Review of Boise Front Low Temperature Geothermal Monitoring Data for Water Year 2019 (October 1, 2018 – September 30, 2019)

Mike McVay, Water Resources Engineer
Idaho Department of Water Resources (IDWR)

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EXECUTIVE SUMMARY

The total gross withdrawals from the four district heating systems in the Downtown Boise-East Boise area of the Boise Front Low Temperature Geothermal Resources Ground Water Management Area in Water Year 2019 (WY19) were 826.9 million gallons (mgal), which is 18.5 mgal less than in Water Year 2018 (WY18). The City of Boise (City) system decreased both gross withdrawals and injected water in WY19 by 36.2 and 35.4 mgal, respectively, and the net withdrawals by the City were 0.75 mgal less than in WY18. The BWSWD systems increased net withdrawals by 10.8 mgal. The combined net withdrawals for all systems in WY19 were 266.1 mgal, which is 10.1 mgal more than WY18. Approximately 68% of the water withdrawn in WY19 was re-injected, which is a decrease of approximately 2% from WY18.

In general, water levels in the Downtown Boise-East Boise area declined from WY18 to WY19. Both the shallowest (maximum) and deepest (minimum) water levels for the BLM well declined 0.3 feet. The Kanta well maximum water level rose 0.1 feet from WY18 to WY19. Monitoring equipment issues during WY18 preclude an analysis of minimum water levels; therefore, only the maximum water-level change in the Kanta well is presented. The changes in maximum water levels for the three Boise Warm Springs Water District (BWSWD) wells were as follows: a decline of 1 feet in the East well, decline of 1 foot in the West well, and a decline of 8 feet in BWSWD #3. The minimum water levels for the East and West wells were 23 and 12 feet lower, respectively, and the minimum water level for BWSWD #3 declined 5 feet.

The maximum average monthly water temperature for the State of Idaho Capitol Mall (State) production well did not change from WY18 to WY19. The average of the monthly temperatures was also 0.04 degrees Fahrenheit (°F) higher in WY19. The maximum temperature for BWSWD system in WY19 was the same as in WY18. The maximum water temperature for the City system was approximately 0.4°F higher in WY19.

Withdrawals and Re-Injection

Combined gross and net withdrawals from the four Downtown Boise-East Boise district heating systems were 826.9 mgal and 266.1 mgal, respectively, in WY19 (Table 1 and Figure 1). Gross withdrawals decreased 18.5 mgal (-2%), and net withdrawals increased 10.1 mgal (+4%). Approximately 68% of the fluids were re-injected, which is a 2% increase over WY18.

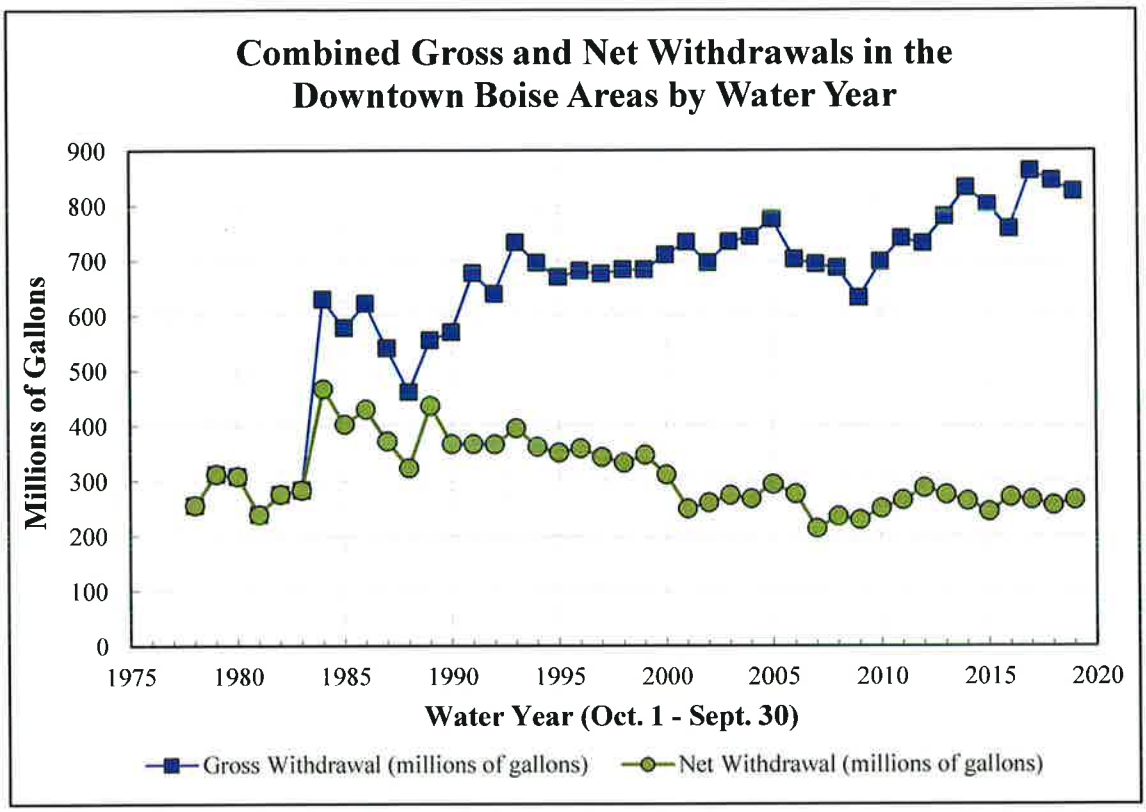

Figure 1. Gross and net withdrawals for the four district heating systems in the Downtown Boise area for water years 1978 through 2019.

