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1423

RESPONSE OF BOISE GEOTHERMAL AQUIFER TO EARTH TIDES

by

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BACKGROUND

Residences in a portion of Boise, Idaho have used water from low-temperature geothermal wells for space heating since about 1900. Exploration for additional supplies in a new area began in the late 1970's, culminating in three separate development projects in the early 1980's; one by the State of Idaho, one by the Veteran's Administration and one by Boise Geothermal, Ltd. for the City of Boise (Fig. 1). Anderson & Kelly was retained to design and supervise five deep supply wells and two injection wells for the various projects, as well as for the overall hydrogeologic responsibilities for each project.

Boise Geothermal Ltd. (BGL) Wells Nos. 2 and 4 were tested in April and May 1982 in order to determine:

1) discharge-drawdown relationships at individual wells,
2) aquifer characteristics from the data collected at various observation wells,
3) the effect, if any, at Warm Springs Water District wells,
4) the effect, if any, on the overlying "cold-water" aquifer system and,
5) any other parameters that could be used in an evaluation of the geothermal aquifer system.

The principal objective of the testing and evaluation was to demonstrate the capability of these two wells to supply a peak demand of 2,000 gallons per minute (gpm) for the Boise City Geothermal Space Heating Project.

Several of the geothermal wells in the Boise area had been tested for short periods of time in 1980-81. In addition, a base-line data collection program was underway that involved periodic water-level (pressure) measurements at most of the local geothermal wells. Consequently, the trend of seasonal water level variations, the sensitivity to barometric and earth-tidal influences, and general magnitude of response to flow testing was anticipated.

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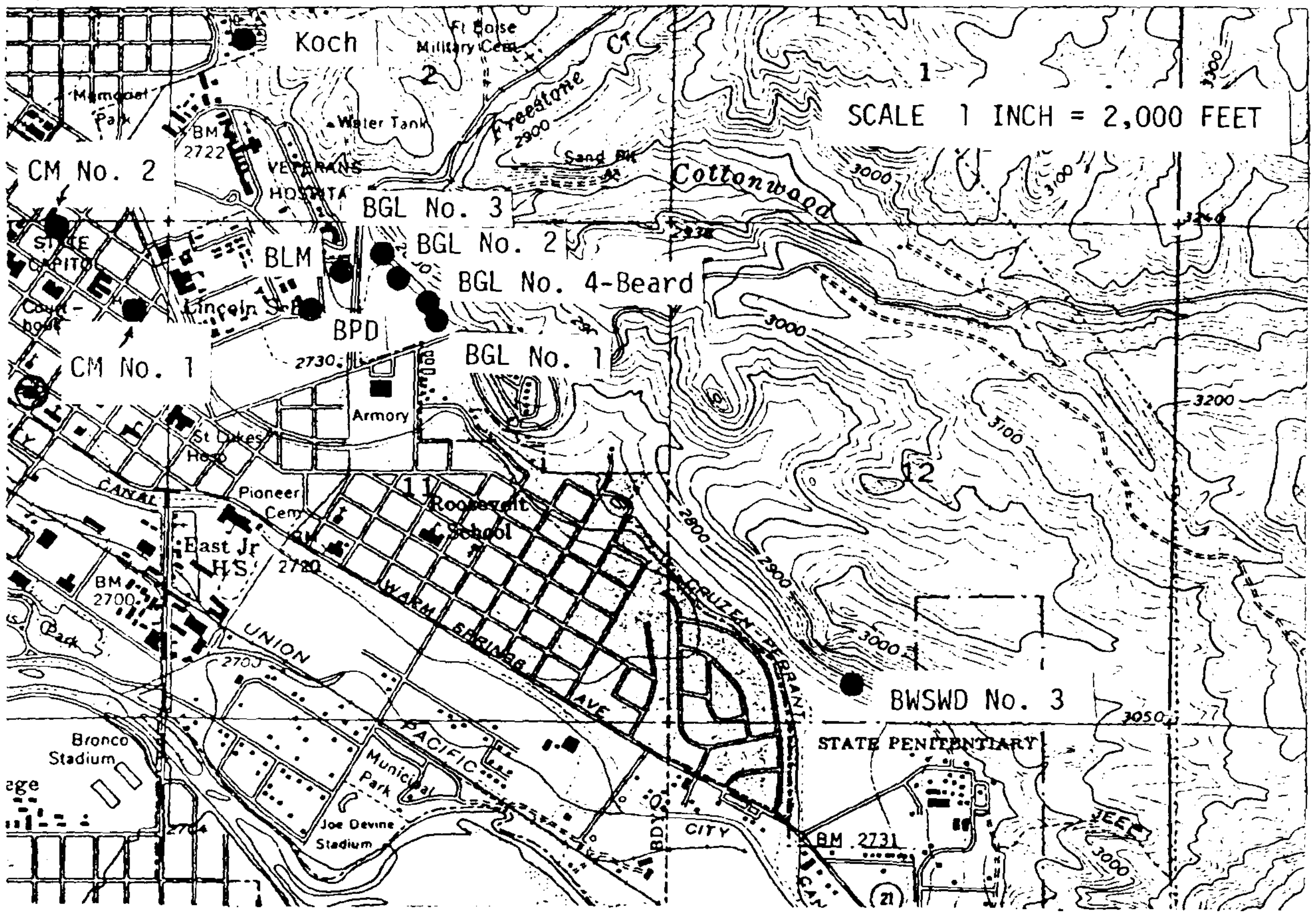


