaction, and chemical characteristics of the soils.

Preparing a general description of subsurface soil conditions, and our opinions on the types of foundation support which appear to be most feasible. A brief discussion of potential problems related to site development and grading is also included.

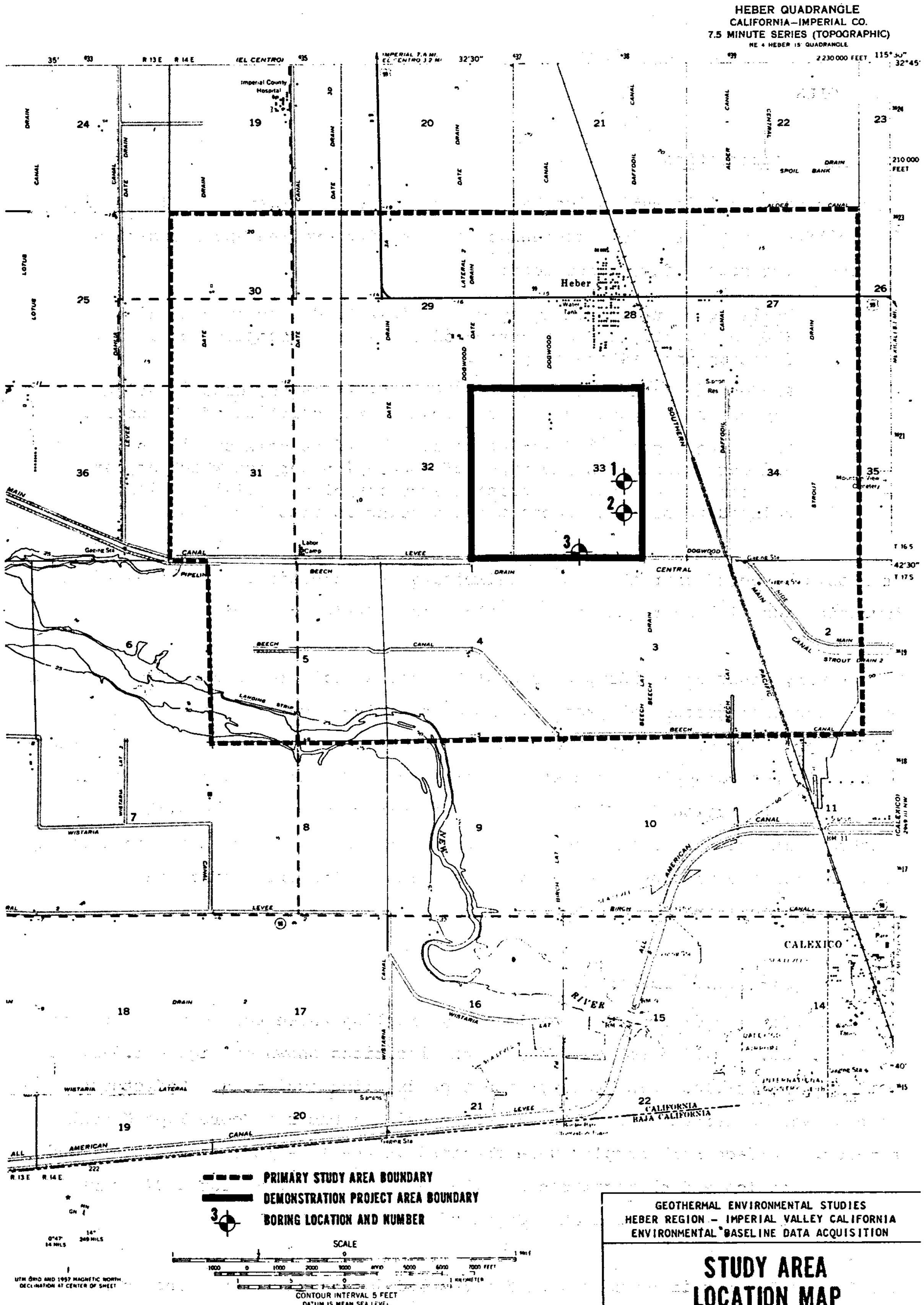
It should be noted that this is a preliminary investigation. A more detailed investigation will be required to develop final design criteria.

The primary study area encompasses a 31-km^2 (12 sq mi) area surrounding the site of the proposed geothermal project. More intensive investigation has been conducted on the site of the proposed demonstration project, which is a 2.6-km^2 (1 sq mi) area occupying the eastern one-third of Section 32 and the western two-thirds of Section 33, T16S, R14E. Test borings were located within the southeastern quarter of the demonstration project area, which is the most likely location for the proposed geothermal power plant. The area boundaries and boring locations are shown on Figure 1.5-1.

1.5.2 Field Investigation

The subsurface conditions were explored by drilling three test borings to depths of 9.6 to 30.8 m (31.5 to 101.0 ft) at the locations shown on Figure 1.5-1. The borings were drilled using rotary-wash type drilling equipment. Undisturbed samples were obtained at regular intervals using a Dames & Moore Type U soil sampler. Surface bulk samples were obtained at the locations of Borings 1 and 2 for compaction and chemical tests. The water level was measured 24 hours after completion in Boring 1 at a depth of 4.9 m (16 ft).

The *Log of Borings* is presented on Figures 1.5-2 through 1.5-5. The soils are classified in accordance with the Unified Soil Classification System, which is



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

STUDY AREA LOCATION MAP

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.5-1

BORING 1

SURFACE ELEVATION: –1.5m

LABORATORY TEST DATA

DEPTH IN FEET	TESTS REPORTED ELSEWHERE	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	STRENGTH TEST DATA: TYPE OF TEST	STRENGTH TEST DATA: NORMAL OR CONFINING PRESSURE (kN/m²)	STRENGTH TEST DATA: SHEAR STRENGTH (kN/m²)	STRENGTH TEST DATA: DEVIATOR STRESS (kN/m²)	MOISTURE CONTENT (%)	DRY DENSITY (gm/cm³)	BLOWS/m ■ SAMPLES
0	COMP									■
	EXP	53	32	AL				27.6	1.56	36 ■
5				UC		40		25.1	1.62	33 ■
10	C							33.4	1.46	43 ■
15				UC		48		31.5	1.47	66 ■
20								27.4	1.52	46 ■
25								31.7	1.49	56 ■
30	C							28.3	1.54	82 ■
35				UC		38		30.5	1.46	62 ■
40								27.6	1.52	89 ■
45				DS	167	153		20.7	1.70	300+ ■
50				DS	192	148		26.3	1.52	134 ■
55										
60				-200 (6%)				23.4	1.59	300+ ■
65										
70										

SYMBOLS / DESCRIPTION (DEPTH IN METERS 0–21)

- **CH** — REDDISH BROWN CLAY WITH A TRACE OF ALKALI (MEDIUM STIFF)
- **ML** — REDDISH BROWN CLAYEY SILT
- **CH** — REDDISH BROWN CLAY (MEDIUM STIFF)
  - GRADING STIFF
- **ML** — REDDISH BROWN MICACEOUS SILT (MEDIUM STIFF)
- **CH** — REDDISH BROWN CLAY (STIFF)
  - GRADING TO INCLUDE THIN LAYERS (2–5cm) OF SILT
  - GRADING FREE OF SILT
  - (GRADING TO STIFF)
  - GRADING TO INCLUDE VERTICAL SILT LENSES AND TO MEDIUM STIFF
  - GRADING TO INCLUDE TRACES OF DECAYED VEGETATION AND SILT LAMINATIONS
- **SM** — LIGHT REDDISH BROWN SILTY FINE SAND (DENSE)
- **SP** — LIGHT REDDISH BROWN MICACEOUS FINE SAND (MEDIUM DENSE)
  - (GRADING TO DENSE)

CONTINUED ON FOLLOWING PAGE

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

LOG OF BORINGS

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.5-2

BORING 1 (CONT.)

SURFACE ELEVATION: –1.5m

DEPTH IN FEET	LABORATORY TEST DATA: TESTS REPORTED ELSEWHERE	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	STRENGTH TEST DATA: TYPE OF TEST	STRENGTH TEST DATA: NORMAL OR CONFINING PRESSURE (kN/m²)	STRENGTH TEST DATA: SHEAR STRENGTH (kN/m²)	STRENGTH TEST DATA: DEVIATOR STRESS (kN/m²)	MOISTURE CONTENT (%)	DRY DENSITY (gm/cm³)	BLOWS/m SAMPLES	SYMBOLS	DESCRIPTION	DEPTH IN METERS
70				DS	240	225		20.4	1.68	204 ■	SP	LIGHT REDDISH BROWN MICACEOUS FINE SAND (DENSE)	22
75													23
80				-200 (5%)				23.2	1.57	300+ ■			24, 25
85													26
90								23.8	1.54	250 ■			27, 28
95													29
100								19.5	1.61	300+ ■		PERCHED WATER LEVEL AT 4.9m (16ft) 24 HR AFTER COMPLETION. BORING COMPLETED ON 1/27/76	30, 31
105													
110													

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

LOG OF BORINGS

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.5-3

BORING 2

SURFACE ELEVATION: −1.5m

LABORATORY TEST DATA

DEPTH IN FEET	TESTS REPORTED ELSEWHERE	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	STRENGTH TEST DATA: TYPE OF TEST	STRENGTH TEST DATA: NORMAL OR CONFINING PRESSURE (kN/m²)	STRENGTH TEST DATA: SHEAR STRENGTH (kN/m²)	STRENGTH TEST DATA: DEVIATOR STRESS (kN/m²)	MOISTURE CONTENT (%)	DRY DENSITY (gm/cm³)	BLOWS/m	SAMPLES
0	CHEM										■
5				DS	36	36		24.2	1.54	43	■
10								30.7	1.51	33	■
15								25.4	1.62	75	■
20				UC		41		32.0	1.44	52	■
25								30.7	1.48	57	■
30								27.0	1.57	98	■
35			NP	AL				34.5	1.41	59	■
40								26.3	1.56	250	■
45								34.4	1.42	56	■
50								10.5	1.54	300+	■

SYMBOLS	DESCRIPTION
CH	REDDISH BROWN CLAY (MEDIUM STIFF)
ML	LIGHT REDDISH BROWN MICACEOUS SANDY SILT
SM	LIGHT REDDISH BROWN SILTY FINE SAND (LOOSE)
CH	REDDISH BROWN CLAY WITH THIN LENSES OF SILTY CLAY SILT (MEDIUM STIFF)
	(GRADING TO STIFF)
	GRADING TO INCLUDE THIN LENSES OF SMALL SHELLS AND SHELL FRAGMENTS (MEDIUM STIFF)
	GRADING FREE OF SHELLS
ML	LIGHT REDDISH BROWN MICACEOUS SILT
CH	REDDISH BROWN CLAY (STIFF)
ML	LIGHT REDDISH BROWN MICACEOUS SILT (STIFF)
SM	LIGHT REDDISH BROWN MICACEOUS SILTY FINE SAND (DENSE)
ML	GRAY BROWN MICACEOUS SILT (STIFF)
SP	LIGHT BROWN MICACEOUS FINE SAND (DENSE)

BORING COMPLETED ON 1/28/76

DEPTH IN METERS: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

LOG OF BORINGS

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.5-4

BORING 3

SURFACE ELEVATION: –1.5m

LABORATORY TEST DATA

DEPTH IN FEET	TESTS REPORTED ELSEWHERE	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	STRENGTH TEST DATA: TYPE OF TEST	STRENGTH TEST DATA: NORMAL OR CONFINING PRESSURE (kN/m²)	STRENGTH TEST DATA: SHEAR STRENGTH (kN/m²)	STRENGTH TEST DATA: DEVIATOR STRESS (kN/m²)	MOISTURE CONTENT (%)	DRY DENSITY (gm/cm³)	BLOWS/m SAMPLES
0										
	EXP							28.2	1.54	20 ■
5				DS	48	31		28.6	1.49	20 ■
10								27.1	1.56	36 ■
15								35.2	1.41	62 ■
20				DS	95	74		20.2	171	36 □ 65 ■
25								31.2	1.49	85 ■
30				DS -200 (14%)	120	85		20.2	1.68	56 ■

SYMBOLS / DESCRIPTION

DEPTH IN METERS	SYMBOLS	DESCRIPTION
0	CH	REDDISH BROWN CLAY (MEDIUM STIFF)
1–2	ML	REDDISH BROWN SANDY SILT (SOFT)
2	CH	REDDISH BROWN CLAY (STIFF)
5	SM	LIGHT REDDISH BROWN MICACEOUS SILTY FINE SAND (LOOSE)
		GRADING TO MEDIUM DENSE
7	CH	REDDISH-BROWN CLAY WITH A TRACE OF ALKALI (STIFF)
9	SM	LIGHT REDDISH BROWN SILTY FINE SAND (MEDIUM DENSE)

BORING COMPLETED ON 1/27/76

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

LOG OF BORINGS

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.5-5

described on Figure 1.5-6. A key to samples, blow counts, soil consistency, and laboratory test abbreviations used on the boring logs is presented on Figure 1.5-7.

1.5.3 Laboratory Tests

Laboratory tests were performed to evaluate strength, consolidation, expansion, compaction, classification, and chemical characteristics of the soils. The tests are described in the following subsections.

Direct Shear: Direct shear tests were performed on representative samples of the sandy soils to evaluate their strength characteristics. The test method is described on Figure 1.5-8. The results are presented on the Log of Borings. Shear strengths presented are peak values.

Unconfined Compression: Unconfined compression tests were performed on representative samples of the cohesive soils to evaluate their strength characteristics. The test method is described on Figure 1.5-8. The shear strengths are taken as one-half of the peak axial stress (unconfined compression strength) and are presented on the Log of Borings.

Consolidation: Consolidation tests were performed to provide data for estimating settlements. The test method is described on Figure 1.5-8, and the results are presented on Figure 1.5-9.

Expansion: Expansion tests were performed on samples of the upper clay by saturating them in the consolidometer under an applied load of 4.79 kN/m^2 (100 psf). Axial movements were recorded over a period of time sufficient to permit the samples to achieve maximum expansion. The water was then siphoned and the samples allowed to air-dry at room temperature. The linear shrinkage from the saturated to the air-dry condition was measured. Measurements of expansion and shrinkage are expressed as a percentage of the original height of the sample, which was 2.54 cm (1 in), at field moisture. The results are presented in Table 1.5-1.

TABLE 1.5-1

EXPANSION TEST RESULTS

Boring No.	Depth (m)	Expansion, Field Moisture to Saturated (%)	Shrinkage, Saturated to Air-Dry (%)
1	0.9	3.1	7.8
3	0.9	0.4	4.7

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILT AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

UNIFIED SOIL CLASSIFICATION SYSTEM

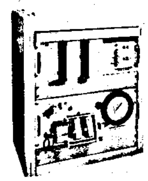
FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA.

FIGURE NO. 1.5-6

Method Of Performing Direct Shear and Friction Tests

Direct shear tests are performed to determine the shearing strengths of soils. Friction tests are performed to determine the frictional resistances between soils and various other materials such as wood, steel, or concrete. The tests are performed in the laboratory to simulate anticipated field conditions.



Direct shear apparatus with electronic recorder

Each sample is tested within three brass rings, two and one-half inches in diameter and one inch in length. Undisturbed samples of in-place soils are tested in rings taken from the sampling device in which the samples were obtained. Loose samples of soils to be used in constructing earth fills are compacted in rings to predetermined conditions and tested.

Direct Shear Tests

A three-inch length of the sample is tested in direct double shear. A constant pressure, appropriate to the conditions of the problem for which the test is being performed, is applied normal to the ends of the sample through porous stones. A shearing failure of the sample is caused by moving the center ring in a direction perpendicular to the axis of the sample. Transverse movement of the outer rings is prevented.

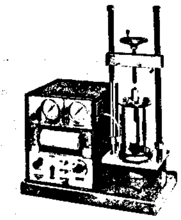
The shearing failure may be accomplished by applying to the center ring either a constant rate of load, a constant rate of deflection, or increments of load or deflection. In each case, the shearing load and the deflections in both the axial and transverse directions are recorded and plotted. The shearing strength of the soil is determined from the resulting load-deflection curves.

Friction Tests

In order to determine the frictional resistance between soil and the surfaces of various materials, the center ring of soil in the direct shear test is replaced by a disk of the material to be tested. The test is then performed in the same manner as the direct shear test by forcing the disk of material from the soil surfaces.

Methods of Performing Unconfined Compression and Triaxial Compression Tests

The shearing strengths of soils are determined from the results of unconfined compression and triaxial compression tests. In triaxial compression tests the test method and the magnitude of the confining pressure are chosen to simulate anticipated field conditions.



Triaxial compression test unit

Unconfined compression and triaxial compression tests are performed on undisturbed or remolded samples of soil approximately six inches in length and two and one-half inches in diameter. The tests are run either strain-controlled or stress-controlled. In a strain-controlled test the sample is subjected to a constant rate of deflection and the resulting stresses are recorded. In a stress-controlled test the sample is subjected to equal increments of load with each increment being maintained until an equilibrium condition with respect to strain is achieved.

Yield, peak, or ultimate stresses are determined from the stress-strain plot for each sample and the principal stresses are evaluated. The principal stresses are plotted on a Mohr's circle diagram to determine the shearing strength of the soil type being tested.

Unconfined compression tests can be performed only on samples with sufficient cohesion so that the soil will stand as an unsupported cylinder. These tests may be run at natural moisture content or on artificially saturated soils.

In a triaxial compression test the sample is encased in a rubber membrane, placed in a test chamber, and subjected to a confining pressure throughout the duration of the test. Normally, this confining pressure is maintained at a constant level, although for special tests it may be varied in relation to the measured stresses. Triaxial compression tests may be run on soils at field moisture content or on artificially saturated samples. The tests are performed in one of the following ways:

Unconsolidated-Undrained: The confining pressure is imposed on the sample at the start of the test. No drainage is permitted and the stresses which are measured represent the sum of the intergranular stresses and pore water pressures.

Consolidated-Undrained: The sample is allowed to consolidate fully under the applied confining pressure prior to the start of the test. The volume change is determined by measuring the water and/or air expelled during consolidation. No drainage is permitted during the test and the stresses which are measured are the same as for the unconsolidated-undrained test.

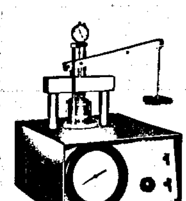
Drained: The intergranular stresses in a sample may be measured by performing a drained, or slow, test. In this test the sample is fully saturated and consolidated prior to the start of the test. During the test, drainage is permitted and the test is performed at a slow enough rate to prevent the buildup of pore water pressures. The resulting stresses which are measured represent only the intergranular stresses. These tests are usually performed on samples of generally non-cohesive soils, although the test procedure is applicable to cohesive soils if a sufficiently slow test rate is used.

An alternate means of obtaining the data resulting from the drained test is to perform an undrained test in which special equipment is used to measure the pore water pressures. The differences between the total stresses and the pore water pressures measured are the intergranular stresses.

Method Of Performing Consolidation Tests

Consolidation tests are performed to evaluate the volume changes of soils subjected to increased loads. Time-consolidation and pressure-consolidation curves may be plotted from the data obtained in the tests. Engineering analyses based on these curves permit estimates to be made of the probable magnitude and rate of settlement of the tested soils under applied loads.

Each sample is tested within brass rings two and one-half inches in diameter and one inch in length. Undisturbed samples of in-place soils are tested in rings taken from the sampling device in which the samples were obtained. Loose samples of soils to be used in constructing earth fills are compacted in rings to predetermined conditions and tested.



Dead load-pneumatic consolidometer

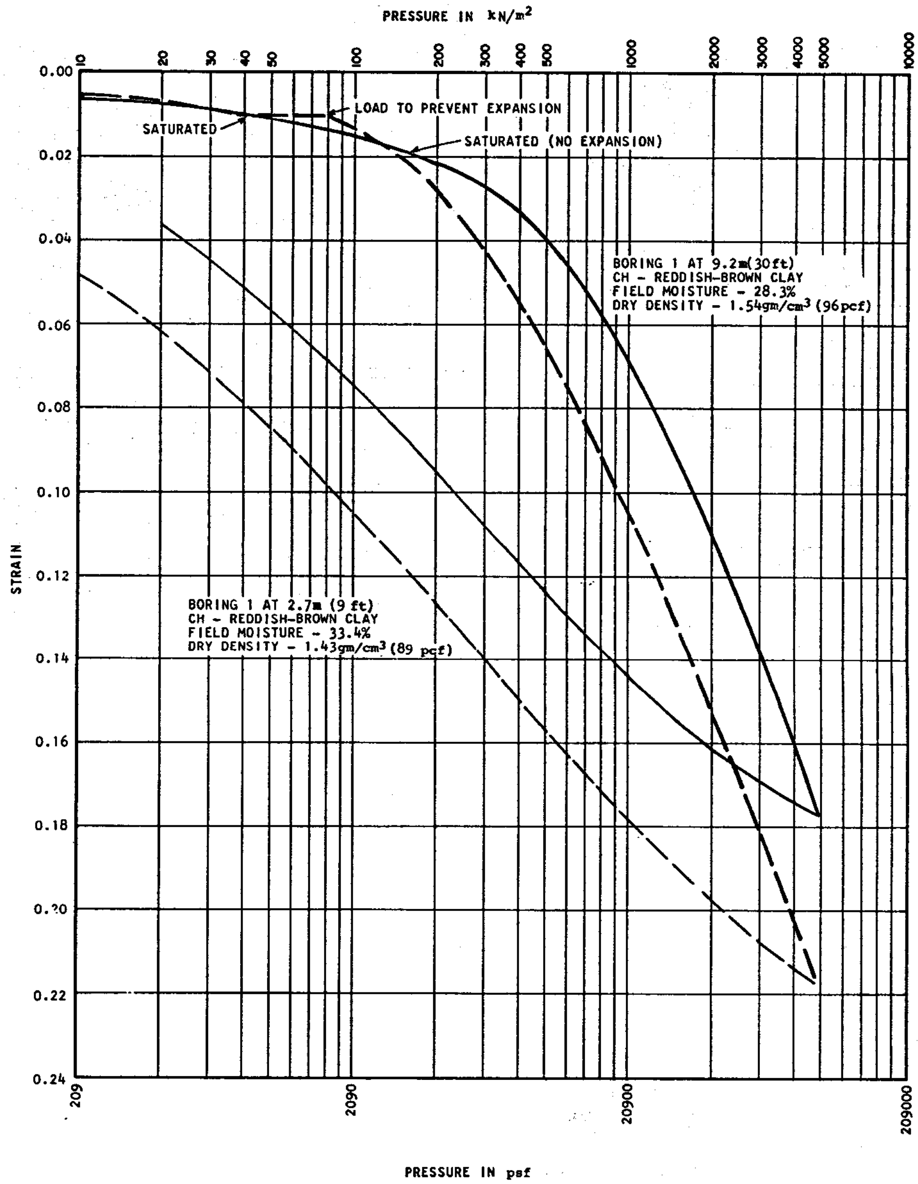
In testing, the sample is rigidly confined laterally by the brass ring. Axial loads are transmitted to the ends of the sample by porous disks. The disks allow drainage of the loaded sample. The axial compression or expansion of the sample is measured by a micrometer dial indicator at appropriate time intervals after each load increment is applied. Each load is ordinarily twice the preceding load. The increments are selected to obtain consolidation data representing the field loading conditions for which the test is being performed. Each load increment is allowed to act over an interval of time dependent on the type and extent of the soil in the field.

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

LABORATORY TEST METHODS

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY SAN DIEGO, CALIFORNIA	FIGURE NO. 1.5-8



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

CONSOLIDATION TEST DATA

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.5-9

■ INDICATES DEPTH OF UNDISTURBED SAMPLE

⊠ INDICATES DEPTH OF DISTURBED SAMPLE

□ INDICATES DEPTH OF SAMPLING ATTEMPT WITH NO RECOVERY

BLOW COUNTS ARE BLOWS PER METER OF PENETRATION FOR A DAMES & MOORE TYPE U SAMPLER DRIVEN WITH A 110 KG (240 LB) WEIGHT FALLING 61 CM (24 IN).

COMPACTNESS OF COARSE GRAINED SOILS

	RELATIVE DENSITY
VERY LOOSE	0 TO 15
LOOSE	15 TO 35
MEDIUM DENSE	35 TO 65
DENSE	65 TO 85
VERY DENSE	85 TO 100

CONSISTENCY OF FINE GRAINED SOILS

	SHEAR STRENGTH IN (kN/m^2)	SHEAR STRENGTH IN psf
VERY SOFT	LESS THAN 12	LESS THAN 250
SOFT	12 TO 24	250 TO 500
MEDIUM STIFF	24 TO 48	500 TO 1000
STIFF	48 TO 96	1000 TO 2000
VERY STIFF	96 TO 192	2000 TO 4000
HARD	GREATER THAN 192	GREATER THAN 4000

ELEVATIONS

ELEVATIONS ARE ESTIMATED FROM THE 1957 USGS 7.5 MINUTE QUADRANGLE.

LABORATORY TEST ABBREVIATIONS

DS	DIRECT SHEAR TEST
UC	UNCONFINED COMPRESSION TEST
TX/UU	UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
TX/CU	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
TX/CU/PP	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST WITH PORE PRESSURE MEASUREMENTS
TX/CD	CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST
SA	SIEVE ANALYSIS
-200	PERCENT PASSING THE NO. 200 SIEVE
HA	HYDROMETER ANALYSIS
MA	COMBINED SIEVE AND HYDROMETER ANALYSIS
AL	ATTERBERG LIMITS
C	CONSOLIDATION TEST
EXP	EXPANSION TEST
COMP	COMPACTION TEST
PERM	PERMEABILITY TEST
CHEM	CHEMICAL TESTS

SI - U.S. CONVERSION FACTORS

TO CONVERT	TO	MULTIPLY BY
METERS (m)	FEET (ft)	3.28
CENTIMETERS (cm)	INCHES (in)	0.394
KILOGRAMS (kg)	POUNDS (lb)	2.205
NEWTONS PER SQUARE METER (N/m^2)	POUNDS PER SQUARE FOOT (psf)	0.0209
KILONEWTONS PER SQUARE METER (kN/m^2)	POUNDS PER SQUARE FOOT (psf)	20.88
GRAMS PER CUBIC CENTIMETER (gm/cm^3)	POUNDS PER CUBIC FOOT (pcf)	62.4

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

KEY TO SAMPLES, BLOW COUNTS, SOIL CONSISTENCY AND LABORATORY TESTS

FEBRUARY, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.5-7

Compaction: A compaction test was performed on the surface sample from Boring 1 to determine the compaction characteristics (optimum moisture content and maximum dry density). The test was performed in accordance with ASTM Test Designation D 1557-70. The maximum dry density is 1.97 gm/cm^3 (123 pcf) at an optimum moisture content of 12.0 percent.

Atterberg Limits: Atterberg limit tests were performed for classification purposes and to assist in evaluating expansion characteristics. The test mthods are ASTM D 423-66 (1972) and D 424-59 (1971). The results are presented on the Log of Borings.

Percent Fines: The percentage of soil by weight finer than a U.S. Standard No. 200 sieve was determined for some of the sandy samples for classification purposes. The results are presented on the Log of Borings.

Moisture-Density: The field moisture content and dry density were measured in conjunction with each of the above tests, and additional moisture-density tests were performed for correlation purposes. The results are presented on the Log of Borings.

Chemical: The surface sample from Boring 2 was chemically tested for agricultural suitability and fertility, with additional determinations of selected extractable heavy metals (cadmium and lead). We suggest that additional chemical tests of this type be performed on samples from the study area in conjunction with future work, in order to provide more comprehensive baseline data. The chemical tests were performed by Agri-Science. The results are presented in Table 1.5-2.

1.5.4 Subsurface Conditions

The site lies in the bed of what was once Lake Coahuila, a body of water which occupied Imperial Valley during the Pleistocene period and whose beach line is still discernible around the edges of the valley. The soils of this old lake bed, which wells indicate to be as much as 600 m (2,000 ft) in thickness, were deposited on the rock floor of the valley by the debris-laden Colorado River. At the close of the Pleistocene period, the quantities of water flowing into the lake decreased to such a degree that the rate of evaporation was greater than the rate of inflow. The lake has progressively receded (except for periods when the Colorado River overflowed its banks, as in 1905) since that time, until today the Salton Sea is all that remains of the old Lake Coahuila.

The site is level, is currently under cultivation, and is criss-crossed by a number of shallow irrigation ditches. It is underlain by lakebed deposits of clay, silt, and fine sand. The borings indicate predominantly medium stiff to stiff clays with interbedded layers of sandy silt and silty sand to depths of 12 to 15 m (40 to 50 ft). The deep boring, Boring 1, disclosed a continuous deposit of dense silty fine or fine sand to the maximum depth explored.

The clays in Imperial Valley are generally expansive and undergo large volume changes with variations in moisture content. Alternate swelling and shrinkage have produced internal fissures and fractures in these soils. In some cases, vertical fractures are filled with silts and sands.

Expansion tests from Borings 1 and 3 indicate that the soils in the demonstration project area are not as expansive as they are farther north in Imperial Valley.

Sandy and silty strata below depths of 1.5 to 3.0 m (5 to 10 ft) are generally saturated; seepage in these strata and seepage through fractures in shallow cohesive strata are believed to represent perched ground water from surface irrigation. An unsaturated sample of sand from a depth of 15.2 m (50 ft) in Boring 2 indicates that the permanent ground water table may be below that depth.

Borings for this preliminary investigation were limited to the southeastern quarter of the demonstration project area; however, only minor variations within the primary study area would be expected.

1.5.5 Summary

Grading: Most of the area is under cultivation. It is estimated that the upper 0 to 15 cm (0 to 6 in) of material in the cultivated areas is highly organic and would need to be stripped and wasted. The soils below depths of 0.3 to 0.6 m (1 to 2 ft) are generally saturated from irrigation or capillary action. These soils are plastic, wet of optimum moisture content for compaction, and difficult to dry out. Moisture contents at shallow depths are on the order of 25 to 30 percent, which is approximately twice the optimum. Therefore, they are very difficult to work with for use as compacted fill and particularly as trench or foundation backfill. However, backfilling with granular materials could result in problems because of the expansive nature of the in situ soils. If possible, excavations for foundations should be cut neat and the concrete placed without the use of forms or backfill. Narrow trenches could be backfilled with sand to within about 0.6 m (2 ft) of subgrade, then capped with clay. In large trenches where heavy equipment could be used, trenches could be backfilled with sand to 0.6 to 0.9 m (2 to 3 ft) above utility lines and clay used for the remainder of the backfill.

It will be necessary to excavate any zones of softened, saturated material beneath and adjacent to existing irrigation ditches, and to replace them with properly compacted natural soils.

Design for Expansive Soils: Special design provisions may be necessitated because of the expansive nature of the soils. Typically, this might consist of continuous girder-type wall footings or grade beams extending to depths of 0.9 to 1.5 m (3 to 5 ft) around building perimeters to avoid changes in moisture content under footings, pile caps, or floor slabs. Moisture barriers are required for concrete floor slabs to be painted, covered with tiles, etc. Full-depth asphalt, where the base and subbase, as well as the wearing surface are asphaltic, might be considered for pavements for roadways and parking lots. Unstabilized aggregate bases tend to serve as reservoirs for free water which would be undesirable for these expansive subgrade soils.

The clay soils are essentially saturated at shallow depths over most of the area. Precautions must be taken during construction to prevent drying them out under foundations, floor slabs, pavements, etc., because subsequent resaturation by infiltration and capillary action would result in heave and cracking. Similarly, any areas that are dry initially must be wetted prior to placing foundations, floor slabs, or pavements. It will be difficult to add water to dried out areas. Spraying them with materials to prevent evaporation, or periodic, regular light sprinkling to maintain them at the desired moisture content is suggested.

Increases and decreases in moisture content of the subgrade soils under footings or floor slabs should be minimized after construction. Since the soils are nearly saturated at present, they should not undergo serious changes if the following precautions are taken:

> The ground surface around the perimeters of any buildings should be paved for a minimum width of 1.5 m (5 ft), and should be sloped to drain water away from the buildings.

Any planter boxes should be provided with paved bottoms and drains emptying above grade.

Any heaters or driers should be adequately insulated and ventilated to prevent drying out the expansive subgrade soils.

Trees should not be planted within 15 m (50 ft) of any structure.

If future studies confirm that the soils in the project area are less expansive than in other parts of Imperial Valley, design provisions for expansive soils could be less extensive than outlined above.

Foundations: Light to moderately loaded structures can probably be supported on continuous foundations, or individual spread foundations connected by conti uous grade beams, established at depths of 0.9 to 1.5 m (3 to 5 ft). This would include one-or two-story concrete buildings with column loads of 22,600 to 68,000 kg (50 to 150 kips), wall loads of 2,230 to 2,980 kg per linear meter (1,500 to 2,000 lb per linear ft), and ground floor storage loads on the order of 24,000 N/m^2 (500 psf). Settlements in these cases would generally be 2.5 cm (1 in) or less.

Heavy and/or settlement-sensitive structures, or those with vibratory loadings, will probably require driven pile foundations. Piles have also been used extensively for heavy storage tanks. Piles designed for downward loads of 27,000 to 45,000 kg (30 to 50 tons) would be 12 to 15 m (40 to 50 ft) long.

Reservoirs: Most of the shallow soils are impervious and ideal for construction of leak-proof reservoirs. However, shallow silt and sand layers, such as encountered at Borings 2 and 3, might cause excessive horizontal seepage from shallow reservoirs. In such areas, the reservoirs would require compacted clay linings and perhaps compacted clay or concrete "cutoff walls" extending through the previous strata.

If the soils are highly expansive and the reservoirs are subjected to alternate filling and emptying, it might be necessary to stabilize the clay linings with lime, cement, or other additives, or to line the reservoirs with impervious membranes or asphaltic concrete.

1.6 HYDROLOGY

1.6.1 Introduction

This section describes surface and subsurface hydrology of the Heber KGRA and environs. Surface water flow in streams, canals and drainage ditches in and near the study area is discussed. Occurrence and levels of ground waters at and in the vicinity of the site are taken up. While shallow aquifer data is the principal concern, deep geothermal ground water hydrology data is discussed to a limited extent. Soil characteristics related to ground water are briefly described from available data.

Present and projected water uses are reviewed particularly with respect to agricultural irrigation, the major water demand of the Imperial Valley. Imported water as well as indigenous water use is discussed in relating water use to waste production.

This section also deals with historical and present chemical characteristics of existing surface water flows, determined from water quality data available in the records and literature of public agencies. Ground water quality and quality of waters in deep strata are similarly characterized. Water quality impacts of waste loads are described. Also treated in the text are water quality control regulatory plans, policy and actions which might tend to bring about changes in existing water quality conditions.

Potential for site flooding from flows in natural or man-made water conveyances is evaluated. Measures for protection against flooding, if needed, are discussed at a preliminary level.

1.6.2 General Hydrological Setting

Rainfall. Heber KGRA is located in the Imperial Valley, near the westerly fringe of the Colorado River Desert. The climate is arid: hot and dry. Annual precipitation averages less than 7.62 cm (3 in.), although localized high-intensity, short duration summer thunderstorms move across the valley occasionally. The greatest rainfall of recent record occurred in September 1939, when three large and one small strom passed through the basin within a period of four weeks.[1] Over 12.7 cm (5 in.) fell at Imperial during the 48-hour period September 5 through 7. Total rainfall for the month of September 1939 for communities near Heber were: El Centro, 17.1 cm (6.75 in.); Brawley, 13 cm (5.13 in.); Imperial 17.9 cm (7.06 in.).

Figure 1.6-1 presents an isohyetal map of mean annual rainfall for the Imperial Valley, while Table 1.6-1 lists annual precipitation at selected desert stations.[2]

TABLE 1.6-1

AVERAGE PRECIPITATION FOR SELECTED STATIONS

Month	Brawley*		El Centro*		Indio*		Niland**	
	cm	in	cm	in	cm	in	cm	in
October	0.61	0.24	0.64	0.25	0.58	0.23	0.46	0.18
November	0.25	0.10	0.23	0.09	0.76	0.30	0.43	0.17
December	1.1	0.42	1.14	0.45	1.73	0.68	0.99	0.39
January	0.84	0.33	0.99	0.39	1.27	0.50	0.89	0.35
February	0.89	0.35	1.04	0.41	1.07	0.42	0.61	0.24
March	0.33	0.13	0.51	0.20	0.64	0.25	0.33	0.13
April	0.20	0.08	0.30	0.12	0.25	0.10	0.10	0.04
May	0.025	0.01	0	0	0.025	0.01	TR	TR
June	0.025	0.01	0.025	0.01	0.025	0.01	TR	TR
July	0.05	0.02	0.25	0.10	0.30	0.12	0.03	0.01
August	0.81	0.32	0.94	0.37	0.84	0.33	0.69	0.27
September	0.74	0.29	0.66	0.26	1.09	0.43	0.25	0.10
Total	5.8	2.30	6.73	2.65	8.59	3.38	4.78	1.88

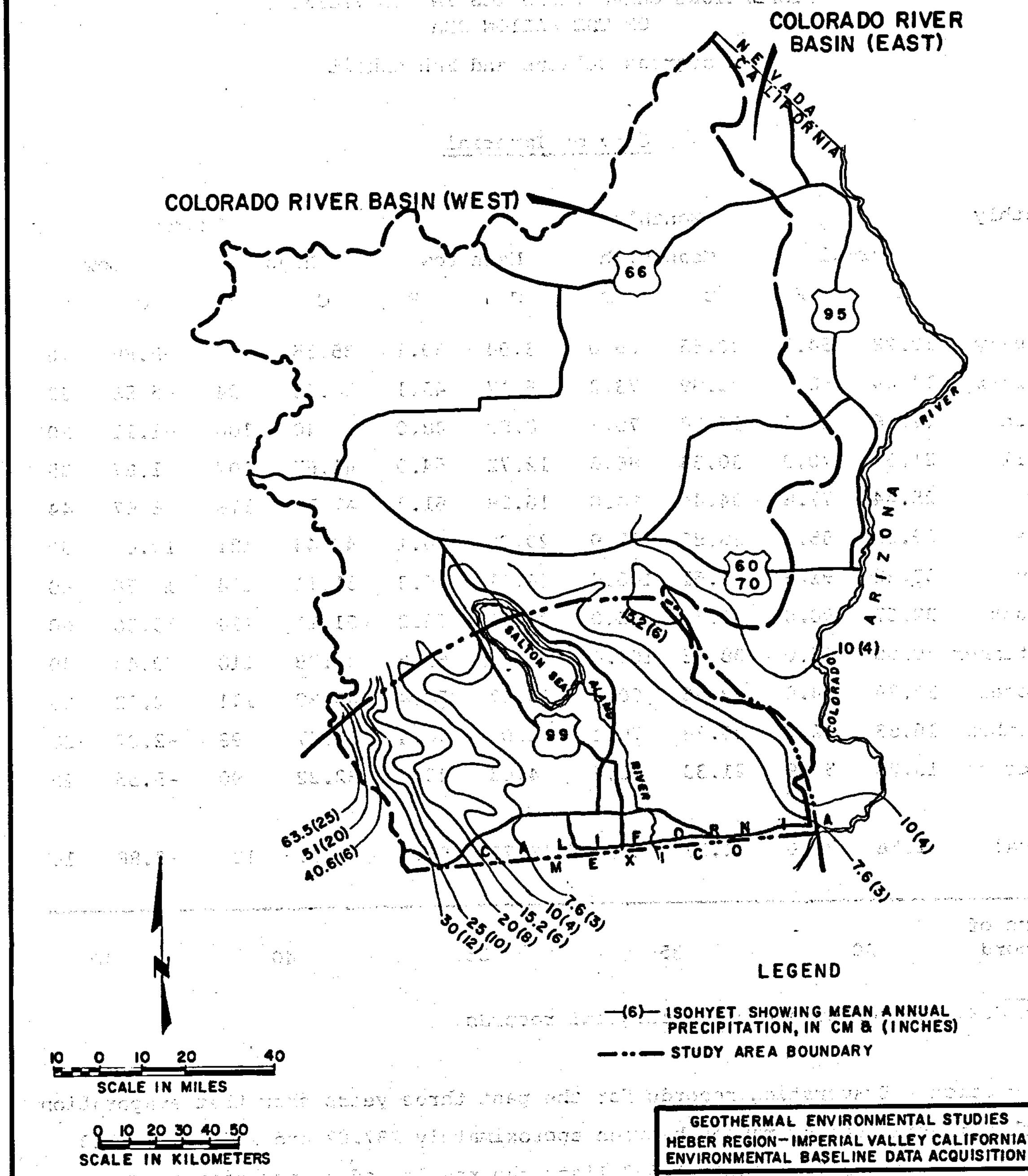
* 30-year period, 1930-31 through 1959-60

** 19-year period, 1941-42 through 1959-60

From U.S. Weather Bureau and Imperial Irrigation District Climatological Records

Mean monthly temperatures at the City of Imperial range from 12.27C (54.1F) in January to 33.22C (91.8F) in July. Mean high temperatures for the months of June through July are all above 37.77C (100F) at the same station. Recorded extremes at Imperial are -8.88C (16F) in January and 51.11C (124F) in July and August. In nearby El Centro, the recorded high temperature is 48.33C (119F) on July 14 and 16, 1936, while the low is -8.88C (16F) on January 22, 1937.

Table 1.6-2 presents a 30 to 40 year temperature characteristic record for the City of Imperial,[2] about 10.5 KM (8 mi) north of the city.



SOURCE:
WATER QUALITY CONTROL PLAN REPORT— 1975

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION— IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

ISOHYETAL MAP
IMPERIAL VALLEY

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.6-1

TABLE 1.6-2

TEMPERATURE CHARACTERISTICS IN THE VICINITY OF THE SALTON SEA

In degrees Celsius and Fahrenheit

City of Imperial

Monthly	Normal		Monthly Mean High		Mean Low		Extreme High		Extreme Low	
	C	F	C	F	C	F	C	F	C	F
January	12.28	54.1	20.55	69.0	3.94	39.1	35.55	96	-8.88	16
February	14.44	58.0	22.89	73.2	6.17	43.1	34.44	94	-5.56	22
March	17.56	63.6	26.28	79.3	8.89	48.0	40	104	-1.11	30
April	21.61	70.9	30.33	86.6	12.72	54.9	41.67	107	1.67	35
May	25.44	77.8	34.44	94.0	16.28	61.3	47.78	118	6.67	44
June	29.50	85.1	38.83	101.9	20.06	68.1	49.44	121	10.0	50
July	33.22	91.8	41.61	106.9	24.61	76.3	51.11	124	15.56	60
August	32.67	90.8	40.56	105.0	24.56	76.2	51.11	124	15.56	60
September	30.00	86.0	38.56	101.4	20.89	69.6	47.78	118	9.44	49
October	23.78	74.8	32.56	90.6	14.67	58.4	43.89	111	2.22	36
November	16.83	62.3	25.78	78.4	8.0	46.4	36.67	98	-2.22	28
December	13.28	55.9	21.33	70.4	4.83	40.7	32.22	90	-5.55	22
Annual	22.56	72.6	31.17	88.1	13.78	56.8	51.11	124	-8.88	16
Years of Record	30		35		35		40		40	

From U.S. Weather Bureau climatological records

Evaporation. Evaporation records for the past three years show that evaporation in the Imperial Valley ranges between approximately 287.02 and 297.18 cm (113 and 117 in.) annually. Table 1.6-3 lists the results of evaporation measurements by the Imperial Valley Conservation Research Center at Brawley, using five Class A Weather Bureau evaporation pans at five different locations throughout the valley. Minimum monthly evaporation recorded during the three year period was 8.38 cm (3.3 in.) during December, 1974, while maximum evaporation for a single month reached 39.62 cm (15.6 in.) during the month of July 1975.

TABLE 1.6-3

EVAPORATION
IMPERIAL VALLEY

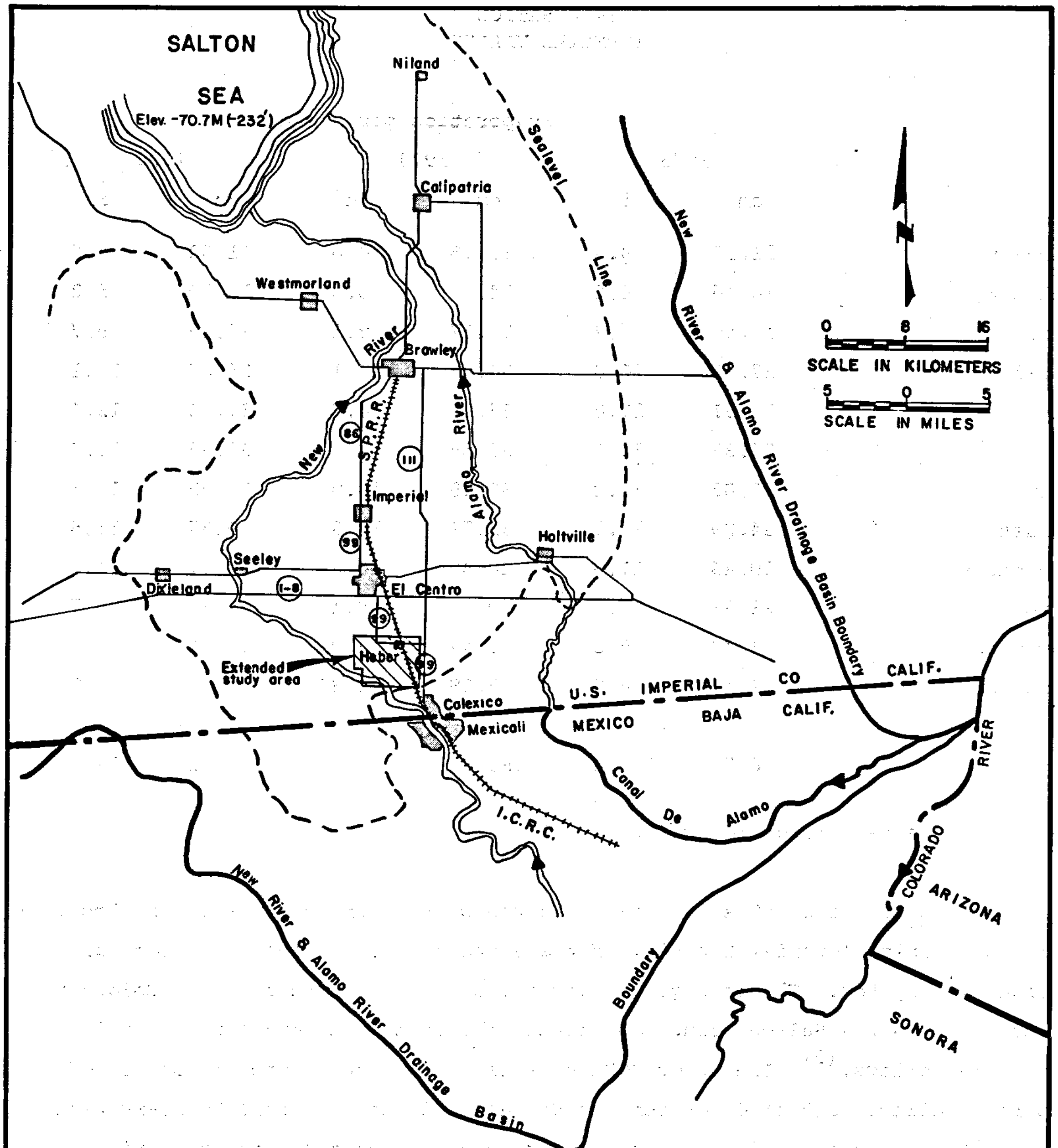
	Evaporation per Month					
	1973		1974		1975	
	cm	in	cm	in	cm	in
January	11.18	4.4	10.16	4.0	11.68	4.6
February	10.16	4.0	14.99	5.9	13.20	5.2
March	19.56	7.7	20.57	8.1	22.10	8.7
April	27.43	10.8	30.73	12.1	25.65	10.1
May	32.51	12.8	36.07	14.2	31.50	12.4
June	36.32	14.3	37.59	14.8	38.86	15.3
July	35.05	13.8	35.05	13.8	39.62	15.6
August	34.29	13.5	33.78	13.3	39.37	15.5
September	29.46	11.6	26.42	10.4	29.97	11.8
October	23.37	9.2	20.57	8.1	22.10	8.7
November	14.73	5.8	12.47	4.9	13.72	5.4
December	12.19	4.8	8.38	3.3	9.65	3.8
Totals	286.51	112.8	286.77	112.9	297.43	117.1

Source: Imperial Irrigation District Files

Surface Waters. Heber KGRA is located in the West Colorado River Basin, Imperial Hydrologic Unit, Imperial Subunit, of the State of California's hydrological designation system. The main geographic feature of California's West Colorado River Basin is the Salton Trough containing the Salton Sea and Imperial and Coachella Valleys.(3) The Heber KGRA site is in the south-central portion of Imperial Valley. Situated between the Sea and the international boundary with Mexico, the Imperial Valley's flat lands make up one of the most productive farming areas in the country.

Figure 1.6-2 shows the southerly portion of the West Colorado River Basin in the vicinity of the KGRA.

Drainage is across essentially flat land in Mexico and in the United States. At its southwesterly extremity the basin is fringed by the Sierra de los Cupas, a



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION– IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

WEST COLORADO RIVER BASIN
UNITED STATES & MEXICO

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.6-2

ridge rising to an elevation of 1102 m (3546 ft). The southeasterly boundary in Mexico is a low divide in the Colorado River delta, at an elevation of 25 to 35 m (82 to 115 ft) separating drainage into the Gulf of Mexico and to the Salton Sea. Lands within the Imperial subunit in Mexico are essentially a southerly extension of the Imperial Valley, with irrigated agriculture being carried on very much the same as in the United States using water from the Colorado River.

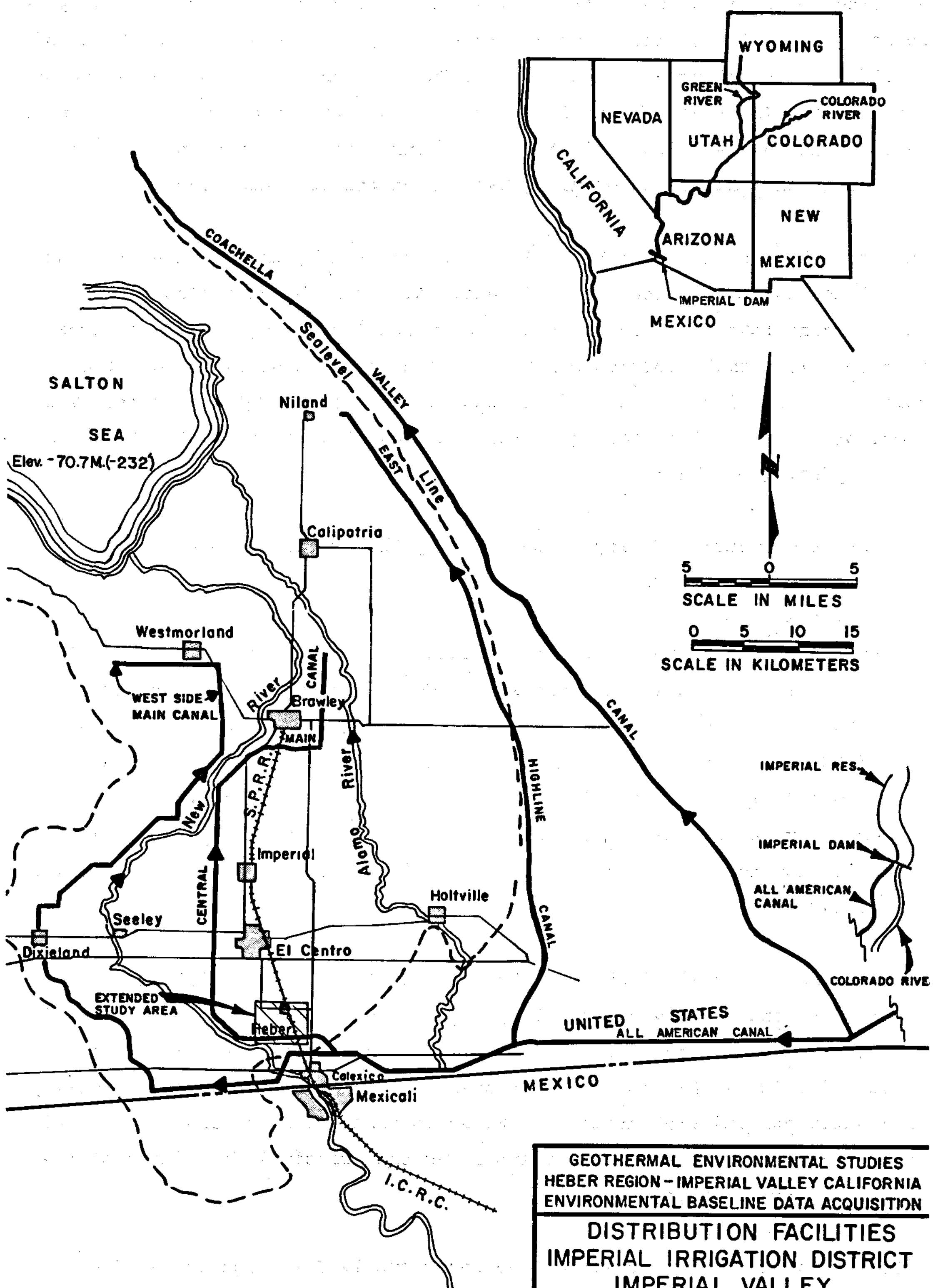
To the west, the west Colorado River Basin is bordered by the peninsular range of coastal mountains in southern California. Although the east slope of these mountains drains toward the Salton Sea, the Imperial hydrologic unit receives runoff from only a small portion of the mountain range, centering about the communities of Ocotillo and Mountain Springs in the Coyote Wells subunit. The remainder of the east slope mountain drainage flows toward the Salton Sea in different hydrologic subunits.

On its east, the Imperial Valley is bordered by the Chocolate Mountains and a fringe of desert sand hills.

Despite the fact that it receives only a negligible amount of natural runoff, the Salton Sea is the State's largest lake. Consisting mostly of irrigation drainage, this inland salt-water body covers 932.4 sq km (360 sq mi) and has 160.9 km (100 mi) of shoreline. Since the water surface elevation of the sea is about 70.7 m (232 ft) below sea level, it is the sink for all surface flow in the trough. Surface drainage from the Heber KGRA, at elevation -3.048 m (-10 ft) finds its way to the Salton Sea via the valley's natural and man-made water conveyance systems.

Although not now naturally linked to the Colorado River, Imperial Valley is very closely tied to and totally dependent upon the stream for support of its multi-million dollar agricultural industry. Facilities operated by the Imperial Irrigation District (IID) distribute Colorado River Water throughout the valley and carry away agricultural drainage. Water is taken from the river at Imperial Dam by the District. Figure 1.6-3 illustrates the principal facilities of the District in Imperial Valley.

The Colorado River provides drainage and water supply for large areas of seven states, including 800,000 acres of desert farmlands in Southern California. The waters of the Colorado are created by flows from numerous tributaries, draining



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

DISTRIBUTION FACILITIES
IMPERIAL IRRIGATION DISTRICT
IMPERIAL VALLEY

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.6-3

an area of 626,780 sq km (242,000 sq mi). Control of the river to conserve its water and generate electrical energy was initiated with completion of Hoover Dam in 1935. Lake Mead, formed by the dam, can store a two-year flow of the river for use in the Lower Colorado River Basin. Normally, the only flow in the river below Imperial Dam consists of 1850 million cubic meters (1.5 million ac ft) allocated to Mexico annually by treaty.

Before flood control on the Colorado River was achieved, the stream was swollen with snow melt every Spring, diminishing to a trickle as the year wore on. Floods surged along its course and into the Gulf of California almost annually. Early in the century, berms were thrown up along the lowest reach of the river to protect farmlands in Mexico and in the Imperial Valley. In 1905, the rampaging river breached its berm east of Mexicali, roaring across the flat terrain into the low-lying Salton Sink. By 1907, the ruptured levey had been mended and strengthened and the river confined to its normal course. However, the episode brought about some changes in the Imperial Valley important to present and future surface water hydrology of the Heber KGRA: (1) creation of the New River and (2) conversion of the Salton Sink into a major body of water persisting up to the present time.

Salton Sea. The Salton Sea is a saline body of water, occupying a natural site 48.27 km (30 mi) long, from 16.09 to 24.14 km (10 to 15 mi) wide, with an average depth of 9.14 m (30 ft). Its surface elevation, which varied from 59.44 to 76.2 m (195 to 250 ft) below sea level in 1907 and 1925, respectively, is now about 70.7 m (232 ft) below sea level.

The Salton Sea receives drainage from 19,425 sq km (7500 sq mi) of surrounding watershed in Riverside, San Diego and Imperial Counties and from the Mexicali Valley in Mexico. While natural runoff into the Sea is almost negligible, this huge sink is the recipient of approximately 1726.9 million cubic meters (1.4 million ac ft) per year of agricultural drainage from the Coachella and Imperial Valleys, along with a lesser amount of municipal and industrial waste. Generally, more than 90 percent of the surface inflow to the sea comes from the Imperial Valley and about 10 percent from the Coachella Valley and other areas.[3]

The average annual inflow from all sources for a recent six year period is presented in Table 1.6-4. Outflow from the sea is primarily by evaporation, which on the average, nearly offsets the inflow.

TABLE 1.6-4

AVERAGE ANNUAL INFLOW TO THE SALTON SEA[4]
1965 THROUGH 1970

	Source	Flow, Millions of Units/Years Cubic Meter	Ac Ft	Percent of Total
1.	Republic of Mexico	131.99	0.107	8.1
2.	Imperial Valley Irrigation Returns	1,228.56	0.996	75.8
3.	Imperial Valley Communities and Institutions	9.88	0.008	0.6
4.	Coachella Valley Irrigation Returns	122.12	0.099	7.5
5.	Coachella Valley Communities and Institutions	6.17	0.005	0.4
6.	Natural Runoff and Seepage	197.36	0.160	7.6
	TOTAL	1,622	1.315	100.0

Ground Water. As pointed out in Reference 3, ground water is stored in the sediments in the valley floor, the mesas in the west and the sand hills on the east. These sediments are of Pleistocene origin and their fine texture inhibits ground water movement in the valley. Tile drain systems are required to dewater soil to a depth below the root zone of crops and to prevent the accumulation of water on the surface.

Since yield is poor and ground water is of inferior quality, few wells have been drilled in these sediments. The rare wells in the valley offer domestic use only. In the higher Coyote Wells Hydrologic Subunit and Davies Hydrologic Subunit, in the mountain foothills to the west of Imperial Valley, water yield from wells is higher and quality better. Ground water is virtually the only supply in those areas.

Factors that diminish ground water reserves are consumptive use, evapotranspiration, evaporation from soils where ground water is near the surface, and losses through outflow and export. Ground water outflow to the Salton Sea from the entire hydrologic unit is about 2,500,000 cubic meters (2000 ac ft) per year.

The principal sources of recharge are percolation of runoff and seepage from the irrigation canals. Annual replenishment of good quality ground water is about 6,000,000 cubic meters (5000 ac ft) in the Imperial Valley. The storage capacity of the hydrologic unit is about 27,000 million cubic meters (22 million ac ft), within an average 61 m (200 ft) depth zone above the deepest wells in each hydrologic subdivision; most of the wells are more than 168 m (550 ft) deep. Large amounts of water are available, in most areas due to years of percolation of irrigation return flows, but the quality of the water is poor.

Soils. Reference 2 presents the following summary of the geological nature of soils underlying the Imperial Valley:

> The Salton Trough has been filled with clastic sediments from the Colorado River drainage delta, its major source, and from the largely meta-igneous complex of the adjacent mountain areas (Dibblee, 1954, and Muffler and Doe, 1968). These sediments are principally continental deposits, consisting of fanglomerates, conglomerates, and lacustrine sandstones or claystones and represent essentially continuous deposition since Miocene time. However, the older sediments are marine, and minor marine incursions of the Gulf of California also occurred throughout the deposition of the younger formations (Muffler and Doe, 1968).
>
> An evaluation of the major rock units in the Salton sea Area indicates that sedimentary rocks having the capacity for ground water storage underlie most of the area and extend as far south as the Gulf of California. Except for the northwest shore, along the periphery of the Salton Sea, the high salinity of the ground water in these sedimentary rocks makes the water generally unsuitable for most uses. The nonmarine sediments (Qc) and alluvial deposits (Qa) are unconsolidated and their general coarse-grained nature indicates they have a high capacity for ground water storage. The coarser sand and gravel members of the upper Pliocene formations (P), although not as permeable as the Qa and Qc sediments, may function as storage and transmission conduits within the ground water reservoir. The less permeable sedimentary rocks are the lake deposits (Ql) and the fine claystone members of the nonmarine sediments (Qc) and Pliocene formations (P). Evaporities in the lake deposits have been a significant contributor of salt to the Salton Sea. Rocks of the Miocene-Eocene (M) and lower Pliocene formations (P), volcanic rocks (V), and granitic and metamorphic rocks (m) have the least potential for ground water storage. Sediment thickness is known to exceed 13,000 feet, according to well logs; and geophysical studies suggest it may exceed 20,000 feet (Biehler, 1964).

From an agronomic point of view, Calcareous soils of the Imperial Valley are considered "saline" because the electrical conductivity is usually greater than four milliohms per cubic centimeter and exchangeable sodium-percentage is less than 15. Ordinarily, pH is about 8.2. Source of the salinity is the Colorado River water transported to the valley for crop irrigation.[5]

Chemical characteristics of soils classified as saline are mainly determined by the types and amounts of salts present. The salts present control osmotic pressure, which determines the amount of water that enters plant roots, a critical water quality characteristic in the Imperial Valley.

Sodium in Imperial Valley soils is displaced by the soluble cations of calcium and magnesium and therefore is not absorbed to any significant extent. Permeability is not affected by sodium dispersion of the soils. Consequently, adequate leaching can be acquired without soil amendments, but a good drainage system must be provided to remove the saline water. Base exchange results in a retention of calcium in the soil which is regarded as "beneficial" salt and in the export of large amounts of chloride and sodium which are "harmful" salts.

The percentage increase of chlorides in drainage effluent is more marked than other salts. The decrease in sulfate content is due chiefly to precipitation of gypsum in the salts. During 1974, as a result of leaching phenomena, salinity of agricultural drainage water was 2683 mg/l, as compared to the 911 mg/l salinity concentration of the water supply.

1.6.3 Surface Water Hydrology

Natural Streams. The New and Alamo Rivers, the main drainage courses of the Imperial Valley carry surface runoff and agricultural irrigation return water from farm lands in the Imperial Valley and Mexico to the Salton Sea.

The New River rises about 24 km (15 mi) below the Border in Mexico, flows 105 km (65 mi) northward and empties into the Salton Sea, draining the west side of the Imperial Valley. Approximately 75 percent of the 7252 sq km (2800 sq mi) watershed is in the United States. Because of vaguely defined watershed boundaries resulting from low topographical relief in Mexicali Valley, the 25 percent allocated to Mexico also includes areas draining into the Alamo River. Flow in the river ranges from about 136 million cubic meters (110,000 ac ft) per year at the International Boundary to about 555 million cubic meters (450,000 ac ft) at the gaging station near Westmoreland.(3) Flow is mainly irrigation return water and treated and untreated municipal waste water from a number of communities in California and Mexico.

Figure 1.6-2 depicts the New River and Alamo River drainage basin in California and Baja California. As can be seen, both rivers enter the United States in relative close proximity. The New River traverses a distance of 76.8 km (48 mi) from entering into the United States to its terminus at the sea. The river drops in elevation from sea level at the international boundary to 70.7 m (232 ft) below sea level at its mouth, a flat slope of 0.91 m per km (4.8 ft per mi). At the same time, the Alamo River traverses 60.8 km (38 mi) in its more direct route to the Salton Sea from the Border, dropping at a rate of about 1.12 m per km (6 ft per mi).

The New River enters the United States at Calexico, just under 8 km (5 mi) south of Heber. Downstream from the border, it follows a meandering northwesterly course, cutting through a corner of the extended study area in Section 5- Town 17 South-Range 14 East. Typical of the stream for most of its length in Imperial Valley, the river near the KGRA is confined in a small chasm gouged out by the 1905-07 flooding. As it crosses through the study area corner, the depression is about 12.2 m (40 ft) deep and 457.2 m (1500 ft) wide. Eight kilometers (5 mi) downstream, due west of Heber, its depth is unchanged, but width of the defile has increased to 914.4 m (3000 ft).

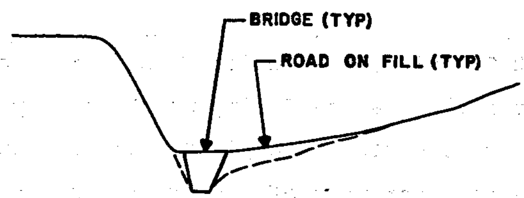
Normally, the New River forms a narrow thread along the bottom of its canyon. As a result, cattle feeding and other agricultural activities take place on bottom land along some reaches of the river.

Despite its proximity, the New River does not normally provide direct surface drainage for the Heber KGRA. Land elevations in the vicinity of Heber range from 1.52 m (5 ft) below sea level to 6.1 m (20 ft) below sea level. Surface drainage tends to fan out in a northwesterly to northeasterly direction, away from or paralleling the river. Surface drainage is normally carried to the Alamo River via the IID agricultural drains. Large volumes of sheet runoff would enter both the New and the Alamo Rivers at points several miles from the study area.

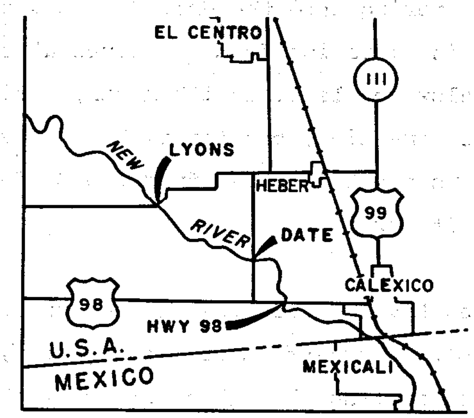
Using the formula:

$$Q = A \left(\frac{1.49}{n} \right) R^{\frac{2}{3}} S^{\frac{1}{2}}$$

(where A represents cross sectional area; R, hydraulic radius; S, slope of stream in feet per foot and n, the coefficient of roughness (.06)), maximum flow capacity of the New River chasm west of the study area was estimated to be 3174 CMS (112,000 CFS).[14][15] Figure 1.6-4 presents the analysis.



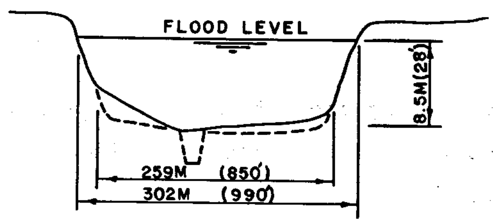
HWY. 98



LOCATION MAP

CROSS SECTION ON NEW RIVER

1" = 4 MI.
1.55" = 10 KM. ±



DATE STREET

USE DATE STREET SECTION:

$Q = AV$

$= A\left(\frac{1.486}{n}\right) R^{\frac{2}{3}} S^{\frac{1}{2}}$

$A = 920' \times 28' = 25{,}760$ sq. ft.