As shown in Table 1, the State, Veteran's Administration (VA), and BWSWD systems increased gross withdrawals in WY19. The City was the only system to decrease gross withdrawals, with 36.2 mgal less (-16%) than in WY18. The City also reduced net withdrawals by 0.75 mgal (-11%). Because the State and VA systems re-inject all of their water, the increase in combined net withdrawals is a result of increased usage in the BWSWD system.

The State delivered approximately 12 mgal to the City in October 2018. The City used this water and subsequently re-injected it. However, the volume of water delivered was not quantified because it did not flow through the City's production meter. Therefore, the volume of State water delivered to the City has been calculated assuming 92% of the delivered water was re-injected by the City; 92% is the average re-injection rate for the week before and the week after the State deliveries. The volume of water provided by the State has been deducted

from the State's gross withdrawals, and added to the City's gross withdrawals in an effort to more closely describe the permit holder's system operational needs in WY19.

It is important to note that the gross withdrawals and injection volumes that are reported in the City of Boise's annual report for Water Right Permit 63-3426 represent the raw production- and injection-well meter values, and do not reflect how much the State provided to the City. In other words, the City's data does not include water delivered by the State, but does capture increased re-injection that resulted from the deliveries.

Table 1. Withdrawals[1] from the four district geothermal heating systems in the Downtown Boise-East Boise areas for Water Year 2018 (October 1, 2018 through September 30, 2019).

System	Gross Withdrawals (million gallons) and percent change from WY18 to WY19	Net Withdrawals[1] (million gallons) and percent change from WY18 to WY19
Boise Warm Springs Water District	251.5 (+5%)	251.5 (+5%)
State of Idaho Capitol Mall	79.1 (+11%)	0 (NC[2])
City of Boise	276.4 (-12%)	14.7 (-5%)
Veterans Administration	220 (+5%)	0 (NC[2])
Total	**826.9 (-2%)**	**266.1 (+4%)**

[1]Net Withdrawals equal Gross Withdrawals minus Injection amounts.
[2]NC = No change.

Withdrawal Trends

Statistical trends provide a technically defensible assessment of changes over time. Statistical significance indicates that there is a non-zero trend in the data at the chosen confidence interval, and the calculated trend is the best linear representation of changes over time. Lack of statistical significance indicates that the trend cannot be considered different than zero (at the chosen confidence interval), and the calculated trend does not represent changes over time. A confidence interval of 95% has been used to determine statistical significance for all Boise Front Low Temperature Geothermal trends.

The WY18 – WY19 decrease in gross withdrawals and increase in net withdrawals belie the long-term trends in withdrawals. The WY90 – WY19 trends in combined gross and net withdrawals are +5.6 and -4.4 mgal/year, respectively, and both trends are statistically significant (Table 2).

Table 2. Gross and net withdrawal trends and significance for the four district geothermal heating systems in Downtown Boise-East Boise areas for WY90 – WY19.

Withdrawals	Withdrawal Trends (mgal per year)[1]	Withdrawal Trend p-value[2]
Gross Withdrawals	**5.6**	**0.00**
Net Withdrawals	**-4.4**	**0.00**

[1] Trends and significance have been calculated using the Mann-Kendall statistical test.
[2] P-values less than 0.05 indicate the trend is significant at the 95% confidence interval.

Water Levels in the BLM, Kanta, City of Boise, BWSWD, and Harris Ranch Wells

Water levels in the Downtown Boise Front Geothermal Area generally declined in WY19. The BLM well is located near the City, State, and VA wellfields, which makes it a good indicator of system water levels. Both the maximum and minimum water levels declined 0.3 feet from WY18 to WY19 (Figure 2).

The monitoring equipment in the Kanta well began to malfunction in October 2017, and was reset in September 2018 (Figure 3). The City has addressed the equipment issue and has resumed data collection. The maximum water level in September 2018 is assumed to represent the WY18 maximum water level because the maximum water level often occurs near the end of September, but this assumption results in more uncertainty than if data had been collected over the entire water year. Using the September 2018 data, the maximum water level declined 0.1 feet from WY18 to WY19. The data gap prevents an analysis of the change in minimum water levels.

The City BGL #1 well transducer failed in May, and the City is still in the process of repairing/replacing the transducer. The manual measurements have been unusually high for several years, and don't appear to accurately represent the water level in BGL #1, as was noted in previous reports (Figure 4). These issues preclude any analysis of water levels for WY19.

The maximum water levels in both the BWSWD East and West wells declined 1 foot, and the maximum water level in BWSWD #3 well declined 8 feet from WY18 to WY19 (Figures 6 and 7). The minimum values for the East and West wells were 23 and 12 feet higher, respectively and the minimum water level in BWSWD #3 well declined 5 feet from WY18 to WY19 (Figures 6 and 7). It is important to note that the water levels in all BWSWD wells are reported to the nearest foot.

