FLOW TESTING
OF
BOISE GEOTHERMAL LTD.
WELLS NOS. 2 AND 4

ANDERSON & KELLEY
Consultants in Engineering and Geology
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OF
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CONTENTS

INTRODUCTION
Purpose and Scope 1
Previous Investigations 1
Present Investigation 1
Acknowledgements 2

REGIONAL HYDROGEOLOGY
Well Locations and Construction 3
Regional Water Levels 4

INSTRUMENTATION AND PROCEDURES
Test Well Instrumentation 5
Observation Well Instrumentation 5
Other Factors 7

TEST ANALYSES
BGL-2 Step Tests 9
BGL-2 Constant Rate Test 10
BGL-4 Step Tests 13
BGL-4 Constant Rate Test 16

SUMMARY AND CONCLUSIONS
BGL-1 Well 19
BGL-2 Well 19
BGL-3 Well 19
BGL-4 Well 20
BLM Well 20
Beard Well 20
CM-1 Well 20
CM-2 Well 21
Other Wells 21
Long Term Production 21

REFERENCES 25
FIGURES

Following Page

Figure 1 - Location Map and Well Construction Data
Figure 2 - Hydrograph of BGL-3 and Barometric Pressure
Figure 3 - Hydrograph of BGL-3 and Plot of Earth Tides
Figure 4 - Drawdown at BGL-3 During BGL-2 Test
Figure 5 - Drawdown at BGL-3, BGL-4, and BLM
Figure 6 - Drawdown at CM-1, BLM, BGL-3, and BGL-4
Figure 7 - Distance/Drawdown Plot
Figure 8 - Recovery of BLM After BGL-4 Test
Figure 9 - Hydrograph of BGL-3 and Barometric Pressure
Figure 10 - Hydrographs of CM-1 and BGL-3
Figure 11 - Drawdown of BGL-2 During BGL-4 Test
Figure 12 - Projected Local Annual Drawdown Cycle
Figure 13 - Hydrographs of BLM Well

APPENDIX

Hydrograph of BGL-3
Hydrograph of Koch 'Old' Well
Hydrograph of BWSWD #3
Sketch of Test Apparatus
Sketches of Observation Well Instrumentation
Barometric Record for April 7-11, 1982
Step Test Data for BGL-2 at Q=400 GPM
Step Test Data for BGL-2 at Q=1000 GPM
Observation Well Data for Step Test of BGL-2
Constant-Rate Test Data for BGL-2
Observation Well Data for Constant-Rate Test of BGL-2
Step Test Data for BGL-4
Constant-Rate Test Data for BGL-4
INTRODUCTION

Purpose and Scope

Boise Geothermal Ltd. Wells Nos. 2 and 4 were tested in April and May 1982 in order to determine discharge-drawdown relationships at individual wells, aquifer characteristics from the data collected at various observation wells, the effect (if any) at Warm Springs Water District wells, the effect (if any) on the overlying "cold-water" aquifer system and 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.

Previous Investigations

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 activities, and general magnitude of response to flow testing could be anticipated. A detailed description of the test program, including the method of measurement at the various observation wells is in a subsequent section of this report.

Present Investigation

It was planned to flow each well at a constant discharge rate for two to seven days, as well as to flow each at both a lower and higher rate for short periods. Well No. 2 was to be flowed first because of its known high-discharge capacity.

Well No. 2 was step-tested on April 7, 1982, with the first step at 400 gpm. The well was flowed for 65 minutes and recovery measurements were made until the next step began about 2.5 hours later. The next step was at 1,000 gpm for one hour. Recovery measurements were made until
the next morning when the long-term test started. This test was run for seven days at a constant rate of 900 gpm and recovery measurements taken for 10 days. The maximum temperature at the end of the 7-day flow period was 77.7°C (171.9°F).

Well No. 4 which had not been tested previously was flowed briefly on April 26 to determine the general magnitude of discharge capability. It was discovered that the 12-inch well-head valve, which had been almost impossible to move manually, was open only partially, and may have been almost completely closed. Consequently, a multiple-step flow test was run the next day to determine if this condition would be detrimental to data collection during the planned testing. The multiple-step testing was started at a rate of less than 35 gpm and increased to a maximum rate of about 180 gpm. The consistent discharge-drawdown relationships indicated that future testing could proceed as planned. A constant-discharge flow test was run for slightly less than two days at 160 gpm, starting on April 28. The maximum temperature measured at the end of the test was 76.7°C (170.1°F).

Acknowledgements

EG&G Idaho, Inc. provided supplemental equipment and instrumentation that was helpful in data collection. The cooperation and assistance of Ray Sanders, Brent Russell and Dennis Goldman, who also observed and assisted in data collection during the testing of Boise Geothermal No. 2, is appreciated.
REGIONAL HYDROGEOLOGY

Well Locations and Construction

The following map shows the location of two test wells and their areal relationship with the various observation wells, together with other pertinent data (Figure 1). 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 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. The location of the various wells are shown on the following figure.

<table>
<thead>
<tr>
<th>Well No.</th>
<th>Total Depth</th>
<th>Open Interval</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL No. 1</td>
<td>2,000 ft.</td>
<td>830-1,700</td>
<td>Perforated</td>
</tr>
<tr>
<td>BGL No. 2</td>
<td>880</td>
<td>642-880</td>
<td>Perforated</td>
</tr>
<tr>
<td>BGL No. 3</td>
<td>1,897</td>
<td>680-840</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>886-901</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,050-1,897</td>
<td>Open-hole</td>
</tr>
<tr>
<td>BGL No. 4</td>
<td>1,103</td>
<td>720-800</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>850-870</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>900-1,040</td>
<td>Perforated</td>
</tr>
<tr>
<td>Beard</td>
<td>1,282</td>
<td>823-925</td>
<td>Screened</td>
</tr>
<tr>
<td></td>
<td></td>
<td>964-1,279</td>
<td>Perforated</td>
</tr>
<tr>
<td>BLM</td>
<td>1,224</td>
<td>780-800</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,014-1,056</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,118-1,138</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,156-1,181</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,200-1,224</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,234-1,252</td>
<td>Perforated</td>
</tr>
<tr>
<td>CM No. 1</td>
<td>2,152</td>
<td>1,750-2,152</td>
<td>Open-hole</td>
</tr>
<tr>
<td>CM No. 2</td>
<td>3,030</td>
<td>1,260-2,550</td>
<td>Perforated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,550-3,030</td>
<td>Open-hole</td>
</tr>
<tr>
<td>BWSWD No. 3</td>
<td>600</td>
<td>214-600</td>
<td>Open-hole</td>
</tr>
<tr>
<td>Koch</td>
<td>1,224(?)</td>
<td>600-1,224</td>
<td>Open-hole</td>
</tr>
<tr>
<td>Boise Park</td>
<td>385</td>
<td>256-385</td>
<td>Perforated</td>
</tr>
</tbody>
</table>
Regional Water Levels

