GL00907

LOW-TEMPERATURE RESOURCE ASSESSMENT PROGRAM

by

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ABSTRACT

In Fiscal Year 1991, Congress appropriated money for the Department of Energy to begin a new program in the evaluation and use of low- and moderate-temperature geothermal resources. The objective of this program is to promote accelerated development of these resources to offset fossil-fuel use and help improve the environment. The program will consist of several components, including: (1) compilation of all available information on resource location and characteristics, with emphasis on resources located within 8 km (5 miles) of population centers; (2) development and testing of techniques to discover and evaluate low- and moderate-temperature geothermal resources; (3) technical assistance to potential developers of low- and moderate-temperature geothermal resources; and (4) evaluation of the use of geothermal heat pumps in residential and commercial applications. Program participants will include the Geo-Heat Center at the Oregon Institute of Technology, the University of Utah Research Institute, the Idaho Water Resources Research Institute and agencies of state governments or Universities in most of the western states.

INTRODUCTION

Low-to-moderate temperature geothermal resources are widely distributed throughout the United States (Reed, 1983) and can provide a source of energy for many direct-heat applications. In contrast to other renewable resources, geothermal energy is not hindered by a cyclical output as in the case of wind and solar. It is a base load (constant output) resource the application of which does not require sophisticated storage strategies. Geothermal energy in the low temperature range can have a significant impact on U.S. energy consumption, especially with regard to space heating. Space heating in the 50° to 82°C (120° to 180°F) range is by far the largest single U.S. energy use, representing 45 percent of all energy use below 260°C (500°F). Matching geothermal resources to meet these space heating requirements would result in much better use of U.S. energy reserves and reduce emissions from fossil fuel.

Much of the recent interest in developing direct-heat resources may be attributed to a Department of Energy initiative, the State Coupled Program, which began in 1977. As a result of this program, geothermal resource maps were compiled and distributed for 18 western states. The maps, typically printed at a scale of 1:500,000, identify wells and springs with anomalous temperatures, and were released from 1980 to 1983. These maps, and the data and reports upon which they were based, have been extremely useful to the more aggressive developers, and form an important starting point for the current update assessment study.

The Geo-Heat Center of Oregon Institute of Technology authorized a study of the collocation of geothermal resources and communities for eight western states (Allen, 1980). The criteria used in this study included incorporated cities located within 8 km (5 miles) of a thermal well or spring having a temperature of 50°C (122°F) or greater. This inventory identified a total of 1,277 hydrothermal sites within 8 km (5 miles) of 373 cities, having a combined population of 6,720,347 persons, in the eight states. The total heat for all cities, exclusive of industrial loads, was estimated at 140 x 10^{12} kJ/yr (133 x 10^{12} Btu/yr).

While the 1980 Allen study was quite instructive and arrived at impressive population and heat-load estimates, it was limited in scope to only eight states, and did not account for low-temperature uses for agriculture, greenhousing, or aquaculture. Also, it predated the publication of results from the DOE State Coupled Program. Clearly, the Allen study is outdated.

We believe a complete inventory of collocated resources and population centers will indicate a potential heat load for the western states (exclusive of industrial loads) more than 10 times the Allen estimates. It is apparent that geothermal energy could make a much more substantial contribution to our energy picture; but, the private sector needs the necessary information and stimulation.

LOW-TEMPERATURE PROGRAM

The program is a cooperative effort among a number of academic and state institutions working with potential direct-heat developers. The three principal institutions are the Geo-Heat Center at the Oregon Institute of Technology, the Idaho Water Resources Research Institute at the University of Idaho, and the Earth Science Laboratory of the University of Utah Research Institute. State Teams compiling data for ten states in the west are also participating. In addition, participation of eastern institutions knowledgeable in geothermal heat pumps is planned. The tasks for this project are discussed below.

Compilation of Data on Hydrothermal Resources

State geothermal resource teams will review and update their geothermal resource inventories which were completed as part of the USGS-DOE national assessment from 1977-1983. Each state will prepare a comprehensive digital database in table format and a resource map at a scale of 1:1,000,000. UURI and OIT will provide technical guidance and coordination, and UURI will complete 10 fluid chemistry analyses for each state. Table 1 identifies the state agencies and principal investigators involved with the project.

Table 1. State Resource Assessment Teams

State	Agency	Principal Investigator
California	Division of Mines and Geology	Leslie Youngs
Colorado	Colorado Geological Survey	James Cappa
Idaho	Idaho Water Resources Research Institute	Leland Mink
Montana	Bureau of Mines and Geology	Wayne Van Voast
New Mexico and Arizona	New Mexico State University-Southwest Technology Development Institute	James Witcher and Rudi Schoenmackers
Nevada	Bureau of Mines and Geology	Larry Garside
Oregon	Dept. of Geology and Mineral Industries	George Priest
Utah	Utah Geological Survey	Robert Blackett
Washington	Division of Geology and Earth Science	Eric Schuster

The compilations will include resources in the temperature range of 20° to 150°C (68° to 300°F) many of which have potential to supply energy to collocated cities within approximately 8 km (5 miles) of a resource as well as greenhouses, aquaculture, mining, and other process applications.

The State Teams, under subcontract to OIT and with guidance from UURI, are reviewing drilling records and other information to identify new resources and verify temperatures and flow rates of springs and wells which may have changed substantially since the previous statewide geothermal resource inventory. The databases will be organized into tables linked by common data-fields, using the preliminary database from the Utah Geological Survey as a model for uniformity in presentation (Blackett, 1993). Information to be contained in the tables is listed below:

Table 1. Location: ID number, source name, county code, latitude and longitude.

Table 2. Description: ID number, source name, type of

source, temperature (°C), flow rate (L/min), depth of wells (m), current resource use, and references to relevant studies (geology, geophysics, geochemistry, hydrology) completed for the site.

Table 3. Geochemistry: ID number, source name, pH, TDS, major cations, major anions, cation-anion balance, chemical species that may cause scale and corrosion products, and light stable isotopes.

Simultaneously, we will collect and interpret demographic and other data to evaluate potential heat loads, fossil-fuel displacement, utility electrical-demand reduction and load-leveling opportunities, and environmental benefits for potential geothermal direct-heat applications.

These two data sets, resource and demographic, will be jointly interpreted with the main objective of making a prioritized list of resources which have highest potential for economic development with significant benefit for in depth studies. Promising resources for near-term development will be studied in more detail when Phase 2 funding becomes available.

At the same time, we will undertake R&D on better cost effective methods for locating low-and moderate-temperature geothermal resources and on siting successful test and production wells. Part of this work will encompass development of better well-testing methods and better hydrologic models of these hydrothermal resources. These tasks are expected to pay off in further discoveries of resources and in better methods to evaluate reservoir production and ultimate-development capacity at an earlier stage in the development cycle than is possible now.

Geothermal Heat Pump Analysis and Use

We are collecting and interpreting information on the performance of residential and commercial installations of geothermal heat pumps (GHPs). This will yield information on: (1) the most effective and successful utility marketing and incentive programs to expand GHP markets; (2) the benefit to utilities from reduced peak demand and higher annual load factors; (3) barriers to market entry; (4) the potential total national energy savings contribution from GHPs; and (5) suitability of GHPs for northern climates. Energy-use patterns are being documented before and after installation of GHPs in typical residential and commercial situations, along with energy savings and life-cycle costs.

Based on contacts with 36 utilities, they see geothermal heat pumps as a peak reducing demand side management (DSM) tool and many offer incentives of some kind. Incentive programs offered by utilities to customers include: rebates of $125 to $500 per ton of installed capacity, low cost loans, discounts on electric rates for the heat pump system, and in some cases they install ground coupled closed loops. In some cases, heat pumps are seen as a means of retaining customers with all-electric homes built in the 1960s to early 70s who are now tempted to switch to cheaper natural gas. Barriers to market entry of GHPs are higher initial costs ($800 to $1000/ton) than other HVAC systems due to incremental cost of the ground loop heat exchanger installation and a lack of an infrastructure of ground loop contractors and dealers. Where there are good contractors and inspections, customer satisfaction has been good.

A preliminary performance analysis has been evaluated for two ground-coupled heat pump (GCHP) residential systems in Minnesota from data obtained from United Power Association, Elk River, MN (Connett, 1993). Data was collected on an hourly basis, monitoring ground loop supply and return temperatures, outside air temperature, compressor power, circulating pump power, and water heater power.

The first home (260 m^2 or 2800 ft^2) located in Stanchfield, MN was installed with a 4-ton heat pump using a vertical ground-coupling of five 45.7 m (150 ft) boreholes. Figure 1 shows a comparison of the geothermal heat pump with an air-source heat pump for a peak winter day when the outside temperature was at -28°C (-18°F). The geothermal heat pump had a 7.4 Kw lower peak demand and 5,294 Kwh lower annual heating and cooling energy than the air heat pump. The annual savings for the GHP was 11% for the cooling and 34% for the heating seasons compared to the air heat pump.

Figure 1. Demand comparison of a geothermal heat pump (vertical ground-coupled) with an air-source heat pump.

