Great West Engineering, Inc.

Judith Basin
2022 Monitoring Data Summary Report

Central Montana Regional Water Authority

November 2022

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1. INTRODUCTION

The Central Montana Regional Water Authority (CMRWA) is in the process of constructing the Musselshell-Judith Regional Water System (MJRWS). As part of this work, CMRWA has undertaken monitoring of water resources in Judith Basin pursuant to a water resources plan[1] and the associated monitoring program (**Figure 1**).[2] This report is presenting data collected from the inception of the monitoring program to October 2022. The monitoring program is ongoing and will collect and publish data on an approximately annual basis.

The Judith Gap RWIS[3] station is operated by the Montana Department of Transportation (MDT). CMRWA contributed a precipitation monitoring instrument to this location that was installed in late 2016. Big Spring near Lewistown is monitored by FWP using instrumentation and data acquisition equipment and software paid for through a State grant sponsored by CMRWA. Judith River near Sapphire Village is monitored by the U.S. Geological Survey. This gauge was reinstated in 2014 pursuant to the watershed monitoring plan prepared by CMRWA. Data from these locations are presented in this report.

Great West Engineering, Inc. is the engineer for the MJRWS project. Western Groundwater Services, LLC prepared this report working as a subconsultant to Great West Engineering.

2. TIME HISTORY PLOTS

Data presented are current to October 2022. The monitoring system was started in 2016. Changes to the monitoring system since that time include:

- The Jenni Ranch well is no longer monitored due to potential for frost damage to the sensor. Data are presented in the 2021 data summary report and are available on-line.

- The Peterson Ranch well is no longer monitored because a pump has been installed in the well, precluding measurement of aquifer pressure. Data are presented in the 2021 data summary report and are available on-line.

- The CMRWA #3 well sensor was pulled from the well in early July 2022 due to construction work on the well.

- The CMRWA #2 well sensor was pulled from the well in early July 2022 due to construction work on the well.

- The barometric and temperature sensor in the U Bet Wellfield has been removed in relation to wellfield construction work.

- The Judith Gap Mauws Kootenia well experienced a gap in data collection from early December 2021 to March 2022 due a leak in the plumbing.

1 Western Groundwater Services, LLC (2014) Water Resources Monitoring Plan, Central Montana Regional Water Authority, report to Great West Engineering, Inc.

2 Western Groundwater Services, LLC (2020) Judith Basin Monitoring System, Final Report, Central Montana Regional Water Authority, report to Great West Engineering, Inc.

3 Road Weather Information System

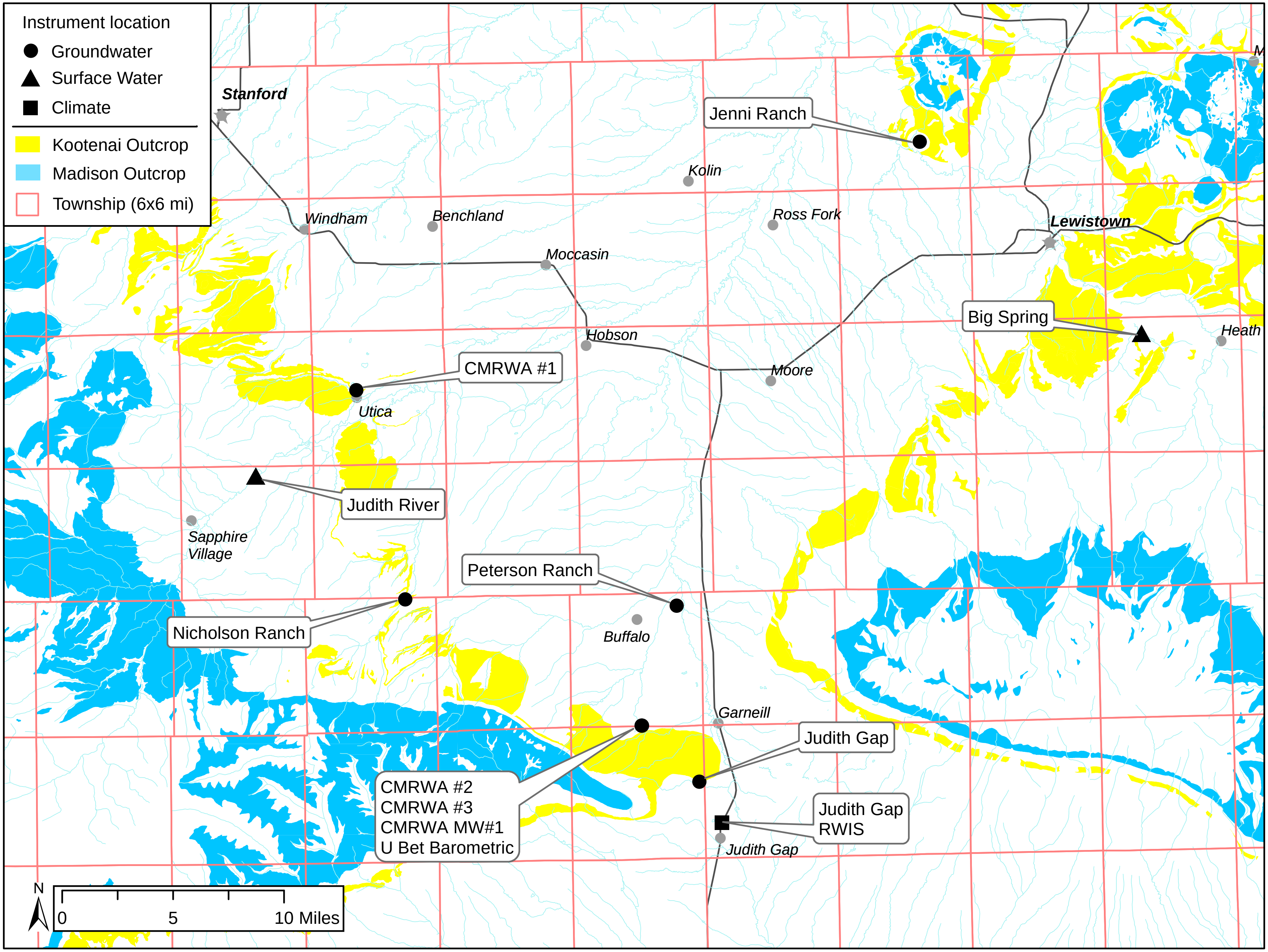

Figure 1. Location Map

2.1 Data Archive

Well data are archived on the Montana Bureau of Mines and Geology Ground Water Information Center (GWIC) website, where they can also be reviewed and downloaded by accessing the data using the GWIC identification number.[4] Big Spring data are now being archived on the Montana Department of Natural Resources (DNRC) Stream and Gauge Explorer (StAGE) website (https://gis.dnrc.mt.gov/apps/stage/gage-report/) by entering "Big Springs" in the location search field. These data are collected by Montana Fish, Wildlife and Parks (FWP) and are transmitted by FWP to DNRC. Judith River data are available directly from the USGS stream flow monitoring site.[5] The Judith Gap RWIS data are available through a public information request directly to MDT.[6]

2.2 Data Plots and Interpretations

2.2.1 Groundwater

Madison wells CMRWA #1, CMRWA #2, and CMRWA #3 exhibit large amplitude seasonality on top of a longer period climatic trend (**Figures 2** to **4**). CMRWA #1 and #2, having longer data records, illustrate seasonal peaks and valleys that climb to a peak in September 2020. From this time on, well water levels plummet to the most extreme lows observed to-date. CMRWA #1 declines 105 feet (ft), from 306 ft below ground surface (bgs) to 411 ft bgs. CMRWA #2 declines 57 ft from 263 ft bgs to 320 ft bgs, and CMRWA #3 declines 58 ft from 190 ft bgs to 248 ft bgs. The recent large declines reflect drought conditions that prevailed in 2020 and 2021. The spurious departures from the primary data trend shown in CMRWA #1 starting in February 2021 are likely indicating this sensor needs to be pulled and serviced, as there are no other plausible explanations.