Obs. Wells	Ref. Pt. Elev.	Distance(ft) From No. 2	No. 4	Primary Measuring Device
BGL No. 1	2,749.10	462.0	150.9	Transducer & Recorder
BGL No. 2	2,748.81	-	317.9	-
BGL No. 3	2,770.45	524.3	835.7	Type F-Float
BGL No. 4	2,749.00	317.9	-	-
Beard	2,746.94	346.4	29.5	Pressure gage-Hg Mano.
BLM	2,742.20	672.8	977.8	Pressure gage-Hg Mano.
CM No. 1	2,715.65	2,895.5	3,130.7	Transducer & Recorder
CM No. 2	2,709.18	3,818.1	4,096.2	Pressure gage-Hg Mano.
BWSWD No. 3	2,789.55	±7,000.	±6,700.	Type F-Float
Koch	±2,755.	3,060.	3,366.	Type F-Float
Boise Park Dept. (BPD)		±1,000-1,500.		Steel Tape

Figure 1.

HYDROGEOLOGY

The geothermal system presently is considered to consist of fractured and faulted rhyolite beds of the Idavada Group (Wood and Burnham, 1983). The present hypothesis is that deeply circulating geothermal water rises by mass-convection through permeable zones associated with normal faulting along the boundary of the Idaho Batholith and the Snake River Plain. The geothermal water then moves laterally, in a southwest direction, in the fractured rhyolite and interbedded sandstones and conglomerates. Basalt beds do not appear to be a part of the geothermal aquifer system. In fact, the basaltic tuff, basalt and lacustrine claystone beds that overlie the rhyolite sequence act as aquitards, creating a confined aquifer system.

Most of the geothermal wells drilled in the early 1980's are located at surface elevations that are lower than the maximum potentiometric surface of the geothermal aquifer system. An exception is BGL No. 3, where excellent records of water levels could be collected using a standard float-activated water-level recorder. The following table summarizes well construction and completion data for the various wells utilized in the testing program. This information shows that most of the geothermal wells are open to a large percentage of the known thickness of the geothermal aquifer. The response to testing confirmed the reliability of these as valid observation points with the exception of the BWSWD No. 3 well, where no response (except to the nearby BWSWD Nos. 1 and 2 pumping) was observed and the Koch well, which appears to be in a separate (or at least isolated) geothermal aquifer.

Well No.	Total Depth	Open Interval	Remarks
BGL No. 1	2,000 ft.	830-1,700	Perforated
BGL No. 2	880	642-880	Open-hole
BGL No. 3	1,897	680-840	Perforated
		886-901	Perforated
		1,050-1,897	Open-hole
BGL No. 4	1,103	720-800	Perforated
		850-870	Perforated
		900-1,040	Perforated
Beard	1,282	823-925	Screened
		964-1,279	Perforated
BLM	1,224	780-800	Perforated
		1,014-1,056	Perforated
		1,118-1,138	Perforated
		1,156-1,181	Perforated
		1,200-1,224	Perforated
CM No. 1	2,152	1,750-2,152	Open-hole
CM No. 2	3,030	1,260-2,550	Perforated