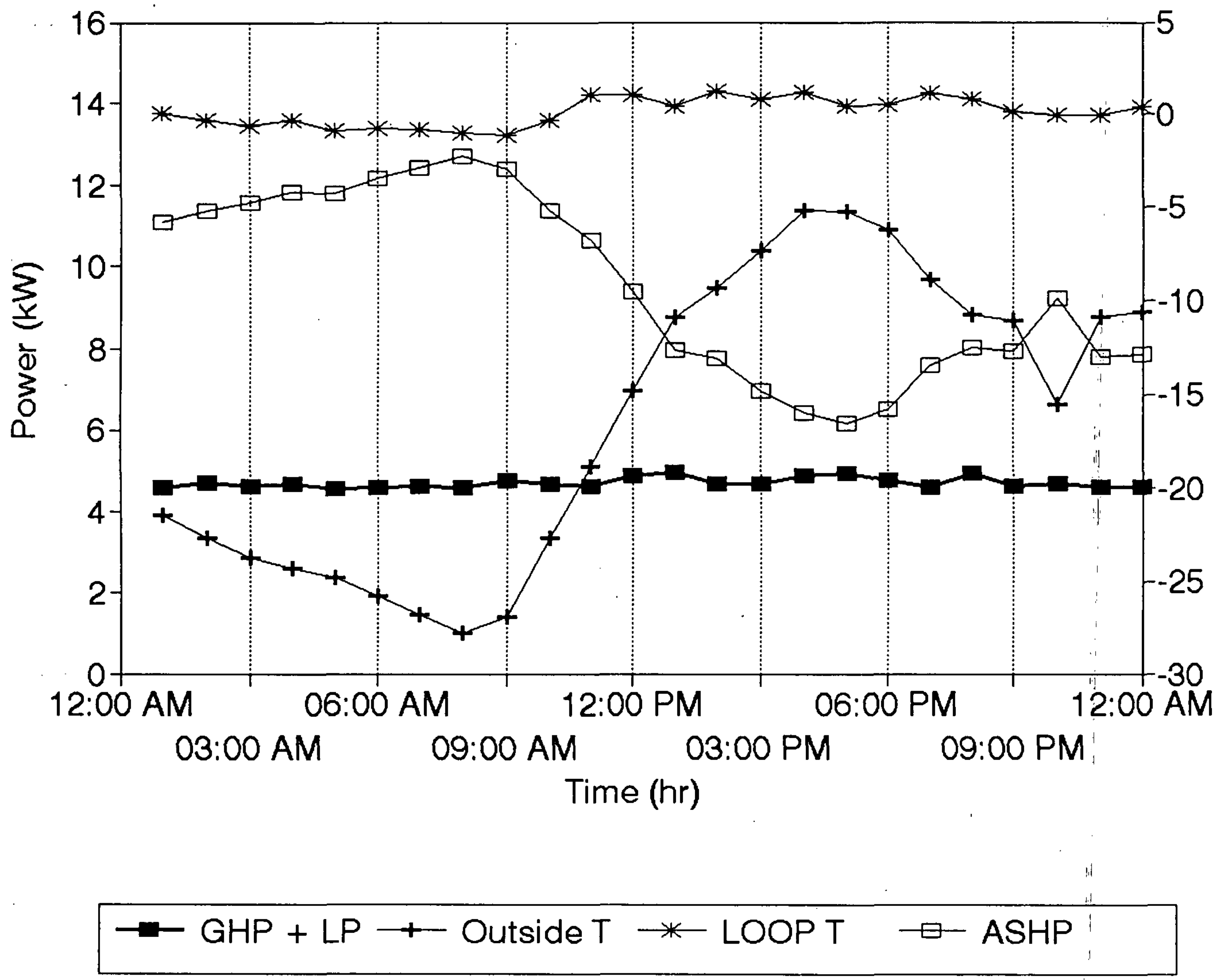
The second home (260 m^2 or 2800 ft^2) located in Zimmerman, MN was installed with a 5-ton heat pump using a horizontal ground-coupling of 671 m (2200 ft) of pipe. The GHP had a 5.7 Kw lower peak demand than the air heat pump on the coldest winter day. Figure 2 shows a comparison of water temperatures in the loops for the vertical and horizontal configurations. A difference of about 6°C (10°F) in the winter and 11°C (20°F) in the summer will result in a better performance for the vertical ground-coupled heat pump.

Figure 2. Loop supply temperature comparison for vertical and horizontal ground-coupled heat exchangers.

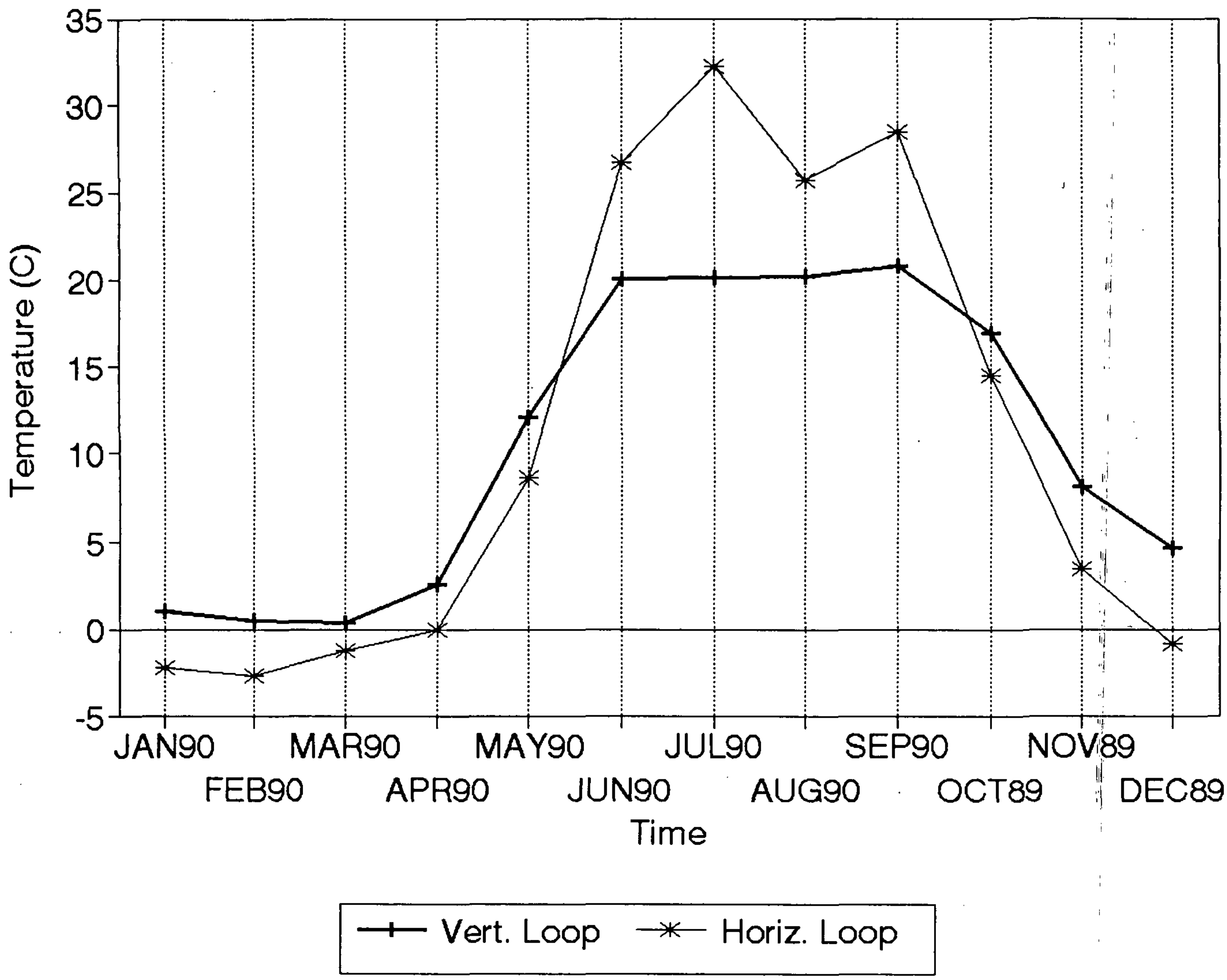
In the course of the above work, we will identify weaknesses in the technology and data base, with the objective of describing needed R&D that would accelerate GHP use.

Outreach and Public Education

All project personnel are working cooperatively and closely with state and local agencies, energy offices and other public entities. This network will bring information on geothermal resources and their uses to the public and to potential geothermal developers. We are also working closely with the Geothermal Resources Council, the National Geothermal Association, the



Power (kW)
Temp. (deg. C)
Time (hr)
12:00 AM
03:00 AM
06:00 AM
09:00 AM
12:00 PM
03:00 PM
06:00 PM
09:00 PM
12:00 AM
GHP + LP
Outside T
LOOP T
ASHP



35
30
25
20
15
10
5
0
-5
Temperature (C)
JAN90
FEB90
MAR90
APR90
MAY90
JUN90
JUL90
AUG90
SEP90
OCT89
NOV89
DEC89
Time
Vert. Loop
Horiz. Loop

Geothermal Education Office and other entities in the geothermal community. We are developing brochures on geothermal direct-heat, fact-sheets on GHPs and geothermal energy in general. We will also produce an informative video for general national distribution on geothermal energy and its advantages.

FUTURE PLANS

The state teams will complete their inventory, database listings, and resource occurrence maps in FY-93 and early FY-94. These will be reviewed and edited by UURI and OIT. OIT will complete the collocation study and with UURI and IWRRI, will prioritize resources for more detailed study. The results will be reviewed by and discussed with the appropriate state teams. UURI will complete fact sheets to inform Congress of the progress, and with OIT and IWRRI will solicit support for Phase 2 funding of additional states and detailed studies for the most promising resources for near-term development. We envision the present program to be the first part of an ongoing effort that will take possibly 5 years to complete.

Further information on this program can be obtained by contacting any of the authors, or Mr. Joel Renner, INEL, P.O. Box 1625-3830, Idaho Falls, ID 83415 or Mr. Marshall Reed or Mr. Lew Pratsch, U.S. Department of Energy, 1000 Independence Avenue SW, Washington, D.C. 20585.