Kootenai wells Judith Gap Mauws, Nicholson Ranch, and CMRWA MW#1 show similar trends as the Madison wells, but with much less fluctuation (**Figures 5** to **7**). The Judith Gap well, which is the primary well for the Town of Judith Gap and is pumped up to several times in a day, shows about 9 ft of decline in static water level from June 2020 to September 2022. CMRWA MW#1, which is not pumped, declined 14 ft over the period from August 2020 to October 2022. Data for both wells indicates there was no aquifer recharge during 2021, or at most very little. The Nicholson well, which is in regular use for stock and domestic uses, has about 4 ft of decline from May 2020 to September 2022, but it also has a small recharge peak in May 2022, and a flattening of the trend in 2021. These conditions indicate the Nicholson well aquifer did receive some recharge in 2022 and also a lesser amount in 2021. This well also may be completed in the upper Kootenai, whereas Judith Gap and CMRWA MW#1 are completed in the basal Kootenai sandstone (aka Third Cat Creek).

Big Spring discharge measurements show a variety of peaks and valleys that correspond moderately to precipitation data at the Crystal Lake SNOTEL, but with a variable lag period (**Figure 8**). The peaks and valleys span a range in flow rate from a low of 82 cubic feet per second (cfs) to a high of slightly less than 100 cfs. A decline of 18 cfs occurred from September 2020 to December 2021, the largest single decline in the period of record, and which is attributed to drought conditions. Spring discharge appears to be increasing through 2022, however, recent declines in precipitation at Crystal Lake suggest the flow rate is likely to revert to a declining trend in early 2023.

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4 http://mbmggwic.mtech.edu/

5 https://waterdata.usgs.gov/mt/nwis/uv/?site_no=06110020

6 https://www.mdt.mt.gov/mdt/information_request.shtml. Re: Judith Gap RWIS atmospheric data in converted units. These data require processing to obtain precipitation as daily totals.

2.2.2 Surface Water Data

The Judith River gauge above Carr Creek reflects seasonal precipitation in the Little Belt Mountains (**Figure 9**). The range in flows is from nearly dry at 0.6 cfs to 769 cfs during the 2018 runoff period. Late season base flow was substantially depressed in 2016 and again in early 2022. The gauge was indicating unusually high base flow in 2022 of about 10 cfs.

2.2.3 Climate Data

Climate data are collected at the Judith Gap RWIS and also at the U Bet Wellfield (**Figures 10** and **11**). The Judith Gap RWIS is located about 6-miles southeast from the U Bet Wellfield. These data have been analyzed to estimate groundwater recharge from precipitation using a soil water balance method based on Thornthwaite (1948)[7] with modifications to include solar radiation (**Table 1**). A 5-year average analysis for years 2017 through 2021 also was completed (**Figure 12**).

Table 1. Yearly Soil Water Balance Analysis Results

Year	Total Precipitation (in)	Net Precipitation (in)	Actual Evapotranspiration (in)	Groundwater Recharge (in)
2017	13.5	10.0	8.7	1.3
2018	21.2	15.6	10.9	4.7
2019	27.1	20.2	14.4	5.8
2020	15.5	11.5	10.5	0.9
2021	13.0	9.7	9.7	0.0
Average	18.1	13.4	12.0	1.4
Total Precipitation – measured; Net Precipitation – total minus interception, runoff and sublimation; Actual Evapotranspiration – calculated by soil water balance; Groundwater Recharge – calculated by soil water balance.				

These groundwater recharge estimates are most applicable to recharge into the Kootenai aquifer, but also are relevant to the Madison aquifer. Years 2018 and 2019 show large precipitation totals and correspondingly high groundwater recharge. Years 2020 and 2021 show much lower precipitation and correspondingly lower groundwater recharge, with none estimated for year 2021. The result for 2021 is consistent with the groundwater time history plots.

At lower elevations, groundwater recharge occurs typically in the months of April and May due to the combination of snow melt and higher precipitation. There can be a time lag for the recharge to actually enter the aquifer, however, for both the Kootenai and Madison it appears the seasonal recharge enters the aquifer in the same year after some lag time on the order of a few months. This relation also appears to apply to Big Spring.

The results over the five year period show there is not a consistent proportional relation between total precipitation and groundwater recharge. The percentage of total precipitation that becomes groundwater recharge ranged from 0% (2021) to 22% (2018). For the five year period, there was an average groundwater recharge depth equal to 8% of total precipitation.