Due to a data gap in measurements for both of the Harris Ranch wells, it is not possible to analyze the WY18 – WY19 water-level changes. In order to give an indication of water-level changes in both the East and West wells, changes have been calculated using November 2017 and November 2019 water levels. The East and West Harris Ranch wells have risen 0.7 feet and 0.3 feet over the last two years (Figure 5).

Water-Level Trends

Water levels in the Downtown Boise Front Geothermal Area have generally risen over the last 14 years, with statistically significant rising trends in 4 of 5 wells analyzed. The water-level trends in BWSWD #3 are not statistically significant. The City BGL #1 and BGL #2 wells were not analyzed for trend due to insufficient data.

Table 3. Water-year water-level trends for select wells in the Downtown Boise-East Boise areas for WY05 – WY19.

Wells	Max Water Levels Trend (ft. per year)[1]	Max WL Trend p-value[2]	Min Water Levels Trend (ft. per year)	Min WL Trend p-value
BLM Well	**0.4**	**0.00**	**0.7**	**0.02**
Kanta Well[4]	**0.4**	**0.00**	**0.7**	**0.02**
City of Boise[3]	NA	NA	NA	NA
Boise Warm Springs Water District[5]	0.20	0.49	0.59	0.35
Harris Ranch[6]	**0.5**	**0.00**	**0.5**	**0.00**

[1] Trends and significance have been calculated using the Mann-Kendall statistical test.

[2] P-values less than 0.05 indicate the trend is significant at the 95% confidence interval.

[3] Water-level trend has been not been calculated for BGL #1 nor BGL #2 due to lack of reliable data during the WY05 – WY19 period.

[4] Kanta minimum water-level trend has been calculated without 2018 data.

[5] Water-level trend has been calculated for only BWSWD #3.

[6] Water-level trend has been calculated for only Harris Ranch West.

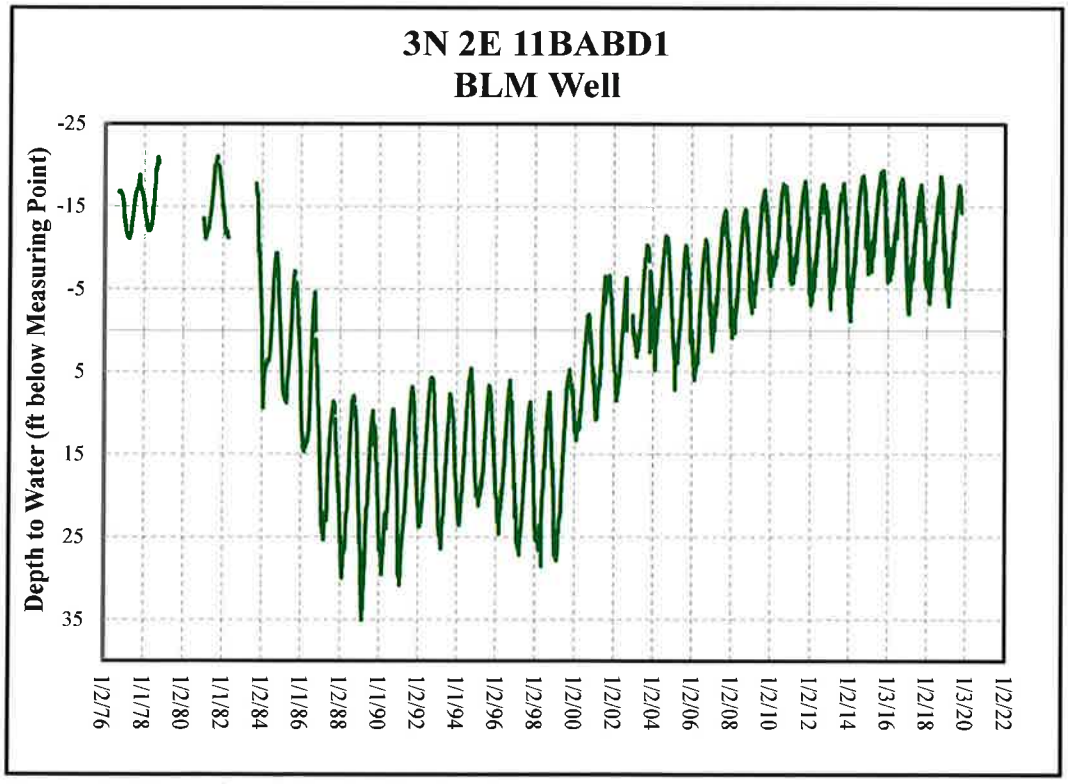

Figure 2. Water levels in the BLM well.