ACKNOWLEDGEMENT

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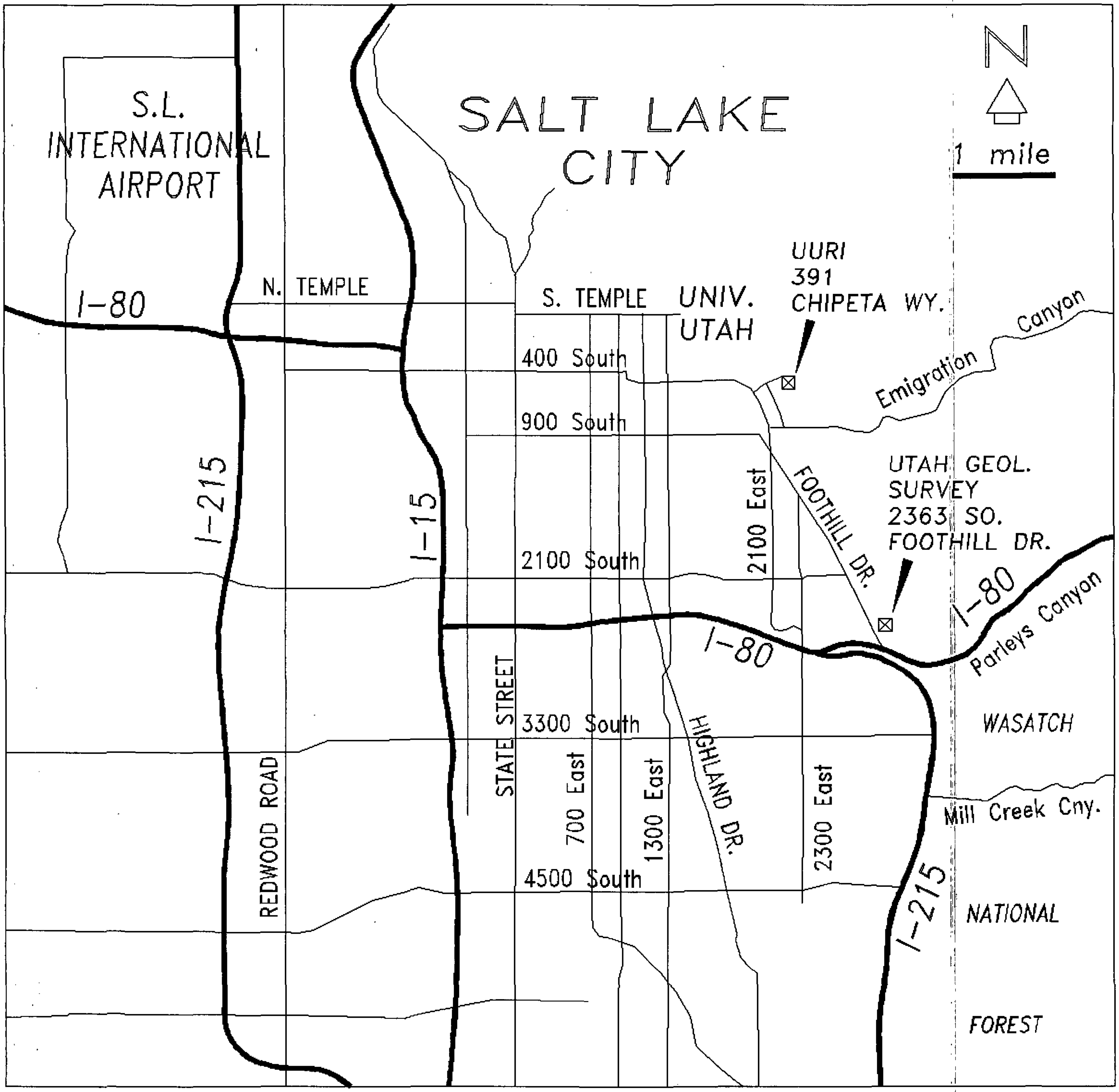
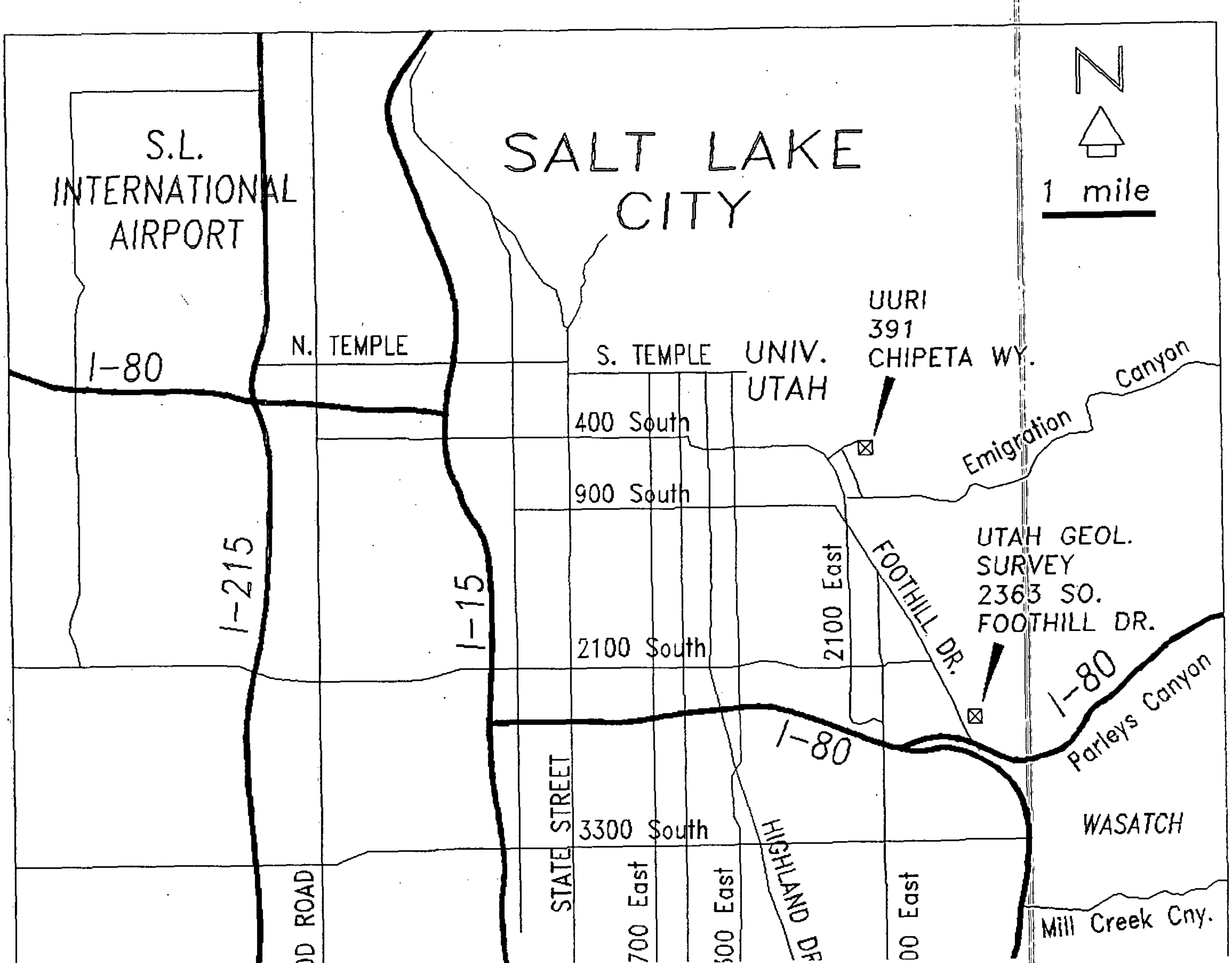
Connett, G., 1993. "Gary Ostrum Ground Water Heat Pump", United Power Association, Elk River, MN, 11 p.

Muffler, L.J.P., editor, 1979. "Assessment of Geothermal Resources of the United States - 1978", U.S. Geological Survey Circular 790, 163 p.

Reed, M.J., editor, 1983. "Assessment of Low-Temperature Geothermal Resources of the United States - 1982", U.S. Geological Survey Circular 892, 73 p.



PHONES: UGS – (801)467-7970; UURI – (801)584-4442



ACCOMMODATIONS

We have inquired about accommodations for three motels on the east bench, fairly near the Utah Geological Survey and UURI. A number of restaurants are near the Scenic Motel. Commercial or government rates (where applicable) for a single room are shown.