7 Thornthwaite, C.W. (1948) An Approach toward a Rational Classification of Climate. Geographical Review, 38, 55-94.

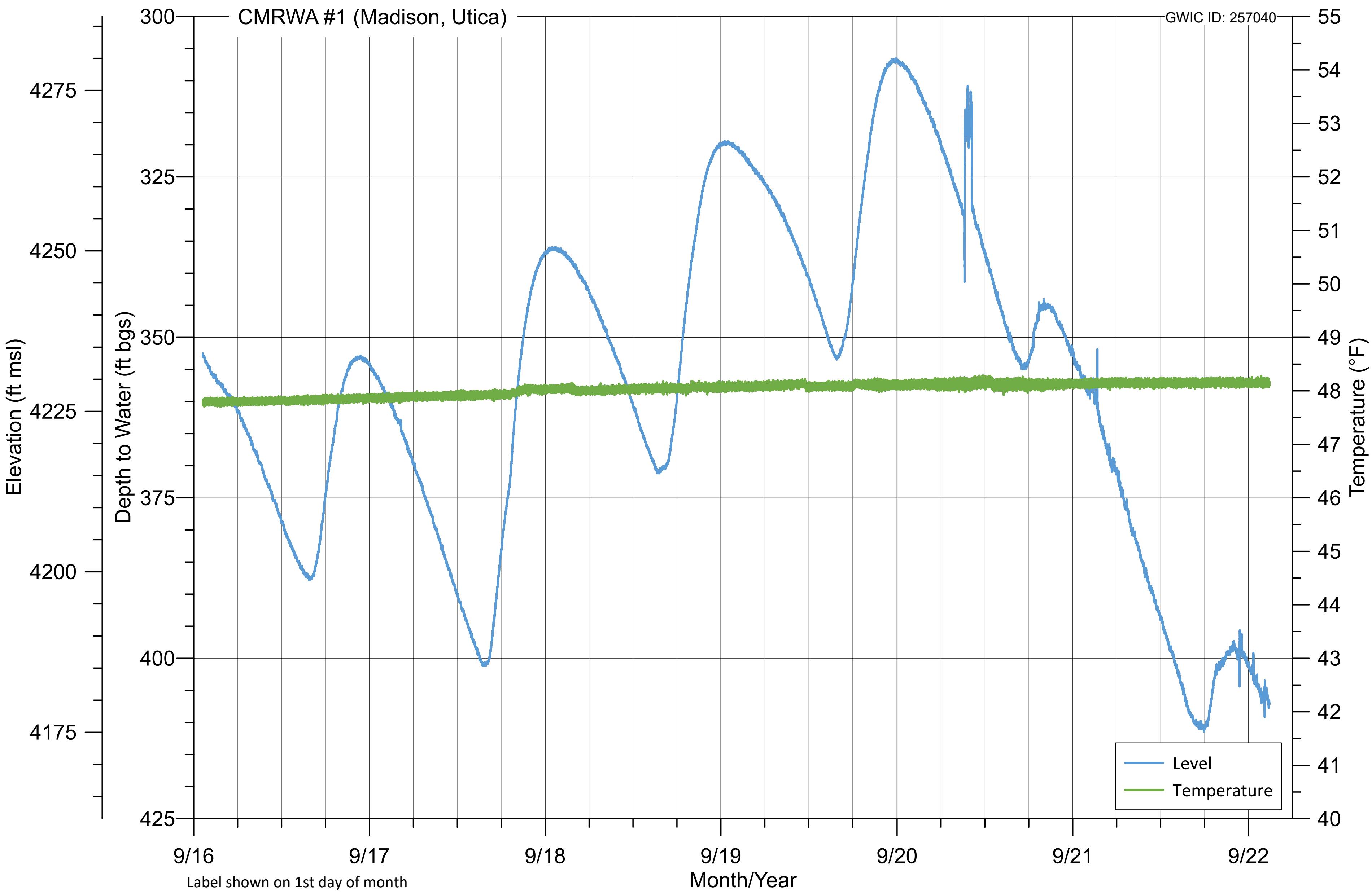

