TECHNICAL MEMORANDUM

Evaluation of Wyckoff Groundwater Level Data July 1, 2018 through September 30, 2018

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This memorandum summarizes the Wyckoff groundwater level results for the July 1 through September 30, 2018 (Quarter 3) monitoring period and evaluates the data to support the determination on whether upper aquifer hydraulic containment was achieved for the quarterly monitoring period.

Summary/Recommendations

- The upper aquifer recovery wells and groundwater treatment system operated 24 hours per day, 7 days per week, except for temporary shutdowns due to low water levels, power outages, and maintenance.
- Hydraulic containment was maintained at all the well pairs over the 92-day monitoring period, with the lower aquifer to upper aquifer groundwater elevation ratios ranging from 1.37 to 2.39 for Quarter 3. A ratio of greater than 1.0 indicates hydraulic containment was maintained.
- The groundwater elevation data from the transducers in the 10 well pairs will be downloaded again on December 31, 2018 to maintain a quarterly data evaluation schedule consistent with that used in the definition of hydraulic containment.
- All in-use transducers at the site were last calibrated on March 1, 2018. Calibration events are conducted annually to confirm accurate water level measurements.

Water Level Data Collection

The July 1 through September 30, 2018 period represents the next consecutive 92-day quarterly monitoring interval following the Quarter 2 (April 1 through June 30, 2018) evaluation presented in *Evaluation of Wyckoff Groundwater Level Data April 1, 2018 through June 30, 2018* (CH2M Memorandum, August 21, 2018). The locations of the monitoring wells are shown on Figure 1 and the wells with transducers are listed in Table 1. Model 705 KPSI™ Level and Pressure Transducers are installed in 22 upper aquifer wells and 18 lower aquifer wells and were last calibrated in March 2018. All recorded water level data are available in e-format upon request.

Table 1. Wells with Transducers and Upper Aquifer/Lower Aquifer Well Pairings, July 1 through September 30, 2018

Well Pairs for Vertical Gradient Evaluation			Other Wells with Transducers	
Upper Aquifer		Lower Aquifer Well ID		
Well ID	Compartment		Upper Aquifer Recovery Wells[a]	Lower Aquifer Wells
MW14	1	CW05	E-02b	CW09
MW18	1	02CDMW01	E-04b	P-1L
PO03	1	99CDMW02A	E-06b	P-2L
CW03	2/3	CW02	E-07b	P-3L
VG-2U	2/3	VG-2L	MW-21	P-5L
VG-3U	2/3	VG-3L	RPW-1	P-6L
VG-5U	1	VG-5L	RPW-2	PZ03
PO13	1	VG-1L	RPW-4	SE02
CW13	1	VG-4L	RPW-5	
CW08	1	P-4L	RPW-6	
			PW-8	
			PW-9	

[a] All upper aquifer recovery wells are screened across Compartments 1/2/3 except MW-21, which is screened in Compartment 1.

[b] The E-0x series of wells are located within the Pilot Test sheet pile wall.

Groundwater Treatment Plant Operations

The groundwater treatment plant (GWTP) and all nine of the upper aquifer extraction wells operated 24 hours per day, 7 days per week during Quarter 3, as conditions permitted. Several extraction well shutdowns occurred during the monitoring period because of low water levels, power outages, or maintenance. The dates during which the extraction wells were shut down for periods greater than 24 hours are listed in Table 2. These periods are graphically overlain with the rainfall records and are shown in Figure 3. For the Quarter 3 monitoring period (July 1 through September 30, 2018), 1.4 inches of rainfall were recorded.

The total volume of water extracted from the upper aquifer was 4,582,239 gallons during the 92-day monitoring period, equating to an average pumping rate of approximately 35 gallons per minute (gpm) for the 92 days where all or portions of the wellfield were in operation. When fully operating, and upper aquifer water levels allow, the system can pump about 72 gpm.