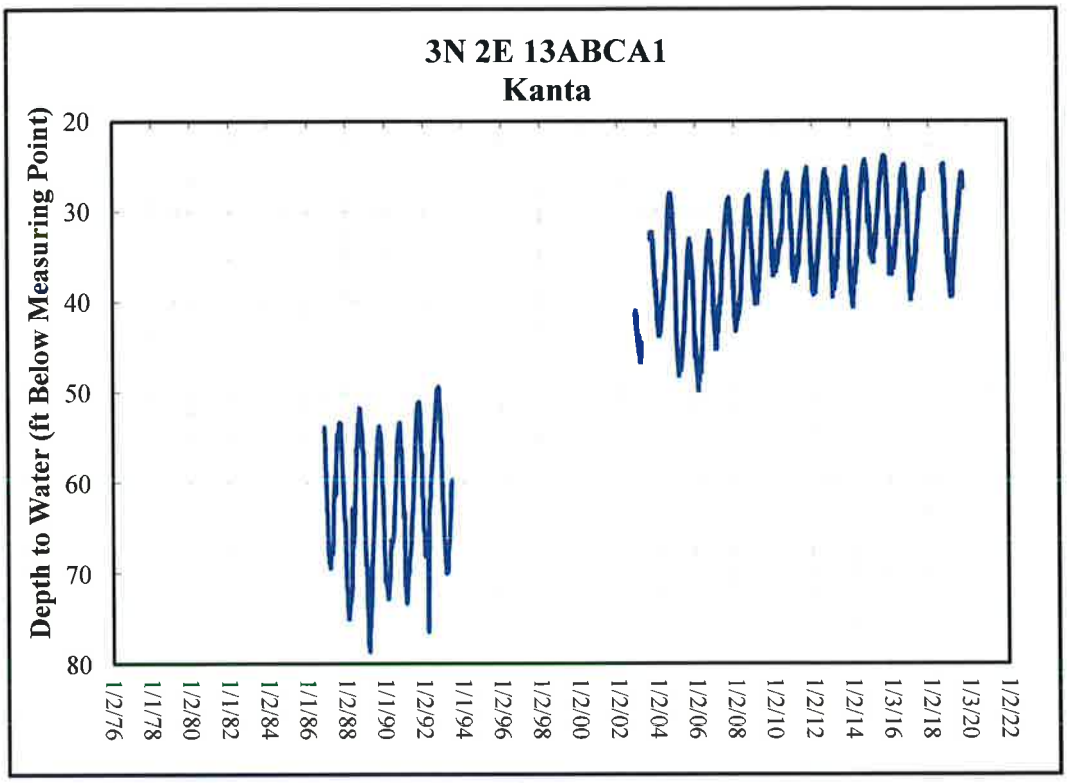

Figure 3. Water levels in the Kanta well.

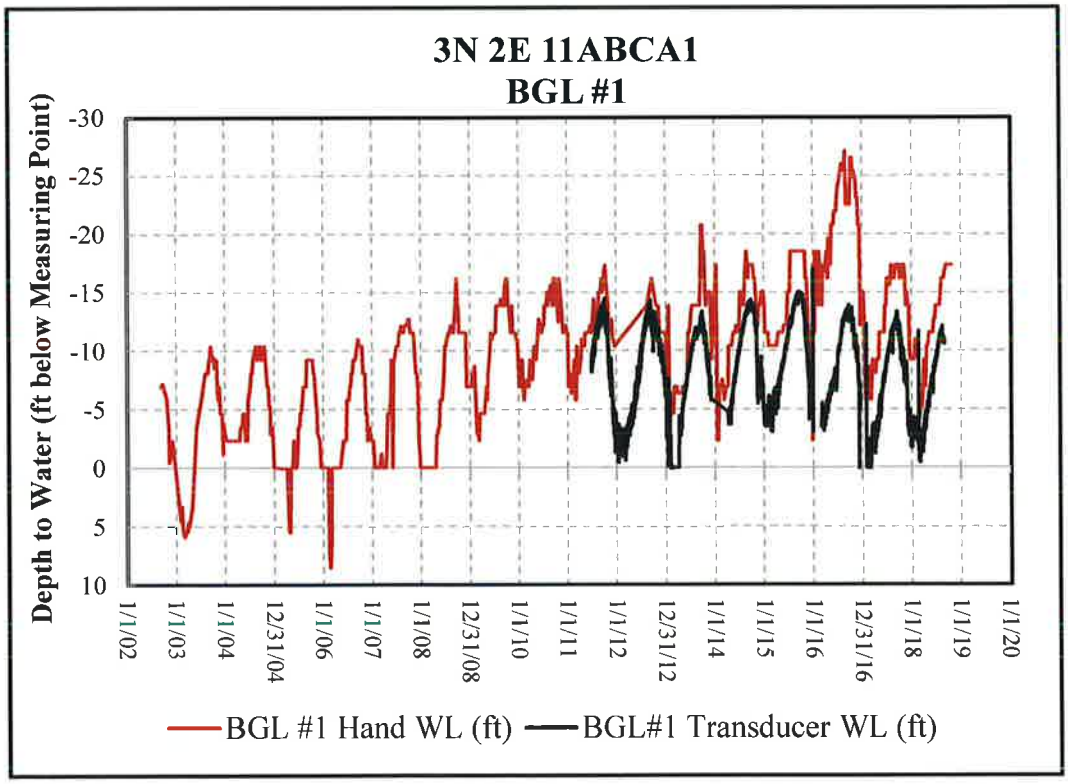

Figure 4. Water levels in the City of Boise's BGL #1 well only through WY18.

