State of California

The Resources Agency
Department of Conservation
Division of Mines and Geology
801 K Street, MS 08-38
Sacramento, CA 95814-3531

Les Youngs
Geologist/Geophysicist
R.G. 3803, G.P. 902

Tel: 916.322.8078
FAX: 916.324.1396
CALNET: 8.492.8078
E-mail: lyoungs@consrv.ca.gov

CALIFORNIA LOW-TEMPERATURE GEOTHERMAL RESOURCES UPDATE – 1993

1994

This was an "Unpublished Report"

L. Youngs

DEPARTMENT OF CONSERVATION

DIVISION OF MINES AND GEOLOGY

This work was performed under Contract No. 1092-023(R) for the Low-Temperature Geothermal Resources and Technology Transfer Program with the State of Oregon by and through the State Board of Higher Education on behalf of Oregon Institute of Technology, Geo-Heat Center.

ACKNOWLEDGEMENT

This work was supported, in whole or in part, by the U.S. Department of Energy, via a contract with the Idaho National Engineering Laboratory. The subcontract Number is C92-120253. Such support does not constitute an endorsement by the U.S. Department of Energy of the views expressed in this publication.

CALIFORNIA LOW-TEMPERATURE GEOTHERMAL RESOURCES UPDATE - 1993

1994

By Leslie G. Youngs

STATE OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CALIFORNIA LOW-TEMPERATURE GEOTHERMAL RESOURCES UPDATE - 1993

INTRODUCTION

Current Program

The U.S. Department of Energy - Geothermal Division (DOE/GD) recently sponsored the Low-Temperature Geothermal Resources and Technology Transfer Program to bring the inventory of the nation's low- and moderate-temperature geothermal resources up to date and to encourage development of the resources. The Oregon Institute of Technology, Geo-Heat Center (OIT/GHC) and the University of Utah Research Institute (UURI) established subcontracts and coordinated the project with the state resource teams from the western states that participated in the program. The California Department of Conservation, Division of Mines and Geology (DMG) entered into contract numbered 1092-023(R) with the OIT/GHC to provide the California data for the program. This report is submitted in fulfillment of that contract.

A major goal of the Low-Temperature Geothermal Resources and Technology Transfer Program was to update and compile a database of thermal springs and wells that are in the temperature range of 20°C to 150°C for each state. The databases were to be designed for use on personal computers and have the capability of being accessed and managed using readily available commercial spreadsheet or data management software. A statewide map showing the geothermal resources was to be computer generated utilizing the new databases. A second important goal of the contract was to complete a statewide collocation study of these geothermal resources with communities and other potential users. Demographic and geothermal data were to be provided for communities located within 8 kilometers of known resources having a temperature of at least 50°C.

Background

The statewide database of low-temperature geothermal resources in California has not been updated for over a decade. In 1980, DMG produced the "Geothermal Resources Map of California" (Higgins and Martin, 1980). The map depicted low-temperature resource locations including wells and springs. Subsequently, DMG published the "Technical Map of the Geothermal Resources of California" (Majmundar, 1983) that presented water chemistry data coded on the map as well as water chemistry tables presented in an accompanying text (Majmundar, 1984). The data developed at that time was readily shared between the U.S. Geological Survey (USGS) and DMG. The USGS incorporated or updated the data into their GEOTHERM (Bliss, 1983) main-frame computer database of geothermal information for their Geothermal Research Program. The GEOTHERM file was abandoned in 1983.

DMG's "Technical Map of the Geothermal Resources of California" and the accompanying text containing the water chemistry data, are out-of-print. There is a small reserve of the "Geothermal Resources Map of California" (Higgins and Martin, 1980) available from DMG only as a flat rolled map.

Access to that original compiled geothermal water chemistry data became difficult. The new Low-Temperature Geothermal Resources and Technology Transfer Program has provided a new update and convenient access to the low-temperature geothermal data of California.

DATA SOURCES

The USGS GEOTHERM file and DMG data compiled for the California statewide geothermal resource maps were used as the base for the new compilation. DMG has published many detailed resource assessment reports on the low-temperature geothermal systems in California (see Bibliography). These reports were primarily funded by the DOE's State-Coupled Resource Assessment Program of the late 1970's - early 1980's. These reports provided much new data that have been incorporated into the newly compiled database. Files of The Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR) and files at the California Energy Commission contain valuable data on low-temperature geothermal wells drilled in California over the past 10 years. These files provided additional data for the new database. Some new information on geothermal resources in California was found in mineral and water resource investigations, technical reports, and other publications of the USGS as well as journal articles. A notable source of geothermal data is the transactions of the Geothermal Resources Council. As a result of reviewing the literature and searching older geothermal databases, we were able to compile a 200-entry bibliography of low-temperature geothermal data sources of California. The bibliography is at the end of this report. The bibliography should be of aid to those geothermal researchers requiring more detailed information about the geothermal systems of California than can be interpreted from the newly compiled computer database. The bibliography includes all of the source references for the data listed in the new database.

In addition to the above data sources, we accessed and searched two nationally maintained water quality databases for pertinent data relating to geothermal resources in California. The databases are the U.S. Environmental Protection Agency (EPA) STORET water quality information system and the USGS Water Resources Division WATSTORE (National Water Data Storage and Retrieval System) water information system. We determined that the two databases contain a large amount of duplicate data. We applied tests to selected STORET and WATSTORE files for completeness of data, consistency of repeated data measurements, whether or not the data indicated a geothermal origin, plausibility of data, and for duplicate records that may have previously been entered into our newly compiled database. As a result of these tests we selected only a few new records from these files that could be reliably incorporated into the new DMG database without carrying out major field checking. The selected data on geothermal springs and wells in California from all data sources were entered manually from a keyboard into a LOTUS 123 spreadsheet on a personal computer. All of the computer records were visually checked with the original sources for accuracy and completeness. A variety of computer sorting, selection, and comparison routines were employed to arrange and edit the new database.

Because the emphasis of this new database is to show the statewide distribution of low- to moderate-temperature geothermal resources and because of proprietary restrictions, many commercial high-temperature well data were generally not entered into the database. However, a few representative wells especially in the designated California Known Geothermal Resource Areas (K.G.R.A.) were entered into the database. The new DMG California low-temperature database contains 989 entries of thermal springs and wells. That is 354 locations more than the early 1980's DMG inventory of California's low-temperature geothermal resources.

DATA FORMAT

State Database

The new California low-temperature geothermal resources database was designed to be readily accessible and maintained on personal computers. The general format of the database was devised at a meeting of the State Team Principal Investigators in Salt Lake City, July 8, 1993.

The source data were entered into a LOTUS 123 spreadsheet containing 35 data fields. The field names; general description of their contents; and explanation of codes used to represent type, status, and use of the thermal springs and wells are listed below:

Field Name	Description
ID#	- Identification number assigned to each well or spring for this report.
SOURCE NAME	- Name of spring, well owner, or other identification.

TYPE	- Springs: SP Wells: SW - well drilled to control spring flow. WW - water well. NLT - noncommercial low-temperature. TG - temperature gradient. INJ - injection well. OIL - petroleum well. X - type not confirmed, but most appear to be high-temperature exploration wells.
PLOT	- Location is plotted on the statewide map: Y = yes. N = no.
LAT	- Latitude in decimal degrees.
LONG	- Longitude in decimal degrees.
CO.	- California county three letter code. County codes are shown in Appendix A at the end of this report.
AREA	- Community or local region where spring or well is located.
HTEMP (°C)	- Highest recorded temperature found in data sources in degrees Celsius. This field does not appear in the Tables in the text.
TEMP (°C)	- Temperature in degrees Celsius. W-warm, H-hot.
DEPTH (m)	- Well depth in meters.
DRILL DATE	- Year well was drilled. This field does not appear in the Tables in the text.
FLOW (L/min)	- Flow rate in liters per minute.
STATUS	- Operating status: F - flowing. P - pumped. I - idle. A - abandoned. D - dried up. H - heat exchanger in well.

USE	- Use of the resource: A - augmenting water supply. B - direct use in baths/pools. C - space heating. D - district heating. E - irrigation. F - fish farming (aquaculture). G - greenhouse applications. H - heat exchanger in use. I - idle, abandoned, or undeveloped. J - bottled water.
DATE	- Date of data.
pH	- The pH of fluid in pH units.
CONDUCT	- Conductance as micromhos per centimeter.
Na - As	- Concentrations of the major cations and anions as milligrams per liter (Mg/L).
TDSm	- Total dissolved solids measured (Mg/L).
TDSc	- Total dissolved solids calculated (Mg/L).
REFERENCE	- Source of data.
PAGE(s)	- Page reference in source of data.

The database entries were organized alphabetically by county (the CO. field). The county name is represented in the database with a standard three letter code that is defined in Appendix A. A secondary grouping of the database organizes the spring and well locations in each county by the AREA field. The AREA field contains the name of a California community or local region where each spring or well is located. After the database organization was completed a sequentially increasing identification number (ID# field) was assigned from top to bottom of the list of entries. The identification numbers are used to identify the locations plotted on Plate 1. The identification number is unique to this database and may be changed in subsequent updates to the database.

Users of the database can select a great variety of search and sort parameters using standard personal computer database management software to choose those records of interest from the database. Plot files to produce computer generated maps of selected data can be made utilizing the latitude and longitude coordinates in the database.

The complete database computer file is on the enclosed 3 1/2 inch diskette. The LOTUS 123 spreadsheet file and extension name is CALHOT.WK1. Also on the diskette is a file of the database in ASCII format labeled CALHOT.PRN. The database as hard copy is organized in Tables 1, 2, and 3 at the end of the text. Table 1 contains location data, descriptive data, and physical parameters of the thermal springs and wells. Table 2 contains the data that relate to water chemistry. Table 3 repeats some data that are in Table 1, but it primarily lists the source reference from which the data were obtained. The references are listed in the abbreviated form (author(s), date) and can be related to the complete reference in the bibliography at the end of this report.

State Map

A computer plot showing the locations of California's low-temperature geothermal springs and wells was generated utilizing the data organized in the database (Plate 1). The map is at the scale 1:1,000,000. An explanation of the plot symbols is included on the map. A reduced version of the map is shown in Figure 1. The new database contains more entries of known geothermal wells than are plotted on the map. Because the emphasis of the map is to show low-temperature resources, in areas where there are many known high-temperature (greater than 150° C) geothermal wells, especially within the K.G.R.A.'s, only a representative few have been plotted. Similarly, in areas where there are many known low- to moderate-temperature thermal wells only a few have been plotted for map clarity. Therefore, since some of the geothermal well locations in the database have not been plotted on the map, not all of the identification numbers in the database appear on the map.

The spring and well locations are given in coordinates of latitude and longitude. The location coordinates have been transcribed from a variety of published and unpublished sources. Some have been digitized from USGS topographic maps during the new database compilation. And some are derived by converting from the California well locating system of Township, Range, Section, and Subsection. The location information has been edited, but not all locations have been verified in the field. Therefore, the accuracy of some of the location coordinates may not meet some database user's requirements.

Known Geothermal Resource Areas (K.G.R.A.)

The previous DMG geothermal resources of California maps (Higgins and Martin, 1980; Majmundar, 1983) show the locations of California's K.G.R.A.'s that were designated by the U.S. Bureau

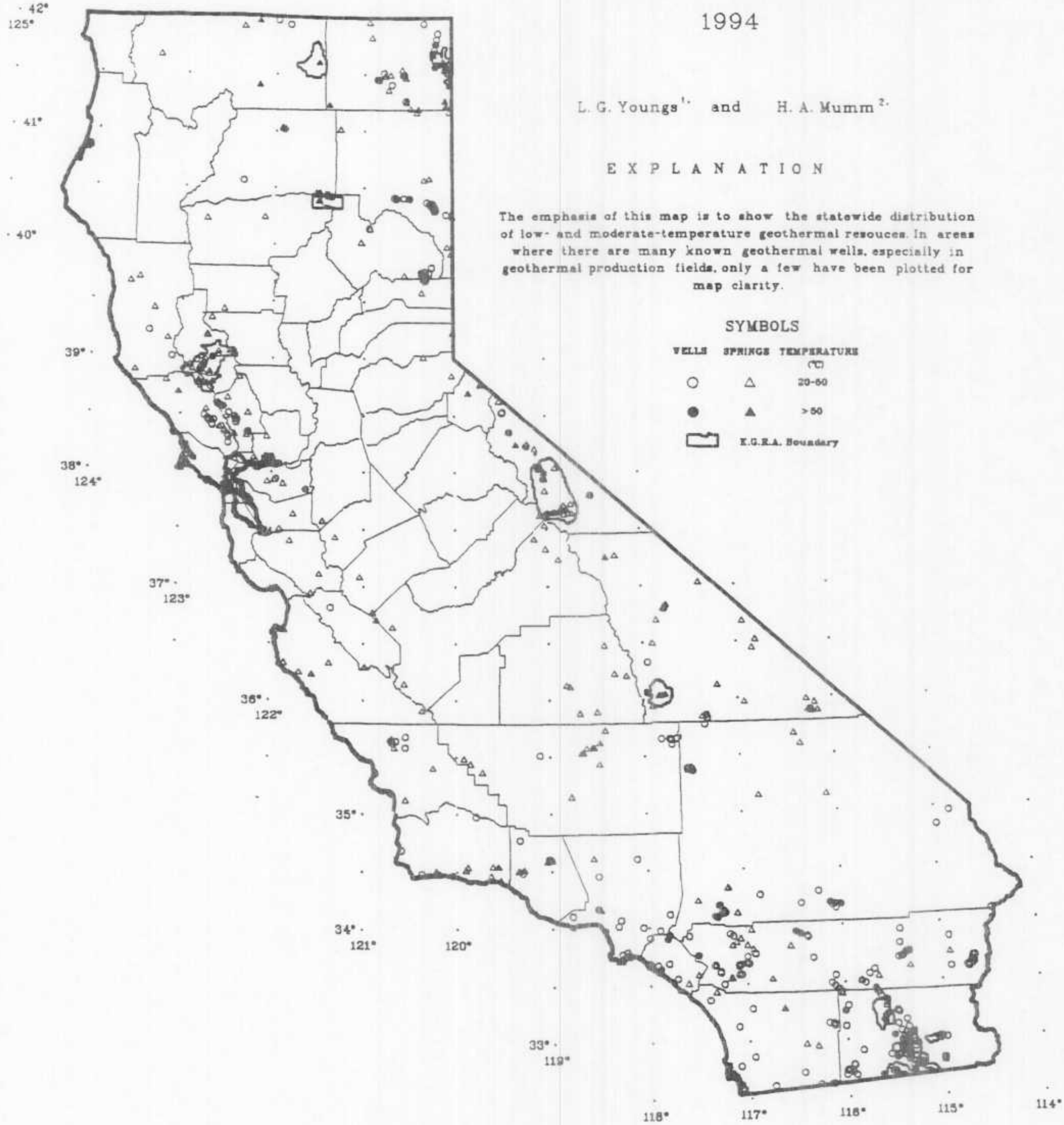
Geothermal Wells and Springs in California

1994

L. G. Youngs[1.] and H. A. Mumm[2.]

EXPLANATION

The emphasis of this map is to show the statewide distribution of low- and moderate-temperature geothermal resouces. In areas where there are many known geothermal wells, especially in geothermal production fields, only a few have been plotted for map clarity.