Periodic water level measurements have been made in many of the wells listed above for more than one year. The Boise Geothermal Ltd wells, as well as the Beard and BLM wells, and the State Capitol Mall (CM) wells show a seasonal variation of about 10 feet. The high level occurs in September and the low level is reached in the March-April period. The records of most of these wells are based on periodic pressure measurements, either by gage or mercury (Hg) manometer, converted to feet of water. However, Boise Geothermal Ltd. No. 3 (BGL-3) has an almost continuous record since a water-level recorder was installed in June 1981. The hydrograph of BGL-3 is included in the Appendix.

The Koch "old" well has a completely different annual cycle. This well is located adjacent to a more recently drilled well that is used by the Koch residence for space heating and domestic hot water. The highest water level occurs in the spring and the lowest level occurs in the fall. The magnitude of the variation is about the same (10 feet) as for the other geothermal wells in the vicinity, as described above, but the cycle is almost completely opposite. The hydrograph of this well, also derived from weekly recorder charts, is in the Appendix. Although the individual weekly charts show the effect of pumping from the nearby supply well, the seasonal trend is apparent.

Boise Warm Springs Water District (BWSWD) well No. 3 has a trend that is similar to the BGL and CM wells in timing but the annual variation is 80 feet from low to high water levels. The proximity of this well to Nos. 1 and 2 which supply hot water at varying rates on a demand basis, suggests a comparison to those pumping rates. The correlation is quite good, as shown on the figure in the Appendix.

As shown by the foregoing, April is the best month to perform testing of geothermal wells. The annual cycle of water levels (pressure) is at its low point and trend is flat. Use of geothermal wells is minimal and, consequently, a planned new stress (testing) should be easily recognized at observation wells within the system. However, because the pressure is lower, the flow rate capacity at individual wells is also lower.
INSTRUMENTATION AND PROCEDURES

Test Well Instrumentation

The two wells tested were similarly equipped, with equipment and instrumentation being moved from BGL-2 to BGL-4 after completion of the first step. A diagrammatic sketch is included in the Appendix.

The wells were completed with a 12-inch full opening gate valve on the 12-inch casing, attached to a flanged tee with a 12-inch blind flange at the top and an 8-inch gate valve mounted horizontally. The discharge piping from the well was 8-inch I.D. steel pipe with a thermometer well installed immediately below the 8-inch valve and an orifice plate assembly at the discharge end. Discharge rates were controlled by the 8-inch valve and measurements of flow rate were made by visual observation of the water manometer located two feet upstream of the orifice and by reference to standard tables. Back-pressure measurements were made by visual observation of the pressure gage or Hg manometer. Temperature measurements were made by visual observation of the Hg thermometer installed in the thermometer well.

Observation Well Instrumentation

Water level recorders (Stevens Type F) were installed on BGL-3, Koch and BWSWD No. 3 wells, which are wells that are located at surface elevations higher than the water level (potentiometric surface) of the geothermal aquifer system. In general, 8-day time gears were used prior to the test period in order to establish the existence of any trend. During the actual testing of BGL-2 and BGL-4, faster time gears were installed on BGL-3, utilizing a 4-hour record during period of initial drawdown and recovery. Stage gears used varied from 1:1 at BGL-3, to 1:5 at BWSWD No. 3 and 1:10 at the Koch well. Recorder chart records were supplemented by electric sounder or steel tape measurements, particularly when replacing charts. Depth to water measurements also were made in the "cold water" well of the Boise Park Department located in the Fort Boise Community Center area during the testing of BGL-2.
Pressure transducer-recorder installations obtained data at the BLM and CM-1 wells during the testing of BGL-2 and BGL-4, as well as at the latter wells when used as an observation well rather than the tested well. All of these wells, together with the remainder of the observation wells, were equipped with pressure gages (psig) and/or Hg manometers. The Hg manometers consisted of a simple U-tube filled with mercury and connected to the well head. The differential pressure was measured by the difference in levels in the U-tube, referenced to a permanent scale attached to the U-tube assembly.

All pressure readings, whether recorded from visual observations or taken from recorder charts, were converted to feet of water using the relationship: 1 psi = 2.31 feet of water. All Hg manometer readings were converted to feet of water using the relationship: 1 inch Hg = 1.133 feet. It is recognized that some temperature corrections could be applied to be precisely accurate but during the test analyses only differential values (change in water level) were used.

Water level data for the individual wells found in the Appendix were converted to feet of water by simple conversion of the initial (pre-test) pressures in order to establish a uniform reporting method. Actual water level elevations referenced to mean sea level were determined prior to testing and are tabulated below. The same constants, mentioned above, were used to establish the head of water which was then added to (or subtracted from) the reference point elevation. Diagrams of individual wells are included in the Appendix.

<table>
<thead>
<tr>
<th>Well</th>
<th>Date</th>
<th>Time</th>
<th>Measurement</th>
<th>Elevation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL-1</td>
<td>4/7/82</td>
<td>1022  hrs</td>
<td>Hg Manometer</td>
<td>2,761.39 ft.</td>
<td>*</td>
</tr>
<tr>
<td>BGL-2</td>
<td>4/7/82</td>
<td>1144  hrs</td>
<td>Gage</td>
<td>2,766.23</td>
<td>T=47.6°C</td>
</tr>
<tr>
<td>BGL-3</td>
<td>4/7/82</td>
<td>1024  hrs</td>
<td>Tape</td>
<td>2,758.53</td>
<td>*</td>
</tr>
<tr>
<td>BGL-4</td>
<td>4/7/82</td>
<td>1141  hrs</td>
<td>Hg Manometer</td>
<td>2,765.70</td>
<td>*</td>
</tr>
<tr>
<td>Beard</td>
<td>4/7/82</td>
<td>1139  hrs</td>
<td>Gage</td>
<td>2,762.57</td>
<td>*</td>
</tr>
<tr>
<td>BLM</td>
<td>4/7/82</td>
<td>1030  hrs</td>
<td>Hg Manometer</td>
<td>2,757.41</td>
<td>*</td>
</tr>
<tr>
<td>CM-1</td>
<td>4/7/82</td>
<td>1000  hrs</td>
<td>Gage</td>
<td>2,739.54</td>
<td>*</td>
</tr>
<tr>
<td>CM-2</td>
<td>4/7/82</td>
<td>0850  hrs</td>
<td>Hg Manometer</td>
<td>2,743.10</td>
<td>*</td>
</tr>
<tr>
<td>BWSWD-3</td>
<td>4/6/82</td>
<td>1430  hrs</td>
<td>Tape</td>
<td>2,685.25</td>
<td>**</td>
</tr>
</tbody>
</table>