$P = 850' + 70' + 70' = 990'$

$R = A/P = 26.0$

$S = .0004$

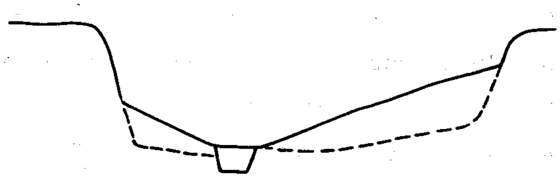
$n = .06$

$Q = 25{,}800 \times 1.486 / .06\,(26.0)^{\frac{2}{3}} (.0004)^{\frac{1}{2}}$

$= 112{,}000$ cfs

$=$ 3,174 cms

$=$ 190,000 cu m/min



LYONS CROSSING

SCALES: HORIZ.: 1cm = 60M (1" = 500')
VERT.: 1cm = 6M (1" = 50')

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY, CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

NEW RIVER CAPACITY

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.6-4

At its closest point, the Alamo River is approximately 16 km (10 mi) east of the KGRA. Flow in the river at the international boundary is about 2.9 million cubic meters (2400 acre feet) per year, but this increases to over 1110 million cubic meters (900,000 acre feet) per year at the gaging station near Calipatria.[3] This flow is mainly irrigation return water, with some treated sewage effluent from a number of California communities.

The Water Quality Plan Report for the West Colorado River Basin sums up the two principal streams of the Imperial Valley as follows:[3]

> The New and Alamo "rivers" could appropriately be called drainage channels because runoff from precipitation is insignificant when compared with the quantity of return flow these channels receive from irrigation and municipal uses.

Surface Flow in New and Alamo Rivers. The United States Geological Survey (USGS) has maintained a gaging station on the Salton Sea near Westmorland since 1904. A gaging station has been maintained on the Alamo River at the international boundary by the United States Section, International Boundary and Water Commission (IBWC) since 1942, while USGS has maintained a gaging station on the Alamo River at Niland since 1943. Similarly, IBWC has maintained a gaging station on the New River at the international boundary since 1942, while the USGS has conducted measurements on the river near Westmorland since 1943 (see Reference 3).

Flow measurements at the international boundary generally show that the amount of water entering the United States via the Alamo River is quite small, normally about 0.056 CMS (2 CFS) in volume. Because it conveys municipal, industrial and agricultural waste water from the Mexicali area, flow in the New River at the border is considerably greater, normally ranging between 3.54 and 4.96 CMS (125 and 175 CFS).

Table 1.6-5 summarizes New River flow computations performed by the IID for the period March 1951 through December 1975 based upon gage readings at the international boundary. Discharges were as low as 0.54 CMS (19 CFS) in the early years, ranging as high as 15.7 CMS (556 CFS) in recent years. Largest recorded flow at the border between 1944 and the present was 25.5 CMS (900 CFS) on January 29, 1963.

TABLE 1.6-5

NEW RIVER
STREAM FLOW MEASUREMENTS

Year	Month	Average Daily Discharge Low CMS	Low CFS	High CMS	High CFS	Maximum Daily Discharge CMS	CFS
	New River at International Boundary						
1951	June	0.051	18.0				
	April			3.00	106.0		
	September					5.21	184.0
1952	February	0.091	32.0				
	November			1.87	66.0		
	July					4.28	151.0
1953	August	0.57	20.0				
	April			1.95	69.0	4.11	145.0
1954	July	0.48	17.0				
	October			1.84	65.0	3.68	130.0
1955	April	0.65	23.0				
	November			3.20	113.0		
	August					5.63	234.0
1956	June/September	2.69	95.0				
	November			3.54	125.0	3.54	125.0
1957	July	1.73	61.0				
	January			4.02	142.0		
	November					6.60	233.0
1958	January	2.61	92.0				
	October			5.32	188.0		
	August					7.16	253.0
1959	Júly	3.40	120.0				
	December			5.92	209.0	9.71	343.0
1960	July/August	4.05	143.0				
	April			6.88	243.0		
	September					8.04	284.0
1961	September	3.65	129.0				
	March			5.49	194.0		
	February					15.15	535.0
	New River at Outlet						
1962	February	14.16	500.0				
	December			20.02	707.0		
	January					31.80	1,123.0
1963	December	14.56	514.0				
	September			22.8	808.0	33.45	1,181
1964	December	11.24	397.0				
	March			18.66	659.0	20.33	718.0

TABLE 1.6-5 (Cont'd)

Year	Month	Average Daily Discharge				Maximum Daily Discharge	
		Low		High			
		CMS	CFS	CMS	CFS	CMS	CFS
	New River at International Boundary						
1965	October	3.29	116.0				
	December			7.42	262.0	15.75	556.0
1966	July	2.83	100.0				
	March			4.98	176.0	6.94	245.0
1967	August	2.35	83.0				
	September			5.04	178.0	6.09	215.0
1968	December	3.34	118.0				
	April			5.15	182.0	6.43	227.0
1969	October	3.12	110.0				
	April			4.73	167.0		
	January					7.87	278.0
1970	November	3.06	108.0				
	April			5.38	190.0		
	March					8.27	292.0
1971	December	3.60	127.0				
	August			5.13	181.0	7.36	260.0
1972	July	3.54	125.0				
	October			6.40	226.0	16.85	595.0
1973	September	4.11	145.0				
	February			5.24	185.0		
	January					7.87	278.0
1974	September	3.71	131.0				
	January			5.44	192.0	6.46	228.0
1975	November	3.09	109.0				
	April			5.12	181.0	5.81	205.0

Data from Imperial Irrigation District

Although not shown in the tabulation, maximum stream flow in the river in recent years is reported to have occurred as a result of major rainstorms in 1939. At the time, rate of flow reached 142 CMS (5000 CFS). Below Calexico, the flow is reported to have crested at elevation 10.67 m (35 ft) below sea level, some 7.62 m (25 ft) below the embankments on either side of the river.*

Table 1.6-6 shows the annual runoff at gaging stations in the Alamo River and the New River adjacent to the Salton Sea for the period 1943 through 1967.[2]

* Discussion with Imperial County Deputy Engineer Jim Haines.

TABLE 1.6-6

ALAMO AND NEW RIVERS
ANNUAL RUNOFF*

Calendar Year	Alamo River Near Calipatria		New River Near Westmorland	
	Million Cubic Meters	Acre Feet	Million Cubic Meters	Acre Feet
1943	606,000	491,350	604,000	490,030
1944	624,000	505,850	622,000	504,520
1945	641,000	519,480	598,000	485,220
1946	713,000	578,390	587,000	475,750
1947	696,000	564,340	546,000	442,530
1948	665,000	539,240	544,000	441,360
1949	752,000	610,020	555,000	450,240
1950	748,000	606,810	568,000	460,650
1951	792,000	641,960	604,000	490,040
1952	860,000	697,410	646,000	524,060
1953	933,000	756,990	667,000	540,550
1954	904,000	732,680	608,000	492,770
1955	807,000	654,450	488,000	395,850
1956	844,000	684,060	530,000	429,640
1957	768,000	622,830	497,000	402,560
1958	758,000	614,400	500,000	405,200
1959	804,000	651,680	536,000	434,230
1960	842,000	682,400	549,000	445,000
1961	833,000	675,500	539,000	437,000
1962	840,000	681,300	562,000	455,300
1963	893,000	723,700	589,000	477,500
1964	695,000	563,500	451,000	365,900
1965	660,000	535,100	441,000	357,800
1966	753,000	610,700	473,000	383,500
1967	765,000	620,100	473,000	383,300

*Source: DWR Bulletin No. 143-7

No determination has yet been made of the volume of flood flow in the New River near Heber KGRA which would result from a 100-year frequency storm. However, in 1974 the U.S. Army Corps of Engineers (C of E) did initiate a flood plain information study of the stream at Brawley. Purpose of the study is to identify flood hazard areas and evaluate associated flood hazards along the study reach. The resulting report will present information that points out flooding problems caused by past floods and flooding problems that may result from large future floods which can reasonably be expected in the area.

In the course of the study, a computer simulated (C of E HEC-1) standard project storm will be used to estimate the volume of runoff in the New River and water surface elevations in the 16 km (10 mi) stretch being investigated. While the standard project storm will be applied throughout the C of E study area, computer programming is such that the volume of runoff and flood levels are not determined for reaches of the river upstream and downstream from the section being studied. Therefore, stream flow conditions in the southerly reach of the stream brought about by a 100-year frequency storm will remain undefined pending specific study.

Personnel of the Imperial County Department of Public Works express the view that the maximum flow in the river will not exceed 142 CMS (5000 CFS) below Calexico during a 100-year frequency flood flow, cresting at approximately 10.67 m (35 ft) below sea level, as compared to surrounding higher land elevations of 3.048 m (10 ft) below sea level. Culverts which convey the New River under Interstate Highway 8 near Seeley are designed for a maximum flow of 142 CMS (5000 CFS). Each of the four drainage structures has a cross section of 3.048 m by 3.048 m (10 ft by 10 ft) and a length of 64.92 m (213 ft).

Computed capacity of the Heber reach of the New River was earlier estimated to be 3174 CMS (112,000 CFS) a volume far in excess of flows listed in Table 1.6-5 and the 141.6 CMS (5000 CFS) flow maximum flood flow anticipated by local agencies.

Because of the very flat topography in the Imperial Valley, severe storms can produce a significant amount of sheet flow over the surface of agricultural and urbanized lands. For example, it was learned that one of the September 1939 storms caused sheet flow of runoff water 15.24 cm (6 in.) deep in El Centro for a period of four hours. On the other hand, the catchment area of the KGRA is almost limited to the study zone itself as a result of natural and man-made drainage features. Thus, sheet flow problems that might occur would not equal those at El Centro.

During lesser storms, IID drains tend to intercept and rapidly carry off much sheet flow; because of their depth, the drains also tend to act as runoff storage and control structures.

The drains have been installed only for the purpose of conveying irrigation drainage and were not designed or intended to provide flood protection of any sort. Design capacity of the typical drain is approximately 0.424 CMS (15 CFS), although an estimated 7.92 CMS (280 CFS) might be carried when flowing full, depending upon outlet conditions. IID facilities are discussed in detail below.

Despite the paucity of information on past and projected flooding in the southerly end of the Imperial Valley, it is reasonable to conclude that the Heber KGRA is well protected from serious flooding resulting from storm runoff. Factors contributing to the favorable assessment are: (1) dams and other protective works on the Colorado River, (2) carrying capacity of the New River channel, (3) very limited upstream catchment area and (4) existence of Imperial Irrigation District agricultural drains throughout the area. Available information therefore indicates only a minimal need for flood protection at the site.

1.6.4 Imperial Irrigation District Facilities

So extensive are the water supply and drainage facilities of IID in the Imperial Valley that they must be considered part of the local hydrological system. Beginning at the turn of the century, Imperial Valley landowners have created what is now the largest desert irrigation development in the Western Hemisphere. Some 3700 million cubic meters (3 million ac ft) of water per year are now imported into the valley and distributed throughout the one million acre District in man-made facilities. As a result, this desert valley can boast of a $500,000,000 per year agricultural output. The history of irrigation development in Imperial Valley is replete with perseverence, foresight and sound planning.

In 1901 private interests achieved the first diversion from the lower Colorado River to irrigate lands in California and Mexico. The Alamo Canal was constructed to supply river water to both the Mexicali and Imperial Valleys. Following the Colorado's 1905-07 rampage, private owners of the system found themselves in financial trouble, although growth continued. By 1910, approximately 1600 km (1000 mi) of canal were in place and over 77,000 hectares (190,000 acres) under irrigation. In 1911, IID was formed to acquire the rights of the bankrupt California Development Company from the Southern Pacific Railroad.[6]

Just two year later, the international canal system covered more than 202,000 hectares (500,000 acres), serving water to 20,000 hectares (50,000 acres) in Mexico and 106,600 hectares (264,000 acres) in the United States. Transfer of properties from mutual water companies to the District took place over a period of years, and it was not until 1922 that the entire existing system was under public ownership. During the same year, the Colorado River Compact apportioning the river's water among the states in the basin was signed.

Threats to the viability of agriculture in the Imperial Valley from salinity problems were recognized early in the century, leading to construction of an irrigation drainage system beginning in 1922.[7] Fortunately, the mineralized irrigation return water can be readily conveyed to the New or Alamo Rivers via a network of ditches crisscrossing the flat farmlands. Once in the rivers, the agricultural waste drains directly to the Salton Sea. In 1924, President Coolidge created a public water reserve at Salton Sea, the lands to be used for storage of excess water from irrigation of lands in Imperial and Coachella Valleys. It has been only over the past 20 years that recreational and wildlife uses of the sea have gained recognition.

In 1928, the Boulder Canyon Project Act was passed to authorize construction of Hoover Dam and the All-American Canal (AAC) system, which includes Imperial Dam, desilting works, the AAC and the Coachella Main Canal. The latter facility was planned as a method of conveying Colorado River water to the valley without crossing the border into Mexico.

Imperial Dam, 483 km (300 mi) below Hoover, diverts water from the Colorado River on the California side into AAC and on the Arizona side to the Gila Gravity Main Canal. The dam, 1059 m (3475 ft) long, raises the river level 7 m (23 ft). Construction of the dam and desilting works began in 1936 and was completed in 1938. Resulting works prevent vast quantities of river-bed sediment from entering the canals and creating operation and maintenance difficulties.

Irrigation water was supplied to the valley via the Mexican canal system until completion of AAC. AAC now delivers water to the Imperial and Coachella Valleys of Southern California and to the Yuma project in southwestern Arizona and southeastern California. Started in 1934, AAC delivered its first water to Imperial Valley in 1941. One of the world's largest canals, it extends westward 128.7 km (80 mi) paralleling the Mexican border to Imperial Valley. The Coachella main canal branches from AAC 32.2 km (20 mi) west of Yuma and runs northwesterly 198 km (123 mi) to the Coachella Valley. The branch canal was completed in 1948.

AAC proper serves about 214,500 irrigable hectares (530,000 acres) of land in IID's Imperial division, while the Coachella main canal delivers water to some 31,600 hectares (78,000 acres) in the Coachella division. The canal also furnishes water to 27,100 hectares (67,000 acres) in the Yuma project. AAC has a capacity of 429.2 CMS (15,155 CFS) and the Gila Gravity Main Canal 62.3 CMS (2200 CFS).

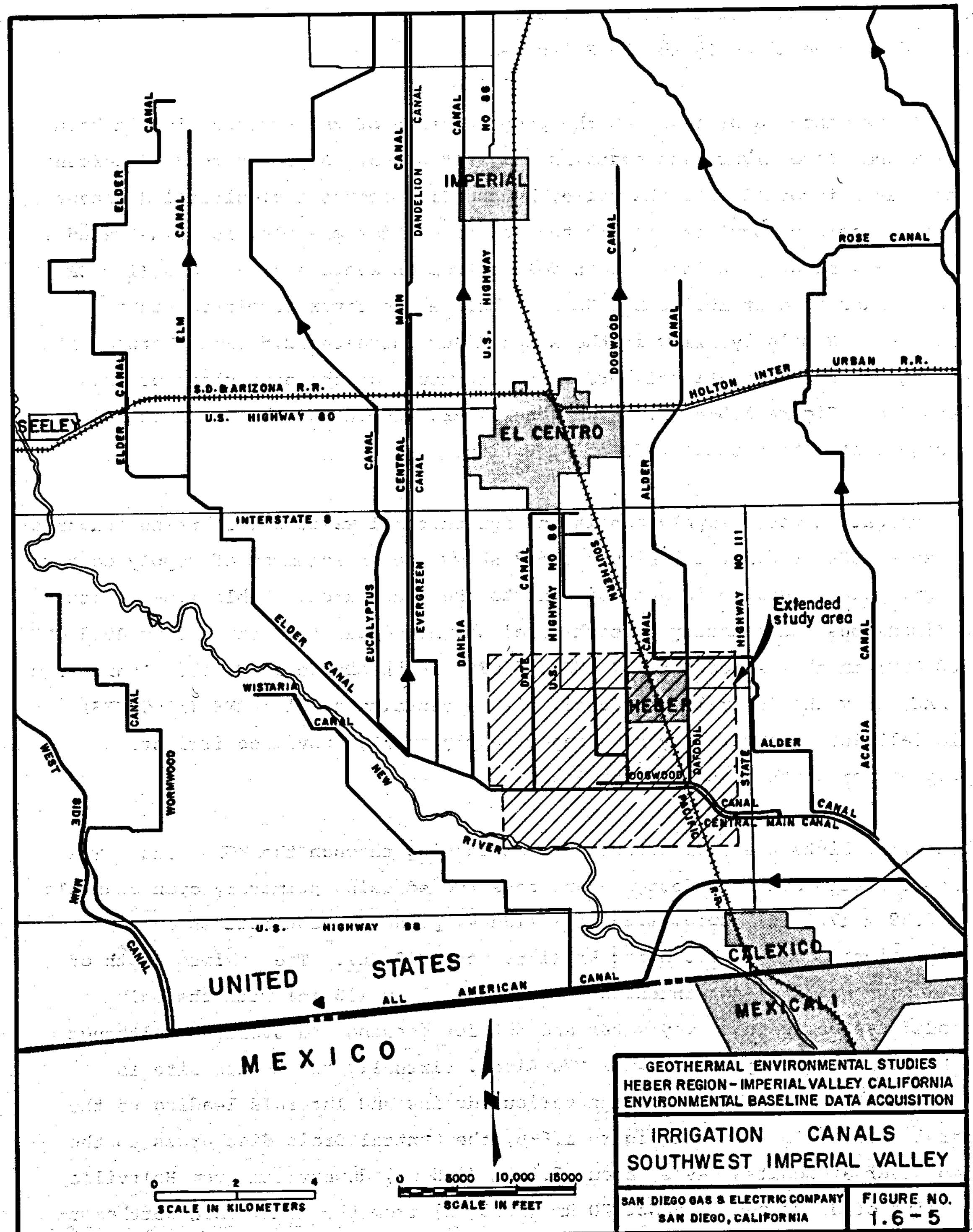
Figure 1.6-5 depicts the major delivery facilities of IID as they now exist in southwest Imperial Valley.

Within the Imperial Valley, AAC feeds three main irrigation supply canals, each of which begins at the border and flows northerly toward Salton Sea. These are the East Highline Canal, extending some 80.5 km (50 mi) north from the border through the easterly portion of the district (not shown). The Central Main Canal traverses some 51.2 km (32 mi) along 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 westerly end of the AAC and proceeds along the westerly extremity of the Imperial Valley to the vicinity of Salton Sea, a distance of some 72 km (45 mi).

A network of smaller irrigation canals take off from the three main canals, traversing the valley floor at intervals of 1.6 km (1 mi) or less. The valley contains a total of 2626 km (1641 mi) of irrigation canals and laterals.

After the Central Arizona Project becomes operational in about the mid-1980's and California's diversions from the Colorado River are reduced to 5427.4 million cubic meters (4.4 million ac ft) per year basic appropriation, it is expected that diversions to the IID will be reduced by a small amount to keep the total California agricultural uses within the 4749 million cubic meters (3.85 million ac ft) per year limit.[2]

IID also operates some 2230 km (1394 mi) of drainage canals throughout the Imperial Valley. Tile drainage systems installed beneath most of the valley's irrigated fields capture the percolating irrigation water 1.2 m (4 ft) or more below the ground surface, discharging it to a nearby drainage canal. Generally,

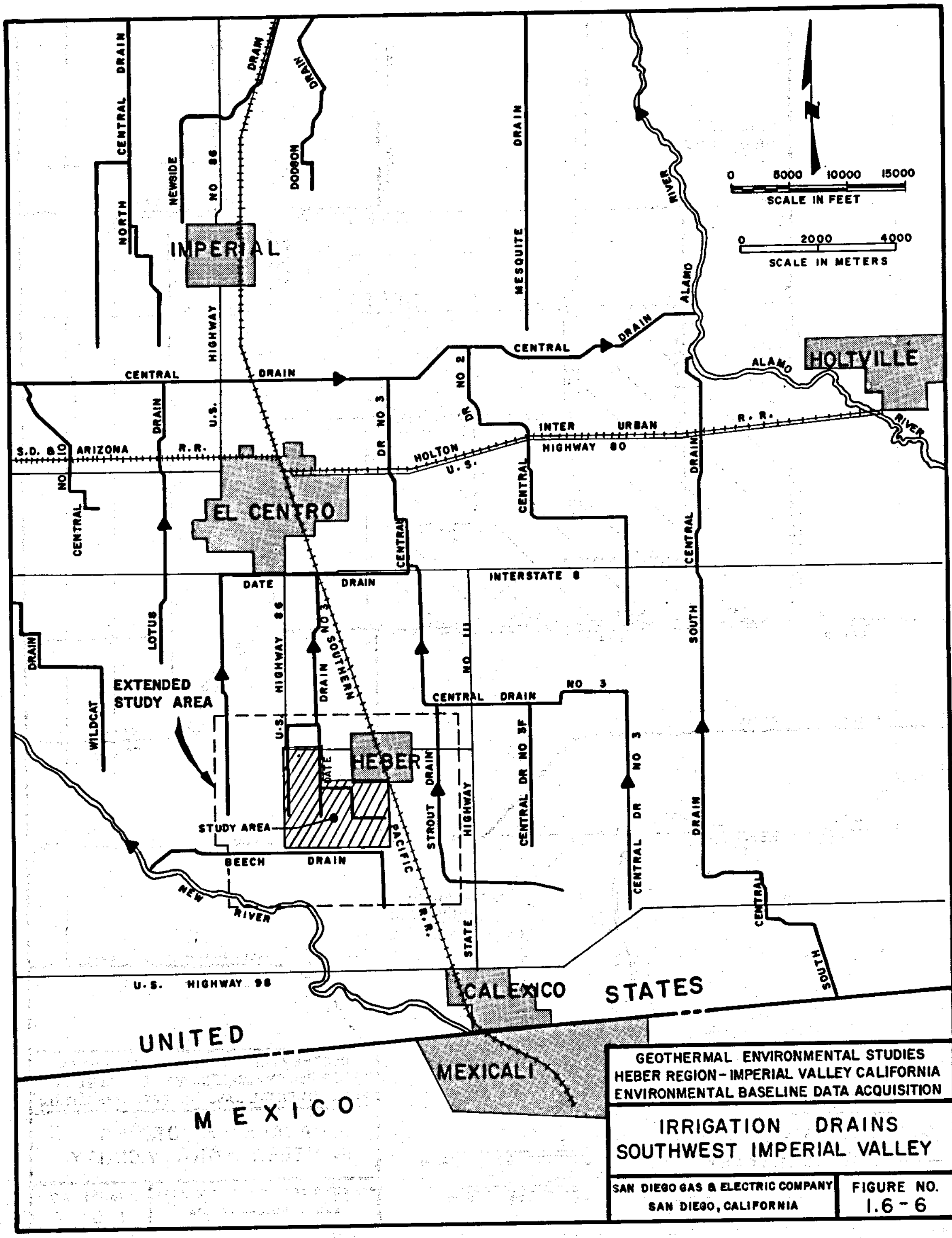

IMPERIAL
EL CENTRO
HEBER
CALEXICO
MEXICALI
SEELEY
UNITED STATES
MEXICO
ROSE CANAL
HOLTON INTER URBAN R.R.
S.D. & ARIZONA R.R.
U.S. HIGHWAY 80
INTERSTATE 8
U.S. HIGHWAY 98
U.S. HIGHWAY NO 86
HIGHWAY NO 111
ALL AMERICAN CANAL
CENTRAL MAIN CANAL
ELDER CANAL
ELM CANAL
DANDELION CANAL
MAIN CANAL
CENTRAL CANAL
DOGWOOD CANAL
ALDER CANAL
EUCALYPTUS
EVERGREEN
DAHLIA
WISTARIA CANAL
NEW RIVER
WORMWOOD
WEST SIDE MAIN CANAL
ACACIA CANAL
SOUTHERN PACIFIC
Extended study area
GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION
IRRIGATION CANALS
SOUTHWEST IMPERIAL VALLEY
SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA
FIGURE NO. 1.6-5
SCALE IN KILOMETERS
SCALE IN FEET
0 5000 10,000 15000

drainage canals in the westerly part of the valley empty into the New River, while those to the east discharge to the Alamo River. A small number of drainage canals discharge directly to the Salton Sea.

Agriculture waste water makes up the preponderance of the surface flow in both the New and Alamo Rivers and sustains the Salton Sea. Approximately 30 percent of the water imported into the valley by the IID becomes agricultural drainage. The influence upon surface flow in the New river, for example, is illustrated in Table 1.6-5, showing an increase in volume from an average of 3.9 CMS (140 CFS) at the border to over 19.8 CMS (700 CFS) before the river terminates in the Salton Sea. Similarly, flow in the Alamo River increases 275 times between its crossing of the international border and its mouth at the east shore of the Salton Sea. Figure 1.6-6 shows the general arrangement of the agricultural drainage system in southwest Imperial Valley.

Both irrigation water supply canals and agricultural waste water drains traverse the Heber KGRA study area. Figure 1.6-7 shows the arrangement of supply canals and agricultural drains in and adjacent to the study area. Table 1.6-7 lists the dimensions and capacity of each canal shown. Capacities range from 45.3 CMS (1600 CFS) in the AAC down to .7 CMS (25 CFS) in the Daffodil Canal. Apart from the AAC, only the Central Main Canal, with a capacity of 31.1 CMS (1100 CFS) would fall into the category of a major supply trunk, providing irrigation supply as far north as the Salton Sea.

Table 1.6-8 lists the agricultural drains passing through the KGRA area. The drainage system has been designed and constructed using primarily open channels with 2.29 m (7.5 ft) depth, 1.25 to 1 side slope and 3 foot bottoms on an average slope of about 1.0 m per km (1 ft per 1000 ft). The maximum depth of the flowing water is not intended to exceed 45.7 cm (18 in) with the only intended use being to convey water and not for ponding and storage. Although the Heber KGRA is adjacent to the New River, virtually the entire site is drained to the Alamo River through various drains and laterals leading to the Central Drain. As shown in Figure 1.6-6, the Central Drain discharges to the Alamo River at Rositas Waste, about 5.6 km (3.5 mi) downstream from Holtville. The point of discharge is about 20 km (12.5 mi) from the KGRA, in a northeasterly direction. Valley topography dictates gravity discharge to the Alamo River at a relatively remote point, rather than to the nearby New River.



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

IRRIGATION DRAINS
SOUTHWEST IMPERIAL VALLEY

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.6 - 6

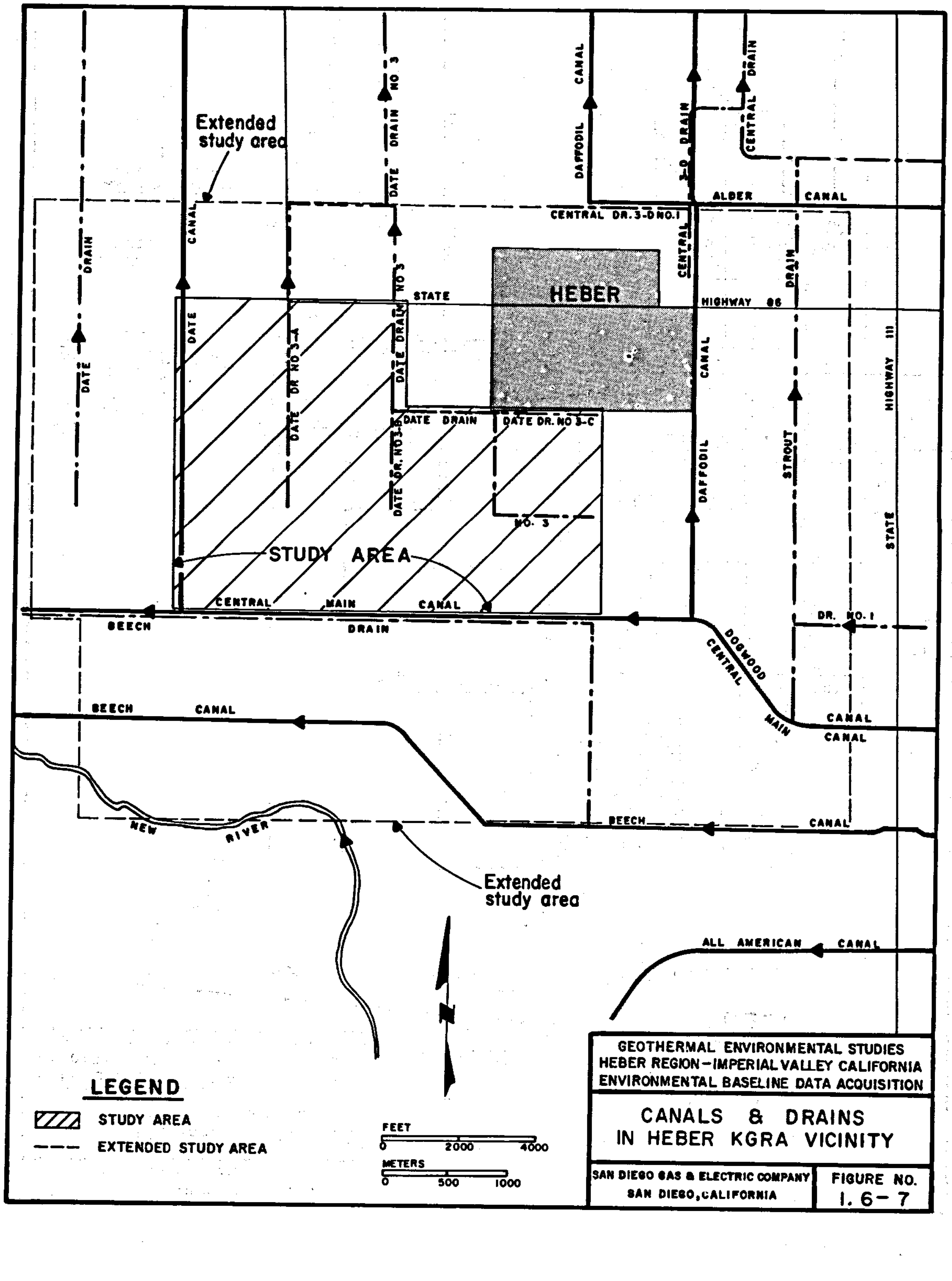

Extended study area
STUDY AREA
HEBER
DATE DRAIN
DATE CANAL
DATE DR NO 3-A
DATE DRAIN NO 3
DATE DRAIN
DATE DR. NO 3-B
DATE DR. NO 3-C
NO. 3
STATE HIGHWAY 86
DAFFODIL CANAL
3-D DRAIN
CENTRAL DRAIN
ALDER CANAL
CENTRAL DR. 3-D NO. 1
STROUT DRAIN
DR. NO. 1
STATE HIGHWAY 111
CENTRAL MAIN CANAL
BEECH DRAIN
DOGWOOD CENTRAL MAIN CANAL
BEECH CANAL
NEW RIVER
ALL AMERICAN CANAL
LEGEND
STUDY AREA
EXTENDED STUDY AREA
FEET 0 2000 4000
METERS 0 500 1000
GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION-IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION
CANALS & DRAINS IN HEBER KGRA VICINITY
SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA
FIGURE NO. 1.6-7

TABLE 1.6-7

CAPACITY OF CANALS IN VICINITY OF HEBER KGRA*

Facility Name	Reach	Dimensions						Capacity	
		Top Width		Bottom Width		Depth			
Canal		Meters	Feet	Meters	Feet	Meters	Feet	CMS	CFS
Central Main Canal	Hy. 111 to Dahlia Canal	24.38	80.0	13.7	45.0	2.74	9.0	31.15	1100.0
Dogwood Canal	Hy. 111 to Hy. 86	9.75 9.14	32.0 30.0	6.09 3.05	20.0 10.0	1.83 2.44	6.0 8.0	4.67 2.27	165.0 @Hy.111 80.0 @Hy. 86
Dogwood Lateral No. 2	Dogwood Canal to Hy. 86	6.7 5.48	22.0 18.0	2.74 2.74	9.0 9.0	1.83 1.52	6.0 5.0	1.56 0.99	55.0 @Head 35.0 @Hy. 86
Alder Canal	Hy. 11 to 90° Turn	6.4	21.0	2.44	8.0	1.83	6.0	3.68	130.0
Dahlia Canal	Central Main Canal to Hy.86	6.4	21.0	1.83	6.0	1.52	5.0	5.09	180.0 @Head 130.0 @Hy. 86
Daffodil Canal	Central Main Canal to Hy. 86	3.35	11.0	0.61	2.0	1.07	3.5	0.85 0.71	30.0 @Head 25.0 @Hy. 86
Beech Canal	Hy. 111 to New River	3.66	12.0	0.61	2.0	1.22	4.0	1.42	50.0
All-American Canal	Hy. 111 to New River	35.35	116.0	20.12	66.0	4.88	16.0	45.31	1600.0
Date Canal	Central Main Canal to Sec. 19	3.66 3.35	12.0 11.0	0.61 0.61	2.0 2.0	1.22 1.07	4.0 3.5	1.56 0.85	55.0 @Head 30.0 @Del. 17
Birch Canal Lateral No. 3	West of All-American Canal	5.18	17.0	2.01	6.0	1.83	6.0	0.85	30.0

* Information Courtesy of Imperial Irrigation District

TABLE 1.6-8

AGRICULTURAL DRAINS IN VICINITY OF HEBER KGRA*

Facility Name	Reach
Canal	
Beech Drain	Beech Canal to New River
Date Drain	Section 31 to Interstate 8
Date Drain No. 3A	Section 32 to Date Drain #3
Date Drain No. 3B	Section 32 to Date Drain #3
Date Drain No. 3	Date Drain No. 3B to Section 17
Central Drain No. 3D	Heber to Central Drain
Central Drain No. 3	Hy. 111 to Alder Canal Lateral No. 5
Strout Drain	Strout Drain No. 1 to Central Drain
All-American Drain No. 9	Hy. 111 to New River
All-American Drain No. 10	Hy. 111 to New River
Alder Drain	Alder Drain to Central Drain

* Information Courtesy of the Imperial Irrigation District

Although the drainage system was not installed to convey storm runoff, it does perform that function as an added benefit. As reported previously, full flow capacity of the typical open-drain channel is estimated at 7.92 CMS (280 CFS). Since an in-depth analysis of the drainage system was considered beyond the scope of this study, the above capacity does not account for obstructions, low-capacity culverts, hydraulic anomalies or other features which would tend to reduce drainage capacity.

Threat of major flooding in the Heber KGRA as a result of canal malfunction is considered to be remote. According to IID personnel, supply canals are carefully operated to deliver a volume of water approximately equaling the amount ordered by farmers on any given day. Wasteways are provided for discharge of excess to the rivers without damage, should consumptive use not meet the rate of delivery. Canals are under constant surveillance for malfunctions and are equipped for fast shut-down in the rare event that a serious problem is detected.

Similarly, drains offer little or no threat of flooding beyond minor ponding in very localized areas. Most drains have hydraulic carrying capacity much greater than their normal load. Should a blockage occur or a pump fail, many of the drains would store water for a considerable period before overflow, allowing time for detection and correction. Any overflow would usually be able to find its way to a functioning drain within a short distance.

Water rates levied by IID for general irrigation use or use by cities, unincorporated towns, private water companies, mutual water companies and water utility districts range between $2.43 and $2.84 per 1000 cubic meters ($3.00 and $3.50 per ac ft) depending upon the applicable schedule.(9)

Water is delivered to water users associations for commercial and industrial purposes at a rate of $2.84 per 1000 cubic meters ($3.50 per ac ft) or $70.42 per year per hectare ($28.50 per ac) served if the water is not metered. In addition to other charges, all lands within the service area of the District which are entitled to water service must pay a yearly service charge of $3.71 for each gross hectare ($1.50 per each gross ac) or fraction thereof, whether water is actually used or not. Lands not subject to assessment pay an additional $3.71 yearly for each gross hectare ($1.50 for each gross ac) or fraction thereof.

Hydroelectric energy is generated for Imperial and Coachella Valleys at plants constructed by the IID. Four hydro plants, located at Drops 2, 3 and 4 and Pilot Knob on the AAC have a combined nameplate capacity of 72,400 kilowatts.(8) The El Centro steam-electric station has an installed capacity of 180,000 kilowatts. The Brawley gas turbine and diesel plant has an installed capacity of 34,500 kilowatts.

The power service area includes all of Imperial County and the AAC service area in Coachella Valley with a gross area of 16,674 sq km (6,483 sq mi). On December 31, 1971, the system had 40,526 customers, or about 99 percent of all people residing in the area. During 1971, a total energy sale of 889,058,600 kilowatt hours was made.

The transmission system consists of 283 km (183 mi) of 161-KV lines, 731.2 km (457 mi) of 161/92 KV lines and 566.4 km (354 mi) of subtransmission lines. There are approximately 4530 km (2831 mi) of distribution lines as follows: 2995 km (1872 mi) in Imperial Valley, 1402 km (876 mi) in Coachella Valley and 132.8 km (83 mi) in the Bard-Winterhaven area.

Rates for sale of electricity in the District range from 1.45¢ per kilowatt hour for purchases of 21,000 kilowatt hours per meter per month to 4.25¢ per kilowatt hour for purchases of 200 kilowatt hours per meter per month for general service. General wholesale power service is available at a rate ranging between 0.95¢ per kilowatt hour for amounts over 400,000 kilowatt hours per month to 1.25¢ per kilowatt hour for amounts of 75,000 kilowatt hours per month, plus a demand charge of at least $300 per month. District electricity schedules are subject to a fuel and energy cost adjustment.

1.6.5 Occurrence of Shallow Ground Waters

In general, ground water elevations beneath the Imperial Valley are affected by delivery and application of Colorado River water to the land, depth of tile drain lines beneath the fields, and the drainage canals which intercept and carry away ground water for direct discharge to the New and Alamo Rivers. In general, ground water is reported to be 1.8 to 2.4 m (6 to 8 ft) below the ground surface throughout most of the Imperial Valley.*

Figure 1.6-8 shows the locations of observation wells regularly monitored by the IID staff to determine ground water levels within the Heber KGRA. Table 1.6-9 shows the results of ground water measurements over the past two years, in terms of depth of ground water at a particular well location in feet below the ground surface. The figure also shows ground water elevation lines indicating average depth of ground water below the ground surface for the two year period.

TABLE 1.6-9

GROUND WATER MEASUREMENTS IN HEBER KRGA

Depth of Ground Water
Below Ground Surface

Well No.	Date	Measurements by Imperial Irrigation District — Measurement: Meters	Feet
627	May 13, 1975	1.37	4.5
	May 28, 1974	1.43	4.7
	November 6, 1974	2.01	6.6
	February 7, 1974	2.01	6.6
	Average	1.71	5.6

* Discussion with IID staff.

TABLE 1.6-9 (Cont'd)

Well No.	Date	Measurement Meters	Measurement Feet
628	-		
	May 28, 1974	1.08	3.55
	-		
	February 7, 1974	0.96	3.15
	Average	1.02	3.35
629	May 13, 1975	3.29	10.8
	May 28, 1974	3.31	10.85
	June 6, 1974	3.34	10.95
	February 7, 1974	3.46	11.35
	Average	3.35	10.98
393	May 27, 1975	1.15	3.8
	November 6, 1974	2.06	6.75
	May 28, 1974	1.72	5.65
	February 7, 1974	2.06	6.75
	Average	1.95	6.4
394	May 27, 1975	1.37	4.5
	June 6, 1974	2.21	7.25
	May 28, 1974	1.49	4.9
	February 7, 1974	1.57	5.15
	Average	1.58	5.2
395	May 27, 1975	1.30	4.25
	November 6, 1974	1.43	4.7
	May 28, 1974	1.51	4.95
	February 7, 1974	1.65	5.4
	Average	1.46	4.8
380	February 8, 1974	1.97	6.45
	July 2, 1975	1.97	6.45
	November 7, 1974	2.00	6.55
	May 28, 1974	2.00	6.55
	Average	1.98	6.5
381	February 7, 1974	1.98	6.5
	July 7, 1975	2.74	9
	November 7, 1974	1.95	6.4
	May 28, 1974	1.95	6.4
	Average	2.16	7.1
381A	February 7, 1974	1.04	3.4
	May 29, 1975	0.69	2.25
	November 6, 1974	0.84	2.75
	May 28, 1974	0.73	2.4
	Average	0.62	2.03
381B	February 7, 1974	2.09	6.85
	May 29, 1975	1.71	5.6
	November 6, 1974	2.13	7
	May 28, 1974	2.12	6.95
	Average	2.01	6.6
382A	March 22, 1974	0.97	3.2
	-		
	November 26, 1974	1.51	4.95
	June 6, 1974	1.22	4
	Average	1.25	4.1

TABLE 1.6-9 (Cont'd)

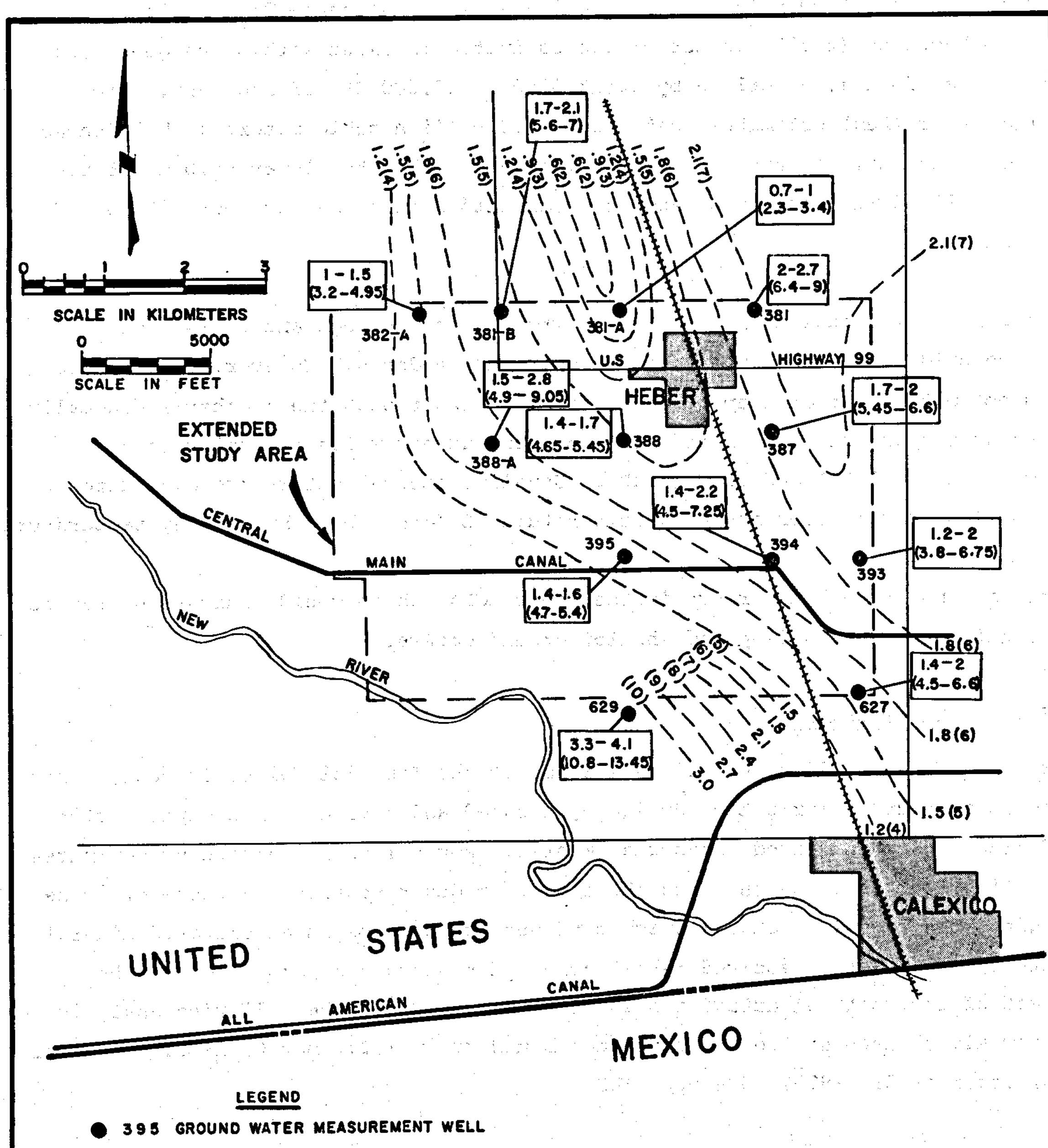
Well No.	Date	Measurement Meters	Feet
386	February 7, 1974	0.70	2.3
	May 29, 1975	0.64	2.1
	November 6, 1974	0.68	2.25
	May 28, 1974	0.65	2.15
	Average	0.67	2.2
387	February 7, 1974	2.04	6.7
	May 29, 1975	1.66	5.45
	November 6, 1974	2.00	6.55
	May 28, 1974	2.01	6.6
	Average	1.90	6.2
388	February 7, 1974	1.51	4.95
	May 27, 1975	1.97	6.45
	November 6, 1974	1.52	5
	May 28, 1974	1.42	4.65
	Average	1.52	5
388A	February 7, 1974	1.77	5.8
	May 29, 1975	2.76	9.05
	June 6, 1974	1.49	4.9
	May 28, 1974	1.71	5.6
	Average	1.92	6.3

Ground water measurements for the period 1974/75 show minor changes in elevation at each well, ranging from 0.12 to 1.28 m (0.4 to 4.2 ft) for the period of measurement. Changes of this magnitude would reflect irrigation practices within and adjacent to the study area. It is understood that, historically, shallow ground water elevation contours have remained approximately the same, and no major differences are anticipated for the future.

1.6.6 Occurrence of Deep Ground Waters

Because of the exceptional depth of sediments underlying the Salton Trough, ground water is found at 1000 meters and more (several thousand feet) beneath the surface (see Reference 2). Existence of deep waters is attributed to long-term percolation of surface flows from the Colorado River system in the Salton Sea area. As a result of high desert evaporation rates, the percolating waters underwent concentration of dissolved minerals. Deep waters underlying Imperial Valley are therefore highly saline.

Circulating in proximity to the underlying geothermal anomaly, deep ground waters are heated several hundred degrees above ambient temperature of surface water. Heat probably also contributes to mineralization by causing increased dissolving of salts from the soil mantle.



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION – IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

OBSERVATION WELLS IN HEBER KGRA VICINITY IMPERIAL IRRIGATION DISTRICT

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.6-8

Studies in recent years have lead to the conclusion that the Imperial and Mexicali Valleys form a large geothermal area (see Reference 2). At least 810,000 hectares (2 million acres) are estimated to exist within the geothermal zone in California, underlain by about 6100 m (20,000 ft) of sediment. One investigator (Rex) estimates that about 3700 billion cubic meters (3 billion ac ft) of geothermal reserves are present, assuming that the lower 4570 m (15,000 ft) are filled with hot brine and the sediments have an average porosity of 10 percent.

At a number of locations in the Salton Trough, hot springs and wells give surface evidence of the superheated conditions at depth. However, temperature does not match that of deep ground water in contact with the geothermal anomally. Temperatures of "thermal water" from hot springs and wells generally range between 72.2C (162F) and 162C (324F). Usually, thermal waters are considered to be shallow ground water having a temperature 8C (46F) above human body temperature.

There are no known hot springs in the Heber KGRA, which would indicate hydraulic discontinuity between deep and shallow ground waters.

1.6.7 Water Quality

Surface. Water quality in surface streams of the Imperial Valley is poor, since flow is made up of irrigation drainage, treated and untreated municipal wastes, and treated and untreated industrial wastes. Agricultural drainage predominates, amounting to more than ten times the flow from other sources. Because of these origins, the prevalent characteristic of surface streams is an elevated mineral content, along with dissolved fertilizers and residuals of pesticides. The effect of agricultural activities in Mexico is shown in the following analysis of New River water at the international boundary by IID: May 6, 1975, 4634 mg/l TDS; December 31, 1975, 4984 mg/l TDS.

At some locations, coliform bacteria concentrations are high and dissolved oxygen levels depressed as a result of municipal waste discharges. The most notable example of water quality degradation occurs in the New River at the international border, resulting from discharges of untreated and treated sewage by Mexicali and untreated industrial wastes in that city.

Table 1.6-10 indicates historical water quality conditions in the New River at the international boundary, and at an IID gaging station which is located 7.68 km

(4.8 mi) upstream of the point of discharge of New River into the Salton Sea.[4] Table 1.6-11 presents more recent data on New River water quality. Similar data for the Alamo River is listed in Table 1.6-12. As mentioned above, over-all quality of the surface flow is indicated as poor.

TABLE 1.6-10

WATER QUALITY IN NEW RIVER (1962-1966)

(Compiled from State Department of Water Resources Stream Sampling Data)

Water Quality Indicator	Units	DWR Station 57-International Boundary, 96.48 km (60.3 Mi) Upstream of Salton Sea			DWR Station 58-Imperial Irrigation District Gaging Station, 7.68 km (4.8 Mi) Upstream of Salton Sea		
		Max.	Min.	Avg.	Max.	Min.	Avg.
Flow	CFS	193	108	144	687	384	507
Temperature	°F	92	52	71	86	53	70
pH	--	8.0	7.0	7.3	7.8	7.2	7.5
Electrical Conductivity EC x 10^6	Micromhos	8,921	5,288	7,354	7,133	4,634	5,828
Total Dissolved Solids	mg/l	6,060	3,500	4,865	4,528	2,664	3,900
Coliform	MPN/ml	620,000	43,000	160,000	62,000	4,300	10,400
Total Hardness	mg/l	1,255	962	1,111	1.158	826	1,061
Non-Carbonate Hardness	mg/l	1,017	696	873	926	612	839
Dissolved Oxygen	mg/l	8.6	0.4	6.3	9.2	6.6	7.9
Turbidity	mg/l	280	50	128	650	185	298
Boron (B)	mg/l	2.55	1.12	1.79	1.85	0.88	1.30
Calcium (Ca)	mg/l	266	208	242	263	187	233
Magnesium (Mg)	mg/l	145	104	123	128	87	117
Sodium (Na)	mg/l	1,500	874	1,209	1,120	603	890
Potassium (K)	mg/l	-	-	-	44	15	-
Chloride (Cl)	mg/l	2,600	1,340	2,001	1,838	886	1,400
Sulfate (SO_4)	mg/l	876	589	732	860	647	797
Nitrate (NO_3)	mg/l	31	1.2	14.4	42	12	25
Bicarbonate (HCO_3)	mg/l	370	209	291	295	251	288
Fluoride (F)	mg/l	1.8	0.72	1.03	1.1	0.7	0.87
Percent Sodium	%	72	29	65	67	61	63

TABLE 1.6-11

WATER QUALITY IN NEW RIVER (4/15/75)

Sampling and Analysis By
California Regional Water Quality Control Board
Colorado River Basin Region

Constituent	Unit	Location Sampled: International Boundary-River Kilometer 105.6 (Mile 66)	State Hwy 80 River Kilometer 74.4 (Mile 46.5)	Keystone Road River Kilometer 48 (Mile 30)	State Hwy 111 River Kilometer 23.25 (Mile 15.5)	Lack Road River Kilometer 9.6 (Mile 6)
Total Dissolved Solids	mg/l	4880	4695	2470	4520	3785
Suspended Solid Solids	mg/l	41	135	218	232	280
Volatile Suspended Solids	mg/l	15	25	32	35	30
Settleable Solids	ml/l	0.1	0.4	0.5	0.3	0.6
pH	-	7.3	7.4	7.4	7.8	7.6
$20^{o}C$ BOD_5	mg/l	7.0	7.0	7.0	6.0	7.0
Ammonia (N)	mg/l	1.8	1.8	0.96	1.1	0.96

TABLE 1.6-12

WATER QUALITY IN ALAMO RIVER (11/1/73)

Sampling and Analysis By
California Regional Water Quality Control Board
Colorado River Basin Region

Constituent	Unit	Location Sampled: International Boundary River Kilometer 94.4 (Mile 59)	Meloland and Grumble Road River Kilometer 62.4 (Mile 39)	Keystone Road River Kilometer 50.8 (Mile 31.75)	Hwy. 111 River Kilometer 25.6 (Mile 16)	Garst Road River Kilometer 5.6 (Mile 3.5)
Total Dissolved Solids	mg/l	1935	2635	2655	2760	2655
Suspended Solids	mg/l	21	181	122	40	302
Volatile Suspended Solids	mg/l	3	14	11	15	20
Settleable Solids	ml/l	0.1	0.2	0.2	0.2	0.4
MBAS	mg/l	0.02	0.0	0.04	0.0	0.0
Phosphate PO_4	mg/l	0.06	0.62	1.0	0.10	1.6
Nitrate NO_3	mg/l	0.55	42	53	43	42
pH	-	7.9	8.2	8.0	7.7	7.7
20°C BOD_5	mg/l	1.0	2.0	6.0	6.0	7.0

Discharges affecting the New River above Heber KGRA include that of the City of Calexico and those in Mexico. Municipal sewage is treated in an activated sludge secondary treatment plant before discharge to the river by Calexico; adverse impact upon river water quality, if any, by that city is therefore minimal.

On the other hand, according to the Regional Water Quality Control Board:[10]

> The City of Mexicali, in Mexico discharges at least the following wastes into New River in the vicinity of the International Boundary with California:
>
> (a) Raw sewage from a population of approximately 130,000;
>
> (b) Partially treated sewage (discharge from raw sewage stabilization ponds) from a population of approximately 370,000;
>
> (c) Untreated industrial wastes from numerous industries, including a major slaughterhouse;
>
> (d) Garbage dump drainage; and,
>
> (e) General community and industrial trash.......
>
> Although the City of Mexicali has diverted a major portion of its untreated sewage away from the New River, and is constructing additional trunk lines to divert additional portions, this diversion hardly keeps pace with the City's growth as indicated by the following data:

MEXICALI SEWERAGE DATA

	Population Discharging Raw Sewage	
Year	To Stabilization Ponds	To New River
1955	0	25,000
1975	370,000	130,000

The Regional Board goes on to describe the nature of the stream flow at the international boundary, 5 km (3 mi) above the Heber KGRA, as follows:

> Sewage and other waste discharged from Mexicali cause the following conditions to exist in New River at the International Boundary and downstream into California:
>
> (a) Plainly visible sewage solids and other waste matter in the New River.
>
> (b) A zero dissolved oxygen content, causing nuisance conditions, which prohibit the development of aquatic resources.

(c) A biochemical oxygen demand (which is a measure of decomposable organic matter) reaching 237 milligrams per liter of New River water, which causes gross septic conditions in the river water.

(d) High fecal coliform counts reaching a maximum of 24 million fecal coliform colonies per 100 milliliters of New River water, which is a gross unsanitary condition and health hazard to the people of Imperial Valley, California.

State and federal agencies continue to press for completion of facilities in Mexico which would bring about acceptable water quality conditions in the New River at the boundary. Mexican authorities anticipate completion of needed interceptor sewers, now under construction, by January 1977. In the interim, the condition of the river in and near Heber KGRA will remain highly unsanitary. Even with termination of all raw sewage discharge, it does not appear that the Mexican discharge will entirely meet state/federal water quality objectives for the New River.

Salton Sea. Salton Sea water is sodium chloride in character and similar to ocean water. Its 38,000 mg/l salinity is greater than that of the ocean. The water is unsuitable for either domestic or agricultural purposes. Because there is no outflow from the Sea, the concentration of TDS is increasing (see Refference 3). Analyses of Salton Sea water by DWR are listed in Table 1.6-13 (see Reference 2).

TABLE 1.6-13

ANALYSES OF SALTON SEA WATER
STATE DEPARTMENT OF WATER RESOURCES

	Unit	9/22/75*	5/8/67	9/15/64
Calcium (Ca)	mg/l	-	873.0	-
Magnesium (Mg)	mg/l	-	1073.0	-
Sodium (Na)	mg/l	-	10300.0	9880.6
Potassium (K)	mg/l	-	219.0	-
Carbonate (CO_3)	mg/l	-	-	-
Bicarbonate (HCO_3)	mg/l	-	153.0	-
Sulfate (SO_4)	mg/l	8940.0	7910.0	-
Chloride (Cl)	mg/l	15669.0	14810.0	13550.0
Nitrate (NO_3)	mg/l	-	12.0	0.0
Fluoride (F)	mg/l	-	0.0	-

TABLE 1.6-13 (Cont'd)

	Unit	9/22/75*	5/8/67	9/15/64
Boron (B)	mg/l	-	3.0	10.0
Silicon Oxide (S_iO_2)	-	-	-	-
Hardness Calcium Carbonate (CA CO_3)	mg/l	-	6595.0	-
Total Dissolved Solids	mg/l	39470.1	36966.0	33900.0
EC x 10^6	umho	44444.0	-	-
Temperature	C	30.5	26.6	27.8
pH	-	8.5	6.9	8.2
Dissolved Oyxgen	mg/l	5.9	-	-
Turbidity	units	4a	-	-

* Sampled by Department of Water Resources for preparation of Bulletin 130-75. Hydrologic Data 1974, Volume V, Southern California. Station Location: Salton Sea State Park

The most serious problem is the Sea's increasing salinity and its possible adverse effects on the salt water game fishery. Most fishing is for the Corvina, which weigh from 1.4 to 11 kg (3 to 25 lbs). According to the State Department of Fish and Game, the TDS concentration must not exceed about 40,000 mg/l for the fishery to survive (see Reference 3). By 1973, the TDS concentration had reached about 38,000 mg/l. Additional salts are continually brought into the sea by irrigation drainage. No salts are removed because the sea is a sink and the water evaporates.

The average salt inflow to the sea between 1963 and 1972 was estimated at 4.03 billion kg (4.44 million tons) per year. This results in an annual increase of 550 mg/l TDS concentration at the present volume of water in the sea. Paradoxically, the inflow is also a "fresh water" replenishment for the sea, since its salinity is about 2600 mg/l TDS.

The Salton Sea is also abundantly supplied with mineral nutrients, primarily compounds of nitrogen and phosphorous which encourage algae growth. Although the fishery has probably benefited from these nutrients, there are a number of adverse effects.

The immediately visible results are discoloration and reduction of clarity. In addition, death and decomposition of large masses of algae often temporarily deplete dissolved oxygen in certain areas. The anaerobic condition produces obnoxious odors, and at times, has killed fish and intermediate food chain organisms (see Reference 3).

A joint federal/state investigation was conducted in 1972-73 seeking to preserve the sport fishery and recreational use of the Salton Sea, consistent with its primary purpose as a repository for agricultural drainage. Each of the several alternative plans evaluated were found economically and environmentally justified and financially feasible.

Colorado River Water. Since it is the origin of all irrigation, municipal and industrial water used in Imperial Valley, quality of Colorado River water at Imperial Dam is a major factor in water resources management in the valley. Table 1.6-14 lists quality of water at Imperial Dam during water year 1972/73. More recent data, made available by IID, shows the following water quality in AAC below Drop No. 1: May 6, 1975, 854 mg/l TDS; December 31, 1975, 902 mg/l TDS.

TABLE 1.6-14

ANALYSES OF COLORADO RIVER WATER

		Imperial Dam	
Constituent or Characteristic	Units	Maximum	Average*
pH	Scale	8.1	8.0
Conductivity	Micromhos	1403.0	1306.0
Calcium (Ca)	mg/l	95.0	88.0
Magnesium (Mg)	mg/l	36.0	34.0
Sodium (Na)	mg/l	173.0	145.0
Potassium (K)	mg/l	5.1	5.0
Carbonate (CO_3)	mg/l	0.0	0.0
Bicarbonate (HCO_3)	mg/l	188.0	174.0
Sulfate (SO_4)	mg/l	370.0	336.0
Chloride (Cl)	mg/l	152.0	128.0
Nitrate (NO_3)	mg/l	2.2	1.6
Fluoride (F)	mg/l	0.7	0.5
Boron (B)	mg/l	0.21	0.18
Total Dissolved Solids	mg/l	962.0	856.0
Total Hardness	mg/l	385.0	360.0

* Mathematic Average of DWR Quarterly Samples for 1972/73 water year.

With its salt burden as high as 902 grams per cubic meter (1.25 T per AF), it can readily be seen that the river intensifies salinity problems in the valley. After completion of AAC, the river's salinity at Imperial Dam averaged about 700 parts per million. For the period 1965 to 1969, the salinity increased to an average of 875 parts per million.

Due to the predominance of clay and heavy loam soils in Imperial Valley, most farmers have installed tile drainage systems and use irrigation water in excess of plant needs to leach out the salt and thus maintain a favorable salt balance in the root zone.

The amount of water needed for leaching increases in proportion to the salinity of the applied irrigation water. Any increase in salinity of irrigation water results in a penalty since more water is required for the equivalent crop output.

The Colorado River Board of California has projected that river salinity at Imperial Dam will increase to 1340 mg/l by the year 2000 unless salinity control measures are undertaken.

Recognizing the problems created by increasing salinity, the Environmental Protection Agency (EPA) on December 18, 1974 issued a regulation requiring the states of the Colorado River Basin to adopt water quality standards for salinity, consisting of numeric criteria and a plan for implementation for salinity control.[11] Consistent with the regulation, the recommended flow-weighted average annual numeric salinity criteria for three locations in the lower main stem of the Colorado River system are as follows:

Below Hoover Dam	723 mg/l TDS
Below Parker Dam	747 mg/l TDS
Below Imperial Dam	879 mg/l TDS

Agricultural Drains. Because farm drainage has the greatest influence in quality of local surface waters in the Imperial Valley, data was obtained from IID to illustrate the salt load of a typical agricultural drain. The data is presented in Table 1.6-15, showing TDS concentrations ranging randomly from 892 to 2773 mg/l at the same point of discharge within a span of eight years.

TABLE 1.6-15

SALINITY OF AGRICULTURAL DRAINAGE
IMPERIAL IRRIGATION DISTRICT

Location of Sample: Beyschlag Pump

Date Taken	TDS mg/l
10/13/67	2986
1/12/68	2661
4/12/68	1698
7/11/68	1035
10/11/68	989
1/17/69	1028
4/11/69	1121
7/11/69	1188
10/08/69	1420
1/09/70	1101
4/10/70	2216
7/10/70	995
10/09/70	3729
1/08/71	3483
4/09/71	2601
7/13/71	1055
10/08/71	1473
1/14/72	2037
4/04/72	2548
7/18/72	2322
10/13/72	3377
1/12/73	1825
4/06/73	2773
7/20/73	1261
10/12/73	1725
1/15/74	1460
4/19/74	1579
7/19/74	1399
10/24/74	1566
1/30/75	2248
4/04/75	2004
7/11/75	892
10/17/75	1476

Ground Waters. Brackish ground water is present to a moderate degree throughout the Imperial subunit, ranging from 3,000 to 15,000 mg/l TDS. Its principal constituent is sodium chloride. Water from deeper wells in the valley, many of which are artesian, is normally warm, contains high concentrations of boron, chloride and fluoride, and is generally unsuitable for either agricultural or domestic use. Shallow water, usually at levels less than 40 feet is affected by the Colorado River water applied extensively in the irrigated areas. In areas where subsurface drainage is good, the quality approaches that of applied irrigation water. However, in areas where drainage is poor, TDS concentrations may range as high as 73,000 mg/l.

Quality of ground waters beneath the Heber KGRA may readily be determined by pumping and sampling a number of the existing IID observation wells. In the absence of such field data, the salinity levels of Table 1.6-15 may be referred to as a reasonable approximation of existing conditions.

1.6.8 Water Quality Control

Discharges of waste water to the navigable waters of the United States are regulated under the provisions of Public Law 92-500, the 1972 amendments to the Federal Water Quality Control Act. The term "navigable waters" is broadly interpreted to include all surface discharges except those which are confined on the discharger's property and percolate into the ground. EPA is the federal agency with responsibility for carrying out provisions of the law.

In California, the authority of EPA to regulate waste discharges to navigable waters has been delegated to the state government. California has long conducted its own water quality control program, as provided in the Porter-Cologne Act, using a number of boards operating throughout the state. The board having jurisdiction over the Imperial Valley is the California Regional Water Quality Control Board, Colorado River Basin (Regional Board), headquartered at Indio. That agency issues waste discharge requirements, including National Pollutant Discharge Elimination System (NPDES) permits, for all waste discharges in the watershed. Discharges are monitored; enforcement action may be taken in case of infractions.

The Regional Board is also a water quality control planning agency. Its Water Quality Control Plan Report, West Colorado River Basin, has been referred to frequently in the discussion of hydrology to this point (see Reference 3). That document spells out the beneficial water uses the Regional Board intends to protect and restore, the water quality levels needed to sustain the beneficial uses and measures the Regional Board will take to accomplish these levels.

In the Imperial Planning unit*, municipal and industrial uses are designated as beneficial uses for ground water. The following beneficial uses are listed for protection in the surface water of the New River: non-contact water recreation, which involves the presence of water but does not require contact with water, such as picnicking, sunbathing, hiking, beachcombing, camping, pleasure boating, etc.; agricultural supply, including crop, orchard and pasture irrigation, stock watering, support of vegetation for range grazing and all uses in support of farming and ranching operations; warm fresh water habitat, i.e., providing a warm-water habitat to sustain aquatic resources associated with a warm-water environment; wildlife habitat, providing a water supply and vegetative habitat for the maintenance of wildlife; fresh water replenishment, providing a source of fresh water for replenishment of inland lakes and streams of varying salinities.

Beneficial uses declared for the Alamo River and for IID water supply canals are identical with those listed above for the New River. IID supply canals are also protected for municipal supply, while IID drains include only warm-water habitat, wildlife and fresh water replenishment as beneficial uses.

The Salton Sea is protected for both contact and non-contact recreation, wildlife habitat and saline water habitat.

Water quality objectives contained in the Basin Plan Report establish nondegradation as the basic aim of the Regional Board. Characteristics of surface receiving waters explicitly controlled under the objectives are color, taste, odor, floating material, suspended material, settleable material, oil and grease, biostimulatory substances (total nitrate and total phosphate), sediment, turbidity, pH, dissolved oxygen, bacteria, temperature, toxicity, ammonia, pesticides, chemical constituents (inorganic and organic) and radioactivity. Ground water quality objectives relate to tastes, odors, bacteria, chemical constituents, radioactivity and specific objectives for selected areas. No specific objectives have been adopted for the Heber KGRA ground waters.

The Regional Board is now carrying out an implementation program for accomplishment of its water quality objectives. One focus of attention is "point sources," that is, upgrading of discrete municipal and industrial waste discharges. However, the Plan points out that domestic and industrial wastes, in terms of nutrients and TDS, amount to less than one percent of the total wastes generated in the Planning Area.(3) Most of the waste water flow is agricultural drainage.

---

* Coterminus with Imperial Hydrological Unit.

The need for irrigation water and benefits of existing practices are recognized by the Regional Board, which points out that the Salton Sea is the major repository for mineralization irrigation return flow. However, the salinity objective for the sea directs itself toward the problem of increasing concentrations as follows:

> The present salinity of the Salton Sea is about 38,000 mg/l. In order to protect the beneficial uses of the Sea, the water quality objective is to reduce the average salinity to about 35,000 mg/l. The objective cannot be achieved without a salinity control project. Until a salinity control project is implemented, the objective is to limit the rate of increase of total dissolved solids of the Salton Sea to the lowest possible value, consistent with its primary purpose as a reservoir to receive and store agricultural drainage and seepage water.