State of California
Department of Conservation
1. Division of Mines and Geology
2. Information Systems Services

of Land Management (BLM). The K.G.R.A. boundaries were manually drafted onto those older maps. In recent years the BLM has withdrawn some K.G.R.A.'s and amended the boundaries of others. We wanted to show the current designated K.G.R.A.'s on the new map by using plot files of the boundaries. We discovered that no boundary plot files existed. The BLM, USGS, several other state agencies, and private industry were also interested in acquiring files of digitized geodetic coordinates of the K.G.R.A. boundaries. DMG has now digitized those boundaries and the files were used during the plotting of Plate 1. Appendix B explains the process and format we used to produce the boundary files. The files are on the enclosed diskette within the directory labeled CALKGRAS. The K.G.R.A. boundary files are available separately from DMG upon request.

FLUID CHEMISTRY

A part of the Low-Temperature Geothermal Resources and Technology Transfer Program provided for up to ten new water chemistry analyses to be performed by UURI in support of updating the resource inventories of each of the state teams. DMG collected three water samples at Orr Hot Springs, Mendocino County, California and sent them to UURI for analysis. Orr Hot Springs is a small commercial spa complex with pool and bath facilities located in a small canyon in the north Coast Ranges of California. There are at least ten small warm water springs issuing along the banks and in the bed of a small creek. The operators of the resort contacted the DOGGR and subsequently DMG about their concerns over a decrease in the flow rate of the springs. Since water chemistry data recorded in the California database was decades old for Orr Hot Springs, we undertook a 1-day field investigation at the site. The new water chemistry data was entered into the updated database and is now being evaluated.

DISCUSSION

Overview

The preponderance of geothermal development in California over the past decade has been devoted to the utilization of high- and moderate-temperature resources for electrical power generation. California leads the nation in production of electricity from hydrothermal systems with a current total capacity of over 2,500 megawatts electric (MWe). That is enough electricity to provide for the electrical needs of a city with a population of 2 1/2 million. The world's largest geothermal electrical development with a current installed capacity of 1,850 MWe is The Geysers Geothermal Field in the north Coast Ranges of California. Electricity generated from hydrothermal systems is produced in four other regions of California as well. These regions are the Salton Sea/Imperial Valley area of southern

California, the Coso geothermal area within the China Lake Naval Weapons Center in south-central California, the Mammoth Lakes area in the Long Valley Caldera east of the Sierra Nevada in central California, and northeastern California in the Wendell-Amedee/Honey Lake area. Increasing production in all of these geothermal regions is currently under development or study. Other recent or current high-temperature geothermal projects in California include the Clear Lake hot-dry-rock prospect north of The Geysers geothermal area and exploratory drilling for potential electrical generation of Medicine Lake Highlands/Glass Mountain area in Siskiyou County.

Grant and loan programs as well as cost-share programs primarily administered by the U.S. Department of Energy and the California Energy Commission have played a part over the past decade in increasing the interest of Californians of the utilization of their low-temperature geothermal resources. There are currently many successful direct-use, low-temperature geothermal projects in the state. Perhaps the most notable is the City of San Bernardino which uses an underlying geothermal resource of 58°C for space- and domestic-water heating in about 30 buildings in the downtown area. Other smaller district-heating projects in California include the City of Susanville, Lassen County and the space-heating of structures at a large correctional facility at Litchfield, Lassen County. Several other California communities are engaged in various phases of district-heating project development. There are also many commercial, domestic, and public single structure geothermal space-heating projects in the state. Some of the larger facilities among about 25 projects include Indian Springs School in Big Bend, Shasta County; Surprise Valley Hospital, the high school, and the elementary school in Cedarville, Modoc County; Indian Valley Hospital in Greenville, Plumas County; and Modoc High School in Alturas, Modoc County.

The commercial application of low-temperature geothermal resources to the greenhouse and aquaculture (fish farming) industries has greatly expanded in California during the past decade. An important fish farming industry has grown in the northern and eastern area around the Salton Sea in Imperial and Riverside Counties. There are nine facilities in the area raising a variety of fresh water species as well as several kinds of Tilapia. Tilapia are a non-native fish suited to the high salinity waters of the Salton Sea/Imperial Valley area. They are produced for food markets as well as bait fish. Four commercial nurseries in the same area primarily raise roses in greenhouses that are warmed with circulating geothermal fluids in the colder parts of the year. There is also a small greenhouse facility in Susanville, Lassen County that utilizes thermal waters produced from a well in part of their operations.

A unique vocational training center in the state of California provided agricultural training in geothermal greenhouses. The Geothermal Agricultural Heat Center, Lake County began operations in 1989 utilizing 66°C water supplied to a heat exchanger system from two production wells. Horticulture classes were conducted at the greenhouse complex by the Mendocino-Lake Community College District. Regrettably the facilities have recently closed (in 1994).

The commercial geothermal resort/spa business is a relatively large, but poorly documented, industry in California. We were able to delineate approximately 48 commercial spa facilities throughout California that use geothermal waters either directly or indirectly through heat exchanger systems in pools, hot tubs, balneological baths, or mud baths. Most of these facilities are at historically developed hot springs areas. Anecdotal evidence suggests that there has been a renewed interest in "taking the baths" in California beginning in the mid 1980's.

There are at least four mineral water bottling companies in California that are extracting their product from low-temperature geothermal resources. Three facilities in Calistoga, Napa County cool geothermal waters drawn from underlying aquifers then bottle the mineralized water. A large portion of their product has added carbonation and/or flavorings. There is another commercial bottling plant at the Vichy Springs in Ukiah, Mendocino County. The mineral water is produced from a warm water spring.

Perhaps the general overview of the geothermal development in California during the past decade can be enhanced by reviewing some geothermal well drilling statistics. The following chart shows the numbers of documented geothermal wells drilled in California by year from 1980 to 1992.

Geothermal Wells Drilled in California

Year	Low-Temperature Wells Drilled	High-Temperature Wells Drilled	Observation Wells Drilled	Exploration Wells Drilled
1980	7	26	112	14
1981	4	25	116	14
1982	2	27	69	9
1983	4	33	26	5
1984	4	48	32	7
1985	8	34	40	7
1986	7	28	15	1
1987	4	30	17	5
1988	8	26	9	9
1989	3	8	3	3
1990	4	13	4	11
1991	5	12	1	4
1992	5	?	?	?
TOTAL	65	310	444	89

The data in the above chart are from the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources files.

It is evident from the chart that the greater activity has been in high-temperature geothermal development. It can be inferred from the production well statistics that geothermal development in California experienced the most activity during the middle to late 1980's of the past decade.

Collocation of Resources

An important part of the Low-Temperature Geothermal Resources and Technology Transfer Program was to complete a collocation study of geothermal resources and communities in the Western States in order to identify and encourage those communities to develop their geothermal resources. In California we have identified 56 communities located within 8 kilometers (5 miles) of a known geothermal resource with a temperature of at least 50°C. The communities are shown on the state map on Plate 2. Demographic and resource data for each of the communities are listed in Table 4 at the end of the text. A comparison of Plate 2 with the Geologic Map of California (Plate 3) shows that the northern and central California communities collocated with a geothermal resource (≥50°C) are located in the proximity of Cenozoic volcanic rocks. The majority of those communities identified in the southern part of the state are located in sedimentary basins and desert valleys associated with major faulting. The geothermal resources include hot springs, hot water reservoirs, steam and hot brines production fields, and geothermal water produced from some petroleum fields.

Historically, most of the communities that we have identified have experienced some development of their geothermal resources. However, depending on the characteristics of the resource, the potential exists for increased geothermal development for applications such as space- and district-heating, spa and bathing facilities, aquaculture, industrial and greenhouse operations, and possible electrical generation in some areas.

SUMMARY

As a result of participating in the Low-Temperature Geothermal Resources and Technology Transfer Program sponsored by the DOE/GD, DMG has compiled a near 1000-record database of low- to moderate-temperature geothermal wells and springs in California. This is a major update of a decade old inventory. The database is designed for use with readily available commercial software on personal computers (PC's) for ease of accessibility, editing, updating, and transmitting of the data file. The locations of the thermal wells and springs have been plotted on a new state map at a scale of 1:1,000,000.

The new inventory (PC database) of thermal wells and springs reflects the wide distribution and abundance of the low-temperature geothermal resources in California. There has been a determined and relatively successful effort over the past decade to utilize those resources in a variety of applications. There is, however, a great potential for increased development for applications such as space- and district-heating, aquaculture, industrial and greenhouse operations, and thermal spa facilities. In this study we have identified 56 communities that are located within 8 kilometers of a known geothermal resource that has a reported temperature of at least 50°C. We hope those California communities as well as others can benefit from the data presented in this report while pursuing the potential for development of their geothermal resources.

RECOMMENDATIONS

An analysis of the updated low-temperature geothermal resources of California shows that there are many areas that would greatly benefit from a Second Phase local geothermal assessment. After discussions with staff of the California Energy Commission and DOGGR, we have selected (partially based on population data) seven areas and one alternate for proposed assessment studies. Although these areas have had historical and some recent geothermal development as well, they generally lack a comprehensive study of the resource. A resource assessment study of each of the areas would provide potential geothermal developers with basic resource information, provide local governments with data for planning purposes, and serve to increase public awareness of their local geothermal resources. The selected communities or areas are collocated with a known resource having a temperature of at least 50°C.

The list of proposed areas of study is subject to future review based on new geothermal development, local interest, funding, and probability of resource use. We suggest the following California geothermal areas or communities for Second Phase studies (not in any order of preference):

1. Coachella Valley (communities of La Quinta, Palm Desert, and Palm Springs), Riverside County - The Coachella Valley is a major agricultural area with a population around 200,000. There are thermal springs and wells (some recently drilled) along a 20-30 kilometer extent of the west side of the valley. Some have water temperatures of at least 50°C. However, there appears to be no comprehensive study of the resource. Potential application might include aquaculture and food drying processes.

2. Alturas, Modoc County - The geothermal resource underlying this community of 3,500 population is characterized by well "AL" 1 at a depth of 896 meters with a water temperature of 86°C. The resource is used for space heating at the local high school. Although

the area was included in a geothermal resource assessment of Modoc County in 1986 that was sponsored by the California Energy Commission, the city of Alturas would greatly benefit from a comprehensive Second Phase study of the local resource that would include some geophysical surveys. There is a potential to expand space heating to other structures in the community.

3. Lake Elsinore, Riverside County - The rapidly growing area of approximately 20,000 population is overlying a fault controlled, historically developed geothermal resource evidenced by several springs and many thermal wells. A maximum temperature of 54°C has been reported to date. Three wells were drilled in 1985 to provide fluids for space heating of a community building. The project is now idle. The community would greatly benefit from a detailed resource assessment study.

4. Ojai, Ventura County - The community of approximately 8,000 people is located 8 kilometers southeast of Vickers Hot Springs and Stingleys Hot Springs that both discharge water at 51°C. There are two other thermal springs nearby. No encompassing geothermal resource assessment exists for the area.

5. Lake Isabella, Kern County - Several thermal springs south of the community along the Kern River have historically been developed for resort/spa use. A maximum temperature of 54°C at a flow rate of 415 L/min has been reported at Scovern Hot Springs. There is no comprehensive geothermal assessment of this area that is comprised of several small communities having a total population of approximately 10,000.

6. Huntington Beach/Los Angeles Basin, Orange/Los Angeles Counties - The largest metropolitan area of California is in part overlying major oil fields that produce thermal water as a waste product of petroleum production. There are at least 12 petroleum fields with very large quantities of associated thermal water characterized by the Venice Field of 21 million BTU/hour at 82°C. There is great local interest in utilizing the geothermal resource.

7. Hemet/Winchester, Riverside County - A few shallow water wells in this area of 40,000 population have been reported in literature as thermal wells. The greatest reported temperature is 59°C. Very little is known about the source of the warm water and a comprehensive assessment would be of great value to delineate the resource.

ALTERNATE.

Kelley Hot Springs (near community of Canby), Modoc County - The springs flow at 1,250 L/min at 92°C and have been applied to a variety of uses including greenhouse applications and fish farming on a limited scale. All enterprises have been abandoned. The current owners are very interested in development of the resource, but the benefit to the town of Canby (population 450 and about 8 kilometers distant) is unknown.

ACKNOWLEDGEMENTS

Howard Ross of the UURI and Paul Lienau and Gene Culver of the OIT/GHC coordinated the state teams participating in the Low-Temperature Geothermal Resources and Technology Transfer Program. Their guidance is greatly appreciated. Richard Thomas, Ken Stelling, Christy Craig Hunter, Elizabeth Johnson, and Susan Hodgson of the DOGGR provided support and information about geothermal wells in California. Sean Hagerty of the BLM provided data about the designated K.G.R.A.'s in California. Henry Mumm of the California Department of Conservation, Information Systems Services produced the computer plotted map "Geothermal Springs and Wells in California", Plate 1 of this report.