* Long-term shut-in period
** BWSWD Nos. 1 & 2 pumping-discharge rate unknown
Other Factors

The long-term monitoring of water levels at BGL-3, together with the collection of concurrent barograph records, 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-3. Because of the ease of plotting and conversion, an efficiency of 88% (1" Hg = 1' water) has been used to correct "raw" water level data from BGL-3 in the past. Calculation of barometric efficiencies at other wells cannot be made with the same accuracy because of the limited accuracy of shut-in pressure readings at those wells.

Correction for barometric effects at BGL-3 showed another influence on water levels. Daily fluctuations of more than 0.1 feet remained after BE correction. These fluctuations were attributed to earth tidal influences (Robinson, 1939). No attempt was made to correct for earth tides (ET) in the BGL-3 long-term record; the seasonal trend was determined by using either the daily peaks or troughs as a datum point. However, additional data was made available during this study that affords the possibility of some correction or at least the knowledge of timing of ET effects.

A National Oceanic and Atmospheric Administration computer program calculation of theoretical earth tides for April and May 1982 was made available through EG & G. The following figures show the excellent general correlation of water levels and calculated earth tides. However, the relationship during the rise and fall is not exactly linear. Consequently, the magnitude of corrections desirable (i.e. 0.01 ft.) cannot be made. However, the timing of fluctuations are known and judicial selection of water level data within a test period can be made.

The following figures illustrate the influence of barometric pressure and earth tidal effects at BGL-3 (Figures 2 & 3). Included in the Appendix is the barometric pressure record for the period April 7-11, 1982.
<table>
<thead>
<tr>
<th>Obs. Wells</th>
<th>Ref. Pt. Elev.</th>
<th>Distance (ft) From No. 2</th>
<th>Distance (ft) From No. 4</th>
<th>Primary Measuring Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL No. 1</td>
<td>2,749.10</td>
<td>462.0</td>
<td>150.9</td>
<td>Transducer &amp; Recorder</td>
</tr>
<tr>
<td>BGL No. 2</td>
<td>2,748.81</td>
<td>-</td>
<td>317.9</td>
<td>Type F-Float</td>
</tr>
<tr>
<td>BGL No. 3</td>
<td>2,770.45</td>
<td>524.3</td>
<td>835.7</td>
<td>Pressure gage-Hg Mano.</td>
</tr>
<tr>
<td>BGL No. 4</td>
<td>2,749.00</td>
<td>317.9</td>
<td>-</td>
<td>Pressure gage-Hg Mano.</td>
</tr>
<tr>
<td>Beard</td>
<td>2,746.94</td>
<td>346.4</td>
<td>29.5</td>
<td>Transducer &amp; Recorder</td>
</tr>
<tr>
<td>BLM</td>
<td>2,742.20</td>
<td>672.8</td>
<td>977.8</td>
<td>Pressure gage-Hg Mano.</td>
</tr>
<tr>
<td>CM No. 1</td>
<td>2,715.65</td>
<td>2,895.5</td>
<td>3,130.7</td>
<td>Transducer &amp; Recorder</td>
</tr>
<tr>
<td>CM No. 2</td>
<td>2,709.18</td>
<td>3,818.1</td>
<td>4,096.2</td>
<td>Pressure gage-Hg Mano.</td>
</tr>
<tr>
<td>BWSWD No. 3</td>
<td>2,789.55</td>
<td>±7,000.</td>
<td>±6,700.</td>
<td>Type F-Float</td>
</tr>
<tr>
<td>Koch</td>
<td>±2,755.</td>
<td>3,060.</td>
<td>3,366.</td>
<td>Type F-Float</td>
</tr>
<tr>
<td>Boise Park Dept. (BPD)</td>
<td>±1,000-1,500.</td>
<td></td>
<td></td>
<td>Steel Tape</td>
</tr>
</tbody>
</table>

Figure 1.
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 TRANSUDER 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.
The period May 23-26 was chosen to illustrate these effects for the following reasons:

1. Neither BGL-2 nor BGL-4 had been flowed for more than three weeks.
2. The digiquartz transducer, with its greater accuracy, was available and used instead of relying on barograph records.
3. This period had intervals of both relatively constant barometric pressure as well as significant decline.

Obviously, a major factor to be considered during the period of testing would be changes in water levels or trends caused by any other withdrawals from the geothermal system during the test period. Some use of water from BGL-2 was made by the Boise City Public Works Department during April, prior to the testing, but the discharge periods were short and recovery of water levels was almost immediate, as shown by the recorder charts from BGL-3. The only other known discharge was at the "new" Koch well, which probably was less than 30 gpm for short intermittent periods of pumping, and the pumping at the BWSWD wells. Unfortunately, the flow meter on the BWSWD system was broken and the pumping rates of the two wells is not known. However, the pumping water level data indicate the rate probably was about 800 gpm two days prior to and during the first two days of the BGL-2 test. On April 9, the east well was shut down and the pumping rate at the west well was probably about 500 gpm. The reduction in discharge rate is reflected in the BWSWD No. 3 water level data, showing a rise of about 0.2 feet. Of course, the seasonal trend of water levels must be considered but, as previously mentioned, it is at a minimum during the period of the test.
TEST ANALYSES

BGL-2 Step Tests

BGL-3, BGL-4 and the BLM well were the principal wells used for the analysis of the BGL-2 step tests because of their ability to determine changes in water level of 0.01 feet (or less) on the recorder charts. This is a major consideration when the drawdown in BGL-3, only 524 feet from BGL-2, was less than one foot after flowing BGL-2 at 1,000 gpm for an hour. The drawdown in BGL-2 were only about 2.5 to 3 feet at the end of the 400 gpm step test. The following semi-log plot of step-test drawdowns (Figure 4) shows that "boundary conditions" exist within the first few minutes of pumping. It is difficult to fit a straight line to the data. Consequently, the type-curve matching technique was used on the earliest data in an attempt to calculate aquifer characteristics. The log-log plots of the data also showed the existence of boundary conditions.