Scenic Motel, 1345 S. Foothill Drive (801) 582-1527
$29.99 + tax = $32.00 (only rate)

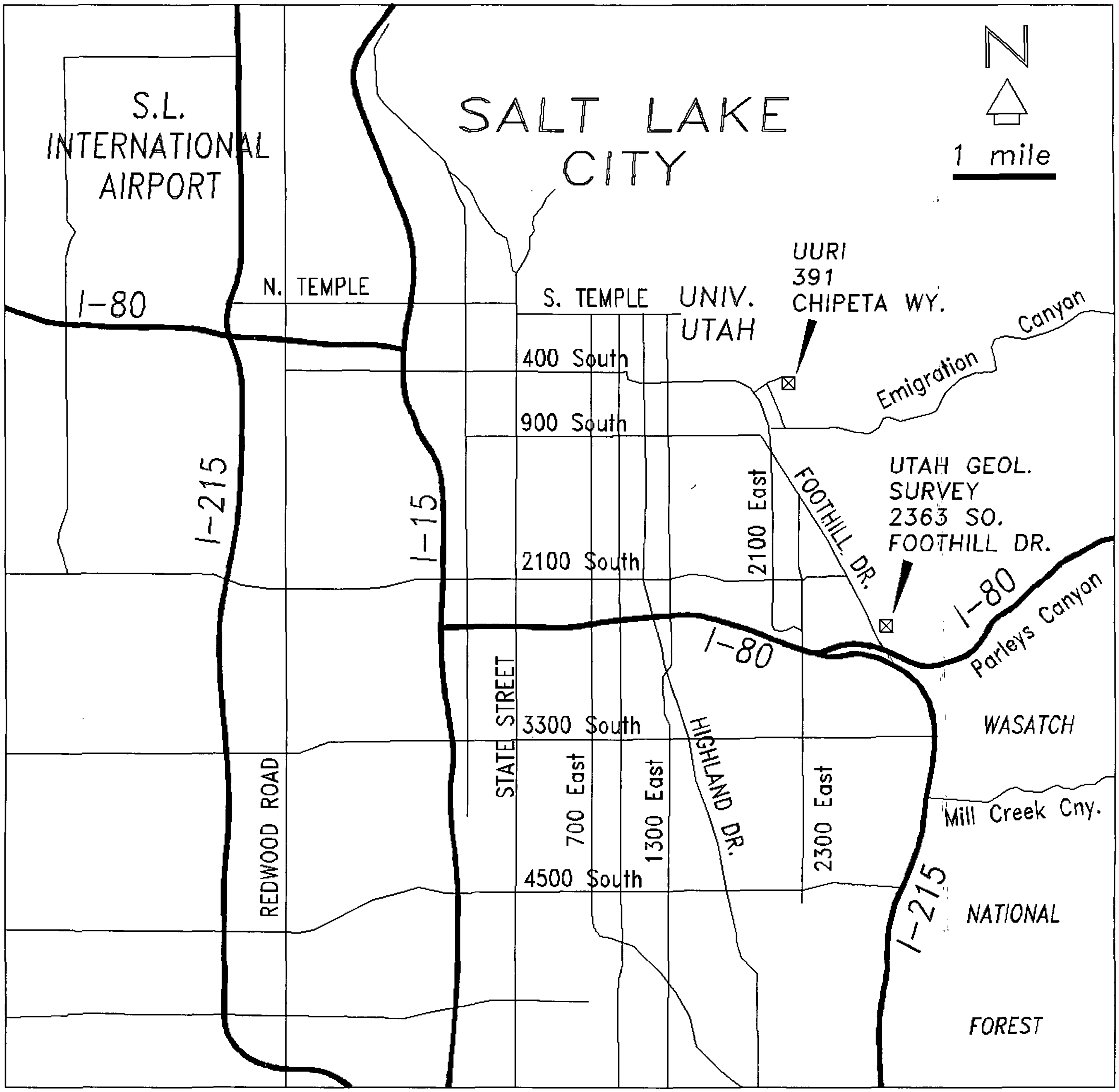
Skyline Inn, 2475 E 1700 S (801) 582-5350
$39.00 + tax = $43.00 (govt. rate)

Country Club Motor Inn, 2665 E. Parley's Way (801) 486-1034
$34.00 + tax = $37.49 (discount rate; $38.00 reg. rate)

The Scenic Motel and the Skyline Inn are closest (2-3 mi) to the UGS offices. There is some (limited) Limo service to these East Side motels; check at the airport. Taxi fare is $15-20. UURI could probably provide transportation from east side motels to the UGS on Thursday morning and a return to motels that night.

For those who might prefer to stay at lower cost motels downtown:

Motel 6-Downtown, 176W Sixth South (801) 531-1252
$31.95 + tax = $35.22



PHONES: UGS – (801)467-7970; UURI – (801)584-4442

Low Temperature Geothermal Meeting Agenda

THURSDAY JULY 8, 1993 8:30 a.m. to 5:00 p.m.

8:30 a.m.

Welcome and Introduction - Blackett, Ross

Origin of the Low-Temperature Resources and Technology Transfer Program - Lienau, Wright

Idaho Water Resources Research Institute Program - Mink

DOE/GD View of the Low-Temperature Program - Reed

GEOTHERM Database - Bliss

Utah Geological Survey - Information Program - Sprinkel

Utah Geological Survey Low-Temperature Program - Blackett

Fluid Chemistry and Geothermometers - Adams/Moore

12:00 - 1:30 p.m. - Lunch - area restaurants

1:30 p.m.

Discussion Items - All

- Database - General
- Database - Geochemical
- Collocation of Resources and Users
- Resource Prioritization
- Problems
- Other Topics

4:00 p.m.

Phase 2 Funding - Wright, Lienau, Mink

FRIDAY JULY 9, 1993

8:30 a.m. - 2:30 p.m.

Field Trip to Midway, Utah (with box lunches)

Carryover of Discussions

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UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

MEMORANDUM

TO: Principal Investigators, State Geothermal Resource Teams, and Other Participants

FROM: Howard Ross *HR*
Paul Lienau

SUBJECT: Informal Meeting, Low-Temperature Resource Assessment Program, July 1993

DATE: June 9, 1993

The best dates for a meeting of the Low-Temperature Resource Assessment Program participants appear to be Thursday and Friday, July 8 and 9. Unfortunately, not everyone involved will be able to attend. We hope to complete most of the relevant discussion on the first day (July 8) but would like to reserve the second day for carry-over discussions, or possibly a one-day geothermal field trip in central Utah if time and interest permit. Bob Blackett, Utah Geological Survey (UGS) has volunteered the use of the UGS conference room at their offices on 2363 South Foothill Drive in Salt Lake City. A map is enclosed.

We propose an informal meeting with a few formal presentations and lots of discussion regarding the databases, problems, collocation of resources, priorities for future work, and how to obtain Phase 2 funding. We hope that these discussions will help to improve, and standardize, the databases.

Some specific topics already suggested for discussion follow:

Database - General

* How should we handle repeated data (chem, temp, flow) for a single well or spring? The time span could be > 50 years.
* How should we handle data from multiple wells or spring vents in a small area (<0.5 km2)?
* Should the database be complete, but edited to form a map output?
* Should we allow data in other than metric units?
* How much location data does DOE/OIT require?
* What unpublished studies or gray literature reports are available which may not be available to State Teams?

Database - Geochemical

* What chemical data should be included in the Tables?
* How much optional data should be included?
* How should non-essential chemistry be handled but preserved?
* Should geothermometer temperatures be included?

EarthInfo *Inc.*

USGS QUALITY OF WATER 1991

PRODUCT OVERVIEW

EarthInfo's USGS Quality of Water provides fast access to the water quality information in the USGS WATSTORE database. The data represents more than 34,000,000 observations, from 215,000 stations, of 5,000 parameters including organics, inorganics, metals, pesticides, and more. All of this data fits on four regional surface water discs and four regional groundwater discs.

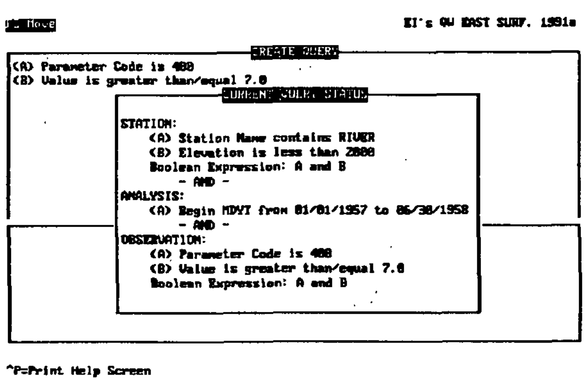
The QW database is indexed and searchable for more than 30 different station, analysis, and observation criteria. Users can create searches to retrieve, in minutes, the exact data of interest.

Earthinfo's new **CD²** (CD-squared, for Compact Disc Database) query engine and **CD²*xs*** access software link the expanded capability of your personal computer with CD-ROM technology. **CD²** provides an advanced CD-ROM database retrieval system that redefines the standard for fast, convenient data access on demand. Data research and tabulation that used to take months can now be accomplished in hours.

FEATURES

• **Operate** the program through drop-down menus and command-key functions. With the intuitive user interface, you can filter data, mark items of interest, move rapidly up and down the database hierarchy, and then export the data you need.

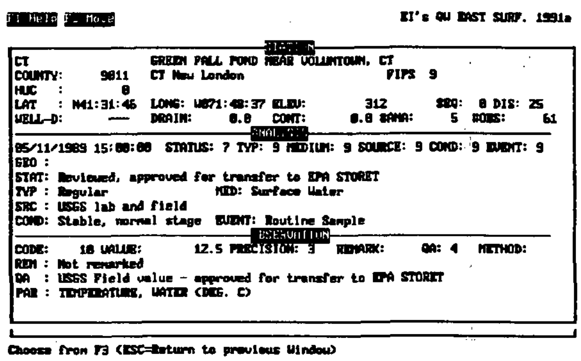
• **Query** the entire contents of a CD-ROM using Boolean combinations of search criteria for station, analysis, and observation records. Use prebuilt queries or build your own.



• **Filter** data sets by restricting the values of station, analysis, and observation fields.

• **Sort** a data set using values in up to five different types of fields.

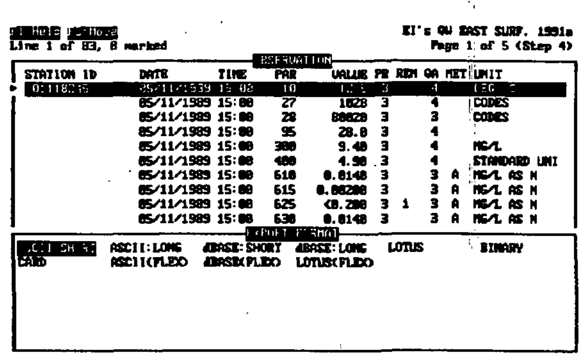
• **View** all station, analysis, and observation information for a specific record with the push of a button.