BAROMETRIC AND EARTH-TIDE EFFECTS

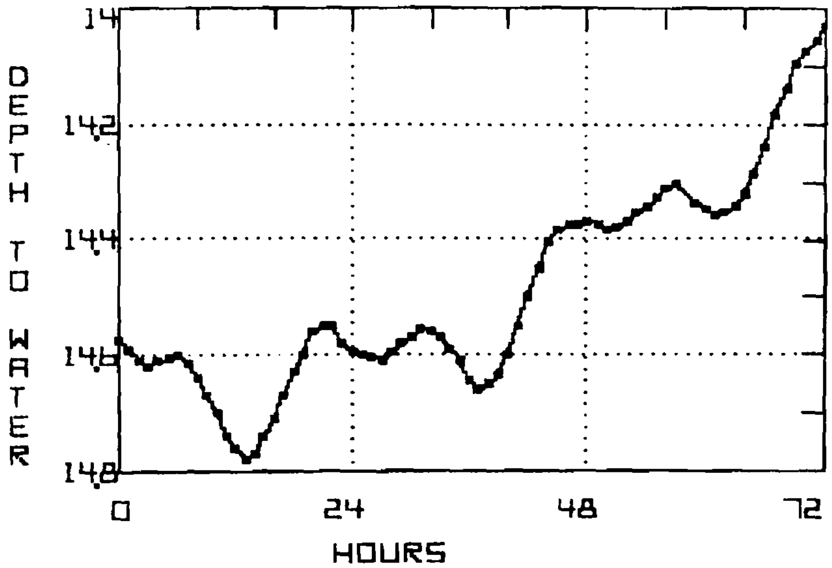
The long-term monitoring of water levels at BGL No. 3, together with the collection of concurrent barograph records, had demonstrated a high degree of barometric efficiency. During a barometric change of nearly one inch of mercury in October 1981, a barometric efficiency (BE) of about 90% was calculated for BGL No. 3. Because of the ease of plotting and conversion, an efficiency of 88% (1 in. Hg = 1 ft. water) was used to correct "raw" water level data from BGL No. 3.

Correction for barometric effects at BGL No. 3, using barograph records, showed another influence on water levels. Daily fluctuations of more than 0.1 feet remained after correction. These fluctuations were attributed to earth-tidal influences (Robinson, 1939). No attempt was made to correct for earth tides in the BGL No. 3 long-term record; the seasonal trend was determined by using either the daily peaks or troughs as a datum point. However, additional data were made available during the study that afforded the opportunity to identify and quantify earth-tide effects on a short-term basis. A calculation of theoretical earth tides for April and May 1982, from a National Oceanic and Atmospheric Administration computer program, and sensitive digiquartz transducer equipment were made available through EG&G Idaho, Inc.

The following two plots (Fig. 2) show the raw data for BGL No. 3 and the inverted plot of barometric pressure obtained from the transducer installation for May 23-26, about three weeks after cessation of flow testing of BGL Nos. 2 and 4. The next two graphs (Fig. 3) show the excellent correlation of corrected water levels with calculated earth tides. The upper plot is the hydrograph of BGL No. 3 corrected for 88% barometric efficiency. The lower plot is of calculated earth tides during the same period. The rising trend of the corrected hydrograph is attributed to the annual seasonal rise in water levels observed in the 1980-81 baseline period.

The data on earth-tide correlation can be used to estimate aquifer parameters (Bredehoeft, 1967) and to correct drawdown data obtained during the testing of BGL Nos. 2 and 4. However, the accuracy of such corrections was considered to be insuffcent for aquifer test analyses. Instead, the timing of fluctuations was considered in the selection of data for analyses.

HYDROGRAPH OF BGL-3 FOR THE PERIOD MAY 23-26 1982
UNCORRECTED DATA FROM STEVENS TYPE F RECORDER CHART



BAROMETRIC PRESSURE FOR THE PERIOD MAY 23-26 1982
DIGIQUARTZ TRANSDUCER READINGS AT ANDERSON & KELLY BUILDING
(NOTE INVERTED SCALE)