The IID and Coachella Valley County Water District have applied for and received NPDES permits for their agricultural discharges. Monitoring is required, but no effluent limitations are in effect at this time.(3) Implementation efforts of the Regional Board are being carried out through cooperative interagency study of the irrigated areas. In addition interstate and federal salinity control activities in the Colorado River Basin are being supported, as well as a cost-effective salt removal program for the Salton Sea, if one can be developed.

(The Regional Board points out that it sets requirements for disposal of all geothermal wastes. Plans for using geothermal resources include proper disposition of concentrated brines by injecting them back into the geothermal aquifer from which they issued, according to the report.)

1.6.9 Industrial Waste Disposal Sites

The Basin Plan recognizes the need for sites upon which hazardous and toxic wastes can be safely disposed. In California, this category of waste is known as Group 1 Waste, and sites judged satisfactory for receiving Group 1 Wastes are known as Class I disposal sites. In general, Class 1 disposal sites are scarce in California.

The Water Quality Control Plan Report lists 13 potential Class I waste disposal sites in and near the Imperial Valley. Among these are: Superstition Mountain, 16 km (10 mi) west of Brawley; eastern Jacumba Mountain (south of Ocotillo), 44.8 km (28 mi) west of El Centro; Jacumba Mountains (vicinity of Devils Canyon), 44.8 km (50 mi) west of El Centro; Fish Creek Mountains, 80 km (50 mi) by road west of Brawley; Vallecito Mountain (northeast end), 76.8 km (48 mi) west of Brawley; Chocolate Mountains (northern portion, near Imperial-Riverside County line), 54.4 km (34 mi) north of Brawley; Chocolate Mountains (north of Niland), 48 km (30 mi) north of Brawley; Chocolate Mountains (northeast of Niland), 46.4 km (29 mi) north of Brawley; Chocolate Mountains (east of Niland), 40 km (25 mi) northeast of Brawley; Chocolate Mountains (northeast of Amos and Regina), 32 km (20 mi) northeast of Brawley; Chocolate Mountains (northeast of Glamis), 67.2 km (42 mi) east of Brawley; Cargo Muchaco Mountains, 40 km (25 mi) east of El Centro; Coyote Mountains, 44.8 km (28 mi) west of El Centro.

REFERENCES - Hydrology

1. Gatewood, J.S. Floods in the Colorado River Basin Below Boulder Dam, September 1939, U.S. Geological Survey, May 1940.

2. Werner, S. L. et al Geothermal Wastes and the Water Resources of the Salton Sea Area, State of California Department of Water Resources Bulletin 143-7, February 1970.

3. Water Quality Control Plan Report, West Colorado River Basin (7A), California Regional Water Quality Control Board, Colorado River Basin Region, April 1975.

4. Interim Water Quality Control Plan for the West Colorado River Basin, California Regional Water Quality Control Board, Colorado River Basin Region, June 1971.

5. Colorado River and Imperial Valley Soils, Imperial Irrigation District, Bulletin 1075.

6. Water and Power Facts, Imperial Irrigation District

7. Soil Survey of Brawley Area, Bureau of Soils, U.S. Department of Agriculture, 1923.

8. Imperial Irrigation District General Map, Imperial Irrigation District, January 1972.

9. Twogood, D.A., Assistant General Manager, Imperial Irrigation District, letter dated February 18, 1976 and attachments.

10. Pollution of New River in Imperial Valley, California, Resulting from Waste Discharges by the City of Mexicali, Mexico, California Regional Water Quality Control Board, Colorado River Basin Region, September 1975.

11. Hurlburt, M.B., The Colorado, Still a Problem River, Colorado River Board of California, May 1970.

12. Need for Improving Salinity of Colorado River (Draft), Colorado River Board of California, May 1970.

13. Proposed Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control Colorado River System, Colorado River Basin Salinity Control Forum, June 1975.

14. Franzini, J.B. and Linsley, R.K., Elements of Hydraulic Engineering, 1955.

15. Design and Procedure Manual, San Diego County Flood Control District, December 1969.

1.7 CLIMATOLOGY

1.7.1 Air Basin Description

The project site lies in the Southeast Desert Air Basin of California. This region includes all of Imperial County, that portion of San Diego, Riverside, San Bernardino and Los Angeles Counties east of the peninsular range, and associated mountain ranges extending up the Tehachapi Mountains, and the portion of Kern County South and East of the Tehachapi Mountains. As shown in Figure 1.7-1, this air basin is one of eleven air basins established by the California Air Resources Board in 1968.[1] Each of these basins defines geographical areas having similar meteorological and air pollution conditions.

The Southeast Desert Air Basin comprises a relatively flat semi-desert area with some rolling hills, extending from the Nevada and Arizona borders to the eastern edge of the coastal mountain range. The project site lies in the southern-most central portion of the basin, approximately 10 km (6 miles) south of El Centro. This region has a climate common with the Great Basin Valleys, lying to the north, being generally windy and hot.

1.7.2 Topography of the Region

The air which moves across California is greatly modified in its course by the very rugged terrain of the state. The northern three-fourths of the state has two main mountain chains which parallel the coast and rise to great heights. The southern one-fourth of the state is in two main sections, a mountainous area to the west which is broken up into a series of ranges, some at elevations greater than 3050 m (10,000 feet) which enclose various valleys and basins and the desert to the east.

The Los Angeles Basin is bounded on the north by the San Gabriel Mountains and the San Bernardino Mountains. To the south, it is bounded along the coast by the Santa Ana Mountains and further inland by the San Jacinto Mountains. This basin is connected on the east by the San Gorgonio Pass to the great interior desert area east of the mountains. To the southeast of the San Gorgonio Pass is Coachella Valley, a large interior valley between the San Jacinto Mountains and the little San Bernardino Mountains. In a distance of about 65 km (40 miles) the valley floor drops about 610 m (2,000 feet) to sea level. The terrain continues to drop below sea level and enlarges to form the Salton Sea, a low area which opens to the Gulf of California. The climate of this eastern desert

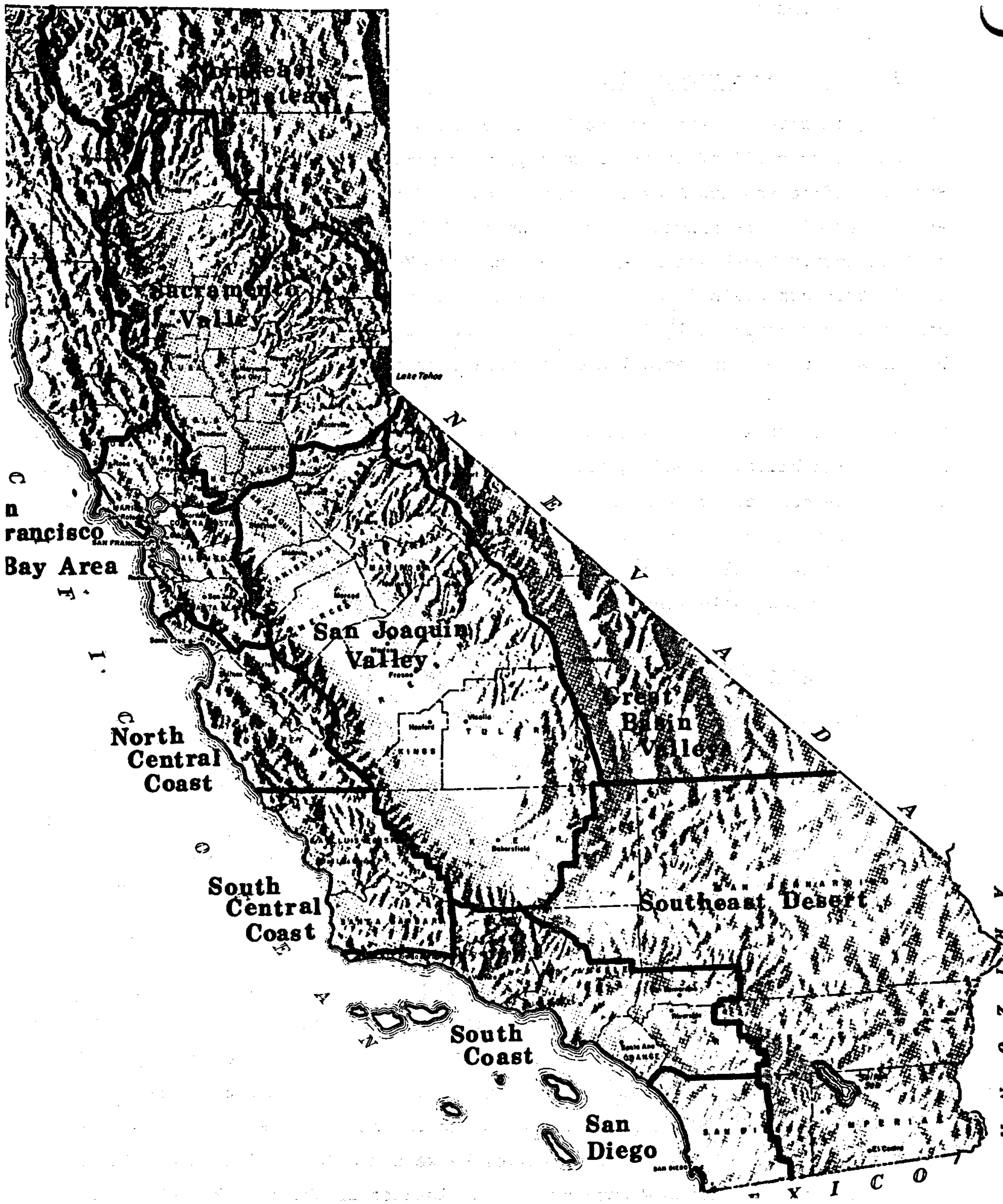


Figure 1.7-1 California Air Basins (Source: State of California, Air Resources Board)

region is influenced considerably by the high mountains to the west and by the low elevation.

1.7.3 General Climatology

The climatology of California is varied, being influenced mainly by the Pacific Ocean.[2] In the region of 30 degrees north latitude to the west of California there is the "semi-permanent Pacific high." It is a region of high pressure that shifts northward and southward on a yearly basis in response to the changing heating of the earth's atmosphere.

This semi-permanent Pacific high, at its northern-most extent during the summer, shields the southern California area from storm centers moving east from the Pacific. During this time, the coastal section of the southern California area is under the influence of the cool, moist Pacific air, whereas the eastern desert of southern California is, basically, under the influence of the hot, dry air from the continent. During this time, the entire southern California area has its dry season, with what precipitation there is coming from sources other than major storm centers. Temperatures can become very high in the eastern desert region and in internal, mountain-locked valleys in the mountainous region. A short distance away, however, along the ocean, temperatures may be very mild, indeed, even cool.

In the fall, as the semi-permanent Pacific high begins to shift southward, storms begin to move further and further south into the west coast of the United States, bringing large amounts of moisture with them. As these mositure laden air masses begin to ascend the California mountains, they cool and precipitation results. By winter, these storm centers are able to penetrate into the southern California area, making winter the rainy season for the entire southern part of the state. Even so, the total preciptiation for areas in the eastern desert can be as little as 5-13 cm (2 to 5 in) per year. In the mountains to the west, over which the moisture laden air has to pass in order to get to the south-eastern desert, annual rainfalls may reach 76-102 cm (30 to 40 in). Along the coast, it may be only 25-38 cm (10 to 15 in). Snow will be found at high elevations during this period.

As the semi-permanent Pacific high begins to move north again in the spring, the Pacific storm centers again begin to be deflected to the north, and the southern California area again approaches a dry summer period.

Occasionally, the atmospheric circulation patterns are such that winds flow out of the central interior of the continent into the southern California desert area and coastal area, bringing very dry and very high velocity winds to the area. This condition is known as the "Santa Ana Wind." These winds can blow as high as 160 km/hr (100 m.p.h.), particularly when local topography such as narrow descending valleys are traversed by them. The occurrence of such winds can lead to serious fire problems on the dry southern California hillsides and mountains. This often results in the temporary closing of highways to vehicles which are susceptible to high wind, such as trucks and light cars. It also can result in the restriction of use of recreational facilities, such as the forests and parks.

On other occasions, moist air from the Gulf of Mexico is able to reach the southern regions, bringing some rain. Thunderstorms may occur throughout the year, being usually light and infrequent along the coast. In the mountains of the interior, they can become more intense and usually occur after a long hot spell, when cool, moist air moves in. No precipitation is produced by many of the thunderstorms, with the result that forest fires and range fires occur frequently. On the other hand, heavy precipitation does occasionally result.

Along the coast, relative humidities throughout the year are moderate to high. Inland, the humidity tends to be high during the winter and low during the summer. The greater the distance from the ocean, the lower the relative humidity tends to be, particularly in areas that are closed off from easy access to the maritime air by narrow passes through mountains or restrictions between valleys.

The extremes in temperature at the same time and only short distances apart, can be great. Temperature differences of a number of tens of degrees can exist between a place along the coast and an interior valley only a few miles away. The coastal areas tend to be moderate throughout the year. The interior valleys and basins can become very hot, often over 38°C (100°F) in the summer.

The eastern desert region is effectively isolated from the marine air to the west by the high mountains.[3] In the summertime the relative humidity is very low, commonly being less than 10% during the hottest part of the day. At nighttime, however, the air cools considerably as the ground gives up much heat by radiation into the clear skies. The area is often windy since there is extreme heating of the air which causes strong updrafts. Winds along the surface are little impeded by the sparse vegetation. The winds are mostly from the south and west. Occasionally, moisture does get into the area from the Gulf of California or from the Gulf of Mexico.

In the fall, and into the winter, some Pacific frontal systems break through, but become relatively weak by the time they reach the area. Most of the small amount of precipitation which the region receives does come as a result of these fronts. The yearly averages, for some places, are as low as 5 cm (2 in). The nights become quite cool, again due to the great loss by radiation of energy into the clear sky. Some cold, dry air occasionally is able to get over the high mountains to the north. However, it is warmed by compression as it drops to low elevations of the southern part of the state and the area has infrequent subfreezing weather. There can be much variation in nighttime temperatures in adjacent high and low areas, becuase the cooled air flows to the low areas and, owing to low winds at night, settles there.

During the spring, the activity again shifts to that of the summer type.

1.7.4 <u>Temperature and Humidity</u>

The climate of Imperial Valley is typical of desert regions. The winter extends from late October to mid-April with temperatures sufficiently low as to require home heating. During the winter mostly clear skies and abundant sunshine are prevalent and out-of-door temperatures are comfortable during the daylight hours. The period from early November through March is the rainy season with an average precipitation rate of about 7.5 cm (3 in) over 16 hours of rainfall during this season.

The sun shines practically every day even during the winter months of December and January when sunshine in this region averages more than eight hours per day. The following exteme temperature conditions up through 1974, were recorded at Imperial Irrigation Districts weather station at Imperial.[4]

Maximum temperature
48 degrees C (119 degrees F), recorded four times since 1914; July 14, 1926; July 16, 1936; July 25, 1943; and June 25, 1970.

Minimum temperature
-9 dgree C (16 degree F), recorded January 22, 1937.

Mean Temperature
35.4 degree C (95.9 degree F) is highest monthly mean temperature, recorded August 1969; 5.7 degree C (42.3 degree F) is lowest monthly mean temperature, recorded February, 1939.

The University of California maintains a weather station at Holtville, which is located approximately 16 km (10 miles) northeast of the project site.[5] Temperature, humidity and rainfall records have been maintained at this station since 1937. The most recent weather records for temperature and humidity are summarized in Tables 1.7.4-1A and 1.7.4-1B for the annual period of July 1974 through June 1975. In Table 1.7.4-1A the temperatures are recorded in degrees F and in Table 1.7.4-1B, in degrees C.

The most complete weather records are maintained by the Imperial Irrigation District. A station is operated at Imperial, approximately 13 km (8 miles) north of the project site, where temperature, humidity, rainfall, wind direction and sunlight incidence are recorded.[4] Annual daily records of these parameters are maintained for every month of the year. In Figure 1.7-2 temperature readings are plotted in degrees F and degrees C, for each month in 1975. Humidity values for this same period are plotted in Figure 1.7-3.

Still another source of temperature data is that provided by the U.S. Department of Agriculture at their Imperial Valley Conservation Research Center in Brawley, California.[6] At the Brawley station, which is located about 27 km (17 miles) north of the project site, daily temperature and rainfall observations are made. Average maximum and minimum temperatures, together with daily average, normal, highest and lowest temperatures for each month of 1975 are summarized in Table 1.7.4-2A, expressed in degrees F and Table 1.7.4-2B, in degrees C.

A comparison of the various temperature data developed for 1975 at the different stations in the vicinity of the project site is represented in Table 1.7.4-3. Temperatures are expressed in both degrees F and degrees C in this summary. These data indicate considerable agreement in temperature observations recorded at all three monitoring sites. The normal values in this tabulation, represent the predicted annual average temperature, based on approximately fifteen years of observations at the Brawley station of the U.S. Department of Agriculture.

1.7.5 Rainfall

June is the driest month of the year in Imperial Valley. Since 1914, only once was there measurable rainfall during that month; 0.10 cm (0.04 in) on June 2, 1948. Traces were recorded in 1918, 1922, 1924, 1929, 1930 and 1932.[4] The maximum rainfall in one day was recorded September 6, 1939, when 10.2 cm (4.08 in) were measured. The maximum total for the month was recorded at 18 cm (7.06 inches) in September 1939. The year 1939 was the highest year on record with

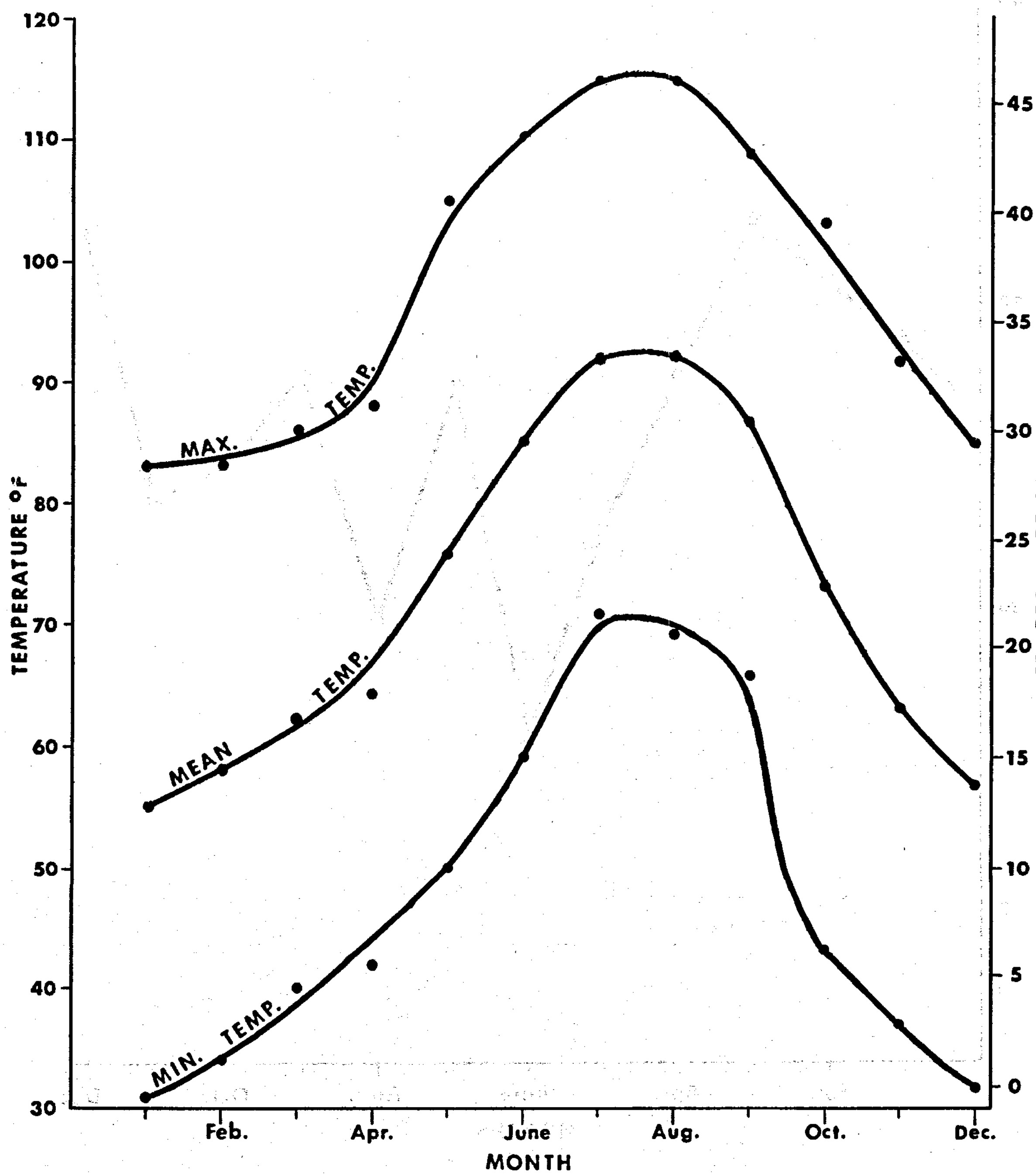


Figure 1.7-2 Temperature Profile 1975 - Imperial Station - Imperial Valley, California (Source: Ref. 4 Imperial Irrigation District)

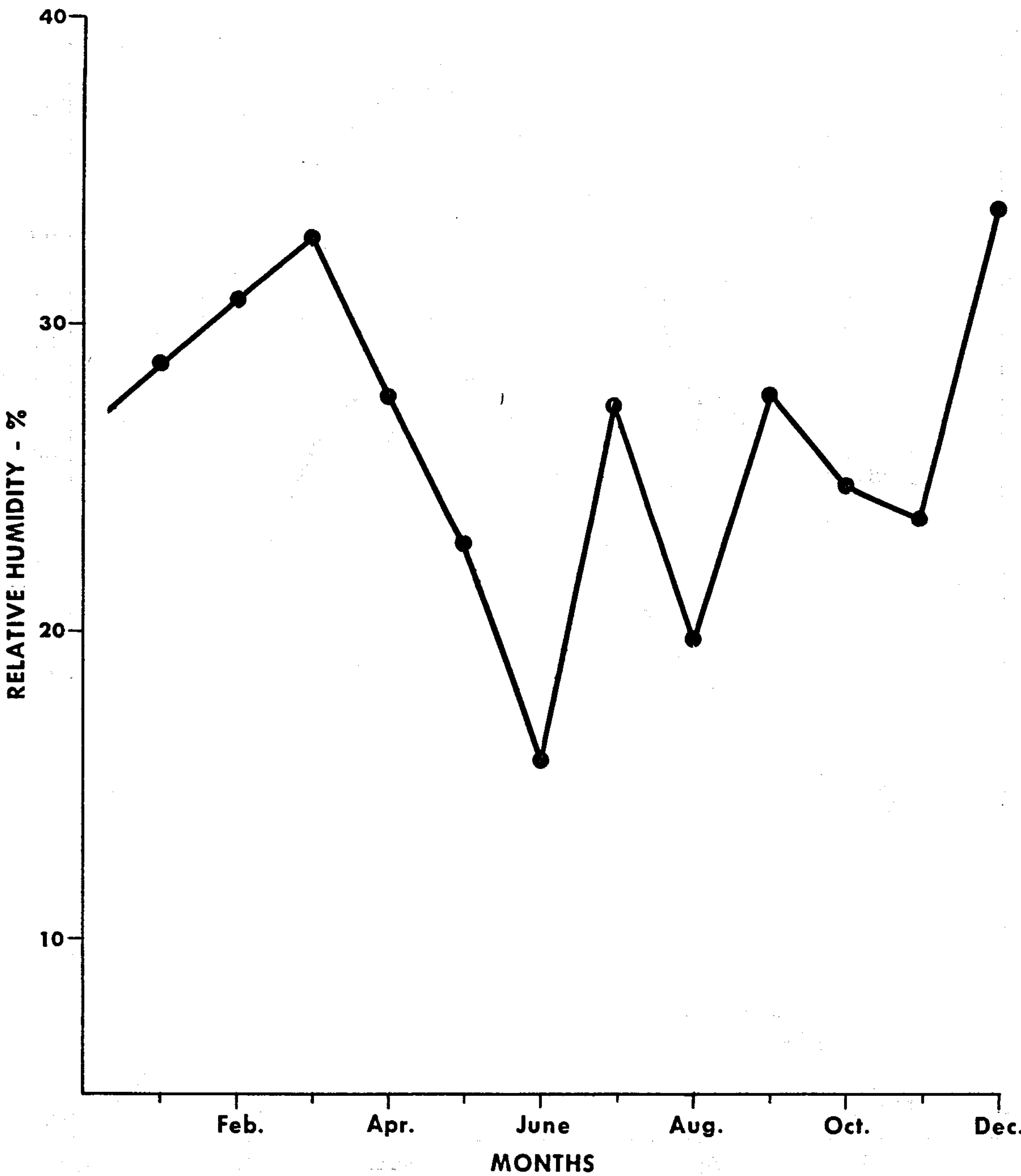


Figure 1.7-3 Humidity Profile 1975 - Imperial Station - Imperial Valley, California

TABLE 1.7.4-1A

TEMPERATURE AND HUMIDITY DATA - ANNUAL SUMMARY REPORT - 1974-1975
HOLTVILLE, CALIFORNIA WEATHER STATION

	*Temp.Deg.F. - T(80")				**Temp.Deg.F - T(31")		Relative Humidity - %		Number of Days Temperature Attained			
Month	Max.	Min.	Mean Max.	Mean Min.	Max.	Min.	Max.	Min.	90°F+	100°F+	110°F+	32°F-
July 1974	111	62	102	73	106	79	74	33	31	24	3	0
Aug.	110	62	105	70	108	76	70	24	31	31	1	0
Sept.	111	62	101	71	104	77	76	30	30	16	1	0
Oct.	103	49	91	60	90	63	67	35	19	3	0	0
Nov.	90	38	81	48	78	49	56	34	2	0	0	0
Dec.	81	29	68	39	65	39	43	35	0	0	0	4
Jan. 1975	83	31	70	37	74	46	54	39	0	0	0	5
Feb.	84	31	70	40	79	52	63	46	0	0	0	2
March	85	36	73	45	82	57	67	46	0	0	0	0
April	85	38	74	46	84	59	79	49	0	0	0	0
May	101	53	87	57	101	69	73	47	1	1	0	0
June	108	52	99	61	111	77	88	39	14	14	0	0

* Temperature, 80 inches above ground level.

** Special temperature, 31 inches above ground level.

Source: Ref. 5, University of California.

TABLE 1.7.4-1B

TEMPERATURE AND HUMIDITY DATA - ANNUAL SUMMARY REPORT - 1974-1975
HOLTVILLE, CALIFORNIA WEATHER STATION

	*Temp.Deg.C - T(200 cm)				**Temp.Deg.C - T(80 cm)		Relative Humidity-%		Number of Days Temperature Attained			
Month	Max.	Min.	Mean Max.	Mean Min.	Max.	Min.	Max.	Min.	$32^{\circ}C$+	$38^{\circ}C$+	$43^{\circ}C$+	$0^{\circ}C$-
July 1974	44	17	39	23	41	26	74	33	31	24	3	0
Aug.	43	17	41	21	42	24	70	24	31	31	1	0
Sept.	44	17	38	21	40	25	76	30	30	16	1	0
Oct.	39	9	33	16	32	17	67	35	19	3	0	0
Nov.	32	3	27	9	26	9	56	34	2	0	0	0
Dec.	27	-2	20	4	18	4	43	35	0	0	0	4
Jan. 1975	28	-1	21	3	23	8	54	39	0	0	0	5
Feb.	29	-1	21	4	26	11	63	46	0	0	0	2
March	29	2	23	7	28	14	67	46	0	0	0	0
April	29	3	23	8	29	15	79	49	0	0	0	0
May	38	11	31	14	38	21	73	47	12	1	0	0
June	42	11	37	16	44	25	88	39	27	14	0	0

* Temperature, 200 cm above ground level.

** Special temperature, 80 cm above ground level.

Source: Ref. 5, University of California

TABLE 1.7.4-2A

TEMPERATURE DATA - 1975
BRAWLEY CALIFORNIA WEATHER STATION

Month	Temperature - °F							Number of Days Temperature Attained			
	Avg. Max.	Avg. Min.	Avg. Daily	Normal	Departure	Max.	Min.	90°F+	100°F+	110°F+	32°F-
Jan. 1975	69.7	35.3	52.5	52.9	-0.4	82	26	0	0	0	10
Feb.	70.5	39.4	55.0	57.9	-2.9	82	30	0	0	0	5
March	74.7	45.0	59.8	62.1	-2.3	86	37	0	0	0	0
April	75.6	47.6	61.6	67.9	-6.3	87	37	0	0	0	0
May	89.8	56.7	73.3	75.7	-2.4	100	48	16	3	0	0
June	101.6	64.3	83.0	83.4	-0.4	111	55	29	22	1	0
July	106.2	74.0	90.4	90.6	-0.2	116	65	31	30	5	0
August	107.5	71.7	89.6	90.4	-0.8	117	59	31	31	10	0
September	102.4	70.5	86.4	84.1	+2.3	110	52	30	23	1	0
October	88.0	54.7	71.4	73.7	-2.3	104	39	12	3	0	0
November	79.0	42.6	60.8	62.1	-1.3	93	30	3	0	0	1
December	71.2	37.4	54.3	53.8	+0.5	84	28	0	0	0	3
Total	1036.2	639.2	838.1	--							
Annual Average	86.4	53.3		71.2							

Source: Ref. 6, U.S. Department of Agriculture

TABLE 1.7.4-2B

TEMPERATURE DATA - 1975
BRAWLEY CALIFORNIA WEATHER STATION

Month	Temperature - °C							Number of Days Temperature Attained			
	Avg. Max.	Avg. Min.	Avg. Daily	Normal	Departure	Max.	Min.	32°C+	38°C+	43°C+	0°C-
Jan. 1975	20.9	1.8	11.4	11.6	-0.2	28	-3	0	0	0	10
Feb.	21.4	4.1	12.8	14.4	-1.6	28	-1	0	0	0	5
March	23.7	7.2	15.4	16.7	-1.3	30	3	0	0	0	0
April	24.2	8.7	16.4	19.9	-3.5	31	3	0	0	0	0
May	32.1	13.7	22.9	24.3	-1.4	38	9	16	3	0	0
June	38.7	17.9	28.3	28.6	-0.3	44	13	29	22	1	0
July	41.2	23.3	32.4	32.6	-0.2	47	18	31	30	5	0
August	41.9	22.1	32.0	32.4	-0.4	47	15	31	31	10	0
September	39.1	21.4	30.2	28.9	+1.3	43	11	30	23	1	0
October	31.1	12.6	21.9	23.2	-1.3	40	4	12	3	0	0
November	26.1	6.6	16.0	16.7	-0.7	34	-1	3	0	0	1
December	21.8	3.0	12.4	12.1	+0.3	29	-2	0	0	0	3
Total	362.2	142.4	252.1	--							
Annual Average	30.2	11.9	21.0	21.8							

Source: Ref. 6, U.S. Department of Agriculture

TABLE 1.7.4-3

COMPARISON OF TEMPERATURE DATA
FOR THE IMPERIAL VALLEY REGION

Station Location	Source	Ref.	Period	Average Temperatures: Maximum °F	Maximum °C	Minimum °F	Minimum °C	Daily °F	Daily °C	Normal* Daily Avg. Temp. °F	°C
Holtville, Cal.	University of California	5	July 1974-June 1975	85.1	29.5	54.0	12.2	69.6	20.9	71.2	21.8
Imperial, Cal.	Imperial Irrigation District	4	Jan-Dec 1975	86.7	30.4	57.3	14.1	72.0	22.2	71.2	21.8
Brawley, Cal.	U.S. Dept. of Agriculture	6	Jan-Dec 1975	86.4	30.2	53.3	11.8	69.8	21.0	71.2	21.8

*Based on 15 years of daily recorded observations.

21.6 cm (8.52 in) of rain while 1956 was the year of least rainfall at 0.41 cm (0.16 in). The average annual rainfall, as measured up through 1974 by the Imperial Irrigation District,[4] is 7.0 cm (2.76 in).

Practically no snowfall of consequence has been recorded in Imperial Valley, except in 1932. On December 12 of that year, snow started at 8:45 p.m. and by 5:00 a.m. the following day, 6.4 cm (2.5 in), had been recorded. In the southeast portion of the valley, 10 cm (4 in) of snow was reported. This was the only general snowfall of record to cover the entire Valley.

Rainfall records are maintained at the Holtville weather station by the University of California Imperial Valley Agricultural Extension.[5] This station is located approximately 16 km (10 miles) northeast of the project site. In Figure 1.7-4, rainfall levels, as recorded at this station for the period July 1974 through June 1975, have been plotted in inches and centimeters, for each month. Also represented on this bar graph are the normal levels based on average values recorded at this station since 1937. The total rainfall for the 12 month period defined in this curve is 4.67 cm (1.84 in) as compared to the normally expected value of 6.59 cm (2.59 in).

Rainfall observations made at the U.S. Department of Agriculture Station at Brawley[6] indicate a total precipitation level for the period January through December in 1975 to be 3.56 cm (1.40 in). The normal rain level for this period was 5.80 cm (2.28 in), indicating a precipitation deficiency of 2.24 cm (0.88 in) for this particular season.

1.7.6 Wind Speed and Direction

One of the most pertinent meteorological factors seriously influencing the transport and dispersion of air-borne pollutants is wind velocity. The speed component determines the pollutant transfer and dilution rate while the directional factor decides the location of the facility and/or area subjected to air pollution impacts.

Wind direction and sunlight observations in the Imperial Valley are made daily by the Imperial Irrigation District.[4] However, these data, illustrated in Table 1.7.6-1 for March, 1976, are of a general nature and not considered suitable for the evaluation and projection of ambient air quality impacts. The absence of wind speed information from this source eliminates the application of these data for the solution of air pollution problems.

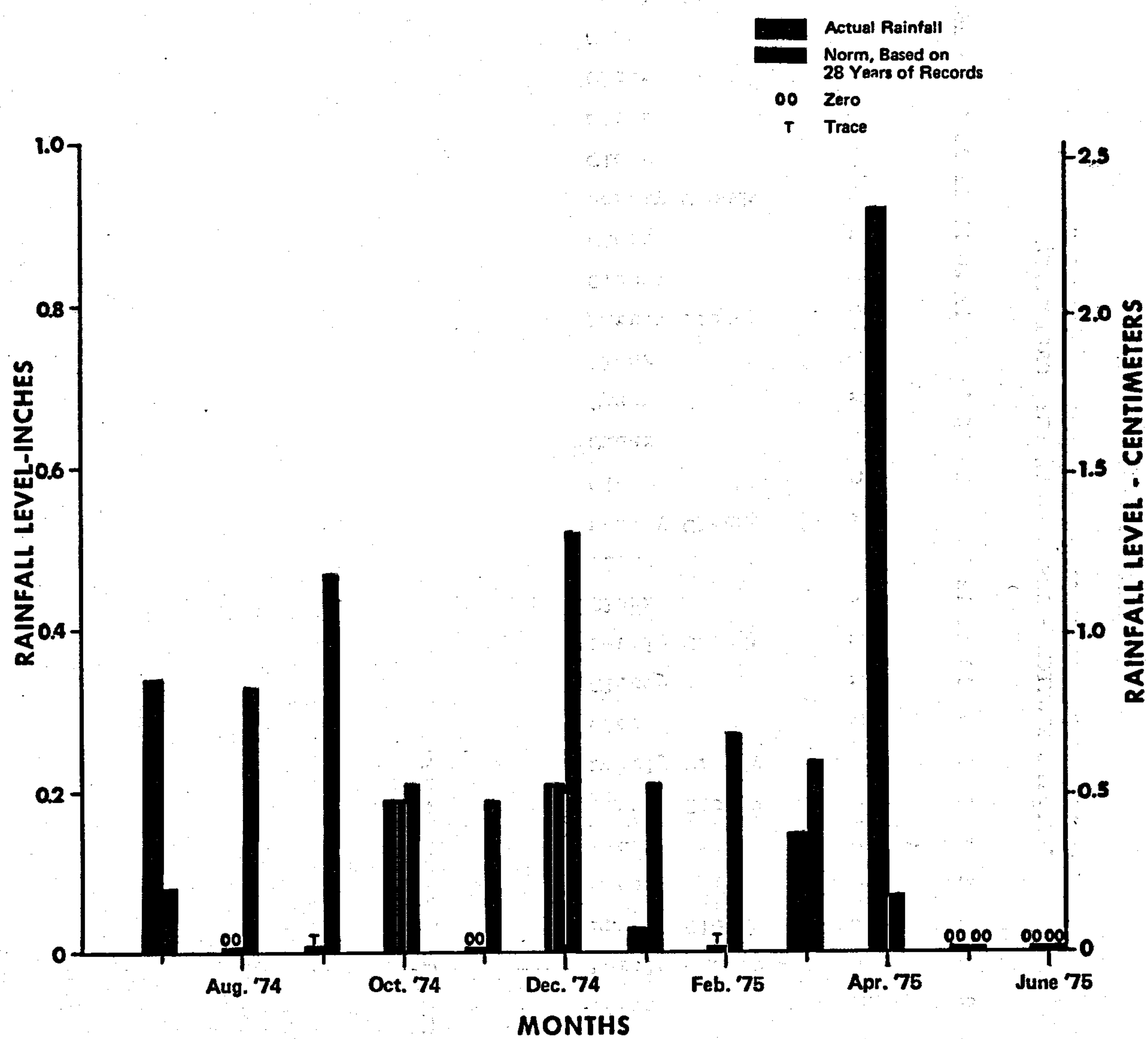


Figure 1.7-4 Rainfall Levels 1974-1975 - Holtville, California
(Source: Ref. 5 University of California)

TABLE 1.7.6-1

WIND DIRECTION AND SUNLIGHT INCIDENCE - MARCH 1975
IMPERIAL STATION - IMPERIAL VALLEY, CALIFORNIA

Date March	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Wind Direction	C	C	NE	NE	Var	Var	SE	SE	W	W	W	W	W	W	C	W	W	C	C	W	W	W	W	C	W	W	C	N	N	N	W
Sunlight Incidence	Clear	Clear	Partly Cloudy	Partly Cloudy	Clear	Clear	Partly Cloudy	Partly Cloudy	Clear	Cloudy	Partly Cloudy	Clear	Clear	Partly Cloudy	Clear	Clear	Clear	Clear	Partly Cloudy	Cloudy	Clear	Partly Cloudy	Clear	Clear	Clear	Clear	Partly Cloudy	Clear	Clear	Clear	Clear

Source: Ref. 4, Imperial Irrigation District

TABLE 1.7.6-2

FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION AT EL CENTRO, CALIFORNIA
FOR MONTHS OF DECEMBER, JANUARY AND FEBRUARY; 1954-1958

Speed, meters per second

Direction	0.5-1.5	2.1-3.1	3.6-5.1	5.7-8.2	8.7-10.8	Greater than 10.8	Avg. Speed	Total
N	121	235	146	86	33	20	4.0	641
NNE	73	131	49	25	4	13	3.4	295
NE	115	151	55	10	2	0	2.5	333
ENE	56	72	13	1	0	0	2.2	142
E	123	168	40	6	0	0	2.2	337
ESE	64	70	38	3	0	0	2.4	175
SE	151	166	90	11	0	0	2.5	418
SSE	82	89	60	8	2	0	2.7	241
S	139	165	53	8	1	0	2.4	366
SSW	105	116	24	8	4	2	2.5	259
SW	239	355	114	54	36	20	3.2	818
WSW	155	399	267	158	124	33	4.5	1136
W	282	901	927	225	76	41	3.8	2452
WNW	136	358	324	58	17	9	3.5	902
NW	187	356	222	53	3	2	3.0	823
NNW	97	139	111	83	24	10	4.1	464
AVG	2.5	4.9	8.3	13.1	18.9	24.7	3.1	
Total	2125	3871	2533	797	326	150		

Total Number of Observations = 10784

Total Number of Calms = 982

Source: Ref. 7, U.S. Department of Commerce

TABLE 1.7.6-3

FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION AT EL CENTRO, CALIFORNIA
FOR MONTHS OF MARCH, APRIL AND MAY; 1954-1958

Speed, meters per second

Direction	0.5-1.5	2.1-3.1	3.6-5.1	5.7-8.2	8.7-10.8	Greater than 10.8	Avg. Speed	Total
N	61	122	102	62	17	3	4.0	367
NNE	43	74	65	28	9	9	4.0	228
NE	82	167	92	12	0	0	2.8	353
ENE	36	81	45	8	0	0	2.9	170
E	104	223	131	11	3	0	2.9	472
ESE	46	148	103	25	0	0	3.2	322
SE	111	259	227	56	1	0	3.3	654
SSE	74	154	116	15	2	0	3.0	361
S	121	206	111	12	0	0	2.7	450
SSW	69	143	64	13	2	0	2.8	291
SW	144	234	239	120	70	44	4.6	851
WSW	56	231	409	581	456	331	7.4	2064
W	117	468	756	550	294	182	5.8	2367
WNW	58	226	305	159	42	16	4.6	806
NW	73	199	192	47	10	2	3.6	523
NNW	38	82	87	62	13	7	4.5	289
AVG	2.6	5.0	8.5	13.4	18.9	25.0	4.7	
Total	1233	3017	3044	1761	919	594		

Total Number of Observations = 11001

Total Number of Calms = 433

Source: Ref. 7, U.S. Department of Commerce

TABLE 1.7.6-4

FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION AT EL CENTRO, CALIFORNIA
FOR MONTHS OF JUNE, JULY AND AUGUST; 1954-1958

	Speed, meters per second							
Direction	0.5-1.5	2.1-3.1	3.6-5.1	5.7-8.2	8.7-10.8	Greater than 10.8	Avg. Speed	Total
N	51	84	58	10	0	1	3.0	204
NNE	22	47	29	5	0	1	3.0	104
NE	62	122	59	5	1	1	2.8	250
ENE	40	136	62	8	3	0	3.0	249
E	126	379	237	37	3	0	3.1	782
ESE	84	307	320	105	7	1	3.8	824
SE	162	640	814	298	31	4	4.0	1949
SSE	82	333	384	120	15	4	3.9	938
S	127	321	219	24	5	2	3.1	698
SSW	64	147	76	11	4	2	3.0	304
SW	81	179	153	79	33	15	4.3	540
WSW	35	122	308	430	277	171	7.2	1343
W	77	164	395	360	189	81	6.0	1266
WNW	38	124	209	74	35	8	4.6	488
NW	65	166	102	31	5	0	3.2	369
NNW	24	67	41	14	3	0	3.3	149
AVG	2.6	5.0	8.5	13.2	18.8	24.4	4.2	
Total	1140	3338	3466	1611	611	291		

Total Number of Observations = 11024

Total Number of Calms = 567

Source: Ref. 7, U.S. Department of Commerce

TABLE 1.7.6-5

FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION AT EL CENTRO, CALIFORNIA
FOR MONTHS OF SEPTEMBER, OCTOBER AND NOVEMBER; 1954-1958

	Speed, meters per second							
Direction	0.5-1.5	2.1-3.1	3.6-5.1	5.7-8.2	8.7-10.8	Greater than 10.8	Avg. Speed	Total
N	85	156	97	38	21	11	3.8	408
NNE	38	88	52	19	5	2	3.3	204
NE	78	143	57	11	0	0	2.7	289
ENE	24	74	17	3	0	0	2.5	118
E	90	166	70	2	0	1	2.6	329
ESE	54	148	85	16	2	0	3.1	305
SE	146	332	255	41	1	0	3.1	775
SSE	70	203	132	28	3	3	3.2	439
S	124	266	136	22	3	0	2.8	551
SSW	78	172	58	18	1	2	2.8	329
SW	141	313	157	58	29	5	3.4	703
WSW	96	382	380	349	186	75	5.4	1468
W	166	763	870	315	101	51	4.3	2266
WNW	96	345	325	75	23	3	3.6	867
NW	116	303	169	38	4	0	3.0	630
NNW	61	125	70	49	8	1	3.6	314
AVG	2.6	4.9	8.3	13.2	18.9	24.3	3.4	
Total	1463	3979	2930	1082	387	154		

Total Number of Observations = 10883

Total Number of Calms = 888

Source: Ref. 7, U.S. Department of Commerce

Long-term wind speed and direction data were obtained from a National Oceanic and Atmospheric Administration (NOAA) station located in El Centro, California.[7] This station is located 10 km (6 miles) north of the project site. Wind speed frequency distribution values were developed for the four seasons over the period January 1954 through December 1958. Frequency distribution data for the months of December, January and February are summarized in Table 1.7.6-2, for the months of March, April and May in Table 1.7.6-3, for the months of June, July and August in Table 1.7.6-4 and for the months September, October and November in Table 1.7.6-5. These wind statistics were converted into suitable wind roses, which are shown in Figure 1.7-5, 1.7-6, 1.7-7, and 1.7-8 for the winter, spring, summer, and fall seasons respectively. The plotted wind data indicate that the prevailing winds for the winter, spring and fall months are from the northwest to the southwest sector. During the summer months there is a shift to the northeast/southeast quadrant. The most prevalent wind direction during the month of March, as shown in Figure 1.7-6, is from the west occurring about 35% of the times. This is in agreement with the daily wind direction observations recorded by the Imperial Irrigation District for March 1975; see Table 1.7.6-1.

For all seasons, southerly winds occur at an average frequency of less than 10 percent. This condition would minimize the transport of potential pollutants to the residential region of Heber, which lies to the north of the project area.

1.7.7 Atmospheric Stability

The dispersion of pollutants is influenced by wind characteristics and atmospheric stability. Thus at stable conditions characterized by minimal atmospheric motion, the dispersion potential is limited. Extremely unstable conditions, marked by a high degree of thermal turbulence accompanied by large convective motions in the atmosphere, yield ideal dispersion conditions.

Atmospheric stability conditions are based on a system of classification devised by Dr. F. Pasquill of the British Meteorological Office.[8] Stability near the ground is dependent primarily on net radiation (insolation) and wind speed. Without the influence of clouds, insolation during the day is dependent on solar altitude which is a function of time of day and time of year. When clouds are present they affect the degree of insolation, their area and thickness decreasing incoming and outgoing radiation. Thus in the Pasquill system, insolation is estimated by solar altitude as modified by total cloud cover and cloud ceiling

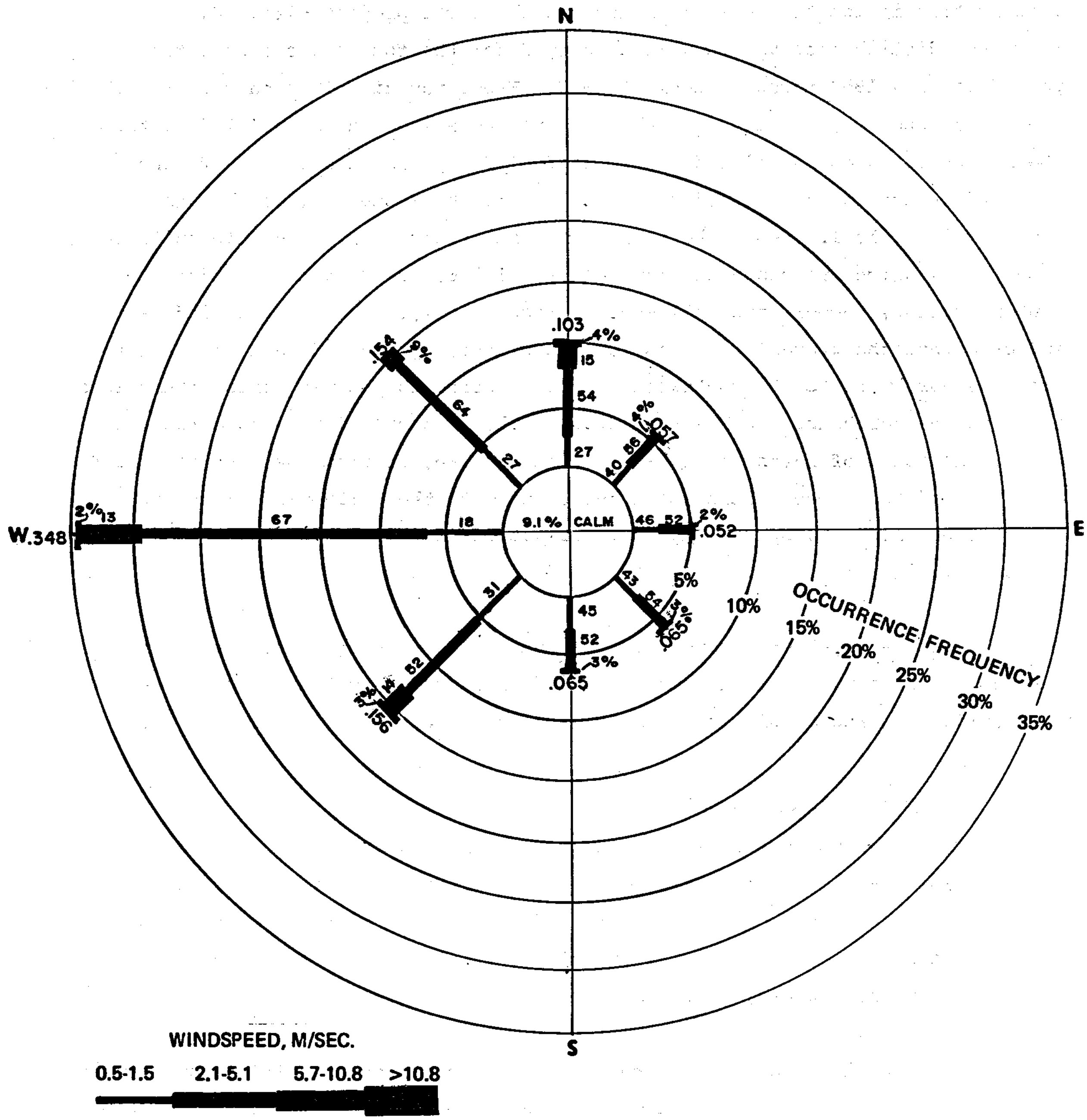


Figure 1.7-5 Wind Rose for El Centro, California Months of December, January and February, 1954 thru 1958 (Source: Ref 7, U.S. Department of Commerce)

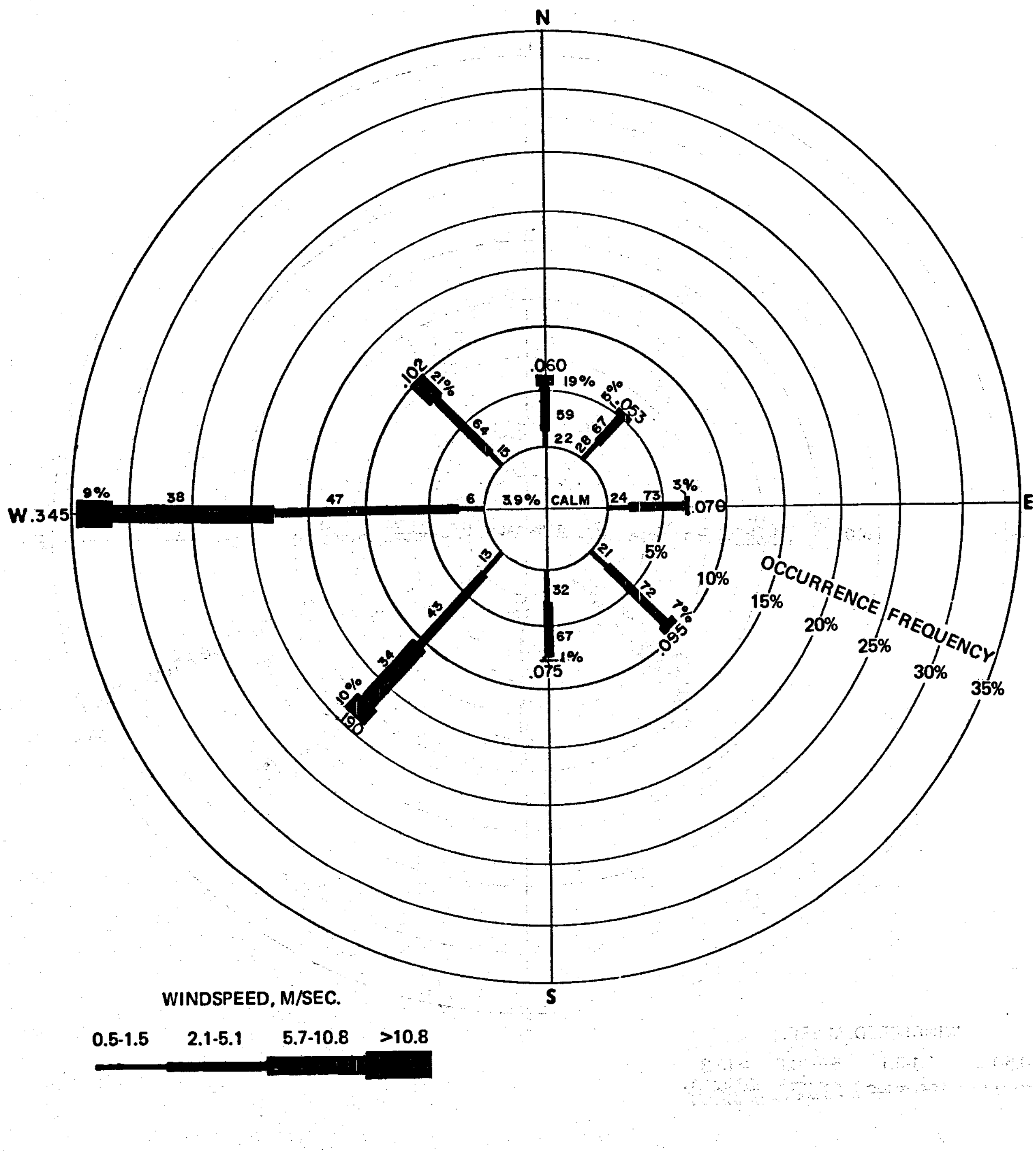


Figure 1.7-6 Wind Rose for El Centro, California, Months of March, April, and May, 1954 thru 1958 (Source: Ref 7, U.S. Department of Commerce)

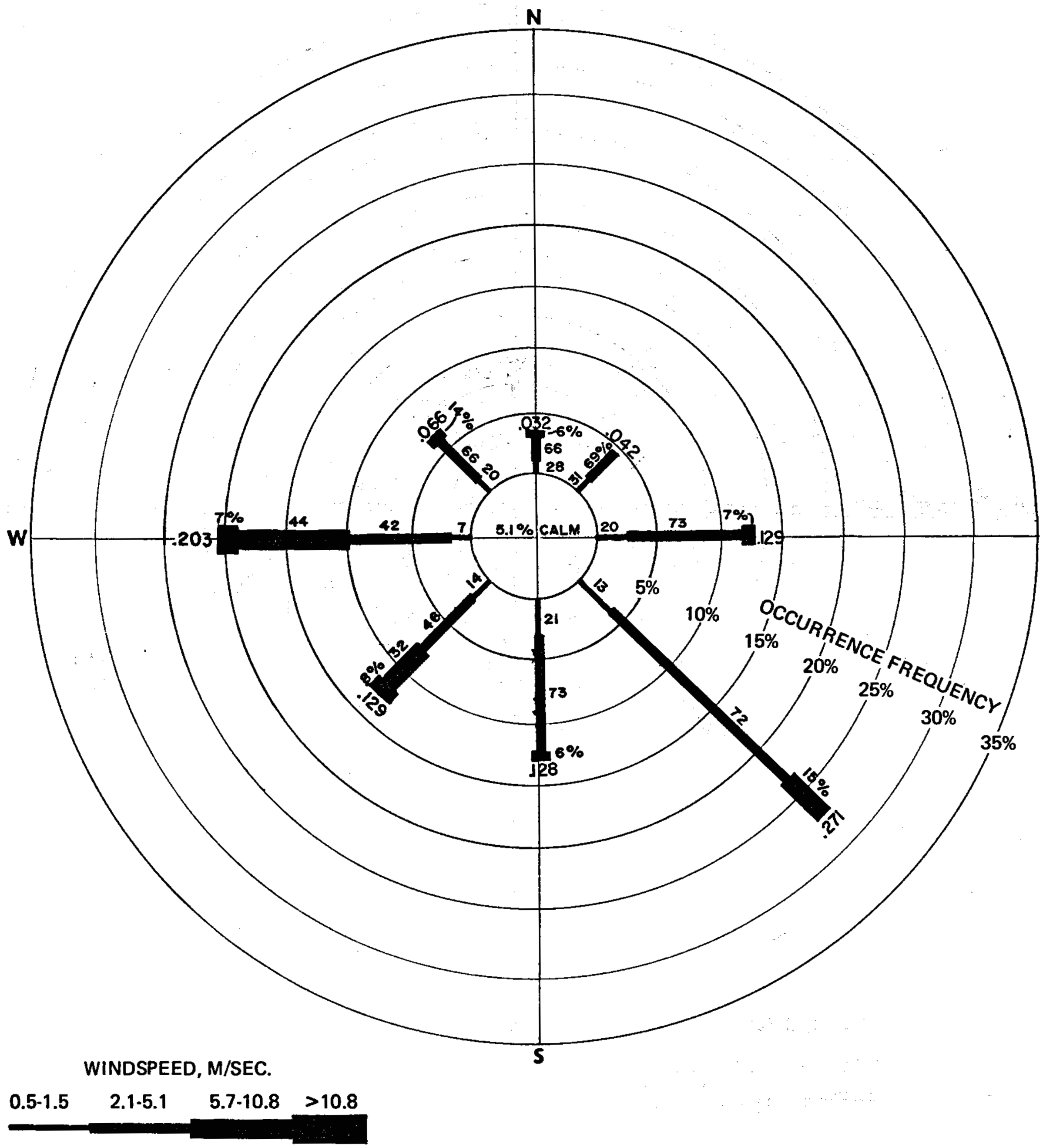


Figure 1.7-7 Wind Rose for El Centro, California, Months of June, July and August, 1954 thru 1958 (Source: Ref. 7, U.S. Department of Commerce)

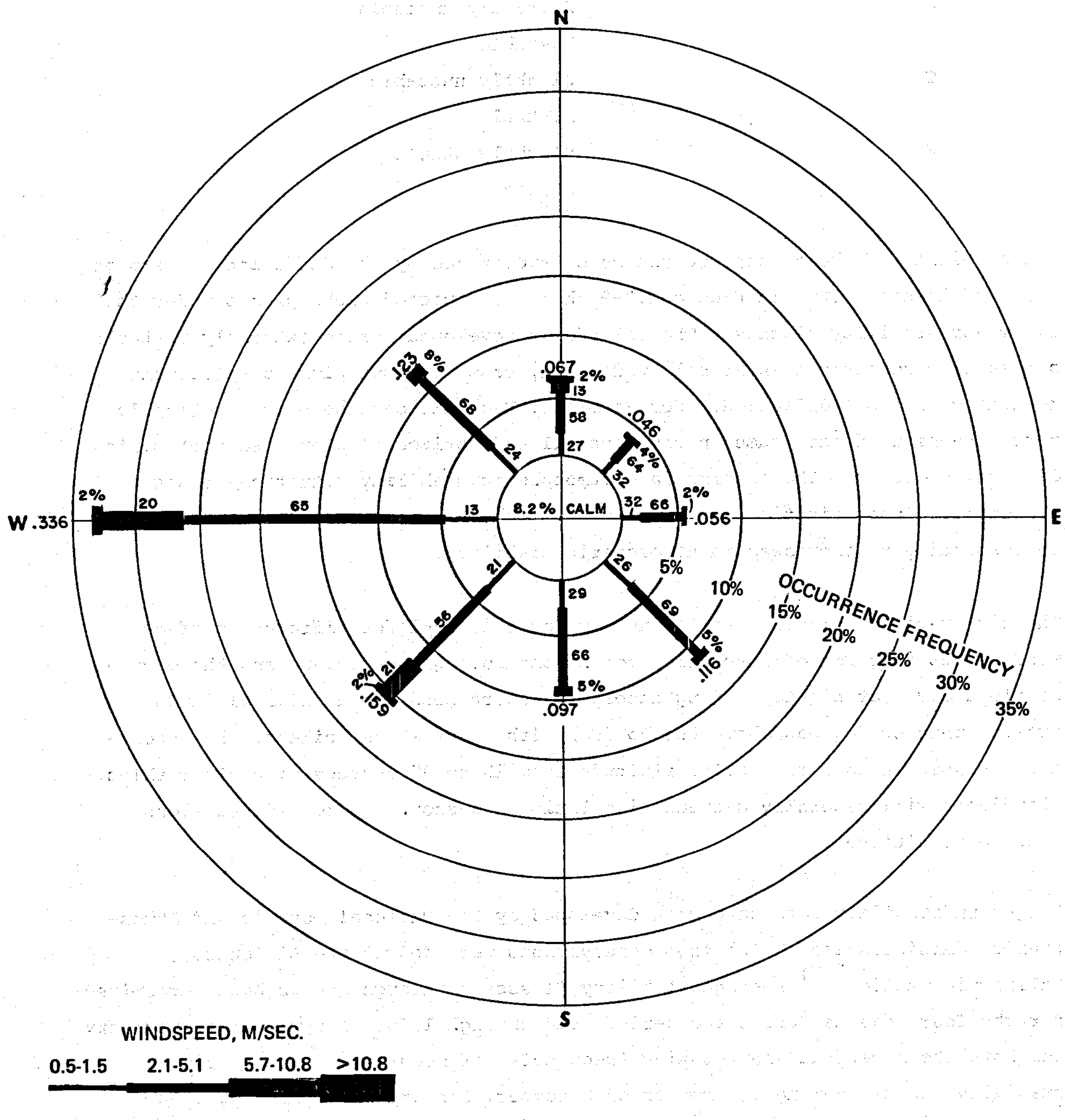


Figure 1.7-8 Wind Rose for El Centro, California, Months of September, October and November 1954 thru 1958 (Source: Ref. 7, U.S. Department of Commerce)

height. Stability categories are identified as follows:

Stability Class	Atmospheric Condition
A	Extremely unstable
B	Unstable
C	Slightly unstable
D	Neutral
E	Slightly stable
F	Stable

The stability of the atmosphere can be characterized by the diffusion pattern of stack effluents. Thus in Figure 1.7-9 there is depicted smoke plumes under the six major stability classes. Thermal eddies developed during extremely unstable atmospheric conditions in Stability Class A, cause maximum plume displacement resulting in ideal diffusion. For Stability F conditions there is practically zero expansion of the plume in the vertical and horizontal planes so that minimal dispersion occurs. The intermediate atmospheric stability situations cause decreasing plume agitation and dispersion effects for Classes B through E corresponding to increases in atmospheric stability.

The six stability classes are defined in Table 1.7.7-1 for different surface wind speeds in terms of insolation conditions during the daytime and the degree of cloud cover at night. Strong insolation corresponds to a solar altitude greater than 60 degrees above the horizon with clear skies while slight insolation is associated with a solar altitude from 15 to 35 degrees with clear skies. Cloudiness will generally decrease insolation and should be considered along with solar altitude.

Long-term stability data have been developed by the National Oceanic and Atmospheric Administration (NOAA) from observations recorded at the El Centro, California station.(7) Average Stability Classes A through F have been determined for the four seasons during the period 1954 through 1958. A typical data summary for both the numerical and relative frequencies of occurrence for the six stability classes during the months of December, January and February, 1954 through 1958, is tabulated on Sheets B-1 through B-12, in Appendix B. Stability frequencies for the total year, expressed on an annual basis were also developed in this program. These average annual occurrence frequencies for the six stability classes in the vicinity of El Centro, California, are summarized in Table 1.7.7-2 for the period 1954 through 1958. Examination of these values

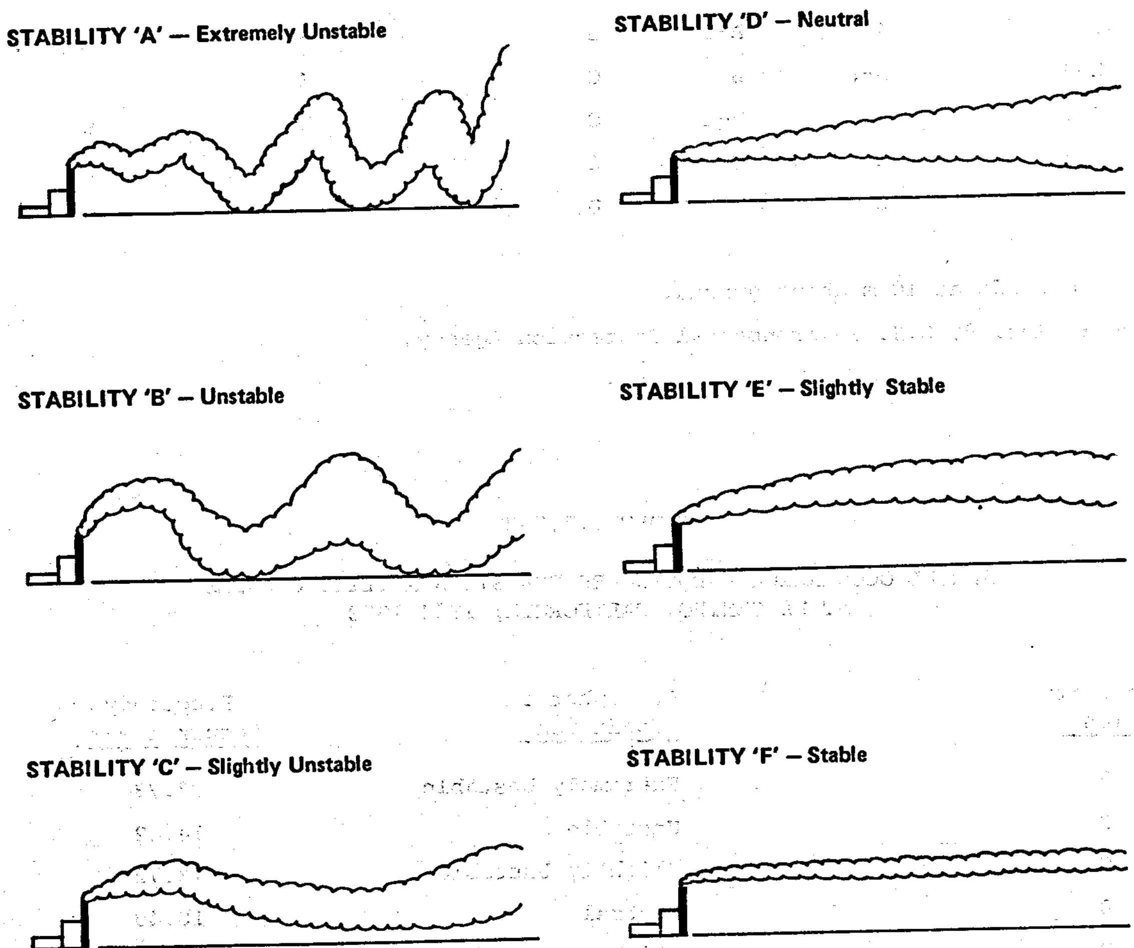


Figure 1.7-9 Plume Dispersion Characteristics for Various Atmospheric Stability Classes (Source: Ref. 9, U.S. Environmental Protection Agency)

TABLE 1.7.7-1

STABILITY CATEGORY DEFINITIONS

*Surface Wind Speed	Stability Classes				
	Daytime Insolation			Nighttime Cloud Cover	
(m/sec)	Strong	Moderate	Weak	≥J4/8 Low Cloud	≤3/8 Cloud
<2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

*Surface winds at 10 m above ground.