• **Save** any set of stations, analyses, or observations. Save queries and query restrictions. Saved sets and queries are stored and can be displayed at any time for loading, renaming, or deleting.

• **Join** two sets together to combine all the records in both sets. Or filter one set with the values in another.

• **Export** data in ASCII, Lotus, dBASE, binary, or card record format. Use flexible export to select only the fields you want, and export preview to see the data before you send it to a file.



WINDOWS ON THE DATA

Station Window: Lists, on three screens, state PO code, station ID, station name, latitude, longitude, hydrologic unit, county, site code, FIPS code, sequence number, district, aquifer type, elevation, well depth, drainage area, and contributing area.

F1-Help F2-Query F3-Move F4-Output F5-Mark F10-Exit   EI's QW EAST SURF. 1991a
Line 1 of 1063, 0 marked   Page 1 of 68 (Step 2)

STATION

ST	STATION ID	NAME	LATITUDE	LONGITUDE	#OBS
CT	01118245	GREEN FALL POND NEAR VOLUNTOW	N41:31:46	W071:48:[illegible]	61
CT	01118255	GREEN FALL R AT LAUREL GLEN,C	N41:28:20	W071:49:00	52
CT	01118280	WYASSUP BK NR N STONINGTON CT	N41:29:12	W071:52:09	40
CT	01118300	PENDLETON HILL BK NR CLARKS F	N41:28:29	W071:50:05	117
CT	01118350	GREEN FALL R AT CLARKS FALLS,	N41:27:17	W071:48:52	73
CT	01118370	YAWBUCS BK NR N STONINGTON, C	N41:27:35	W071:54:12	48
CT	01118373	SHUNOCK R AT N STONINGTON, CT	N41:26:27	W071:52:58	17
CT	01118375	ASSEKONK BK NR N STONINGTON C	N41:26:19	W071:54:39	49
CT	01118380	ASSEKONK BK AT N STONINGTON C	N41:26:19	W071:53:05	51
CT	01118400	SHUNOCK R NR N STONINGTON,CT.	N41:24:36	W071:50:43	11
CT	01118498	PAWCATUCK RIVER AT STILLMANVI	N41:23:10	W071:50:00	15
CT	01118520	PAWCATUCK R NR PAWCATUCK,CT.	N41:20:09	W071:50:22	21
CT	01118525	PAWCATUCK R NR PAWCATUCK, CT.	N41:19:37	W071:50:59	2536
CT	01118535	ANGUILLA BROOK NEAR NORTH STO	N41:24:21	W071:52:41	186
CT	01118550	ANGUILLA BK AT WEQUETEQUOCK,C	N41:21:56	W071:52:00	256
CT	01118620	STONINGTON HARBOR AT STONINGT	N41:20:30	W072:54:44	16
CT	01118621	STONINGTON HARBOR AT STONINGT	N41:20:02	W072:54:46	16
CT	01118622	STONINGTON HARBOR AT STONINGT	N41:19:34	W072:54:35	16

Choose from Menus (F2-F5) (Enter=Step To, ESC=Step Back, ^F=Filter, ^T=Sort)

Analysis Window: Lists, on two screens, station ID, begin date and time, medium, sample type, status, source, hydrologic condition, hydrologic event, geologic unit, end date and time, collecting agency, and analyzing agency.

F1-Help F2-Query F3-Move F4-Output F5-Mark F10-Exit   EI's QW EAST SURF. 1991a
Line 1 of 20, 0 marked   Page 1 of 2 (Step 3)

ANALYSIS

STATION ID	DATE	TIME	MED	TYP	STAT	SRC	COND	EVT	#OBS	GEO
01118245	05/11/1989	15:00:00	9	9	[illegible]	9	9	9	[illegible]	
01118245	09/06/1989	14:00:00	9	9	7	9	9	9	14	
01118245	09/06/1989	14:05:00	9	9	7	9	9	9	12	
01118245	09/06/1989	14:10:00	9	9	7	9	9	9	12	
01118245	09/06/1989	14:15:00	9	9	7	9	9	9	12	
01118255	09/24/1963	13:00:00	9	9	7	A	A	9	22	
01118255	04/09/1964	15:00:00	9	9	7	A	A	9	20	
01118255	09/22/1964	12:00:00	9	9	7	A	A	9	10	
01118280	09/24/1963	12:40:00	9	9	7	A	A	9	20	
01118280	04/09/1964	14:25:00	9	9	7	A	A	9	20	
01118300	04/24/1962	14:50:00	9	9	7	A	A	9	28	
01118300	11/28/1962	14:45:00	9	9	7	A	A	9	29	
01118300	04/18/1963	06:50:00	9	9	7	A	A	9	29	
01118300	04/09/1964	14:40:00	9	9	7	A	A	9	22	
01118300	09/22/1964	12:10:00	9	9	7	A	A	9	9	
01118350	09/24/1963	12:50:00	9	9	7	A	A	9	19	
01118350	09/24/1963	13:10:00	9	9	7	A	A	9	22	
01118350	04/09/1964	14:50:00	9	8	7	A	A	9	20	

Choose from Menus (F2-F5) (Enter=Step To, ESC=Step Back, ^F=Filter, ^T=Sort)

Observation Window: Lists Station ID, date, time, parameter code, parameter name, value, precision, remark code, QA code, method code, and units.

F1-Help F2-Query F3-Move F4-Output F5-Mark F10-Exit   EI's QW EAST SURF. 1991a
Line 1 of 83, 0 marked   Page 1 of 5 (Step 4)

OBSERVATION

STATION ID	DATE	TIME	PAR	VALUE	PR	RMK	QA	MET	UNIT
01118245	05/11/1989	15:00	10	12.5	3		4		DEG. C
	05/11/1989	15:00	27	1028	3		4		CODES
	05/11/1989	15:00	28	80020	3		3		CODES
	05/11/1989	15:00	95	28.0	3		4		
	05/11/1989	15:00	300	9.40	3		4		MG/L
	05/11/1989	15:00	400	4.90	3		4		STANDARD UNI
	05/11/1989	15:00	610	0.0140	3		3	A	MG/L AS N
	05/11/1989	15:00	615	0.00200	3		3	A	MG/L AS N
	05/11/1989	15:00	625	<0.200	3	1	3	A	MG/L AS N
	05/11/1989	15:00	630	0.0140	3		3	A	MG/L AS N
	05/11/1989	15:00	665	0.00300	3		3	A	MG/L AS P
	09/06/1989	14:00	3	1.00	3		4		FEET
	09/06/1989	14:00	10	22.5	3		4		DEG. C
	09/06/1989	14:00	27	1028	3		4		CODES
	09/06/1989	14:00	28	80020	3		3		CODES
	09/06/1989	14:00	95	35.0	3		4		
	09/06/1989	14:00	300	8.50	3		4		MG/L
	09/06/1989	14:00	400	5.00	3		4		STANDARD UNI

Choose from Menus (F2-F5) (Enter=Step To, ESC=Step Back, ^F=Filter, ^T=Sort)

APPLICATIONS

- *Develop environmental impact reports.*
- *Perform hydrological modeling.*
- *Perform engineering analysis required for studies governed by environmental laws: SDWA, FIFRA, CERCLA, CWA, and NPDES.*
- *Establish baseline water quality.*
- *Develop historic trend data.*
- *Correlate basins for regional water quality studies.*

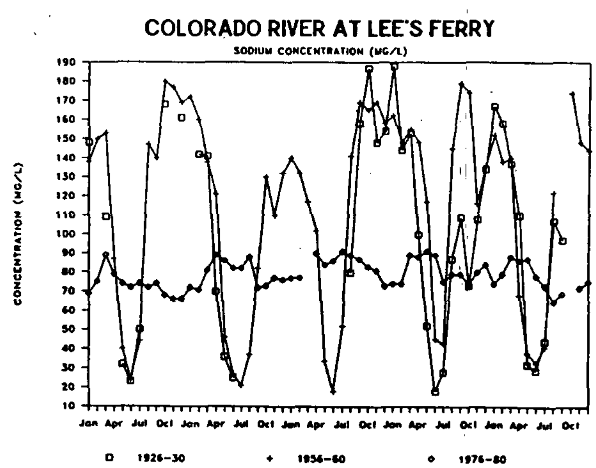
SYSTEM REQUIREMENTS

Minimum:

IBM PC-AT or compatible
640K RAM
DOS 3.0 or higher
CD-ROM drive

Recommended:

80386 or 80486 machine
Fast hard drive
Expanded or extended memory



This graph, produced using **EarthInfo's USGS Quality of Water** and Lotus 1-2-3, shows the effect of Lake Powell on the salt concentration in the lower Colorado River.

EarthInfo *Inc.*

5541 Central Avenue Boulder, Colorado 80301 (303) 938-1788 (303) 938-8183 FAX

UNIVERSITY OF UTAH RESEARCH INSTITUTE
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EARTH SCIENCE LABORATORY
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TELEPHONE 801-524-3422

M E M O R A N D U M

TO: Participants, DOE-GD Low-Temperature Program

FROM: Howard Ross and Paul Lienau

SUBJECT: Phase I Status and Resource Priorities

DATE: September 9, 1994

We note that many participants in the Low-Temperature Program will be attending the GRC Annual Meeting in Salt Lake City, October 2-5. We would like to have a short, informal meeting to discuss final priorities for Phase II studies, and possibilities for future funding (Federal, State, etc.). We suggest Tuesday afternoon, 3:45 to 5:15, as a time with minimum conflict with geoscience papers, but note a conflict with the Panel Discussion on Drilling and Completion.