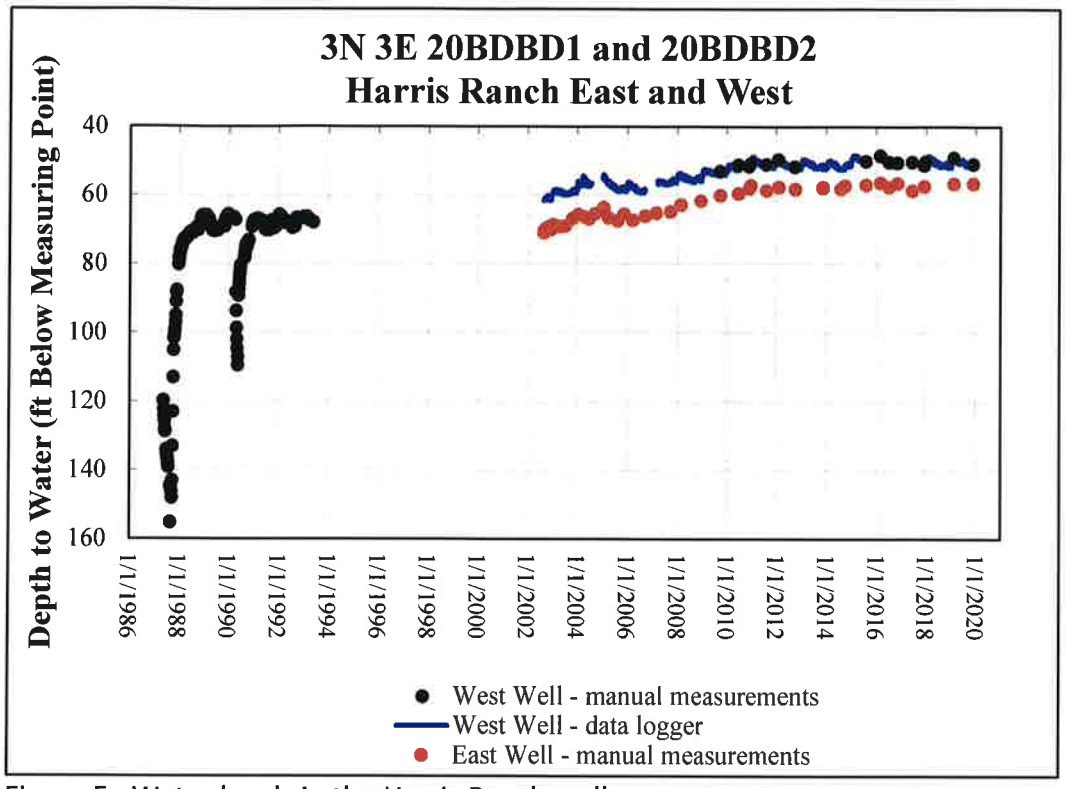

Figure 5. Water levels in the Harris Ranch wells.

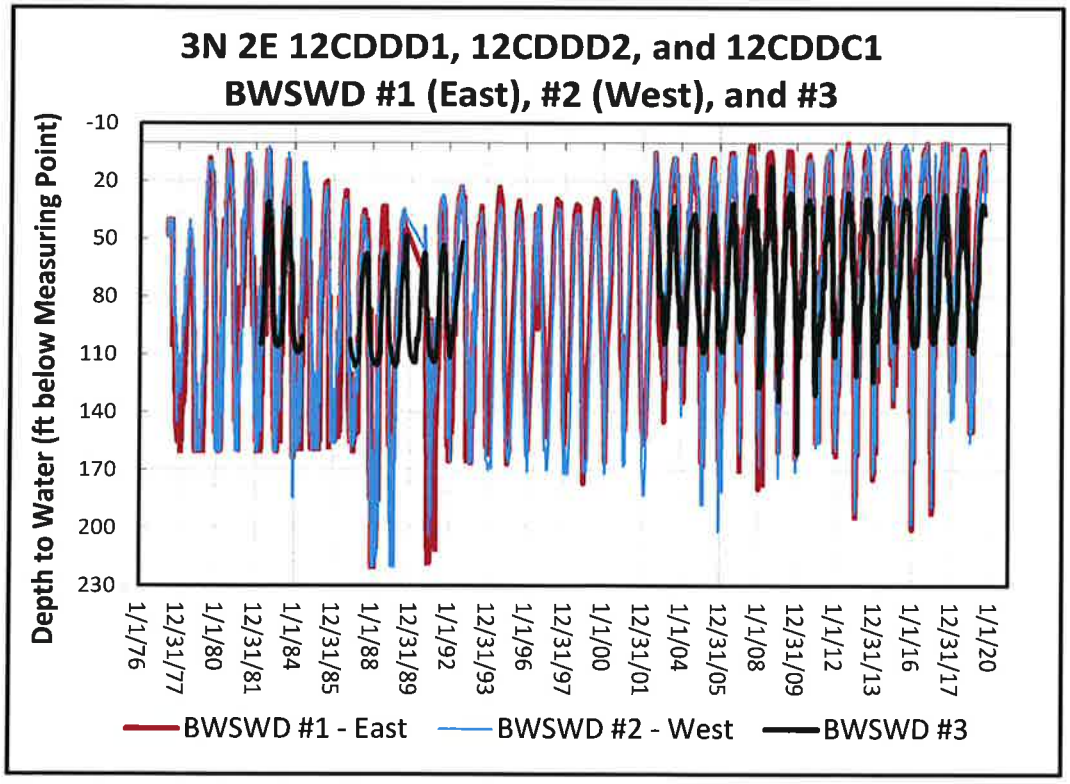

Figure 6. Water levels in the BWSWD wells.