Source: Ref. 9, U.S. Environmental Protection Agency.

TABLE 1.7.7-2

ANNUAL OCCURRENCE FREQUENCIES FOR SIX STABILITY CLASSES AT EL CENTRO, CALIFORNIA; 1954-1958

Stability Class	Atmospheric Condition	Frequency Occurrence-%
A	Extremely Unstable	3.73
B	Unstable	14.42
C	Slightly Unstable	13.72
D	Neutral	10.49
E	Slightly Stable	15.92
F	Stable	41.72
TOTAL		100.00

Source: Ref. 7, U.S. Department of Commerce.

would indicate that the neutral-to-stable atmospheric classes comprise about 68 percent of the total. These relatively stable atmospheric conditions would categorize the dispersion potential of the region as poor. As would be expected, the worst seasonal stability is for the winter months of December, January and February with the netural-to-stable classes totalling 76 percent; see Sheets B-1 through B-12 in Appendix B. Thus any potential air-borne pollutant from the proposed project would cause maximum ambient air quality degradation during the winter months.

REFERENCES - Climatology

1. California Air Basins, California Air Resources Board: Sacramento, Calif., Dec. 1972.

2. Elford, C.R., The Climate of California - Climates of The States Vol. 2; U.S. Dept. of Commerce, Nat'l Oceanic Atmospheric Administration, Water Information Center, Inc.; Port Washington, N.Y.; 1970, pp 538-594.

3. Bennett, C.L. Jr.; Climate of the Southeast Desert Air Basin; California Air Resources Board, Div. of Technical Services; Sacramento, Calif., 1975.

4. Imperial Valley 1974 Weather Summary; Records of Watermaster, Imperial Irrigation District, Imperial, Calif.

5. Weather Data - Annual Summary Report - 1974-75; University of California Imperial Valley Agricultrual Field Station; Holtville, California.

6. Climatological Data - 1975; U.S. Department of Agriculture, Agricultural Research Service, Imperial Valley Conservation Research Center, Brawley, California.

7. Seasonal and Annual (Day/Night) Wind Distribution of Pasquill Stability Classes (6) - Star Program, Station #23199, El Centro, California; Period 1/54-12/58, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Ashville, N.C.; July 24, 1975.

8. Pasquill, F., Atmospheric Diffusion, D. Van Nostrand, London, pp. 297, 1962.

9. Turner, D.B., Dicke, J.L., Air Pollution Meteorology, United States Environmetnal Protection Agency, Research Triangle Park, N.C., August 1973.

1.8 METEOROLOGY

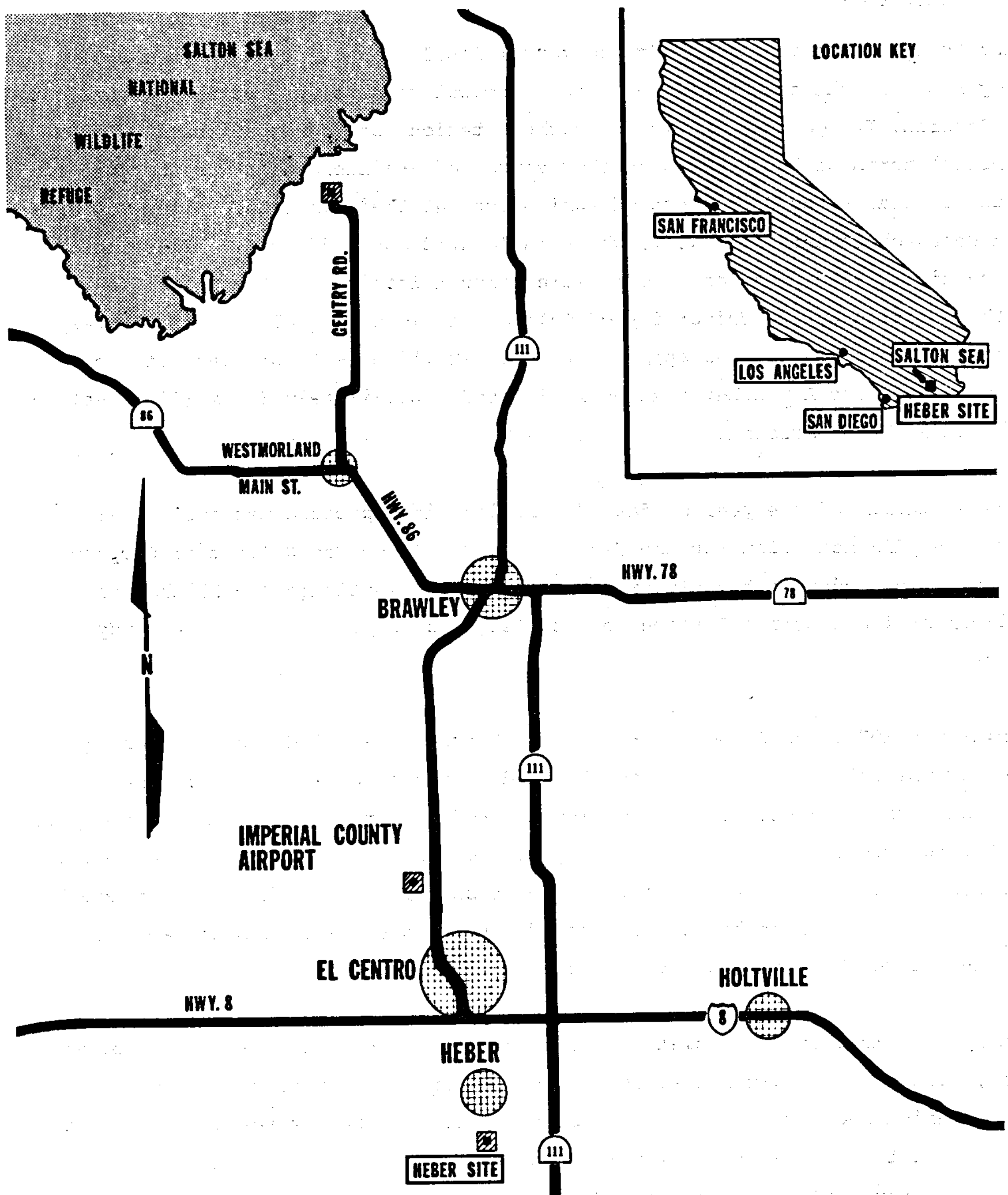
Prior to the inception of the Environmental Baseline Data Acquisition (EBDA) Study Program, the best available meteorological records were being collected at the Imperial Irrigation District's weather station located approximately 13 KM (8 miles) north of the Heber. Another source of available data was that provided by the United States Department of Agriculture at their Imperial Valley Conservation Research Center in Brawley, which is located about 27 KM (17 miles) north of the site. Precipitation records were being maintained at the Holtville weather station by the University of California, Imperial Valley Agricultural Extension, which is located approximately 16 KM (10 miles) northeast of Heber. The nearest Class A weather station is located approximately 84 KM (52 miles) to the east at Yuma, Arizona.

Since a minimum of one year of data describing site-specific meteorological conditions did not exist for the Heber area, San Diego Gas & Electric Company (SDG&E) recommended to the Electric Power Research Institute (EPRI) that an Environmental Monitoring Station be established as a part of the EBDA Study Program.

In mid-June 1976, San Diego Gas & Electric Company installed and began managing an Environmental Monitoring Station located at the potential Heber geothermal power plant site (Figure 1.8-1 and Figure 1.8-2.) A twelve month meteorological monitoring program is currently in progress to continuously record local meteorological conditions. These conditions must be sufficiently known and studied to allow predictions to be made of ground-level concentrations of potential effluents throughout the zone of influence.

Primary data is being accumulated in the form of strip chart recordings for wind speed, wind direction, temperature, and change in temperature with height, precipitation and dew point. In cooperation with the Energy Resources Development Administration (ERDA) Regional Meteorological Program, these same data are being simultaneously provided to magnetic tape recorders which have been supplied by Lawrence Livermore Laboratories. Reduction of the data, summarization and description of the local meteorological conditions are not part of the present acquisition program.

The Heber Environmental Monitoring Station consists of a 60 meter (200 foot) guyed tower constructed of heavy steel tubing (Figure 1.8-3). Sensors mounted

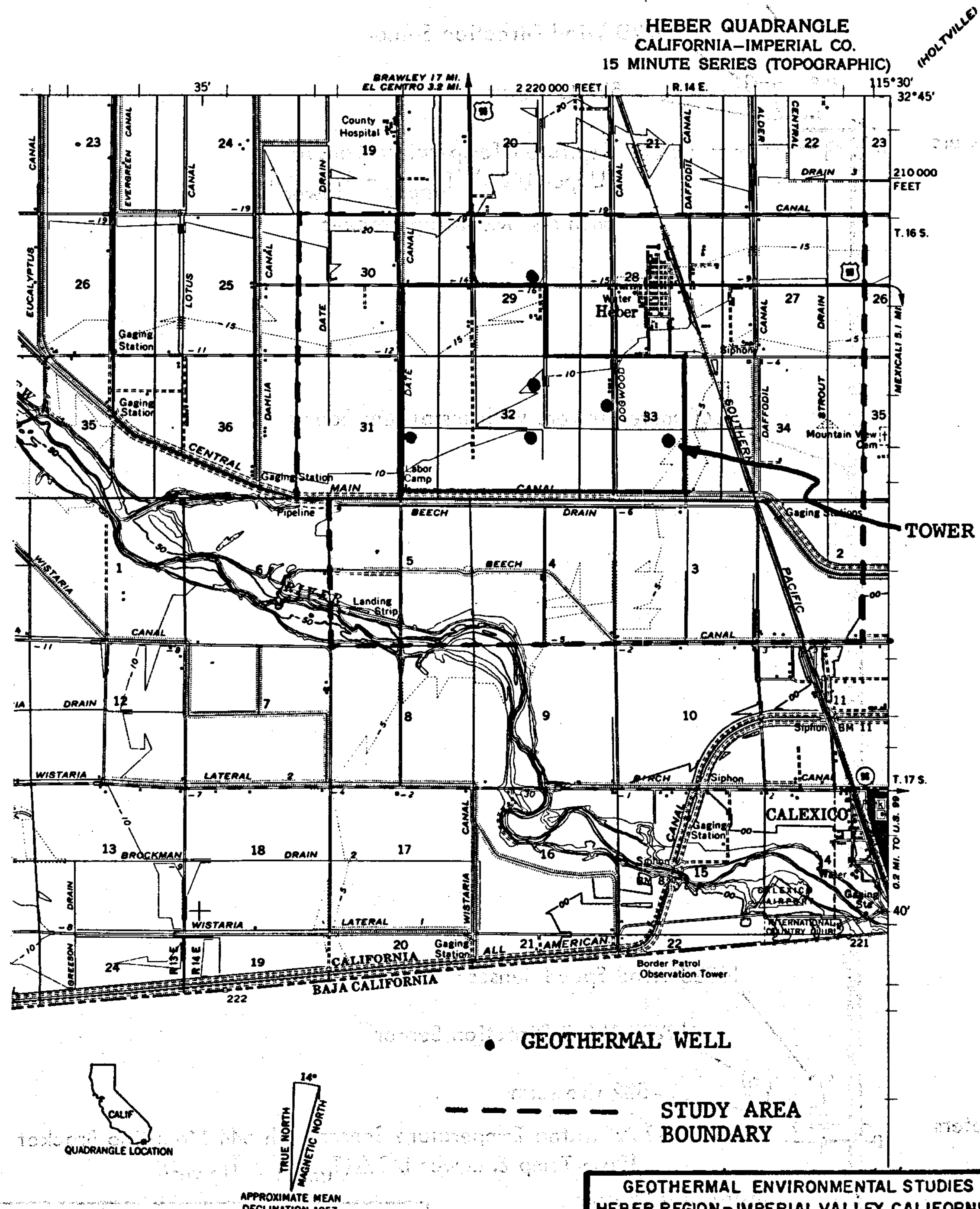


GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

General Location Plan
Heber Site

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO.
1.8-1

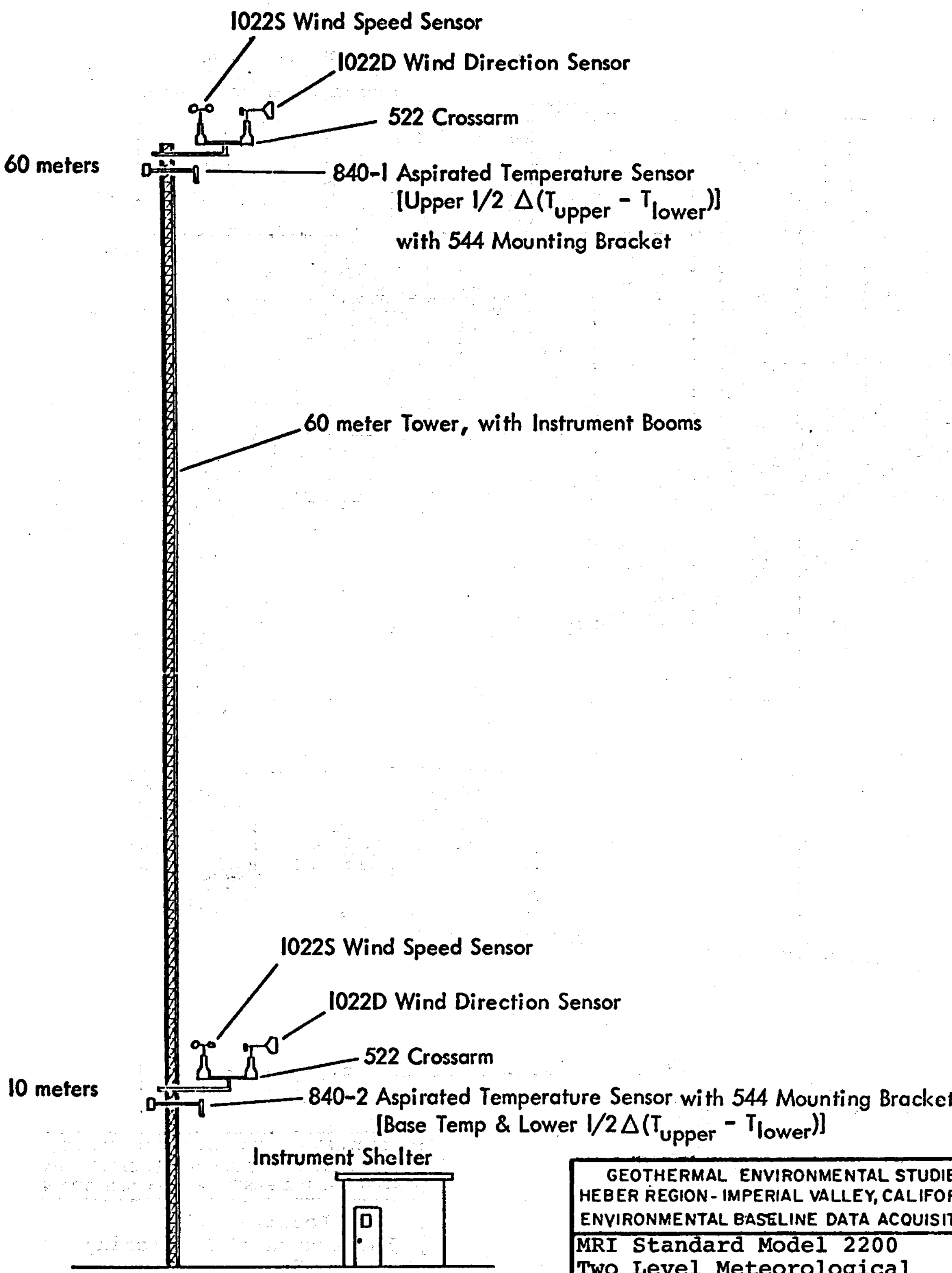


GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

Location of Environmental Monitoring Station

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.8-2



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY, CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

MRI Standard Model 2200
Two Level Meteorological
Tower System

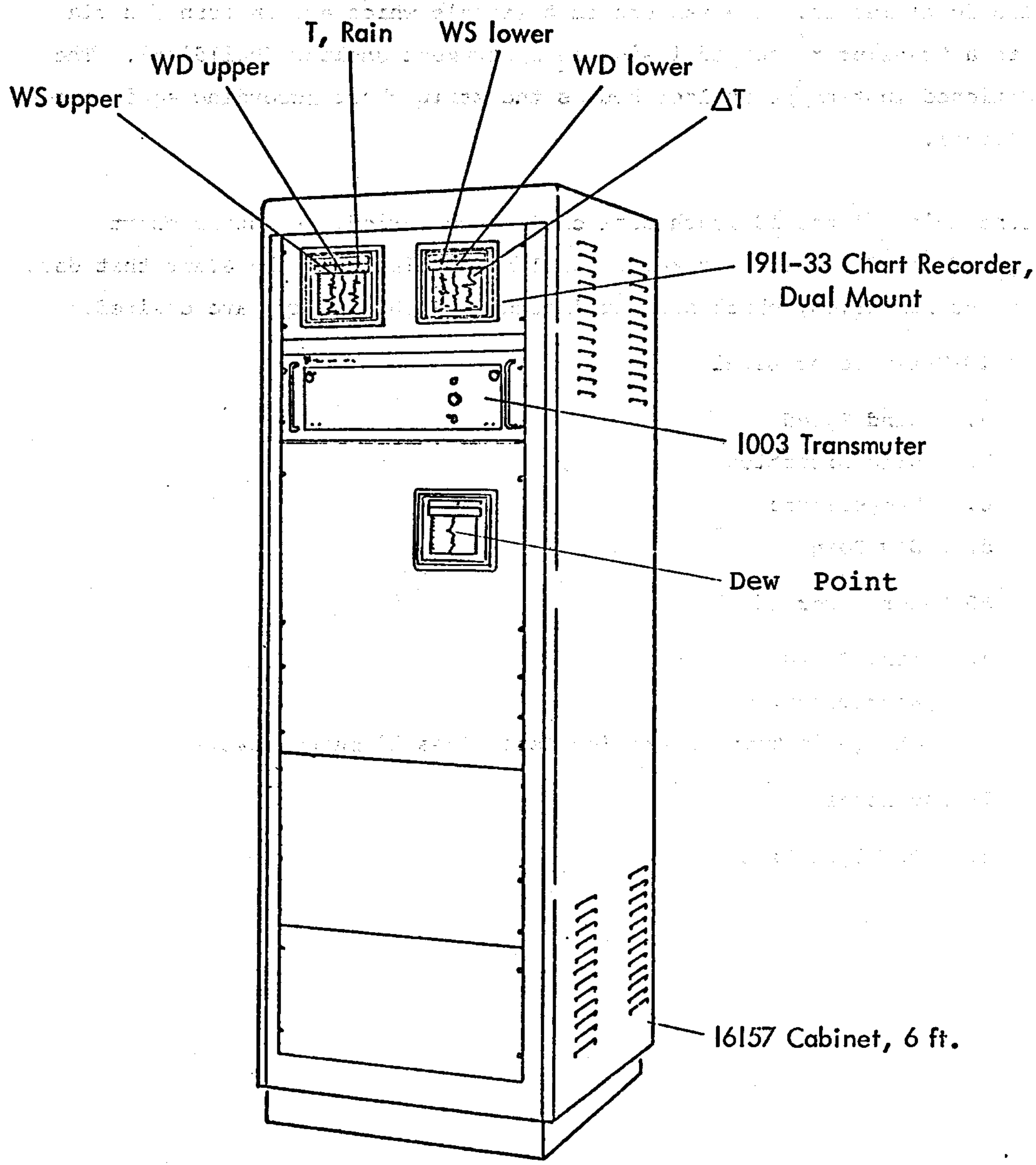
SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO.
1.8-3

on instrument booms are attached to the tower at the 10 meter (33 foot) and 60 meter (195 foot) levels. The sensors emit signals which are in turn fed via cabling to a transmuter located inside an instrument shelter (building). The air conditioned instrument shelter houses the strip chart recording equipment (Figure 1.8-4).

At the conclusion of the 12 month data collection period, the strip chart recordings of the following parameters will be available in the event that data reduction and summaries, which are not included in this study, are desired.

1. 10-Meter Tower Level
   a. Wind Speed
   b. Wind Direction
   c. Temperature
   d. Dew Point
2. 60-Meter Tower Level
   a. Wind Speed
   b. Wind Direction
   c. Change in Temperature (60 meter less 10 meter level)
3. Ground Level
   a. Precipitation



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY, CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

MRI Standard Model 2200 Meteorological System Recording Equipment

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO 1.8-4

1.9 AIR QUALITY

1.9.1 Introduction

The air quality in the Imperial Valley is relatively pristine because of the sparsely populated nature of the region. With agriculture as the major industry, the most prevalent air-borne pollutant is particulate matter in the form of fugitive dusts. In the dry months of late fall, winter and early spring, dust storms generated to a degree dependent on the aridity of the soil and the prevailing wind speeds are the most significant source of fugitive dusts. The predominant source of gaseous pollutants is the motor vehicle. This is particularly so in Imperial Valley because of the negligible level of industrial activity in this region.

The Heber geothermal resource area is located in Imperial County which is one of the regions comprising the Southeast Desert Air Basin. The Air Pollution Control District (APCD) of Imperial County maintains a limited number of rudimentary air quality and meteorology monitoring stations in Brawley, Calexico and El Centro, all three locations within a fifteen mile radius of the project site. The California Air Resources Board (CARB) manages a total of six air quality and meteorology stations in the Southeast Desert Air Basin located at a considerable distance from the proposed project. Each of these stations has particulates and gaseous pollutant measurement capabilities. The CARB also reduces and summarizes monitoring data obtained by the Imperial Valley APCD at the Brawley, Calexico and El Centro stations.

In view of the potential geothermal development being considered for this region, there is a need for the development of complete baseline air quality data. Such potential pollutants as hydrogen sulfide, ammonia, particulates, metal traces and sulfate aerosols could be emitted by geothermal operations. Therefore any viable baseline data acquisition program should be addressed to the determination of the background levels of these contaminants in the atmosphere. The existing governmental monitoring systems in the area are inadequate, being concerned with sensing ambient air concentrations of particulates, nitrogen oxides and oxidants and obtaining some wind speed and direction frequency data.

The need for additional background air quality and meteorology data is realized and, at the present time, three data acquisition programs are currently in progress or have recently been completed. These are being performed by the San Diego Gas & Electric Company, the Lawrence Livermore Laboratory and CARB. Only the CARB data were available at the time of this writing, and these have been incorporated into this Air Quality Report.

1.9.2 Air Basin Description

The Heber geothermal resource area lies in the Southeast Desert Air Basin of California; see Figure 1.9-1. This air basin includes the Air Pollution Control District (APCD) of Imperial County and portions of the APCD for San Diego, Riverside, Kern, San Bernardino and Los Angeles counties.(1)

The area is located about 10 km (6 miles) south of El Centro in the southern portion of Imperial County. Therefore the air quality constraints to be considered are those imposed by the County of Imperial Environmental Quality Control Air Pollution Control District, as specified in their Rules and Regulations, dated October 18, 1971.(2) The region under the jurisdiction of Imperial County APCD is Imperial County. The APCD office is located in El Centro, California.

The rules specifying pollutant emmission levels and ambient air quality standards are enforced by the Imperial County APCD. The ambient air quality standards, defining the maximum permissible concentration for the major particulate and gaseous pollutants are established by the CARB.

1.9.3 Air Pollution Regulations and Standards

The regulations(2) issued by Imperial County APCD are mostly directed at the control of emissions from agricultural and petroleum industries. The specific pollutants addressed in Rules 113 through 131 are particulates and sulfur compounds. Hydrogen sulfide emissions are specifically restricted in Rule 126, concerned with sulfur contents of fuels and non-specifically in Rule 117 which prohibits the discharge of nuisance contaminants into the atmosphere. Those APCD regulations considered pertinent to geothermal operations are as follows:

Rule 113 - Opacity of Emissions

A. No person shall release or discharge into the atmosphere from any existing single source of emission whatsoever, any air contaminant for a period or periods aggregating more than three (3) minutes in any hour which is:

1. As dark or darker in shade No. 2 on the Ringlemann Chart as published by the United States Bureau of Mines, or
2. Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in subsection 1 above.

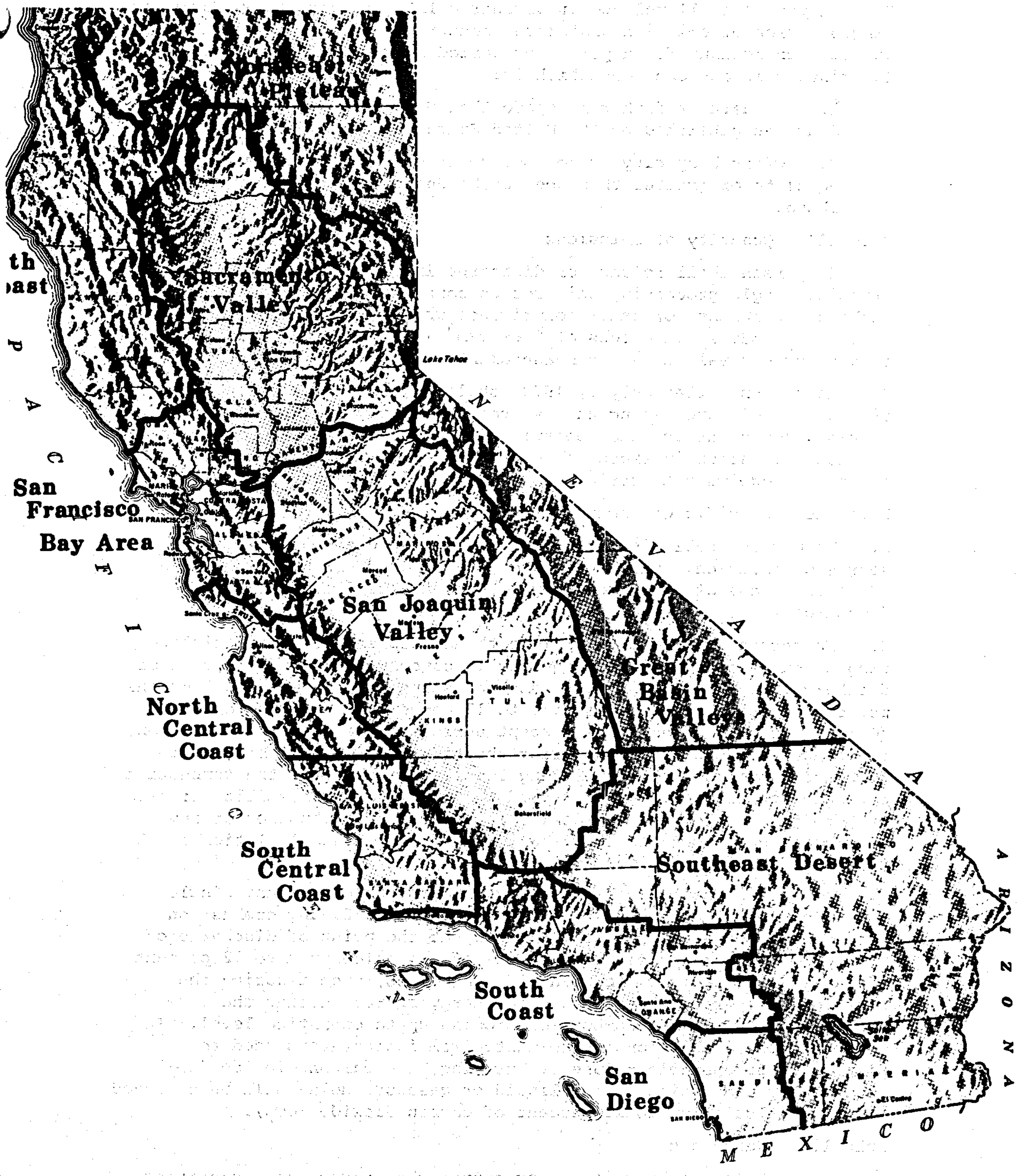


Figure 1.9-1 California Air Basins (Source: State of California, Air Resources Board)

B. No person shall release or discharge into the atmosphere from any single source of emission whatsoever constructed after July 1, 1972, any air contaminant for a period or period aggregating more than three (3) minutes in any one hour which is:

1. As dark or darker in shade than No. 1 on the Ringlemann Chart as published by the United States Bureau of Mines, or

2. Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke descirbed in subsection 1 above.

Rule 114 - Quantity of Emissions

A. No person shall release or dishcarge into the atmosphere from any existing single processing unit source consisting of any article, machine, equipment, or other contrivance which emits dust, fumes, or particulate matter in excess of 0.69 g/m^3 (0.3 grains per cubic foot) of gas, or equivalent metric measurement, at standard conditions.

B. No person, after July 1, 1972, shall build, erect, install, or expand a single processing unit source consisting of any article, machine, equipment or other contrivance which emits dust, fumes, or particulate matter in excess of 0.46 g/m^3 (0.2 grains per cubic foot of gas, or equivalent metric measurement, at standard conditions.

Rule 116 - Specific Contaminants

A. No person shall discharge into the atmosphere from any single source of emission, sulfur compounds, calculated as sulphur dioxide (SO_2) in excess of 0.2 percent by volume, measured at point of discharge.

B. No person shall discharge into the atmosphere from any existing single source of emission, exceeding in concentration at the point of discharge, combustion contaminants consisting of 0.69 g/m^3 (0.3 grains per cubic foot) of gas calculated to 12 percent of carbon dioxide (CO_2) at standard conditions, except during the start of an operation, or change in energy source, during the time necessary to bring the combustion process up to operating level. In measuring the combustion contaminants from incinerators used to dispose of combustible refuse, by burning, the carbon dioxide (CO_2) produced by combustion of any liquids or gaseous fuels shall be excluded from the calculation to 12 percent of carbon dioxide (CO_2).

C. No person shall discharge into the atmosphere from any single source of emission, constructed after July 1, 1972, any combustion contaminants exceeding in concentration at the point of discharge of 0.46 g/M^3 (0.2 grains per cubic foot) of gas calculated to 12 percent of carbon dioxide (CO_2) at standard conditions, except during the start of an operation; or change in energy source, during the time necessary to bring the combustion process up to operating level. In measuring the combustion contaminants from incinerators used to dispose of combustible refuse by burining, the carbon dioxide (CO_2) produced by combustion of any liquid or gaseous fuels shall be excluded from the calculation to 12 percent of carbon dioxide (CO_2).

Rule 117 - Nuisances

No person shall discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of persons or to the public or which endanger the comfort, repose, health or safety of any such persons or the public or which cause or have a natural tendency to cause injury or damage to business or property.

Rule 121 - Dust and Fumes

No person shall discharge in any one hour from any source whatsoever dust or fumes in total quantities in excess of the amount shown in Table 1.9.3-1.

Rule 126 - Sulfur Contents of Fuels

A person shall not burn any gaseous fuel containing sulfur compounds in excess of 1.14 g/m^3 (50 grains per 100 cubic feet) of gaseous fuel, calculated as hydrosulfide at standard conditions, or any liquid fuel or solid fuel having a sulfur content in excess of 0.5 percent by weight.

The provisions of this rule shall not apply to:

a. The burning of sulfur, hydrogen sulfide, acid sludge or other sulfur compounds in the manufacturing of sulfur compounds.

b. The incinerating of waste gases provided that the gross heating value of such gases is less than 42 cal/M^3 (300 British Thermal Units per cubic foot) at standard conditions and the fuel used to incinerate such waste gases does not contain sulfur compounds in excess of the amount specified in this rule.

c. The use of solid fuels in any metallurgical process.

d. The use of fuels where the gaseous products of combustion are used as a raw material for other processes.

e. The use of liquid or solid fuel to propel or to test any vehicle, aircraft, missile, locomotive, boat, or ship.

f. The use of fuel with higher sulfur content where the process conditions or control equipment remove sulfur compounds from the stack gases to the extent that the emission of sulfur compounds to the atmosphere is not greater than that which would be emitted by using a fuel which complies with the provisions of this rule.

Every holder of, and every application for a permit to operate fuel burning equipment under these rules and regulations shall notify the Air Pollution Control Officer in the manner and form prescribed by him, of each interruption in and resumption of the delivery of gaseous fuels to his equipment.

It shall not be a violation of this rule to burn fuel not permitted by this rule when other fuel which complies with this rule cannot be used due to accident, strike, sabotage, act of God, or the failure of the supplier.

Rule 131 - Fuel Burning Equipment

A person shall not build, erect, install or expand any non-mobile fuel burning equipment unit within Imperial County unless the discharge into the atmosphere of contaminants will not and does not exceed any one or more of the following rates:

A. 25.2 g/sec (200 pounds per hour) of sulfur compounds, calculated as sulfur dioxide (SO_2);

B. 17.7 g/sec (140 pounds per hour) of nitrogen oxides calculated as nitrogen dioxide (NO_2);

TABLE 1.9.3-1

MAXIMUM ALLOWABLE CONTAMINANT EMISSION RATES

*Process Wt/Hr		Max. Weight Disch/Hr		*Process Wt/Hr (lbs.)		Max. Weight Disch/Hr (lbs.)		*Process Wt/Hr (lbs.)		Max. Weight Disch/Hr (lbs.)	
lb.	kg	lb.	gm	lb.	kg	lb.	gm	lb.	kg	lb.	gm
50	22.7	.24	109.0	2100	953	4.14	1879	5500	2197	7.03	3191
100	45.4	.46	208.8	2200	998	4.34	1970	6000	2724	7.37	3345
150	68.1	.66	299.6	2300	1044	4.44	2015	6500	2951	7.71	3500
200	90.8	.85	385.9	2400	1089	4.55	2065	7000	3178	8.05	3654
250	113.5	1.03	467.6	2500	1135	4.64	2106	7500	3405	8.39	3809
300	136.2	1.20	544.8	2600	1180	4.74	2151	8000	3632	8.71	3954
350	158.9	1.35	612.9	2700	1125	4.84	2197	8500	3859	9.03	4099
400	181.6	1.50	681.1	2800	1171	4.92	2233	9000	4086	9.36	4249
450	204.3	1.63	740.0	2900	1316	5.02	2279	9500	4313	9.67	4390
500	227.4	1.77	803.6	3000	1362	5.10	2315	10000	4540	10.00	4540
550	249.7	1.89	858	3100	1407	5.18	2351	11000	4994	10.63	4826
600	272.4	2.01	912	3200	1452	5.27	2392	12000	5448	11.28	5121
650	295.1	2.12	962	3300	1498	5.36	2435	13000	5902	11.89	5398
700	317.8	2.24	1016	3400	1543	5.44	2469	14000	6356	12.50	5675
750	340.5	2.34	1062	3500	1589	5.52	2506	15000	6810	13.13	5961
800	363.2	2.43	1103	3600	1634	5.61	2546	16000	7264	13.74	6237
850	385.9	2.53	1148	3700	1679	5.69	2583	17000	7718	14.36	6519
900	408.6	2.62	1189	3800	1725	5.77	2619	18000	8172	14.97	6796
1000	454.5	2.80	1271	3900	1770	5.85	2655	19000	8626	15.58	7073
1100	499.4	2.97	1348	4000	1816	5.93	2692	20000	9080	16.19	7350
1200	544.8	3.12	1416	4100	1861	6.01	2728	30000	13620	22.22	10087
1300	590.2	3.26	1480	4200	1906	6.08	2760	40000	18160	28.3	12848
1400	635.6	3.40	1543	4300	1952	6.15	2792	50000	22700	34.3	15572
1500	681.5	3.54	1607	4400	1997	6.22	2823	60000	27240	40.0	18160
1600	726.4	3.66	1661	4500	2043	6.30	2860	or			
1700	771.8	3.79	1720	4600	2088	6.45	2928	more			
1800	817.2	3.91	1775	4800	2179	6.52	2960				
1900	862.6	4.03	1829	4900	2224	6.60	2996				
2000	908.7	4.14	1879	5000	2270	6.67	3028				

*To use the above table, take the process weight per hour as such is defined in Rule 100. Then find this figure on the table, opposite which is the maximum number of pounds of contaminants which may be discharged into the atmosphere in any one hour. As an example, if "A" has a process which emits contaminants into the atmosphere and which process takes 3 hours to complete, he will divide the weight of all materials in the specific process, in this example, 1,500 lbs. divided by 3 giving a process weight per hour of 500 lbs.

The Table shows the "A" may not discharge more than 1.77 lbs. in any one hour during the process. Where the process weight per hour falls between figures in the left hand column, the exact weight of permitted discharge may be interpolated.

C. 1.3 g/sec (10 pounds per hour) of combustion contaminants as defined in Rule 100 and derived from the fuel.

For the purpose of this Rule, a fuel burning equipment unit shall be comprised of the minimum number of boilers, furnances, jet engines or other fuel burning equipment, the simultaneous operations of which are required for the production of useful heat or power.

Fuel burning equipment serving primarily as air pollution control equipment by using a combustion process to destroy air contaminants shall be exempt from the provisions of this Rule.

Nothing in this Rule shall be construed as preventing the maintenance or preventing the alteration or modification of any existing fuel burning equipment unit which will reduce its mass rate of air contaminant emissions.

This Rule shall not apply to any processing operation in which a flame directly contacts the material being processed, until such time as Federal Standards (health, education and welfare) are completed.

Rules 114, 116 and 126 have been amended as of June 6, 1972.

Those rules apply to normal, typical, steady, on-stream operations of the reference facility. As a further explanation of plant upset conditions, the APCD adopted two additional rules on April 16, 1974, pertaining to process breakdowns and start-ups. These rules are as follows:

Rule 148.1 - Breakdowns

Emissions exceeding any of the limits established in this regulation which are a direct result of a breakdown of any air pollution control equipment or related processing equipment shall not be deemed to be in violation of the rules establishing such limits, provided the following requirements of this section are met:

(a) Any such breakdown of equipment is reported to the office of the District within thirty (30) minutes after such breakdown should reasonably have been discovered.

(b) The breakdown is subject to repair, and is actually repaired, within four (4) hours of its occurrence.

Provided, however, that breakdowns of equipment shall not be construed to provide an excuse for violation of

Rule 117 of these Rules and Regulations.

Violations of emission limits due to breakdowns which are not reported or repaired as herein required or which create a nuisance as defined by Rule 117 are subject to enforcement action by the District as are all other violations.

Rule 148.2 - Start-up Exemptions

Emissions exceeding the limits established in these regulations as a direct result of the start-up of a long term or continuous operation shall not be deemed to be in violation of the rules establishing such limits if approval for said start-up has been obtained in advance from the Air Pollution Control Officer. Provided, however, start-up emissions may not result in violation of Rule 117 of these Rules and Regulations.

The ambient air quality standards, expressed as concentrations in ambient air for the various recognized pollutants, are specified by the California Air Resources Board (CARB). These ambient air concentration levels, together with the National Ambient Air Quality Standards, are represented in Table 1.9.3-2.

One of the pollutants limited by CARB is hydrogen sulfide (H_2S) which is one of the potential contaminants associated with geothermal processing. The maximum allowable level of 0.03 ppm is believed to be considerably above the odor threshold limit of 0.0005 ppm.[3] Therefore even though satisfying the State's ambient air quality standards, it is possible that the hydrogen sulfide emissions might violate the APCD Rule 117 pertaining to nuisance-type contaminants.

1.9.4 Pollutant Emissions Inventory

The pollutant emissions inventory prepared by Imperial County APCD for 1975 reflects the agricultural nature of the region.[4] Referring to Table 1.9.4-1, Sheets 1 and 2, of the total particulate matter emissions of 10.2 ton/day, 7.5 ton/day are contributed by agricultural operations and associated processes. In the compilation of these values for particulates, no allowance has been made for fugitive dusts generated by agricultural tilling operations and arid land dust storms. It is believed that the air-borne dust emitted by these latter sources would far outweigh the total particulate matter emissions of 10.2 ton/day estimated in Table 1.9.4-1. In the San Joaquin Valley Air Basin, with somewhat similar terrain and climate as that in Imperial Valley, but with about six times the acreage, the total fugitive dust emissions have been estimated to be approximately 1,100,000 ton/year equivalent to 3,000 ton/day. The various sources contributing to this total value are summarized in Table 1.9.4-2.[5] Of the total of 1,089,520 ton/year, of fugitive dusts expressed in this Table, 848,350 ton/year or 78 percent of the total, are contributed by agricultural operations. Allowing for the acreage ratio of San Joaquin Valley to Imperial Valley, then an approximate order-of-magnitude fugitive dust emissions for the latter would be approximately 500 ton/day.

The Midwest Research Institute[6] has estimated dust emission factors for such sources as unpaved roads, agricultural tilling and aggregate storage piles. It was found in this investigation that dust emitted by agricultural tilling is directly proportional to the silt content of the soil and the tilling implement speed and inversely proportional to the square of the surface moisture content. Emission factors in the range of 40 to 80 lb/acre of soil tilled were suggested.

TABLE 1.93-2

STATE AND FEDERAL AMBIENT AIR QUALITY STANDARDS APPLICABLE IN CALIFORNIA

Pollutant	Averaging Time	California Standards Concentration	Federal Standards Primary	Federal Standards Secondary
Photochemical Oxidants (Corrected for NO_2)	1 hour	0.10 ppm (200 ug/m^3)	160 ug/m^3 (0.08 ppm)	Same as Primary Standard
Carbon Monoxide	12 hours	10 ppm (11 mg/m^3)	—	Same as
	8 hours	—	10 mg/m^3	Primary
	1 hour	40 ppm (46 mg/m^3)	40 mg/m^3 (35 ppm)	Standard
Nitrogen Dioxide	Annual Average	—	100 ug/m^3 (0.05 ppm)	Same as Primary Standard
	1 hour	0.25 ppm (470 ug/m^3)	—	—
Sulfur Dioxide	Annual Average	—	80 ug/m^3 (0.03 ppm)	—
	24 hours	0.04 ppm (105 ug/m^3)	365 ug/m^3 (0.14 ppm(	—
	3 hours	—	—	1305 ug/m^3 (0.5 ppm)
	1 hour	0.5 ppm (1305 ug/m^3)	—	—
Suspended Particulate Matter	Annual Geometric Mean	60 ug/m^3	75 ug/m^3	60 ug/m^3
	24 hours	100 ug/m^3	260 ug/m^3	150 ug/m^3
Lead (Particulate)	30-Day Average	1.5 ug/m^3	—	—
Hydrogen Sulfide	1 hour	0.03 ppm (42 ug/m^3)	—	—
Hydrocarbons (Corrected for Methane)	3 hours (6–9 a.m.)	—	160 ug/m^3 (0.24 ppm)	Same as Primary Standard
Visibility-Reducing	1 Observation	In sufficient amount to reduce the prevailing visibility to 10 miles when the relative humidity is less than 70%	—	—

ppm — Parts per million (a unit used to report gaseous pollution levels)
ug/m^3 — Micrograms per cubic meter (unit used to report particulate pollution levels)
mg/m^3 — Milligrams per cubic meter

TABLE 1.9.4-1

EMISSIONS INVENTORY FOR THE IMPERIAL COUNTY PORTION OF THE SOUTHEAST DESERT AIR BASIN - (1975) Sheet 1 of 2

EMISSION SOURCE	Reactive Organic Gases	Particulate Matter	NO_X	SO_X	CO
	STATIONARY SOURCES				
			TONS/DAY		
PETROLEUM					
Production					
Refining					
Marketing	0.3				
SUBTOTAL	0.3				
ORGANIC SOLVENT USERS					
Surface Coating	0.1				
Dry Cleaning					
Degreasing					
Other					
SUBTOTAL	0.1				
CHEMICAL					
Petrochemical					
Sulfur Plants					
Sulfuric Acid Plants					
Pulp and Paper					
Other					
SUBTOTAL					
METALLURGICAL					
Ferrous					
Non Ferrous					
SUBTOTAL					
MINERAL					
Glass and Frit					
Asphalt Batching		0.5			
Asphalt Roofing					
Cement Production					
Concrete Batching		0.2			
Other					
SUBTOTAL		0.7			
INCINERATION					
Open Burning (Dumps)					
Open Burning (backyard)	1.8	0.7	0.5	-	3.6
Incinerators	0.1	0.7	-	-	1.0
Other					
SUBTOTAL	1.9	0.8	0.5	-	4.6

Source: Ref. 4 - Imperial County APCD

TABLE 1.9.4-1 (continued)

EMISSIONS INVENTORY FOR THE IMPERIAL COUNTY PORTION OF THE SOUTHEAST DESERT AIR BASIN - (1975) Sheet 2 of 2

EMISSION SOURCE	Reactive Organic Gases	Particulate Matter	NO_x	SO_x	CO
	STATIONARY SOURCES				
			TONS/DAY		
COMBUSTION OF FUELS					
Steam and Power Plants	0.1	0.1	2.6	0.1	
Other Industrial	0.1	-	1.7	-	0.2
Domestic and Commercial	-	-	0.2	-	-
SUBTOTAL (Daily Av. Yr.)	0.2	0.1	4.5	0.1	0.2
AGRICULTURE					
Debris Burning	1.3	1.2	0.1	-	4.4
Orchard Heaters	-	-	-	-	-
Agr. Product Proc. Plts.	3.1	6.3	1.5	-	-
SUBTOTAL	4.4	7.5	1.6	-	4.4
TOTAL STATIONARY SOURCES	6.9	9.1	6.6	0.1	9.2
	MOBILE SOURCES				
MOTOR VEHICLES					
Gasoline Powered					
Exhaust	14.2	0.6	7.1	-	103.0
Blowby	1.4	-	-	-	0.2
Evaporation	4.1	-	-	-	-
Diesel Powered	0.8	0.3	1.1	0.1	2.4
SUBTOTAL	20.5	0.9	8.2	0.1	105.6
AIRCRAFT					
Jet Driven	0.3	-	-	-	-
Piston Drive	1.0	-	0.3	-	5.0
SUBTOTAL	1.3	-	0.3	-	5.0
SHIPS AND RAILROADS	0.4	0.2	0.5	0.1	1.1
TOTAL TRANSPORTATION	22.2	1.1	9.0	0.2	111.7
GRAND TOTAL	29.1	10.2	15.6	0.3	120.9

Source: Ref. 4, Imperial County APCD.

The importance of fugutive dusts in Imperial Valley lies in the fact that on most days the California 24-hour ambient air standard of 100 ug/m^3 for particulates in this region is exceeded. Judging from the relative dust emission magnitudes from various sources developed in Table 1.9.4-2, it could be concluded that agricultural operations are the cause of these violations. Another aspect of these natural and uncontrolled emissions is that their influence on the ambient air quality of the region is probably more significant than particulate emissions from a geothermal facility.

The mobile source gaseous pollutant emissions identified in the Imperial County inventory (Table 1.9.4-1) are extremely low and reflect the relatively light motor vehicle activity in this region. In the adjoining San Diego County, the estimated annual carbon monoxide (CO) emissions, mostly generated by motor vehicles, were 515,000 tons, equivalent to 1,400 ton/day[7]. This value represents greater than an order-of-magnitude multiplier over the daily value of 105.6 ton/day represented for Imperial County.

1.9.5 Ambient Air Quality

The California Air Resources Board (CARB) maintains records for over 200 air quality monitoring stations in California. Some are partial stations, measuring only one pollutant, and others are complete stations monitoring five or more gaseous pollutants and several components of particulate matter. At many of the larger stations, such meteorological data as wind speed and direction are also recorded. In addition, the CARB operates a mobile air quality surveillance unit to provide supplemental information in data-sparse regions. The pollutants usually measured are oxidants (O_3), carbon monoxide (CO), hydrocarbons (HC), sulfur dioxide (SO_2) and particulate matter. The mobile unit also has hydrogen sulfide and oxides of nitrogen monitoring equipment.

Various criteria have been established by the CARB to determine data credibility.[8] Thus, for any annual summary, there must be at least 46 measurements of daily maximum-hour concentrations or 1,096 measurements of hourly concentration. For particulate pollutants by Hi-Volume sampling, there must be at least 12 measurements of 24-hour duration. The sampling/measurement methods for each of the pollutants, as recommended by the Air Resources Board, is shown in Table 1.9.3-1.

A CARB air quality surveillance unit was situated in Niland from January 6 to March 15, 1976 and in Calexico from January 8 to February 25, 1976. Hydrogen

TABLE 1.9.4-2
SAN JOAQUIN VALLEY AIR BASIN SUMMARY
ESTIMATED ANNUAL EMISSIONS FROM FUGITIVE DUST SOURCES - 1972

County	Unpaved Roads		Agriculture		Construction		Tailings Piles		Aggregate Storage		Cattle Feedlots		County Emission
	Veh. Mi/Day	Emis. T/Yr	Acres	Emis. T/Yr	Acres Per/Yr	Emis. T/Yr	Acres	Emis. T/Yr	10^3 Tons	Emis. T/Yr	10^3 Head	Emis. T/Yr	Total Tons/Yr
Amador	750	520	3,400	60	-	-	-	-	-	-	-	-	580
Calaveras	4,350	2,940	1,000	Neg.	-	-	-	-	-	-	-	-	2,940
Fresno	158,000	70,040	887,500	117,300	964	16,200	-	-	562	1,620	130	410	205,570
Kings	62,050	36,900	399,100	133,000	-	-	-	-	-	-	45	360	170,260
Madera	90,400	58,510	208,800	40,000	180	3,020	-	-	55	160	-	-	101,690
Mariposa	7,300	4,920	1,000	Neg.	-	-	-	-	-	-	-	-	4,920
Merced	11,200	7,550	303,300	28,100	-	-	-	-	-	-	67	540	36,190
San Joaquin	1,300	8,840	362,200	29,000	500	8,390	-	-	300	860	-		47,090
Stanislaus	800	540	177,500	23,600	125	2,100	-	-	80	230	70	560	27,030
Tulare	20,350	3,530	506,800	189,000	-	-	-	-	-	-	30	240	192,770
Tuolumne	2,650	1,800	1,200	Neg.	-	-	-	-	-	-	-	-	1,800
Kern (portion)	27,800	3,300	557,000	288,290	290	4,870	-	-	315	900	165	1,320	298,680
AQCR Activity Totals	386,950		3,408,800		2,059		-		1,312		507		
AQCR Emission Totals		199,390		848,350				-		3,770		3,430	1,089,520

sulfide, hydrocarbons, and nitrogen oxides were among the parameters measured during this study.

The Imperial Valley APCD operates three air quality monitoring stations - at Brawley, Calexico and El Centro (Figure 1.9-2). Particulates are monitored at all three stations by Hi-Volume measurements. At the El Centro station, oxidants (O_3) sulfur dioxide (SO_2) and lead particulates are also measured. The monitoring data collected by the APCD are reduced and collated by the CARB and issued in their Air Quality Summaries.

Livermore Laboratories, under contract to ERDA, began an air quality and meteorology data acquisition program on August 1, 1976. This study involves ambient monitoring of critical pollutants (H_2S, SO_2, O_3 and particulates) at five locations throughout the Imperial Valley. Initial monitoring sites were chosen at Niland, Brawley, Heber, Elmore Ranch and Calexico (see Figure 1.9-2). In addition, a climatology program will provide information on the atmospheric transport and dispersion characteristics in the region. Initial data from this program are expected to become available about January, 1977.

The most recently available particulate data supplied by Imperial County APCD for the period August, 1975 through July, 1976 are summarized in Table 1.9.5-1. The maximum daily concentrations in each month at all three particulate monitors were well in excess of the California standard of 100 ug/m^3. This air pollution situation is caused almost solely by fugitive dust emissions.

The latest 12 months of CARB gaseous and particulate data for El Centro are summarized in Table 1.9.5-2.(9) From the table it can be seen that the maximum SO_2 concentrations are comfortably below the state standard. The maximum ozone concentrations exceeded the state standards on one or more days during two of the 12 months summarized, while particulate lead concentrations were over the standards by only once.

The CARB mobile unit monitoring data for Calexico and Niland are presented in Tables 1.9.5-3 and 1.9.5-4 respectively. From the Tables it can be seen that the federal air quality standard for oxidants of .08 ppm was exceeded during five of the 1,393 hours recorded at Niland, but was not exceeded for any of the 1,135 hours measured at Calexico. Ambient air quality standards for sulfur dioxide, hydrogen sulfide, and carbon monoxide were not exceeded at either

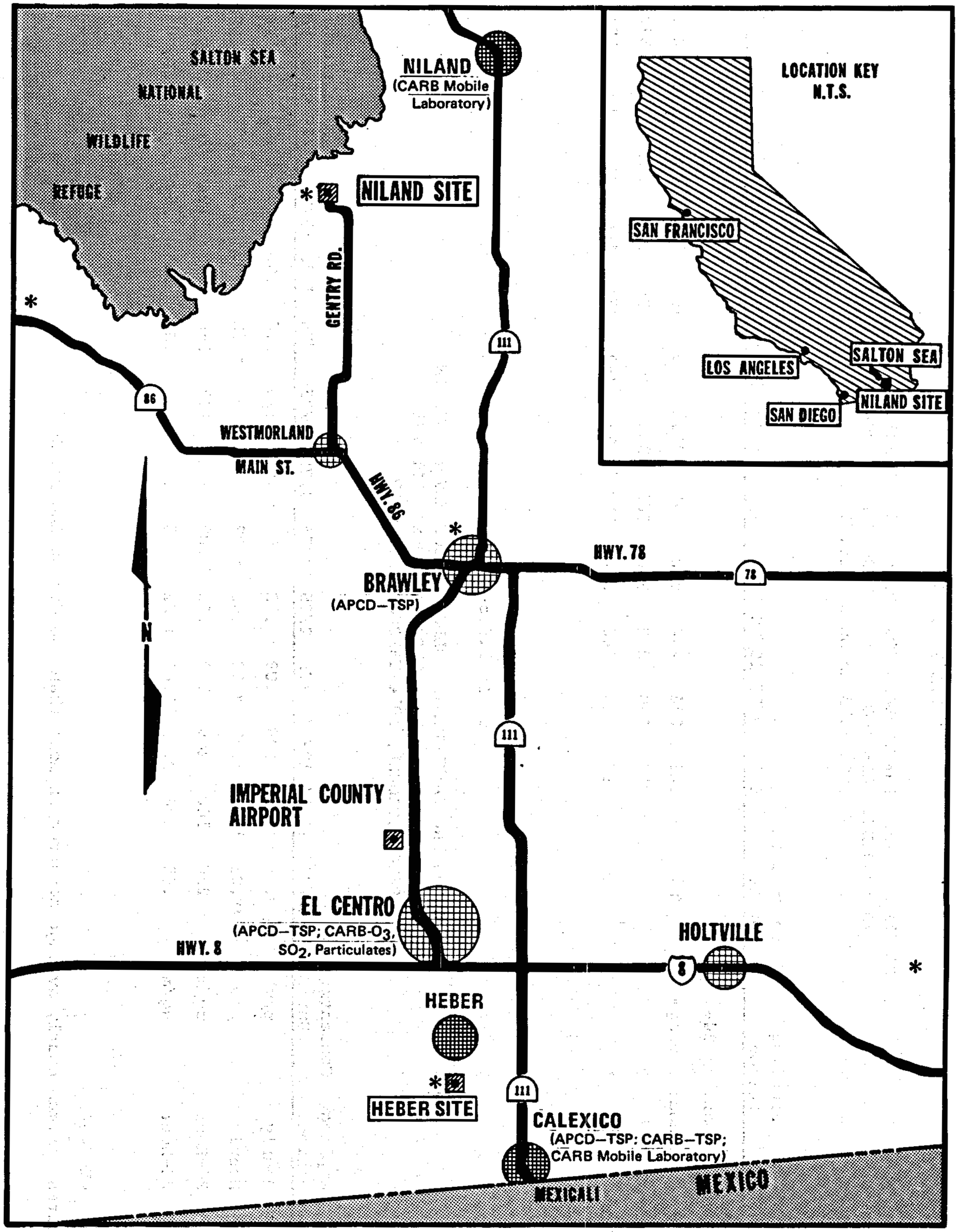


Figure 1.9-2 Location of Existing Air Quality Monitors in Imperial County, California (*Indicates Location of Lawrence Livermore Laboratories Mobile Monitors).

TABLE 1.9.5-1

MAXIMUM MONTHLY PARTICULATE CONCENTRATIONS IN AMBIENT AIR AT BRAWLEY, CALEXICO AND EL CENTRO FOR THE PERIOD AUGUST, 1975 through JULY, 1976

Location	Sampling Period	Concentration Units	8/75	9/75	10/75	11/75	12/75	1/76	2/76	3/76	4/76	5/76	6/76	7/76
Brawley	Maximum 24-hour average	ug/m3	249	224	244	460	222	314	489	459	156	400	298	275
Calexico	"	"	272	289	273	386	365	309	463	235	340	252	498	372
El Centro	"	"	194	214	140	312	177	178	260	371	156	393	193	271

TABLE 1.9.5-2

GASEOUS AND PARTICULATE POLLUTANT CONCENTRATIONS IN AMBIENT AIR AT EL CENTRO, CALIFORNIA FOR THE PERIOD OCTOBER, 1974 THROUGH SEPTEMBER, 1975

Pollutant	Sampling Period	Concentration Units	10/74	11/74	12/74	1/75	2/75	3/75	4/75	5/75	6/75	7/75	8/75	9/75	California Standards
O_3	Hourly	ppm	*.08	.08	.06	.09	.12	.08	*.09	.13	.10	.08	*.08	.09	.10 ppm
SO_2	Hourly	ppm	*.01	*.02	*.02	*.02	.03	*.02	.02	*.02	*.02	*.03	*.02	*.02	.50 ppm
TSP	24-Hour	ug/m^3	220	160	245	172	105	209	134	142	358	343	194	205	100 ug/m^3
Lead	24-Hour	ug/m^3	.65	.48	2.18	1.43	1.22	.65	.43	.52	.34	.53	.53	.52	1) 1.5 ug/m^3

1) 30 day average

* Indicates maximum hourly average occurred on more than one day during month.

TABLE 1.9.5-3

SUMMARY OF MOBILE UNIT AIR MONITORING DATA
LOCATION: Calexico SITE: 13C01

CONTAMINANT		MONITORING PERIOD	NUMBER OF OBS	RANGE OF CONCS. LO	RANGE OF CONCS. HI	AVERAGE ALL CONCS.	AVERAGE MAX HOURS
O_3	ppm	Jan 8 - Feb. 25, 1976	1135	0	.08	.03	.05
CO	ppm	" " " " "	984	0	20	1.2	5.3
NO	ppm	" " " " "	1132	0	.26	.02	.08
NO_2	ppm	" " " " "	1132	.02	.27	.08	.14
NOx	ppm	" " " " "	1132	.02	.48	.09	.21
TS	ppm	Jan 29 - Feb 25, 1976	1140	0	.03	<.01	<.01
H_2S	ppm	" " " " "	544	0	.01	<.01	<.01
SO_2	ppm	" " " " "	544	0	.01	<.01	<.01
THC	ppm	Jan 8 - Feb 25, 1976	984	1.7	16.0	3.0	6.1
CH_4	ppm	" " " " "	984	1.7	10.8	2.4	4.0
NMHC	ppm	" " " " "	984	0	8.2	.6	2.6
COH		" " " " "	567	0	4.5	.4	1.2
TSP	ug/m^3			71	348	205	
LEAD	ug/m^3	*					

CONTAMINANT	CONCENTRATIONS OVER STANDARDS 1 HR	3 HR	8 HR	24 HR	30 DAY	COMMENTS
O_3 >.08	0					
CO >35/>9	0		0			
NO						
NO_2 >.25	1					
NOx						
H_2S >0.03	0					
SO_2 >.5/>.04	0			0		
THC						
CH_4						
NMHC >.24		32				
COH						
TSP >100				9		
LEAD >1.5						* not presently available

TABLE 1.9.5-4

SUMMARY OF MOBILE UNIT AIR MONITORING DATA
LOCATION: Niland SITE: 13D01

CONTAMINANT		MONITORING PERIOD	NUMBER OF OBS	RANGE OF CONCS. LO	RANGE OF CONCS. HI	AVERAGE ALL CONCS.	AVERAGE MAX HOURS
O_3	ppm	Jan 6 - March 15, 1976	1393	0	.10	.02	.04
CO	ppm	Jan 8 - March 15, 1976	1367	0	2	.1	.3
NO	ppm	Jan 6 - March 15, 1976	1647	0	.09	<.01	.02
NO_2	ppm	" " " " "	1647	0	.09	.01	.02
NOx	ppm	" " " " "	1647	0	.11	.02	.04
TS	ppm	Feb 25 - March 15, 1976	437	0	.03	<.01	<.01
H_2S	ppm	Feb 11 - March 15, 1976	552	0	0	0	0
SO_2	ppm	Feb 11 - March 15, 1976	730	0	0	0	0
THC	ppm	Jan 8 - March 15, 1976	1367	1.4	5.1	1.9	2.8
CH_4	ppm	Jan 8 - March 15, 1976	1367	1.4	5.1	1.9	2.7
NMHC	ppm	Jan 8 - March 15, 1976	1367	0	1.1	<.1	.1
COH		Jan 13 - March 15, 1976	737	0	1.9	.2	.6
TSP	ug/m^3	Jan 10 - March 13, 1976	10	37	124	85	
LEAD	ug/m^3	*					

CONTAMINANT	CONCENTRATIONS OVER STANDARDS 1 HR	3 HR	8 HR	24 HR	30 DAY	COMMENTS
O_3 >.08	5					
CO >35/>9	0		0			
NO						
NO_2 >.25	0					
NOx						
H_2S >0.03	0					
SO_2 >.5/>.04	0			0		
THC						
CH_4						
NMHC >.24		4				
COH						
TSP >100				4		
LEAD >1.5						* not presently available

location during the sampling period. Non-methane hydrocarbons were above standards four of 61 days at Niland and 32 of 42 days recorded at Calexico. Total suspended particulate concentrations exceeded standards on occasion at both remote locations.

The major pollutant present in the atmosphere in the Imperial Valley is particulate matter in the form of fugitive dusts. These particulates are emitted from agricultural operations, improved roads and arid lands through wind erosion. Other pollutants of consequence in the Imperial Valley are those associated with motor vehicle travel - CO, NO_x and oxidants (O_3). Under some conditions it is possible that oxidants and oxides of nitrogen are transported into the Imperial Valley from the adjoining heavily populated San Diego and South Coast air basins. The limited data currently available suggest low background concentrations of hydrogen sulfide and sulfur dioxide. Additional data expected from Lawrence Livermore Laboratory will further define the ambient concentrations of these and other pollutants in the Imperial Valley.

REFERENCES - Air Quality

1. California Air Basins, California Air Resources Board, the Resources Agency, Sacramento, California, December 1972.

2. Rules and Regulations, Adopted October 18, 1971, County of Imperial Environmental Quality Control, Air Pollution Control District, El Centro, California.

3. Leonardos G. Kendall D., Barnard N.; Odor Threshold Determinations of 53 Odorant Chemicals, J-APCA, Vol. 19, No. 7, 91-95, February 1969.

4. Emissions Inventory for the Imperial County Portion of the Southeast Desert Air Basin, transmitted to VTN by John V. Taylor, Asst. Air Pollution Control Officer for Imperial County, El Centro, California, February 1976.

5. Investigation of Fugitive Dust - Sources, Emissions and Control, PED Co. Environmental, Cincinnati, Ohio, May 1973.

6. Cowherd, Chatten Jr., Development of Emission Factors for Fugitive Dust Sources, Midwest Research Institute, Kansas City, Missouri, Paper No. 74-81 presented at the National APCA Meeting, 1974.

7. Operational Plan for Air Pollution Control in San Diego County, County of San Diego Air Pollution Control District, December 22, 1971.

8. Ten Year Summary of California Air Quality Data, 1963-1972; California Air Resources Board; Sacramento, California, January 1974.

9. California Air Quality Data - October 1974 through September 1975 California Air Resources Board, Sacramento, California, Vol. VI, No. 4, and Vol. VII, Numbers 1, 2 and 3.

1.10 AMBIENT SOUND LEVELS

A comprehensive survey of ambient noise levels existing in the Heber region of Imperial County, California, has been conducted. The purpose of the survey is to establish data relative to the existing noise environment in the vicinity of potential geothermal development site in the Heber area and to gain representative estimates of noise levels existing in the community itself. With these baseline data the future noise impact of a geothermal facility can be predicted, both in the plant vicinity and in the Heber Community. The Heber area was thoroughly canvessed and five noise measurement sites were selected which would categorize the current community and regional noise environment and which could be used as monitoring locations. In this latter regard security of the site was an important factor since a noise recorder would need to be left unattended for several days at a time to compile noise profile data. Ambient noise level information was recorded digitally on magnetic tape and subsequently analyzed by computer to establish the acoustical baseline.

1.10.1 Identification and Selection of Measurement Sites

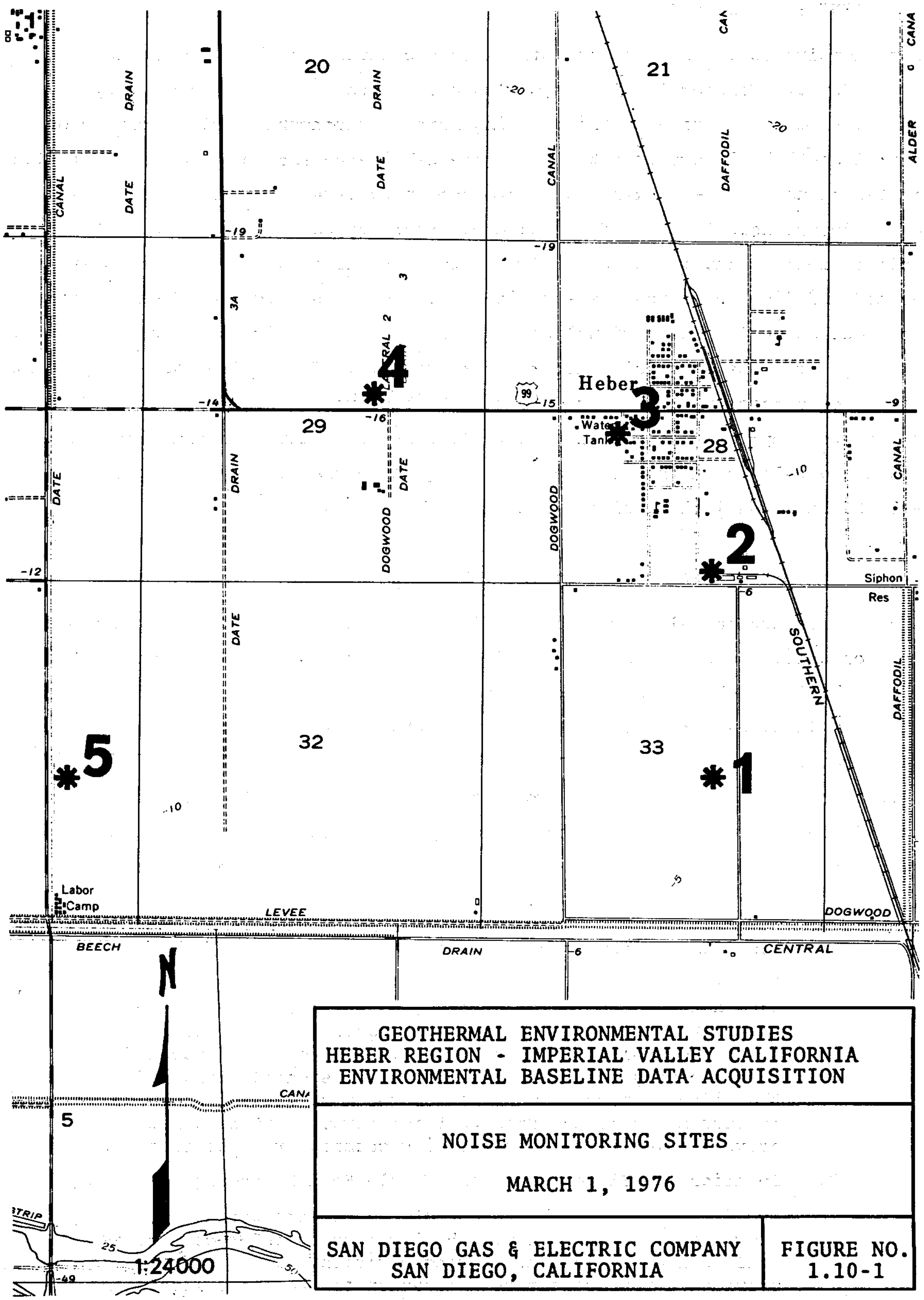
Five noise measurement sites were identified and selected to provide a representative community and regional noise profile. One site was the location of a geothermal well which is considered a high potential location for the geothermal facility. All sites were within the defined subregional area for the environmental study but geographically dispersed so as to provide an adequate profile. The location of the individual measurement sites is shown on Figure 1.10-1. All sites offered security to leave a noise recorder unattended for several days. A description of each monitoring site and the rationale for its selection is as follows:

1. Location 1: Nowlin Well No. 1

   This location provides noise levels representative of the candidate geothermal plant site, as well as an indication of the acoustical environment in the agricultural areas south of the Community of Heber. The site is several hundred feet from a county road and so would be occasionally impacted by the noise of passing vehicles or the more distant sound of infrequent railroad train traffic; however, it is a relatively quiet site because of its setback from the roadway.