Calculated transmissivity (T) values at BGL-3 for both step tests at BGL-2 are about 825,000 gpd/ft and the calculated storativity (S) is about \(1 \times 10^{-3}\). The value of S would appear to be almost an order of magnitude too high based on the high barometric efficiency. Consequently, it can be speculated that boundary conditions are "in the data" almost instantaneously at BGL-3 and preclude calculation of a representative T.

The semi-log plot of data from the BLM well (Figure 5) shows that both negative and positive boundary conditions are apparent. A type-curve solution of the earlier data produced T values of about 125,000 gpd/ft and S values of about \(1.5 \times 10^{-4}\).

The following table summarizes the calculated aquifer characteristics at various observation wells, using the earliest time data.
DRAWDOWN AT BGL-3, BGL-4, AND BLM DURING STEP TEST AT BGL-2
AT A FLOW RATE OF 1000 GPM, APRIL 1982

TIME (MINUTES)
<table>
<thead>
<tr>
<th>Well</th>
<th>Test Rate</th>
<th>Max. Drawdown</th>
<th>T(gpd/ft)</th>
<th>Storativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL-3</td>
<td>400 gpm</td>
<td>0.271 ft.</td>
<td>845,000</td>
<td>1.0 x 10^{-3}</td>
</tr>
<tr>
<td>BGL-3</td>
<td>1,000</td>
<td>0.618</td>
<td>817,500</td>
<td>1.2 x 10^{-3}</td>
</tr>
<tr>
<td>BLM</td>
<td>400</td>
<td>0.580</td>
<td>127,300</td>
<td>1.5 x 10^{-4}</td>
</tr>
<tr>
<td>BLM</td>
<td>1,000</td>
<td>2.060</td>
<td>114,600</td>
<td>1.7 x 10^{-4}</td>
</tr>
<tr>
<td>BGL-4</td>
<td>1,000</td>
<td>1.390</td>
<td>164,000*</td>
<td>3.6 x 10^{-4}</td>
</tr>
</tbody>
</table>

*Sensitivity of recording insufficient for reliable calculation.

The difference in these calculated values points out the local heterogeneity of the aquifer system, which also is reflected in the yields of individual wells. The transmissivity at BGL-2, based on the specific capacity of the 400 gpm step, is in excess of 400,000 gpd/ft. The small magnitude of drawdowns, together with the fast response, presents a formidable problem in the collection of meaningful data. The longer term testing, where data can be collected at more distant observation wells, allows calculation of "effective" aquifer characteristics, even though boundary conditions are "averaged in", so to speak.

**BGL-2 Constant Rate Test**

The constant-rate test was started after about 19 hours of recovery from the last step test at BGL-2. The discharge rate was maintained at 900 gpm for the entire 7-day test. Water level (or pressure) measurements were made at all of the observation wells. Continuous data collection was made at BGL-3, BGL-4, CM-1, BWSWD-3 and the Koch well through the use of recorders, while periodic observations were made at those wells and the remainder of the observation wells by use of Hg manometers, pressure gages or steel tape.

No observable effect on water levels could be detected from the recorder charts from BWSWD-3 or the Koch well. Apparently the Koch well is separated from the main aquifer system and at BWSWD 3 the effect of flowing BGL-2 was minimal or could not be separated from other influences. In addition, the Boise Park Department "cold" irrigation well was not affected by the flow at BGL-2. The remainder of the discussion of analyses will be restricted to those wells where
measurable effects occurred.

The following semi-log plot (Figure 6) summarizes the nature of drawdowns within the system. Although only four wells are plotted, the individual well graphs for BGL-1, CM-1 and the Beard well are similar. Omission of these on the composite plot was done in the interest of clarity. The plotted data have not been corrected for barometric pressure effects or earth tides. However, larger scale plots for individual wells show that such corrections are relatively small and do not alter the general trend. A barometric efficiency of 88% correction to the BGL-3 data is shown to demonstrate this. A falling barometer through most of the test resulted in less observed drawdown than would have occurred if the pressure had been constant. Consequently, all corrections are additive. This correction shows that the last point (at about 10,000 minutes) really does not depart from the trend of previous points; the barometric pressure had risen and was nearly the same as at the beginning of the test so the correction was less. Earth tide corrections could change the magnitude of individual points by about 0.1 foot but this would not alter the trend.

Semi-log plots of data from each of the wells show two distinct breaks in slope. The first slope, up to about 500 minutes, has an s (drawdown) of about one foot, or a calculated T of more than 200,000 gpd/ft. As discussed earlier, this is probably not representative of the actual (early time) T, which has been calculated to be more than double that value. However, the 200,000 value seems to be of the right order of magnitude. The second slope has an s of about 2 to 3 feet and the final slope has an s of about 5 to 6 feet per log cycle. This means that the prevailing effective transmissivity in the last 4 to 5 days of test was about 40,000 gpd/ft, an order of magnitude lower than in the first few hours of the test.

An attempt was made to determine the theoretical location of boundaries, whether actual barriers or a change in transmissivity that would effect observed drawdowns. This was unsuccessful because of the extremely small magnitude of drawdowns observed before boundary effects are a factor. However, because of the lack of response in the Koch well, it seems safe to assume that one boundary is located between that well and the other observation wells. Although several breaks in slope (indicative of boundaries) are apparent, it is not known if each
represents a new boundary. If at least two actual boundaries are present, the theoretical image wells used in such an analysis can react to these boundaries and produce additional boundary effects.

None of these boundary effects are considered to be the result of changes in thermal conditions. A reduction in temperature increases the viscosity and, therefore, reduces the effective transmissivity. However, such a change in temperature would be expected to be gradual and an abrupt change in $T$ would not occur. A transition from "hot" to "cold" is not consistent with other hydrogeologic conditions known to exist in the area.