Figure 2. CMRWA #1 Time History Plot

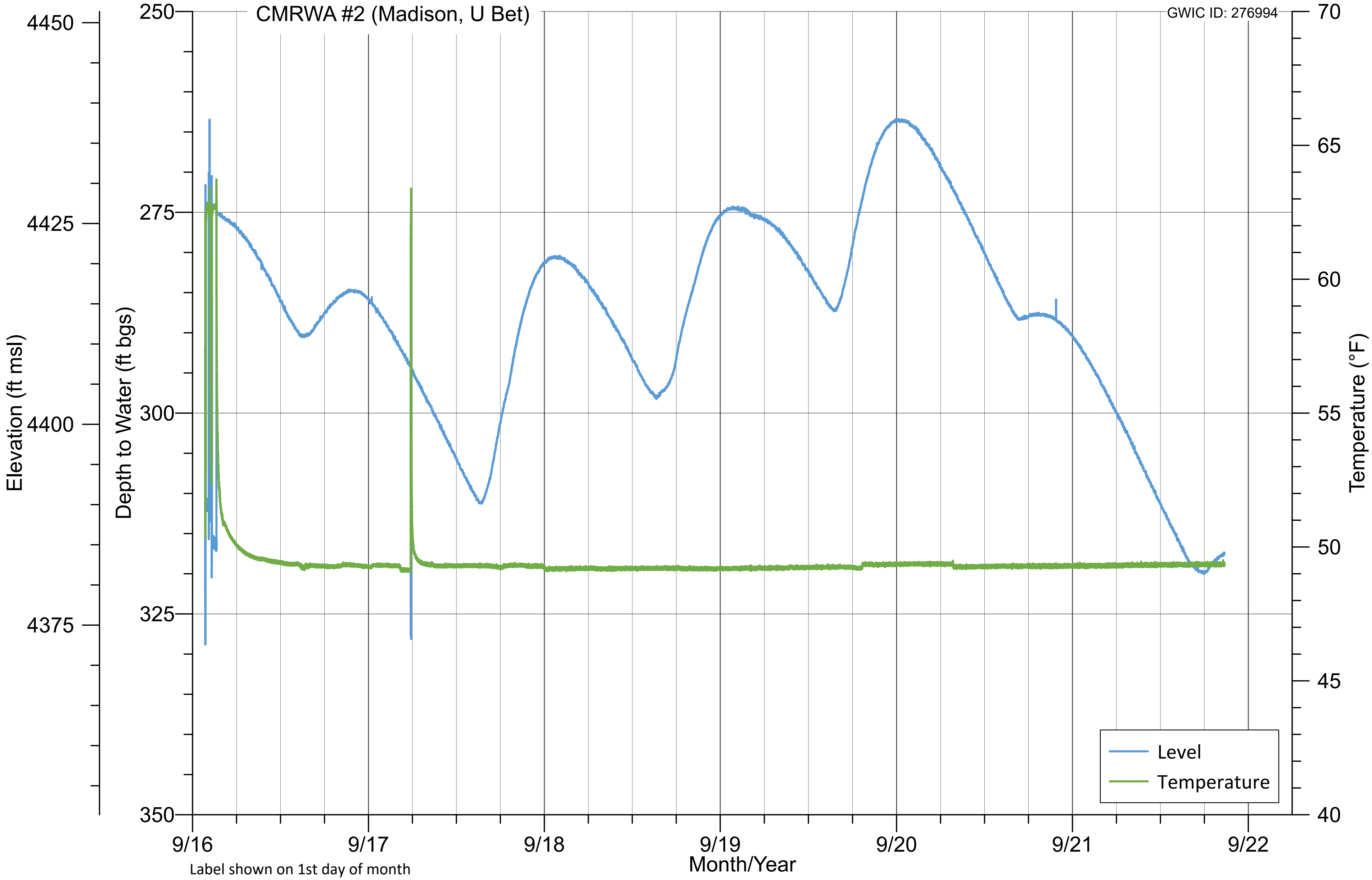

Figure 3. CMRWA #2 Time History Plot

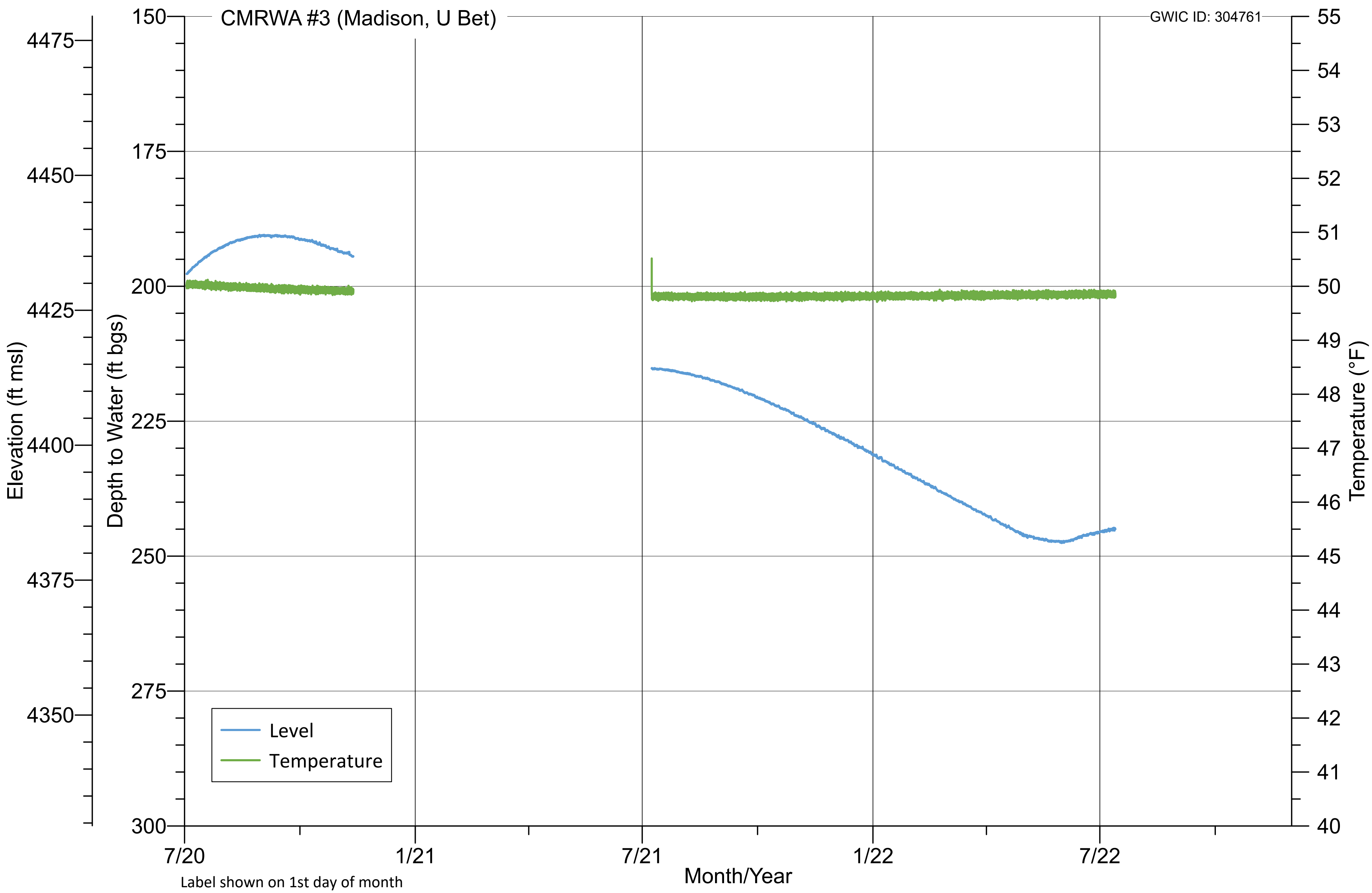

Figure 4. CMRWA #3 Time History Plot