Hydraulic Containment Evaluation

Upper aquifer hydraulic containment at the Wyckoff site is evaluated using water level data from 10 upper and lower aquifer well pairs as shown in Table 1 (see Figure 1 for the well locations). Hydrographs for each of the 10 well pairs have been prepared and are presented in Figures 2a through 2j. Seven of the upper aquifer wells are screened in Compartment 1 while three upper aquifer wells are screened in Compartment 2/3.

Table 2. Former Process Area Extraction Well Pump Shutdown Periods Greater than 1 Day

Offline Dates	Wells	Reason
May 14, 2018 – Beyond September 30, 2018	PW-6, PW-9	Low water level
June 25 – July 2, 2018	EW-6	EW-2 & EW-6 pumps cycling on/off due to low water levels
July 2 – July 9, 2018	EW-2	EW-2 & EW-6 pumps cycling on/off due to low water levels
July 9 – July 16, 2018	EW-6	EW-2 & EW-6 pumps cycling on/off due to low water levels
July 16 – July 23, 2018	EW-2	EW-2 & EW-6 pumps cycling on/off due to low water levels
July 23 – July 30, 2018	EW-6	EW-2 & EW-6 pumps cycling on/off due to low water levels
July 30 – August 6, 2018	EW-2	EW-2 & EW-6 pumps cycling on/off due to low water levels
August 6 – August 13, 2018	EW-6	EW-2 & EW-6 pumps cycling on/off due to low water levels
August 13 – August 20, 2018	EW-2	EW-2 & EW-6 pumps cycling on/off due to low water levels
August 20 – August 27, 2018	EW-6	EW-2 & EW-6 pumps cycling on/off due to low water levels
August 27 – September 4, 2018	EW-2	EW-2 & EW-6 pumps cycling on/off due to low water levels
September 4 – September 10, 2018	EW-6	EW-2 & EW-6 pumps cycling on/off due to low water levels
September 10 – September 17, 2018	EW-2	EW-2 & EW-6 pumps cycling on/off due to low water levels
September 17 – September 24, 2018	EW-6	EW-2 & EW-6 pumps cycling on/off due to low water levels
September 24 – October 1, 2018	EW-2	EW-2 & EW-6 pumps cycling on/off due to low water levels

Hydraulic containment at each well pair is evaluated by first calculating the average groundwater elevations in the upper and lower aquifers using the water elevation data recorded every 15 minutes during the monitoring period. Then the average upper and lower aquifer groundwater elevations at each well pair are compared relative to each other. If the average lower aquifer groundwater elevation is greater than the average upper aquifer groundwater elevation at the well pair, an upward (positive) vertical gradient is indicated. Additionally, if an upward vertical gradient is present, the ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for that well pair is greater than 1.0 for the duration of the monitoring period, and a hydraulic-containment-maintained determination is made.

Additional evaluations are conducted through examination of short-term periods when downward hydraulic gradients occur. Groundwater elevations for each well pair are compared at each 15-minute recording, and the summary statistics: average, maximum, and minimum difference in groundwater elevation for each well pair are calculated, along with a duration analysis for negative (downward) gradients. The duration analysis includes the number of downward gradient events observed during the monitoring period, their average duration (hours), and the cumulative duration (days and percent) for the monitoring period. A downward vertical gradient is indicated when the difference between the lower and upper aquifer groundwater elevations at each 15-minute recording have a negative value (e.g. average upper aquifer groundwater elevation greater than the average lower aquifer groundwater elevation). The summary statistics and hydraulic containment evaluation data for the well pairs are summarized in Table 3 and are based on the 92-day monitoring period (Quarter 3) from July 1 through September 30, 2018, which corresponds to the quarterly period used for assessing hydraulic containment.