It is doubtful that an exact definition of the type or location of boundaries or changes in transmissivity can be made without additional wells and/or extensive testing, using highly sophisticated instrumentation that would be devoted to that sole purpose. The behavior of the system in response to the magnitude of the presently planned project has been determined and is adequate for future projections of effects. Obviously, after a season or two of actual production, a better understanding of the system will evolve.

The most important aspect of the change in effective transmissivity, caused by the aforementioned boundary conditions, is the higher transmissivity of the early time portion. The test data show that, during the first few hours of a new stress the system responds in accordance with high $T$ characteristics. Long-term average discharge rates will be in accordance with the lower $T$ values. This means that the periods of high stress (peak demands) typically of short duration will have little effective effect, the long-term average discharge from the geothermal system will determine the magnitude of drawdowns. This is confirmed by the observation well data shown on Figure 7. Although the plot of the individual wells shows considerable "scatter" (again confirming heterogeneity), the slope of the line shown has a calculated $T$ of nearly 200,000 gpd/ft. In other words, the cumulative effect of a progressively lower effective $T$ is one of "averaging", and includes the effect of the early (high $T$) values. The drawdown measured at an observation well is in response to the "average" $T$ rather than the prevailing calculated $T$ at that time.

A sensitive digiquartz transducer and Hewlett-Packard recorder was made
available by EG&G shortly before shut in of the BGL-2 constant rate test. This equipment requires 120 VAC current, which restricted its use to either the BLM or CM-1 wells. It was installed on the BLM well to record recovery from the long-term test.

The following table summarizes the early-time data calculations of aquifer characteristics for the BGL-2 long-term test.

<table>
<thead>
<tr>
<th>Well</th>
<th>Test</th>
<th>T (gpd/ft)</th>
<th>S</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL-1</td>
<td>Drawdown</td>
<td>400,000(?)</td>
<td>-</td>
<td>**</td>
</tr>
<tr>
<td>BGL-3</td>
<td>Drawdown</td>
<td>264,000</td>
<td>2.6x10^{-3}</td>
<td>**</td>
</tr>
<tr>
<td>BGL-3</td>
<td>Drawdown</td>
<td>255,000</td>
<td>3.1x10^{-3}</td>
<td>*</td>
</tr>
<tr>
<td>BGL-4</td>
<td>Drawdown</td>
<td>264,000</td>
<td>4.0x10^{-4}</td>
<td>**</td>
</tr>
<tr>
<td>BLM</td>
<td>Drawdown</td>
<td>164,000</td>
<td>1.4x10^{-3}</td>
<td>**</td>
</tr>
<tr>
<td>BLM</td>
<td>Recovery</td>
<td>375,000</td>
<td>1.2x10^{-4}</td>
<td>*</td>
</tr>
<tr>
<td>Beard</td>
<td>Recovery</td>
<td>286,000</td>
<td>-</td>
<td>**</td>
</tr>
<tr>
<td>CM-1</td>
<td>Drawdown</td>
<td>290,000</td>
<td>4.0x10^{-4}</td>
<td>**</td>
</tr>
<tr>
<td>CM-1</td>
<td>Drawdown</td>
<td>271,700</td>
<td>5.0x10^{-4}</td>
<td>*</td>
</tr>
</tbody>
</table>

* This type-curve matching method
** Cooper-Jacob straight line method

Calculations of parameters using data from BGL-1 result in T values generally in excess of those from other wells even though BGL-1 has the lowest discharge capacity of any well in the area. Furthermore, the response is much slower, resulting in calculations of very high S values. However, after about 100 minutes the data plot is similar to the other wells. This anomaly has not been explained completely but a reduced hydraulic conductivity in close proximity to the well bore is indicated.
This well had not been tested or even flowed since completion of drilling. Consequently, it was necessary to flow it briefly to determine the discharge capacity to plan for testing. The well was flowed on April 26 and the maximum discharge rate was found to be less than 200 gpm. During this time the lower (12-inch) valve was difficult to operate and it was believed to be only partially open. At the completion of drilling in September 1981 the flow was estimated to be about 400 gpm. Because of the annual variation in pressure within the system, a discharge of less than 400 gpm in April was not surprising. However, the suspected partially open valve also could have been a factor. A multiple-step flow test was run the next day in an attempt to determine if the valve opening was responsible for the restricted flow.

The well was at or near temperature equilibrium, having been shut-in for several weeks. Therefore, as the well was flowed, the density difference due to heating the column within the well would affect the well-head pressure. It was decided to flow the well at a low discharge rate initially and, before each incremental change in discharge, to shut in the well to obtain the prevailing shut-in (static) pressure at each step. Although some errors are inherent from a theoretical basis, past experience has shown this procedure is reasonably accurate for the intended purposes.

The well was flowed at about 30 gpm for the first step and increased through several more steps to a maximum rate of about 180 gpm. The table below summarizes the results. If the valve had been a significant factor in reducing the higher flow rates, the specific capacities at those rates would have been significantly lower than those observed. Furthermore, any significant head loss through the valve would have reduced the pressure above the valve and, therefore, would have reduced the available drawdown. The pressures observed were consistent with calculated values. It was concluded that the reduced capacity was due to the system pressure being at its seasonal low.
The second part of the BGL-4 step test was conducted on May 5, five days after termination of the 2-day constant rate test. This test was run at about 185 gpm for 95 minutes. The purpose of this test was to obtain additional early-time data at nearby observation wells while flowing at a relatively low discharge rate. The constant rate test had shown that the aforementioned boundary conditions would arrive at observation wells somewhat slower and could be identified. A sensitive transducer-strip chart recorder combination was installed at BGL-1 and BGL-2 and the digiquartz transducer-HP recorder installation was located at the BLM well. The test was started with the intent of maintaining 185 gpm. However, because of numerous factors, particularly the heat-up of the water column in the well, the first 15 minutes were at 165 to 177 gpm. After that a rate of 187.5 gpm was established and maintained for the balance of the test.