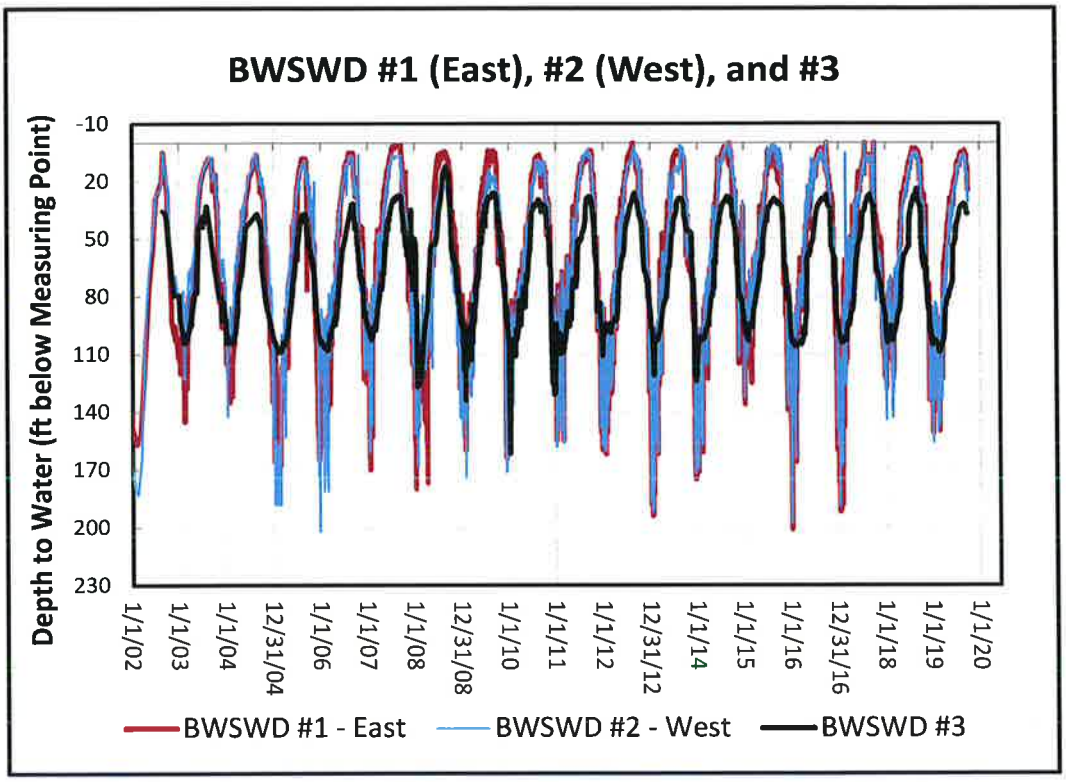

Figure 7. Water levels in the BWSWD wells, January 2002 through September 2019.

Water Supply Temperatures for the City of Boise, State of Idaho Capitol Mall, and BWSWD.

The maximum daily-average water temperature for the City was approximately 0.3°F lower in WY19 than in WY18 (Figure 11). The calculated trend of -0.01 °F from WY05 to WY19 is not statistically significant (Table 5).

The maximum monthly water temperature for the State of Idaho Capitol Mall Production well[1] did not change from WY18 to WY19 (Figure 9). The water-year average of the maximum monthly temperatures was 0.04°F lower in WY19 (Figure 10). It is important to note that in some water years, data that met the requirements for analyses were available for six months; in other years, fewer than six months had temperature data that met the requirements. The calculated trend of -0.03 °F per year is not statistically significant (Table 5).

The maximum annual temperature for the BWSWD system did not change from WY18 to WY19 (Figure 8). The calculated water-temperature trend from WY05 to WY19 is zero, and is not statistically significant (Table 5). This is a unique situation in which the calculated trend is zero, and the statistical test indicates the trend is not statistically different from zero.

Table 5. Water-year maximum temperature trends in the four district geothermal heating systems in the Downtown Boise-East Boise areas for WY05 – WY19.

System	Calculated Trend (^{0}F per year)[2]	Trend p-value[3]
Boise Warm Springs Water District	0.00	0.80
State of Idaho Capitol Mall[1]	-0.03	0.22
City of Boise	-0.01	0.59
Veterans Administration	NA	NA

[1] Readings that are preceded by 8 hours of discharge rates over 300 gallons per minute are valid for use in this analysis.

[2] Trends and significance have been calculated using the Mann-Kendall statistical test.

[3] P-values less than 0.05 indicate the trend is significant at the 95% confidence interval.