Based on the information presented in Table 3, the following determinations were made:

- The average lower aquifer to upper aquifer groundwater elevation ratios were greater than 1.0 at all 10 well pairs for the 92-day monitoring period, indicating hydraulic containment was maintained at each location.
- Negative vertical gradients were observed at 2 of 10 monitoring well pairs. Downward (negative) vertical gradient events typically occur during the lowest semidiurnal tide period when the lower aquifer groundwater elevation declines below the upper aquifer groundwater elevation (see Figures 2a through 2j). Groundwater elevations in the upper aquifer Compartment 2/3 and all lower aquifer wells are strongly influenced by daily tidal fluctuations while water levels in the upper aquifer Compartment 1 wells show much less tidal influence. At both locations where negative gradients were observed (PO13/VG-1L and CW08/P-4L), the upper aquifer well is screened in Compartment 1.
- At both well pairs (PO13/VG-1L and CW08/P-4L), the average duration of the downward gradient periods was 2 hours and 3 hours, respectively. The total negative gradient duration for the 92-day period was 0.8 percent and 3.7 percent (0.7 to 3.4 days, respectively).
- Well pair CW08/P-4L had both the highest negative gradient duration and the highest number of negative gradient events for the 92-day monitoring period. CW08/P-4L also had the highest total negative gradient duration during the Quarter 2 – 2017, Quarter 3 – 2017, and Quarter 1 – 2018 monitoring periods. The frequency of downward gradients at well pair CW08/P-4L is unusual in that this well pair is located a similar distance (190 feet) from production well RPW2 as is VG-3U/VG-3L, which had no negative gradient events.
- Maximum downward vertical gradients occurred on July 13, 2018 at both well pairs. All the extraction wells except PW-6, PW-9, and EW-6 were in operation. A minus tide of -3.51 feet mean lower low water (MLLW) occurred on July 13, 2018 with comparable minus tides observed before and after July 13, 2018 and again on August 10, 2018.

Summary

During the Quarter 3 monitoring period, hydraulic containment was maintained at all 10 well pairs. Negative hydraulic gradient events occurred at 2 of the 10 well pairs. The maximum observed negative gradients, for the two well pairs during the Quarter 3 period, occurred on July 13, 2018 when all but three extraction wells were in operation (Figure 3). The greatest minus tide, during the day of the observed maximum negative gradient was -3.51 feet MLLW.

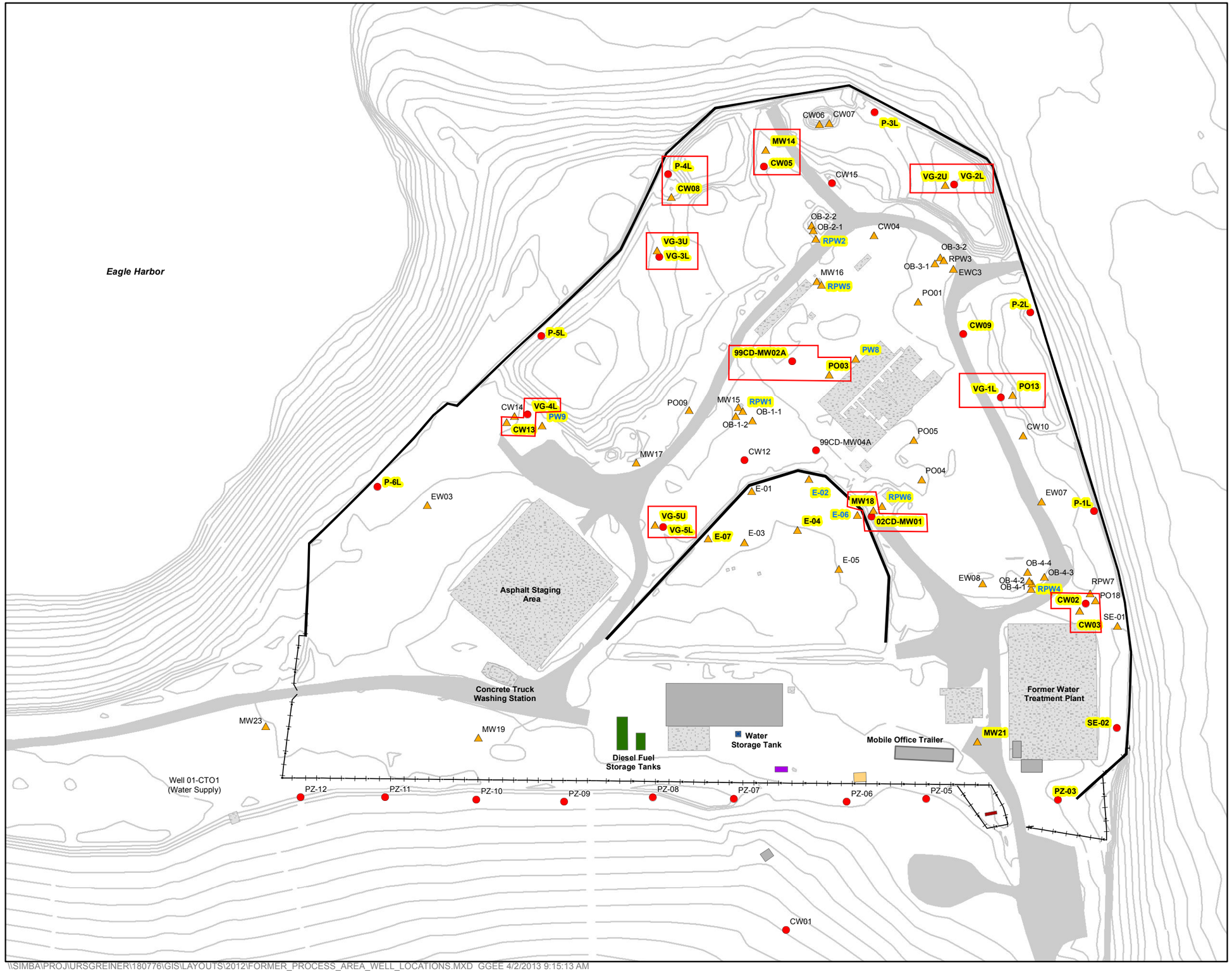
Table 3. Summary of Groundwater Elevation Data by Well Pair July 1 through September 30, 2018