A procedural error resulted in the loss of early-time data recording at the BLM well. However, the pressure record showed that the drawdown had reached steady-state conditions there and was constant for the last 23 minutes of the test. Within 20 seconds of shutdown at BGL-4, recovery at BLM began and was recorded at 10-second intervals. This recovery data was treated as drawdown data for aquifer characteristic calculations (see Figure 8). The data from BGL-1 were marginal at best. The 0-0.15 psig range would not maintain a consistent recorder track before starting the test and the 0-1.5 psig range was not sensitive enough to provide meaningful data. This is not too surprising when the maximum drawdown measured at these wells was about 0.3 feet or less. A similar situation occurred at BGL-2 using a 0.5 and 5.0 psig range. These data could not be used. The recorder chart at BGL-3 again provided excellent drawdown data and numerous time checks were made to improve on the time accuracy. The table below summarizes the aquifer characteristics calculations for this test of BGL-4.

<table>
<thead>
<tr>
<th>Step 0</th>
<th>Drawdown</th>
<th>Specific Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 gpm</td>
<td>1.5 ft.</td>
<td>20. gpm/ft.</td>
</tr>
<tr>
<td>97</td>
<td>5.8</td>
<td>16.8</td>
</tr>
<tr>
<td>136</td>
<td>10.2</td>
<td>13.3</td>
</tr>
<tr>
<td>155</td>
<td>13.7</td>
<td>11.3</td>
</tr>
<tr>
<td>182</td>
<td>17.7</td>
<td>10.3</td>
</tr>
</tbody>
</table>

The table above presents the drawdown and specific capacity data for the BGL-4 step test.

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Q = 187 GPM
r = 977.8
T = 420,000 gpd/ft
S = 2.6 \times 10^{-5}

MATCH POINT
W(u) = 1.0
u = 1.0
s = .051 \text{ ft.}
\frac{r^2}{t} = 8.8 \times 10^{9}

RECOVERY OF BLM AFTER BGL-4 STEP TEST, MAY 1982
### Well Test T (gpd/ft) Storativity Remarks

<table>
<thead>
<tr>
<th>Well</th>
<th>Test</th>
<th>T (gpd/ft)</th>
<th>Storativity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL-1</td>
<td>Drawdown</td>
<td>195,000</td>
<td>2.5 x 10⁻⁴</td>
<td>**</td>
</tr>
<tr>
<td>BGL-3</td>
<td>Drawdown</td>
<td>800,000</td>
<td>4.2 x 10⁻⁴</td>
<td>*</td>
</tr>
<tr>
<td>BGL-3</td>
<td>Drawdown</td>
<td>651,000</td>
<td>5.0 x 10⁻⁴</td>
<td>*</td>
</tr>
<tr>
<td>BGL-3</td>
<td>Recovery</td>
<td>875,000</td>
<td>4.6 x 10⁻⁴</td>
<td>*</td>
</tr>
<tr>
<td>BLM</td>
<td>Recovery</td>
<td>420,000</td>
<td>2.6 x 10⁻⁵</td>
<td>*</td>
</tr>
<tr>
<td>BLM</td>
<td>Recovery</td>
<td>441,000</td>
<td>2.4 x 10⁻⁵</td>
<td>**</td>
</tr>
</tbody>
</table>

* Theis type-curve matching method
** Cooper-Jacob straight line method

### BGL-4 Constant Rate Test

The test was started on April 28 and run for 48 hours at a rate of 100 gpm. BGL-2 and BGL-3 were the principal nearby observation wells used, equipped with a sensitive transducer-record and float recorder, respectively. The digiquartz transducer was installed at CM-1 but it became apparent that the "noise" in the system (i.e. possible barometric pressure and earth tidal influences, as well as the beginning of the seasonal rise) precluded accurate measurements of drawdown there.

Figure 9 shows the uncorrected water level record from the recorder on BGL-3 and the barometric pressure record during the BGL-4 constant rate test. This shows about 2 days of drawdown and 4 1/2 days of the recovery period. As discussed previously, BGL-3 has a high barometric efficiency. Consequently, the barometric pressure record (plotted inversely) suggests that the decline of the water level at BGL-3, as well as its subsequent rise, in the first part of the record may be partially the result of changes in barometric pressure. The scales on these plots are directly comparable (1" Hg=1' water or 88% B.E.) for clarity. The barometric record also suggests the flattening in the water level trend at the end of the period is due to the rise in pressure.

Figure 10 shows the uncorrected water level at CM-1, from the transducer data record, and the corrected water level record at BGL-3. The CM-1 record does not reveal a marked drawdown or recovery from the BGL-4 test, but it does show the same rising trend as noted on the
WATER LEVEL AT BGL-3 FROM NOON APRIL 28 TO MIDNIGHT MAY 4 1982
DATA FROM STEVENS TYPE F RECORDER CHART

BAROMETRIC PRESSURE FROM NOON APRIL 28 TO MIDNIGHT MAY 4 1982
DATA FROM BAROGRAPH RECORD AT ANDERSON & KELLY BUILDING
NOTE INVERTED SCALE

Figure 9.
WATER LEVEL AT CH-1 FROM NOON APRIL 28 TO MIDNIGHT MAY 4, 1982
DATA FROM DIGIQUARTZ TRANSDUCER CONVERTED TO FEET OF WATER

Figure 10.

WATER LEVEL AT BGL-3 FROM NOON APRIL 28 TO MIDNIGHT MAY 4, 1982
DATA FROM STEVENS TYPE F RECORDER CHART CORRECTED FOR 88% B.E.
BGL-3 uncorrected data. More importantly, this trend is virtually identical to the trend of the corrected data for BGL-3, ignoring the observations probably due to earth tides. This shows that changing barometric pressure has little or no effect at CM-1 and that no correction for barometric efficiency is necessary.

The corrected record for BGL-3 shows a less pronounced (but better defined) drawdown due to the BGL-4 test in the early data and a continuous rising trend for the balance of the period. Because this trend is similar to that seen in the CM-1 plot, as well as because the magnitude of rise is greater than the drawdown, the rise is considered to be a regional effect.

An excellent record (see Figure 11) was obtained from BGL-2 during the first 26 minutes of the test. The data plot fits the Theis type curve throughout this time period. The calculated aquifer characteristics values are: $T=261,900 \text{ gpd/ft}$ and $S=1.8 \times 10^{-4}$. The curve match is one of the best of the entire test data.