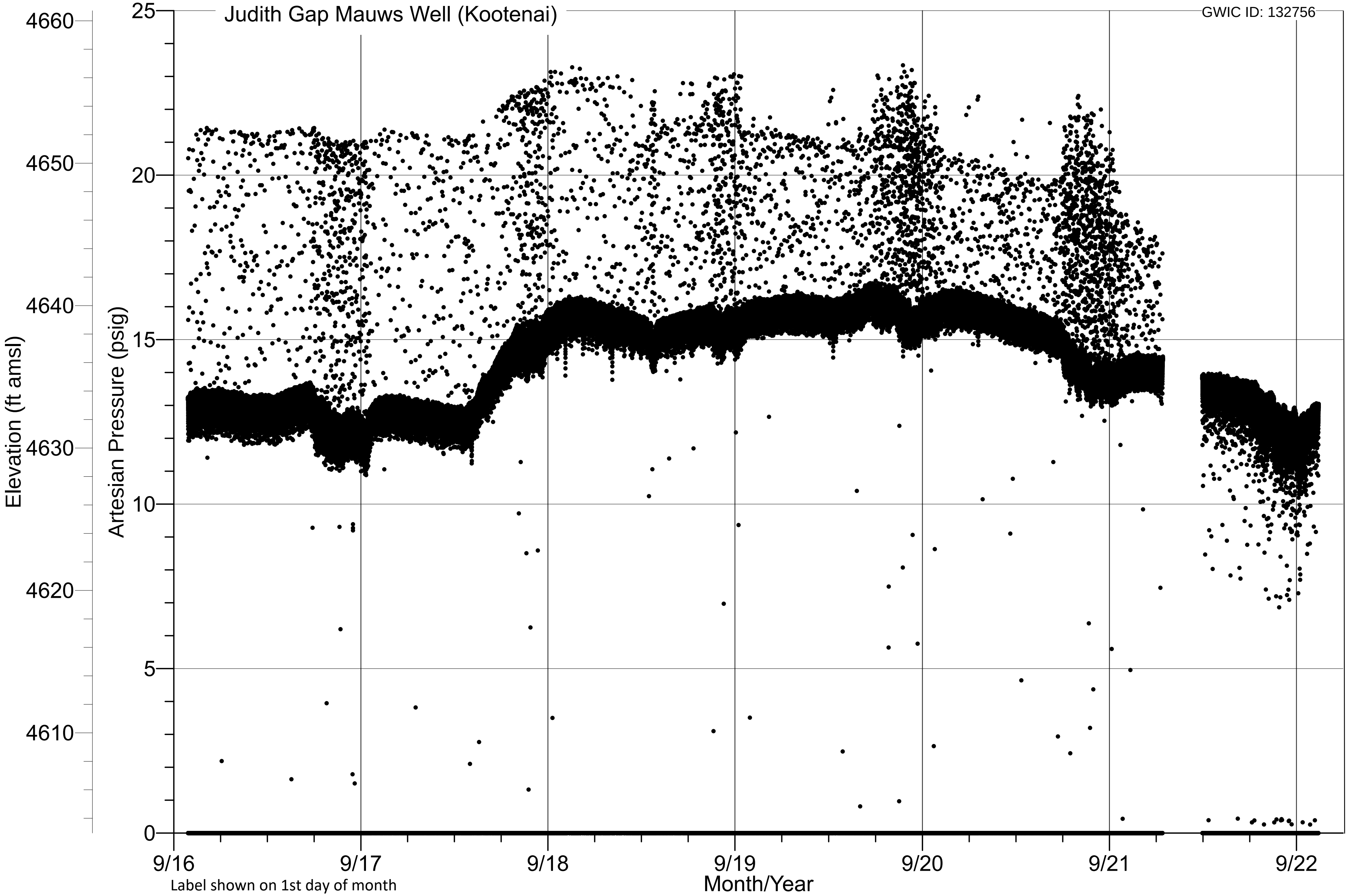

Figure 5. Judith Gap Mauws Well Time History Plot

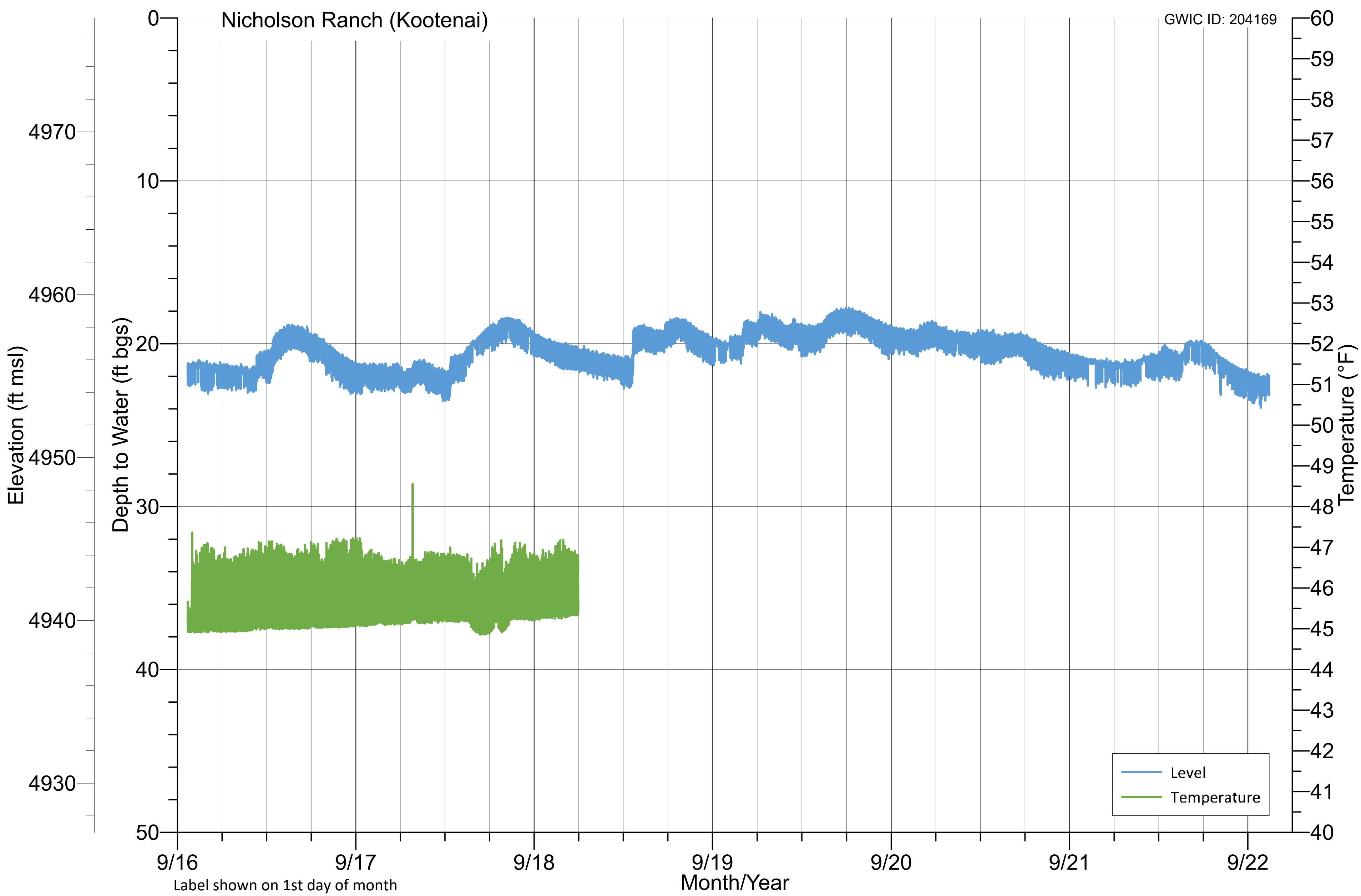

Figure 6. Nicholson Ranch Time History Plot