Well Pair	Figure	Upper Aquifer Average Groundwater Elevation (feet MLLW)	Lower Aquifer Average Groundwater Elevation (feet MLLW)	Ratio (Average Lower Aquifer Water Level/ Average Upper Aquifer Water Level)[a]	Summary Statistics Short Term Comparison - Water Level Difference between the Upper and Lower Aquifer Wells (feet)			Duration Analysis – Downward (Negative) Gradient			
					Average	Max	Min	Number of Negative Gradient Events	Average Duration of Negative Gradient (hours)	Total Duration of Negative Gradient (days)	Percent Duration of 92-day Monitoring Period[b]
MW14/CW05	2a	4.36	9.10	2.09	4.74	7.07	1.27	none			
MW18/02CDMW01	2b	3.96	9.28	2.34	5.32	7.29	2.44	none			
PO03/99CDMW02A	2c	3.83	9.14	2.39	5.31	7.67	1.76	none			
CW03/CW02	2d	5.09	8.47	1.66	3.38	5.41	0.63	none			
VG-2U/VG-2L	2e	6.35	8.68	1.37	2.33	2.84	1.88	none			
VG-3U/VG-3L	2f	4.52	9.58	2.12	5.06	6.37	3.35	none			
VG-5U/VG-5L	2g	6.28	10.71	1.70	4.42	6.34	1.53	none			
PO13/VG-1L	2h	4.99	8.73	1.75	10.71	6.64	-0.47	8	2	0.7	0.8%
CW13/VG-4L	2i	7.32	10.86	1.48	3.54	5.85	0.01	none			
CW08/P-4L	2j	5.45	8.54	1.57	3.09	6.03	-1.50	27	3	3.4	3.7%

[a] Ratio > 1 = hydraulic containment was achieved

[b] Percent Duration of Monitoring Period = total duration of negative gradient in days divided by the number of calendar days in the monitoring period

Figures



LEGEND

- Lower Aquifer Well
- Upper Aquifer Well
- Fence
- Wall
- Roads
- Buildings
- Concrete Slab

Well labels:

highlighted - well is monitored with transducer
blue text - production well
red boxed wells - well pair monitored for hydraulic containment