2. Location 2: El Toro Land and Cattle Feed Warehouse

   The fenced area at the corner of the El Toro warehouse provided a secure area for the location of the recorder, as well as a convenient monitoring position. This location provides a representative indication of the noise levels on the south edge of the Heber Community, including the Heber



GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

NOISE MONITORING SITES

MARCH 1, 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 1.10-1

School and the residential area nearest the proposed plant site. It lies approximately .7 mile north of Nowlin Well No. 1 (the candidate geothermal plant site), and has an unobstructed noise propgation path across agricultural lands from the well. The monitoring location is approximately equidistant (about 50 feet) from the centerline of two adjacent roadways and is affected by passing vehicle noise. The location chosen is well shielded from noise generated by mechanical blowers associated with feed lot operations. It is occasionally subjected to noise from heavy equipment such as tractors or trucks taking part in feed lot activities.

3. Location 3: Heber Utilities Water Works-Water Plant

   Near the center of the Community of Heber as well as being within 200 feet of State Route 86, this site was chosen to provide a sample of the urban noise level in the community. The recorder was located atop the one-story Heber waterworks building to afford it protection from passing ground level activities and to minimize the effects of acoustical shielding by nearby buildings. The predominant noise element would be motor vehicle traffic.

4. Location 4: Hulse Well No. 1

   This location was chosen as appropriate to characterize the noise generated by traffic along Route 86, west of the community where the vehicles are at highway speed. Agricultural activity in nearby fields would also be measured. The site is set back approximately 200 feet from centerline of Highway 86.

5. Location 5: Magma Holtz Well No. 2

   This site, some 2.2 miles to the west of the candidate plant site, is representative of the agricultural region in the southwestern portion of the study area. It is located sufficiently close to a farm worker labor camp to acoustically characterize it. Also highway traffic from a county road approximately 200 feet to the west will be recorded.

1.10.2 Measurement Methodology

The equipment used to record ambient sound levels was the NOMAL 2B precision sound level recorder system manufactured by Nomal Data Systems, Inc. The NOMAL system consists of a sound level meter and a data recorder in a compact weatherproof box which can be left unattended for extended periods. The system is battery powered (12Vdc). The system includes the NOMAL noise level data recorder with a single microphone input, a Bruel & Kjaer (B&K) 1/2 in. free field microphone (Type 4163), a B&K condenser microphone preamplifier (Type 2619/S) and a B&K wind screen. The NOMAL noise level data recorder package contains a sound level meter, an A-weighted filter, an A-D converter and the tape recorder. AMPEX C90 recording cassettes were used. Sound data were recorded on the cassette tape for computer analysis.

Measurements were made in A-weighted sound pressure levels (dBA). The data gathering was done in the range between 32 and 92 dBA, with a two-second scan rate. This means that only levels between 32 and 92 dBA were recorded, and that the instantaneous sound level was taken every two seconds. The two-second scan rate was selected to give the maximum amount of data consistent with the specified time period at each site. Over 800,000 individual measurements were made, recorded and processed during the course of the study. In only one case was there a noise level encountered above 91 dBA during the measurement period, and that was for a period of 8 seconds. In some cases, there were levels below 32 dBA, primarily at night or early in the morning. These low levels have little effect on the composite scale selected for use in this project (L_{dn}).

The NOMAL system was calibrated with a pistophone calibrator at each site as part of the set-up procedure. The microphone was fitted with a wind screen and positioned between 4 and 8 feet above the ground except in location 3 (water works) where it was approximately 14 feet above ground.

During the first phase of the study the objective was to record three days of sound data at each site to include two weekdays and one weekend day. Thus 72 hours of sampling would be available upon which to develop an initial composite noise rating. At one site a battery failure prevented a full three days worth of data being obtained during the initial data collection phase, however both weekday and weekend data were obtained. The initial data were recorded during the period January and February 1976.

Subsequent to the initial data collection phase each site was to be monitored for one additional day at a period approximately six months later to verify the initial sound data and/or to determine any significant variations therein. Also at this time one additinoal days worth of data was collected for the site where the battery failure occurred during phase one. The second data collection phase took place in July and August 1976.

1.10.3 Data Processing

The cassette tapes were processed by computer system to yield individual time related data for each site. The Digital Equipment Corporation PDP-8/A computer system was used. For each site all data were compiled into hourly periods and within each hourly period several acoustical indicators were calculated. After calibration and site identification are entered into the computer for each tape, the computer processes the data in hourly increments and it is printed out in histogram form.

The metrics listed every hour in the printout include five percentile readings and equivalent sound level, A-weighted (L_{eq}). L_{10}, for example, is that level exceeded 10 percent of the time. Thus, it is near the top of the range of noise levels recorded during the period in question. L_{50} is the median noise level, and L_{90} the lowest 10 percentile level. The term L_{eq} is a noise level averaging system based on the energy contained in each sound level. It is the basis for computing the Community Noise Equivalent Level (CNEL) and the Day-Night Average Sound Level (L_{dn}) measures used by the State of California and the U.S. Environmental Protection Agency (EPA), respectively. The only difference among the three is that L_{eq} is generally taken over an hour period, while CNEL and L_{dn} are 24-hour levels calculated from the hourly L_{eq}. The L_{dn} system artificially adds 10 dBA to L_{eq} levels measured between 10:00 p.m. and 7:00 a.m. before energy averaging, while the CNEL system adds 5 dBA to levels measured between 7:00 p.m. and 10:00 p.m., as well as 10 dBA to nighttime levels between 10:00 p.m. and 7:00 a.m. before averaging. These additive factors reflect the increased sensitivity to noise during these periods.

Thus, in summary for each of the five sites four different noise measures are calculated:

1. L_{eq}
2. Percentile readings (L_{10}, L_{50}, L_{90})
3. CNEL, and
4. L_{dn}

Only CNEL and L_{dn} are computed on a daily basis.

1.10.4 Baseline Noise Data

Tables 1.10-1 and 1.10-2 summarize the results of the noise monitoring data for the five sites in terms of L_{dn} and CNEL, respectively. From a practical standpoint there is no significant variation between L_{dn} and CNEL, however both are shown since the State of California and EPA utilize different terms.

1.10.5 Data Analysis and Summary

Conditions for noise data collection were excellent during both recording periods. No severe weather conditions such as rain or thunderstorms occurred with the exception of some periods of moderate winds. Thus weather was not a significant factor effecting the baseline noise data.

TABLE 1.10-1

HEBER REGION BASELINE NOISE DATA
DAY - NIGHT AVERAGE SOUND LEVEL (L_{dn} - dB)

Location	Phase 1 - Jan/Feb 1976 Day 1	Day 2	Day 3	Phase II Jul-Aug 76	4 Day Avg. L_{dn}	Std. Dev. (σ)
Site 1 (Nowlin Well No. 1)	50.00	54.20[b]	50.34[a]	55.68	52.56	±2.8
Site 2 (El Toro Land)	62.83	60.47	64.92[a]	60.16	62.10	±2.2
Site 3 (Heber Utilities)	60.30	60.92	60.17[a]	61.90	60.82	±.8
Site 4 (Hulse Well No. 1)	58.06	56.07	57.66[a]	61.90[a]	58.42	±2.5
Site 5 (Magma Holtz Well No. 2)	54.53	62.67	56.31[a]	57.62	57.78	±3.5

(a) Weekend day
(b) Recorded in Aug. 76

TABLE 1.10-2

HEBER REGION BASELINE NOISE DATA
COMMUNITY NOISE EQUIVALENT LEVEL (CNEL) - dB

Location	Phase 1 - Jan/Feb 1976 Day 1	Day 2	Day 3	Phase II Jul-Aug 76	4 Day Avg. L_{dn}	Std. Dev. (σ)
Site 1 (Nowlin Well No. 1)	50.16	54.42 [b]	50.55 [a]	55.73 [a]	52.72	±2.8
Site 2 (El Toro Land)	63.14	60.64	65.11 [a]	60.46	62.34	±2.2
Site 3 (Heber Utilities)	60.64	61.24	60.43 [a]	62.30	61.15	±.8
Site 4 (Hulse Well No. 1)	58.25	56.31	58.02 [a]	62.02 [a]	58.65	±2.4
Site 5 (Magma Holtz Well No. 2)	54.89	62.69	56.51 [a]	58.02	58.03	±3.4

(a) Weekend day
(b) Recorded in Aug. 76

The noise monitoring data are reflective of the types of activities expected to impact upon each site. Site No. 1 is the quietest as would be expected because of setback from well-traveled roadways. The L_{dn} measured on the four days here is in the 50-55 dB range. Sites 2 and 3 which are in the Community of Heber showed levels ranging from L_{dn} 60 dB to 65 dB. This is quite typical of an urbanized area with motor vehicle noise. The El Toro site (No. 2) showed more variation probably due to the operational profile of heavy equipment in the feed yard and other related industrial activities, whereas the Heber Utilities site very consistently reflected traffic noise on nearby Highway 86 and noise from the utility plant itself. Site 4 west of Heber showed some variation particularly in the summer reading which was apprximately 5 dB higher than the Phase I recording. This is discussed below under seasonal variation factors. At Site 5, there was a variation in one day only which was due to a single hourly period (1800 - 1900) where apparently nearby agricultural equipment raised the hourly L_{eq} to 74.64 dB. Without this one hour, the L_{dn} level would have been 58.2 dB, which is in better agreement with the levels measured at that site for the other days and at other similar sites.

In general, noise levels increased with proximity to populated areas and well-traveled roads. Levels taken in the center of agricultural fields, away from habitation and roadways, were quiet as might be expected (L_{dn} 50-55 dB). Non-urban areas near roadways - experienced levels of L_{dn} 55-60 dB. Urban areas of Heber were in the L_{dn} 60-65 dB range. The Heber region is impacted by noise levels typical of a developed area, principally due to road traffic, agricultual equipment and some industrial activities.

The results of the six month verification data phase show a trend toward slightly higher noise levels in the summer months than those recorded during the previous winter period especially in these areas subjected to agricultural equipment activities and truck traffic (Sites 1, 4 and 5). There were some high noise levels at Site 4 on Route 86 during the nighttime possibly reflecting field harvest activities. In general it was the observation of the personnel handling the data recording equipment that there was more agricultural related activity during the summer period. This reflected itself in the higher recorded levels. Nevertheless the standard deviations of the noise data were typical of those found in most monitoring studies (± 3 dB). The urban sites (El Toro Land and Heber Utilities) had the smallest standard deviations.

Noise levels measured at all sites fell into the "caution" (normally acceptable intermediate exposure) catgegory as set out in the Imperial County Noise Element of the General Plan.(1) It should be noted that all sites, except Site No. 1, have higher noise levels than L_{dn} 55 dB which has been identified by the EPA as the limit to prevent outdoor activity interference and annoyance and to protect health and welfare.(2) Eventual development of geothermal facilities in the Heber region must comply with the terms, conditions and standards of Imperial County for geothermal development.(3) This will require octave band analysis of geothermal related noise sources as measured at the parcel boundary.

REFERENCES - Ambient Sound Levels

1. County of Imperial, Noise Element, General Plan, October 1, 1974.

2. U.S. Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety, Washington, D.C., 1974, pp 4.

3. County of Imperial, Department of Public Works, TERMS, CONDITIONS, STANDARDS, AND APPLICATION PROCEDURES FOR INITIAL GEOTHERMAL DEVELOPMENT IMPERIAL COUNTY, May 1971.

4. Noise Control Act of 1972, Public Law 92-574, 92 Congress, HR 11021, October 27, 1972.

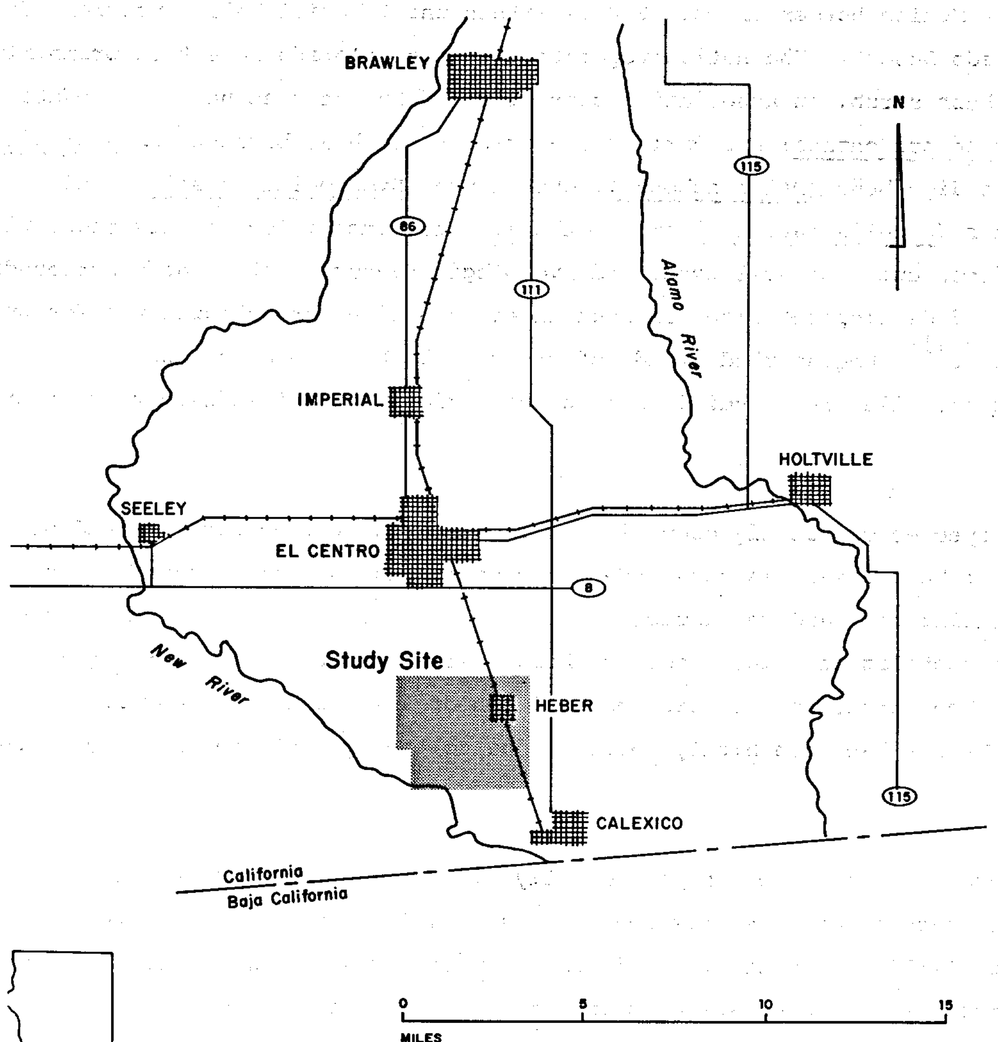
2.0 BIOLOGICAL SETTING

The proposed Heber Geothermal Development Project site is located near the California-Mexico border (Figure 2.0-1) within the Imperial Valley portion of the Colorado Desert. The native vegetation in the Colorado Desert is primarily creosote bush scrub, an association characterized by the presence of creosote bush (Larrea tridentata) and various co-dominants such as burro-bush (Ambrosia dumosa), indigo bush (Dalea schotti), cheesebush (Hymenoclea salsola), and brittlebush (Encelia farinosa) among others. The composition of this vegetation type is dependent upon soil types and hydrologic factors. The region surrounding the proposed development site has been under intensive agricultural use for up to 70 years.[1] Undisturbed stands of creosote bush scrub do not occur within the 12 square mile area studied, nor in the regional area immediately adjacent to it.

Wildlife species originally occurring in the Imperial Valley region would be expected to be the same as those presently common in Colorado Desert regions having similar soil and vegetation composition. These species include a large number of reptiles and small rodents, birds, some predators, and a few game species. The numbers and species composition of animals now present in the Imperial Valley has been highly modified due to the agricultural history in the area.

Agricultural drains, although periodically cleared of vegetation and in a continual state of early succession and revegetation, are a major source of cover for wildlife in most of the intensively farmed areas in Imperial Valley. Many of the plant species are also important wildlife food species.

Numerous canals and drains associated with the intense agricultural development in Imperial Valley support aquatic resources which historically were restricted to the Colorado River and its associated backwaters. The extent of the development of aquatic biota in these irrigation canals and wastewater drains is related to both water quality and the periodic nature of their flow rates.



GEOTHERMAL ENVIRONMENTAL STUDIES HEBER REGION - IMPERIAL VALLEY CALIFORNIA ENVIRONMENTAL BASELINE DATA ACQUISITION	
Location of the Heber Geothermal Development Study Site. 17 August 1976	
SAN DIEGO GAS & ELECTRIC COMPANY SAN DIEGO, CALIFORNIA	FIGURE NO. 2.0-1

2.1 TERRESTRIAL VEGETATION

2.1.1 Methodology

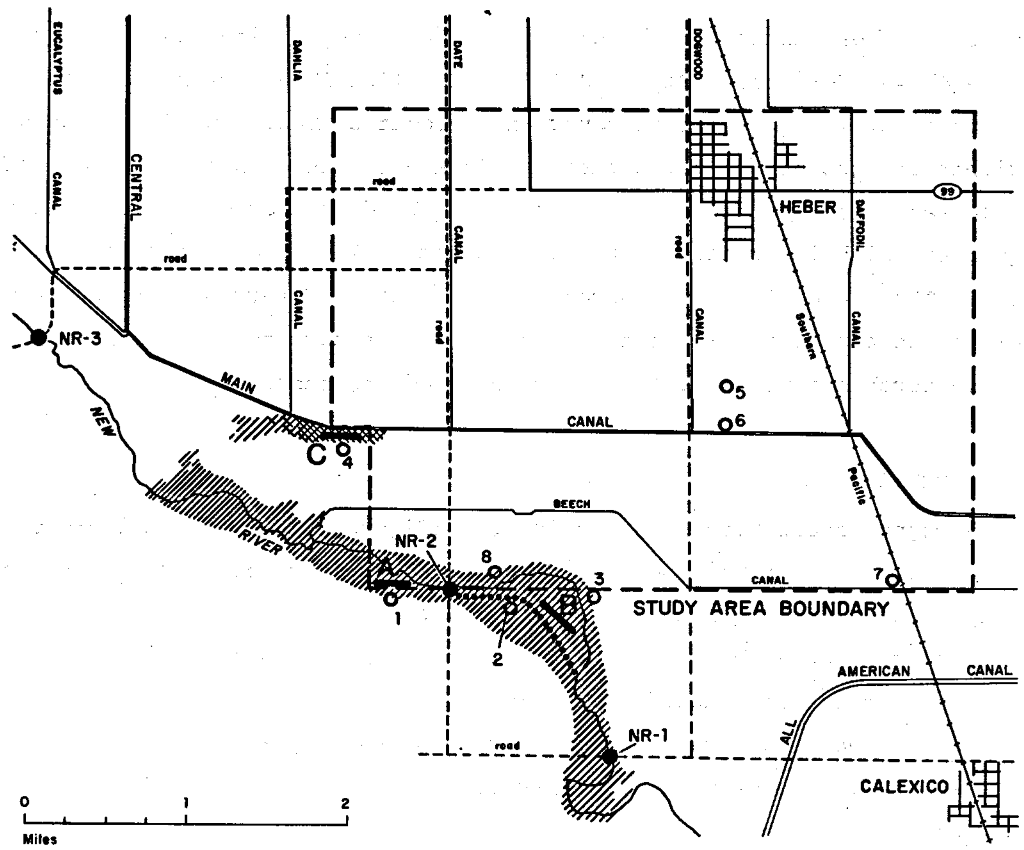
Three sites, representative of the non-agricultural vegetation in the Heber area, were chosen for study (Figure 2.1-1). The line intercept method was selected to determine the percent cover and percent composition of the shrubs found within the geothermal development study area. Based on a visual evaluation of the vegetation during field reconnaissance, the densities were such that the point quarter and belt transect methods were not utilized for determination of densities. The one-centare (one square meter) plot to determine percent ground cover of herbaceous plants was not utilizied because herbaceous plants did not occur in measurable numbers at the sites selected for sampling.

2.1.2 Description

Two habitat types occur within the study area (Figure 2.1-1), which includes about 12 square miles around the geothermal development site: agriculture and desert riparian. On the agricultural land a variety of crops such as lettuce, onions, asparagus, sugar beets, cabbage, alfalfa, and hay are grown. Since modern irrigation was instituted in the Imperial Valley about 1900, intensive agriculture has been practiced throughout most of the Imperial Valley region (see Reference 1). The proposed facility location is currently under such intensive agricultural use.

Remnants of native vegetation occur in the southwest corner of the study area adjacent to the New River (Figure 2.1-1). This desert riparian area comprises a very small portion of the total study area (approximately 3 percent). Native species which occur in this vegetation type include mesquite, four-wing saltbush, arrowweed, quailbush, and iodine bush. Additional species include shrubby seal blight, a very few individuals of creosote bush, and tamarisk, an introduced species which forms very dense stands in some areas (Table 2.1-1).

At Site A (Figure 2.1-1) the total ground cover exceeded 100 percent (Table 2.1-2). Arrowweed contributed 56.6 percent to this total while four-wing saltbush and tamarisk contributed 28.5 and 22.2 percent, respectively. Quailbush covered only 4.5 percent of the ground at this site (Table 2.1-2). At Site B six shrub species were present in contrast to the four species at Site A. Vegetation was more sparse in this area, however, with a total ground cover of only 36 percent. Arrowweed had the greatest ground cover percentage with 15.9 percent. Other



KEY:

- DESERT RIPARIAN
- DISTURBED DESERT RIPARIAN
- AGRICULTURAL
- VEGETATION SAMPLE SITE
- O MAMMAL SAMPLE SITE
- ••••••• AVIFAUNA TRANSECT
- ● AQUATIC SAMPLING STATIONS

GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY, CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

Vegetation, wildlife and aquatic sample sites.

17 August 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 2.1-1

TABLE 2.1-1

NON-AGRICULTURAL PLANT SPECIES OBSERVED
OR EXPECTED TO OCCUR WITHIN THE HEBER GEOTHERMAL STUDY AREA

Scientific Name	Common Name
TREES AND SHRUBS	
Allenrolfea occidentalis*	Iodine bush
Atriplex canescens ssp. linearis*	Four-winged saltbush
Atriplex lentiformis*	Quail bush
Baccharis glutinosa	Mule fat
Baccharis sarothroides*	Broom baccharis
Larrea tridentata*	Creosote bush
Parkinsonia aculeata*	Mexican palo verde
Pluchea sericea*	Arrowweed
Prosopis juliflora*	Mesquite
Suaeda fruticosa*	Shrubby sea blight
Suaeda torreyana	Torrey sea blight
Tamarix sp.*	Tamarisk
FORBS	
Asclepias sp.	Milkweed
Baileya pauciradiata*	Lax flower
Chenopodium album*	Lamb's quarters
Coldenia plicata	Plicate coldenia
Convolvulus arvensis*	Bindweed
Crypthantha sp.	Forget-me-not
Eriogonum sp.	Buckwheat
Heliotropium curassavicum var. oculatum*	Chinese pusley
Malva sp.	Mallow
Najas quadalupensis	Common water nymph
Oenothera sp.	Evening primrose
Polygonum sp.	Knotweed
Potamogeton pectinatus	
Rumex pulcher*	Fiddledock
Sonchus oleraceus*	Sow thistle

TABLE 2.1-1 (continued)

Scientific Name	Common Name
FORBS (continued)	
Sysimbrium irio*	London rocket
Typha latifolia	Cattail
GRASSES AND GRAMINOIDS	
Avena fatua*	Wild oat
cf. Cynodon dactylon*	Bermuda grass
Distichlis spicata*	Salt grass
Juncus spp.	Rush
Phlaris minor*	Canary grass
Phragmites australis*	Common reed
Polypogon monspeliensis	Rabbit's foot grass
Scirpus spp.	Bulrush

* Species observed

TABLE 2.1-2

PERCENT GROUND COVER AND RELATIVE COVER OF PLANT SPECIES OCCURRING IN NON-AGRICULTURAL AREAS IN THE HEBER GEOTHERMAL STUDY AREA

Scientific Name	Site A Ground Cover	Site A Rel. Cover	Site B Ground Cover	Site B Rel. Cover	Site C Ground Cover	Site C Rel. Cover
Allenrolfea occidentalis			4.8	14.1		
Atriplex canescens	28.5	25.6	3.1	9.0	10.3	25.9
Atriplex lentiformis	4.5	4.0				
Larrea tridentata			2.8	8.1		
Plucea sericea	56.6	50.6	15.9	46.7	29.5	74.1
Prosopis juliflora			9.1	26.6		
Tamarix sp.	22.2	19.8	.9	2.5		
	111.8	100.0	36.6	100.0	39.8	100.0

shrubs present at this site included mesquite, iodine bush, four-wing saltbush, creosote bush and tamarisk in order of decreasing percent cover (Table 2.1-2). On a subsequent field survey (June 1976) it was found that this area ahd been burned and most of the vegetation that had been previously sampled had been destroyed. Herbaceous plants and ephermeral winter annuals that might be expected to occur in this area were not observed during the winter and spring sampling periods in January and June 1976. Site C (Figure 2.1-1), a disturbed area adjacent to the Central Main Canal, is less diverse than Sites A or B. Only two plant species were present. Arrowweed comprised 29.5 percent of the ground cover and four-wing saltbush covered 10.3 percent (Table 2.1-2).

The canals and drains in the study area support several herbaceous species including salt grass, Bermuda grass, common reed, and Chinese pusley; however none occurred in measurable quantities within the study site.

2.1.3 October 1976 Field Survey

During October 1976 a supplementary botanical field servey was conducted of the Heber Geothermal Development Project site. Each of the three vegetation sites was visited and qualitative observations were made of these areas.

Site A appeared unchanged from the winter and spring surveys. The roadside has been somewhat disturbed by road grading and no herbaceous plants were found to be growing in this area.

Site B, which was burned in the spring of this year, is recovering from that disturbance. Tamarisk and arrowweed are revegetating the area, however the mesquite does not seem to be recovering. Some herbaceous plants, sand verbena (Abronia villosa), London rocket (Sisymbrium irio) and chinch weed (Pectis papposa) were growing in the sandy soil above the burned area. These annual plants were probably responding to the heavy rains that fell in this area in September.

Site C appeared to be unchanged from the winter and spring serveys. No new species of plants were noted in this area which is adjacent to the Central Main Canal.

A reconnaissance of the canals and drains in the remaining portion of the study area revealed no new plant species.

2.1.4 Rare and Endangered Plants

No rare or endangered plants were observed and, because of the intensive agriculture and generally disturbed nature of the vegetation in the Heber area, no rare and endangered species are expected to occur in the geothermal development study area.

REFERENCES - Terrestrial Vegetation

1. California Region Framework Study Committee, Comprehensive Framework Study California Region, Appendix X: Irrigation and Drainage, Pacific Southwest Inter-Agency Committee Water Resources Council, 1971.

2.2 TERRESTRIAL WILDLIFE

2.2.1 Mammals

Methodology. To assess the relative abundance and species composition of small mammals, two parallel trap lines of 15 Smith live traps, each spaced at 15m intervals, were placed in various native, desert riparian, disturbed, and agricultural areas (Figure 2.1-1), in January and July of 1976. Trap lines 1, 2, 3, and 8 were located along the New River, a major drain in the Imperial Valley, which supports remnants of native desert riparian vegetation. Trap line 4 was located along the Central Main Canal on a strip of disturbed ground between the canal and adjacent agricultural plantings. Trap line 5 was placed in an alfalfa field near the Knowlin geothermal well site; line 6 was located near a drainage ditch which borders agricultural plantings; line 7 was set in a strip of vegetation comprised mainly of tamarisk and saltbush and bordered by the Southern Pacific Railroad tracks and agricultural plantings.

Larger mammals and predators were identfied by observation of sign, tracks, scat, droppings, spotlight transects, and the coyote scent post technique of the U. S. Fish and Wildlife Service.

Spotlight transects were established in the New River drainage to determine the occurrence, habitat utilization and relative abundance of predators and other nocturnal wildlife. These transects were conducted by vehicle along access roads within the New River drainage at an approximate speed of 10 miles per hour. All animals observed within an illuminated transect 1.5 km. in length by 30-50 m in width were counted. Results of these types of surveys represent only those animals visibly active at the time the survey was made. Ten percent of less of the population may be observed with this method due to the escape or avoidance responses of the larger mammals.

Three coyote scent post lines with 10 scent stations each were located in the New River drainage adjacent to small mammal trap lines 1, 2 and 3. Each scent station consisted of a one meter diameter circle of sifted earth with an attractant placed in the center. Tracks present within the one meter circle were identified and recorded daily. After tracks were recorded the station was raked smooth and reset. Each scent post line was run for two days.

Information gathered in these studies was compared with documented species ranges[1] and with data gathered in recent California Department of Fish and Game studies[2,3] of Imperial Valley drainages and the Coachella Canal. Several wildlife species that may be expected to occur in the study area, based upon observations in the above reports, were not observed during the winter, spring and early summer surveys in the present study.

Description - Small Mammals. Seven species of rodents were trapped in the study area (Table 2.2-1). In areas where native or non-agricultural vegetation remains (trap lines 1, 2, 3, 8), the cactus mouse (*Peromyscus eremicus*) was the most abundant rodent. The round tailed ground squirrel (*Citellus tereticaudus*), long tailed pocket mouse (*Perognathus formosus*), and the deer mouse (*Peromyscus Maniculatus*) were also trapped in these areas. Additional species expected to occur in the desert riparian areas are listed in Table 2.2-1).

In disturbed areas, trap lines 4 and 7, the round tailed ground squirrel (*Citellus tereticaudus*) and the house mouse (*Mus musculus*) were most common.

Species most common in, and bordering, agricultural plantings included the western harvest mouse (*Reithrodontomys megalotis*), the deer mouse (*Peromyscus Maniculatus*), and the house mouse, (*Mus musculus*).

The lack of small mammal diversity in agricultural areas near Heber is primarily due to the lack of habitat variety and disruption of native vegetation. A uniform habitat, e.g., agricultural areas, often results in the presence of only a few small mammal species which are able to utilize the specific variety of food and cover afforded by the vegetation present. The house mouse is an example of one of these species. The long tail pocket mouse, on the other hand, is probably more sensitive to human disturbances and would be replaced by the more resistant and resilient species such as the house mouse and the deer mouse.

Description - Medium-Sized Mammals and Predators. Tracks of the black-tailed jackrabbit (*Lepus californicus*), the desert cottontail (*Sylvilagus audubonі*), and the raccoon (*Procyon lotor*) were observed in the scent post survey stations. Additional sign observed in the study area indicated that the muskrat (*Ondatra zibethica*) was also present in the Heber area. Sign observation does not permit estimates of relative abundances or densities, however, interpolation of data obtained in previous studies (see Reference 2) indicates that muskrat densities in drains and irrigation canals average from slightly less than one to almost seven individuals per mile.

TABLE 2.2-1

MAMMAL SPECIES OBSERVED OR EXPECTED TO OCCUR WITHIN THE HEBER GEOTHERMAL STUDY AREA

Scientific Name	Common Name
INSECTIVORA	
Soricidae	Shrews
Notiosorex crawfordi	Gray shrew
CHIROPTERA	
Phyllostomatidae	Leaf-nosed bats
Macrotus californicus	California leaf-nosed bat
Choeronycteris mexicana	Hognose bat
Vespertilionidae	Evening bats
Myotis velifer	Cave myotis
Myotis californicus	California myotis
Myotis yumanensis	Yuma myotis
Myotis occultus	Arizona myotis
Myotis thysanodes	Fringed myotis
Myotis volans	Hairy-winged myotis
Myotis subulatus	Small-footed myotis
Plecotus townsendii	Western big-eared bat
Lasiuris borealis	Red bat
Lasiuris cinereus	Hoary bat
Eptesicus fuscus	Big brown bat
Pipistrellus hesperus	Western pipistrelle
Euderma maculata	Spotted bat
Antrozous pallidus	Pallid bat
Molossidae	Free-tailed bats
Tadarida brasiliensis	Brazilian free-tailed bat
Tadarica femorosacca	Pocketed free-tailed bat
Tadarida molossa	Big free-tailed bat
Eumops perotis	Western mastiff bat

TABLE 2.2-1 (continued)

Scientific Name	Common Name
LAGOMORPHA	
Leporidae	Hares and Rabbits
*Lepus californicus**	Black-tailed hare
*Sylvilagus auduboni**	Desert cottontail
RODENTIA	
Sciuridae	Squirrels and Chipmunks
Ammospermophilus leucurus	Antelope ground squirrel
*Citellus tereticaudus**	Round-tailed ground squirrel
Geomyidae	Pocket Gophers
Thomomys bottae	Botta pocket gopher
Heteromyidae	Pocket Mice and Kangaroo Rats
Perognathus longimembris	Little pocket mouse
Perognathus spinatus	Spiny pocket mouse
*Perognathus formosus**	Long-tailed pocket mouse
Perognathus penicillatus	Desert pocket mouse
Dipodomys merriami	Merriam's kangaroo rat
Dipodomys deserti	Desert kangaroo rat
Castoridae	Beaver
Castor canadensis	Beaver
Cricetidae	Cricetine Mice and Rats
*Reithrodontomys megalotis**	Western harvest mouse
*Peromyscus eremicus**	Cactus mouse
*Peromyscus maniculatus**	Deer mouse
Sigmodon hispidus	Hispid cotton rat
Neotoma lepida	Desert wood rat
*Ondatra zibethica**	Muskrat
Muridae	Old World Rats and Mice
Rattus norvegicus	Norway rat
*Mus musculus**	House mouse

TABLE 2.2-1 (continued)

Scientific Name	Common Name
CARNIVORA	
Canidae	Foxes and Coyotes
Vulpes macrotis*	Kit fox
Canis latrans	Coyote
Procyonidae	Raccoons
Procyon lotor*	Raccoon
Mustelidae	Weasels, Skunks and Badgers
Taxidea taxus	Badger
Mephitis mephitis*	Striped skunk
Mustela frenata	Longtail weasel
Felidae	Cats
Felis domesticus*	Feral house cat

* Species observed

Although beaver sign was not observed in the present field studies, beaver are known to be present in the Ramer Lake Wildlife Refuge. However, further information on their distribution in the Imperial Valley is not available.

Description - Predators. The number of predators and larger mammals observed during spotlight transects was minimal. Only the striped skunk and feral housecat were observed. It appears that feral cats are a dominant predator along drains and canals and that the striped skunk is the most abundant native predator. Although no badger were observed they have been reported in the Imperial Valley by California State Fish and Game biologists (see Reference 2).

Kit fox (Vulpes macrotis) sign, both fresh burrows and tracks, were observed near the New River drainage and small mammal trap line 4. No direct observations of coyotes were made; however, many farmers report that they are numerous (see Reference 2) and that many den along drain banks.

Description - Game Mammals. Cottontail, black-tailed jackrabbit and mule deer are the only three species of game mammals found in the Imperial Valley region (see Reference 2).

Track counts at scent post stations indicate that cotton-tails are very abundant and black-tailed jackrabbits are only moderately abundant. Mule deer are very rare throughout the Imperial Valley (see Reference 2) and were not observed in the study area. Much of the riparian vegetation along drains is unimportant to deer except where very dense riparian thickets occur (see Reference 2).

Description - Rare, Endangered or Protected Mammals. None of the species listed in Table 2.2-1 are rare, endangered or protected according to the California Department of Fish and Game and Federal regulations (U.S. Department of Interior) (see References 2 and 3). Most of the observed and expected species, i.e., coyote, raccoon, deer mouse, and house mouse, are cosmopolitan and commonly occur near and in rural agricultrual areas similar to the geothermal development study area.

2.2.2 Reptiles and Amphibians

Methodology. A number of reptiles and amphibians were identified by observation during field studies in July. Many other species are expected to occur in this region based upon distributions and observations noted in the literature review [4,5] (see Reference 3) and are therefore included on the species list (Table 2.2-2).

Description. Stebbins (see References 4 and 5) lists 31 species of reptiles and six species of amphibians in the region of the study area. Of these, 12 species of reptiles and two species of amphibians were captured or observed in studies by the California Department of Fish and Game (see Reference 3). Five species of reptiles and amphibians were observed during the present study (Table 2.2-2). Great Basin whiptails (Cnemidophorus tigris tigris), side blotched lizards (Uta stansburiana), and bullfrogs (Rana catesbeiana) were the most abundant reptiles and amphibians in the study area. The relatively low diversity of species observed compared to that reported by Stebbins (see References 4 and 5) and the California Department of Fish and Game (see Reference 3) is primarily due to agricultural development and non-native vegetation in the study area. The distribution of reptiles is greatly affected by vegetation in the environment (see Reference 3) and agricultural plantings in the study area apparently restrict the distribution of many native species in the Imperial Valley.

There are no rare, endangered or threatened reptiles or amphibians known to occur in the study area.[6,7] There are, however, a number of species protected with special regulations by the California Department of Fish and Game (see Reference 6). Possession limits have been placed on various species listed in Table 2.2-2. Several of these species may be present in the study area.

The spiny softshell turtle is a game species caught by many anglers for food. To prevent overexploitation a possession limit of five has also been placed on this species. These turtles are attracted to waters having a bottom of mud, sand, or gravel and also to canals and irrigation ditches. They have been observed in canals and drains in the Imperial Valley.

Although the study area is at the edge of the desert tortoise's range none were observed and none are expected to occur. Large scale agricultural development has almost completely removed the desert tortoise's native habitat in the study area.

2.2.3 Avifauna

Methodology. Two types of field survey techniques were used to determine abundance and diversity of bird species in the Heber study area. A qualitative census, conducted within the agricultural area, consisted of walking a transect

TABLE 2.2-2

REPTILES AND AMPHIBIANS OBSERVED OR EXPECTED TO OCCUR WITHIN THE HEBER GEOTHERMAL STUDY AREA

Scientific Name	Common Name
REPTILES	
Callisaurus draconoides	Zebra-tailed lizard
Uta stansburiana stejnegeri*	Desert side-blotched lizard
Urosaurus graciosus graciosus	Western brush lizard
Sceloporus magister magister	Yellow-backed spiny lizard
Cnemidophorus tigris tigris*	Great Basin whiptail lizard
Coleonyx variegatus	Desert banded gecko
Crotaphytus wislizenii wislizenii	Long-nosed leopard lizard
Phrynosoma m'calli	Flat-tailed horned lizard
Phrynosoma platyrhinos calidiarum	Southern desert horned lizard
Trionyx spiniferus	Spiny softshell turtle
Masticophis flagellum piceus*	Red racer
Chionactis occipitalis	Colorado Desert shovel-nosed snake
Crotalus atrox*	Western diamondback rattlesnake
Crotalus cerastes laterorepens	Mojave Dessert sidewinder
Phyllorhynchus decurtatus	Western leaf-nosed snake
Pituophis melanoleucus affinis	Sonora gopher snake
Arizona elegans eburnata	Desert glossy snake
Salavadora hexalepis hexalepis	Desert patch-nosed snake
Lampropeltis getulus	California kingsnake
Rhinocheilus lecontei lecontei	Western long-nosed snake
AMPHIBIANS	
Bufo Woodhousei	Woodhouse's toad
Bufo cognatus	Great Plains toad
Scaphiopus couchi	Couch's spadefoot toad
Rana catesbeiana*	Bullfrog

* Species observed

through one habitat type and recording all the species of birds observed. The second method used was the Emlen strip census, a quantitative method.[8] The field technique requires an observer to walk an established transect usually one mile in length and 824 feet wide. The area observed equals 40.47 hectares (100 acres), a convenient and widely used base in population density studies. All individual birds seen and heard are recorded species, according to their lateral distance from the transect route. These lateral distances are utilized to determine population densitites (see Reference 8). This method was used for population estimates in the desert riparian vegetation type (Table 2.2-3, Figure 2.1-1).

Description. A variety of bird species occur within the Heber area (Table 2.2-4), which is primarily agriculture land with some desert riparian in the southwest corner of the study area. The most common birds observed in the agricultrual areas during the January field reconnaissance were the kestrel (Falco sparverius), mourning dove (Zenaida Macroura), common egret (Casmerodius albus), long billed curlew (Numenius americanus), Brewer's blackbird (Euphagus cynaocephalus), western meadowlark (Sturnella neglecta), and the white winged sparrow (Zonotrichia leucophrys). Bird species most frequently observed in the desert riparian include the verdin (Auriparus flaviceps), phainopepla (Phainopepla nitens), and the ruby crowned kinglet (Regulus calendula).

During the April/May survey period the most common species encountered in the agricultural areas were the red-winged black bird (Agelaius phoeniceus), western flycatcher (Tyrannus verticalis) and the burrowing owl (Speotyto cunicularia). The mourning dove and red-wing black bird were the two major species utilizing the desert riparian.

The most abundant bird species observed during the July field effort in both habitat types were the mourning dove, burrowing owl, and the house finch (Carpodacus mexicanus).

Based upon literature surveys a number of additional species are expected to occur within the Heber area as seasonal visitors for wintering, breeding and summer activities, while other birds are permanent residents. However, it should be noted that habitat and seasonal preferences are not always strictly observed and that exceptions do occur[9,10] (see Reference 2).

TABLE 2.2-3

ABSOLUTE DENSITIES OF BIRD SPECIES AT THE NEW RIVER DRAIN
COMPUTED FROM EMLEN STRIP CENSUSES
CONDUCTED APRIL-MAY AND JULY 1976

Species	Number Observed	Number (per 40.47 hectares)	Relative Density (%)
APRIL-MAY			
Gambel's quail	8	63	11
Mourning dove	30	148	25
Lesser nighthawk	7	21	4
Ladder-backed woodpecker	3	37	6
Crissal thrasher	2	25	4
Verdin	8	73	12
Wilson's warbler	9	99	17
Red-winged blackbird	20	121	21
	87	587	100
JULY			
Killdeer	4	10	2
Mourning dove	43	423	70
Ground dove	2	19	3
Lesser nighthawk	4	50	8
Ladder-backed woodpecker	1	2	.5
Crissal thrasher	1	2	.5
Verdin	1	10	2
Red-winged blackbird	9	88	14
	65	606	100

General species distributions currently available in the literature indicate that several species of raptors are expected to occur within the region surrounding the proposed geothermal development site[11,12] (see References 2 and 9). Species observed include the Cooper's hawk (Accipiter cooperii), sharp-shinned hawk (Accipiter striatus), red-tailed hawk (Buteo jamaicensis), kestrel, burrowing owl, and the barn owl (Tyto alba). No rare or endagered raptor species were observed in the Heber area. However, the prairie falcon (Falco mexicanus) and the golden eagle (Aquila chrysaetos) may occur at any time of the year. Both are considered threatened and/or endangered (see References 6 and 7).

Most raptor species which may breed in the area do so during spring and early summer. Those that do breed in the Imperial Valley are expected to primarily utilize the desert riparian habitat that is available along the New River.

Waterfowl observed in the study area included the long billed curlew, western sandpiper (Calidris mauri), greater yellowlegs (Tringa melanoleucus), and the killdeer (Charadrius vociferus). These and other species of water associated birds both migratory and resident species, forage in the agricultural fields and utilize the Heber area year around. Some changes in species composition occur with seasonal changes and crop rotation.

The New River may provide a suitable habitat for the endangered Yuma clapper rail (Rallus longirostris yumanensis) (see Reference 7), however no rails were observed. They are known to occur along other rivers and drainage channels in the Imperial Valley (see Reference 2). In addition to the Yuma clapper rail, the California black rail (Laterallus jamaicensis) and yellow billed cuckoo (Coccyzus americanus) may possibly be found along the New River. Both of these species are considered to be rare by the State of California (see Reference 6).

The most important upland game bird occurring in this area is the mourning dove. Population densities of 200 per mile of drainage canal have been estimated in some areas of the Imperial Valley (see Reference 2). With the continued reduction of suitable habitat along the Colorado River, areas like the New River become important for water requirements, roosting sites and cover for nesting.

2.2.4 November 1976 Field Study

An avian field reconnaissance was conducted in November to observed bird species utilizing the Heber Geothermal Study Area during the fall season. The most common species observed during this survey period included the yellow-rumped warbler (Dendroica coronata), California gull (Larus californicus) and American kestrel (Falco sparveritus). Raptors observed included the harrier (Circus cyaneus), red-tailed hawk (Buteo jamaicensis) and barn owl (Tyto alba) as well as the kestrel.

An Emlen strip census was conducted at the New River site, which had been burned during the spring. Some of the vegetation in the area is recovering from the effects of the fire. However it cannot be determined at this time what impacts the burning had on the fall species composition in the sample area. The most commonly observed bird species during the strip census included the yellow-rumped warbler, verdin (Auriparus flaviceps) and white-crowned sparrow (Zonotrichia leucophrys) (Tables 2.2-4 and 2.2-5). Additional species noted included the black-tailed gnatcatcher (Polioptila melanura), phainopepla (Phainopepla nitens), house finch (Carpodacus mexicanus), loggerhead shrike (Lanius ludovicianus), mourning dove (Zenaida macroura) and the common flicker (Colaptes auratus).

The area around the test site was surveyed. The equipment now in use within the compound that was not being operated during earlier surveys is generating a noticeably increased amount of noise. This may account for there being no birds in the immediate area of the test site during the November survey.

Other bird species observed within the study area included the ringed-billed gull (Larus delawarensis), water pipit (Anthus spinoletta), orange-crowned warbler (Vermivora celata), yellow throat (Geothlypis trichas), savannah sparrow (Passerculus sandwichensis) and song sparrow (Melospiza melodia).

TABLE 2.2-4

BIRDS OBSERVED OR EXPECTED TO OCCUR
WITHIN THE HEBER GEOTHERMAL STUDY AREA

Scientific Name	Common Name
Ardea herodias	Great blue heron
Casmerodius albus*	Common egret
Nycticorax nycticorax	Black-crowned night heron
Mycteria americana	Wood stork
Branta canadensis*	Canada goose
Cathartes aura*	Turkey vulture
Accipiter striatus*	Sharp-shinned hawk
Accipiter cooperii*	Cooper's hawk
Buteo jamaicensis*	Red-tailed hawk
Buteo albonotatus	Zone-tailed hawk
Parabuteo unicinctus	Harris' hawk
Circus cyaneus	Marsh hawk
Aquila chrysaetos	Golden eagle
Falco mexicanus	Prairie falcon
Falco sparverius*	American kestrel
Lophortyx gambelii*	Gambel's quail
Rallus longirostris	Yuma clapper rail
Laterallus jamaicensis	California black rail
Gallinula Chloropus	Common gallinule
Fulica americana*	American coot
Charadrius vociferus*	Killdeer
Capella gallinago	Common snipe
Numenius americanus*	Long-billed curlew
Numenius phaeopus	Whimbrel
Actitis macularia	Spotted sandpiper
Catoptrophorus semipalmatus	Willet
Tringa melanoleucus*	Greater yellowlegs
Calidris mauri*	Western sandpiper
Recurvirostra americana	American avocet
Himantopus mexicanus*	Black-necked stilt
Larus argentatus*	Herring gull
Larus californicus*	California gull

TABLE 2.2-4 (continued)

Scientific Name	Common Name
Columba livia*	Rock dove
Zenaida asiatica*	White-winged dove
Zenaida macroura*	Mourning dove
Columbina passerina*	Ground dove
Scardafella inca	Inca dove
Coccyzus americanus	Yellow-billed cuckoo
Geococcyx californianus*	Roadrunner
Tyto alba*	Barn owl
Otus asio	Screech owl
Bubo virginianus	Great horned owl
Micrathene whitneyi	Elf owl
Speotyto cunicularia*	Burrowing owl
Phalaenoptilus nuttallii	Poor-will
Chordeiles acutipennis*	Lesser nighthawk
Archilochus alexandri	Black-chinned hummingbird
Calypte costae*	Costa's hummingbird
Colaptes auratus	Common flicker
Dendrocopos scalaris*	Ladder-backed woodpecker
Tyrannus verticalis*	Western kingbird
Tyrannus vociferans*	Cassin's kingbird
Myiarchus tyrannulus	Wied's crested flycatcher
Myiarchus cinerascens*	Ash-throated flycatcher
Eremophila alpestris	Horned lark
Tachycineta thalassina*	Violet-green swallow
Riparia riparia	Bank swallow
Stelgidopteryx ruficollis*	Rough-winged swallow
Hirundo rustica*	Barn swallow
Corvus corax*	Common raven
Corvus brachyrhynchos	Common crow
Auriparus flaviceps*	Verdin
Thryomanes bewickii	Bewick wren
Campylorhynchus brunneicapillus*	Cactus wren
Salpinctes obsoletus	Rock wren

TABLE 2.2-4 (continued)

Scientific Name	Common Name
Mimus polyglottos*	Mockingbird
Toxostoma bendirel	Bendire's thrasher
Toxostoma lecontei	Le Conte's thrasher
Toxostoma dorsale*	Crissal thrasher
Polioptila melanura*	Black-tailed gnatcatcher
Regulus calendula*	Ruby-crowned kinglet
Anthus spinoletta*	Water pipit
Phainopepla nitens*	Phainopepla
Lanius ludovicianus*	Loggerhead shrike
Sturnus vulgaris*	Starling
Vireo bellii	Bell's vireo
Vireo vicinior	Gray vireo
Vermivora celata	Orange-crowned warbler
Vermivora luciae	Lucy's warbler
Dendroica coronata*	Yellow-rumped warbler
Dendroica nigrescens*	Black-throated gray warbler
Oporornis tolmiei*	MacGilliuary's warbler
Geothlypis trichas*	Common yellowthroat
Wilsonia pusilla*	Wilson's warbler
Passer domesticus*	House sparrow
Sturnella neglecta*	Western meadowlark
Xanthocephalus xanthocephalus	Yellow-headed blackbird
Agelaius phoeniceus*	Red-winged blackbird
Icterus parisorum	Scott's oriole
Euphagus cyanocephalus*	Brewer's blackbird
Cassidix mexicanus	Boat-tailed grackle
Molothrus ater	Brown-headed cowbird
Carpodacus mexicanus*	House finch
Spinus tristis	American goldfinch
Spinus psaltria*	Lesser goldfinch
Pipilo alberti	Albert's towhee
Pooecetes gramineus*	Vesper sparrow
Chondestes grammacus*	Lark sparrow

TABLE 2.2-4 (continued)

Scientific Name	Common Name
Amphispiza bilineata*	Black-throated sparrow
Spizella breweri	Brewer's sparrow
Spizella atrogularis*	Black-chinned sparrow
Zonotrichia leucophrys*	White-crowned sparrow
Melospiza melodia	Song sparrow
Egretta thula*	Snowy egret
Limnodromus scolopaceus*	Long-billed dowitcher
Sayornis saya	Black phoebe
Iridoprocne bicolor	Tree swallow
Telmatodytes palustris	Long-billed marsh wren
Oreoscoptes montanus	Sage thrasher
Turdus migratorius	American robin
Catharus guttata	Hermit thrush
Polioptila caerulea	Blue-gray gnatcatcher
Bombycilla cedrorum	Cedar waxwing
Vireo gilvus	Warbling vireo
Geothlyris trichas*	Common yellowthroat
Melospiza lincolnii	Lincoln's sparrow
Passerculus sandwichensis*	Savannah sparrow

* Species observed

TABLE 2.2-5

ABSOLUTE DENSITIES OF BIRD SPECIES COMPUTED FROM EMLEN STRIP CENSUS, NOVEMBER 18, 1976

Species	Number Observed	Density (Per 40.5 ha)	Relative Density
Mourning dove	4	9	2.3
Common flicker	3	9	2.3
Verdin	10	53	13.4
Black-tailed gnatcatcher	5	45	11.5
Phainopepla	5	27	6.8
Loggerhead shrike	2	18	4.5
Yellow-rumped warbler	24	163	42.0
House finch	2	18	4.5
White-crowned sparrow	8	50	12.7
	63	392	100.0%

REFERENCES - Terrestrial Wildlife

1. Hall, E. R. and Kelsen, K. K., The Mammals of North America, Volumes 1 and 2, the Kenald Press Company, New York, 1959.

2. Gould, G. I. 1975. A Report on Wildlife Resources Associated with Agricultural Drains in the Palo Verde Irrigation District, Coachella Valley County Water District and Imperial Irrigation District. California Department of Fish and Game.

3. California Department of Fish and Game. 1974. Inventory of the Fish and Wildlife Resources, Recreational Consumptive Use, and Habitat in and Adjacent to the Upper 49 Miles and Ponded Areas of the Coachella Canal.

4. Stebbins, R. C., A Field Guide to Western Reptiles and Amphibians, Hougton Mifflin Company, Boston, 1966, pp. 1-279.

5. Stebbins, R. C. 1954. Amphibians and Reptiles of Western North America. McGraw-Hill Book Co., Inc., New York.

6. California Department of Fish and Game, Listing of California's Endangered, Rare, and Protected Birds, Mammals, Reptiles and Amphibians, and Fish, January 1975.

7. U. S. Department of Interior, Threatened Wildlife of the United States, Resource Publication 114, 1973.

8. Emlen, J. T. , "Population densities derevised from transect counts." Auk. 88:323-343 (1971).

9. Brown, V., Weston, H., and Buzzell, J., "Handbook of California Birds", 2nd Edition Naturegraphs, Healdsburg, California, 1961.

10. Peterson, R. T., A Field Guide To Western Birds, 2nd Edition, Riverside Press, Cambridge, Mass., 1961.

11. Bent, A. C., Life Histories of North American Birds of Prey, Part 1, 2nd Edition, Dover Publications Inc., New York, 1961.

12. Bent, A. C. , Life Histories of North American Birds of Prey, Part 2, 2nd Edition, Dover Publications Inc., New York, 1961.

2.3 AQUATIC BIOLOGY

Methodology

Studies were conducted during April 26-28, 1976 to determine the relative abundance and species composition of fish, benthic invertebrates, algae and aquatic plants in the New River and associated agricultural drains. Three sampling stations were selected in the New River (Figure 2.1-1).

Information collected during the present studies was supplemented by literature review and personal interviews with local California Department of Fish and Game biologists.

Fish

Floating experimental gill nets of varying mesh size (0.5 inch - 2.5 inch bar mesh) were used to sample fish in the New River. Each net was set for an 18 hour period. A variable-voltage, DC, battery-operated backpack shocker and a seine were used to supplement collections by gill nets. Fish were preserved and later identified in the laboratory.(1)

Benthos

Benthnic macroinvertebrates were collected with a drift sampler. Samples were taken in triplicate at each station, preserved in 70 percent isopropyl alchohol and returned to the laboratory for identification and enumeration.(2,3)

Plankton

Plankton was collected at each station by pouring 20 litres of water through an 0.20 millimeter plankton net. Samples were preserved in a 5 percent solution of formalin. Identification was conducted in the laboratory.(4,5)

Water Quality

Measurements of dissolved oxygen, temperature (using a Yellow Springs disolved oxygen meter, Model 51A), and pH (using a Photovolt meter, Model 125) were conducted in the field. Additional water samples were collected and returned to the laboratory for analysis of specific conductivity and total dissolved solids.(6)

Sediment

Sediment samples were dug by hand trowel to a depth of approximately 15 centimeters.

Samples were then dried in an oven (see Reference 6) and sieved through U. S. Standard sieves on a Tyler shaker, for grain size analysis. Standard sieve sizes utilized included Tyler equivalent #10, 20, 40, 60, 100, 150, and 200.

Description

Habitat Evaluation. Habitat categorizations were based upon a combination of stream parameters including substrate, water quality (field and laboratory evaluations), spawning potential, cover, productive benthic substrate, and relative abundance of fish populations (Table 2.3-1).

Fish. Two species of fish were collected in gill nets from the downstream station (NR-3), the bluegill (*Lepomis macrochirus*) and the shiner (*Notropis lutrensis*).[7] Based upon previous studies of agricultural drains in this area[8] and discussions with local California Department of Fish and Game biologists several other species are expected to occur in the study area (Table 2.3-2).

Game fish were not observed in the section of New River within the Geothermal Study Area, primarily because of poor water quality and unfavorable stream substrate conditions. Although populations of game fish are low, the New River is of some value to the entire aquatic system within the Imperial Valley. Non-game fish can act as a valuable food resource for game species present elsewhere in the drain system, provide biological control of nuisance insects such as mosquitos, and are important in general ecological dynamics such as the recycling of nutrients and as contributors to biological diversity. In addition, according to studies by the California Department of Fish and Game (see Reference 8) the presence of non-game fish in agricultural drains of the Imperial Irrigation District indicates that with proper management the same area is capable of supporting game fish populations.

Aquatic Invertebrates. Benthic invertebrates were observed or collected at aquatic stations in the New River and in other drains in the study area (Table 2.3-2). Additional benthic invertebrates and aquatic insects which have been observed in the study area (see Reference 8) are included on the species list. Many benthic species collected are typically found in aquatic systems with poor water quality and are able to adapt to a burrowing life style in fine sediments. Others, such as crayfish, freshwater snails, damselflies, dragonflies, waterboatmen and backswimmers are essential to a balanced ecosystem and serve as food items for non-game fish, game fish and various birds (see Reference 8).

TABLE 2.3-1

PHYSICAL CHARACTERISTICS AND HABITAT EVALUATION AT EACH AQUATIC SAMPLE SITE ON THE NEW RIVER WITHIN THE SDG&E GEOTHERMAL STUDY AREA

Characteristics and Evaluation	New River #1	New River #2	New River #3
Date sampled	4/26/76	4/26/76	4/26/76
Average width (meters)	15	13	10
Average depth (meters)	1.5	1	1.5
Stream flow	Rapid	Rapid	Rapid
Stream flow level	Maximum	Maximum	Maximum
Air temperature (°C)	30.0	29.0	30.0
General weather conditions	Sun, Clear	Sun, Clear	Sun, Clear
Stream bank vegetation	Dense riparian growth	Dense riparian growth	Dense riparian growth
Stream substrate	Black clay, Mud, Muck	Black clay, Mud, Muck	Black clay, Mud, Muck
Spawning potential	Poor	Poor	Poor
General aquatic habitat	Poor	Poor	Poor

TABLE 2.3-2

SPECIES OF PLANKTON, INVERTEBRATES, AND AQUATIC VERTEBRATES OBSERVED OR EXPECTED TO OCCUR IN DRAINS AND CANALS OF THE HEBER GEOTHERMAL STUDY AREA

Scientific Name	Common Name
PHYTOPLANKTON	
Bacillariophyceae	Diatoms
Fragilariales	
Fragilaria sp.*	
Diatoma sp.*	
Achnanthales	
Cocconeis sp.*	
Naviculales	
Navicula sp.*	
Caloneis sp.*	
Pinnularia sp.*	
Amphiphora sp.*	
Amphora sp.*	
Cymbella sp.*	
Nitzschiales	
Nitzschia sp.*	
Surirellales	
*Cymatopleura**	
*Surirella**	
Chlorophyceae	Green Algae
Ulotrichales	
Ulothrix sp.*	
Protoderma sp.*	

TABLE 2.3-2 (continued)

Scientific Name	Common Name
INVERTEBRATES	
Annelida	
Oligochaeta	Aquatic Earthworms
Hirudinea	Leeches
Insecta	
Diptera	True Flies
Chironomidae	
Ephydridae	
Brachydeutera	
Odonata	Damselflies*
	Dragonflies
Hemiptera	Bugs
Corixidae	Water Boatmen
Notonectidae	Backswimmers
Coleoptera	Beetles
Hydrophilidae	Diving Beetles
Crustacea	
Decapoda	Crayfishes
Cambarinae	
Cambarus sp.*	
Mollusca	
Gastropoda	Snails
Physa sp.*	
Lymnaea sp.*	
Bivalvia	Clams
_Corpicula fluminea_*	

TABLE 2.3-2 (continued)

Scientific Name	Common Name
VERTEBRATES	
Osteichthyes	Bony Fish
Centrarchidae	Sunfish Family
Micropterus salmoides	Largemouth Bass
*Lepomis macrochirus**	Bluegill
Ictaluridae	Catfish Family
Ictalurus melas	Black Bullhead
Ictalurus nebulosus	Brown Bullhead
Ictalurus punctatus	Channel Catfish
Cichlidae	Cichlid Family
Tilapia mossambica	Mozambique Tilapia
Cyprinidae	Minnow Family
Cyprinus carpio	Carp
Netemigonus crysoleucas	Golden Shiner
*Notropis lutrensis**	Red Shiner
Poecilidae	Topminnow Family
Gambusia affinis	Mosquito Fish

* Taxa observed

Plankton. Plankton were represented by two major families: Chlorophyceae and Bacillariophyceae (Table 2.3-2). The Bacillariophyceae, represented by 13 genera, comprise the majority of plankters found in the New River.

Sediment Analyses. Grain size analysis indicated that all stations sampled had a high percentage of fine sediments (Figures 2.3-1 through 2.3-3). High percentages of fine sediments associated with high T.D.S. and low dissolved oxygen are generally correlated with poor development of the benthos and algae required for a productive fishery.

Water Quality. Water quality parameters analyzed included total dissolved solids, specific conductivity, dissolved oxygen, pH, and temperature (Table 2.3-3).

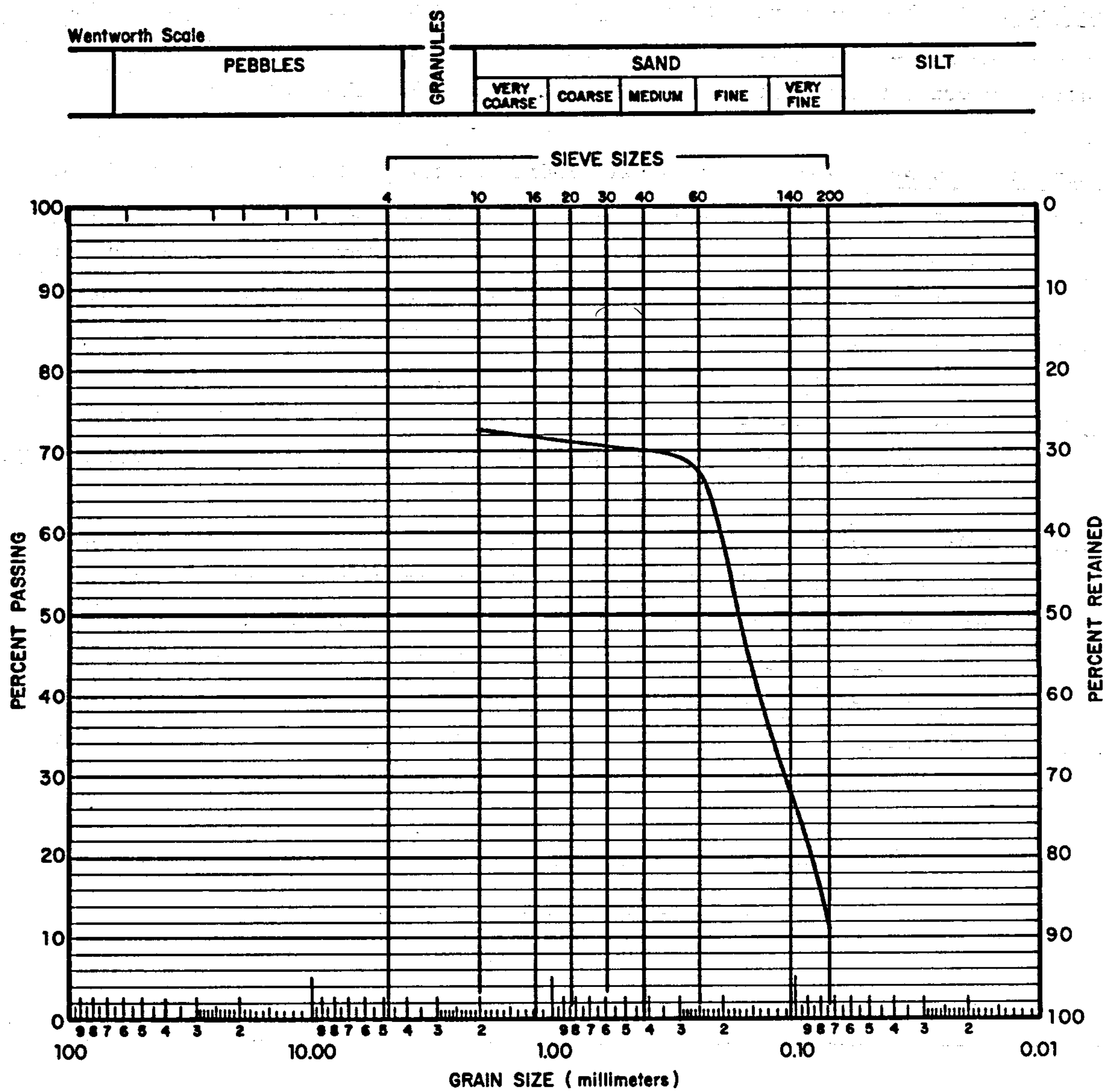
Total dissolved solids ranged from a low of 4772 mg/l at Station NR-1 to a high of 5440 mg/l at Station NR-2. The high T.D.S. readings are typical of values obtained throughout the agricultural drain system in the Imperial Valley.[9] Such high readings are due to high levels of agricultural runoff (including leachate from tile grids) and evaporation due to the high temperatures encountered in the area. These readings are an indication of poor water quality in the New River.