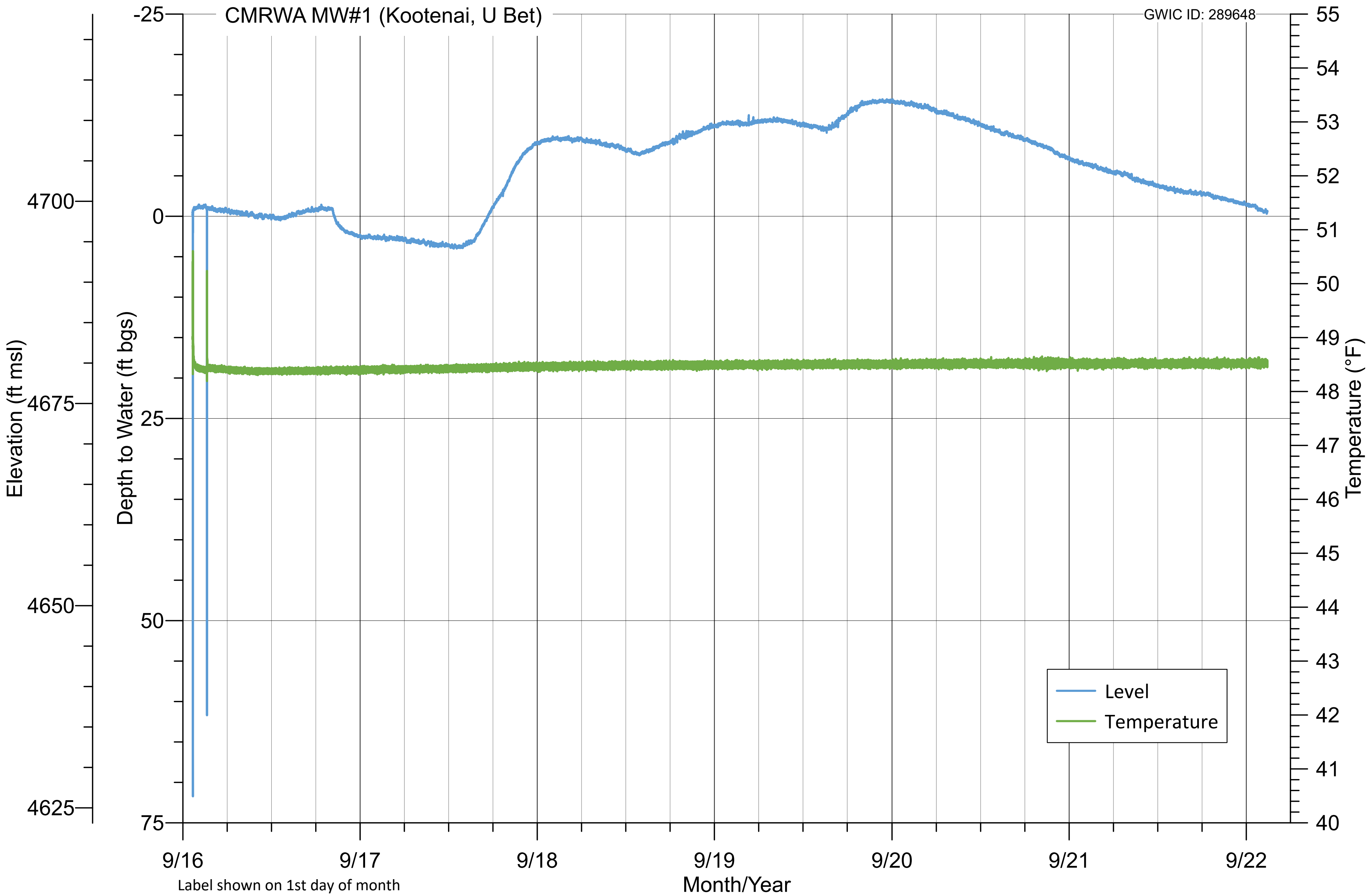

Figure 7. CMRWA MW#1 Time History Plot

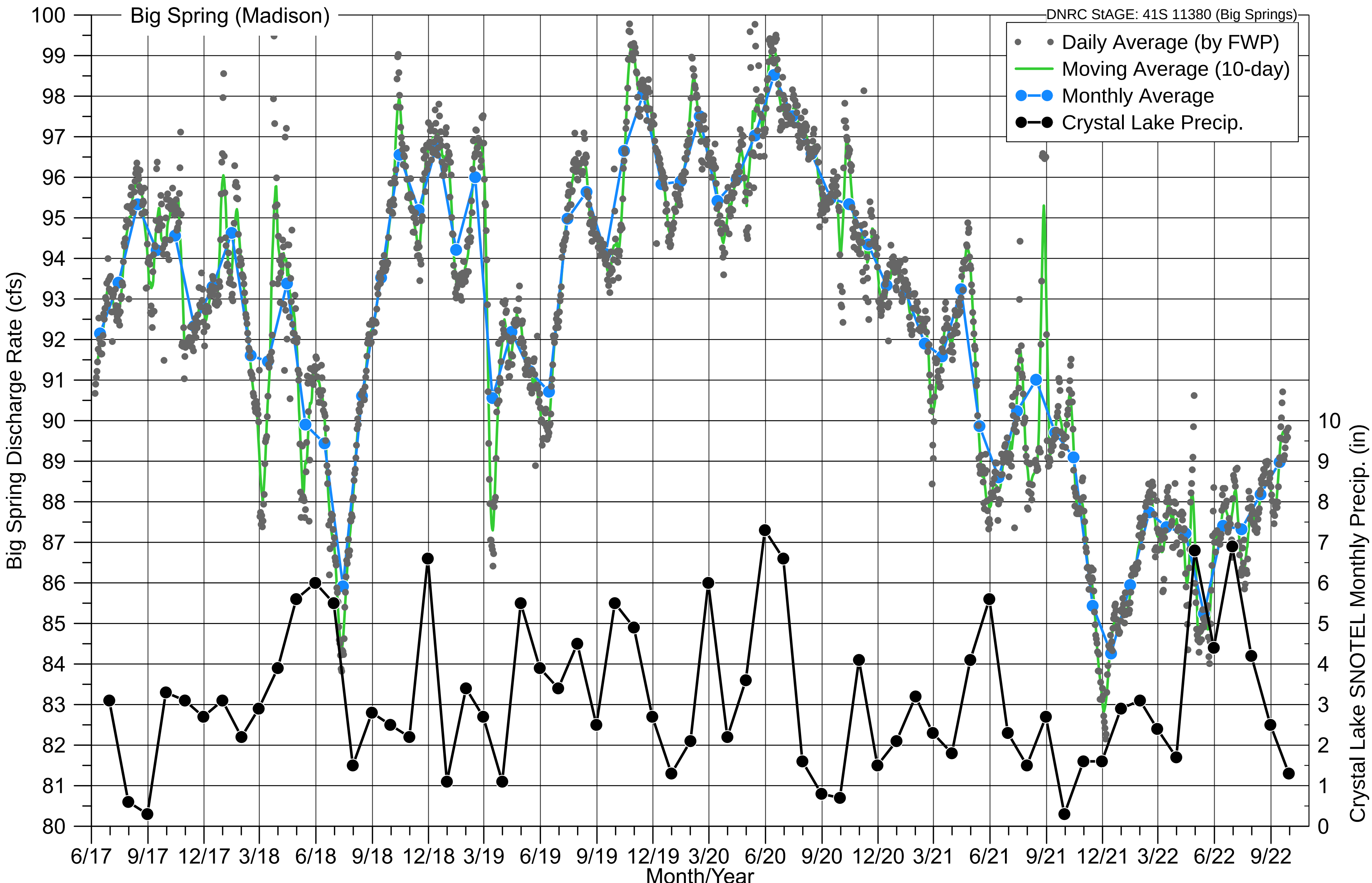

Figure 8. Big Spring Time History Plot