TABLE 1. CALIFORNIA GEOTHERMAL SPRINGS AND WELLS - DESCRIPTIVE DATA

ID#	SOURCE NAME	TYPE	PLOT	LAT	LONG	CO.	AREA	TEMP (°C)	DEPTH (m)	FLOW (L/min)	STATUS	USE	DATE
1	Crohare Spring	SP	Y	37.6320	121.7620	ALA	Pleasanton	21.0		8			
2	Warm Springs	SP	Y	37.5030	121.9067	ALA	Fremont	27.0					
3	Grovers Hot Springs	SP	Y	38.6980	119.8450	ALP	Markleeville	60.0		400	F	B,H	05/17/82
4	Unnamed Spring	SP	Y	38.7728	119.7130	ALP	Markleeville	65.0		473			
5	Valley Springs	SP	N	38.1952	120.8225	CAL	Valley Springs	24.0		4			
6	Red Eye Spring	SP	Y	39.3510	122.6705	COL	Red Eye Spring	24.0		8			
7	Elgin Mine (Spring)	SP	Y	39.0570	122.4708	COL	Wilbur Springs	69.0		38			
8	Wilbur Hot Spring	SP	N	39.0387	122.4208	COL	Wilbur Springs	55.6		80	F	B	03/09/91
9	"Sunedco/Bailey Min." 1	NLT	Y	39.0333	122.4301	COL	Wilbur Springs	175.0	2711.6	197	A	I	
10	Empire Silver Mine	SP	Y	39.0377	122.4255	COL	Wilbur Springs	38.0		1			
11	Jones Hot Spring (W)	SW	N	39.0338	122.4270	COL	Wilbur Springs	61.9			F	I	03/09/91
12	Unnamed Springs	SP	Y	39.0348	122.4265	COL	Wilbur Springs	61.0		15			
13	Blancks Hot Springs	SP	Y	39.0312	122.4313	COL	Wilbur Springs	49.0		15			
14	Sulphur Spring	SP	Y	37.9147	122.0420	CCA	Mt. Diablo	24.0		8			
15	Unnamed Spring	SP	Y	37.9292	121.9650	CCA	Mt. Diablo	23.0					
16	Unnamed Well	WW	Y	37.9375	121.9542	CCA	Mt. Diablo	23.0	160.0	10			
17	Unnamed Spring	SP	Y	37.8945	121.8737	CCA	Mt. Diablo	21.0					
18	Byron Hot Springs	SW	Y	37.8472	121.6305	CCA	Byron	51.0	75.0	600	I	I	03/23/81
19	Wentworth Springs	SP	Y	39.0130	120.3380	ELD	Wentworth Springs	24.0		6			
20	Meyers Warm Spring	SP	Y	38.8500	120.0250	ELD	Echo Summit	24.0		15			
21	Fish Creek Hot Sps.	SP	Y	37.5320	119.0245	FRE	NE. Fresno Co.	43.0		19			
22	Unnamed Spring	SP	Y	37.4125	119.1392	FRE	NE. Fresno Co.	35.0					
23	Mono Hot Springs	SP	Y	37.3267	119.0167	FRE	Mono Hot Springs	43.0		200			
24	Blaney Meadows Hot Sps.	SP	Y	37.2337	118.8813	FRE	NE. Fresno Co.	43.0		150			
25	Mercy Hot Springs	SP	Y	36.7033	120.8598	FRE	Mercy Hot Sps.	48.0			F	B	12/07/81

TABLE 2. - CALIFORNIA GEOTHERMAL SPRINGS AND WELLS - WATER CHEMISTRY DATA

ID#	pH	CONDUCT	Na	K	Ca	Mg	Fe	Li	B	SiO_2	HCO_3	SO_4	Cl	F	As	TDSm	TDSc
1	7.90		164.0	8.4	27.0	29.0			1.6	37.0	309.0	74.0	150.0	0.20		660	659
2	8.60		116.0	0.3	11.0	0.4			0.6	34.0	304.0	9.0	16.0	0.70		340	339
3	6.70	2000	409.0	12.0	29.0	2.0	0.13	0.66	2.8	89.0	716.0	149.0	182.0	3.80			1236
4																	
5			1687.0		843.0											3000	2530
6	7.20		5050.0	69.0	119.0	209.0		5.80	162.0	100.0	4790.0	8.0	6040.0	2.20		14200	14200
7	7.40		9110.0	506.0	5.9	29.0			240.0	244.0	7240.0	7.0	11000.0	3.00		25900	24699
8	7.68		8580.0	460.0	5.6	54.8		12.10	285.0	199.0	7375.0	157.0	10710.0	3.32	1.20		
9																	
10											11936.0		8460.0				14340
11	7.88		9740.0	513.0	5.6	41.0		14.00	300.0	89.0	8250.0	170.0	11210.0		1.20		
12																	
13																	
14	8.20		308.0	16.0	33.0	17.0		0.09	7.3	100.0	662.0	2.0	221.0	1.10		1050	1050
15	9.10		1500.0	7.6	286.0				10.0	23.0	130.0	16.0	2750.0	0.20		4700	4830
16	9.50		2410.0	12.0	679.0				7.4	17.0	85.0	7.0	4870.0			8210	8210
17	7.70		3100.0	53.0	431.0	12.0		4.60	191.0	16.0	203.0	2.0	5770.0	2.50		10300	10300
18	6.00	34900	3606.0	47.0	415.0	135.0	0.18	0.10	25.7	13.0	511.0		10400.0	0.60			14918
19																	
20	9.40		33.0	0.9	2.4	0.9		0.02	0.3	22.0	55.0	13.0	14.0	0.50		115	114
21																	
22																	
23	6.92		300.0	8.8	70.0	3.2		0.89	2.9	60.0	307.0	74.0	370.0	3.00		1200	1347
24	8.00		200.0	5.0	75.0	0.2		0.65	2.0	51.0	28.0	48.0	400.0	2.10		810	824
25	8.80	3880	675.0	5.0	36.0			0.07	14.0	58.0	23.0	109.0	1275.0	0.50			2209

TABLE 3. CALIFORNIA GEOTHERMAL SPRINGS AND WELLS - REFERENCES

ID#	SOURCE NAME	TYPE	PLOT	LAT	LONG	CO.	AREA	REFERENCE	Page(s)
1	Crohare Spring	SP	Y	37.6320	121.7620	ALA	Pleasanton	Berkstresser, 1968b	
2	Warm Springs	SP	Y	37.5030	121.9067	ALA	Fremont	Berkstresser, 1968b	
3	Grovers Hot Springs	SP	Y	38.6980	119.8450	ALP	Markleeville	Leivas and Bacon, 1982	
4	Unnamed Spring	SP	Y	38.7728	119.7130	ALP	Markleeville	Majmundar, 1984	
5	Valley Springs	SP	N	38.1952	120.8225	CAL	Valley Springs	Leivas and Bacon, 1982	
6	Red Eye Spring	SP	Y	39.3510	122.6705	COL	Red Eye Spring	Berkstresser, 1968b	
7	Elgin Mine (Spring)	SP	Y	39.0570	122.4708	COL	Wilbur Springs	Bliss, 1983	
8	Wilbur Hot Spring	SP	N	39.0387	122.4208	COL	Wilbur Springs	Goff and Janik, 1993	243-244
9	"Sunedco/Bailey Min." 1	NLT	Y	39.0333	122.4301	COL	Wilbur Springs	CA. Div. Oil and Gas, 1993	
10	Empire Silver Mine	SP	Y	39.0377	122.4255	COL	Wilbur Springs	Bliss, 1983	
11	Jones Hot Spring (W)	SW	N	39.0338	122.4270	COL	Wilbur Springs	Goff and Janik, 1993	244-247
12	Unnamed Springs	SP	Y	39.0348	122.4265	COL	Wilbur Springs	Waring, 1965	
13	Blancks Hot Springs	SP	Y	39.0312	122.4313	COL	Wilbur Springs	Waring, 1965	
14	Sulphur Spring	SP	Y	37.9147	122.0420	CCA	Mt. Diablo	Berkstresser, 1968b	
15	Unnamed Spring	SP	Y	37.9292	121.9650	CCA	Mt. Diablo	Berkstresser, 1968b	
16	Unnamed Well	WW	Y	37.9375	121.9542	CCA	Mt. Diablo	Bliss, 1983	
17	Unnamed Spring	SP	Y	37.8945	121.8737	CCA	Mt. Diablo	Pampeyan, 1963	
18	Byron Hot Springs	SW	Y	37.8472	121.6305	CCA	Byron	Leivas and others, 1981	
19	Wentworth Springs	SP	Y	39.0130	120.3380	ELD	Wentworth Springs	Waring, 1965	
20	Meyers Warm Spring	SP	Y	38.8500	120.0250	ELD	Echo Summit	Bliss, 1983	
21	Fish Creek Hot Sps.	SP	Y	37.5320	119.0245	FRE	NE. Fresno Co.	Waring, 1915	
22	Unnamed Spring	SP	Y	37.4125	119.1392	FRE	NE. Fresno Co.	Majmundar, 1984	
23	Mono Hot Springs	SP	Y	37.3267	119.0167	FRE	Mono Hot Springs	Mariner and others, 1977	
24	Blaney Meadows Hot Sps.	SP	Y	37.2337	118.8813	FRE	NE. Fresno Co.	Mariner and others, 1977	
25	Mercy Hot Springs	SP	Y	36.7033	120.8598	FRE	Mercy Hot Sps.	Levias and Bacon, 1982	

TABLE 4.

CALIFORNIA COMMUNITIES NEAR A GEOTHERMAL RESOURCE WITH A TEMPERATURE OF AT LEAST 50°C

City	County	Approx. Lat.	Approx. Long.	Population	Res. Temp. (°C)	Depth (m)	Flow (L/min)	TDS (mg/L)	Remarks
Alturas	Modoc	41°29′	120°32′	3,260	86	896	303	1,537	Data for well "AL" 1 supplying heat to local school. Deepest direct use well.
Bieber	Lassen	41°07′	121°08′	600	46	648	750	N/A	Data for well "BV" 3. Nearby Bassett Hot Springs is 79°C.
Big Bend	Shasta	41°01′	121°55′	150	50	250	114	260	Data for well. "ISS" 1 supplying heat to school.
Bishop	Inyo	37°22′	118°24′	3,490	58	Springs	2,000	510	Data for Keough Hot Springs approximately 7 miles south of Bishop.
Bombay Beach	Imperial	33°21′	115°43′	500	54-78	30-177	1,514	2,100-3,800	Many wells in the Hot Mineral Spa geothermal area.
Boyes Hot Springs	Sonoma	38°19′	122°29′	5,937	53	396	757	1,287	Well "SV" 1 at Sonoma Mission Inn.
Brawley	Imperial	32°59′	115°32′	19,450	200-230	2,700-3,900	80-200	28,000	Wells in North Brawley geothermal field, Imperial Valley.
Bridgeport	Mono	38°15′	119°14′	900	51	300	N/A	N/A	Magma Power Co. well.
Calexico	Imperial	32°40′	115°30′	19,200	140-180	600-2,500	5,600-8,500	14,000-20,000	Heber geothermal field, Imperial Valley.
Calipatria	Imperial	33°08′	115°31′	2,700	230-310	900-1,800	1,500-18,000	280,000	At the southeast of the Salton Sea geothermal field.
Calistoga	Napa	38°35′	122°35′	4,500	137	14-244	1,476	660	Well over 100 geothermal wells in Calistoga.

TABLE 4. continued

City	County	Approx. Lat.	Approx. Long.	Population	Res. Temp. (°C)	Depth (m)	Flow (L/min)	TDS (mg/L)	Remarks
Canby	Modoc	41°27′	120°52′	450	92	Spring	1,250	900	Kelly Hot Spring.
Cedarville	Modoc	41°32′	120°10′	950	69	194	570	N/A	In the Surprise Valley geothermal area. Space heating two schools and hospital.
Clearlake	Lake	38°57′	122°38′	12,100	187	2,385	N/A	N/A	The Clear Lake geothermal region, north of The Geysers. Data for Kettenhofen 1 well.
Colton	San Bernardino	34°04′	117°19′	41,350	51	259	N/A	N/A	Near the City of San Bernardino geothermal area.
Coso Junction	Inyo	36°03′	117°57′	30	200-340	1,460-1,980	750-7,600	4,600	Coso Hot Springs KGRA. Electrical power production.
Costa Mesa	Orange	33°38′	117°55′	97,400	218	2,777	N/A	N/A	Huntington Beach area where hot water is encountered in oil wells.
Desert Hot Springs	Riverside	33°58′	116°30′	12,300	54-70	45-150	10-50	500-1,000	More than 50 hot water wells in the area.
Eagleville	Modoc	41°19′	120°07′	185	59	Springs	500	370	Data for Menlo Baths Hot Springs.
El Centro	Imperial	32°48′	115°34′	32,650	140-180	600-2,500	5,600-8,500	14,000-20,000	Heber geothermal field, Imperial Valley.
Fort Bidwell (and Fort Bidwell Indian Reservation)	Modoc	41°51′	120°09′	230	53	24	N/A	N/A	In the Surprise Valley geothermal area. Data for well 45N/16E-17MI M.
Glamis	Imperial	33°00′	115°05′	N/A	71	207	N/A	N/A	Data is for Smith Brothers Well.

TABLE 4. continued

City	County	Approx. Lat.	Approx. Long.	Population	Res. Temp. (°C)	Depth (m)	Flow (L/min)	TDS (mg/L)	Remarks
leber	Imperial	32°44′	115°32′	2,566	140-180	600-2,500	5,600-8,500	14,000-20,000	Heber geothermal field, Imperial Valley.
lemet	Riverside	33°44′	116°59′	38,000	59	40	N/A	380	Well is 6 miles south of Hemet.
ighland	San Bernardino	34°07′	117°12′	35,650	58	284	18,900	N/A	The City of San Bernardino geothermal area. Data for well "Mill & D" 2.
untington Beach	Orange	33°40′	117°59′	182,800	218	2,539	N/A	N/A	Hot water encountered in oil wells.
ohannesburg	Kern	35°22′	117°38′	300	116	236	N/A	N/A	Less than 5 miles west of the Randsburg KGRA. Data for Magma Power Co. well.
elseyville	Lake	38°59′	122°50′	2,861	64	149	1,500-1,900	N/A	Geothermal greenhouse/ teaching facility 5 miles southeast of Kelyseville. Data for well "AG Park" 3.
ngs Beach	Placer	39°14′	120°02′	2,796	55	Spring	600	371	Data is for Brockway Hot Springs less than 1 mile to the southeast.
Quinta	Riverside	33°41′	116°18′	11,950	83	109	290	N/A	Data for well 5S/6E-24N2S and located 3 miles north of La Quinta.
ke City	Modoc	41°39′	120°13′	190	160	1,508	1,370	N/A	In the Surprise Valley geothermal area. Data for Magma Energy wells.
ke Elsinore	Riverside	33°40′	117°20′	19,200	54	150-180	1,514	300	Many wells.
ke Isabella	Kern	35°37′	118°29′	3,323	54	Springs	415	420	Scovern Hot Springs.

TABLE 4. continued

City	County	Approx. Lat.	Approx. Long.	Population	Res. Temp. (°C)	Depth (m)	Flow (L/min)	TDS (mg/L)	Remarks
Lee Vining	Mono	37°58′	119°07′	900	54	1,220	N/A	N/A	The Mono Basin area.
Litchfield	Lassen	40°23′	120°23′	350	79	434	3,956	N/A	Litchfield geothermal field. Operating geothermal district heating system. Data for well "Johnston" 1.
Lower Lake	Lake	38°55′	122°36′	1,217	52	Spring	50	1,600	The Clear Lake geothermal region, north of The Geysers. Data is for Seigler Springs.
Loyalton	Sierra	39°40′	120°14′	930	51	122	20	N/A	The Sierra Valley geothermal area.
Mammoth Lakes	Mono	37°39′	118°58′	4,900	79	664	N/A	N/A	Geothermal district heating system currently being studied. Data for well "Ohwell" 1.
Markleeville	Alpine	38°42′	119°47′	100	64	Springs	400	1,720	Grovers Hot Springs.
Middletown	Lake	38°45′	122°37′	2,000	73	Springs	250	400	At the southeast of The Geysers geothermal field. Data for Castle Hot Springs.
Newport Beach	Orange	33°37′	117°56′	67,300	218	2,777	N/A	N/A	Huntington Beach area where hot water is encountered in oil wells.
Niland	Imperial	33°14′	115°31′	1,183	230-310	915-1,830	1,500-18,000	up to 300,000	The Salton Sea geothermal field.
Ojai	Ventura	34°27′	119°14′	7,650	51	Springs	27+	1,110	Vickers Hot Springs and Stingleys Hot Springs are approximately 5 miles northwest of Ojai.