State Team P.I.'s are asked to present a brief discussion of the priority resource areas they have selected for more detailed study. These results should be summarized in the final report for Phase I, so only a brief (1-2 pg., bullet style) summary would be needed for these presentations. The discussion could include:

- Status of the site in terms of current use and potential for near-term development;
- Potential for utilization, and what type (space heating/cooling, greenhouses, aquaculture, industrial processes, etc);
- Need for additional exploration, assessment, confirmation drilling, etc.;
- Need for a preliminary engineering analysis;
- Rough estimates of funding requirements.

Each State Team P.I. will have 10-15 minutes to discuss the sites in their states, including questions and answers from other P.I.s. We propose the following agenda.

State Team P.I.s not attending the GRC should send a short (1-3 page) summary of the above information for the five highest priority resource areas in their state to Ross and Lienau by September 26.

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TELEPHONE 801-584-4422

Memorandum

TO: State Team Participants, Low-Temperature Program

FROM: Howard Ross, UURI
Paul Lienau, OIT

DATE: July 22, 1993

SUBJECT: Conclusions from Low-Temperature Program Meeting, July 8, 1993

Conclusions reached through discussion of database items are summarized below.

Database - General:

- Location data should include Latitude and Longitude in degrees and decimal degrees (degrees, minutes, decimal minutes are also acceptable).
- UTM coordinates could be listed, or (later) derived from latitude, longitude.
- Multiple wells or springs in a limited area may be edited to a representative number of entries, at the discretion of the State Team Principal Investigator.
- Multiple well entries in the database may have to be edited to produce a better map (P.I.'s choice).
- Multiple entries for flow rate, temperature, etc. for a single well at different depths and/or times may be included or deleted at the discretion of the P.I. Data included should emphasize (a) the most recent state of the resources and (b) the most reliable data.
- Only metric units (temperature, flow rate, depths, etc.) are acceptable in the database. DOE has formally adopted the metric system (or S.I. units) for reporting.
- Final database tables should include a DISCLAIMER noting that well/spring locations have been taken from various sources, that the locations have been edited for errors, but locations have not been verified in the field and, that the accuracy of the location cannot be guaranteed.

Database - Geochemical:

- The chemical data entries shown in Bob Blackett's Table 3, Analyses of Utah Thermal Waters, contain all the essential information for geothermal purposes. Arsenic values, if available, would be important for water quality considerations.
- If reliable gas analyses (H_2O, CO_2, NH_4, etc.) are available they would be important to hardware design and could be noted by footnotes or in references.
- Chemical database tables should include a DISCLAIMER that analyses may not be complete. Developers should be cautioned that accurate gas analyses, and current fluid analyses, are important input to hardware selection and design, and complete new analyses, including gases, should be obtained to facilitate design and minimize hardware corrosion and scaling problems.
- Entries for geochemical analyses should include a charge balance column as an indicator of analytical quality.
- Non-essential chemical data compiled from water quality analyses could be included as an optional set of columns but could be deleted from the deliverables to OIT and UURI.
- It is difficult to get good quantitative analyses for dilute geothermal fluids; this may be reflected in the charge balance and other analytical quality indicators.
- Geothermometers: Because geothermometers may be so variable, and require geologic input for accurate interpretation, geothermometers should not be included in the database tables. State Team P.I.'s are encouraged to report geothermometer results for selected (priority) resources in a separate table, keyed to other data by sample I.D. Appropriate discussion should be included in the final report.

Priorities for Phase 2 Studies

The State Team P.I.'s should submit a priority list of resource areas (5-10) for more detailed studies. Two general guidelines for inclusion on the list are areas with some development in place and a need for studies to protect the resource or to expand utilization; or high potential for near-term development. Collocation with potential users (community or industry) is an important but not mandatory, criteria. Specific criteria to be considered are listed below.

Criteria

- Proximity to user (within 10 km) for lower-temperature use
- Probable reservoir temperature, and range of possible uses (see OIT-GeoHeat Center Geothermal Direct Use Engineering and Design Guidebook, 1991, pg. 326)
- Potential for substantial flow
- Proximity to transportation infrastructure (major highways, railroads,

airports, etc.).

- Proximity to agricultural centers
- Availability of cold water for irrigation and process water
- Local development trends
- Land status
- Legal considerations (water use conflicts, etc.)

Phase 2 Funding

Mike Wright, Paul Lienau, and Marshall Reed discussed the possibilities and problems for Phase 2 funding in some detail. UURI continues its efforts to develop a high impact, informative fact sheet for distribution to Congress, news media, and environmental organizations. We need the following information from state teams.

ITEM	1993 INVENTORY	1980-83 INVENTORY	CHANGE
Number of thermal wells	________	________	________
Number of resource areas	________	________	________
Number of areas, direct heat use	________	________	________

A brief (1-2 page) write-up of results from the present study, with potential for utilization identified, should also be included.

Please try to get this information to Howard Ross, UURI, by August 5, 1993.

Other

- Marshall Reed will prepare disks containing the edited, selected entries from the earlier Low-Temperature Assessment, and will make these available to those who wish them.

U. S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Mineral resource assessment of undiscovered mineral deposits for selected mineral deposit types in the Kaibab National Forest, Arizona

by

James D. Bliss[1]

with a section on

Mineral resource assessment of solution-collapse breccia pipe uranium deposits

by

James D. Bliss[1] and Charles T. Pierson[2]

Open-File Report

93-329

[1] U.S. Geological Survey, Tucson, Arizona
[2] U.S.Geological Survey, Denver, Colorado

EXECUTIVE SUMMARY

Metallic and nonmetallic resources of the Kaibab National Forest, Arizona
Assessment by the U.S. Geological Survey, 1993

GENERAL

- The Kaibab National Forest (KNF), located on the Colorado Plateau, is an area largely devoid of base- and precious-metal mineral deposits.
- Previous assessment of the Grand Canyon region for uranium deposits suggests that the KNF is in an area with undiscovered uranium resources comparable to the San Juan Basin, historically the most productive uranium area in the United States.
- Quantitative probabilistic mineral resource assessment in the KNF is only possible for uranium due to the absence of appropriate models or to the poor-quality of models for other mineral deposit types (e.g., strata-bound copper, manganese deposit types, replacement iron, bedded gypsum, limestone, flagstone, ashlar, basalt, cinder, scoria, and pumice).
- Industrial minerals, and flagstone production in particular, have been produced in the KNF for about 100 years.
- Industrial minerals are the likely focus of future production.

URANIUM

- Quantitative assessment of uranium in undiscovered solution-collapse breccia pipe deposits is made using the deposit-size-frequency method (DSF, option C), a modification of a technique developed for NURE (National Uranium Resource Evaluation).
- The mean unconditional endowment of 211,000 metric tons (233,000 shorts tons) U_3O_8 for undiscovered solution-collapse breccia pipe uranium deposits in the KNF is 20 percent of the total mean uranium endowment previously predicted for the Colorado Plateau.
- The endowment for the KNF is a portion of the total endowment previously predicted for the Grand Canyon Region; not an additional endowment.
- The North Kaibab Ranger District (fig. 1) contains approximately half of the undiscovered uranium endowment in the KNF.

INDUSTRIAL MINERALS

- Significant past production of flagstone occurred in the Williams District (fig. 12); future production likely will be from extensions of known deposits.
- Outcrops in permissive tracts (fig. 12-13) for flagstone with surface slopes greater than 35 degrees are highly unlikely to be used as future quarry sites.
- Two small areas of high calcium limestones suitable for cement are recognized (fig. 3) in the North Kaibab Ranger District.
- Bedded gypsum deposits are permissive in two different formations in the North Kaibab District (fig. 7) and the Tusayan District (fig. 8); undiscovered deposits probably are likely not compatible with the grade and tonnage model.
- Substantial amounts of cinder, scoria, pumice, and basaltic and related rock types used in construction are identified in the Williams and Chalendar Ranger Districts (figs. 6, 9,10). Suitability of basaltic and related rock types as dimension stone needs to be examined.

Non-technical Summary

The assessment is based on geologic knowledge and data as of 1993--it suggests that little future exploitation in the Kaibab National Forest (KNF)(fig. 1) can be expected for base- and precious-metal deposits (p. 2-5,8). However, the KNF is located in a region with significant undiscovered uranium resources and, given appropriate market conditions, exploitation could occur particularly in the North Kaibab Ranger district (p. 30-33). Deposit types for other metals (manganese, iron) are either small or rare and are unlikely to have much of a role in the economy of the KNF (p. 6-7).

Industrial minerals have a long history of production in the KNF. Production of sandstone used as ashlar (building stone), but mostly for flagging, has occurred for at least 100 years and sales have been world-wide. Production of flagging could continue into the future, likely from extensions of known workings. Demand for flagging in the construction industry is dependent on fashion, and therefore is not easily predicted. Due to low unit value, production occurs only in surface quarries and on hillsides with slopes less than 35 degrees. Outcrops forming cliffs are not workable. The volume of possible extensions of known deposits is not known. Methods to assess undiscovered flagging deposits are not available nor could they be developed using available data (p. 25-26).

Cinder, scoria, pumice, and basalt are extensive in the KNF, particularly in the Williams and Chalendar Ranger Districts (fig. 6, 9, 10). Cinders are used as road metal due to the lack of significant sand and gravel in the KNF. Younger cinder cones have the best quality material and are easily recognized. Cone geometry can be used to predict whether cinders can be easily mined (p. 17). Future production from cinder, scoria, pumice, and basalt is likely to occur in the readily accessible widely recognized deposits at the surface. No assessment of undiscovered deposits of these types were made.