N

0 50 100 Feet

FIGURE 1

Former Process Area Well Locations

WYCKOFF/EAGLE HARBOR SUPERFUND SITE

\\SIMBA\PROJ\URSGREINER\180776\GIS\LAYOUTS\2012\FORMER_PROCESS_AREA_WELL_LOCATIONS.MXD GGEE 4/2/2013 9:15:13 AM

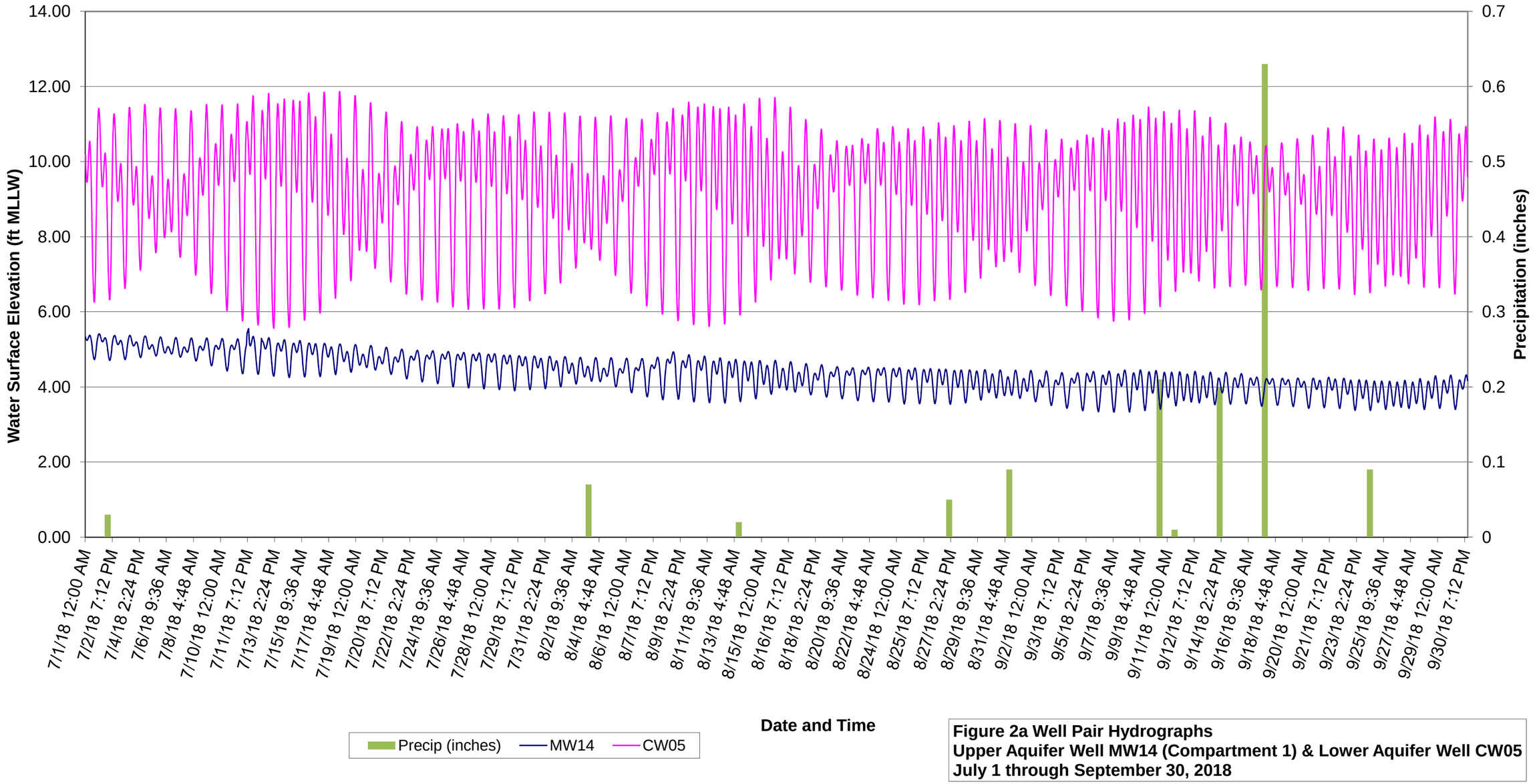


Figure 2a Well Pair Hydrographs
Upper Aquifer Well MW14 (Compartment 1) & Lower Aquifer Well CW05
July 1 through September 30, 2018