TABLE 2.3-3

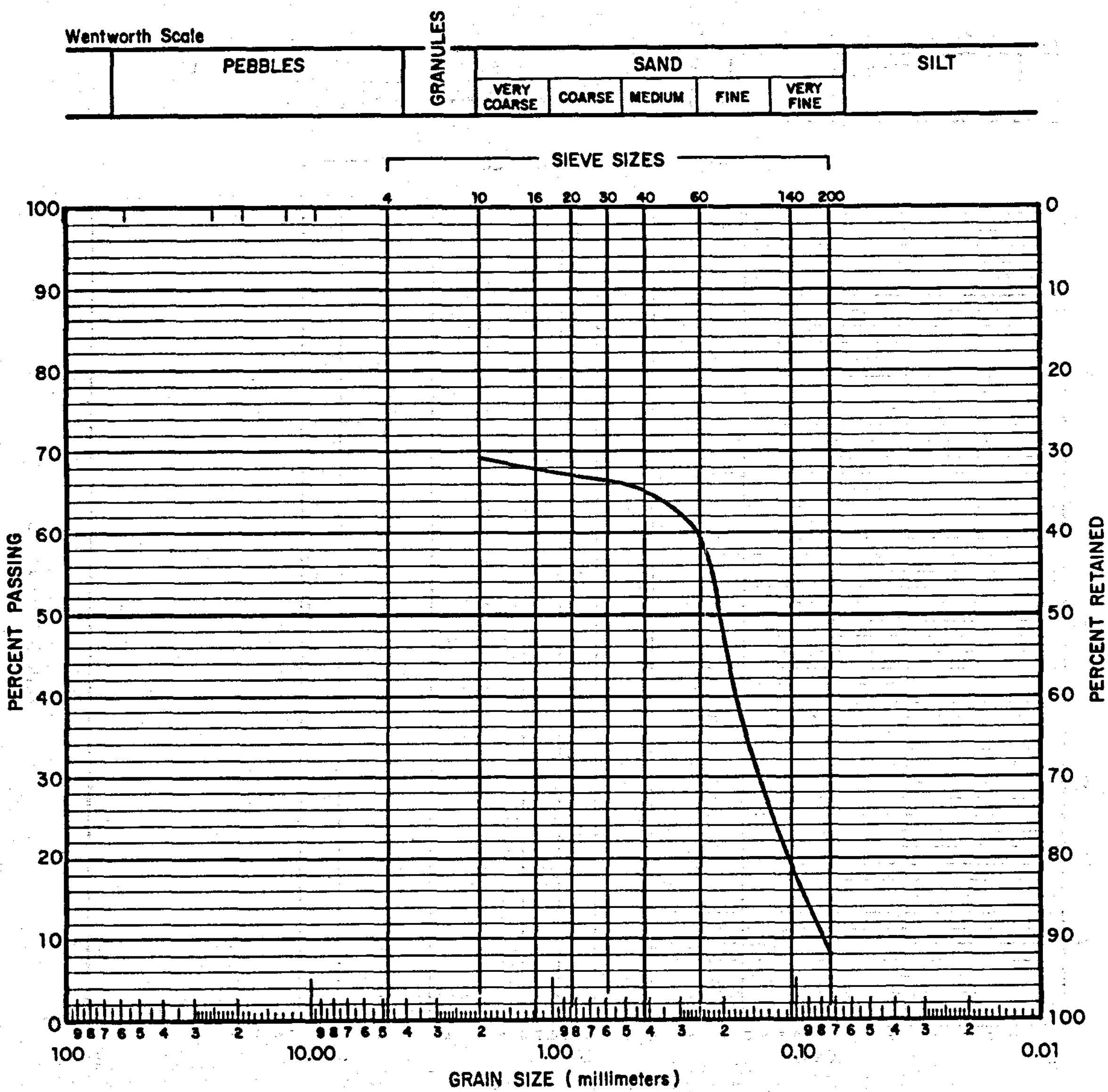
WATER QUALITY MEASURES DETERMINED
FOR THE NEW RIVER IN APRIL 1976

Sample Site	Dissolved Oxygen (mg/l)	pH	Temp. (°C)	Specific Conductivity (umhos/cm @ 25°C)	Total Dissolved Solids (mg/l)
NR-1	4.0	7.3	23.0	8060	4772
NR-2	3.4	7.8	21.5	8180	5440
NR-3	3.6	7.2	23.5	8120	4898

Dissolved oxygen readings ranged from 3.4 to 4.0 mg/l. High water temperature and total dissolved solids both decrease the solubility of dissolved oxygen in natural waters. The dissolved oxygen levels observed are in the range expected for a stream with the other poor characteristics of the New River.



GEOTHERMAL ENVIRONMENTAL STUDIES HEBER REGION - IMPERIAL VALLEY, CALIFORNIA ENVIRONMENTAL BASELINE DATA ACQUISITION	
Sediment grain size distribution, Station NR-1. 17 August 1976	
SAN DIEGO GAS & ELECTRIC COMPANY SAN DIEGO, CALIFORNIA	FIGURE NO. 2.3-1

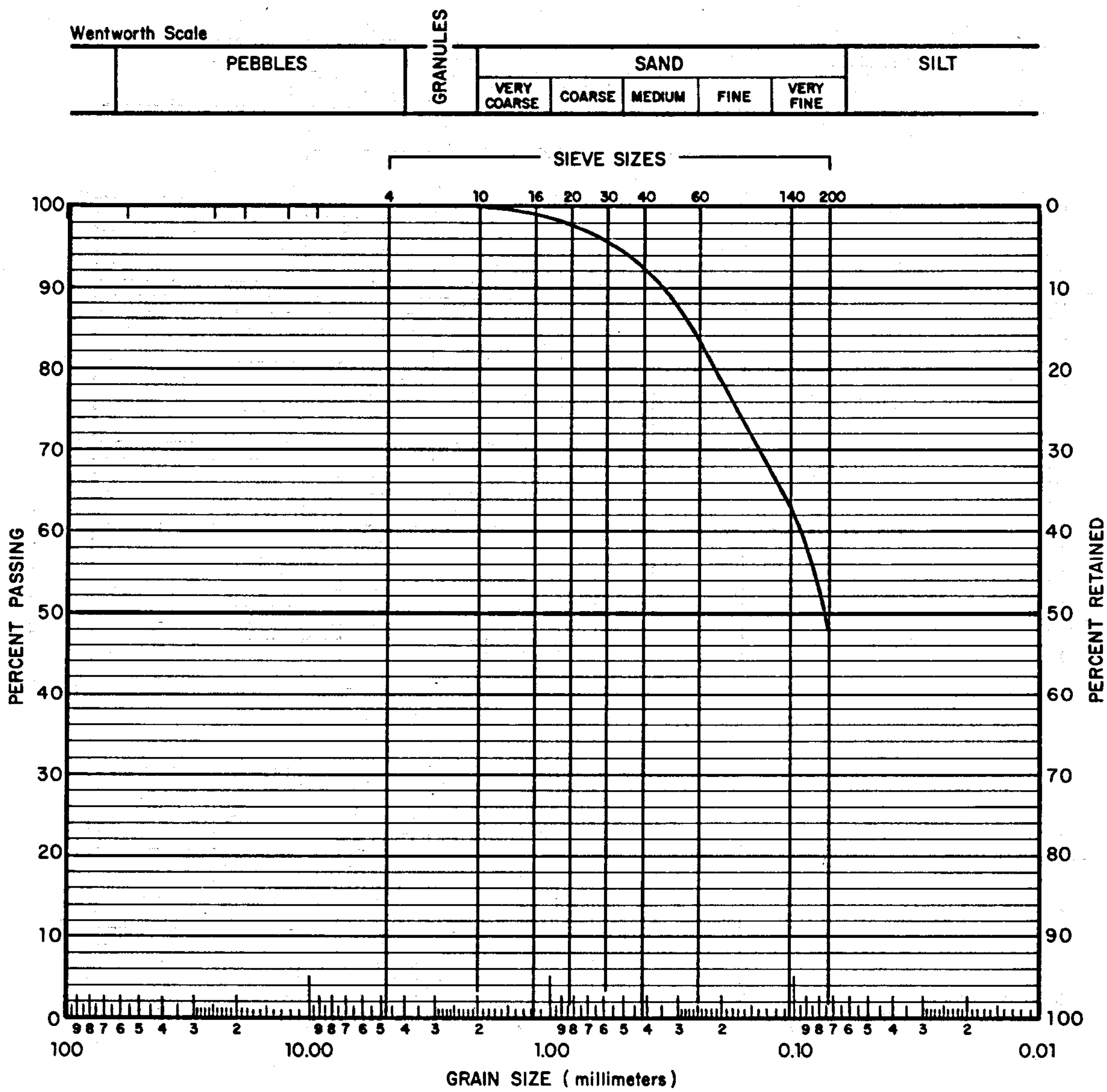


GEOTHERMAL ENVIRONMENTAL STUDIES
HEBER REGION - IMPERIAL VALLEY, CALIFORNIA
ENVIRONMENTAL BASELINE DATA ACQUISITION

Sediment grain size distribution, Station NR-2.
17 August 1976

SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

FIGURE NO. 2.3-2



GEOTHERMAL ENVIRONMENTAL STUDIES HEBER REGION - IMPERIAL VALLEY, CALIFORNIA ENVIRONMENTAL BASELINE DATA ACQUISITION	
Sediment grain size distribution, Station NR-3. 17 August 1976	
SAN DIEGO GAS & ELECTRIC COMPANY SAN DIEGO, CALIFORNIA	FIGURE NO. 2.3-3

REFERENCES - Aquatic Biology

1. Eddy, Samuel. 1969. The Freshwater Fishes. 2nd Edition, Wm. C. Brown Company Publishers, Dubuque, Iowa.

2. Needham, J. G. and Needham, Paul R. 1962. A Guide to the Study of Freshwater Biology. Holden-Day, Inc., San Francisco.

3. Pennak, Robert W. 1953. Freshwater Invertebrates of the United States. The Ronald Press Company, New York.

4. Vinyard, William C. 1974. Key to the Genera of Diatoms of the Inland Waters of Temperate North America. Mad River Press, Eureka, California.

5. Smith, Gilbert M. 1950. Freshwater Algae of the United Stateses. 2nd Edition. McGraw-Hill, New York.

6. American Public Health Association. 1971. Standard Methods for the Examination of Water and Waste Water. 13th Edition. APHA, New York.

7. American Fisheries Society. 1970. Common and Scientific Names of Fishes. 3rd Edition. AFS, Washington, D.C.

8. Herrgesell, P. L. 1975. A Report on Aquatic Resources Associated with Agricultrual Drains in the Palo Verdee Irrigation District. Coachella Valley County Water District and Imperial Irrigation District. California Department of Fish and Game.

9. U. S. Geological Survey. 1970. Quality of Surface Waters of the United States, 1970. U. S. Government Printing Office, Washington, D. C.

3.1 SOCIOECONOMIC PARAMETERS

Table of Contents

3.1.8 Social Services

Hospital Facilities - Public Assistance Expenditures - Public Assistance Recipients - Youth Authority Custody - Vehicle Code Violations

3.1 SOCIOECONOMIC PARAMETERS

List of Figures

3.1.1 Descriptive Population Characteristics

3.1.2 General Demographic Variables

3.1.3 Employment and Income

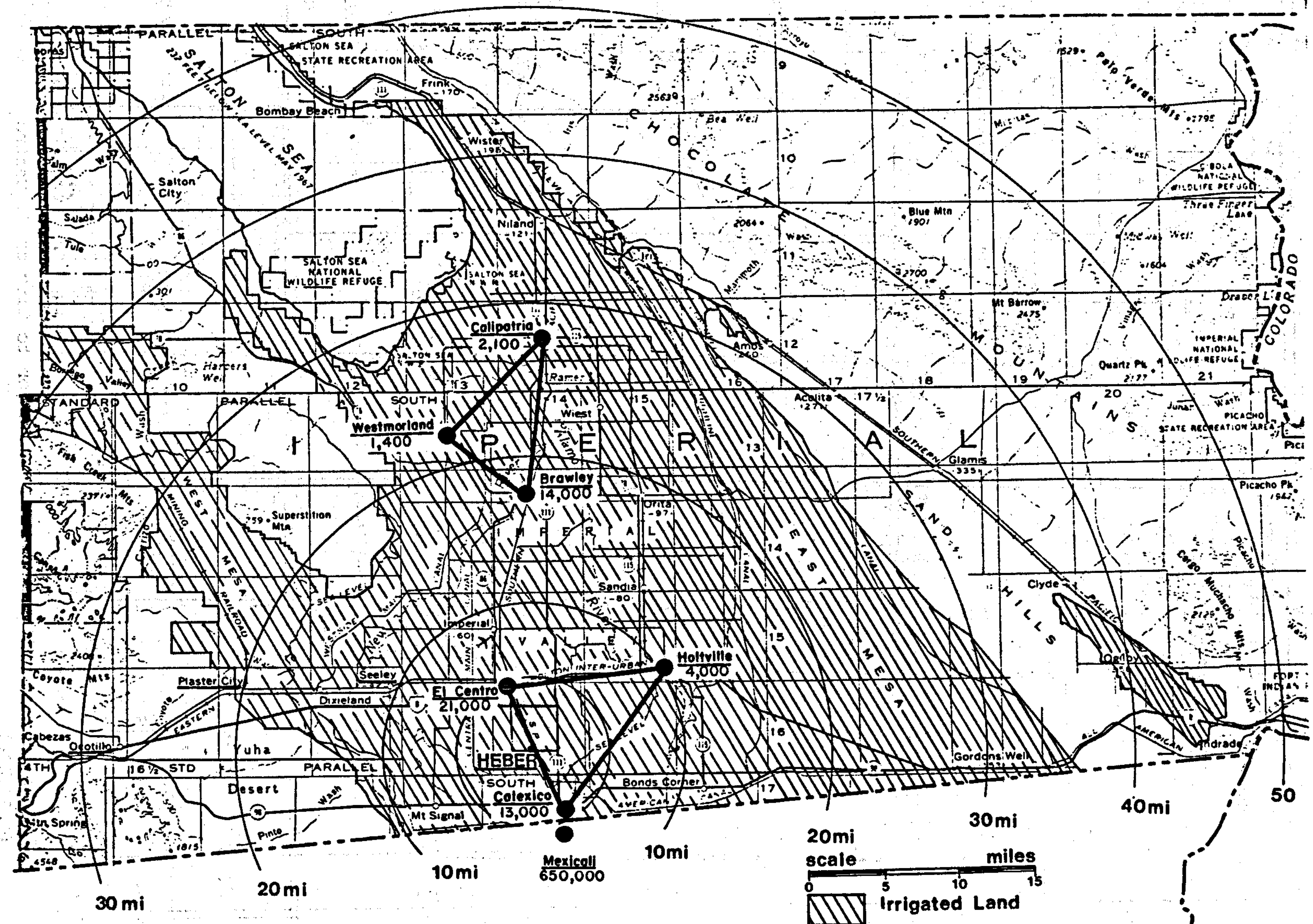


Figure 3.1.1-1 Heber area showing irrigated land

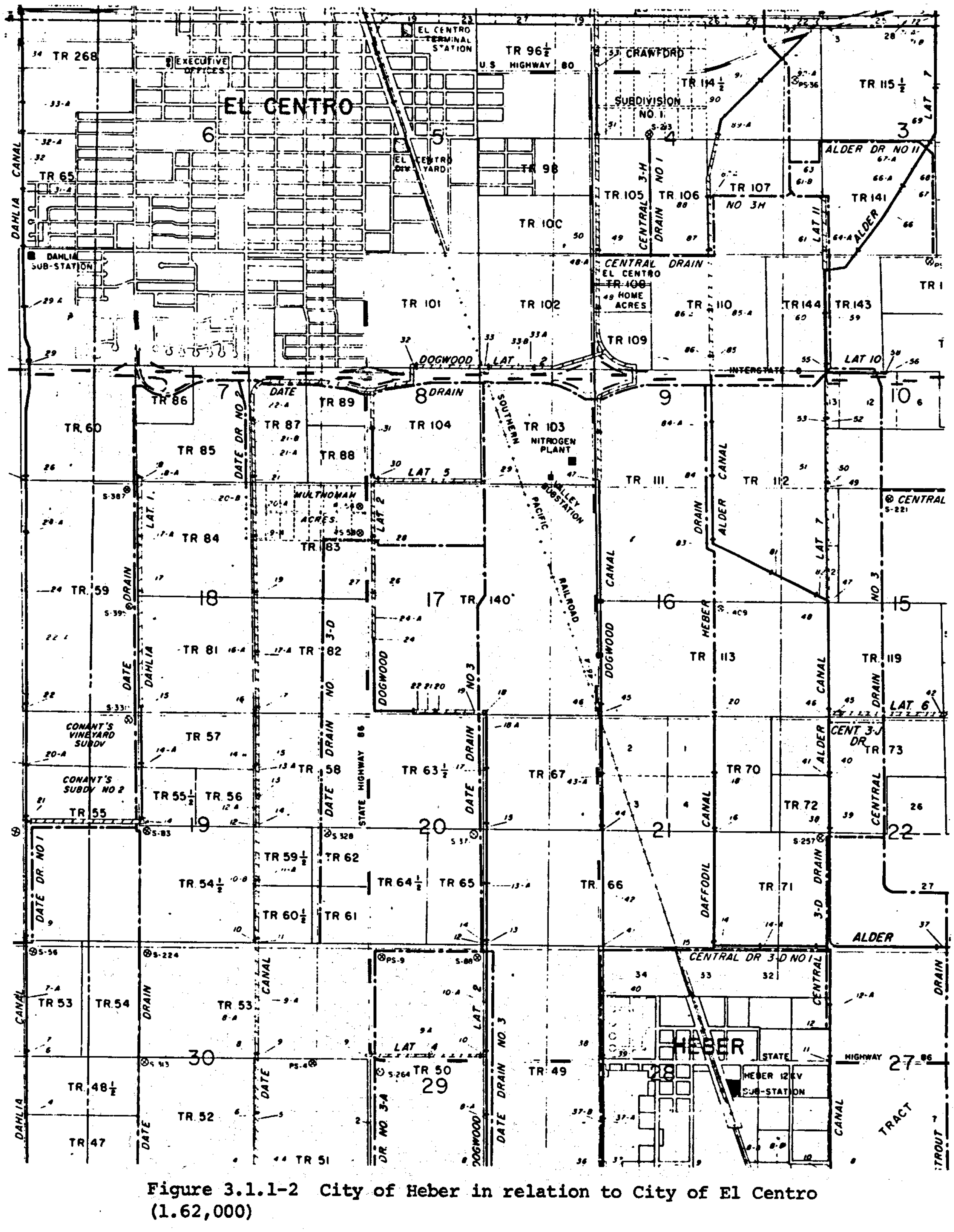


Figure 3.1.1-2 City of Heber in relation to City of El Centro (1.62,000)

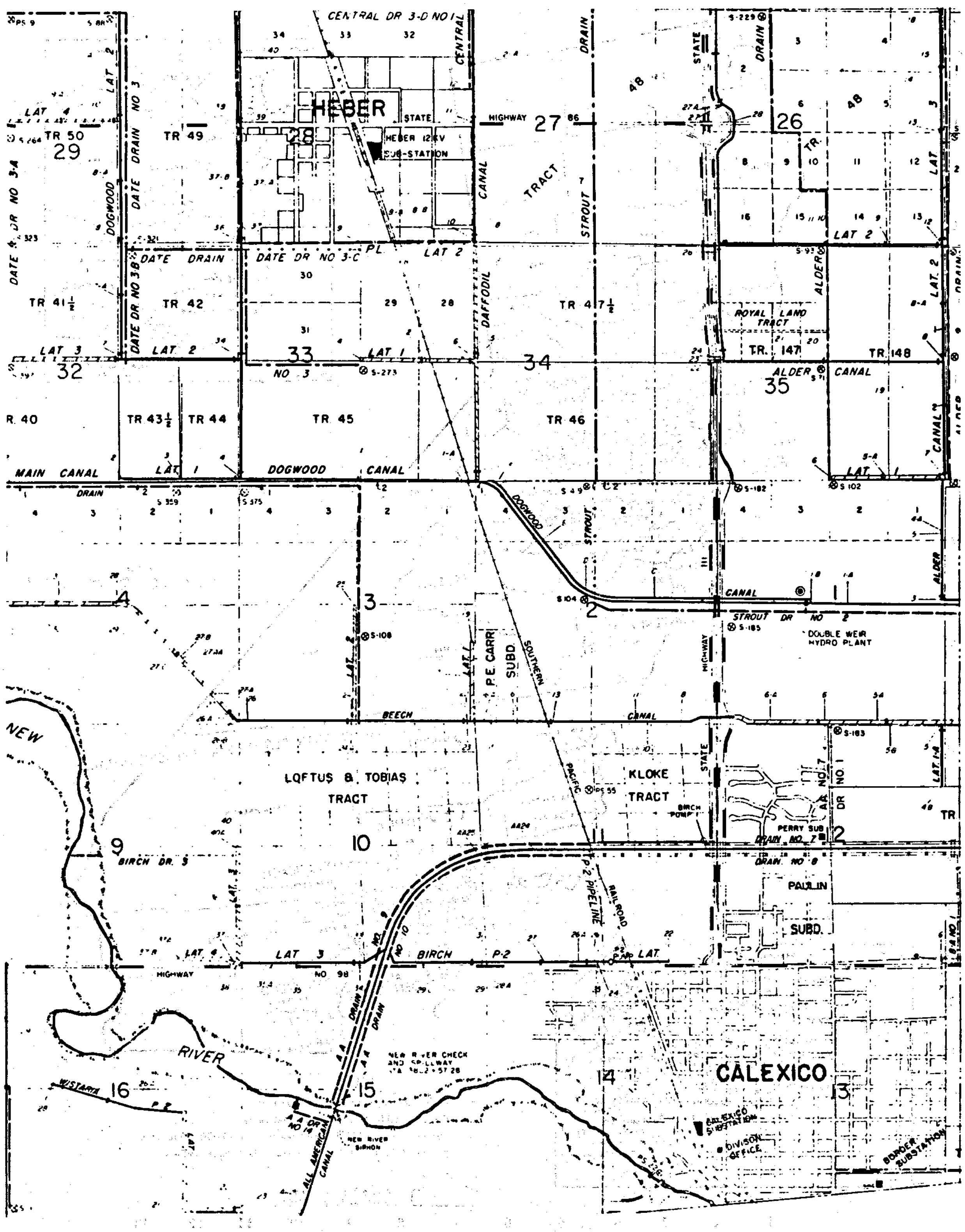


Figure 3.1.1-3 City of Heber in relation to City of Celexico (1:62,000)

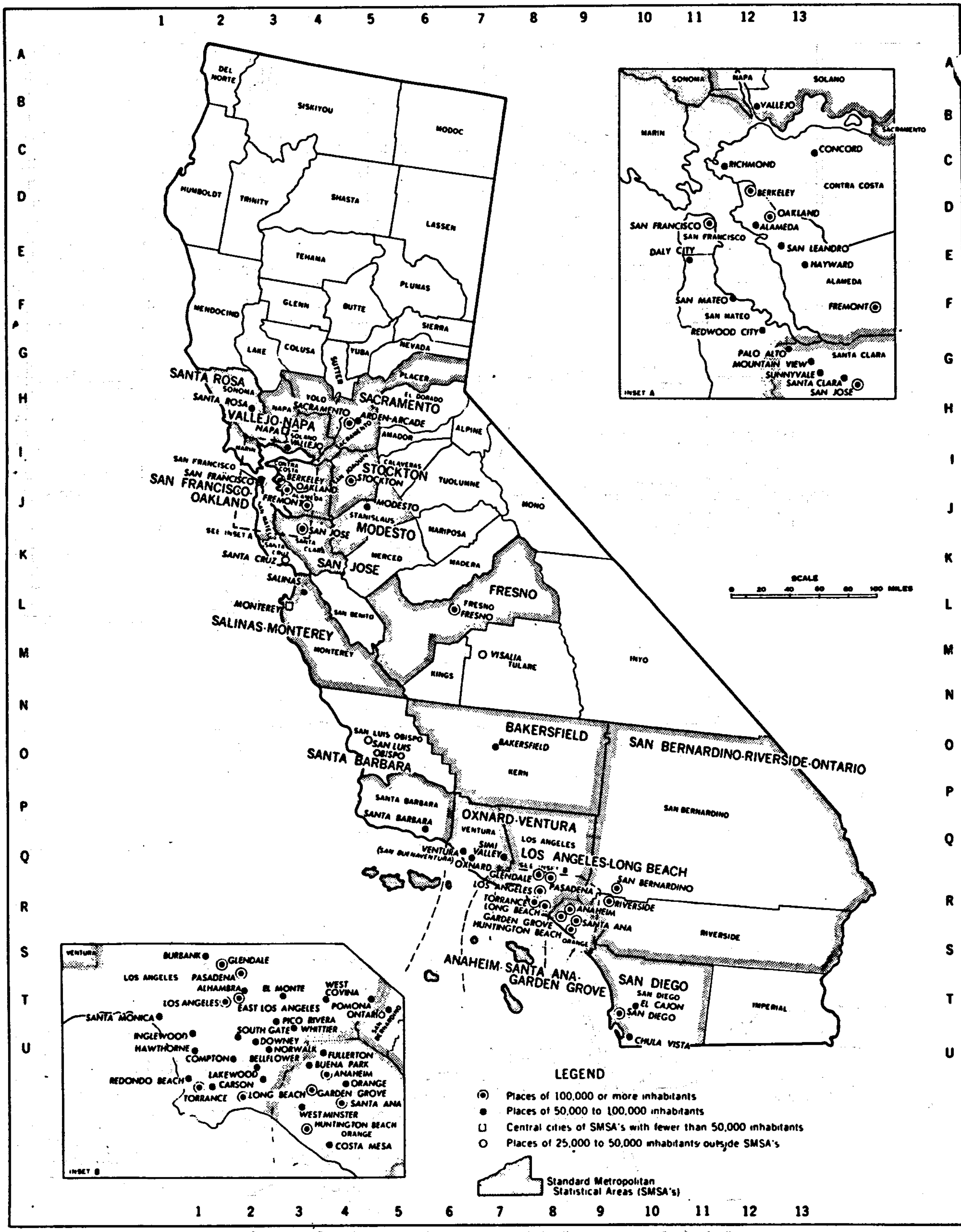


Figure 3.1.1-4 Counties, Standard Metropolitan Statistical Areas and Selected Places for California, 1970 U.S. Census

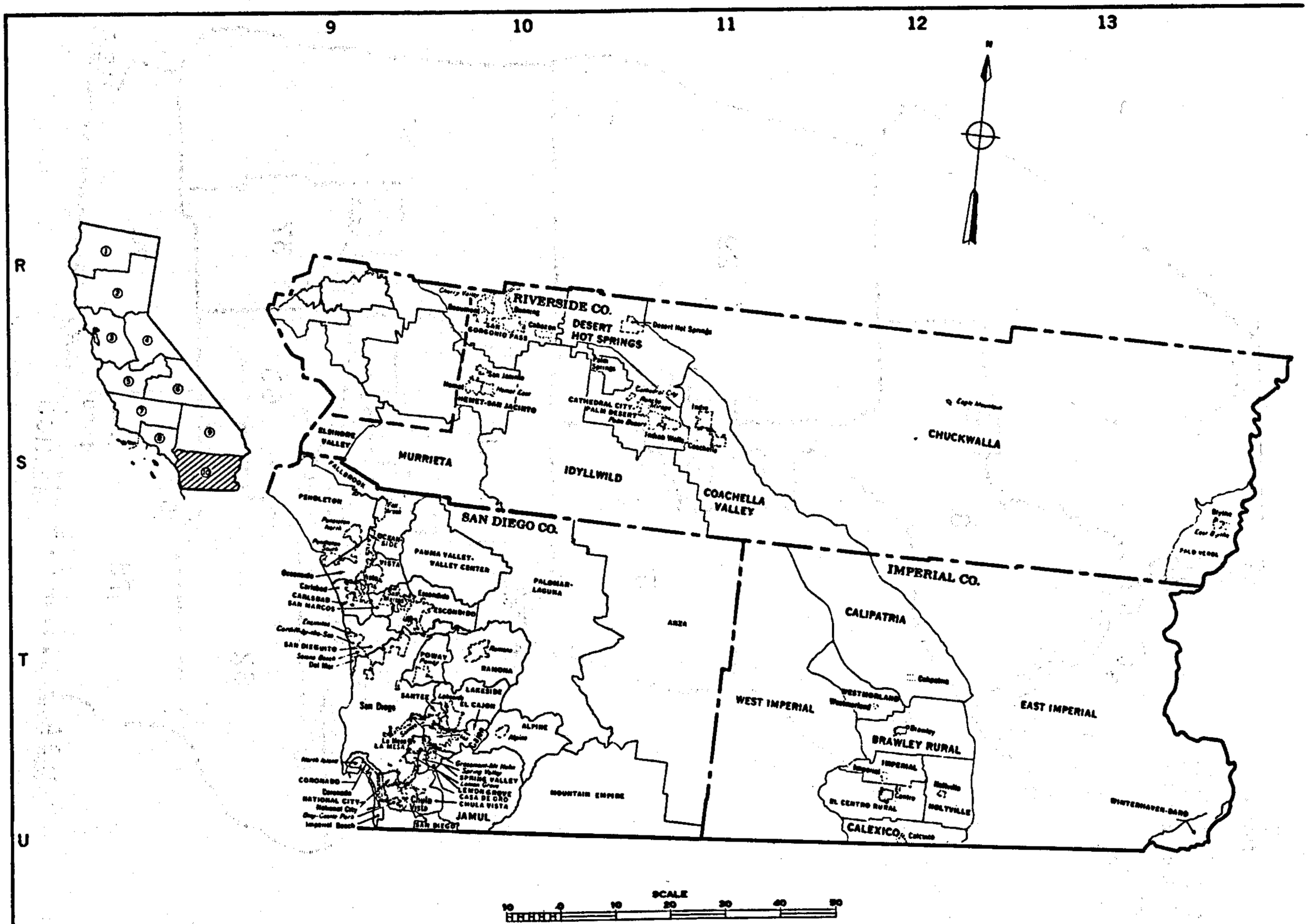


Figure 3.1.1-5 Southern California Region with county subdivisions and census county subdivisions and places, 1970 U.S. Census

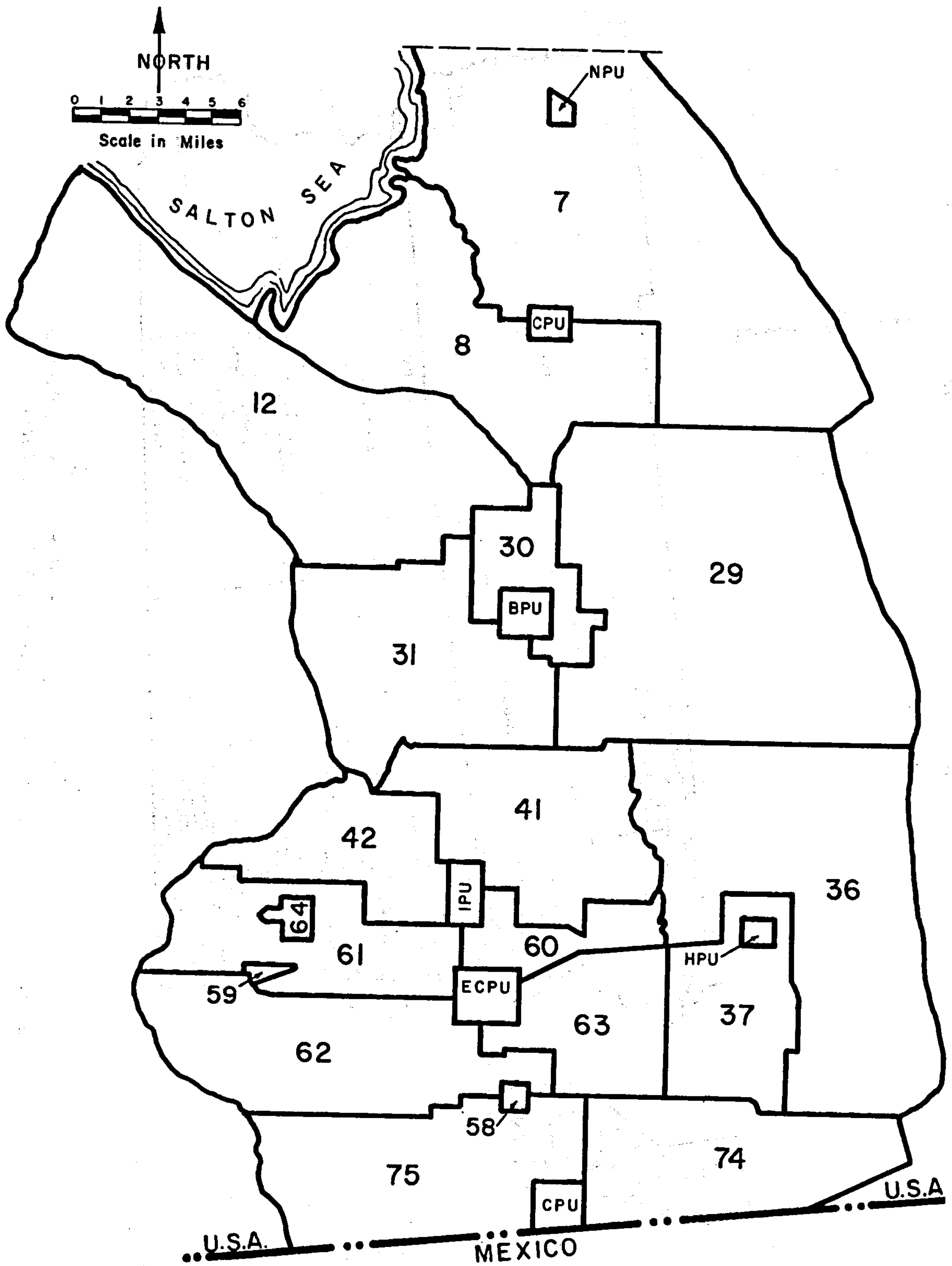


Figure 3.1.1-6 1970 Enumeration Districts of Imperial County

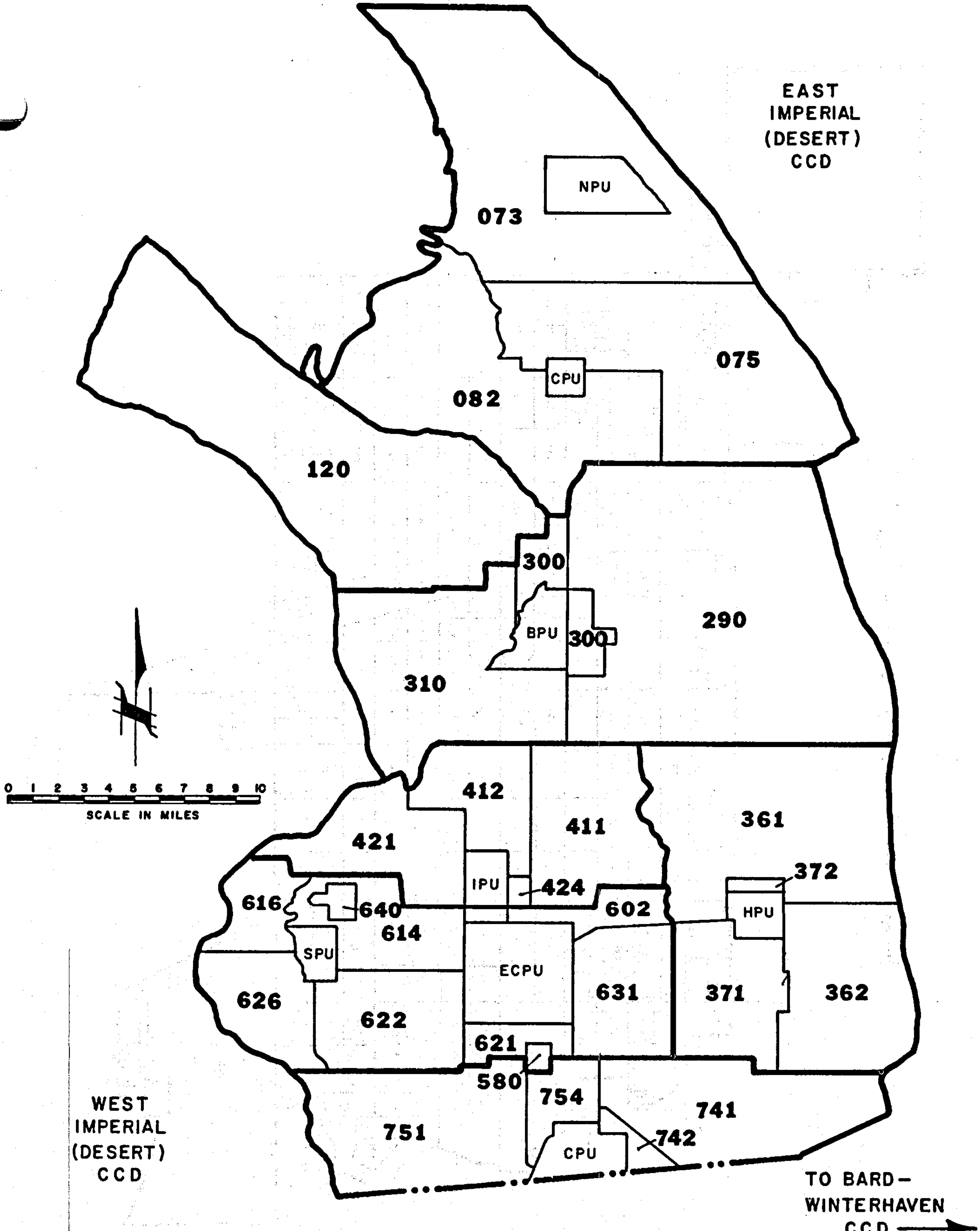


Figure 3.1.1-7 1975 Enumeration Districts of Imperial County

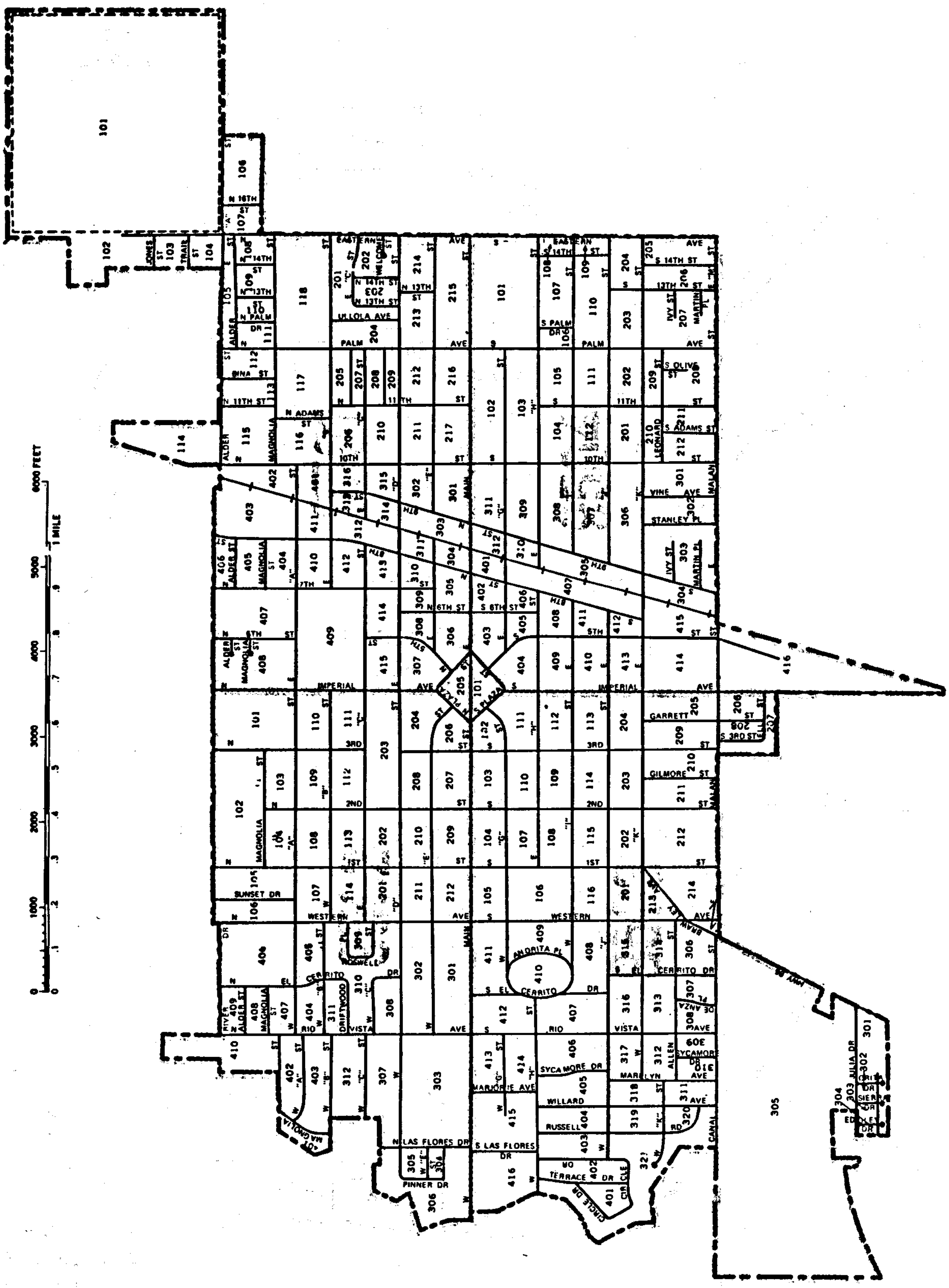


Figure 3.1.1-8 Brawley, 1970 Census Block Units (used for 1970 Census of Housing)

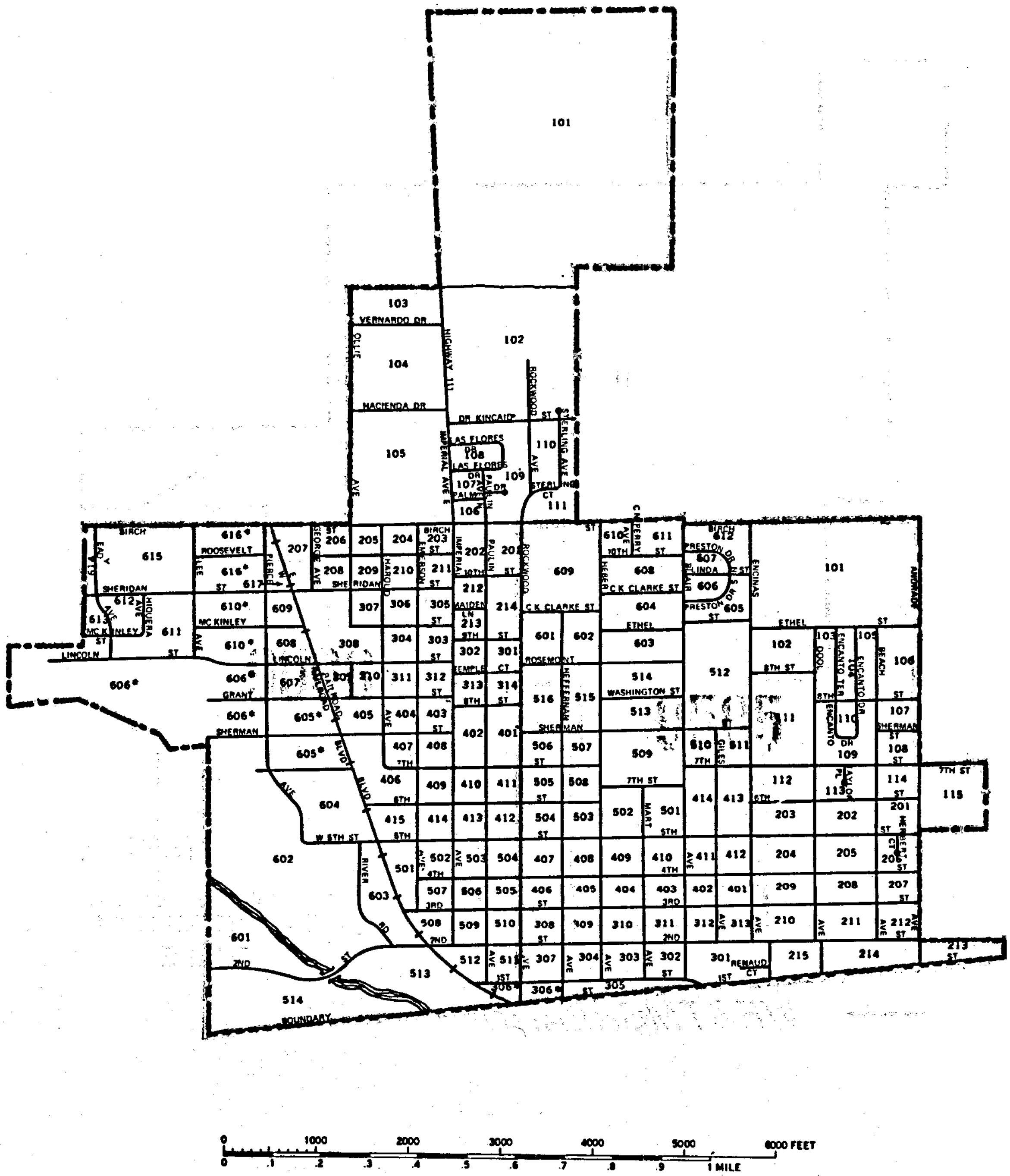


Figure 3.1.1-9 Calexico, 1970 Census Block Units (used for 1970 Census of Housing)

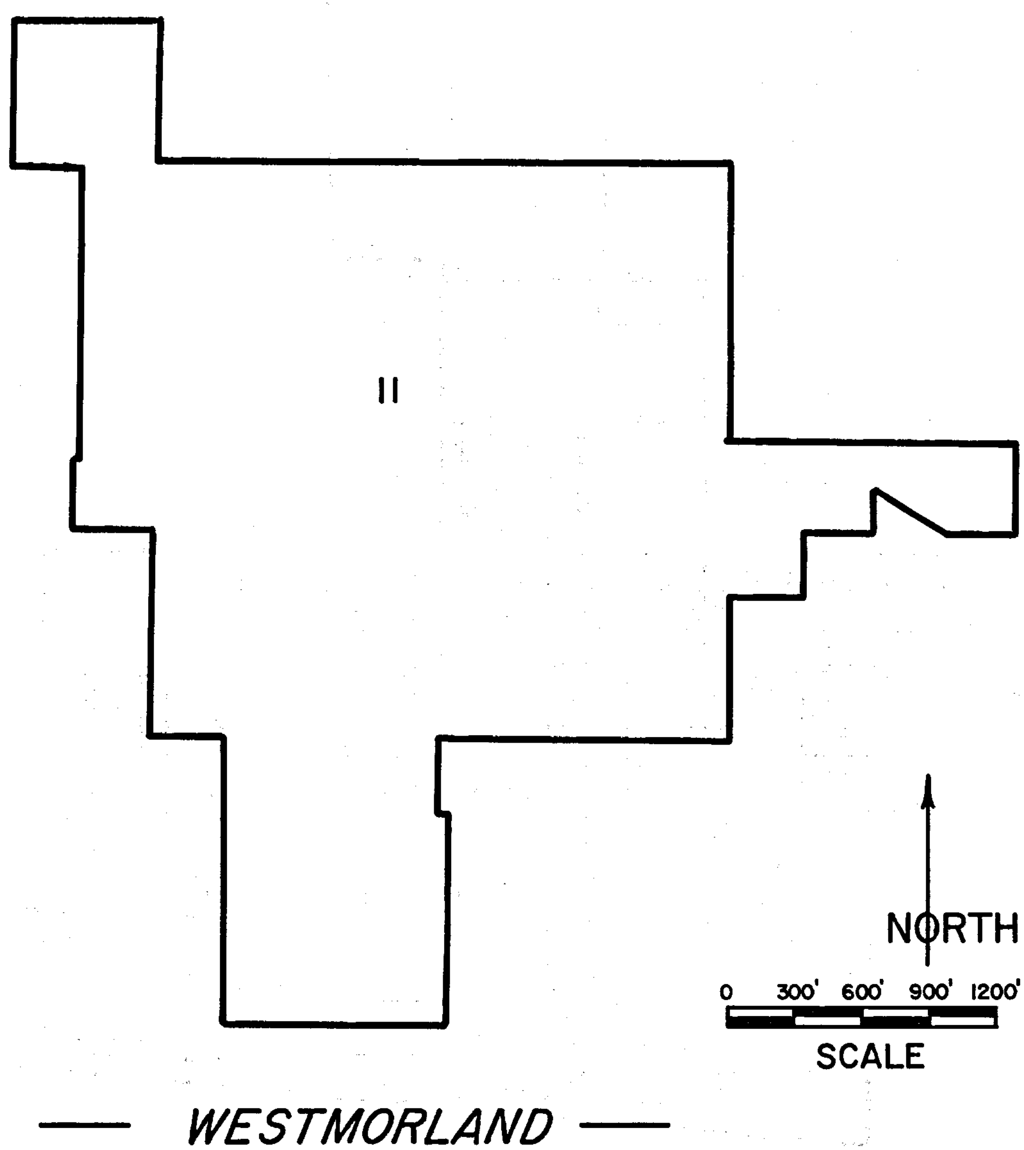


Figure 3.1.1-10 Westmorland, 1970 Census Enumeration Districts

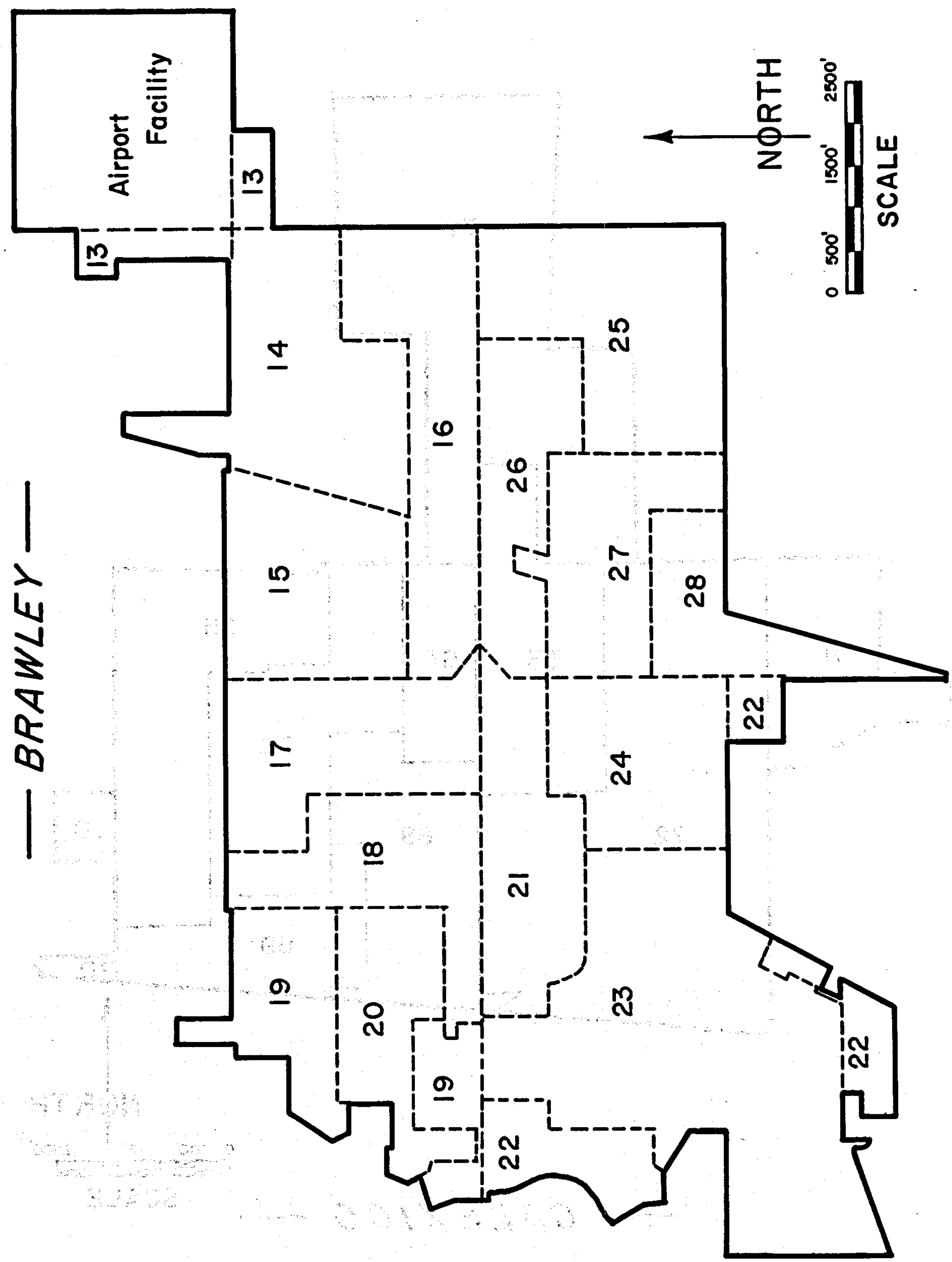


Figure 3.1.1-11 Brawley, 1970 Census Enumeration Districts

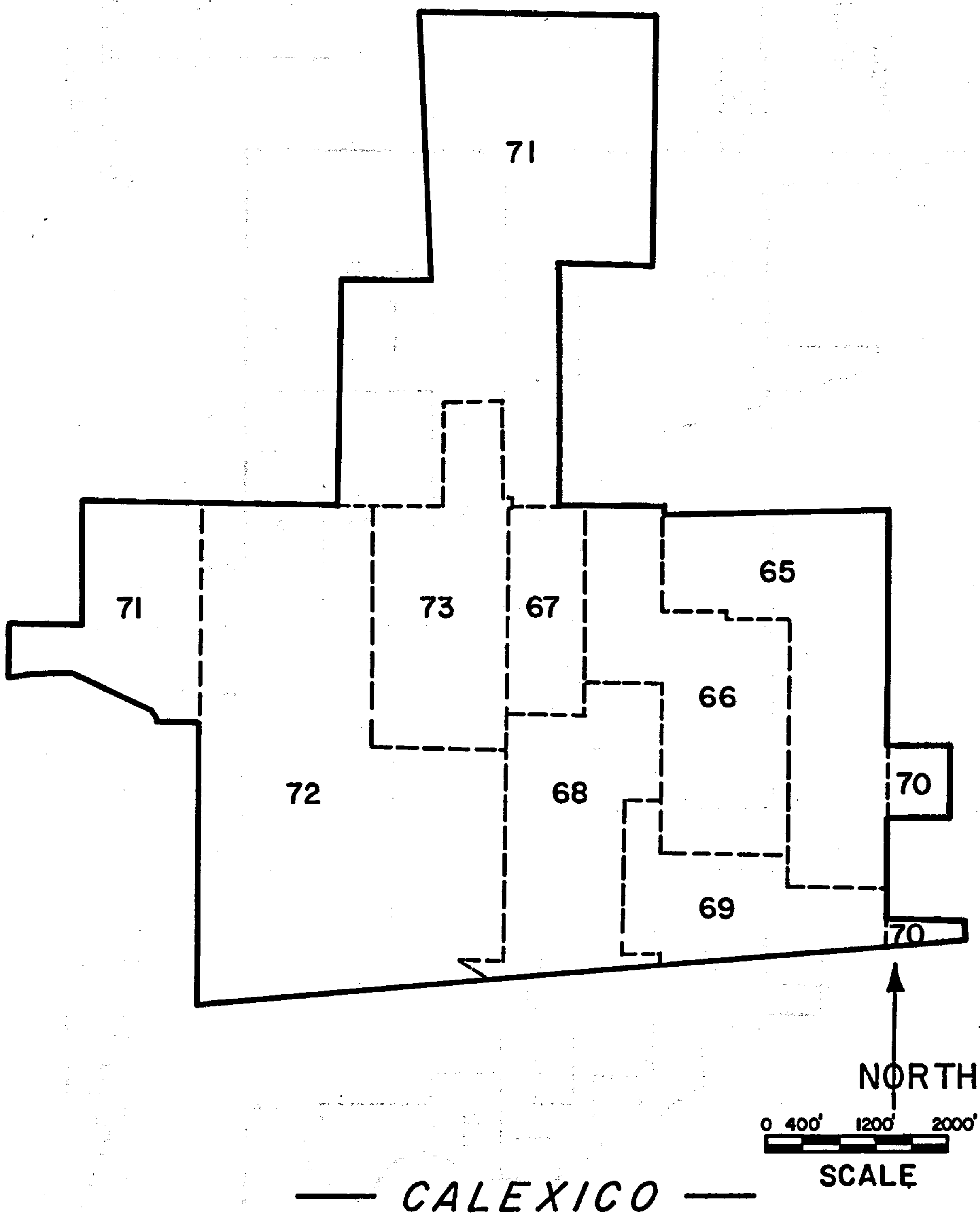


Figure 3.1.1-12 Calexico, 1970 Census Enumeration Districts

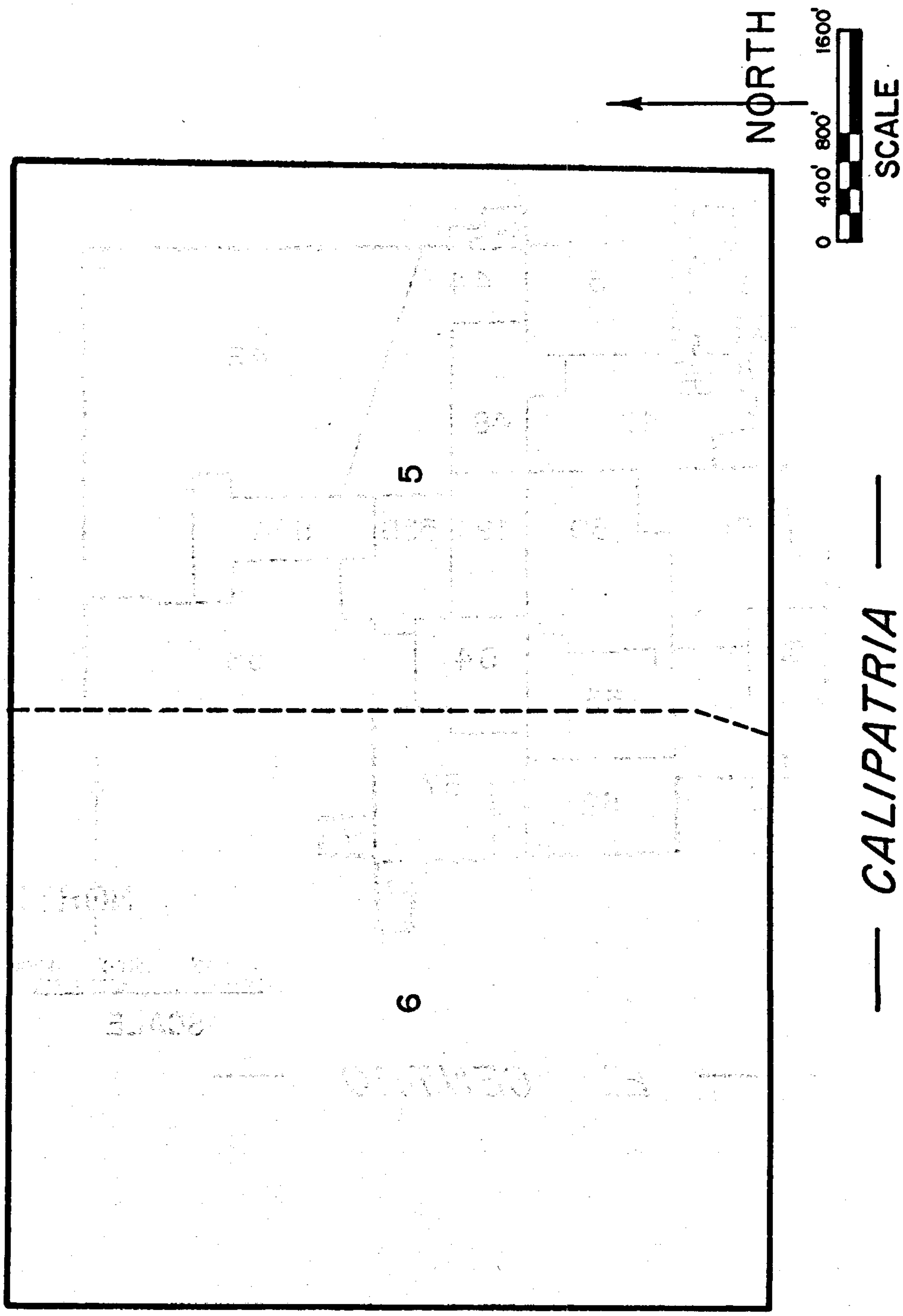


Figure 3.1.1-13 Calipatria, 1970 Census Enumeration Districts

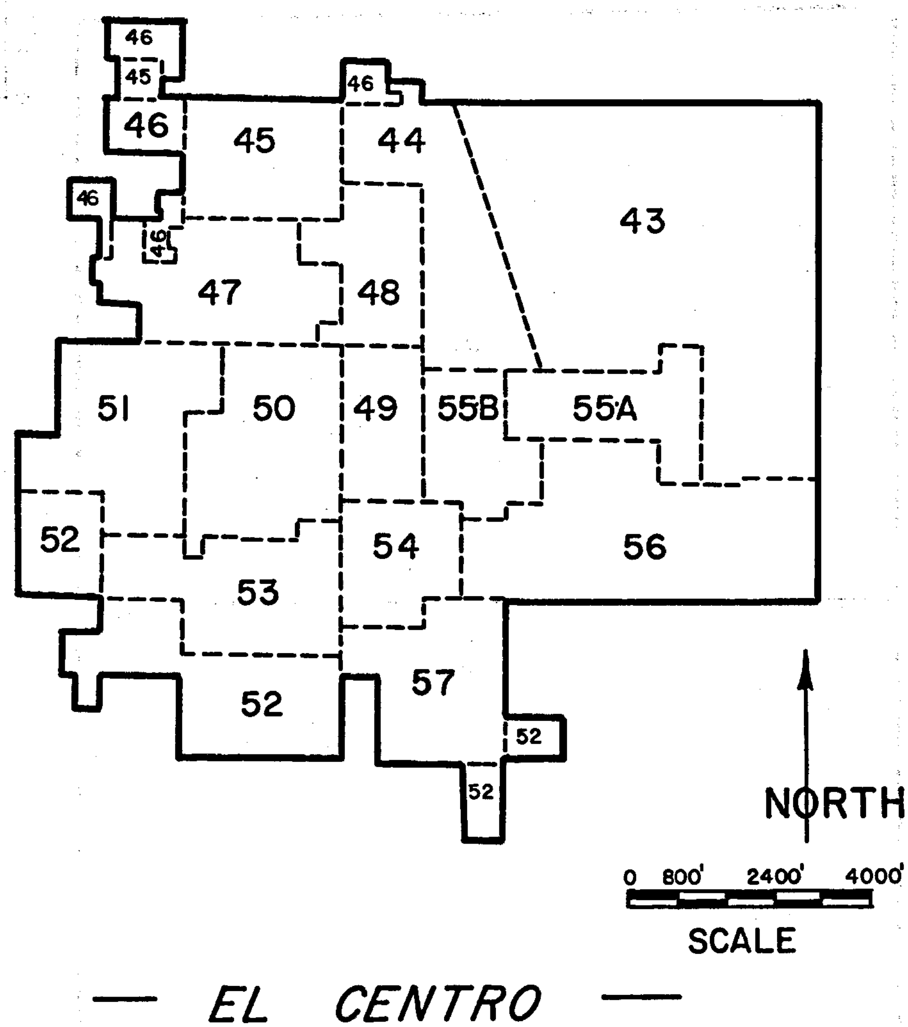


Figure 3.1.1-14 El Centro, 1970 Census Enumeration Districts

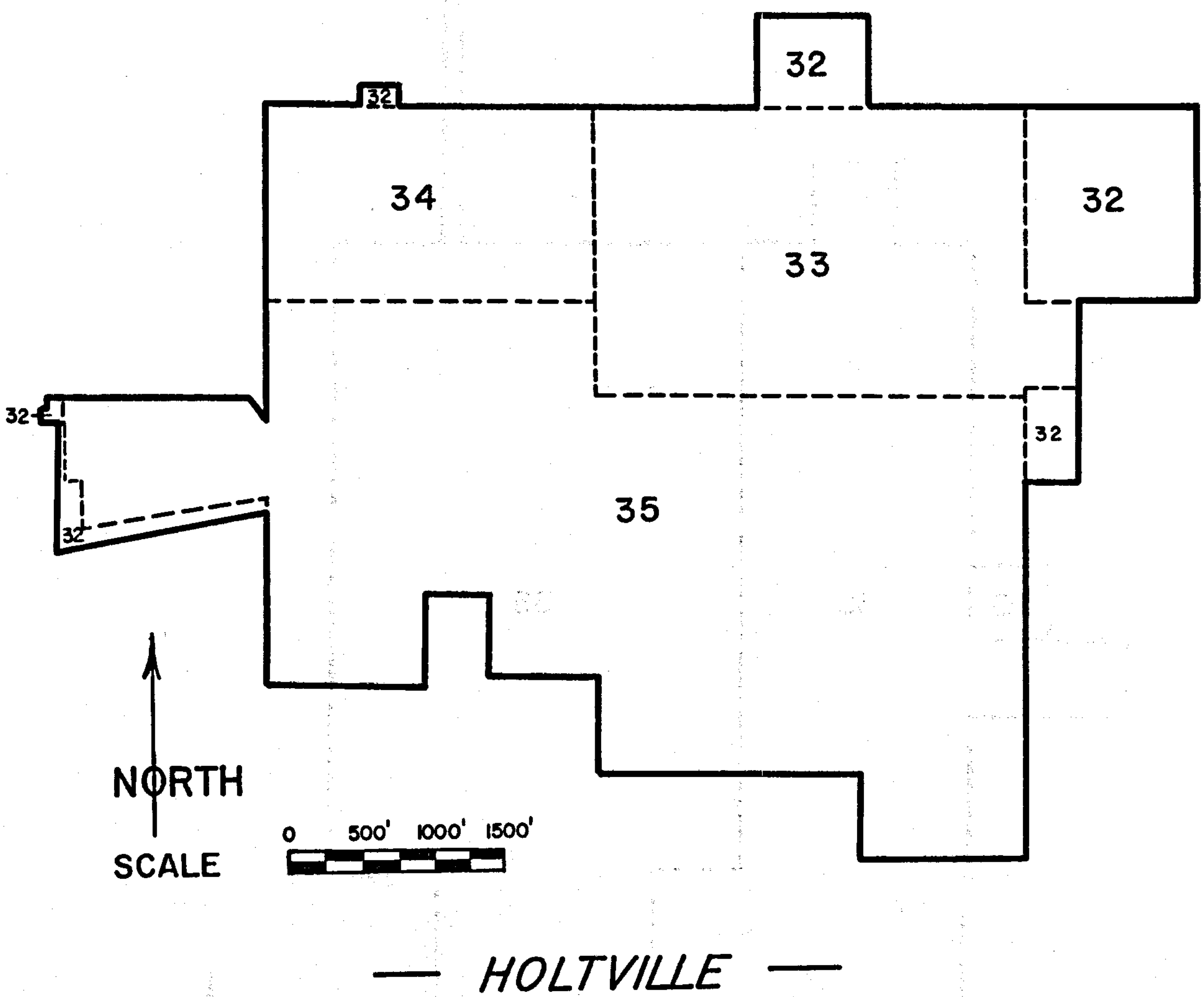


Figure 3.1.1-15 Holtville, 1970 Census Enumeration Districts

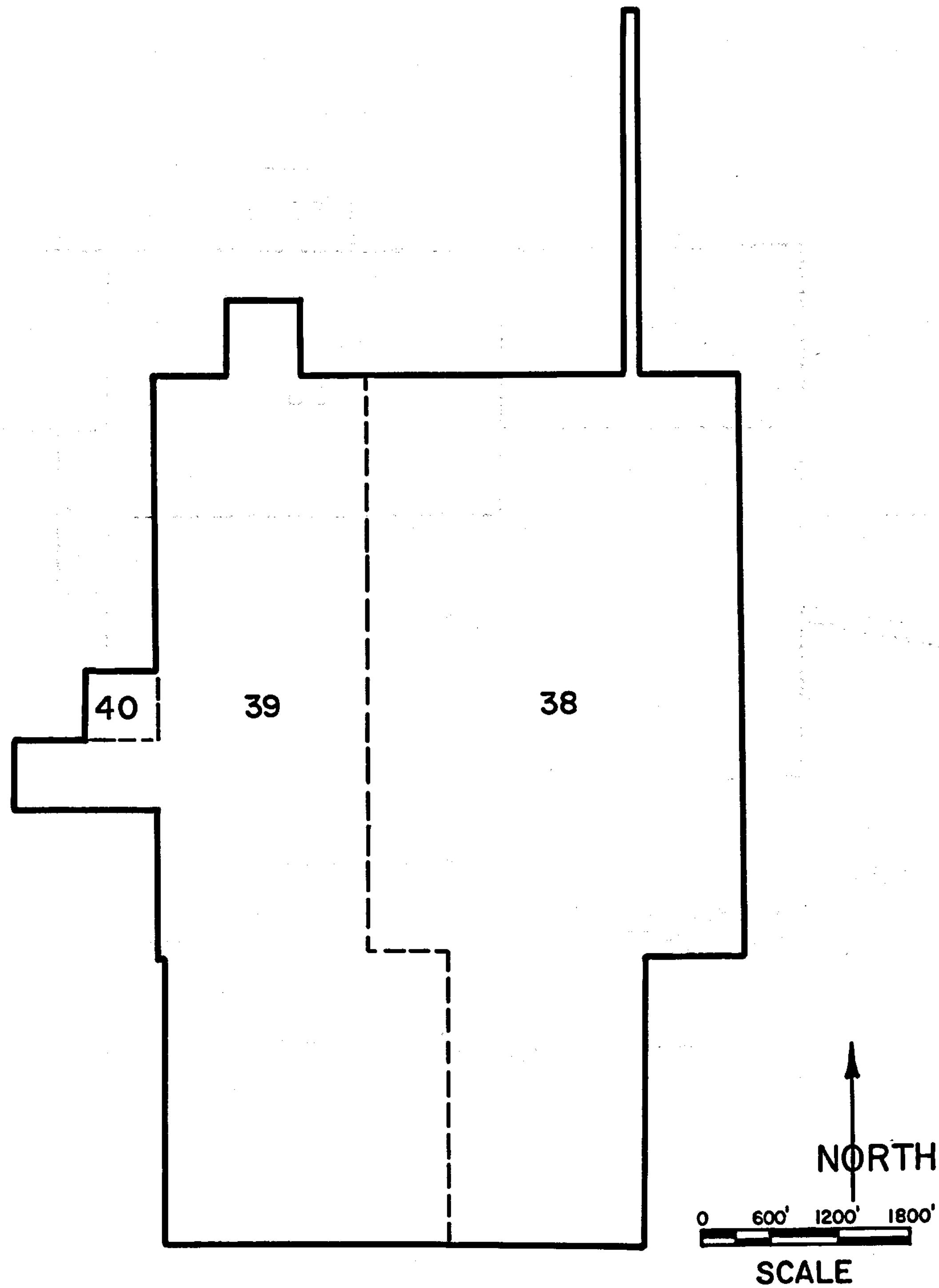


Figure 3.1.1-16 Imperial, 1970 Census Enumeration Districts

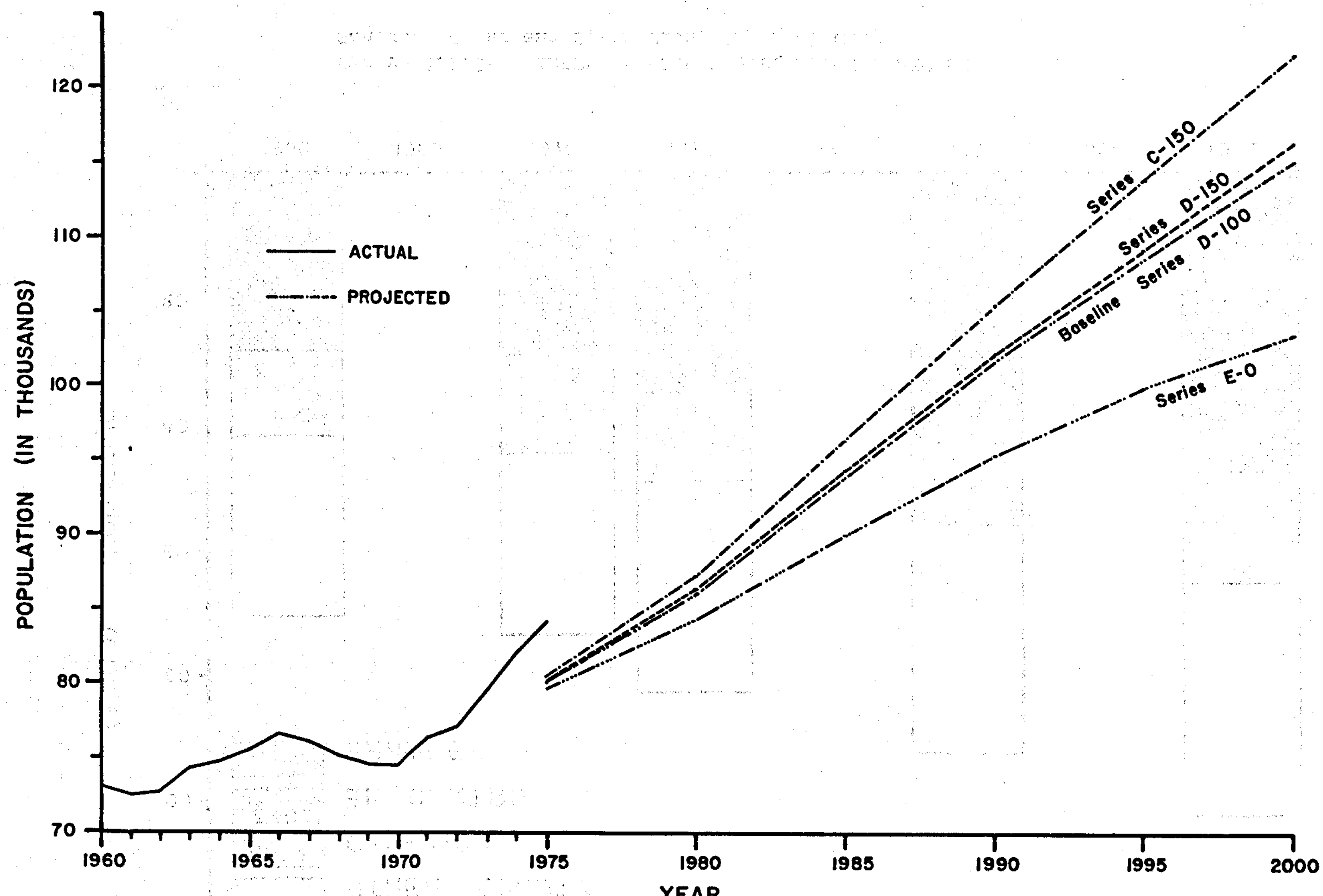


Figure 3.1.2-1 Annual Population Growth, Imperial County (Department of Finance, California).