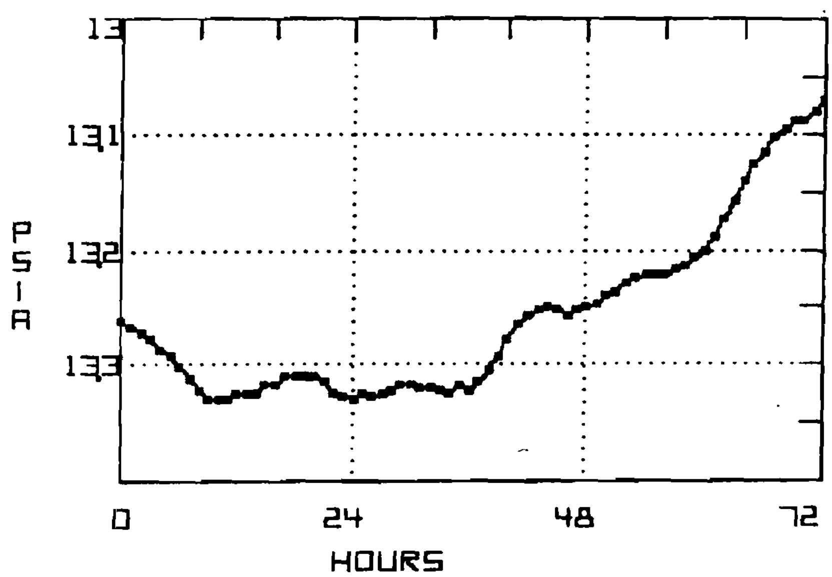
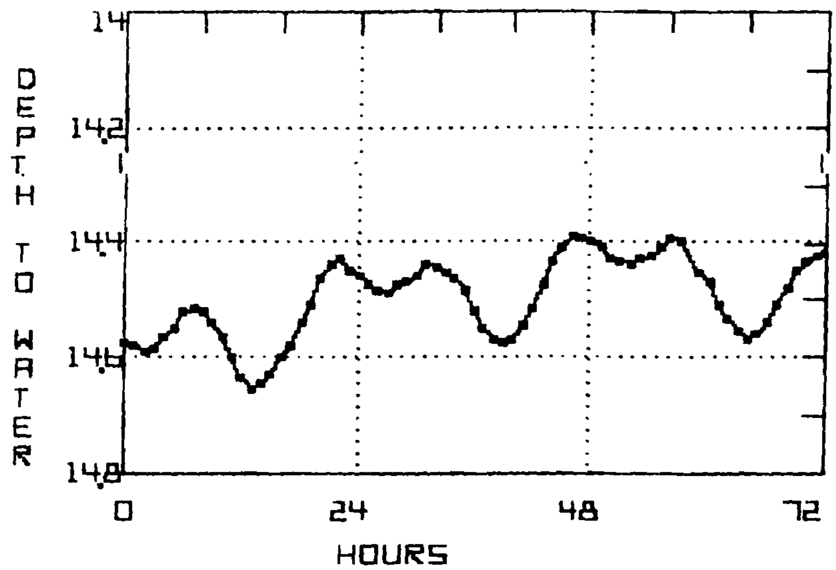


Figure 2.

HYDROGRAPH OF BGL-3 FOR THE PERIOD MAY 23-26 1982

CORRECTED FOR BAROMETRIC EFFICIENCY OF 88%



THEORETICAL EARTH TIDES FOR THE PERIOD MAY 23-26 1982
BOISE GEOTHERMAL LTD. WELL FIELD AREA

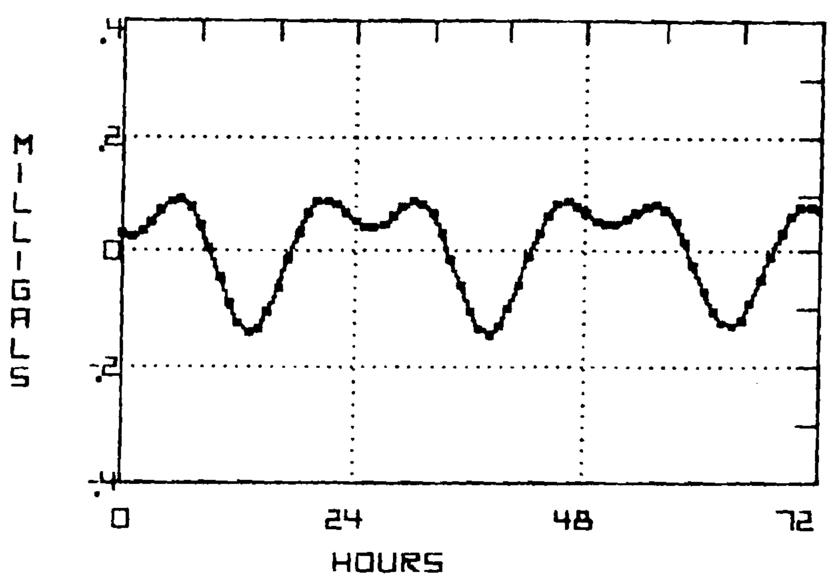


Figure 3.

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