TABLE 4. continued

City	County	Approx. Lat.	Approx. Long.	Population	Res. Temp. (°C)	Depth (m)	Flow (L/min)	TDS (mg/L)	Remarks
Palm Desert	Riverside	33°43′	116°23′	23,750	83	109	290	N/A	Data is for well 5S/6E-24N2S. Located 4 miles east of Palm Desert.
Randsburg	Kern	35°22′	117°39′	280	116	236	N/A	N/A	Less than 5 miles west of the Randsburg KGRA. Data for Magma Power Co. well.
Red Mountain	San Bernardino	35°21′	117°36′	200	116	236	N/A	N/A	Less than 5 miles west of the Randsburg KGRA. Data for Magma Power Co. well.
San Bernardino	San Bernardino	34°07′	117°18′	171,600	58	284	N/A	N/A	The City of San Bernardino has established a geothermal heating district using 58°C water from wells.
San Luis Obispo	San Luis Obispo	35°17′	120°39′	42,600	57	14	N/A	815	Ontario Hot Springs (well) approximately 6 miles south of San Luis Obispo.
Susanville	Lassen	40°25′	120°39′	7,325	79	283	1,325	N/A	Operating geothermal district heating system. Data is for City of Susanville well "Susan" 1.
Temecula	Riverside	33°29′	117°09′	27,400	56	Springs	285	750	Lake Elsinore geothermal area. Data for Murrieta Hot Springs.
Trona	San Bernardino	35°46′	117°22′	1,400	58	183	N/A	53,900	Data for well 24S/43E-9P1 M approximately 6 miles north of Trona in Inyo County.
Twentynine Palms	San Bernardino	34°08′	116°03′	11,950	71	122	N/A	1,000	At least half a dozen known hot water wells (50° to 70°C) near Twentynine Palms.
Warner Springs	San Diego	33°17′	116°38′	30	56	Springs	500	244	About a dozen springs/wells in creek bed.

TABLE 4. continued

City	County	Approx. Lat.	Approx. Long.	Population	Res. Temp. (°C)	Depth (m)	Flow (L/min)	TDS (mg/L)	Remarks
Westmorland	Imperial	33°02′	115°37′	1,400	N/A	N/A	N/A	N/A	Westmorland geothermal area, Imperial Valley.
Widomar	Riverside	33°36′	117°16′	10,411	52	Springs	N/A	300	Lake Elsinore geothermal area. Data for Elsinore Hot Springs.
Winchester	Riverside	33°42′	117°05′	1,689	49	20	N/A	2,260	Several warm water wells i area.

APPENDIX B

BOUNDARIES OF THE CALIFORNIA KNOWN GEOTHERMAL RESOURCE AREAS (K.G.R.A.) EXPRESSED IN LATITUDE, LONGITUDE COORDINATES

BOUNDARIES OF THE CALIFORNIA
KNOWN GEOTHERMAL RESOURCE AREAS (K.G.R.A.)
EXPRESSED IN LATITUDE, LONGITUDE COORDINATES

1994

by Leslie G. Youngs

INTRODUCTION

The Department of Conservation, Division of Mines and Geology (DMG) has digitized the boundaries of the nineteen Known Geothermal Resource Areas (K.G.R.A.) of California as coordinates of latitude, longitude. The data can be used to generate polygons representing the boundaries of the K.G.R.A.'s on small scale maps. Sets of the coordinate pairs that were digitized around the mapped boundary for each K.G.R.A. are in separate ASCII character files as well as LOTUS 123 worksheet files. The files are on the enclosed personal computer diskette. The names of the files as well as the names of the maps from which the boundaries were digitized are listed in Table 1.

METHOD

The Bureau of Land Management (BLM) supplied the legal descriptions as well as maps at various scales of the boundaries of the K.G.R.A.'s in California (Bureau of Land Management, 1988). The boundaries were manually transferred to U.S.G.S. and BLM published paper maps generally at 1:100,000 scale. The boundary lines were then traced on a digitizing tablet in the clockwise direction around each polygon using the U.S.G.S. computer software GSDIG (Selner and others, 1990). At a minimum, points (coordinate pairs of latitude, longitude) were recorded at each section corner around each K.G.R.A. boundary. Additional points were recorded where the boundary side of a section was not a straight line, where partial sections comprised portions of a boundary, and where other features such as lake shores comprised part of a K.G.R.A. boundary. The files were edited using the LOTUS 123 spreadsheet software. The enclosed personal computer diskette contains both the ASCII character file with file extension name .PRN and the LOTUS 123 worksheet file with file extension name .WK1 of coordinates for each K.G.R.A. boundary. Note that the first coordinate pair of latitude, longitude recorded for each boundary was copied to the end of each file to complete closure of the polygon. Intergraph MicroStation software was used to generate the K.G.R.A. boundary polygons from the digitized data. The plots of the California K.G.R.A. boundary polygons are shown on pages 5-23.

Inquires concerning the availability of the K.G.R.A. boundary data files or other related comments should be made to:

Mr. Leslie G. Youngs
Department of Conservation
Division of Mines and Geology
801 K Street, MS 08-38
Sacramento, CA 95814-3531
Phone (916)322-8078

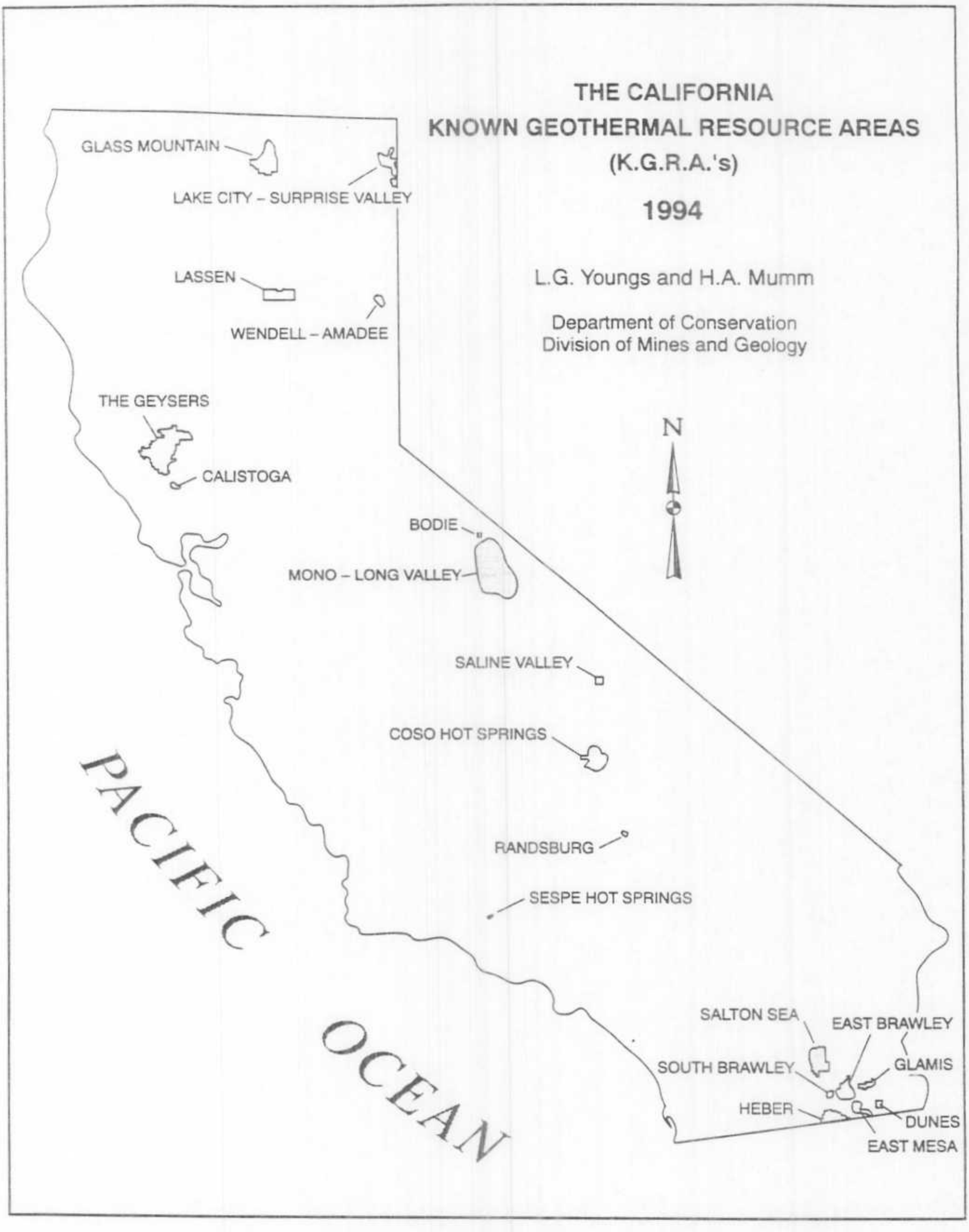
REFERENCES

Bureau of Land Management, 1988, Known geothermal resource areas (K.G.R.A.) in California: Department of Interior, unpublished report, 25 p.

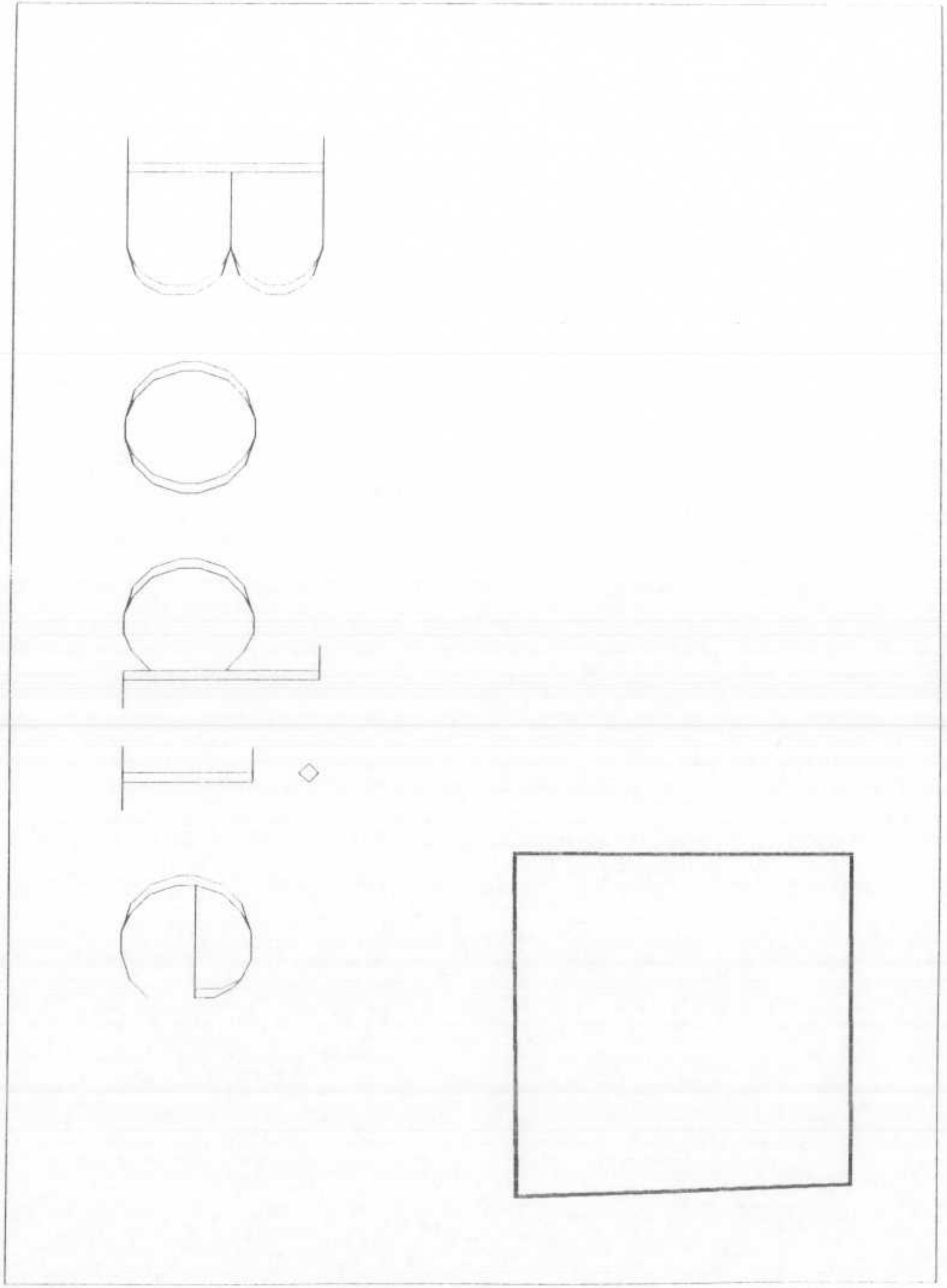
Selner, G.I., Smith, C.L., and Taylor, R.B., 1990, GSDIG version 3.0, a program to determine latitude, longitude coordinates or x,y coordinates using a microcomputer (IBM PC or compatible) and digitizer: U.S. Geological Survey Open-File Report 90-80, 26 p.