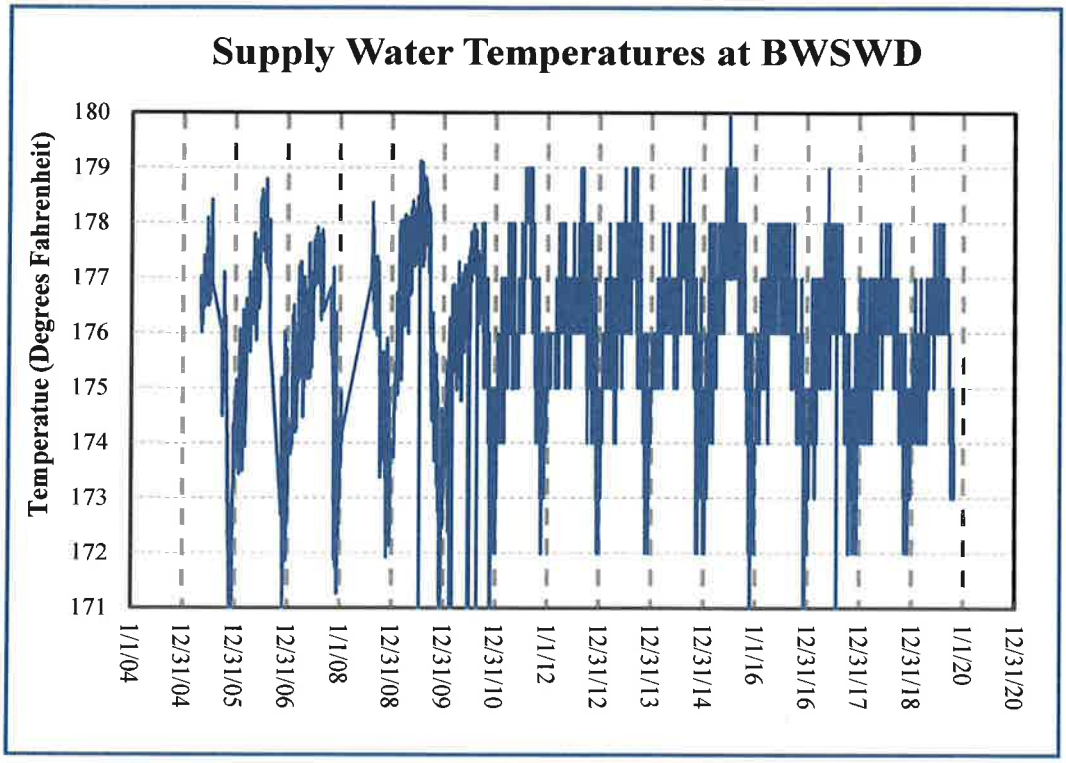

Figure 8. Supply water temperatures for the Boise Warm Springs Water District.

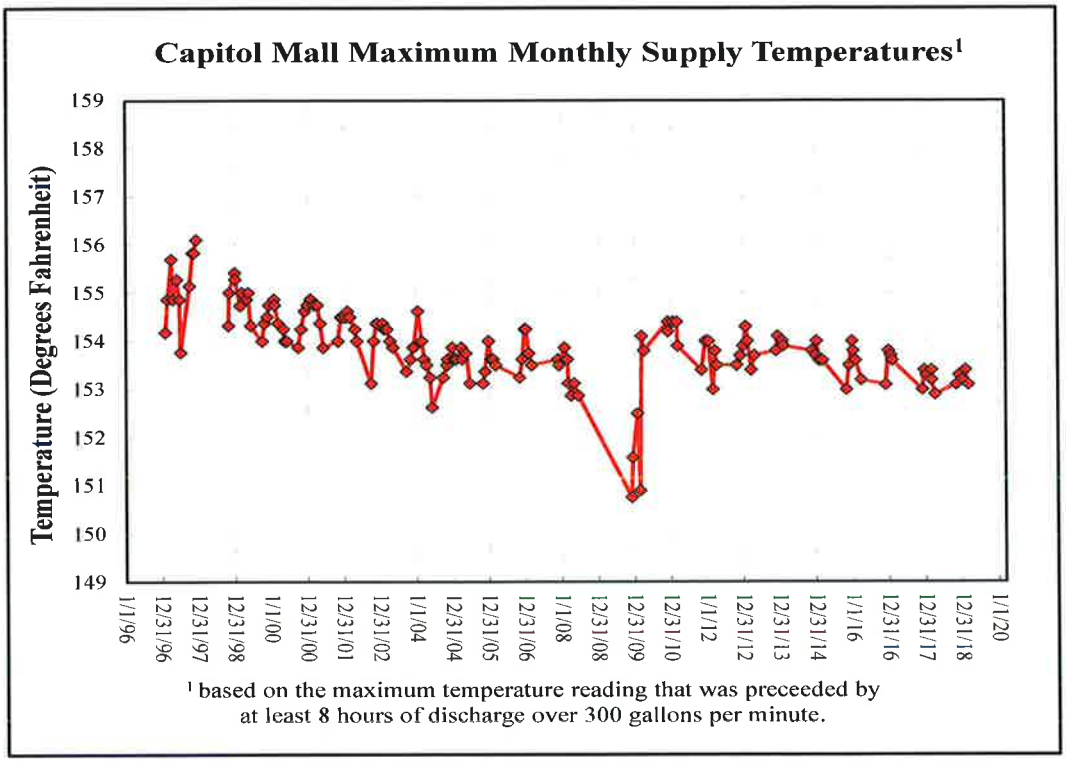

Figure 9. Monthly maximum supply water temperatures for the Capitol Mall geothermal system.