NOTE: Projections based on data from Population Projections for California Counties, 1975-2020, alternative Series D-100, E-0, D-150, E-150, DOF Report 74 P-2, Sacramento, California, June 1974.

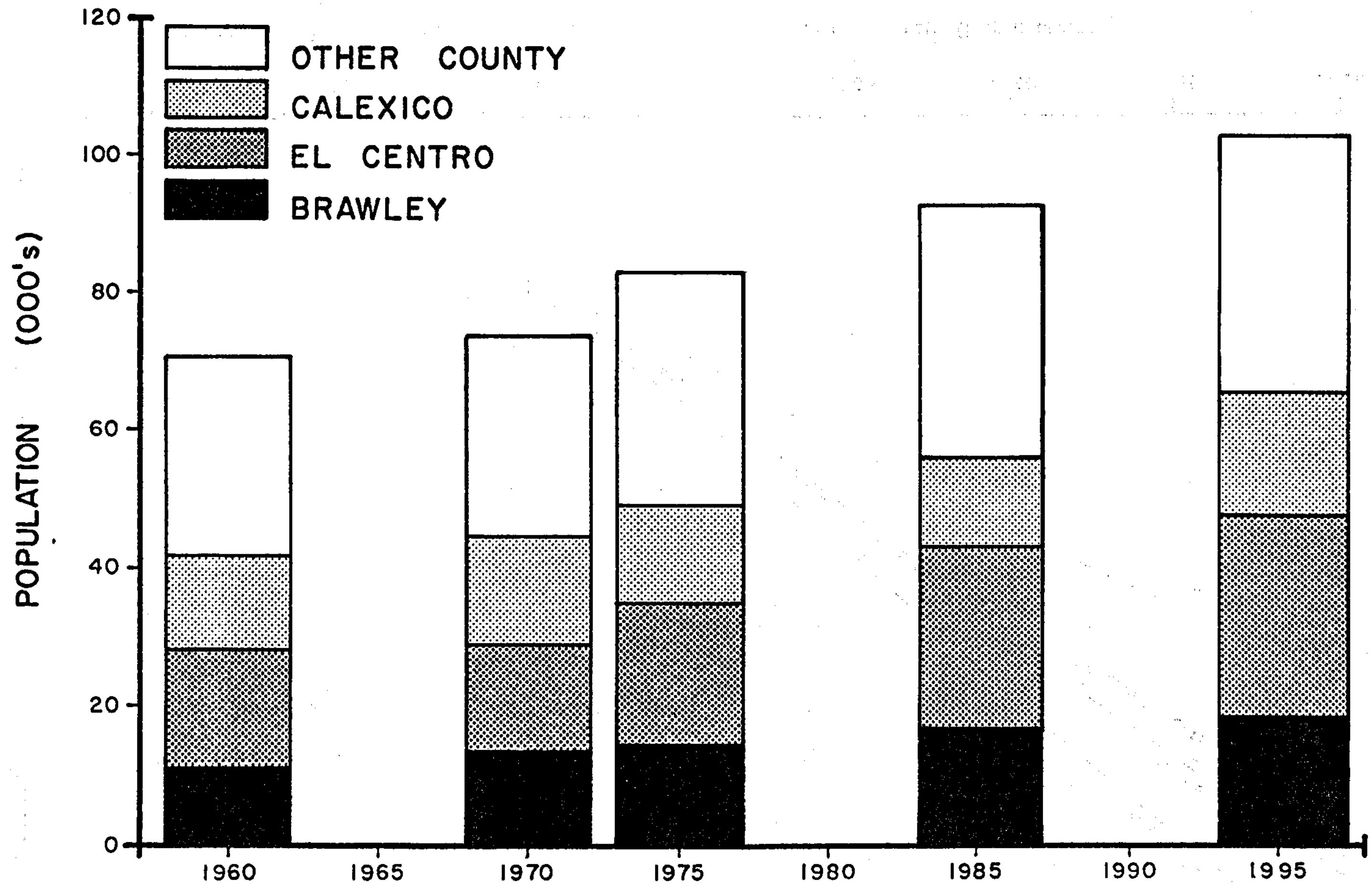


Figure 3.1.2-2 IMPERIAL COUNTY POPULATION FORECASTS
Source: Water and Sewer Plan, Imperial City

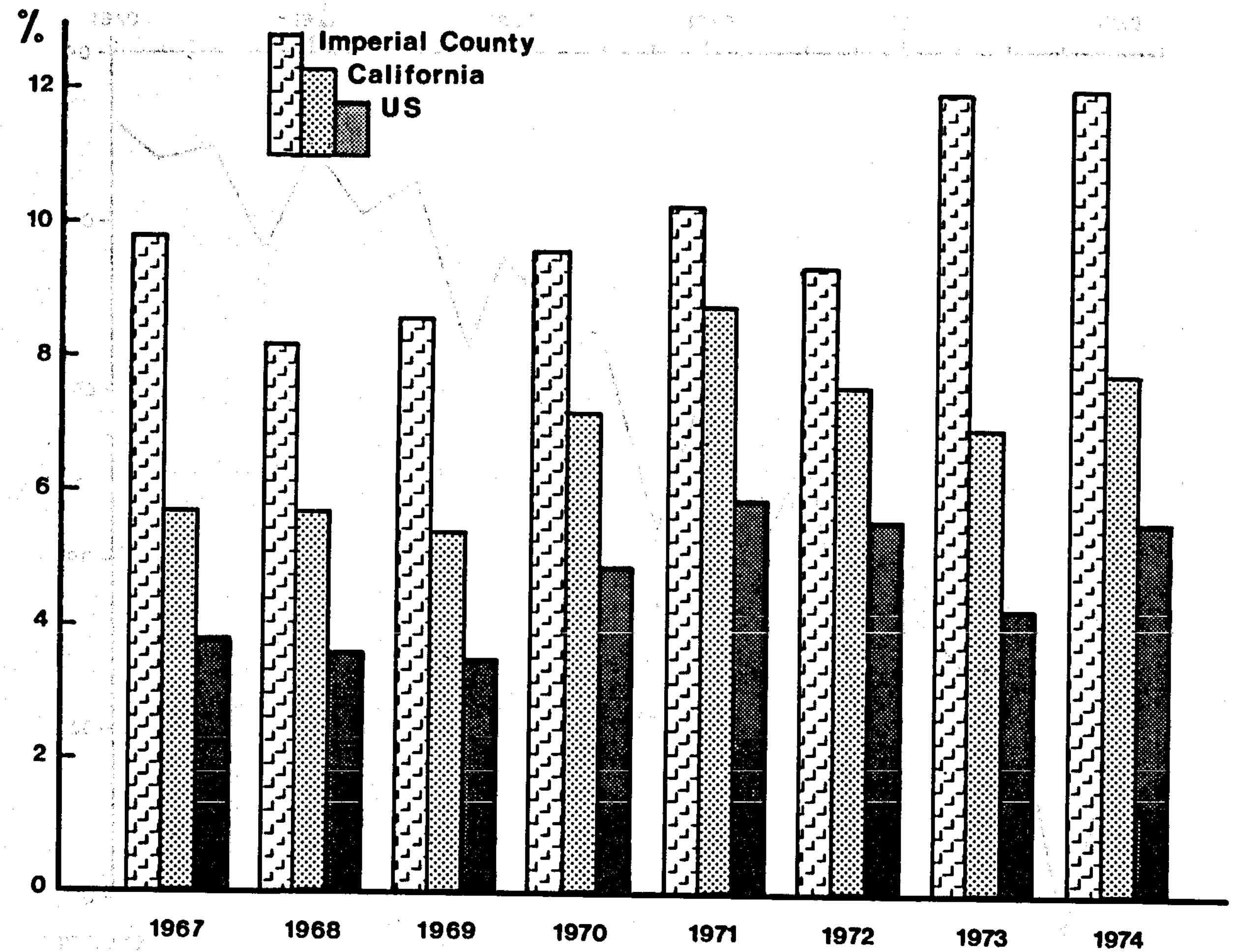


Figure 3.1.3-1 Annual Unemployment Rates (seasonally adjusted) 1970-1975 (from EDD)

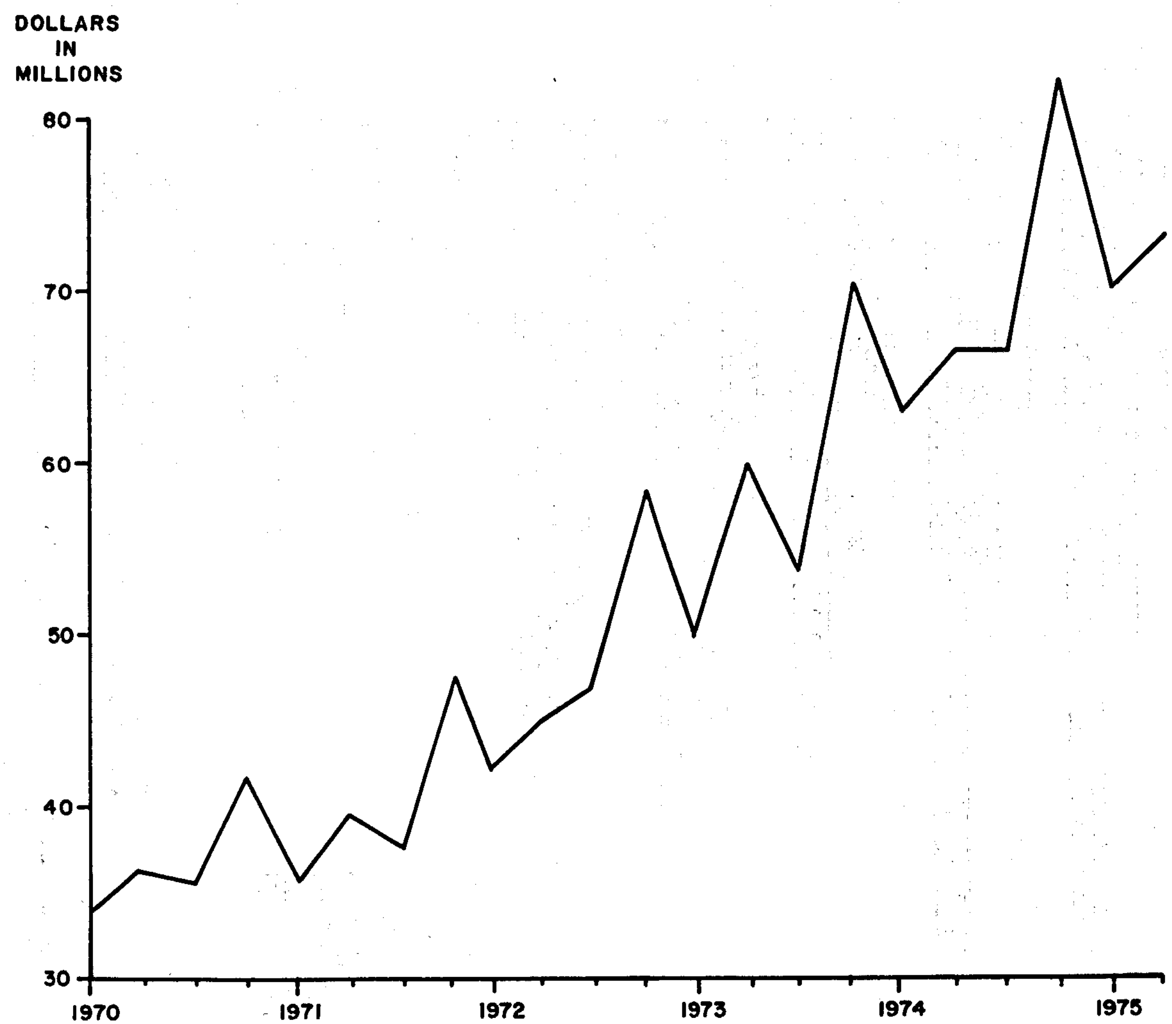
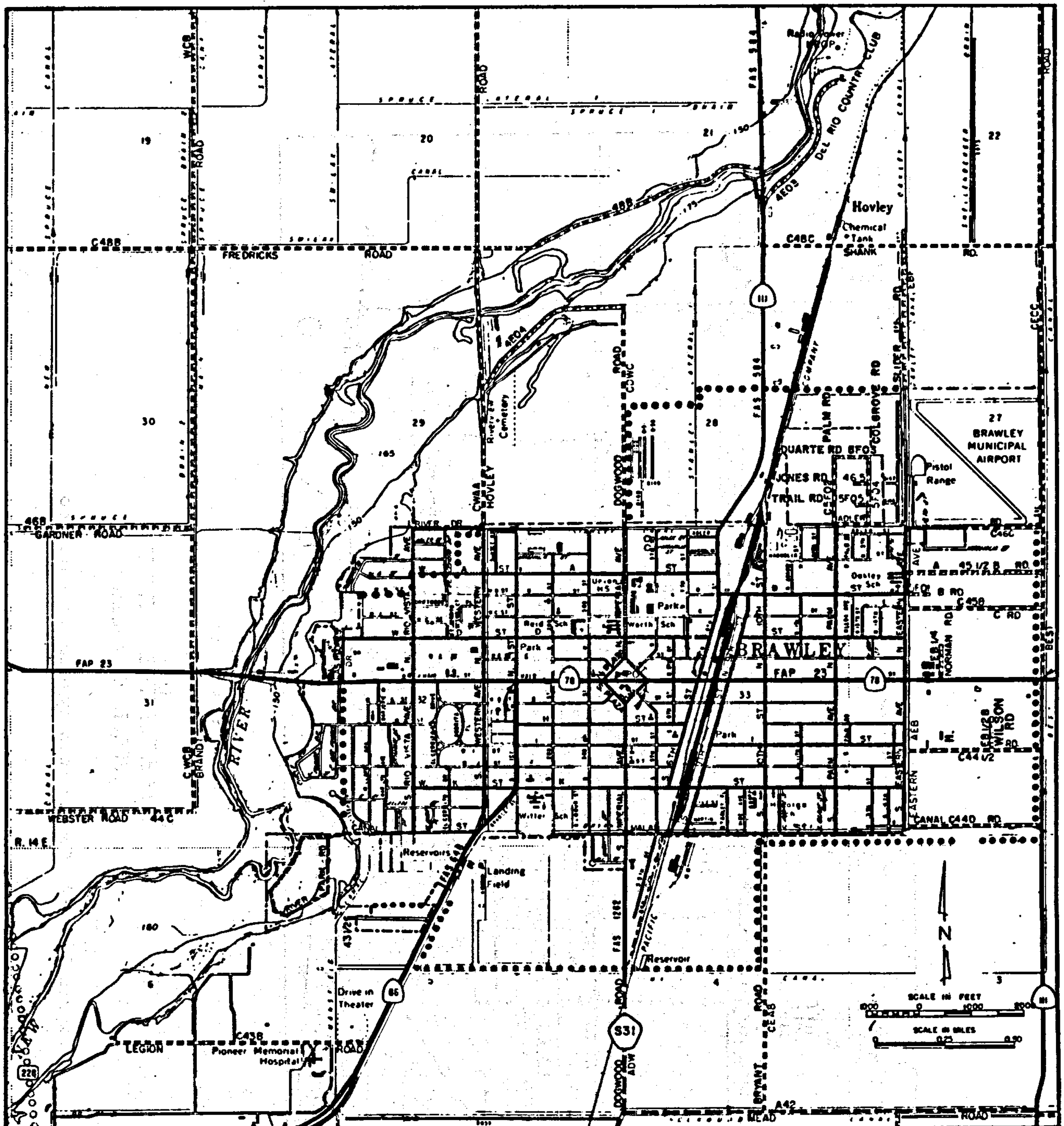


Figure 3.1.5-1 Imperial County Retail Sales (Quarterly)
Source: Board of Equalization, California



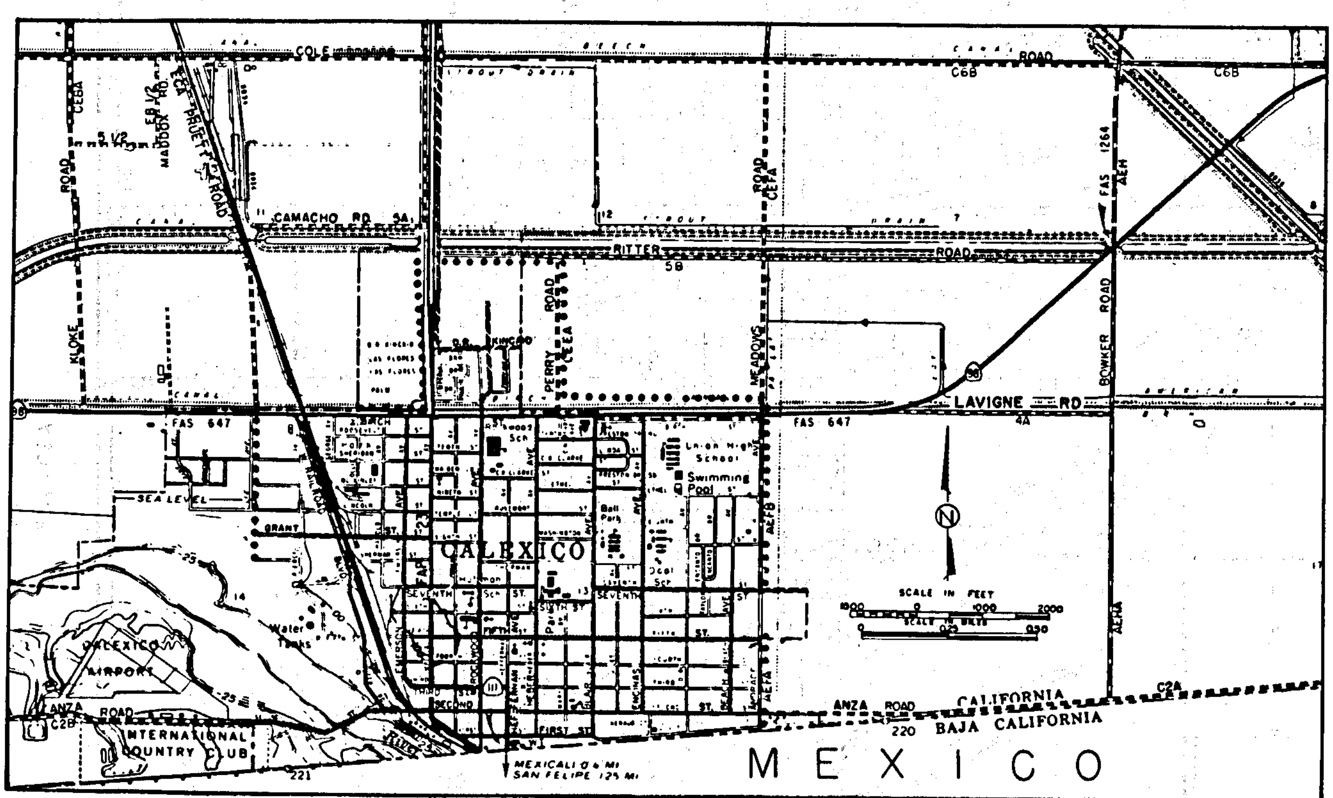
BRAWLEY

T13-14S,R14E

0 0.5 1

SCALE IN MILES

Figure 3.1.6-1 County road system for Brawley



CALEXICO
T17S, R14-15E

0 0.5
SCALE IN MILES

Figure 3.1.6-2 County road system for Calexico

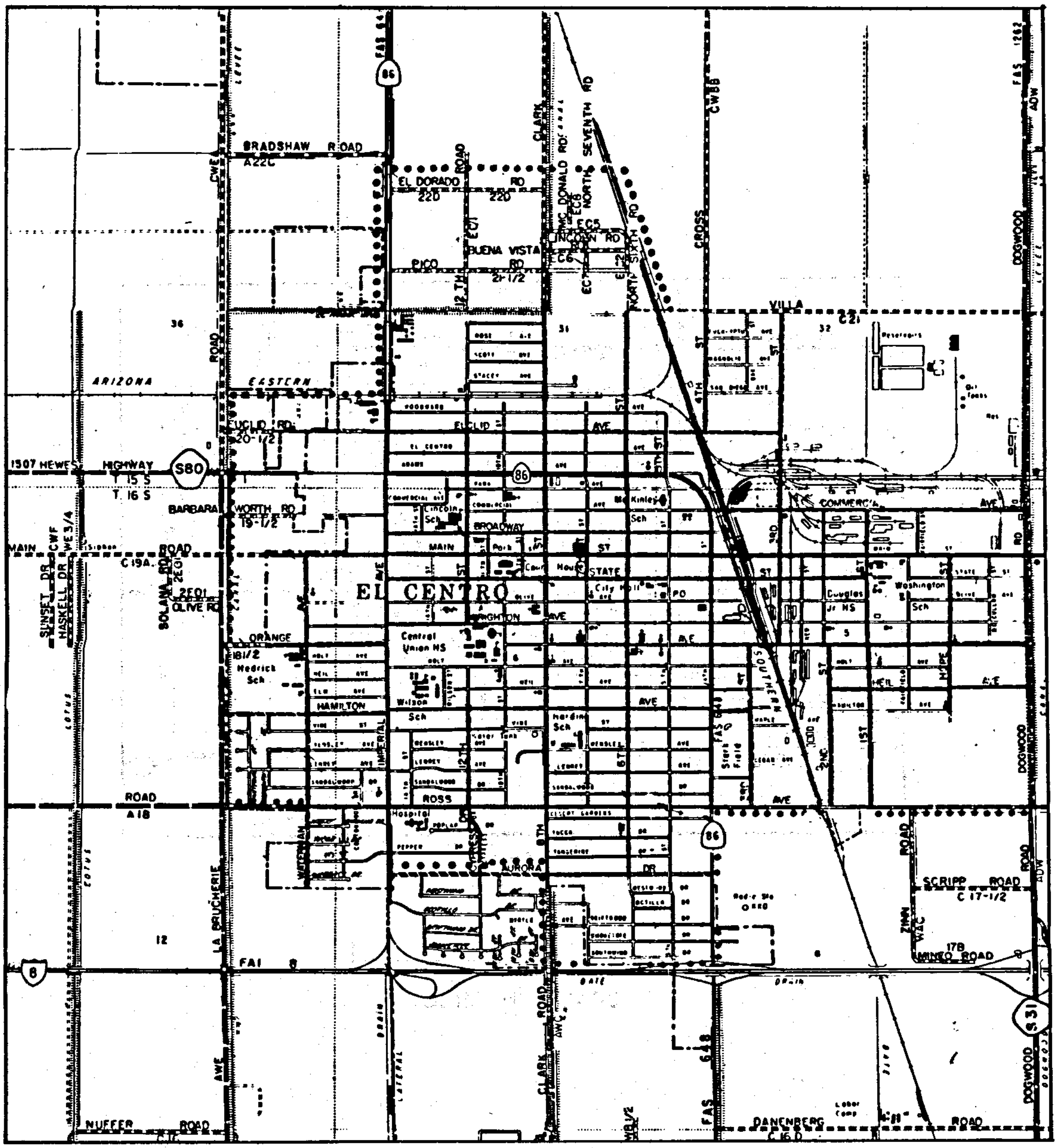


Figure 3.1.6-3 County road system for El Centro

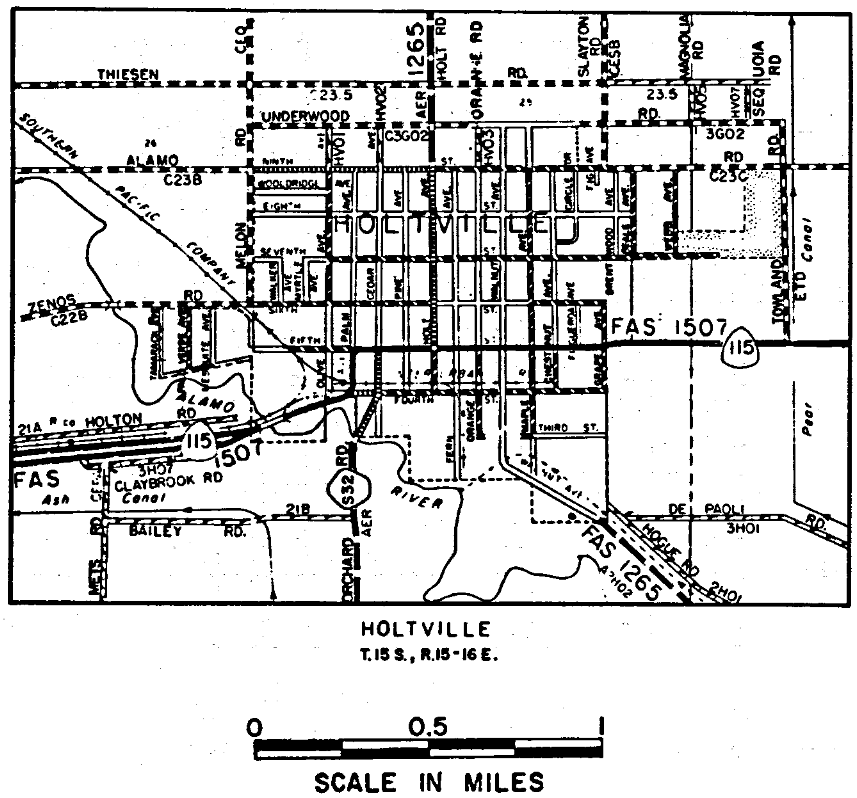


Figure 3.1.6-4 County road system for Holtville

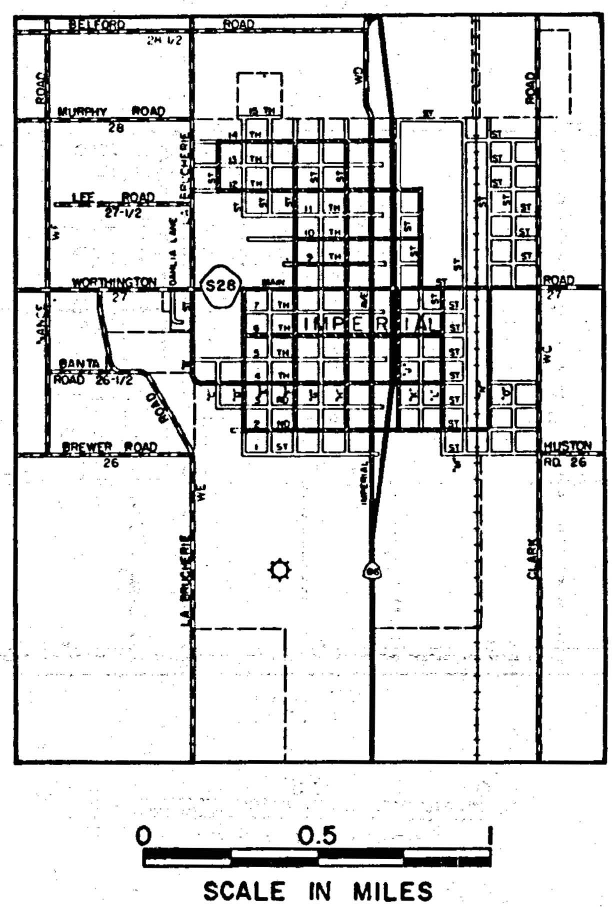


Figure 3.1.6-5 County road system for Imperial

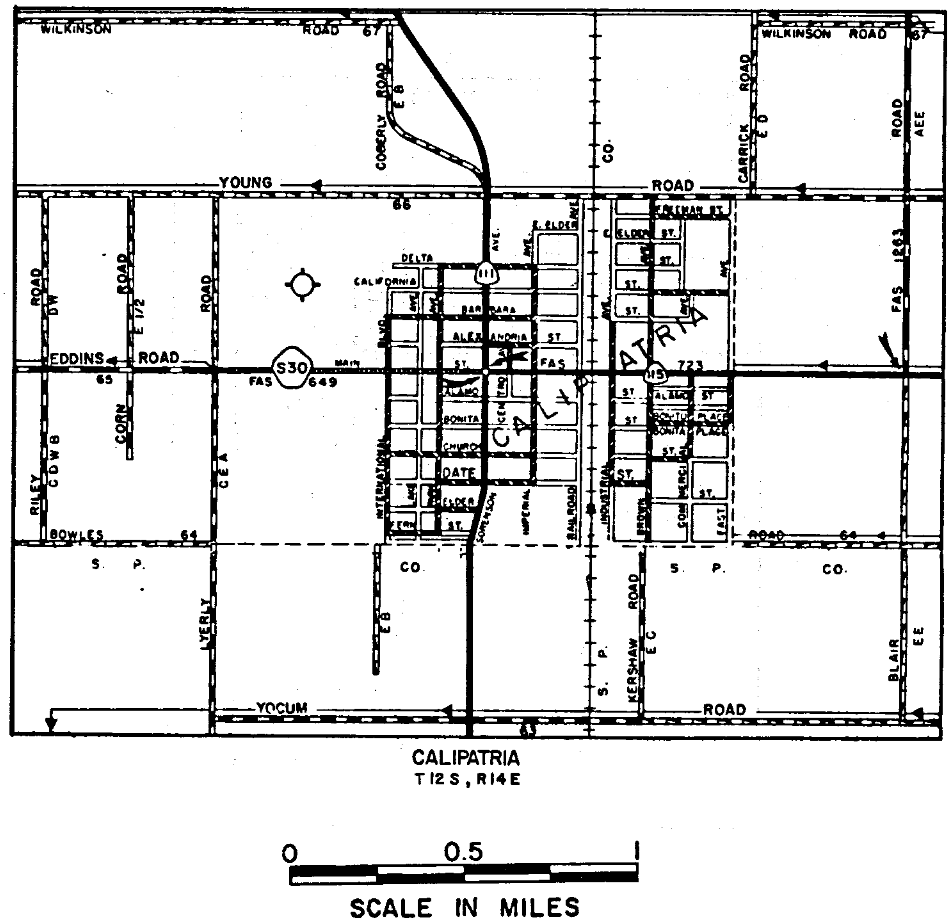


Figure 3.1.6-6 County road system for Calipatria

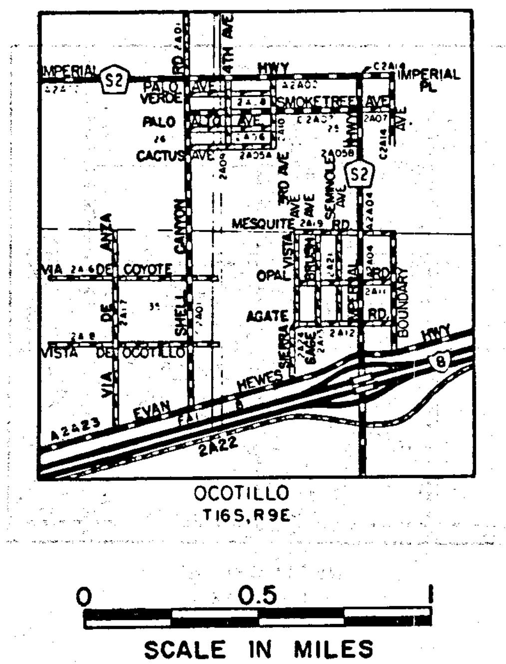
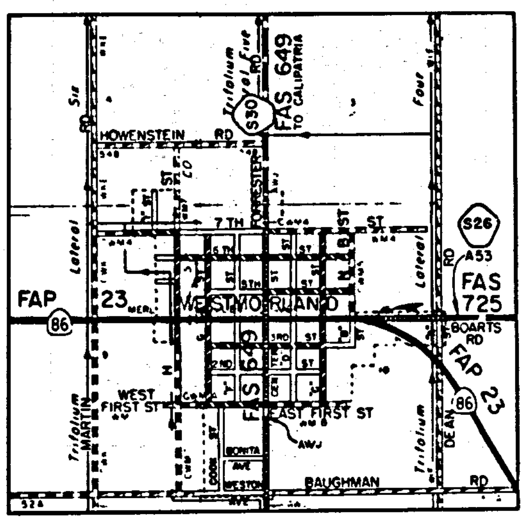


Figure 3.1.6-7 County road system for Ocotillo



WESTMORLAND
T13S, R13E

Figure 3.1.6-8 County road system for Westmorland

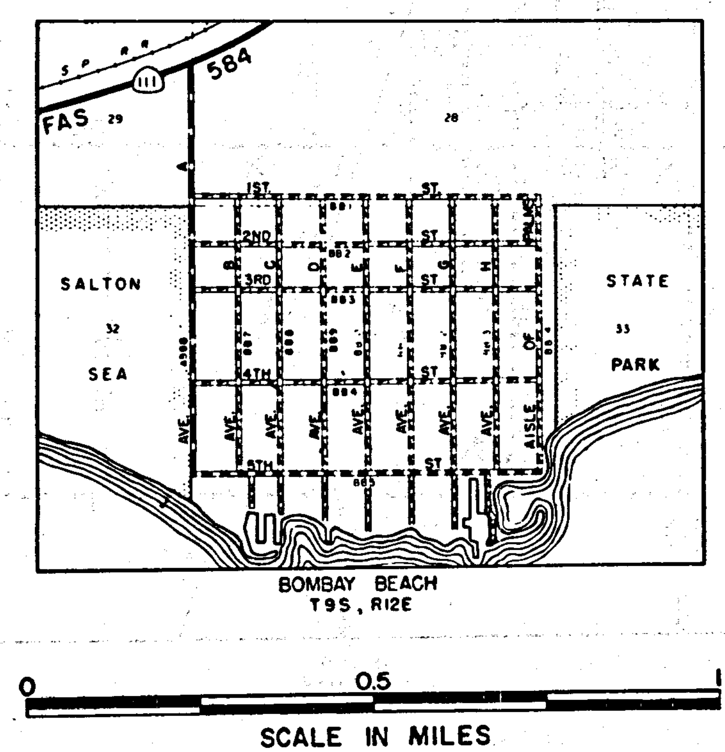


Figure 3.1.6-9 County road system for Bombay Beach

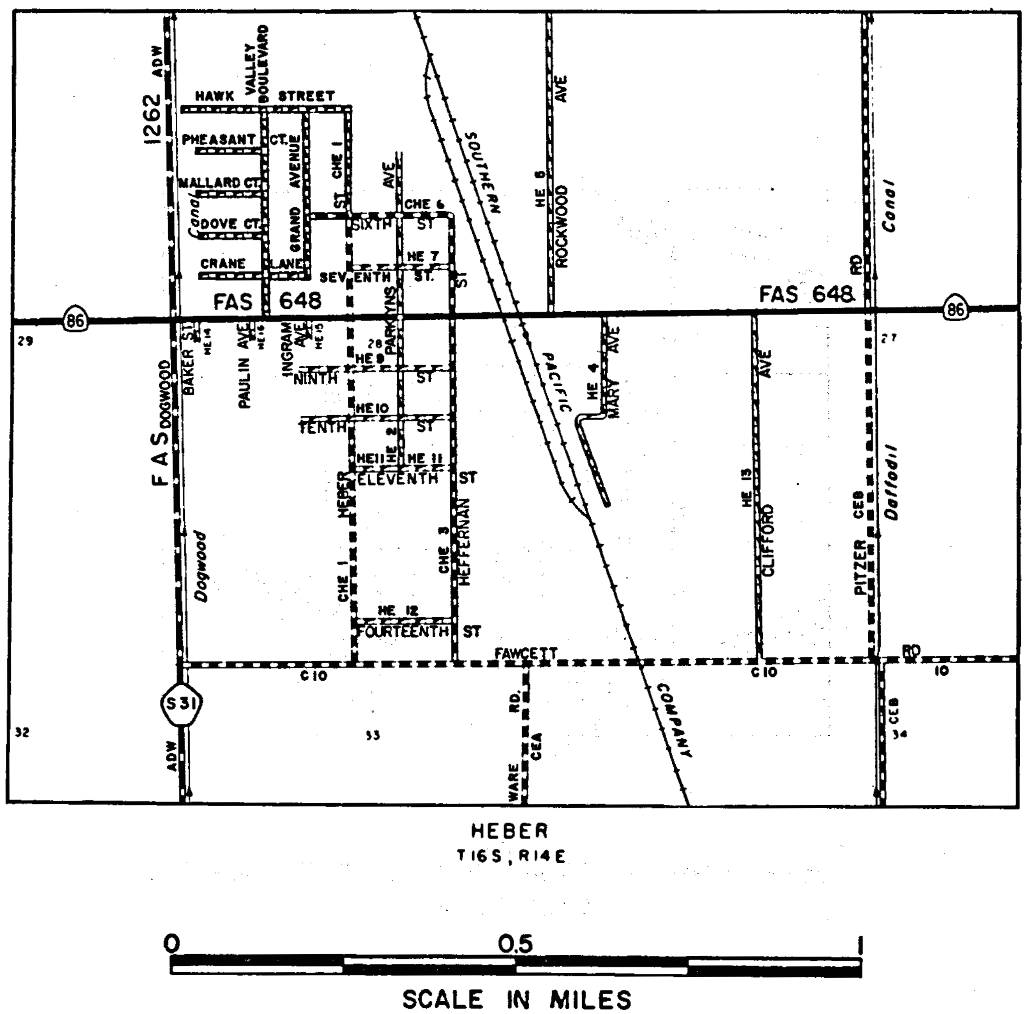
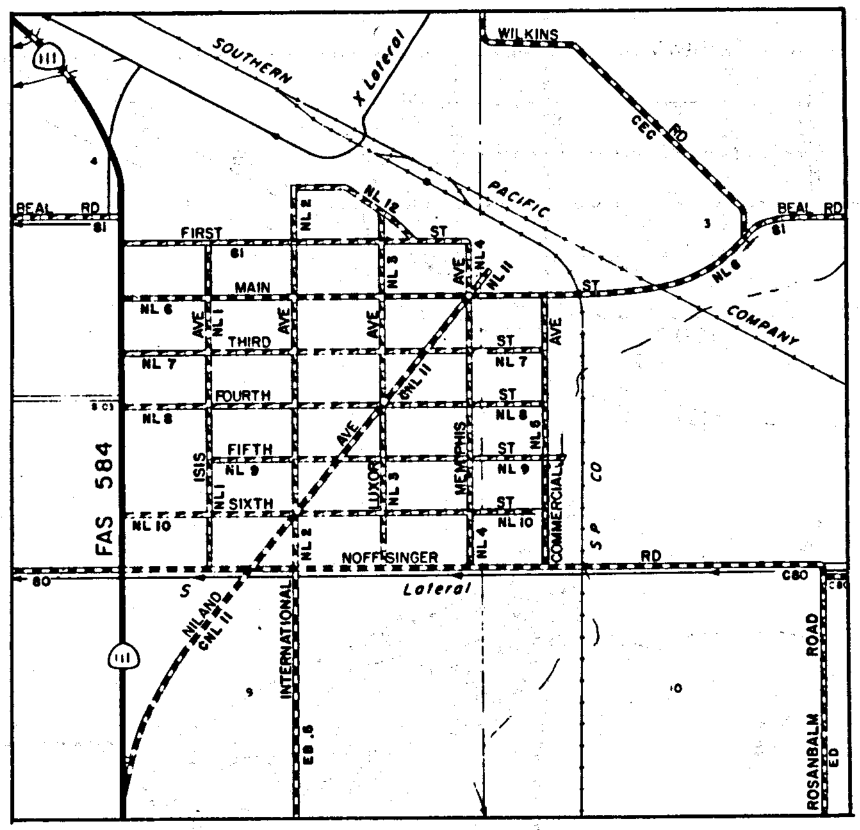


Figure 3.1.6-10 County road system for Heber



0 0.5 1

SCALE IN MILES

Figure 3.1.6-11 County road system for Niland

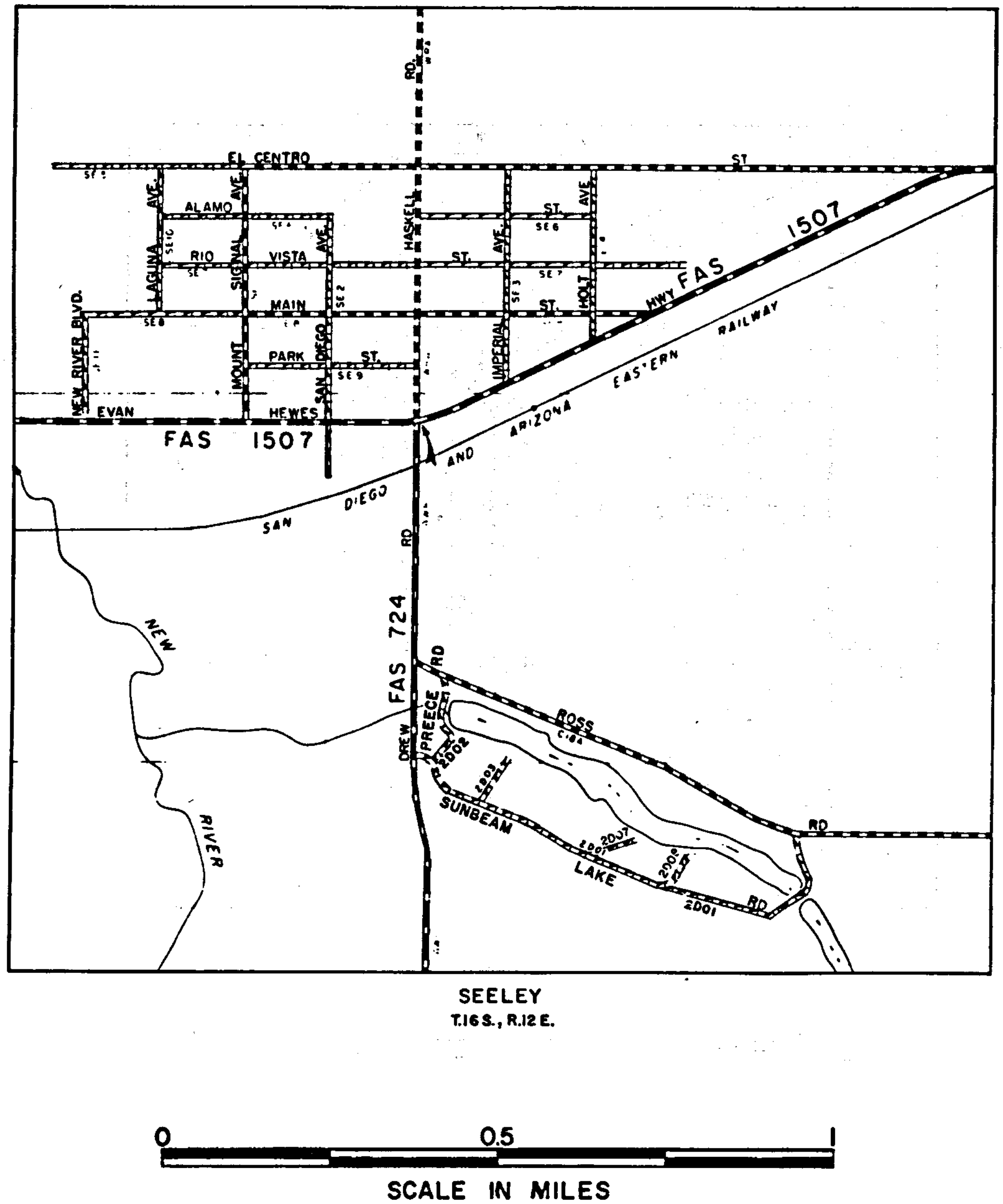


Figure 3.1.6-12 County road system for Seeley

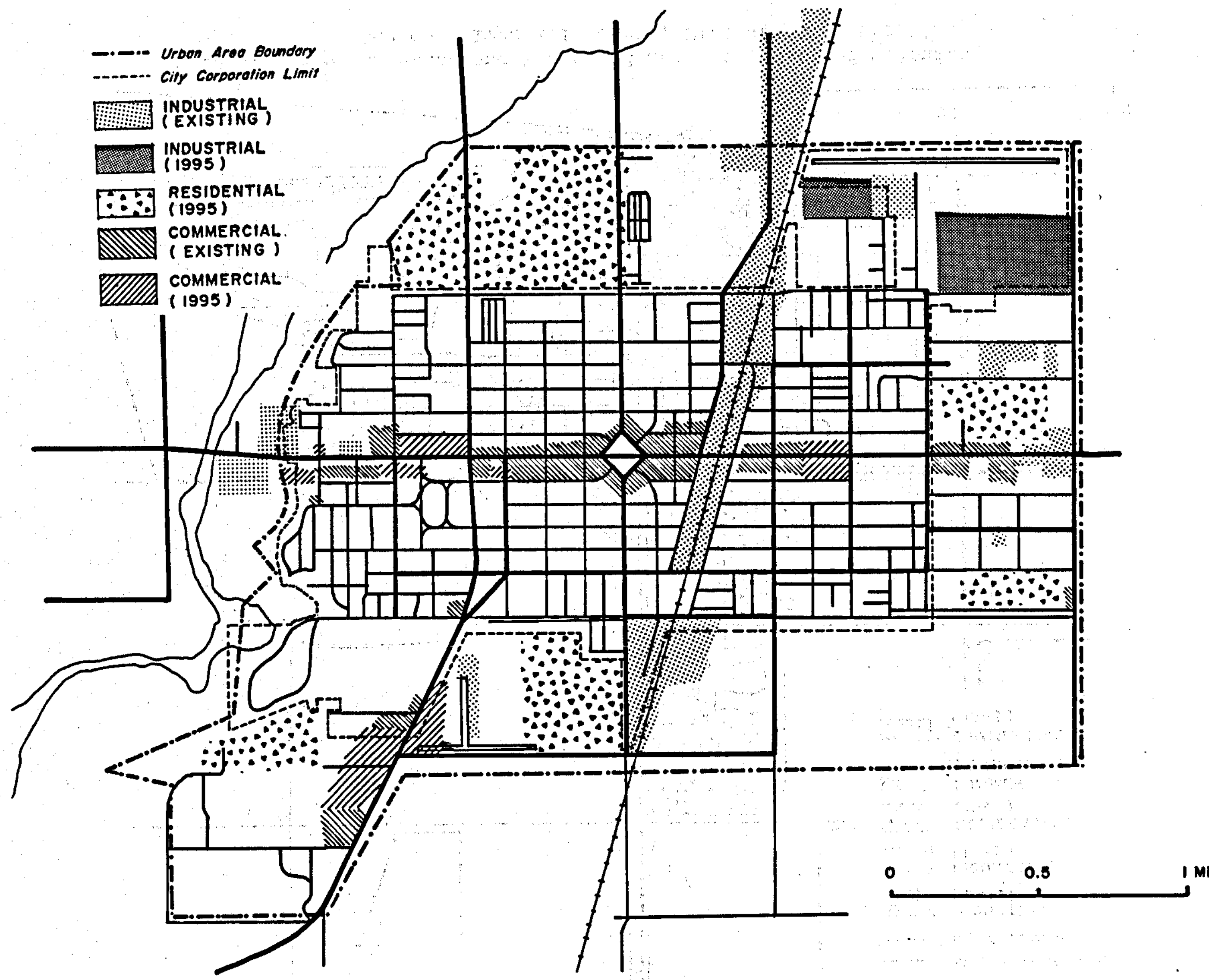


Figure 3.1.6-13 Existing and projected land use, Brawley.
Source: Imperial County

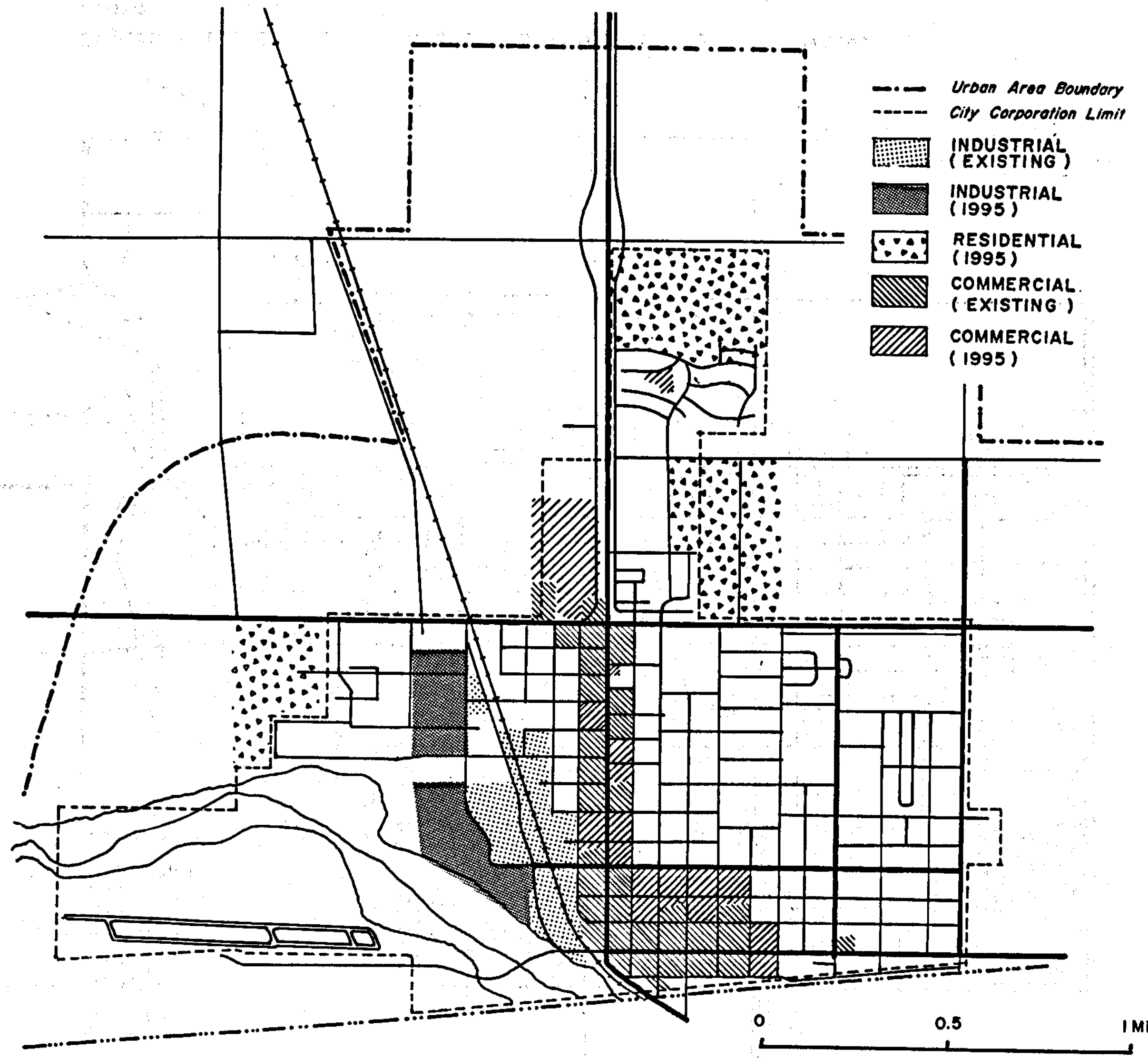


Figure 3.1.6-14 Existing and Projected Land Use, City of Celexico
Source: Imperial County, Ultimate Land Use Plan.

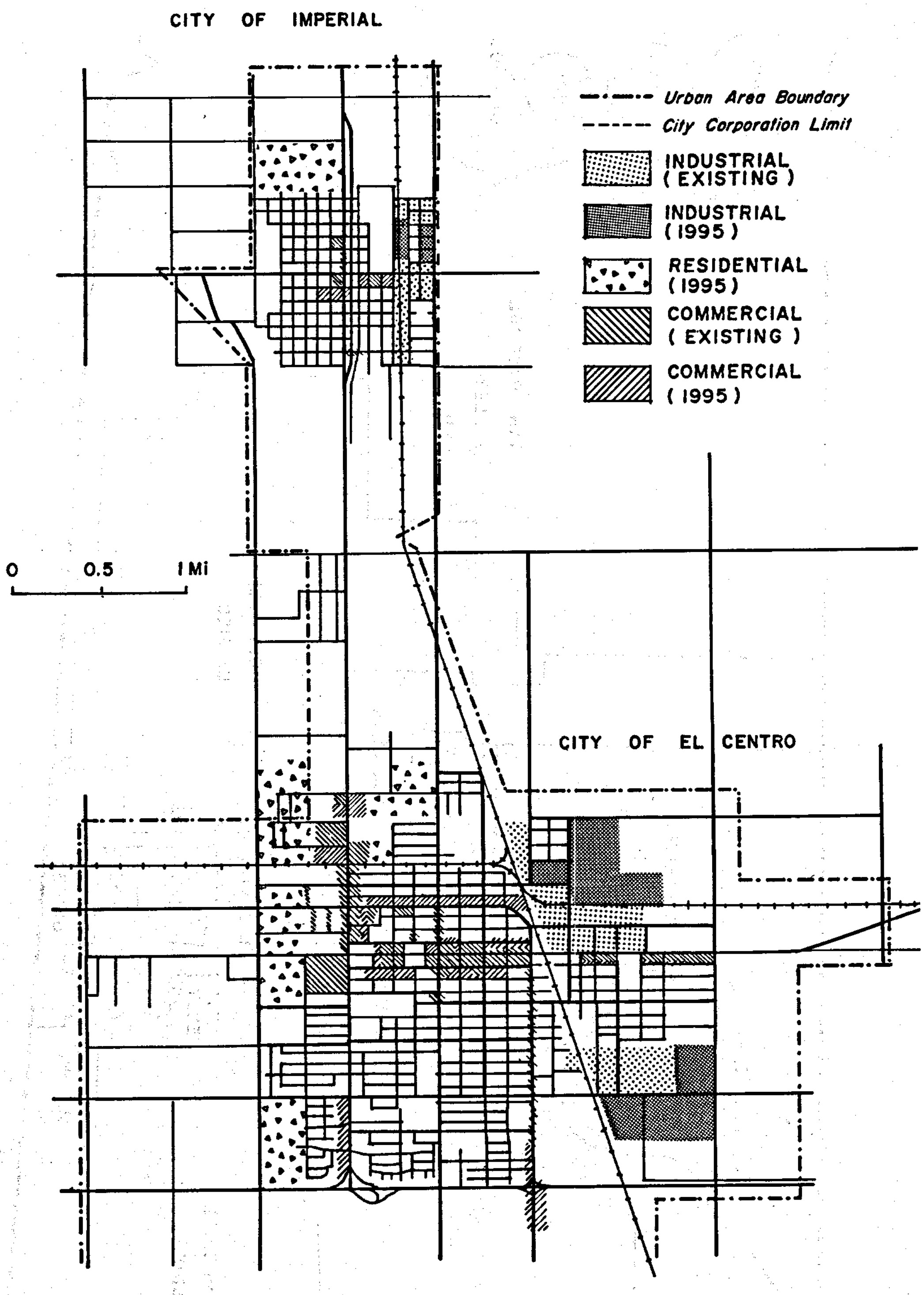


Figure 3.1.6-15 Existing and Projected Land Use - El Centro and Imperial. Source: Imperial County, Ultimate Land Use Plan

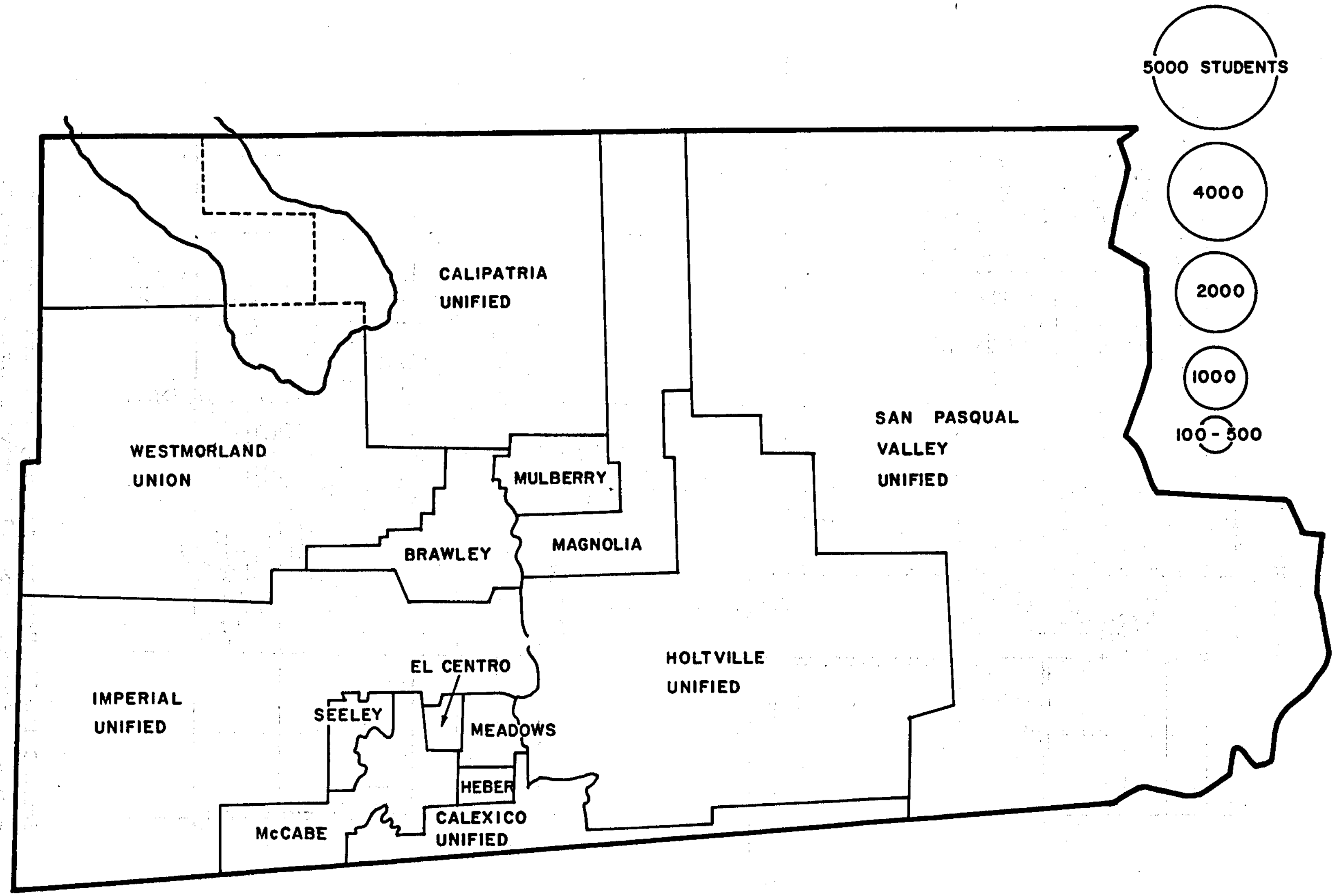
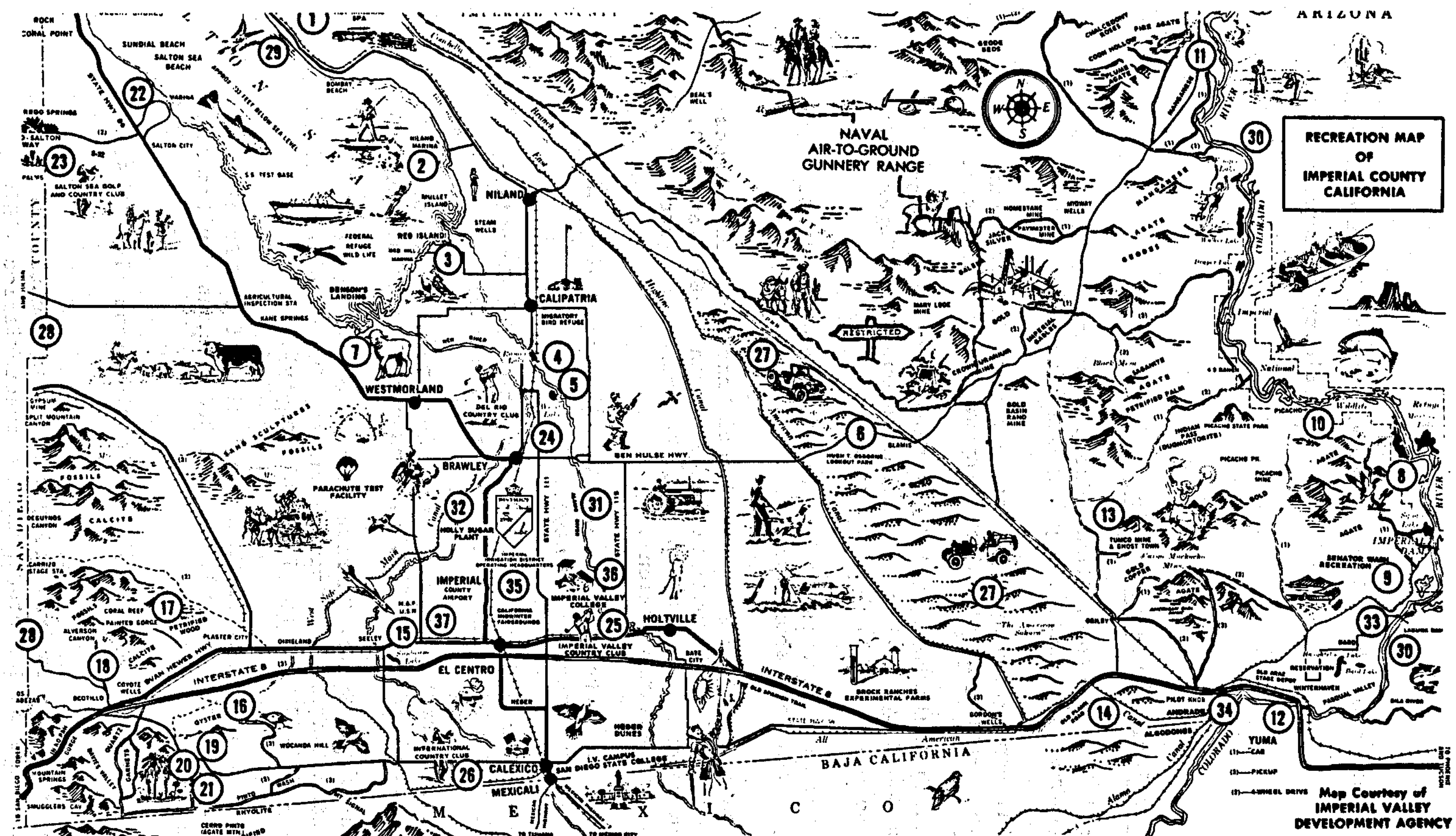


Figure 3.1.7-1 Imperial County School Districts 1969-1970
Source: Imperial County Superintendent of Schools



1. Hot Mineral Spa	**11.** Palo Verde Marina	**21.** Crucifixion Thorns	**29.** Salton Sea State Park
2. Niland Marina	**12.** Old Araz Stage Depot	**22.** Salton Bay Yacht Club and Marina	**30.** Colorado River
3. Red Hill Marina	**13.** Tumco Mine and Ghost Town	**23.** Salton City Golf Course	**31.** Alamo River
4. Ramer Lake	**14.** Old Plank Road	**24.** Rio Vista Golf and Country Club	**32.** New River
5. Wiest Lake	**15.** Sunbeam Lake	**25.** Barbara Worth Golf and Country Club	**33.** Laguna Dam
6. Hugh T. Osborne Lookout Park	**16.** Oyster Shell Beds	**26.** International Golf and Country Club	**34.** Andrade Park
7. Westmorland Boat Landing	**17.** Painted Gorge	**27.** Sand Dunes	**35.** California Midwinter Fairgrounds
8. Ferguson Lake	**18.** Fossil Canyon	**28.** Anza Borrego Desert State Park	**36.** Imperial Valley College
9. Imperial Dam	**19.** Vista de Anza Monument		**37.** Naval Air Facility
10. Picacho Peak Camp	**20.** Petrified Wood Area		

Figure 3.1.8-1 Recreation Map of Imperial County, California
Source: Imperial Valley Development Agency

Tables

This report does not contain the tables listed below. The tables are on file at the Electric Power Research Institute, San Diego Gas & Electric Company, and Geonomics, Inc.