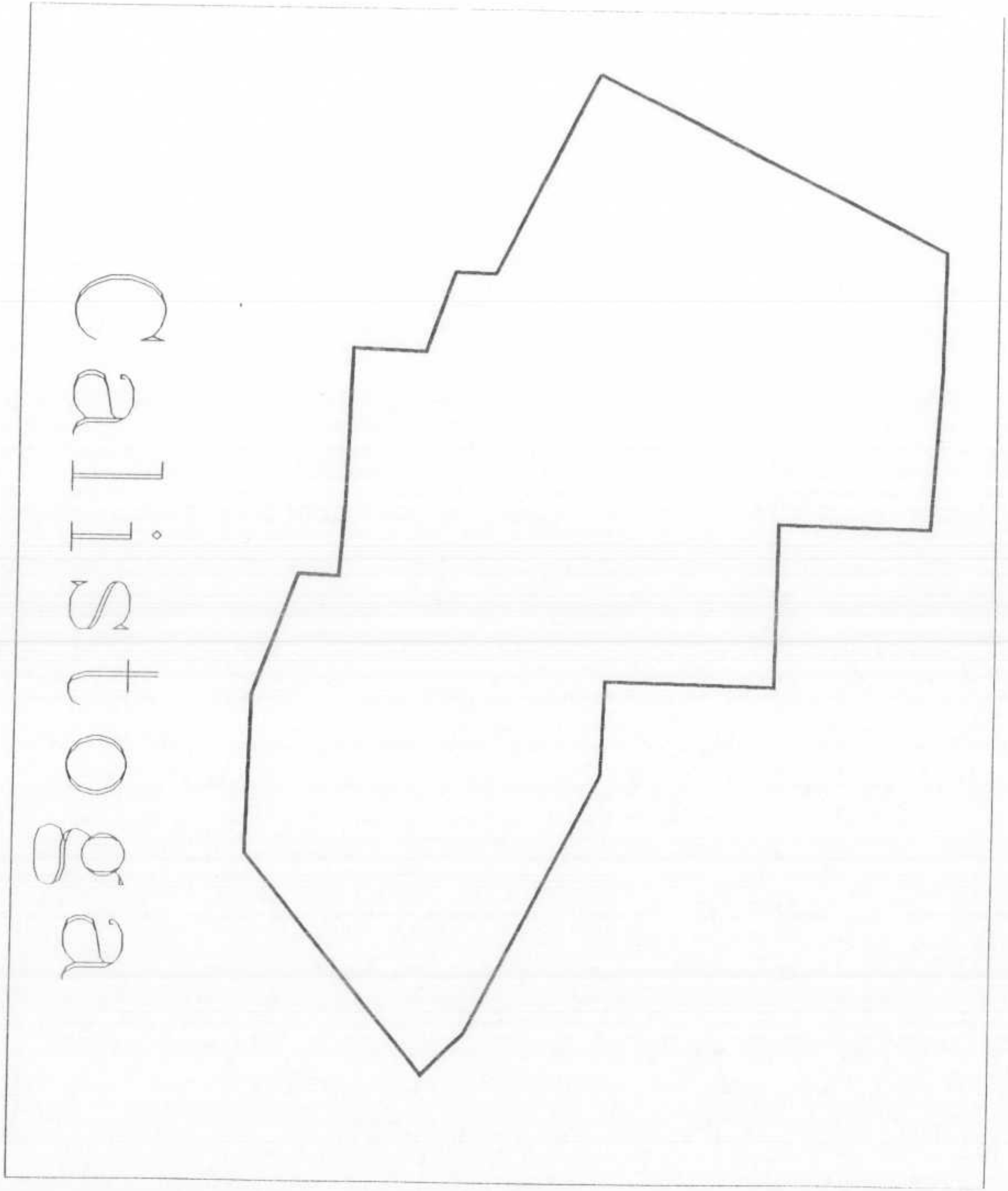
TABLE 1. California K.G.R.A. boundary file names and the names of the maps from which the boundaries were digitized.

K.G.R.A.	FILE NAME	RECORDS	MAP SCALE	MAP NAME	SOURCE
Bodie	BODIE.PRN	5	1:65,000	Bodie	USGS
Calistoga	CALISTOG.PRN	25	1:24,000	Calistoga & Mark West Springs	USGS
Coso Hot Springs	COSOHOT.PRN	76	1:100,000	Darwin Hills & Ridgecrest	BLM
Dunes	DUNES.PRN	14	1:24,000	Glamis S.E. & Cactus	USGS
East Brawley	EBRAWLEY.PRN	62	1:100,000	Salton Sea & El Centro	BLM
East Mesa	EASTMESA.PRN	62	1:100,000	El Centro	BLM
The Geysers	GEYSERS.PRN	173	1:100,000	Lakeport, Healdsburg, & Point Arena	BLM USGS
Glamis	GLAMIS.PRN	35	1:100,000	Salton Sea & El Centro	BLM
Glass Mountain	GLASSMTN.PRN	85	1:100,000	Tulelake & McArthur	USGS
Heber	HEBER.PRN	63	1:100,000	El Centro	BLM
Lake City-Surprise Valley	LAKECTY1.PRN	143	1:100,000	Cedarville & Alturas	BLM
	LAKECTY2.PRN	64	1:100,000	Alturas	BLM
Lassen	LASSEN.PRN	74	1:100,000	Lake Almanor	BLM
Mono-Long Valley	MONOLONG.PRN	136	1:100,000	Yosemite Valley, Benton Range, Bridgeport, & Excelsior Mts.	BLM USGS
Randsburg	RANDSBUR.PRN	27	1:100,000	Cuddeback Lake	BLM
Saline Valley	SALINVLY.PRN	11	1:100,000	Saline Valley	USGS
Salton Sea	SALTON.PRN	60	1:100,000	Salton Sea	BLM
Sespe Hot Springs	SESPEHOT.PRN	15	1:24,000	Topatopa Mountains & Devils Heart Peak	USGS
South Brawley	SBRAWLEY.PRN	25	1:100,000	El Centro	BLM
Wendel-Amedee	WENAMDEE.PRN	26	1:100,000	Susanville	BLM

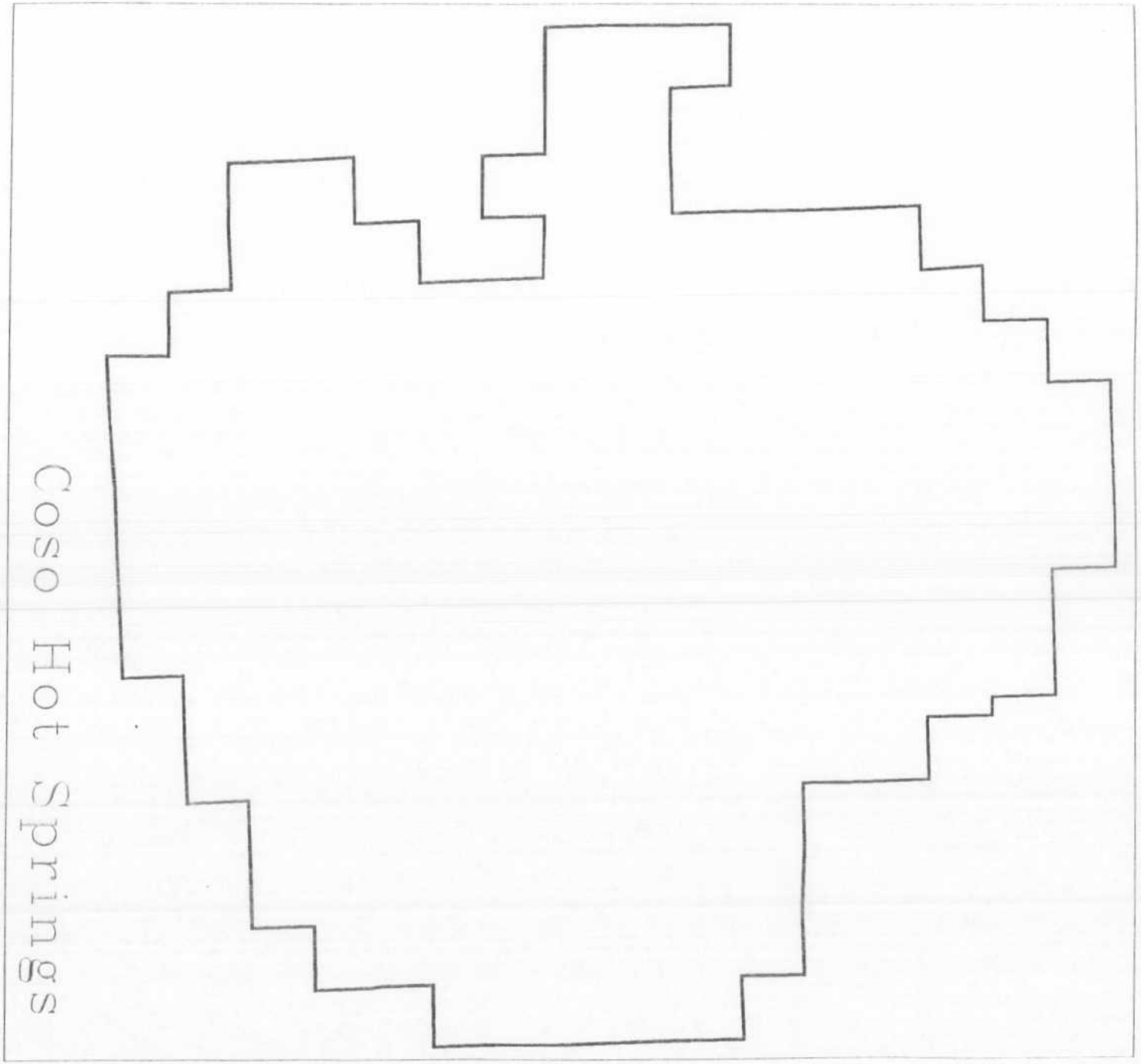


THE CALIFORNIA
KNOWN GEOTHERMAL RESOURCE AREAS
(K.G.R.A.'s)
1994
L.G. Youngs and H.A. Mumm
Department of Conservation
Division of Mines and Geology
N
GLASS MOUNTAIN
LAKE CITY – SURPRISE VALLEY
LASSEN
WENDELL – AMADEE
THE GEYSERS
CALISTOGA
BODIE
MONO – LONG VALLEY
SALINE VALLEY
COSO HOT SPRINGS
RANDSBURG
SESPE HOT SPRINGS
PACIFIC OCEAN
SALTON SEA
EAST BRAWLEY
SOUTH BRAWLEY
GLAMIS
HEBER
DUNES
EAST MESA


Bodie



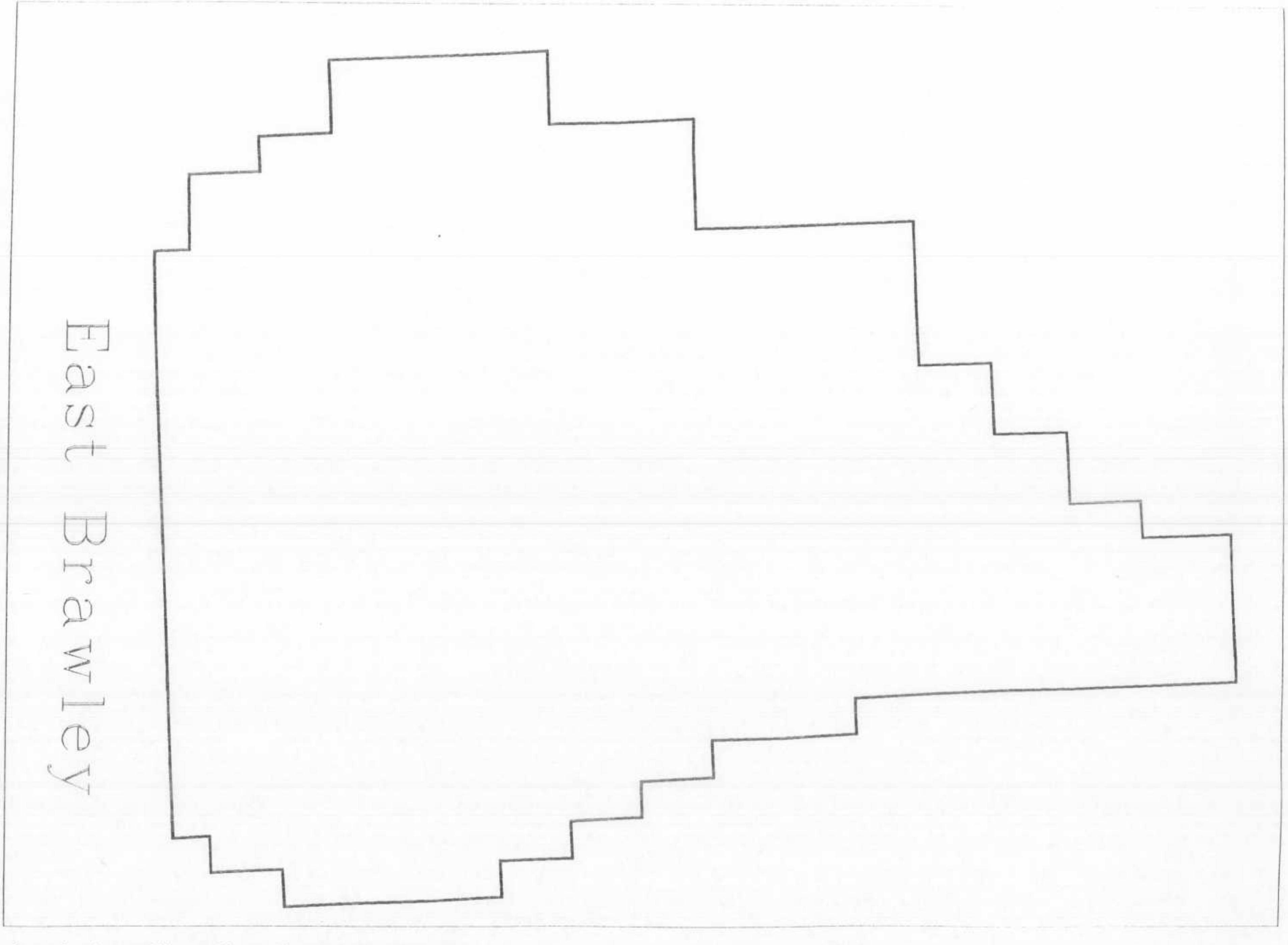
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 08:56:18



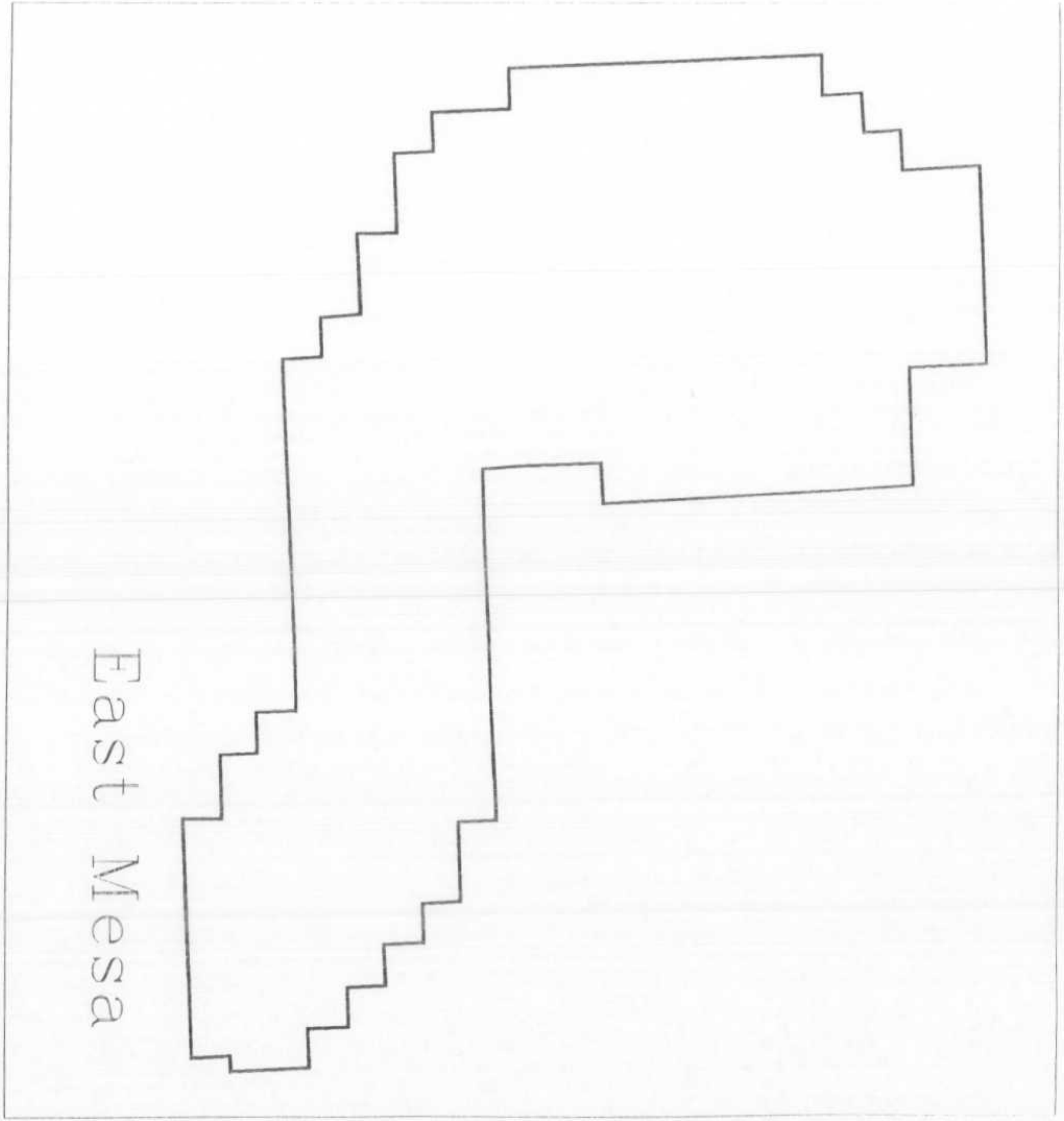
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:00:16