Geology permissible for the occurrence of gypsum deposits is present in the KNF (fig. 7, 8) and known deposits are found adjacent to the KNF. If undiscovered deposits are present, their size would likely be overestimated by present models.

High-calcium limestone, likely appropriate for cement manufacture, occurs in the North Kaibab Ranger District (fig. 3), but additional analysis specific to the two areas of outcrops would be needed.

Sources of construction materials are widely available from several formations in the KNF. Methods to assess undiscovered deposits of construction and dimension materials are not available.

STATE OF COLORADO

COLORADO GEOLOGICAL SURVEY
Division of Minerals and Geology

Department of Natural Resources
1313 Sherman Street, Rm. 715
Denver, Colorado 80203
Phone (303) 866-2611
FAX (303) 866-2461

Howard Ross
University of Utah Research Institute
391 Chipeta Way, Suite C
Salt Lake City, UT 84108-1295

June 30, 1993

RE: Geothermal Project Quarterly report; Second Quarter, 1993.

Dear Howard:

After the first quarter we settled into a design and format for the data bases that seems workable and that will be able to hold all the data. Examples of our earlier editions were sent to you for review and comment. Based upon your comments, changes were made in the construction of the data bases. The GEOCHEM data base is very comprehensive, with 57 possible data entries for each record (analysis). To date, we have identified 93 geothermal areas (>20°C) in the state. We have collected and entered into the GEOCHEM database, 343 geochemical analyses of varying completeness and quality. Some of the data entry fields will have to be eliminated for the final deliverable data base. The LOC and GEN data bases are adequate in design and content.

We are attempting to visit and sample all geothermal sources that are >30° C and are collocated with a population center. These new field data are being added to the data base. The activities for the quarter are shown below:

* Reviewed all CGS geothermal publications and entered data into data base. Location and other corrections noted in the review process were added to a publication in the process of being reprinted (CGS Information Series 6, Hydrogeochemical Data of Thermal Springs and Wells in Colorado).

* Reviewed geothermal well permit files of the Oil and Gas Commission and the State Water Engineer. One new source, the Deganahl well near Yampa, was added as a result.

* Reviewed USGS WATSTOR data base. As a result 42 new analyses of geothermal sources, >20°C, were added to the GEOCHEM data base. Of these, 34 analyses were of new or previously unidentified geothermal sources and 8 were additional analyses of geothermal sources already found through the research work already completed.

* Field notes containing updates of activity and usage of the geothermal sources are being formatted into a narrative document to be submitted as part of the final project deliverables.

* Field visits consisting of one week in May and one week in June were made to geothermal sources in the central, and south- central, part of the state (Including the San Luis Valley). Measurements using a Hanna water test meter were taken at each site. Four samples were taken for analysis by the geochemical laboratory of the UURI. Three geochemical analyses from our May field trip have been completed by UURI and have been entered into the data base. As a result of this field work, two new geothermal sources have been identified and included into the data base.

We have plans for one more field trip to the southwestern part of the state in July. After the field work is completed we will continue to add geochemical data, refine the data bases and work on the narrative report.

I am looking forward to our meeting at UGS offices in Salt Lake on July 8th and 9th.

Sincerely,

Jim

James A. Cappa
Chief, Minerals and Mineral Fuels

Oregon

DEPARTMENT OF
GEOLOGY AND
MINERAL
INDUSTRIES

ADMINISTRATIVE
OFFICE

June 28, 1993

Rec 7/2/93 HPR

Howard Ross
University of Utah Research Institute
391 Chipeta Way, Suite C
Salt Lake City, Utah 84108-1295

Dear Howard,

Following are our comments on the agenda topics of the July 8 Low-Temperature Resource Assessment Program meeting. Where we do not have specific comments we will be happy to go along with whatever the rest of the group decides.

Database - general

Only metric units should be used.

We have tabulated data by township, range and section (nearest quarter-quarter section) and by latitude and longitude when available (only for a fairly small percentage of the entire data base). We can probably arrange to digitize latitude and longitude data on small-scale (1:100,000) maps. Other types of location data would be dificult to provide.

Database - geochemical

No specific comments on any of these items, except to note that if there are several chemical data sets for a specific resource, there will be multiple sets of geothermometers.

Geothermal Resource Map

The amount of data on the geothermal resource map should be kept to a minimum, otherwise, at a scale of 1:1,000,000 the map will get awfully busy (we have over 2,500 data entries). My tendency would be to assign a single number that relates to the database.

If you have any questions, please give me a call at (503) 731-4100.

Sincerely,

Jerry

Gerald L. Black
Geologist

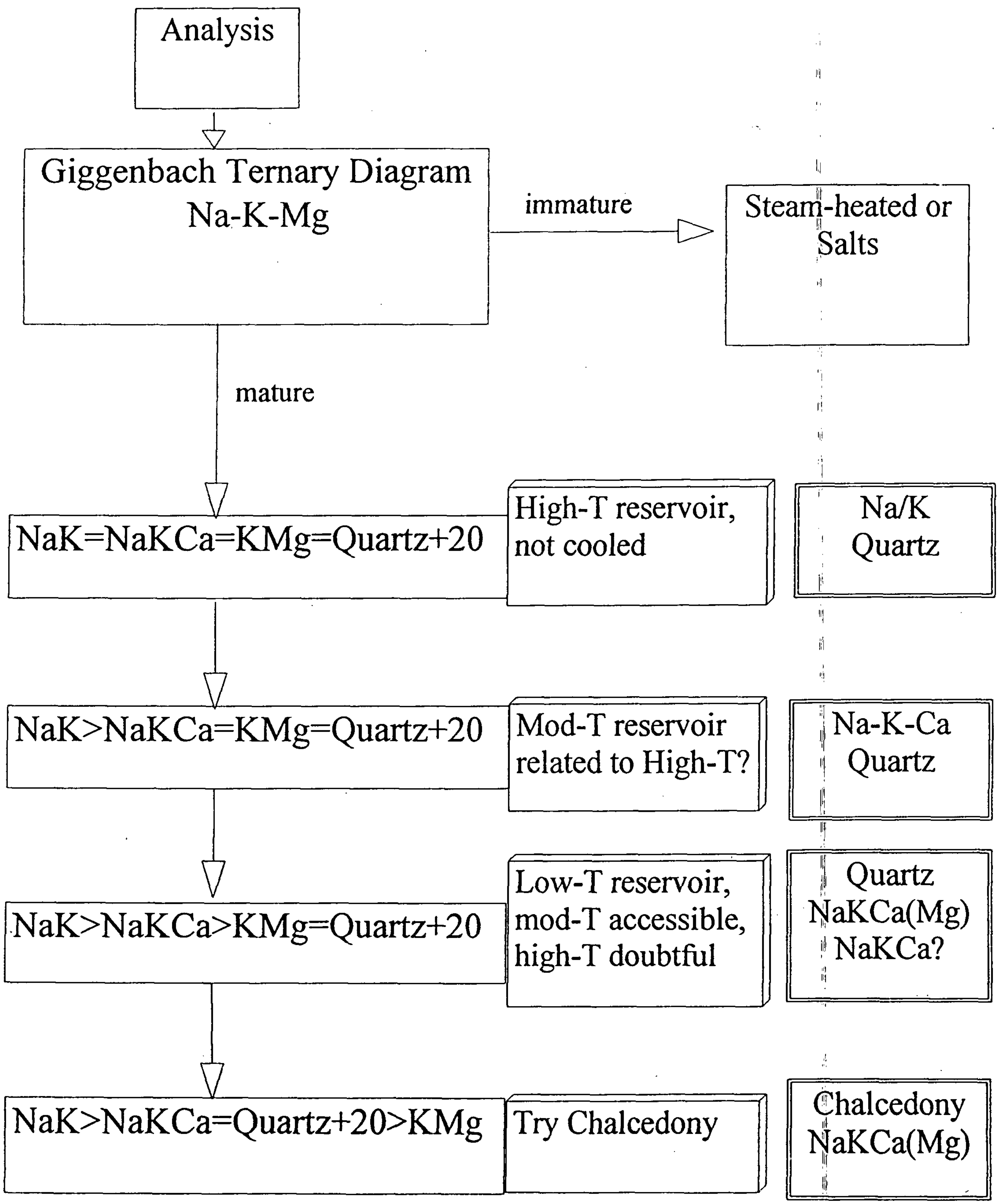
cc. Paul Lienau

STATE OF OREGON 1859

Suite 965
800 NE Oregon Street # 28
Portland, OR 97232
(503) 731-4100
FAX (503) 731-4066

HR

Method	Publication	Common?	Low-Temp?
Na/K	Giggenbach (1988)		
Na/K	Fournier (1981)	yes	
Na/K	Truesdell et al. (1984)		
Na-K-Ca	Fournier and Truesdell (1973)	yes	yes, for relating to mod-T reservoir
Na-K-Ca (-Mg)	Fournier and Potter (1979)	yes	yes, >70°C
K-Mg	Giggenbach (1988)		yes, T is probably too high by 10°C
K-Mg	Fournier (1990)	yes	yes, beware of equations in paper
Quartz	Fournier (1982)	yes	yes
Chalcedony	Fournier (1981)	yes, with care	yes,
SO_4-H_2O (^{18}O)	McKenzie and Truesdell (1977)	yes	