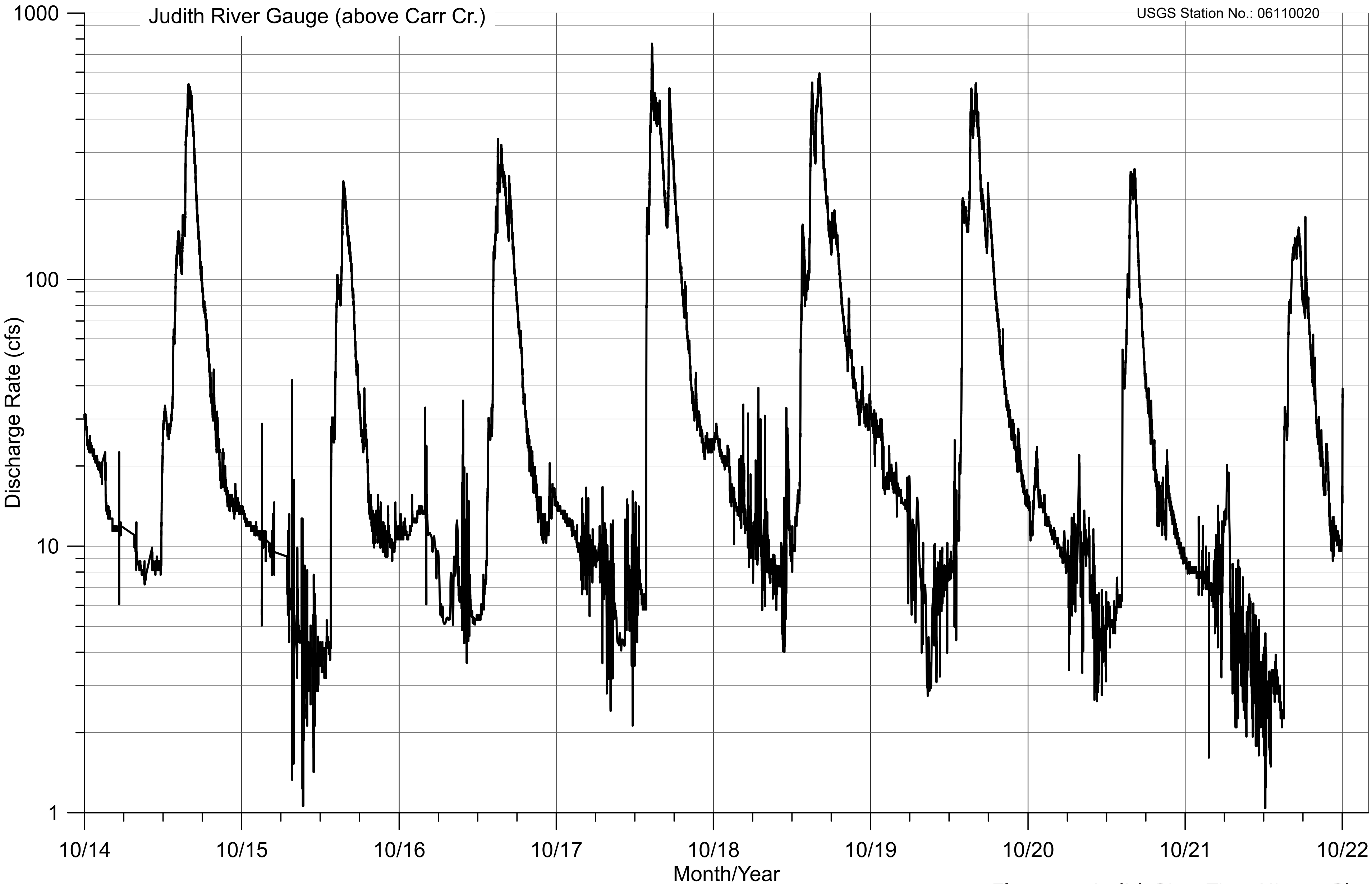

Figure 9. Judith River Time History Plot

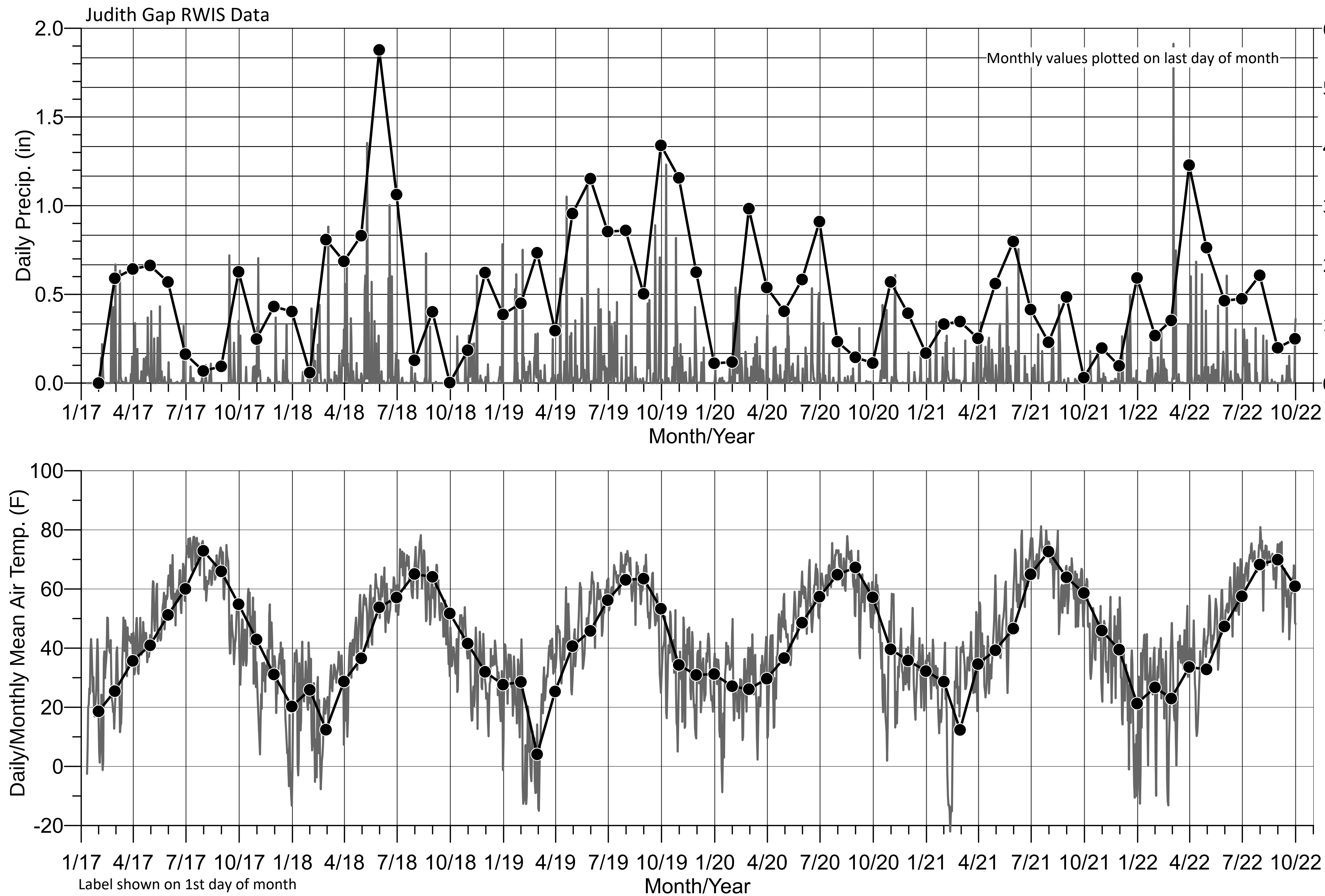

Figure 10. Judith Gap RWIS Time History Plot