Dunes

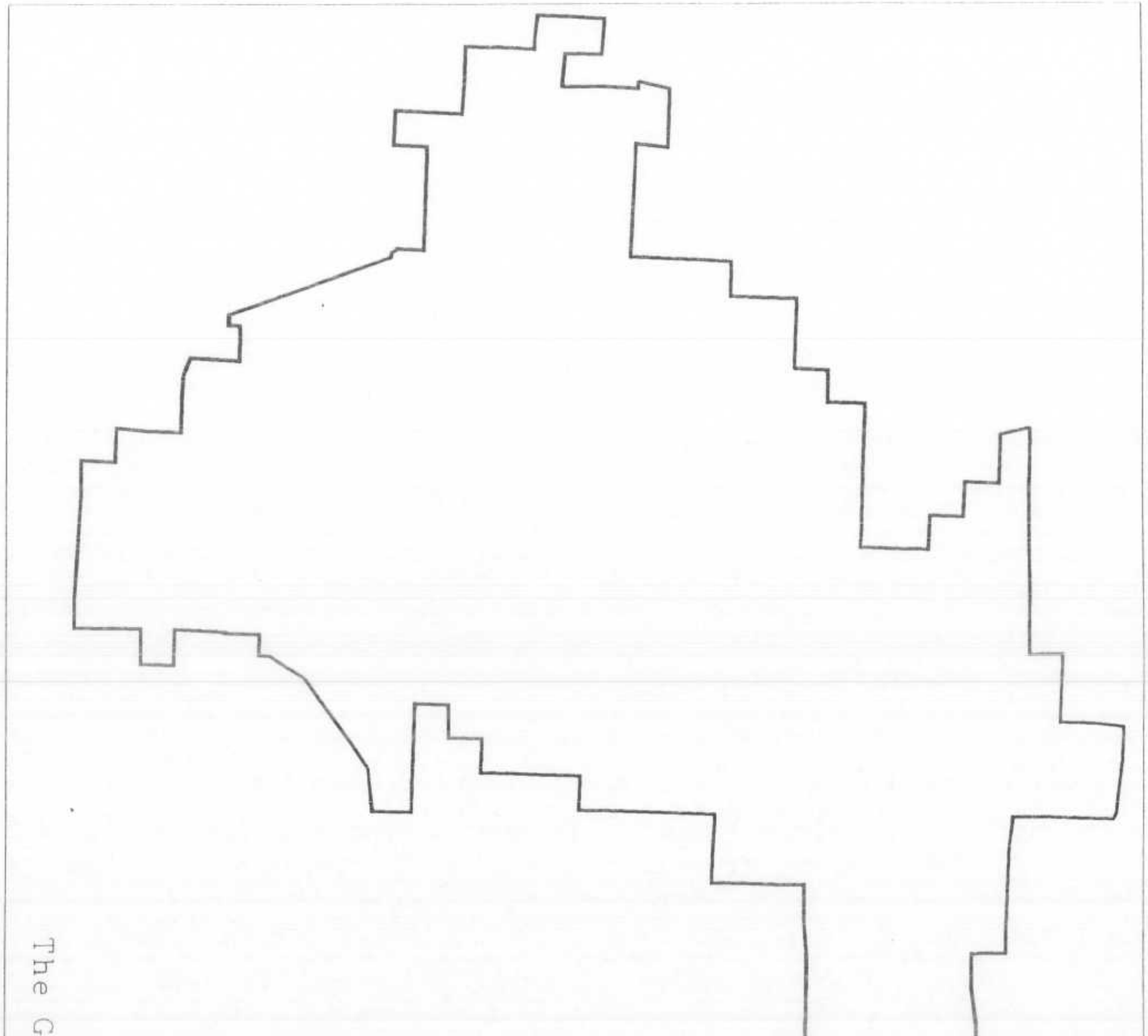
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:05:43



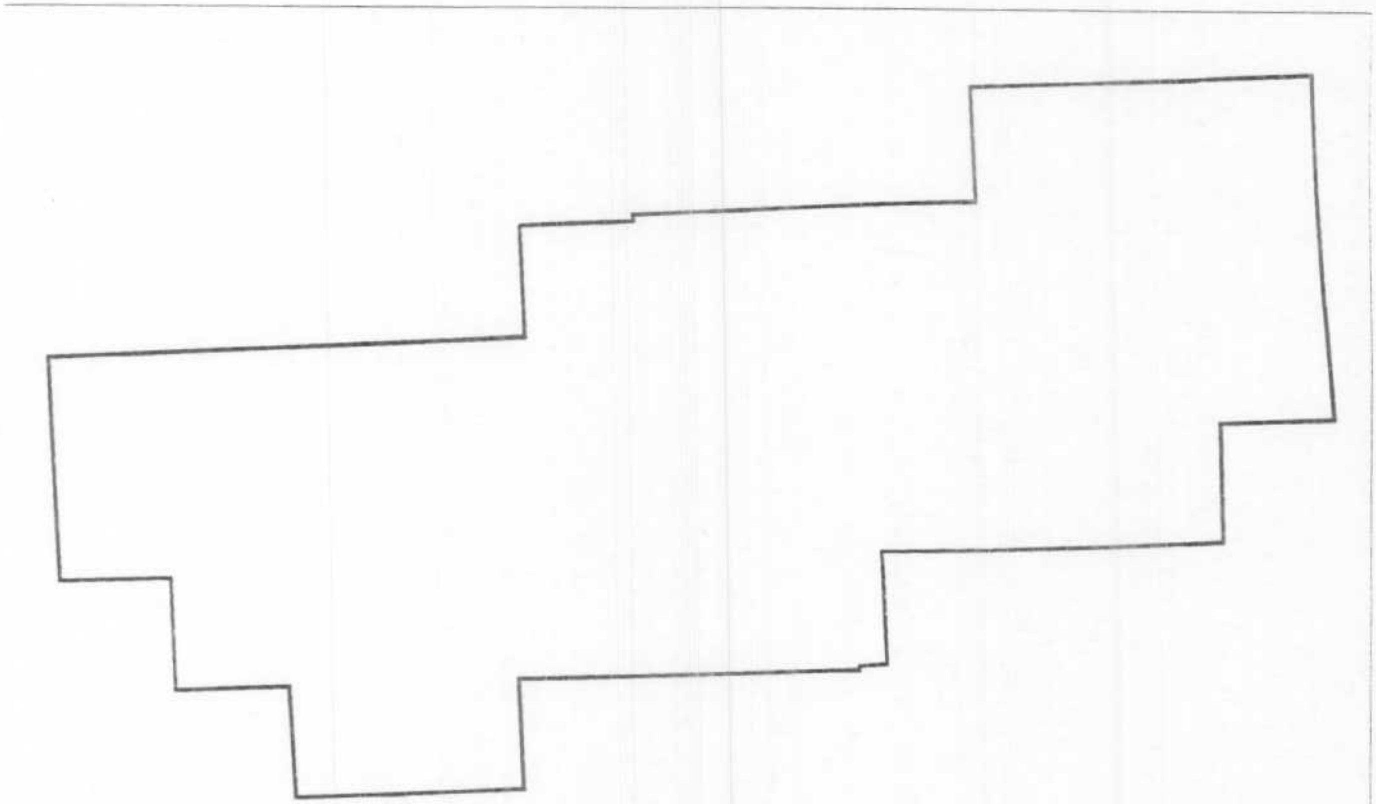
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:04:18



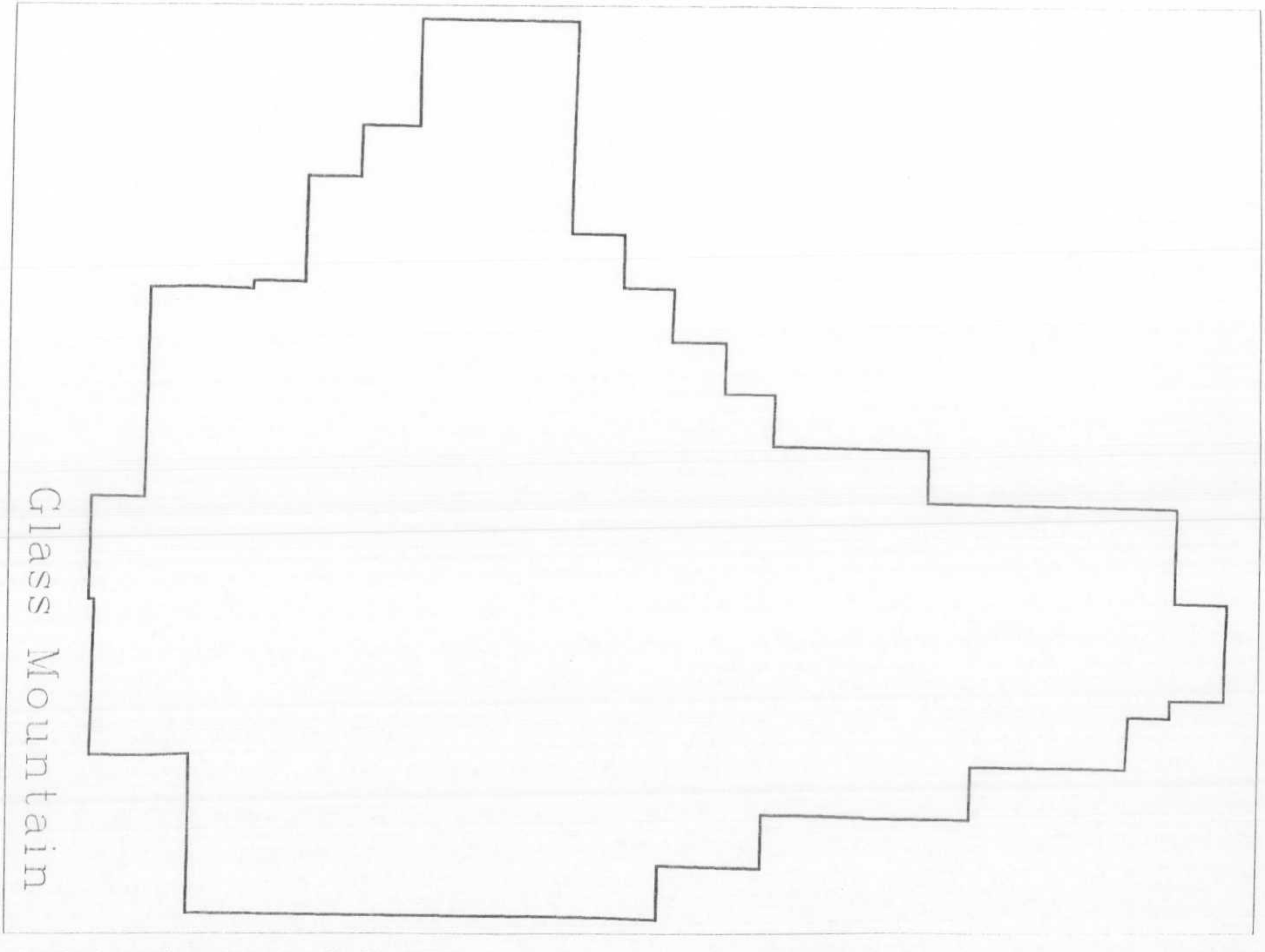
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:07:38