List of Tables

3.1.2 <u>General Demographic Variables</u>

3.1.4 <u>Housing</u>

3.1.6 Land Use

Table 3.1.8-2	Public Assistance, Recipients and Expenditures, 1968-1972 (Department of Social Welfare, Program Support Branch; and Department of Finance, Population Research Division).
Table 3.1.8-3	First Commitments Placed Under Youth Authority Custody, 1964-1972 (Department of Youth Authority, Division of Research and Development).
Table 3.1.8-4	Convictions for Vehicle Code Violations in California, 1960-1974 (Department of Motor Vehicles, Research and Statistics).

3.1 SOCIOECONOMIC PARAMETERS

Data acquisition for the socioeconomic portion of the Environmental Baseline Data Acquisition Study consisted of acquiring access to sources of data banks, contact with governmental and private agencies, and contact with university facilities. A list of agencies contacted in the course of the data acquisition process is presented below. Imperial County was the geographical area of study. Statewide comparative data have been included especially in much of the economic data. The scant data available for the Heber area itself has been included. The current project is based on secondary data sources and relies on no primary survey research.

The social and economic data acquisition portion was constructed within the following contraints. The tabulation and compilation of any on-going socio-economic data base is problematical. The social dynamics of the problem researched, which dictates what is relevant data, cannot be included in tabulation of distributions, population numbers, etc., no matter how detailed. A recapitulation of census or survey data, no matter how diligently collected, may not be accurate. For example, in the U.S. Census, it is estimated that at least 10-15% of the Mexican-American population was left out of the count in Imperial County. There exists a general unreliability of data, which must be accounted for. For example, a crime rate statistic may have increased for a particular city, not because of increase in crime but because of improved methods of reporting and recording criminal acts. Finally, the inconsistencies of various data sets collected at various times for diverse purposes, under the auspices of different government and research agencies are difficult to reconcile. Reconciliation of such diverse data sets is based on the assumption that the data are available for compilation and amenable for integration.

Data Form

A systematic presentation of types of ecological and socioeconomic data (spatially distributed data) can be organized according to (a) areal units; and (b) substantive variables of investigation. The areal unit variable enters into the analysis in two distinct, but not exclusive, forms, either as the sub-areal unit, or as a point statistic such as population density data.

Data has been assembled for geopolitical divisions, such as incorporated cities for census areal units such as enumeration districts, and for service areal units such as school districts. Maps are presented in section 3.1.1 which indicate location of the study area and census divisions. It is suggested that data be collected for other types of social areas if possible. In the on-going compilation of a socioeconomic data base, a taxonomy of areal units could be devised and followed as well.

Organization of Socioeconomic Data Sets Within This Study

It has been possible to organize the data sets presented in this report in the following dimensions:

1. Dominant social and economic categories
2. Areal or spatial divisions, such as governmental jurisdiction and census units
3. Major sources of data
4. Specific social or economic variables
5. Time sequence, with any of the above held constant.

The above represents a pseudo-hierarchy of data presentation in this report. The data have been organized first in dominant social and economic categories, with the other dimensions taking various lesser degrees of precedence in the presentation.

The following explanatory notes may clarify some quantitative aspects of the foregoing organization of data. First, whether the percentage or absolute numbers of the variable is reported depends upon the requirements of the problem. In some cases, relative numbers impart the desired informational picture, for example, in percentage of a racial minority in a city. In others, the absolute number may be more important. For example, the absolute number of school-aged children in an area, or the number of families requiring welfare may be more significant than relative percentages since these numbers alter requirements for facilities and budgets that must accommodate such populations.

A second consideration is that each of the variables listed can be tabulated and analyzed as a variable of change-over-time, provided that data are available for two or more points in time. The construct of analysis would be the rate of increase or decrease of a particular variable, for example, percent population change, change in unemployment rates, or change in income levels. One problem in such longitudinal studies is that in order to assume valid comparisons over time, a constant boundary grid must be maintained for analysis (although in fact they have been altered). For example, the largest city in the county, El Centro, annexed 400 acres in the five-year period, from 1970 to 1975. Methodology for measuring changes in variables over time should encompass the annexation as well as account for a standardized grid for boundary comparability. Compilation for a data base thus should be based on such considerations if measures of change in socioeconomic variables are to be included in subsequent analyses.

A third consideration in compiling a data base for subsequent analyses is that the variable of interest could be a constructed index which is a combination of any number of these variables, for example, an index of socio-economic class or an index of social well-being which is constructed for a composite of weighted variables.

3.1.1 Descriptive Population Characteristics

The demographic data for Imperial County has been mainly compiled from the 1970 U.S. Census. Other sources reveal different figures because of inconsistencies in sampling populations, methods of compiling and intent of the data collection. There exists great diversity even within the presentation of census data in this report. Many of the census tables have been gathered from computer data retrieval runs for specific programs. Several of the tables present identical variables but in different cross-tabulations, and in different formats.

U.S. Census Data

The county was not included in any Standard Metropolitan Statistical Area (SMSA) of the 1970 Census Imperial County is lacking in even some of the most basic data tabulated routinely for any area that was included in a SMSA. Population and housing data for five cities, Brawley, Calexico, El Centro, Holtville and Imperial are enumerated, but only as total counts. Enumeration districts and their relationship to block units are not readily available for either the county or for urban areas. El Centro, the largest city in the county, did not obtain the tabulation of the 1970 Housing Census for the city because of additional costs that it would have required.

Only a small portion of the socioeconomic data from the 1970 Census for enumeration districts has been tabulated in visual form, some of which are presented here, but the completed data set is retrievable by the Lawrence Berkeley Laboratory computer retrieval system. For Imperial County, the first count 1970 Census data for enumeration districts was tabulated, but the computer program for retrieval of this count is not currently in use. The demands for subsequent computer runs by various organizations since the 1970 Census have been for the fourth count census, which contains higher numbers for certain groups, and thereby constitutes a stronger basis of claims for program funded by the federal government. This usage has thus forced the first count retrieval program into osolescence.

Suppression of Data

Absolute numbers in small census divisions which are further divided into classifications are liable to undergo disclosure suppression. Thus the Bureau of Census does not release data when too few individuals are counted in a particular category in order to prevent possible identification of information with individuals. The suppressed data is counted as zero when used in calculations. On some tables of the census an asterisk will appear when a suppression occurred in any number used in the calculation of the item. For example, where a suppression occurred in a total, all percentages calculated from that total will show the suppression asterisk.

Spanish American Population

In 42 states and the District of Columbia, this population is identified in the category "Persons of Spanish Language." In five southwestern states, Arizona, California, Colorado, New Mexico and Texas, this population is identified by "Persons of Spanish Language or Spanish Surname." In the Middle Atlantic States, this population is identified as "Persons of Puerto Rican Birth or Parentage." These categories are not mutually exclusive of other identifying classifications, for example, Spanish American are also counted in the racial categories as White, Black, or Other Races.

3.1.2 General Demographic Characteristics

Data in this section consists mostly of population figures for Imperial County with some raw data on deaths, births, marriages, divorces, vehicle registriation and immigration.

Population projects of the California Department of Finance in June 1974 indicate a range of projections from 1975 to 1985 from 80,000 to approximately 96,000. Because different models for projections are used by different agencies, projections of population may differ greatly especially when extrapolated for several decades into the future.

Population trends in the Imperial County do not necessarily follow the pattern for other counties in the region, nor do they follow national trends, due to the proximity of the United States-Mexican border.

3.1.3 Employment and Income

Average annual employment actually declined in Imperial County between 1960 and 1972. The growth rate has been slow but steady since that period. Tables 3.1.3-1 and 3.1.3-3 give a summary of the total civilian labor force, further divided into non-agricultural wage, salary employment, and agricultural employment. The data from these two tables are not comparable, as the 1960-1972 listings of Table 3.1 are based solely on place of employment while the 1970-1975 series was compared by place of residence for non-agricultural wage and salary employment which represents a much more accurate form of tabulating employment numbers.

The importance of agriculture to Imperial County's economy is shown by the number of workers in the agricultural sector who presently account for more than one fourth of total employment in the county. As a result, employment and unemployment levels within the county are highly correlated with the number of agricultural workers employed. Monthly employment levels are subject to severe fluctuations from the varying agricultural season as shown in Table 3.4. Although demand for the migrant laborer has been reduced considerably with the extensive mechanization of agriculture in the area, migrant farm laborers from Mexico still dominate a large part of the employed workers. Some indication of their conditions and type of work and wage levels is presented in Table 3.1.3-69, the farm labor reports for 1974 and 1975. The only accurate data on the labor force status and its composition is collected from the U.S. Census which forms the major bulk of this section in Tables 3.1.3-10 through 3.1.3-68. The same is characteristic of income statistics for the county. Growth in personal income has been slow historically when compared to the rest of the state. Accurate estimates of personal income are not available only through census surveys. The time series data presented in Table 3.1.3-6 through 3.1.3-9 are California Department of Finance budget Division estimates which are constantly subject to revision and heavily dependent upon the estimates prepared by the National Income Division of the United States Department of Commerce. A conceptual basis of income estimates is essential for using these statistics as they are subject to limitations by the definitions and estimating techniques used to derive them. Particular note should be taken of the fact that income represents receipts before payment of income taxes and certain non-tax charges. Tables 3.1.3-7 and 3.1.3-8 include a per capita income estimate for California and Imperial County based on population estimates prepared specially for the Department of Finance.

3.1.4 Housing

The U.S. Census is the only source of reliable data on housing units in Imperial County. Estimates after 1970 derived by the State Department of Finance are based on interpolations of the census data and some use of construction permits and aare therefore considered to be somewhat unreliable. The 1975 Special Census which includes some information on housing had not been received as of the date for submission of the final report draft. The housing data in the present report includes such variables as the age of the structure, its general condition and available facilities, its value and rent, and number of occupants, all of which serve as important indicators of general welfare among the county's population. However, in order to acquire a reliable and more current data base on housing conditions, it is likely that some type of field survey would be necessary.

3.1.5 Agricultural, Industrial and Commercial

The economy of Imperial County is almost wholly dependent upon agriculture. The county accounted for approximately 20% of Southern California agricultural production in 1974, with record revenues from farm marketing reaching $489.7 million. Table 3.1.5-1 traces the value of agricultural products over a 20-year period. Table 3.1.5-4 indicates the relatively large scale of farming operations. As a result of its dependency upon a primary sector of activity, the economic growth of Imperial County has been slow when compared to the rest of California. The strong surge during the past three years is mostly the result of the advance in livestock and farm commodity prices as Table 3.1.5-5 indicates. A very crude estimate of the revenues made by farmers is attempted in Table 3.1.5-6. The cost estimates were done separately for the month of September while market values are average values for a single year.

Since Imperial County is basically an agricultural region, most of the County's industries are related to farm products. Of the 64 manufacturing firms listed in Table 3.1.5-7 for 1973, only 13 employed more than 20 workers. These firms engage mostly in textiles, fertilizers, food processing and other agriculturally related products.

The lack of substantial investments in the secondary sector is indicated by the figures for new industrial valuation in Table 3.1.5-10. Increased revenues from agricultural products are reflected in retail sale increases for the county as a whole as shown in Table 3.1.5-12. The peak periods are characterized by heavy increases in money spent on farm supplies which form a separate listing in Table 3.1.5-15.

For a better indication of how geothermal development could assist in the economic growth of the county, a more detailed study of the industrial sector is needed, including estimates of the potential for growth within certain industries. Since geothermal energy can be harnessed directly for non-electric use in such ways as textile processing and desalinization plants, both of which have some precedent and demonstrable need in the area, further details of the structures of particular firms and flexibility of rearranging priorities in agricultural production should be made.

3.1.6 Land Use

This section incorporates some aggreage land assessment values and a description of how the land is used in Imperial County. Road maps of the county subdivisions and land use maps which were available for the cities of Brawley, Calexico and Imperial were also included. Because of the predominance of agricultural activity on the county's productive land, Table 3.1.6-5 was added to indicate what crops are grown in the area and how much land each uses. Since different crops can be harvested on the same plot during the space of one year, the totals equal a figure greater than the total area farmable in Table 3.1.6-4.

Land assessment plays a critical part in any evaluation of the effect of a large scale project on county revenues. The data which are lacking and would have to be compiled from the tax assessor's rolls in Imperial County are the number of special districts which encompass the Heber area, their current assessed value, and the tax rate which is levied within each. Whether the area of a geothermal plant falls within the Heber School District or the Calexico Unified School District would make a substantial difference as to who would benefit and what the tax rate would be. Therefore, it is not possible to apply a single tax rate against the total assessed value of the county property shown in Table 3.1.6-1. A study of the tax districts and their rates would have to be carried out before any meaningful consensus could be made on tax benefits.

3.1.7 Education

This section presents data compiled by the Bureau of School Apportionment and the State Assessment Program of the California State Department of Education. Tables 3.1.7-3 and 3.1.7-4 are the most complete sets of school data for Imperial County covering the years 1969-70 and 1974-75. Similar data are available for the intervening period and for some previous years but were not compiled for this report.

The formats for the summary of school district population from the California State Testing Programs have been revised each year. This data should be tabulated in comparable form. For the material presented in this volume a descriptive note is provided as an interpretation of the profile sheets for each table. In addition to comparisons of student achievement in the Imperial Schools, a description of each school is included in the profile with such variables as average daily attendance, assessed valuation of the district and pupil mobility within each school.

3.1.8 Social Services

Compiled under this rubric are tables relating to public health, social insurance, and youth authority wards. There is a noticeable lack of data on religious organizations. Crime rates for the county are difficult to obtain. The absence of any information on the crime rates is because the Department of Corrections tabulates most of its crime data for the counties on the basis of the Adult Probation Subsidy Program, in which Imperial County does not participate. Background factors could also be made available on the wards placed under custody of Youth Authority in Imperial County. As Table 3.1.8-3 indicates, Imperial County has experienced an increase in the number of juvenile delinquencies since the mid-1960's but it is to be noted that absolute numbers on these statistics for Imperial Valley are small.

The Department of Health Statistical Research Division keeps extensive tabulations collected from the various hospitals and other health facilities on their capacity and services available. The department's records, although complete, have not been systematically organized since 1971. Some general statistics are compiled for the counties in California, but were not included as Imperial County comprised such a minimal number in relation to the totals.

Public assistance statistics which indicate a relatively high number of recipients for Imperial County in Table 3.1.8-2 are prepared by the Department of Benefit Payments (formerly, Department of Social Welfare). Further breakdown of the category on the basis of the recipients' status are needed, although the data currently available are also not organized. The 1970 U.S. Census makes some organization of public assistance recipients', which could be obtained through the Department of Benefit Payments' records in any subsequent project.

3.1 SOCIOECONOMIC PARAMETERS

List of Agencies Contacted.

U.S. Agencies

United States Department of Commerce, Bureau of the Census

United States Department of Commerce, Bureau of Economic Analysis

United States Department of Labor, Bureau of Labor Statistics

United States Department of Justice, Immigration and Naturalization Service

United States Environmental Protection Agency, Surveillance and Analyses Division

California State Agencies

California Department of Benefit Payments, Program Support Division

California Department of Corrections, Research Division, Administration Information and Statistics Section

California Department of Education, Bureau of Management

California Department of Education, Bureau of School Apportionments and Reports

California Department of Education, Management Information Center

California Department of Education, State Assessment Program

California Department of Finance, Financial Research Unit

California Department of Finance, Population Research Unit

California Department of Food and Agriculture, Bureau of Statistics

California Department of Health, Center for Health Statistics

California Department of Industrial Relations, Division of Labor Statistics and Research

California Department of Motor Vehicles, Research and Statistics Section

California Department of Youth Authority, Division of Research

California Department of Water Resources

California Employment Development Department, Division of Employment Data and Research

California Employment Development Department, Farm Labor Office

California Employment Development Department, Labor Market Division

California Franchise Tax Board, Research and Statistics

California State Board of Equalization, Statistical Research And Consulting Division

Imperial County and Local Agencies

Heber Public Utilities District, Imperial County

Imperial County Agricultural Commissioner's Office

Imperial County Planning Department

Imperial County Farm Bureau

Imperial County Tax Assessor's Office

Imperial Irrigation District, General Manager's Office

Imperial Irrigation District, Public Information Office

Imperial Valley Development Agency

Other Public and Private Institutions

Bank of America, Public Information Service

Lawrence Berkeley Laboratory, Census Service Division

Southern California Association of Governments, Regional Planning Program

Security Pacific Bank, Economic Research Division

University of California, Berkeley, Institute of Governmental Studies

University of California, Berkeley, Documents Division

University of California, Riverside, Department of Administrative Affairs

University of California, Riverside, Imperial County Agricultural Extension Service

Williams Research Associates, Berkeley

List of References Not Referenced in the Text

American Transit Association, 1975. Papers and Proceedings of Two Energy Crisis Seminars, prepared for American Public Transit Association, Institute for Rapid Transit, and Urban Mass Transportation Administration. National Technical Information Service, U.S. Department of Commerce, February.

Argonne National Laboratories, 1973. Social Costs for Alternate Means of Electrical Power Generation for 1980 and 1990. Prepared for Atomic Energy Commission. National Technical Information Service, U.S. Department of Commerce, March.

Arizona University, 1975. The Impact of Energy Development on Water Resources in Arid Lands, Literature Review and Annotated Bibliography. Prepared for the Office of Water Research and Technology. National Technical Information Service, U.S. Department of Commerce, January.

Backstrom, C.H., and Hursh, G.D., 1963. Survey Research. Evanston, Northwestern University Press.

California State Board of Equalization. Quarterly Reports on Taxable Sales in California. First Quarter, 1970-Second Quarter, 1975.

California State Board of Equalization. Annual Report. 1969-70, 1970-71, 1971-72, 1972-73, 1973-74, (selected tables from unpublished 1974-75 edition).

California State Department of Education. California Public Schools Selected Statistics. 1968-69, 1969-70, 1970-71, 1971-72, 1972-73, 1973-74.

California State Department of Education. Student Achievement in California Schools, Summary of Profiles. 1974-75.

California State Department of Education. Profiles of School District Performance, California State Testing Program. 1968-69, 1969-70, 1970-71, 1971-73.

California State Department of Education. Profiles of School District Performance, California State Testing Program. Imperial County. 1974-75.

California State Department of Education. Profiles of School District Performance, California State Testing Program. A Guide to Interpretation. 1974-75.

California State Department of Education, 1975. Ratios of California Public School Nonteaching Employees to Classroom Teachers As of November 1, 1972, 1973 and 1974. Bureau of School Apportionments and Reports, Sacramento.

California State Department of Education. Private School Directory, 1973.

California State Department of Finance. California Statistical Abstracts, 1961-1975.

California State Department of Finance. Population Projections for California Counties, 1975-2002, Alternative Series D-100, E-0, D-150, E-150 DOF Report 74 P-2, Sacramento, California, June 1974.

California State Department of Public Health. Vital Statistics of California, 1970, 1971.

Catanese, Anthony J., 1972. Scientific Methods of Urban Analyses. Urbana, The University of Illinois Press.

Cockerham, W.C., and Blevins, A.L., Jr., 1975. Land Use and social Change in Jackson Hole. Paper presented at the 70th Annual Meeting of the American Sociological Assocation, August 25-29.

Cole, S., 1973. The Sociological Method. Chicago, The Rand McNally College Publishing Company.

County Supervisors Association of California. County Fact Books, 1966-67.

Cousins, A.N., and Nagpaul, H., 1970. Urban Man and Society: A Reader in Urban Sociology. New York, Alfred A. Knopf.

Davis, J.C., 1973. Statistics and Data Analyses in Geology. New York, John Wiley & Sons, Inc.

De Bell, G., ed., 1970. The Environmental Handbook. New York, Ballantine Books.

Ehrlich, P.R., and Ehrlich, A.H., 1970. Population Resources and Environment: Issues in Human Ecology. San Francisco, W.H. Freeman and Company.

Eisner-Stewart and Associates, 1965. Hot Mineral Spa Area General Plan, Imperial County, California, May.

Employment Development Department, 1975. Area Manpower Review: Annual Labor Market Review-1974 and Manpower Planning Report, Imperial County, California, March.

Employment Development Department. Degree of Service Provided Job Applicants, Monthly Report Table 06. Brawley, Calexico, El Centro. June 30, 1973, June 30, 1975, December 31, 1975.

Employment Development Department, 1975. Imperial County Labor Market Bulletins, April-October.

Employment Development Department, 1975. Labor Supply and Demand, Imperial County, October-December.

Employment Development Department. Semi-Monthly Farm Labor Report. December 29, 1973-January 17, 1976.

Employment Development Department. Monthly Summary of Labor Statistics by Place of Residence, January 1970-May 1975.

Employment Development Department. Monthly Summary of Labor Statistics by Place of Employment. Imperial County, 1960-1972.

Employment Development Department. Summary of Service to Individuals, Monthly Report, Table 91. Brawley, Calexico, El Centro. June 30, 1972-June 30, 1974.

Energy Policy Project of the Ford Foundation, 1974. A Time to Choose: America's Energy Future. Cambridge, Mass., Ballinger Publishing Company.

Energy Policy Project, sponsored by the Ford Foundation. Washington, D.C.

Ficker, V.B. and Graves, H.S., 1971. Social Science and Urban Crisis: Introductory Readings. New York, The Macmillan Company.

Field, A.J., ed., 1971. City and Country in the Third World: Issues in the Modernization of Latin America. Cambridge, Mass., Schenkman Publishing Company.

The Forecast and Analysis Center, 1973. 1973 Report on the State of the County, Working Document No. 1. Orange County, California, November.

The Forecast and Analysis Center, 1974. Report on the State of the County, 1974. Working Document No. 1, Orange County, California, December.

Friedland, W.H. and Thomas, R.J., 1974. Paradoxes of Agricultural Unionism: Society, v.11, no.4, May/June.

Goldscheider, C., 1971. Population, Modernization, and Social Structure. Boston, Little, Brown, and Company.

Gordon, M., 1965. Sick Cities: Psychology and Pathology of American Urban Life. Baltimore, Penguin Books.

Gottlieb, D., 1974. Sociological Dimensions of the Engery Crisis. Final Report for the State of Texas Governor's Energy Advisory Council, December.

Gottlieb, D. and Matre, M., 1975. Conceptions of Energy Shortages and Energy Conserving Behavior. Paper presented at the annual meeting of the American Sociological Association, San Francisco, California, 1975.

Hadden, J.K., Masotti, L.H., and Larson, C.J., 1967. Metropolis in Crisis. Itasca, Illinois, F.E. Peacock Publishers, Inc.

Heer, D.M., 1968. Society and Population. Englewood-Cliffs, New Jersey, Prentice-Hall, Inc.

Hertel, B.R., 1975. Measuring Homogeneity and Stability with the Continuity Correlation Coefficient. Paper presented at the 70th Annual Meeting of the American Sociological Association, August 25-29.

Horn, V., 1975. Geothermal Firm Gets County Approval to Drill 18 East Mesa Exploratory Wells, August 28.

Hunter, Floyd, 1953. Community Power Structure: A Study of Decision Makers. Garden City, New York, Doubleday & Company.

Imperial City Planning, 1970. Demographics.

Imperial City Planning, 1975. Population Data from the 1975 County - DOF Special Census. Synopsis of Unincorporated County Area - ED 30, Brawley County Water District.

Imperial City Planning, 1975. Population Data from the 1975 County - DOF Special Census. Synopsis of Unincorporated County Area - ED 58, Heber.

Imperial City Planning, 1975. Population Data from the 1975 County - DOF Special Census. Synopsis of Unincorporated County Area - ED65B, Seeley County Water District.

Imperial County Agricultural Commissioner's Office. Annual Agricultural Crop Reports. 1955-59, 1961-62, 1971-74.

Imperial County. Community Development Grant Application, Year One.

Imperial County, 1973. Conservation Element, An Element of the Imperial County General Plan, December.

Imperial County. 1975-1976 Migratory Waterfowl Regulations.

Imperial County, 1974. Noise Element, October.

Imperial County, 1973. Open Space Element, An Element of the Imperial County General Plan, August.

Imperial County, 1974. Scenic Highway Element, October.

Imperial County, 1975. Total Civilian Labor Force, Unemployment Rate by Place of Residency, Nonag Wage and Salary Employment by Place of Jobs.

Imperial County, 1973. Ultimate Land Use Plan, June.

Imperial County Department of Public Works, 1971. Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development, Imperial County, May.

Imperial County Planning Department. Population. Published periodically.

Imperial County Technical Assistance Program. Water Treatment and Supply in Heber Public Utility District, July, 1975.

Imperial Irrigation District. Annual Inventory of Areas Receiving Water. Years 1974, 1973, 1972.

Imperial Irrigation District, 1974. Imperial, California Rate Schedules, September.

Imperial Irrigation District. Water and Water Power Facts.

Imperial Valley Development Agency. Economic Profile of Imperial County.

Krumbein, W.C., and Graybill, F.A., 1965. An Introduction to Statistical Models in Geology. New York, McGraw-Hill Book Company.

Leopold, L.B., Clarke, F.E., Hanshaw, B.B., and Balsley, J.R., 1971. A Procedure for Evaluating Environmental Impact. Washington, U.S. Department of the Interior, Geological Survey.

Loewenstein, L.K., ed. 1971. Urban Studies, An Introductory Reader. New York, The Free Press.

MacQueen, D.R., 1973. Understanding Sociology Through Research Reading, Massachusetts.

Maher, E.L., 1975. Consciousness and Decision Making in the Electric Power Industry. Paper presented at the 70th Annual Meeting of the American Sociological Association, August 25-29.

Mesthene, E.G., 1970. Technological Change. New York, Mentor.

National Technical Information Service, 1975. Public Opinion and Sociology of Water Resource Development. 1970-April, 1975. U.S. Department of Commerce.

Nunes, J., IID Eyeing Geothermal Energy Use. The Brawley News, p. 1

Office of the Agricultural Commissioner. Imperial County Agriculture, 1974. Imperial County Board of Supervisors.

Page, A.N. and Seyfried, W.R., 1970. Urban Analysis: Readings in Housing and Urban Development. Glenview, Ill., Scott, Foresman and Co.

Portes, Alejandro, 1974. Return of the Wetback: Society, v.11, no.3, March/April, 1974.

Program Planning Center, 1975. 1974-1975 Report on the State of the County, Working Document No. 3. Orange County, California, June.

Reid, S.T. and Lyon, D.L., 1972. Population Crisis: An Interdisciplinary Perspective. Glenview, Ill., Scott, Foresman and Co.

Rosenbaum, W.A., 1973. The Politics of Environmental Concern. New York, Praeger Publishers.

San Bernardino County, Area VIII, Selected Socio-Economic Characteristics. Community Profile Project, September, 1975.

Schwartz, T.P., 1975. Human Societal Systems in Evolutionary Perspective. Paper presented at the 70th Annual Meeting of the American Sociological Association, August 25-29.

Schwirian, K.P., 1974. Comparative Urban Structure: Studies in the Ecology of Cities. Lexington, Massachusetts, D.C. Heath and Company.

Security Pacific Bank. The Southern California Report: A Study of Growth and Economic Structure, March, 1970.

Security Pacific Bank. Quarterly Economic Report. December, 1975.

Security Pacific Bank. Monthly Summary of Business Conditions in Southern California. June, 1974, December, 1975.

Security Pacific Bank. Monthly Inventory of California Construction Trends. December Issues 1967-1974, November, 1975.

The Southern California Association of Governments, 1975. A Guide to Social Indicators for Local Government, or, How to Improve Your Policy Decisions with Information You Didn't Know You Had, October.

Southern California Association of Governments, 1974. Annual Report.

Southern California Association of Governments, 1974. Appendix to SCAG Development Guide, Growth Forecast Selection. Progress Report 74-1, January.

Southern California Association of Governments, 1975. Proposed SCAG '76 Growing Forecast, or Suggested Revision of SCAG Growth Forecast Policy (June, 1975) as Modified (December, 1975) -- draft.

Southern California Association of Governments. Regional Population, by Counties, 1910-1973. From: Basic Technical Data, Housing and Community Development Program.

Southern California Association of Governments, Regional Cooperation for Regional Problems, 1974. Scag on Energy: A Report to the Executive Committee, preliminary draft, January.

Southern California Association of Governments, 1974. SCAG Development Guide: Growth Forecast Refinement: Progress Report 74-2, October.

Southern California Association of Governments, 1974. Scag Short Range Transportation Plan, April.

Southern California Association of Governments, 1975. Staff Report, Alternative Models for Scag's Involvement in Energy Issues, November.

Southern California Association of Governments, 1975. Staff Report, Alternative Models for Scag's Involvement in Energy Issues, November.

Southern California Association of Governments, 1975. Suggested Revision of Scag Growth Forecast Policy, June.

Sullivan, M., McDougal, St., and Van Huntley, F., 1974. Patterns of Geothermal Lease Acquisition in the Imperial Valley: 1958-1974. University of California, Riverside, August.

Thomas, W.L., Jr., ed., 1956. Man's Role in Changing the Face of the Earth, vol. 1. Chicago, The University of Chicago Press.

Thomas, W.L., Jr., ed., 1956. Man's Role in Changing the Face of the Earth, vol.2. Chicago, The University of Chicago Press.

United States Bureau of the Census, 1970. 1970 Census Users' Guide, Part I., U.S. Department of Commerce, October.

United States Bureau of the Census, 1971. 1970 Census of Housing: General Housing Characteristics, California, Department of Commerce, September.

United States Bureau of the Census, 1972. 1970 Census of Housing: Block Statistics, Selected Areas in California, U.S. Department of Commerce, January.

United States Bureau of the Census, 1971. 1970 Census of Population: General Population Characteristics, California. U.S. Department of Commerce, October.

United States Bureau of the Census, 1971. 1970 Census of Population: Number of Inhabitants, California. U.S. Department of Commerce, September.

United States Bureau of the Census, 1972. 1970 Census of Population: General Social and Economic Characteristics, California. U.S. Department of Commerce, April.

United States Department of Labor. Summary Manpower Indicators from the 1970 Census for Imperial County.

University of California, Riverside. Agricultural Extension Service. Imperial County. Guidelines to Production Costs and Practices, 1974-75, 1975-76.

Wagner, N.N., and Haug, M.H., 1971. Chicanos: Social and Psychological perspectives. St. Louis, the C.V. Mosby Company, 1971.

Walton, J., and Carns, D.E., 1973. Cities in Change: Studies on the Urban Condition. Boston, Allyn and Bacon.

Warren, D.I., and Clifford, D.L. Local Neighborhood Social Structure and Response to the Energy Crisis of 1973-1974. Program in Community Effectiveness, Institute of Labor and Industrial Relations, the University of Michigan, Ann Arbor, Michigan.

Warren, R.L., 1963. The Community In America. Chicago, The Rand McNally & Company.

Wilbur Smith & Associates. Imperial County Subregional Transportation Plan.

Wilson, H.M., 1975. California Set for Geothermal Surge. The Oil and Gas Journal, November 3, p. 32-34.

Wolf, C.P., ed., 1975. Social Impact Assessment. Environment and Behavior, vol.7, no.3, September. Beverly Hills, California, Sage Publications.

3.2 ARCHAEOLOGY

An archaeological evaluation of the probable site area (Primary Area) and the general vicinity (Secondary Area) of a potential geothermal power plant site near the community of Heber in the southern Imperial Valley was undertaken by David D. Smith and Associates, Environmental Consultants, in January-February 1976.

In order to evaluate the archaeological resources of the Primary and Secondary Areas, a) archaeological record searches were requested from pertinent institutions, b) an on-foot archaeological survey covering about 105 acres in the area of the proposed plant was conducted, and c) a vehicular reconnaissance evaluation of the area peripheral to the potential plant site was carried out.

The following sections present a descriptive summary of the a) archaeologic setting of the southern Imperial Valley, b) the procedures used in the archaeological work, c) the field work carried out, and d) results of the field work and institutional record searches.

3.2.1 Archaeologic Setting of the Southern Imperial Valley

From various types of archaeological evidence, it is certain that Early Man crossed the southern portion of Imperial Valley.(1) His cultural remains along the western part of the valley such as in the Yuha Basin, Sweeney Pass, Carrizo Wash, Vallacitos, Truckhaven, and other west valley loci, relate well with those in the Chocolate, Big Maria, and Mule mountains along the Colorado River to the east. Trail remnants on the west and east sides logically connect, although evidence on the valley floor has been obliterated.(2) This absence of evidence is not a result of disruptive activities by historic man, but is from natural burial in the course of aggradation of Colorado River silts as a result of thousands of years of intermittent flooding.

Reliable radiocarbon dating has shown that Yuha Man occupied the southern Imperial Valley at least 21,500 years ago.(3) Although Early Man's subsequent career in the valley is not all that certain, evidence shows that San Dieguito, Amargosan, and Patayan cultures are represented prior to the settling of the later Yuman peoples. In short, there is a rough continuity of cultures from the time of Yuha Man to the recent era.

Some 2,000 years ago, the Yuman group apparently began a penetration across the valley eastward prior to the formation of Lake Cahuilla (also termed the Blake Sea and the LeConte Sea by various authorities).[4] At about that time, the Colorado River diverted its southerly course away from the delta in the Gulf of California and, instead, drained into the Imperial Valley. As a result of this diversion, Lake Cahuilla reached a high point of 42 feet above sea level at about 200 A.D. This enormous body of fresh water covered the land from north of Indio to south of Mexicali, and from Fish Creek Mountains on the west to the East Mesa on the opposite side of the valley.[5]

Although this impressive lake divided the Yuman people, cultural exchange continued. The Kumeyaay on the west side received such innovations as projectile points and ceramics from the east side, both in use about 1,000 A.D. More significant was the introduction of incipient horticulture, the economic base of all sedentary societies in the Greater Southwest.[6][7][8]

Probably in the late 15th centruy, the Colorado River resumed its former southerly course to the Gulf, and Cahuilla Lake began to dry up. The Kumeyaay followed the receding waters until, perhaps in the early 18th century, the desert had fully reclaimed the valley. Even then, however, during some summer floods, the Colorado would overflow into distributory channels through the valley, forming ponds in low basis. These drainways, which in time became the New and the Alamo rivers, enabled the Kumeyaay to maintain a diminished horticultural economy to supplement their hunting and gathering on the desert floor and in the Peninsular Range. In 1854, the first government surveyors in the valley inventoried some 75 garden plots in cultivation along the channels.[9] Two of these were situated somewhat outside the southwest corner of the project's Secondary Area. It is only along these channel banks, then, that one would expect to encounter evidence today that an aboriginal people once inhabited Imperial Valley. Deposition of river silts and intensive modern agriculture have erased other traces.

To reconstruct the material culture of these prehistoric people, one must examine areas other than the valley floor; for example, areas above the 40 foot beach line of ancient Lake Cahuilla. Here, on both sides of the valley, but particularly along the west side, are the archaeological resources which provide the basis for understanding these peoples.

Although not enough is yet known to recount satisfactorily the prehistory of the Yuman in southern Imperial County, it does appear that these people utilized various types of ecosystems. For example, trails link "urban centers" in the Peninsular Range to the west with temporary encampments on the desert floor, indicating that the Kumeyaay divided their year between mountain and desert ecological zones. As seasons turned, the Kumeyaay moved in small bands from one productive zone to another, assuring themselves of a nearly constant food supply the year around. The mountains, the floor, the lake all had various foods which the Indians hunted, gathered, fished, dug and harvested. Except for the Cahuilla peoples to the immediate north, other California tribes did not share this trait of multi-environmental adjustment.

Imperial Valley was dry in 1774 when De Anza made his first crossing, and he encountered few Indians on this leg of his famed trek. With the lake gone, the natives moved onto the desert floor less frequently and for shorter periods. What attracted them at all were their quarries of prophyry, hematite, and clay; gathering seeds in the spring; summer planting; harvesting mesquite beans in early fall; and meeting with other Yumans across the valley and along the Lower Colorado River.[10]

Although nature compelled the Kumeyaay to adjust to environmental changes, they apparently succeeded with the aid of cultural interchanges with eastern groups. They were little influenced by the Spanish and Mexican periods, but with the coming of the Americans they met their greatest challenge, to which they have not yet fully adapted.[11][12]

Concerning the relative abundance and importance of archaeological sites in southern Imperial County, the following generalizations can be made. As to abundance, when the U.S. Government surveyors visited the area in 1854, they recorded only 75 existing Indian sites on the floor of the valley; all these were along the New and Alamo rivers. By contrast, in the area between the 20 foot and 40 foot beach lines of old Lake Cahuilla, at least 500 archaeological sites are now known to be present. Typically, these represent seasonal use areas, temporary camps, and cremation sites.

The sites on the valley floor are probably not more than a few hundred years old at most; older sites, if present, would have been buried by silt deposition from the Colorado. For this reason, the valley floor sites are judged to be of considerably less archaeological importance than the older sites along and above the 20 foot beach line.

3.2.2 Methodology

The objective of the work was to determine whether or not archaeologoical resources are present within the Primary and Secondary areas and, if present, to define the nature, extent, and archaeological significance of these resources. In order to arrive at such a determination, the investigative team arranged for and carried out:

1) a record search of archaeological archives to determine the location and type of known sites in the general area;
2) an on-foot survey to determine the presence or absence of archaeological resources within the Primary Area;
3) a vehicular reconnaissance to ascertain whether unknown sites are likely to be present within the Secondary Area.

Record Searches. Prior to entering the field, record searches were requested from four southern California institutions: the Archaeological Research Unit, University of California, Riverside; San Diego Museum of Man; Department of Anthropology, San Diego State University; and Imperial Valley College Museum. In addition, area property owners and tenants were queried as to their knowledge of the presence of archaeological materials.

On-Foot Survey. To determine the presence or absence of archaeological resources within the 640 acre Primary Area, an on-foot field survey using two teams of two archaeological surveyors each was planned and carried out; details are discussed in the following section on Field Work.

Vehicular Reconnaissance. In order to ascertain whether or not archaeological resources were likely to be present within the overall 12 square mile area of interest for the facility, a vehicular reconnaissance by car of farm roads and ditch banks was planned and carried out. See details in following section.

The field survey team kept three sets of records during the investigation: 1) notations on maps of various terrain features and the survey routes the team followed; b) field notes in bound record books; and c) photographs to illustrate the character of the areas examined.

3.2.3 Field Investigations

Background. Except in the extreme southwest corner of the study area, through which the New River flows, the entire 12 square mile parcel is currently under intensive cultivation. For at least thirty years the area has been deep-plowed to depths of four to six feet. In addition, an extensive system of irrigation canals, drains, and ditches has been constructed; the elements of this system subdivide the area at not greater than quarter section intervals. Further, all cultivated lots have had a network of deep tile drains installed; these drainage lines are placed on centers of a hundred feet or less at depths of 9 to 12 feet. In short, the study area is intensely disturbed to considerable depth by man's activities and, as a result, the probability of archaeological resources being present was considered low.

Vehicular Reconnaissance. In ascertaining whether or not previously unrecorded archaeological sites are present within the approximately 12 square mile Secondary Area (Figure 3.2-1), the investigative team carried out a vehicular reconnaissance. In the course of this reconnaissance along roads and ditch banks, the overall study area was traversed several times; the vehicular traverses totaled more than 16 miles. The team did not note any indications of the presence of archaeological materials in the course of the vehicular reconnaissance of the Secondary Area.

Because of its less disturbed nature, the area along the upper banks of the New River was the only portion of the Secondary Area in which there was a moderate probability that archaeological resources might be present. Previous surveys by Imperial Valley College Museum, however, had not located any sites along this sector of the river, and further on-foot field work by the present team did not reveal any archaeological sites.

On-Foot Surveys. The one square mile Primary Area (i.e. east half of Section 32 and west half of Section 33) was investigated by detailed on-foot surveys. The four members of the survey team walked over extensive portions of the west half of Section 33 and selected representative portions of the east half of Section 33 and selected representative portions of the east half of Section 32. With team members deployed about 65 to 70 feet apart, each member was responsible for an eye scan of about 35 feet to either side of his designated line. Thus, the team had a sweepwidth of about 280 feet. As the team progressed, each member would investigate any unusual item or feature to which his attention was drawn. At the end of a walked sector, the team would move laterally to another, and proceed in the same fashion back to the line or origin.

In this manner, the team members made a detailed on-foot examination of about 70 acres of the 160 acre portion of the Primary Area bracketing the Knowlin No. 1 well site in Section 33 (see Figure 3.2-1). Note also on Figure 3.2-1 that the northern and southern 80 acre parcels of the west half of Section 33 were inaccessible to the survey party. One 80 acre parcel was under irrigation; the other was occupied by a large band of sheep which would have been seriously disturbed by entrance of the survey party.

In the adjoining (east) half of Section 32, the survey team examined slightly more than 35 acres in detail. Extenisve portions of this half section were also under flood irrigation and therefore inaccessible. The 35 acres examined are judged to constitute an effective representative sample of the balance of this half section.

3.2.4 Results of Field and Record Investigations

Field Work. During the vehicular examination of the Secondary Area, no archaeological resources were located. Further, the examination satisfied the survey team that, had such resources existed in prehistoric time, extensive agricultural use and other developments would have subsequently obliterated all evidence thereof.

During the detailed on-foot survey of the Primary Area, although each member encountered scattered remnants of recent historic materials such as broken glass, beer can lids, broken tile, pieces of pipe, and the like, no archaeological materials were noted. In short, based on the results of the detailed surveys, the Primary Area is judged to be devoid of archaeological materials.

Record Searches. The results of the record searches by the four institutions contacted reveal that Imperial Valley College Museum (IVCM) maintains the most complete archaeological file available on Imperial County. In addition to its own records, IVCM has copies of pertinent records held at San Diego State University; San Diego Museum of Man; San Bernardino County Museum; University of California, Riverside; Desert Museum of Palm Springs; University of Nevada, Las Vegas; Northern Arizona State University; Northern Arizona Museum; University of Arizona, Tempe and Tucson; and Colorado River Indian Tribes Museum. In addition, IVCM is a State and Federal repository which generally ensures that the Museum will receive pertinent archaeological data from individuals, government agencies, and various institutions. Further, IVCM has a complete set of U.S. Government

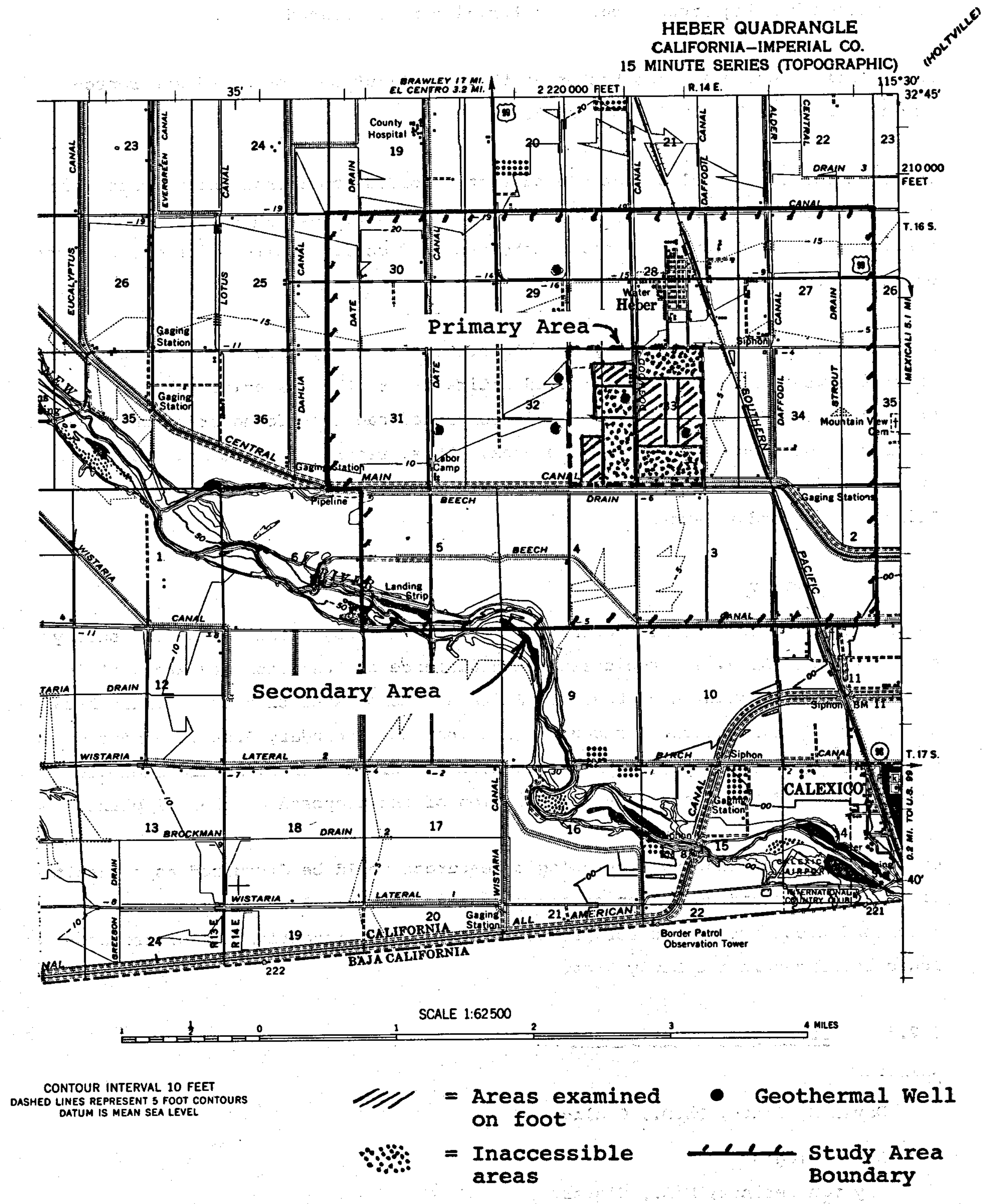


Figure 3.2-1 Location of Primary and Secondary Areas, and areas examined on foot

Surveyors' records, begun in 1854, and other relevant primary sources from which information bearing archaeological material can be gleaned.

The negative responses from the other three institutions contacted are reproduced as Figures 3.2-2, 3.2-3, and 3.2-4.

The IVCM records revealed that the nearest recorded aboriginal encampments were along the New River, in R14E, T18S, Sections 6 and 9, both just outside the perimeter of the Secondary Area. There are no records of sites with the Primary or Secondary study areas.

Further, several property owners or tenants in the Study Area were contacted to determine whether they had ever noted artifacts or other materials while working their fields. None of the individuals contacted had ever found or known of the occurrence of such materials in the area. Thus, record searches and oral inquiries failed to provide evidence of any archaeological site within the Primary or Secondary areas.

3.2.5 Summary

On the basis of the record searches, personal contacts, detailed on-foot surveys of the Primary Area, and vehicular reconnaissance of the Secondary Area, it is the professional opinion of David D. Smith and Associates that the Primary Area is devoid of archaeological resources and that the Secondary Area is almost certainly equally lacking in archaeological resources. Thus, no archaeologic resources would be affected by construction of the proposed geothermal plant.

Owing to the fact that no archaeologic resources would be disturbed as a result of construction and operation of the potential geothermal development, no recommendations are needed for protection or further investigation of archaeologic resources in the Study Area.

3.2.6 Principal Investigators

Principal

David D. Smith, Ph.D., Geology

Lead Archaeologist

Jay von Werlhof, M.A., History
Imperial Valley College Museum

Assistant Archaeologist

Sherilee von Werlhof, A.A., Anthropology

Imperial Valley College Museum

Assistant Archaeologist

Stanley R. Berryman, B.A., Anthropology

SAN DIEGO MUSEUM OF MAN
An educational, non-profit corporation founded in 1915, collecting for posterity and displaying the life and history of man.

January 7, 1976

Ref.: DDS&A 75-445

David D. Smith
David D. Smith and Associates
P.O. Box 929-E
San Diego, California 92109

Dear Dr. Smith:

I am writing with reference to your request of January 5 regarding an archaeological site files record search for the vicinity of Heber in Imperial County.

Although we have site records for Imperial County, these records are not presently mapped. All Imperial County sites from our files have been filed with the Imperial Valley College Museum in El Centro. In a telephone conversation with Jay von Werlhof of IVCM earlier today, he indicated that you had already been in touch with them regarding archaeological information pertaining to the Heber project.

This letter will confirm our telephone conversation of this afternoon. If any San Diego Museum of Man sites are located in the vicinity of the Heber project, they will be included in information you obtain from Imperial Valley College Museum. A separate report from us is not necessary for this project.

Sincerely,

Ken

Ken Hedges
Curator

UNIVERSITY OF CALIFORNIA, RIVERSIDE

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

DRY LANDS RESEARCH INSTITUTE
ARCHAEOLOGICAL RESEARCH UNIT

RIVERSIDE, CALIFORNIA 92502

January 8, 1976

Dr. David D. Smith
David D. Smith and Associates
Box 929-E
San Diego, CA. 92109

Dear Dr. Smith

The Archaeological Research Unit does not maintain site records for Imperial County. We have sites recorded for this County but our data are not the most complete. Imperial Valley College Museum assigns site numbers for this county and therefore have the most complete listing of archaeological resources.

You should address inquires to Jay von Werlhof, Imperial Valley College Museum, 442 Main Street, El Centro, CA. 92243.

Sincerely,

N. Nelson Leonard, III
Chief Archaeologist

cc. von Werlhof

January 21, 1976

Dr. David D. Smith, Ph.D.
President
David D. Smith and Associates
Box 929-E
San Diego, CA. 92109

Dear Dr. Smith,

I am returning the materials which you furnished us with for a record search of the 7,296 acres located on the Heber USGS Quadrangle. Our records do not cover this area, being more or less restricted to the San Diego City and County area, and those fringe regions incidentally covered on maps which also include San Diego County. We do have some records of a few locations in the Imperial County region, but these are incomplete and do not reflect an organized recording system. Rather, they are the result of reporting by interested private parties in the past. Therefore, we are not able to do this particular search for you, and it would probably be better in future to request our services only for projects which would be included in our recording system. I am sorry we could not be of more help to you.

Sincerely,

David C. Hanna, Jr.
Lab Tech: SDSU Anthro.

REFERENCES - Archaeology

1. Rogers, M., Ancient Hunters of the Far West, Copley Press, San Diego, Ca., 1966.

2. Davis, J., "Trade Routes and Economic Exchange Among the Indians of California," University of California Archaeological Survey Reports 54 (1961).

3. Childers, M., Preliminary Report on the Yuha Burial, Imperial Valley College Museum, El Centro, Ca., 1973.

4. Hedges, K., "Hakataya Figurines from Southern California," Pacific Coast Archaeological Society Quarterly 9:3, pp. 1-40, (1972).

5. MacDougal, D. T., et al., The Salton Sea, The Carnegie Institution of Washington, Washington, D.C., (1914).

6. Gifford, E. W., "The Kamia of Imperial County, California," University of California Publications in Archaeology and Ethnology 23:1, (1923).

7. Forde, C. D., "Ethnography of the Yuma Indians," University of California Publications in American Archaeology and Ethnology 28:4, (1929).

8. Kroeber, A.L., Handbook of the California Indians, California Book Company, Ltd., Berkeley, Ca., 1953.

9. U.S. Government Surveyors Notes, Imperial Valley College Museum, Archival Records, microfilm.

10. Moriarty, J., "The Environmental Variations of the Yuman Culture Area of Southern California," Quarterly Bulletin of the Anthropological Association of Canada 1:6:2, 2:6:3, pp. 2-20, 9-23, (1968).

11. Forbes, J. D., Warriors of the Colorado: The Yumans of the Quechan Nation and Their Neighbors, University of Oklahoma Press, Norma, Ok., 1965.

12. Forbes, J. D. , Native Americans of California and Nevada, A Handbook, Naturegraph Publishers, Heraldsburg, Ca., 1968.

3.3 HISTORICAL SITES

An assessment has been conducted of the potential for the occurrence of historical resources at the potential geothermal plant site near the community of Heber in the southern Imperial Valley. The evaluation of the Heber area included an examination of pertinent institutional records, review of local and regional historical literature, and contact with appropriate sources of historic information.

3.3.1 Sources Examined

Included in the records searched were the National Register of Historic Places; the National Registry of Natural Landmarks; California Inventory of Historic Features; and the Imperial Valley College Museum's map of local archaeological resources.

Literature reviewed included standard works in regional history; and published works concerning local history.

Also included in the research on this topic were interviews with leaders in the local historical society and in the researching of local history. Mr. Richard E. Pollock, who is coordinating the compilation of historical resources of local importance with the California State Historical Preservation Section, was contacted regarding recent suggested inclusions, as was Mr. William Sidell of the State Historical Preservation Section.

Other sources are cited in the previous sections of this report, and are listed in the References section.

3.3.2 Summary

This assessment found no historical resources that would be affected in any way by the location of a geothermal facility in the primary study area near Heber. Within the secondary study area there are two sites of importance: the agricultural college building (Figure 3.3-1 and 3.3-2) and the immigrant trail site at New River. The immigrant trail along with all traces of indigenous occupation was destroyed in the 1905-1907 flood. While excavations are not complete, the remains of an adobe structure, located some eight and one half miles northwest of Heber have been identified as a Mexican fort completed in early 1826.[19] Because it represents the first known attempt by non-native Americans to settle

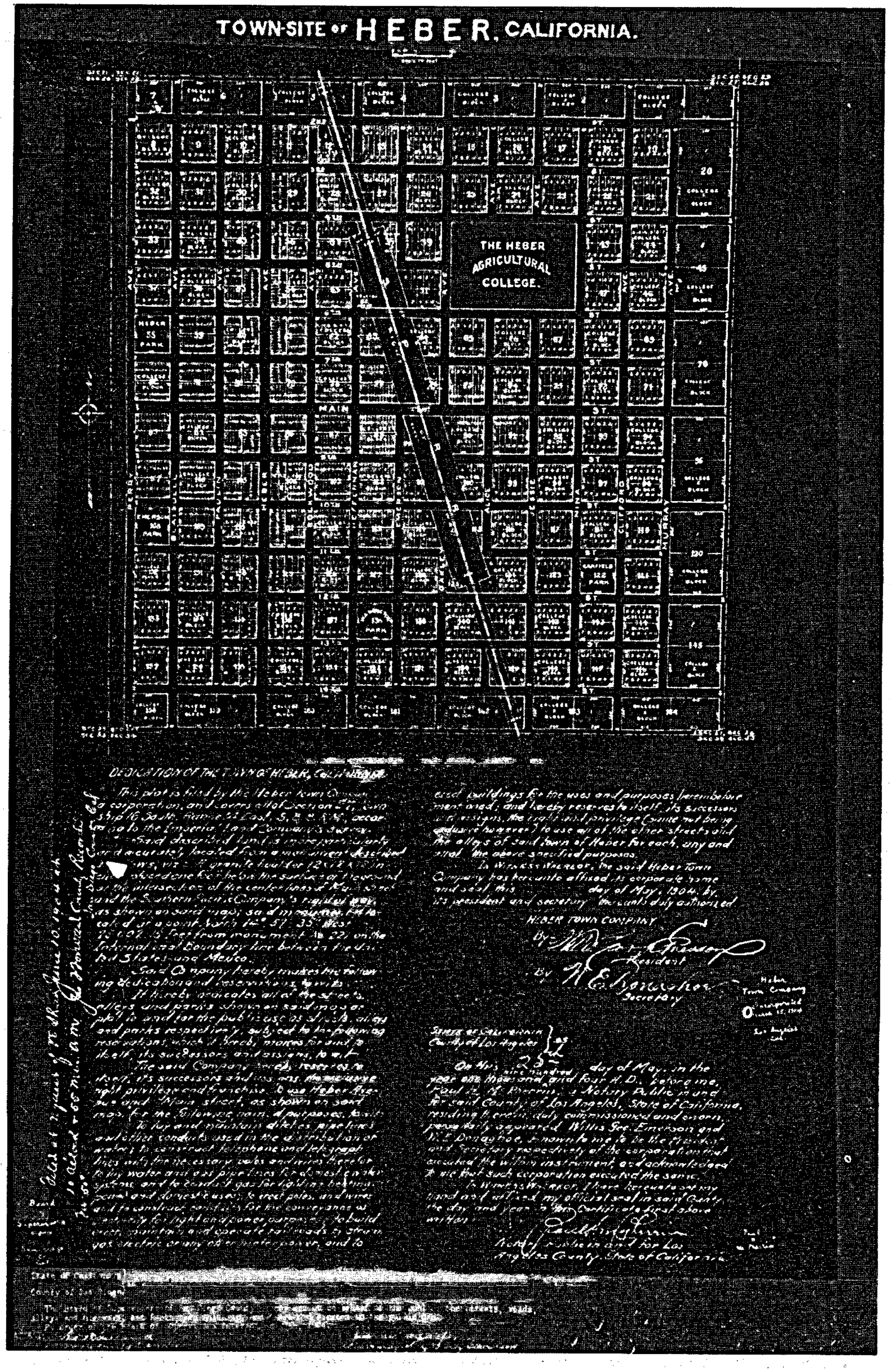


Figure 3.3-1 Plan of Heber Town-Site

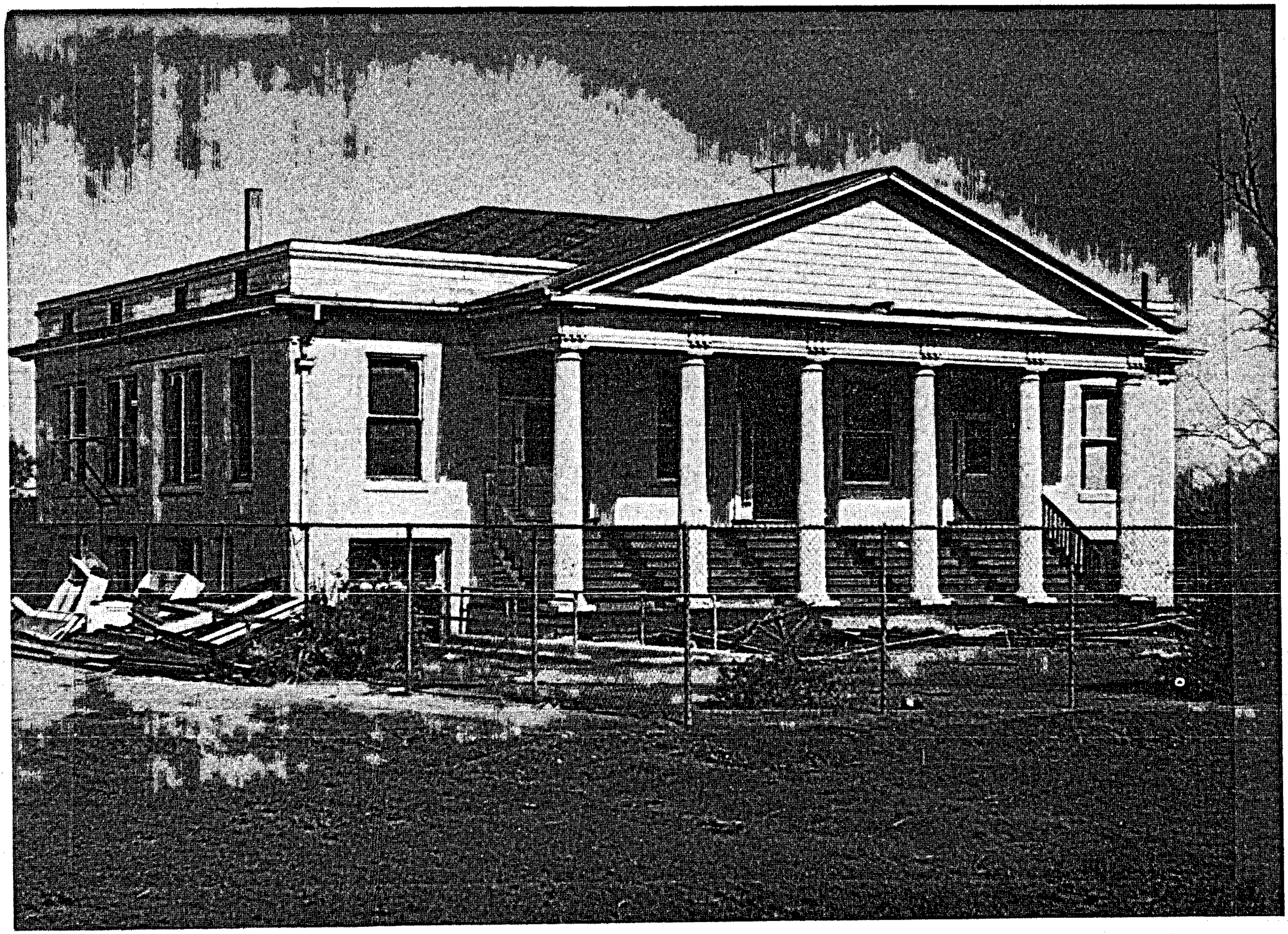


Figure 3.3-2 Heber agricultural college, January 1976

the Imperial Valley, it is an important historical resource. Its location however, is well out of the study area.

3.3.3 Principal Investigators

Principal. David D. Smith, Ph.D., Geology

Historian. John L. Polich, Ph.D., History

REFERENCES - Historical Sites

1. Bolton, H. E., Coronado Knight of Pueblo and Plains, University of New Mexico Press, Albuquerque, N.M., 1949, p. 168.

2. Ibid.

3. Ibid, pp. 161-162.

4. Gifford, E. W., "The Kamia of Imperial Valley," Bureau of American Ethnology 97, (1931).

5. de Vaca, A. N. C., Naufragios y Comentarios, Espasa-Calpe, Madrid, 1957.

6. Bolton, H. E., Coronado Knight of Pueblo and Plains, University of New Mexico Press, Albuquerque, N.M., 1949, p. 174.

7. Forbes, J. D., "Melchoior Diaz and the Discovery of Alta California," Pacific Historical Review 27:4, (1958).

8. Forbes, J. D., Warriors of the Colorado: The Yumans of the Quechan National and Their Neighbors, University of Oklahoma Press, Norman, Ok., 1965, p. 93.

9. Bolton, H.E., Anza's California Expeditions, v. 1, Russell and Russell, New York, 1966, facing p. 120.

10. Bolton, H.E., Coronado Knight of Pueblo and Plains, v. 2, University of New Mexico Press, Albuquerque, N.M., 1949.

11. Ibid.

12. Priestley, H. I., The Colorado River Campaign 1781-1782; Diary of Pedro Fages, University of California Press, Berkeley, Ca. 1913, p. 91.

13. Ibid., pp. 71-72.

14. Hafen, L. R. and Hafen, A., Old Spanish Trail, Arthur H. Clark, Glendale, Ca., 1954.

15. Foster, S. C., "A Sketch of Some of the Earliest Kentucky Pioneers of Los Angeles," Historical Society of Southern California Quarterly 1:3, (1888-1889).

16. Pattie, J. O., Personal Narrative, Thwaites, R. G., ed., AMS Press, New York, 1966.

17. Northrop, E. V., "Authentic Location of Butterfield Overland Stage Trail," The Valley Imperial 1, pp. 43-46, (1956).

18. Forbes, J. D., Warriors of the Colorado: The Yumans of the Quechan Nation and Their Neighbors, University of Oklahoma Press, Norman, Ok., 1965, p. 247ff.

19. Imperial Valley College Museum, Newsletter 3:7, October 1975, p. 1.2ff.

20. Pattie, J. O., Personal Narrative, Thwaites, R. G., ed., AMS Press, New York, 1966, pp. 211-219.