The other transducer and strip chart recorder were installed on the Beard well, only 29.5 feet from BGL-4, in an attempt to obtain drawdown data close to the tested well. The drawdown was recorded but the time and pressure scale factors were not conducive to precise definition of a time-drawdown plot. The Beard well declined about two feet in the 90 seconds and remained essentially at that level for the next few minutes. A pressure scale change was made in an attempt to define any additional drawdown. However, the "noise", referred to previously, did not allow such definition. Prior to shut down, a different transducer was installed on the Beard well with the hope that the recovery could be defined better than drawdown. This, too, was unsuccessful and only showed that recovery was virtually instantaneous. However, after 10 to 15 minutes, a slight decline in pressure was noted. This seemed to be related to cooling of the water column causing increased density of the column and a corresponding reduction in the observed pressure.

An experiment was initiated that was designed to verify the above. The small petcock valve on BGL-4 was opened and allowed to flow for several hours. As the temperature in this flow from BGL-4 increased, the pressure in the Beard well also increased. This showed that the BGL-4 and Beard wells are interconnected, either directly at depth or at
Q = 160 GPM
r = 318 Feet
T = 261,900
S = 1.8 x 10^-4

MATCH POINT

W(u) = 1
u = 1
s = .07 ft
r^2/t = 7.8 x 10^8

DRAWDOWN OF BGL-2 DURING BGL-4 CONSTANT RATE TEST APRIL, 1982

FIGURE 11.
least through fractures or other openings in the geothermal aquifer. This possibility was suspected during the drilling of BGL-4 when some traces of lost circulation material were seen in the drill cuttings. None of this material was used in the drilling of BGL-4 but its use was mentioned in the drilling records of the Beard well.

The following table summarizes the calculated aquifer characteristics from the BGL-4 constant rate test.

<table>
<thead>
<tr>
<th>Well</th>
<th>Test</th>
<th>T (gpd/ft)</th>
<th>Storativity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGL-2</td>
<td>Drawdown</td>
<td>261,900</td>
<td>1.8x10^-4</td>
<td>*</td>
</tr>
<tr>
<td>BGL-3</td>
<td>Drawdown</td>
<td>873,000</td>
<td>4.0x10^-4</td>
<td>*</td>
</tr>
<tr>
<td>BGL-3</td>
<td>Drawdown</td>
<td>789,000</td>
<td>3.8x10^-4</td>
<td>**</td>
</tr>
<tr>
<td>BLM</td>
<td>Drawdown</td>
<td>112,600</td>
<td>5.4x10^-4</td>
<td>**</td>
</tr>
</tbody>
</table>

* Theis type-curve matching method
** Cooper-Jacob straight line method
SUMMARY AND CONCLUSIONS

The numerous analyses to determine aquifer characteristics discussed herein show that relatively consistent transmissivity (T) and storativity (S) values can be calculated from early-time data for each of the wells. However, those early-time transmissivity values persist for, literally, only minutes in some cases. The value in knowing the "true" transmissivity is its aid in understanding the system and, perhaps in the future, in using these values in a numerical simulation model. The following discussion of the individual wells will summarize the present knowledge of aquifer characteristics.

**BGL-1 Well**

This well responds slowly to discharge of nearby wells. Early-time data is virtually nonexistent (to date) but later-time data result in calculations of T which correspond to that calculated for other wells.

**BGL-2 Well**

This well is planned to be the principal supply well for the first phase of the Boise City space heating project because of its extraordinary yield. The well was flowed for a week at 900 gpm and the back-pressure was still 2.8 psig. The specific capacity during the 400 gpm step test indicates T is in excess of 400,000 gpd/ft. When used as an observation well, early-time data indicates T is in the 250,000 gpd/ft range. Storativity was calculated to be about 1.8 x 10^-4.

**BGL-3 Well**

This well is located at a surface elevation higher than the potentiometric level of the geothermal aquifer. Consequently, it does not flow and has been used as the principal water-level monitoring well since its completion in 1981. It has not been tested and its discharge capacity is not known. Its sensitivity to barometric pressure and earth tidal influences indicates a low storativity. This is confirmed by the recent testing of BGL-2 and BGL-4. Calculated values of S are about 4 x 10^-4, using early-time data. Calculated transmissivity
values ranged from about 250,000 to more than 800,000 gpd/ft.

**BGL-4 Well**

The short-term discharge specific capacity of BGL-4 is an order of magnitude lower than that of BGL-2 (20 vs 200 gpm/ft). Consequently, the transmissivity, estimated on that basis, would be less than 50,000 gpd/ft. However, as an observation well during the BGL-2 testing, calculated T values were in the 160,000 to 260,000 gpd/ft range. Storativity (S) values were calculated to be about 4 x 10^-4.

**BLM Well**

Transmissivity values calculated at this well ranged from about 115,000 gpd/ft on drawdown data to more than 400,000 gpd/ft on recovery data. The storativity ranged over two orders of magnitude, from as low as 2.4 x 10^-5 to as high as 1.4 x 10^-3. The existence of boundary conditions seems to be the obvious reason for the wide spread in values, although it cannot be defined at this time. The recovery data, using the digiquartz transducer, seems to be the "best" information. Those data indicated T values about 400,000 gpd/ft and S values in the 10^-4 to 10^-5 range. It is obvious that T is high and S is low; response to changes in stress (shut down) at BGL-2 and BGL-4 were observed at the BLM well within 10 seconds.

**Beard Well**

This well was not used as a primary observation well for calculation of aquifer characteristics but the test data showed that it behaved similarly to BGL-4. During the recovery from BGL-4 testing it was demonstrated that the two wells are interconnected at depth.

**CM-1 Well**

This was the primary observation well outside of the Military Reserve Park area. Data obtained from monitoring CM-1 demonstrated the well-developed hydraulic connection with the BGL wells. Early-time T values were calculated to be slightly less than 300,000 gpd/ft with S about 5 x 10^-4.
CM-2 Well

This well is about 900 feet further from the BGL wells than CM-1 and, consequently, recognition of early-time data was more difficult. This was particularly true because of the use of the sensitive recording equipment at other locations and, therefore, the reliance on Hg manometer data only. After about the first day of the BGL-2 long-term test, the data trend was similar to CM-1 and the other wells shown on Figure 6.

Other Wells

No measurable effects from testing of BGL-2 and BGL-4 could be seen on the records of the Koch and BWSWD No. 3 wells. No estimate of aquifer characteristics at these wells can be made from the testing program data collection. However, it appears certain that the Koch wells are separated from the main geothermal aquifer system. BWSWD No. 3 may be in hydraulic connection with the other geothermal wells discussed above but this assertion is not supported by the test data.