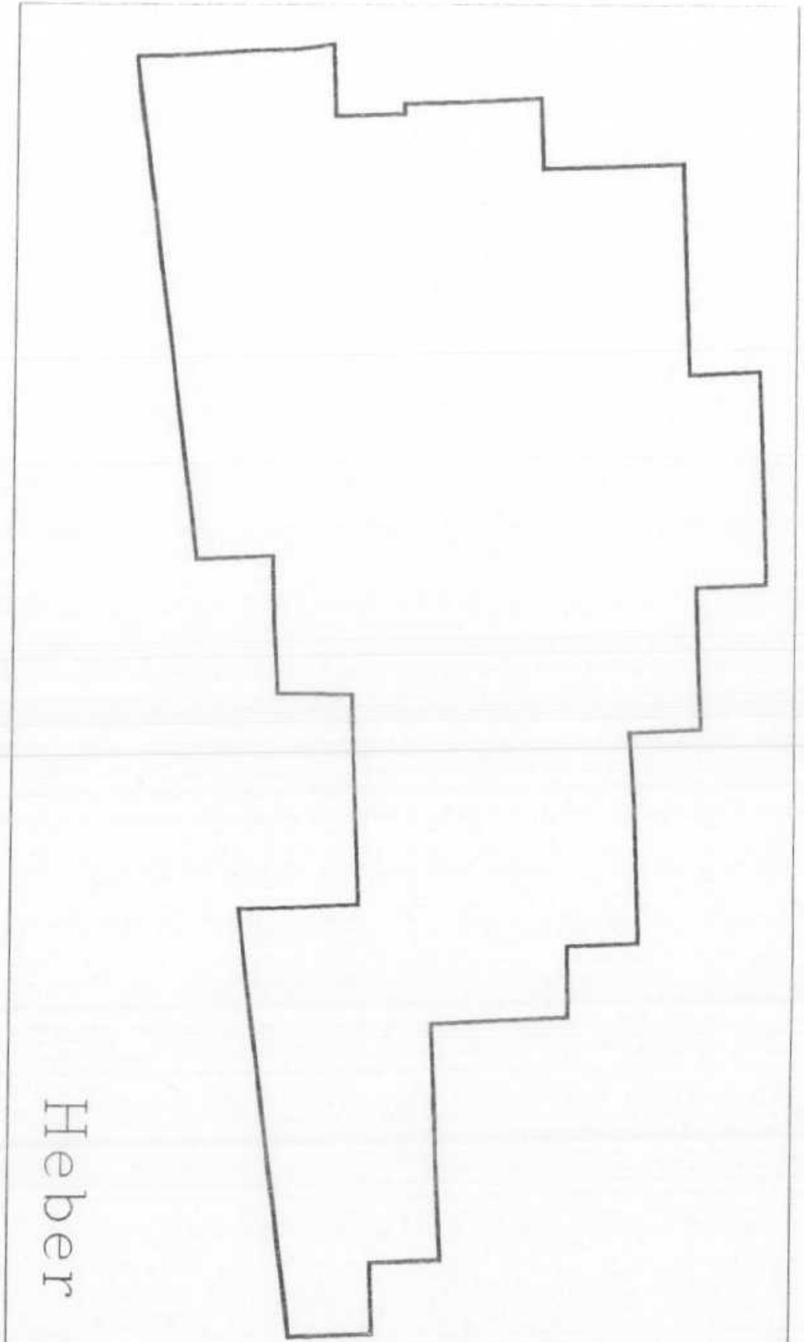
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 08:55:23



c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:05:03

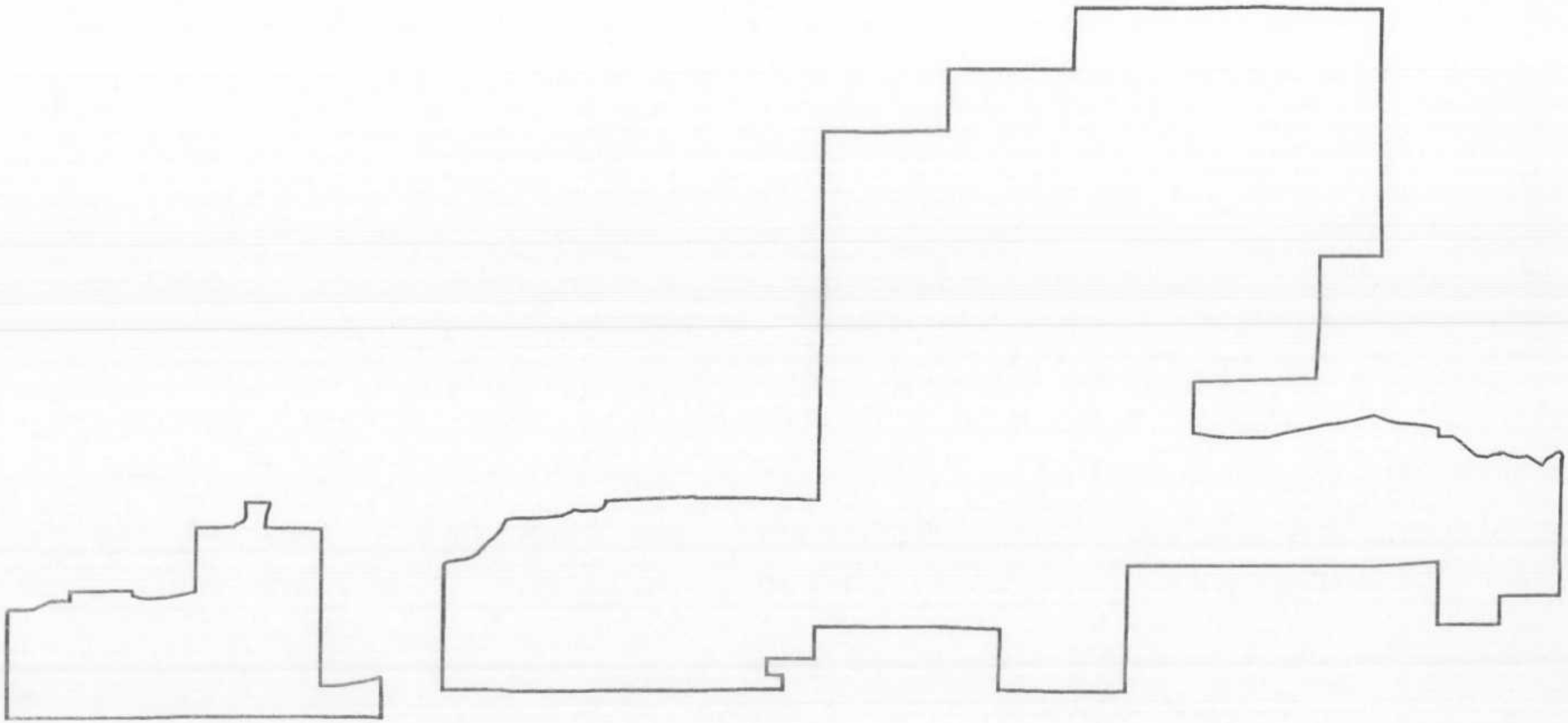


c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 08:50:37

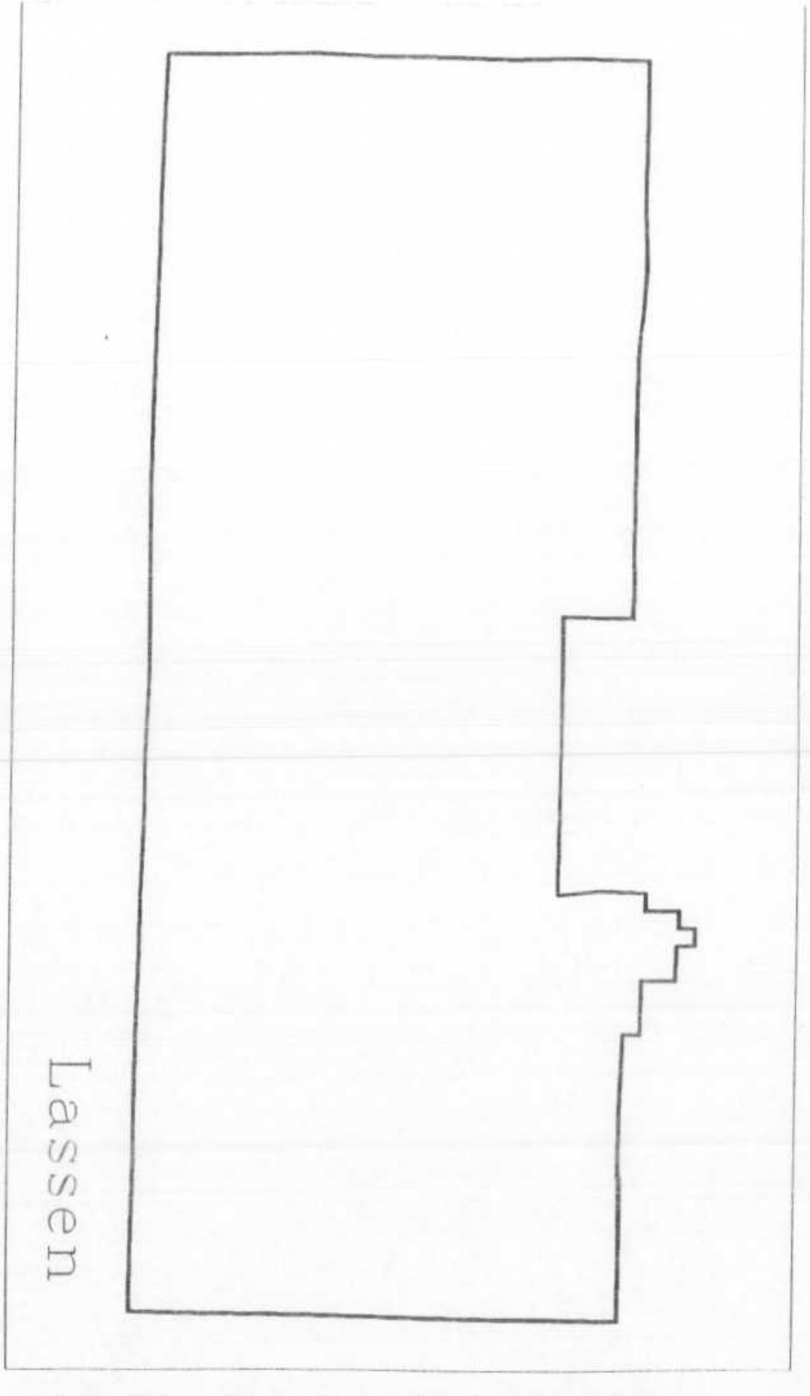


c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:06:23

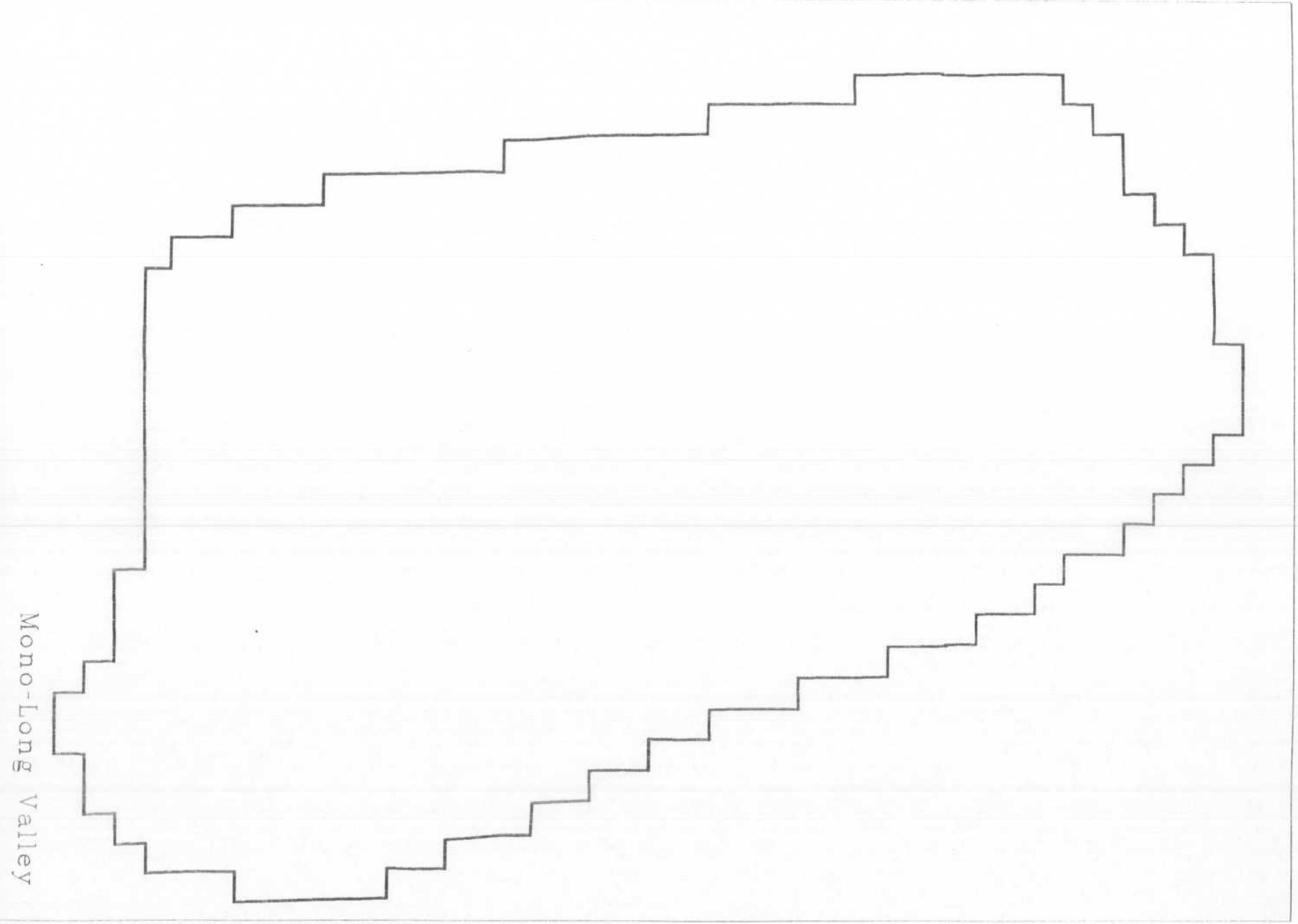
Lake City - Surprise Valley



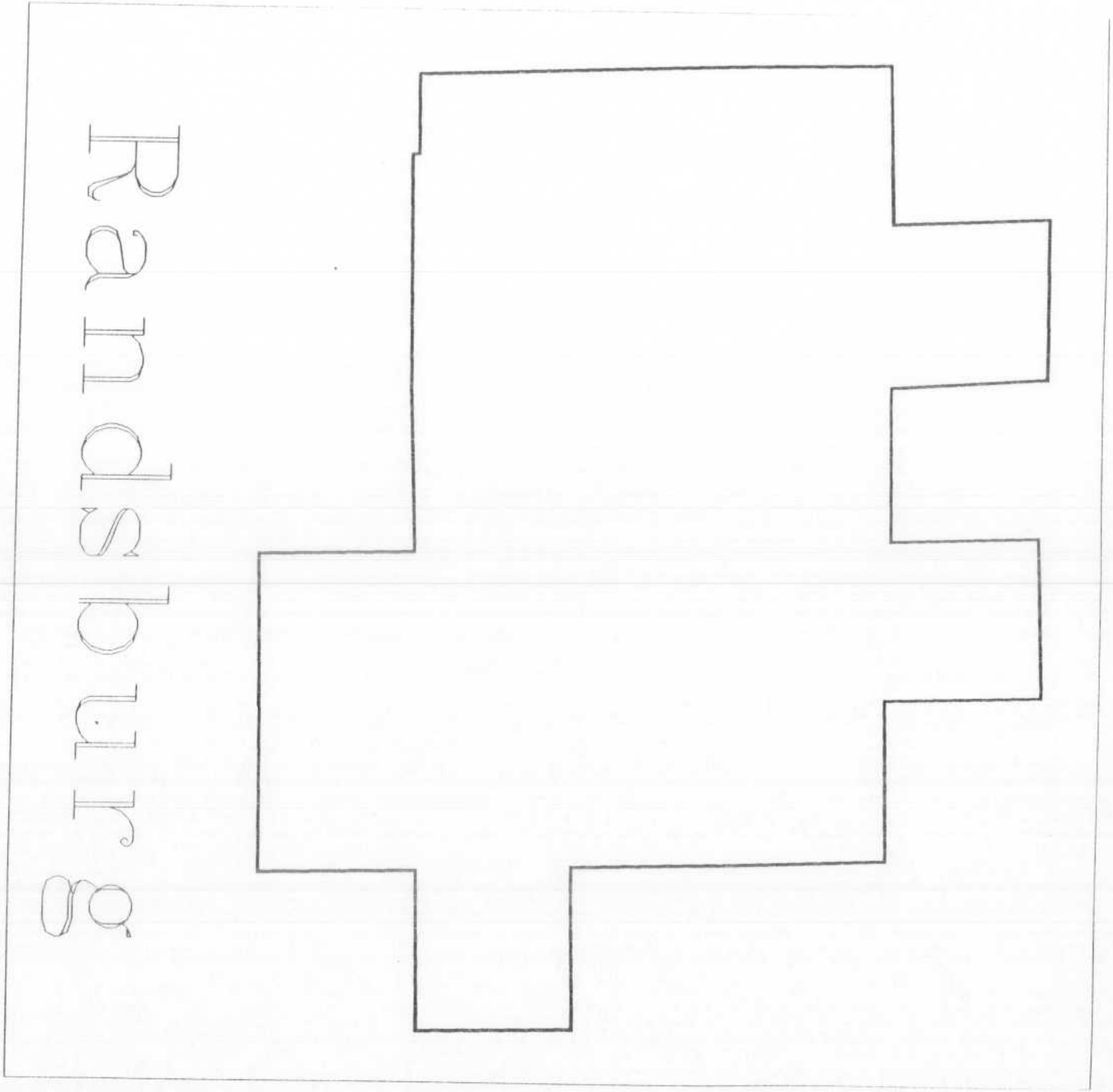
\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 08:51:33