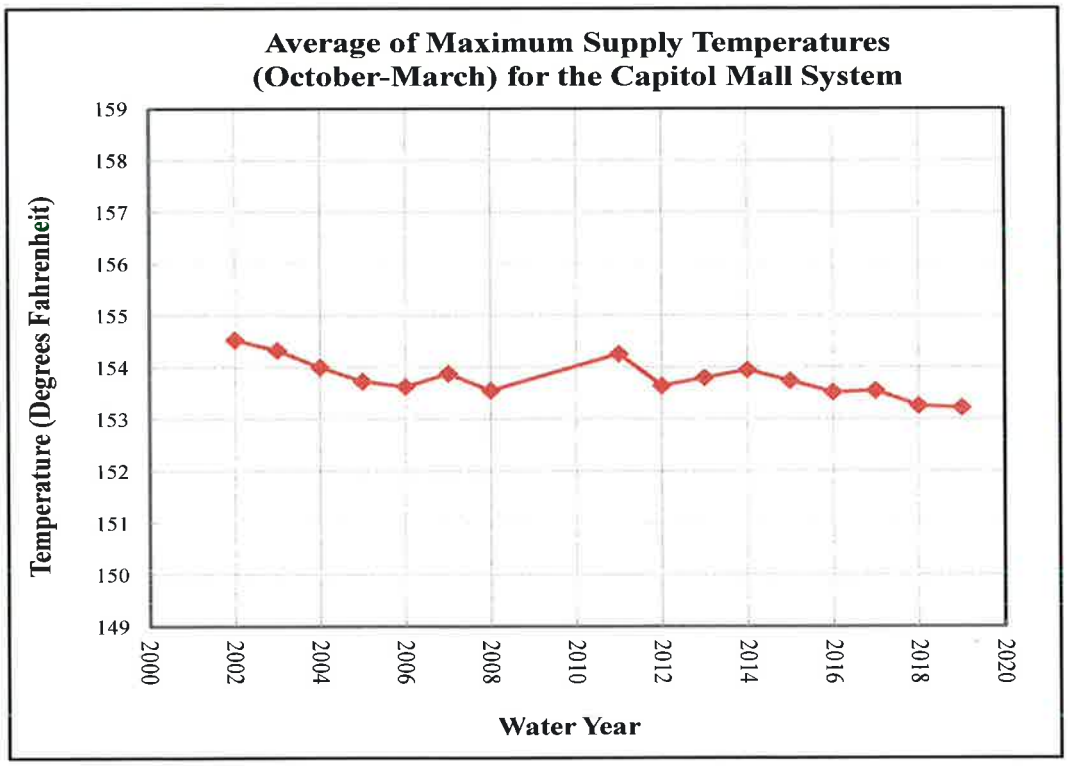

Figure 10. Average of the Capitol Mall maximum supply water temperatures for the October-March time period.

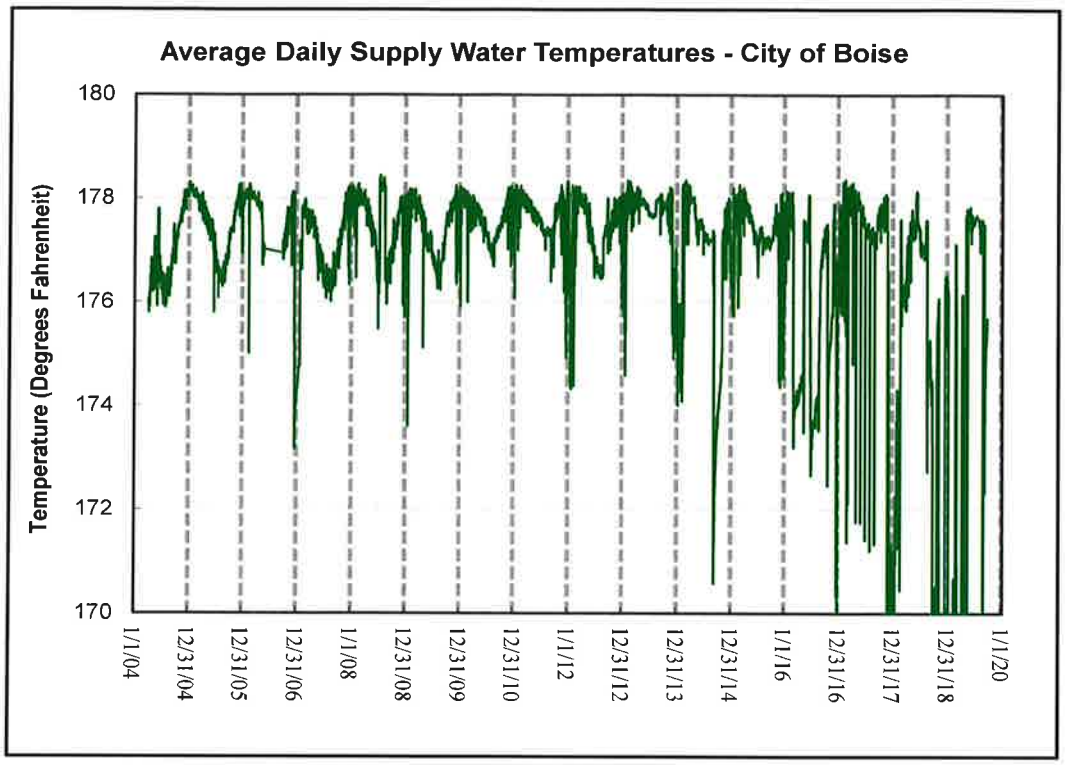

Figure 11. Supply water temperatures for the City of Boise geothermal system. Readings less than 170°F were omitted from the analysis.