Analysis
Giggenbach Ternary Diagram
Na-K-Mg
immature
Steam-heated or
Salts
mature
NaK=NaKCa=KMg=Quartz+20
High-T reservoir,
not cooled
Na/K
Quartz
NaK>NaKCa=KMg=Quartz+20
Mod-T reservoir
related to High-T?
Na-K-Ca
Quartz
NaK>NaKCa>KMg=Quartz+20
Low-T reservoir,
mod-T accessible,
high-T doubtful
Quartz
NaKCa(Mg)
NaKCa?
NaK>NaKCa=Quartz+20>KMg
Try Chalcedony
Chalcedony
NaKCa(Mg)

Example from one of Utah's Hot Springs

Na/K (G)	255
Na/K (F)	242
Na/K (T)	219
Na-K-Ca	201
Quartz	100
K/Mg	107
Na-K-Ca(-Mg)	85
Chalcedony	70

NaK>NaKCa>>KMg>=Quartz
T(low)=90-100; T(mod)=200

Remediation of Scale Build-Up in the Public Water Supply System, City of Philip, South Dakota, Using a Microbial Approach

by

Gilbert K. Arnold

A thesis proposal submitted to the Department

of Geology and Geological Engineering in

partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE IN GEOLOGICAL ENGINEERING

SOUTH DAKOTA SCHOOL of MINES and TECHNOLOGY

RAPID CITY, SOUTH DAKOTA

1996

Introduction

Scale build up and corrosion are major problems in many public water supply systems. The City of Philip, South Dakota has these problems. Because the major source of drinking water for the City of Philip is a geothermal well, the problems are exacerbated. Solution of the scale build up problem at Philip has applications to other municipal water supply systems that do not obtain their drinking water from geothermal sources. Use of geothermal waters for public water supply systems is not common. Use of geothermal waters for direct-use heating and cooling is found in many parts of the world. The United States, The Philippines, Italy, Mexico, New Zealand, many of the countries of Eastern Europe, Iceland, Japan, and some South American countries all use geothermal waters for heating and cooling or for electricity generation (Getty, 1989).

The Madison (Pahasapa) aquifer and the Dakota aquifer of western South Dakota are major sources of drinking water for most communities in the western part of South Dakota. They also have potential for direct-use geothermal heating and cooling. The City of Philip, South Dakota, uses water from the Madison (Pahasapa) aquifer to heat the municipal water-treatment plant, a county maintenance shop, a fish farm, and to provide drinking water for the city (Ekstrum, 1996).

The well at Philip was drilled in 1963 to provide water for the municipal water system. The well is 4800 ft deep and flows 1000 gallons per minute (g.p.m.) at a temperature of 156° F. The well screen is stainless steel. At present, the water from the well cannot be pumped directly into the city water supply system due to a high radium content (~150 pCi/L). The South Dakota Department of Environment and Natural Resources (DENR) will not allow discharge to surface drainage until the radium levels reach acceptable limits (Ekstrum, 1996).

Literature Review

Examples of the direct use of geothermal waters for heating and cooling in the United States include Boise, Idaho where many residential houses have been heated with 170° F ground water since 1892 (Rahn, 1996). Two geothermal heating systems are presently in use in Elko, Nevada heating the high school and several downtown businesses. The Oregon Institute of Technology and about 400 other buildings in Klamath Falls, Oregon are heated with geothermal waters (Rahn, 1996).

Within South Dakota, the City of Hot Springs Civic Center is heated and cooled by geothermal heat pumps using 83° F water (Getty, 1989); Midland, South Dakota, uses water from a deep Madison aquifer well to heat the school buildings and the municipal filter-treatment plant (Rahn, 1988); Saint Mary's Hospital in Pierre, South Dakota uses 107° F water for laundry and for pre-heating air to heat the 132,00 sq.-ft. building; St. Joseph's Indian School in Chamberlain, South Dakota uses 70° F water from three well with heat pumps to provide space heating; and the Diamond Ring Ranch, Hayes, South Dakota, uses 153° F water to heat four homes and some shops (Gries, 1977; Rahn, 1988). Numerous studies of the geothermal potential and geochemistry of the Madison and Dakota aquifers have been done. Darton (1909) mentions hot thermal waters in his report on the geology and underground waters of South Dakota. Gries (1977), Rahn (1988), and Schoon and McGregor (1974) describe the potential uses of geothermal waters. Knirsch (1975) and Knirsch and Carda (1980) reported on the uranium content of the waters near Edgemont, South Dakota. Carda (1975) studied the radium content of water from the Madison limestone.

The Problem

The major problem with the water from the well at Philip, besides the radium content, is scale build-up in the pipes (Ekstrum, 1996). As noted earlier, scale is a problem in many public drinking

Dakota. High temperature, > 150° C (300° F), geothermal brines may have Total Dissolved Solids (TDS) values of up to 400,000 mg/L. Typical geothermal waters in South Dakota Have TDS values of less than 5000 mg/L (Rahn 1988). Nevertheless, the *major* complaint from the Philip system is scaling. Indeed, scaling appears to an ubiquitous problem in virtually all direct-use geothermal applications. Thorhallsson *et. al.* (1976) describe problems with silica scaling in two district geothermal heating systems in Iceland. Corrosion, at least in the Philip well, does not appear to be a problem as evidenced by pictures from a down-hole camera lowered into the Philip well in 1981 which show no significant pitting of the well casing (Ekstrum, 1996)

Objective

The objective of this thesis is to examine the well system at Philip, South Dakota, and determine if a cost-effective means of reducing scale build-up can be found. A variety of methods will be considered, although this thesis will be primarily concerned with using a microbial approach to reducing or controlling scale build-up. Cost analyses comparing chemical and microbial methods will be done. Recommendations will be made as to the best approach. Environmental impacts of using microbes will be examined. Laboratory experiments will be performed to determine which bacteria or suites of bacteria will be most effective.

Work to Be Done

The following is an outline of work to be performed for this thesis. The last part of this section is a suggested time line for tasks to be completed.

1) Samples will be collected from the following locations: a) the well head, b) the water-treatment plant, c) the fish farm, d) the cooling pond, and e) the golf course irrigation system.

2) Data for each sample will include the temperature, pH, Eh, conductivity, dissolved oxygen content, date, and time of sampling.

3) Samples will be transported to SDSM&T for geochemical and bacterial analysis.

4) Laboratory -scale tests will be done to determine which microorganisms work best to control scale build-up.

5) A final report will be issued.

Suggested time-line.

1) Data collection and sample analysis - Dec. 31, 1996.

2) Bacterial tests completed - April 30, 1997.

3) Laboratory tests completed - August 31, 1997.

4) Initial draft of thesis to committee - Sept. 30, 1997

5) Course work examination - approx. Oct. 15, 1997.

6) Final draft of thesis to committee - Nov. 10, 1997.

7) Thesis defense - last week of Nov. 1997.

Projected Budget

X-ray Diffraction Analysis for complete mineralogical description of scale (done by SDSMT Engineering and Mining Experiment Station)	$138.00
Water Sample Analysis (approx. $65.00/sample) - maximum 10 samples (performed by outside laboratory)	$650.00
Trips to location to collect samples (five trips expected) @ $50.00/trip	$250.00
Final Engineering Report Preparation	$150.00
	Total $1188.00

References

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Getty, Michael G., 1989, Hydrogeology and geothermal utilization for the City of Belle Fourche, South Dakota: M. S. Thesis, South Dakota School of Mines and Technology, 90 p.

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U.S. Geological Survey Minerals Information Offices

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U.S. Geological Survey

Minerals Information Offices

Minerals Information Offices

USGS Minerals Information Offices (MIO's) are staffed by geologists and technical information specialists who respond to inquiries about mineral resources. They also work to improve information exchange among the public, the minerals industry, State and Federal agencies, and other generators and users of minerals information.

While each office has special expertise on its geographic region, all offices respond to requests for information on mineral resources throughout the world.

Each MIO is conveniently located near on Earth Science Information Center, where USGS publications and maps are available for over-the-counter purchase.

Washington, D.C.

Geologists at the headquarters MIO specialize in information about USGS mineral-resource programs, and national and international mineral-resource issues. This MIO maintains information about mineral resources of the eastern United States, and shares an office and coordinates activities with the U.S. Bureau of Mines.

Reno, Nevada

The Reno MIO is uniquely situated to disseminate and collect information on the most active exploration region in the United States, including Nevada, Utah, and northern California. This office also maintains links with other active exploration areas, worldwide.

Spokane, Washington

The MIO in Spokane serves the Inland and Pacific Northwest, including Oregon, Washington, Idaho, Montana, Alaska, and Wyoming. In addition, this office is the contact point for information concerning the Anaconda Geological Documents Collection in Laramie, Wyoming and the files of the Defense Minerals Exploration Administration.

Tucson, Arizona

The bilingual staff of the Tucson MIO provides information about USGS programs in, and mineral resources of Arizona, New Mexico, southern California, Colorado, and west Texas. In addition, this office provides information concerning mineral resources of Central and South America and maintains a liaison with the USGS Center for Inter-American Mineral Resource Investigations (CIMRI), also located in Tucson.

Denver, Colorado

The Denver MIO is a satellite office of the Tucson MIO and provides convenient access to digital mineral-resource data. The office is located at the Denver Federal Center, among other government agencies with minerals-related interests.

MIO Resources

- Selected mineral-resource publications and periodicals, including significant USGS publications on mineral-resource topics
- Reports of the International Strategic Minerals Inventory program
- Cables and other reports of the US Department of State's Foreign Service officers
- Information about meetings, conferences, and symposia on mineral-resource subjects
- Contacts with USGS mineral-resource specialists, including geologists, geochemists, and geophysicists

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