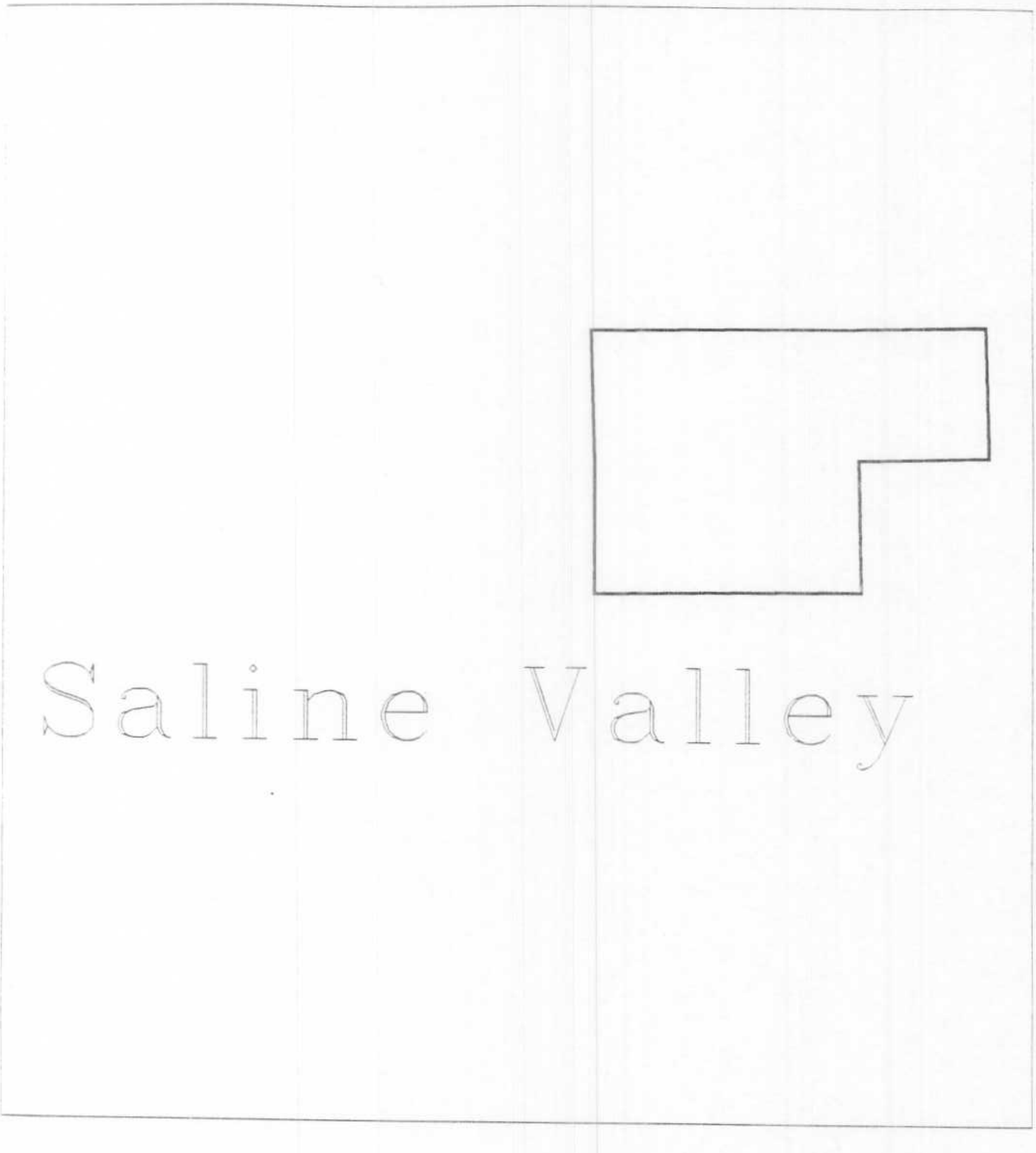
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 08:52:55



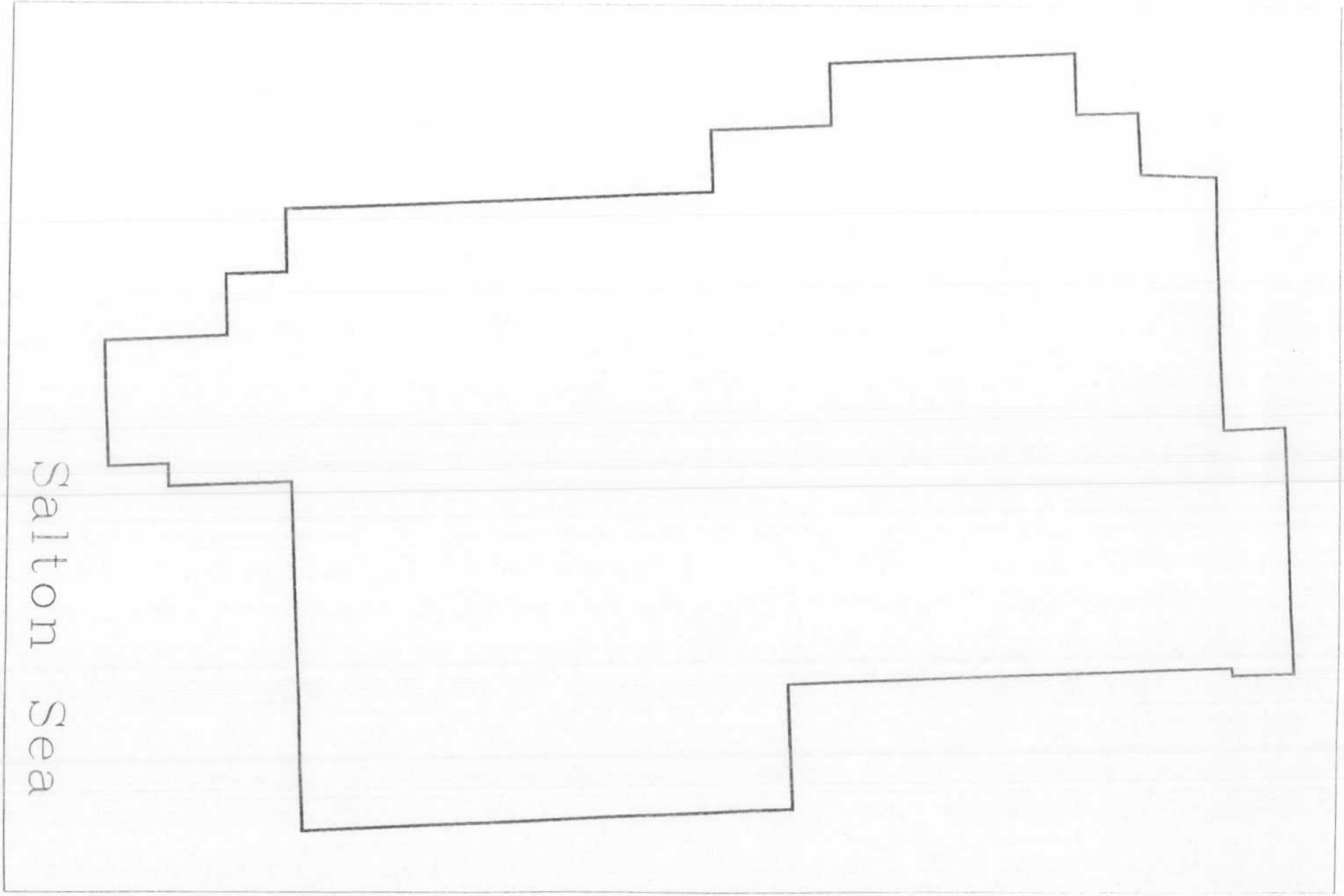
-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 08:58:11



c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:01:22



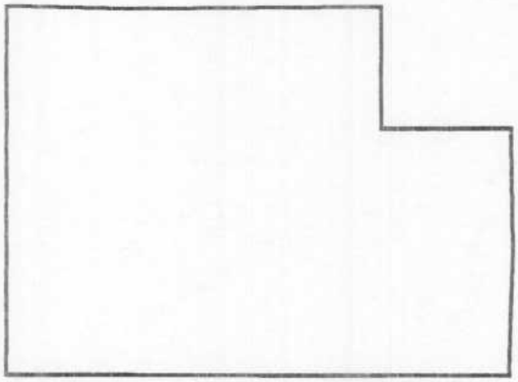
c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:35:37



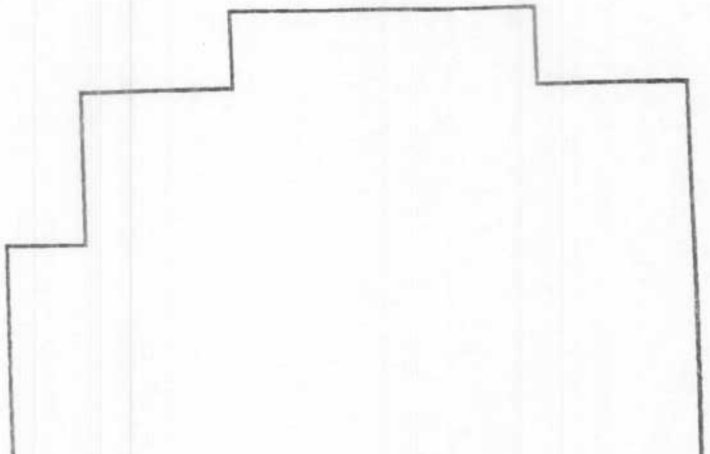
Page 20

c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:02:32

Sespe Hot Springs

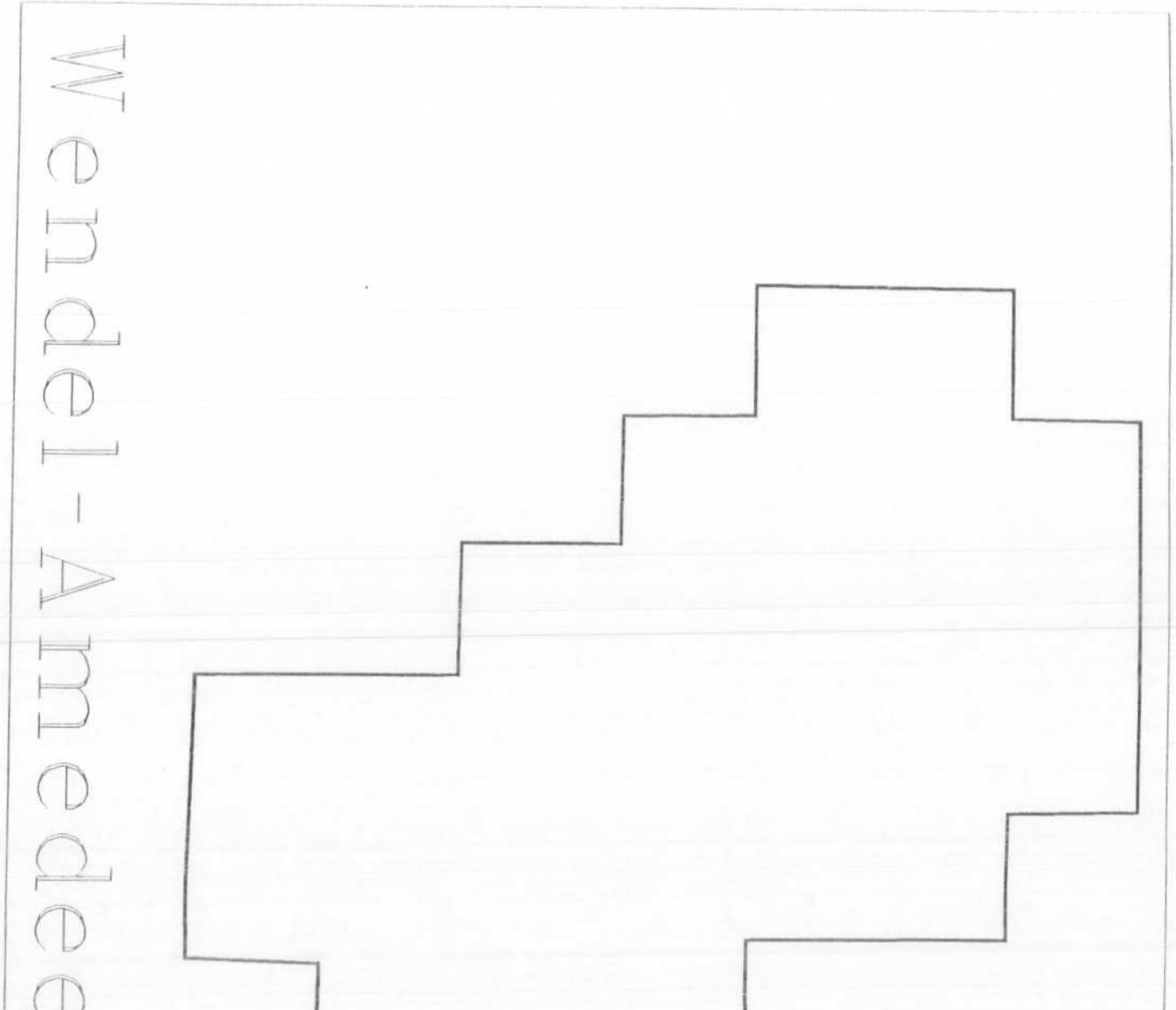


c: \-data\gis\sprgwell\sprgwell.dgn May. 10. 1994 09: 36: 16



South Brawley

c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 09:03:19



c:\-data\gis\sprgwell\sprgwell.dgn May. 10, 1994 08:54:08