The Boise Park Department well, completed in the upper "cold" aquifer system, was not affected by the testing of the BGL wells. Furthermore, it is postulated that this well and other wells in that system will not be adversely affected by prolonged geothermal aquifer production. The various beds or formations that produce the confined nature of the geothermal system obviously have low vertical hydraulic conductivity characteristics. Consequently, any interconnection between the two systems is limited and stresses will be transmitted very slowly, if at all.

Long-Term Production

The projected demand of the initial space heating system is based on a peak capacity of 2,000 gpm, with the average monthly demand based on historical average degree-day calculations. This projected demand is shown below.
The average demand from November through February is about 1,000 gpm. Because the BGL-2 constant-rate test was conducted at 900 gpm, a projection of that drawdown trend, modified slightly, is the best method available at this time for future predictions. Figure 6 shows that drawdowns at the various wells, whether in the BGL well field or at the CM wells, were in the 6- to 8-foot range after the 7-day BGL-2 test. Modification of those trends for the higher average demand from November through February indicates a general lowering of about 21 feet. In other words, production at the BGL wells will reduce aquifer pressures on the order of 10 psi. Obviously this cannot be considered "accurate" in the usual sense but it is considered a reasonable approximation. Many other factors, principally the actual demand on the production wells and the operation of the CM wells for the State office buildings space-heating system, will have the greatest effect.

The peak demand of 2,000 gpm is expected to be about 7 to 10 days in duration, based on historical considerations. Using the same approach as discussed above, it is anticipated that this would produce 9 feet of additional water-level lowering. When the demand following this peak is reduced, recovery of much of this amount would be expected. Daily peak demands in excess of the average demand are not expected to have significant effects because the prevailing transmissivity is high during the early part of the new stress (demand) on the system.
These projections, if realized, together with the seasonal variations already known to exist, could result in a potentiometric surface as much as 20 feet below ground surface in the vicinity of the BGL wells at its low point for the year. At the CM wells this lowering would result in levels a few feet below ground surface without considering the effects of withdrawals and/or injection at those wells.

A variation on this approach is to use the indicated monthly average demand and to compute drawdowns based on monthly incremental changes in the discharge rate. Figure 12 shows the predicted annual cycle of water levels in the general vicinity of the BGL well field for the first heating season.

*Projected Local Annual Drawdown Cycle for First Year Operation*  
Boise Geothermal Space Heating Project  
Average Monthly Demand Based on Historical Degree-Day Records

![Projected Local Annual Drawdown Cycle for First Year Operation](image)  
**Figure 12.**
The method of analysis used to calculate these drawdowns assumes all production is derived from aquifer storage. Consequently, a net decline of a few feet is shown on the graph at end of the first month (September) of the second heating season. However, it should be remembered that this production will be a new major stress on the system. Consequently, until a new state of dynamic equilibrium is established, some net decline can be expected. This concept was first expressed by Theis (1940) and reiterated by Lohman (1972). A short quotation from the latter (p. 63) provides a succinct explanation.

"Prior to development by wells, aquifers are in a state of dynamic equilibrium, in that over long periods of time recharge and discharge virtually balance. Discharge from wells upsets this balance by producing a loss from storage, and a new state of dynamic equilibrium cannot be reached until there is no further loss from storage. This can only be accomplished by:

1. Increase in recharge (natural or artificial).
2. Decrease in natural discharge.
3. A combination of 1 and 2."

The BWSWD development may be a case in point. It is generally recognized that the potentiometric surface at those wells probably was 20 or more feet higher than present at the beginning of the century. Continuous use of that system, probably at annual rates of production comparable to those tabulated above, caused that net lowering. However, in recent years, no discernible change (net annual decline) has been observed. The decline probably occurred in the first few years. Although the data to support this contention is sketchy, at best, a reasonable corollary seems to exist.

Figure 13 shows the generalized annual cycle of water levels at the BLM well prior to production from the BGL wells and the predicted cycle during the first year of production. The difference in elevation is the calculated drawdowns shown on Figure 12. Briefly, the peak elevations in late summer are expected to be only a few feet lower than in the past, but during the heating season the elevations will be more than 20 feet lower.
GENERALIZED HYDROGRAPH OF BLM WELL PRIOR TO PRODUCTION FROM
BOISE GEOTHERMAL SPACE HEATING PROJECT

PROJECTED HYDROGRAPH OF BLM WELL DURING FIRST YEAR OPERATION
BOISE GEOTHERMAL SPACE HEATING PROJECT

Figure 13.
SELECTED REFERENCES


Robinson, Thomas W. (1939) Earth-tides shown by fluctuations of water-levels in wells in New Mexico and Iowa: American Geophysical Union Transactions.

Theis, C.V. (1940) The source of water derived from wells: Civil Eng., v.10, no.5, p. 277-280.
Hydrographs of BGL-3, 'Old' Koch Well, & BWSWD #3
Sketches of Test Well & Observation
Well Instrumentation
BOISE GEOTHERMAL LTD. WELLS

TYPICAL FLOW TEST ASSEMBLY

(Not to Scale)
Boise Geothermal Ltd. No. 1

NOTE: R.P. ELEVATION IS AT 27/16" ON MANOMETER

BOISE GEOTHERMAL LTD. NO. 2

NOTE: CENTER OF GAGE IS ABOUT 0.6' ABOVE R.P. ELEVATION
Boise Geothermal Ltd. #3

Boise Geothermal Ltd. No. 4

Note: R.P. Elevation is at 5 5/16 inches on the manometer.
BLM WELL

R.P. ELEV. = 2742.20

Note: 50" mark on manometer is 2.26' above R.P. ELEV.

DIGIQUARTZ TRANSDUCER

BEARD WELL

R.P. ELEV. = 2746.94

HEISE GAGE

3.00'

STEEL WELL PIT COVER
CAPITOL MALL No. 1

R.P. ELEV. = 2715.65

1.40'

1.00'

0.20'

0.15'

CAPITOL MALL No. 2

TO MANOMETER

6.18'

5.73'

42°

3.31'

R.P. ELEV. = 2709.18

NOTE: R.P. ELEV. IS 3.31' BELOW 42° INCH MARK ON MANOMETER.
Basic Data for Well Tests
& Barometric Record