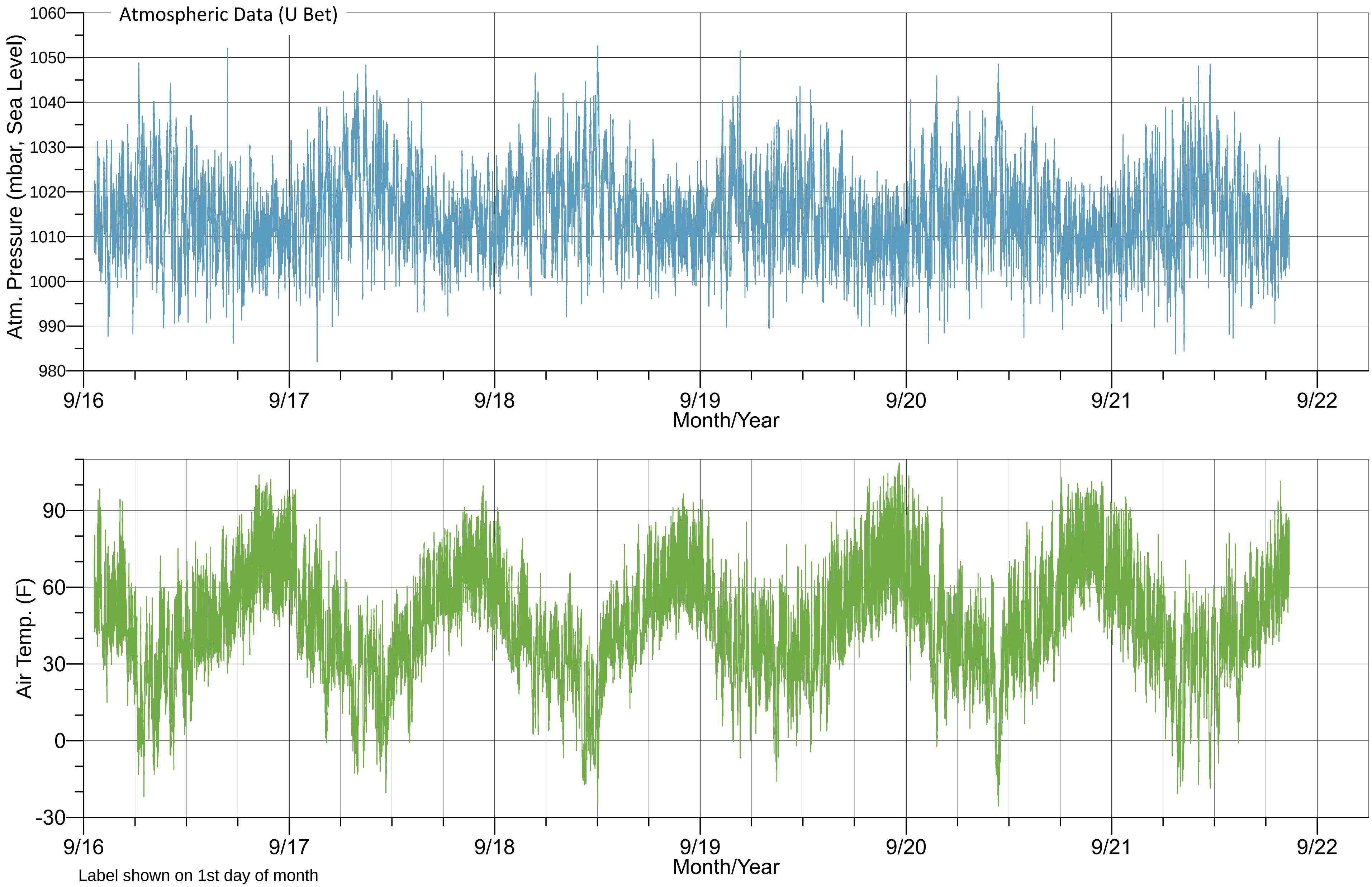

Figure 11. U Bet Wellfield Atmospheric Data

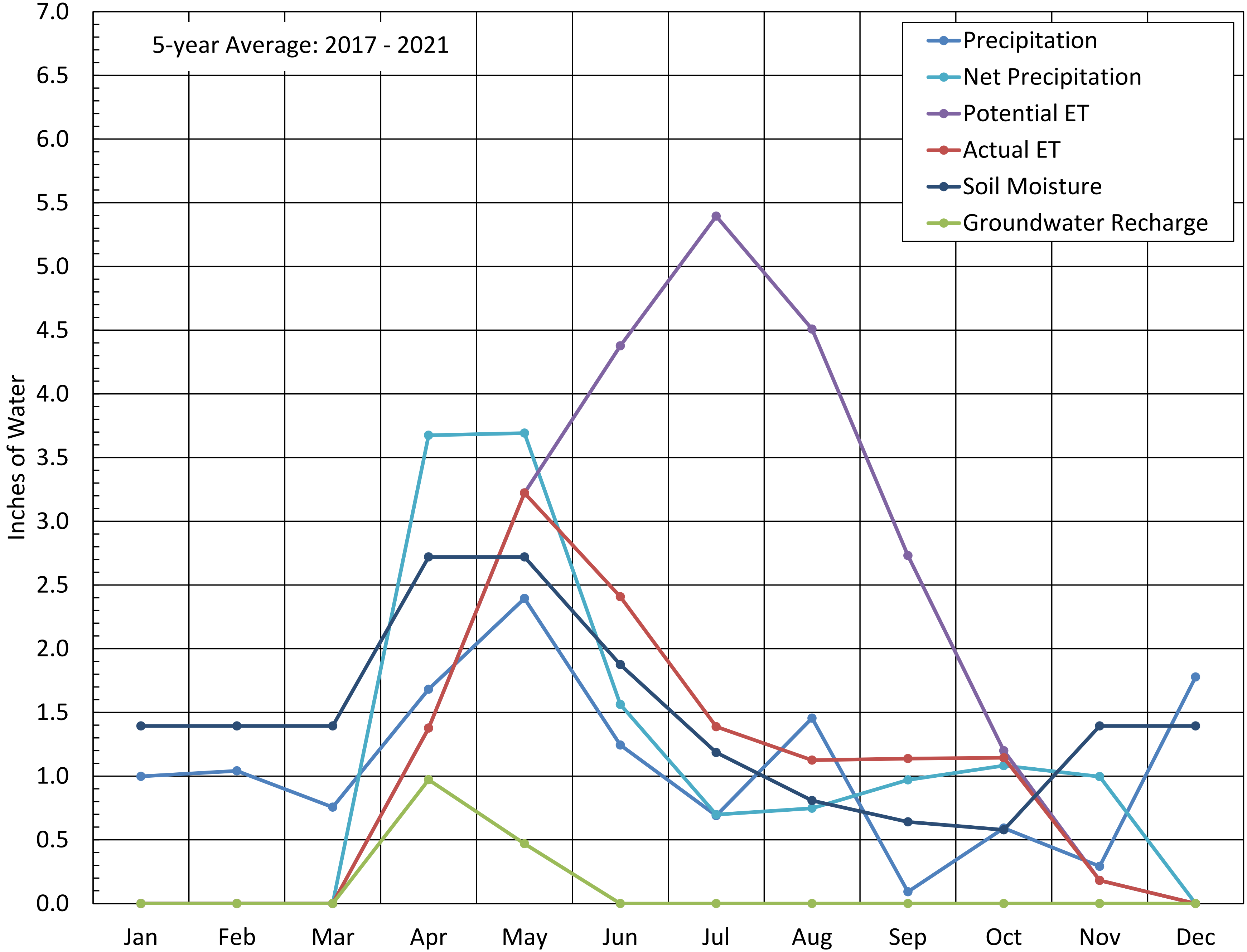

Figure 12. 5-yr Average Soil Water Balance