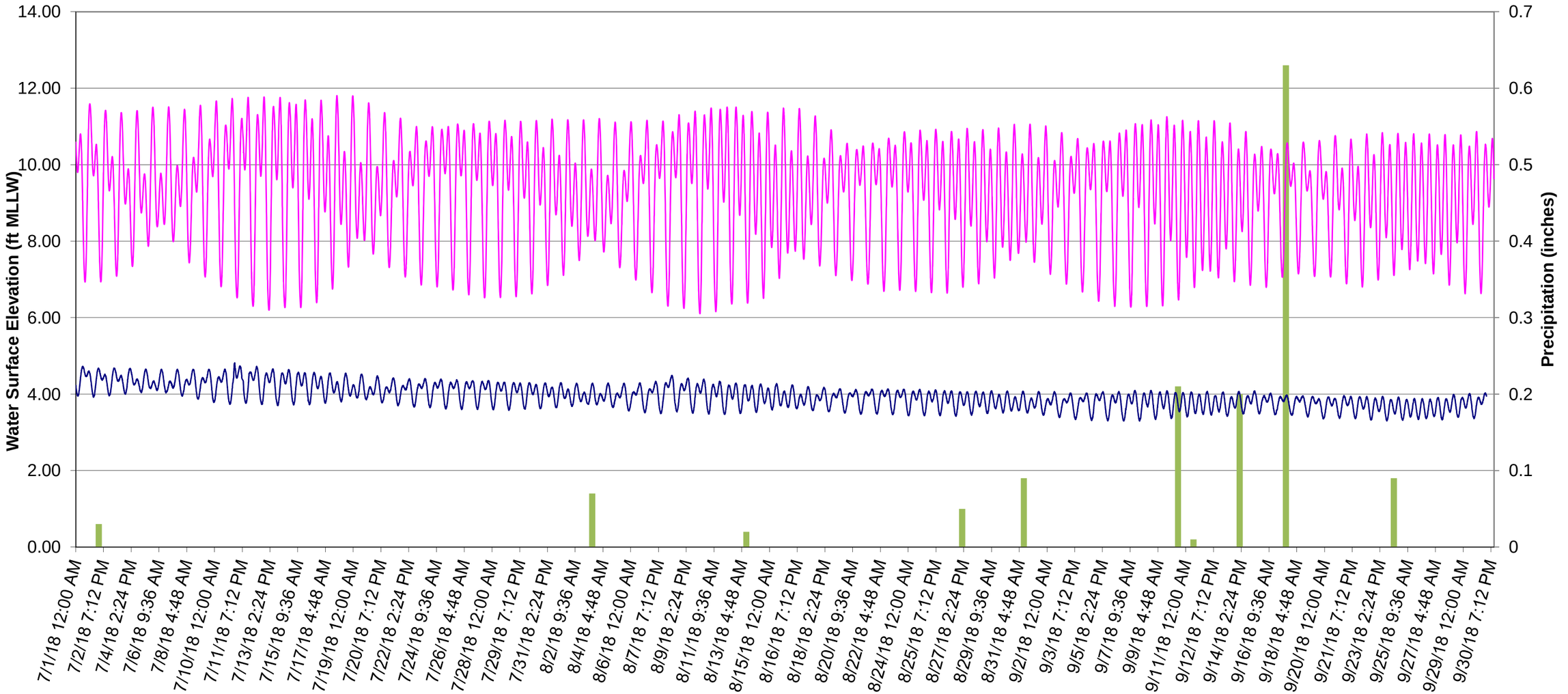


Figure 2b Well Pair Hydrographs
Upper Aquifer Well MW18 (Compartment 1) & Lower Aquifer Well 02CDMW01
July 1 through September 30, 2018

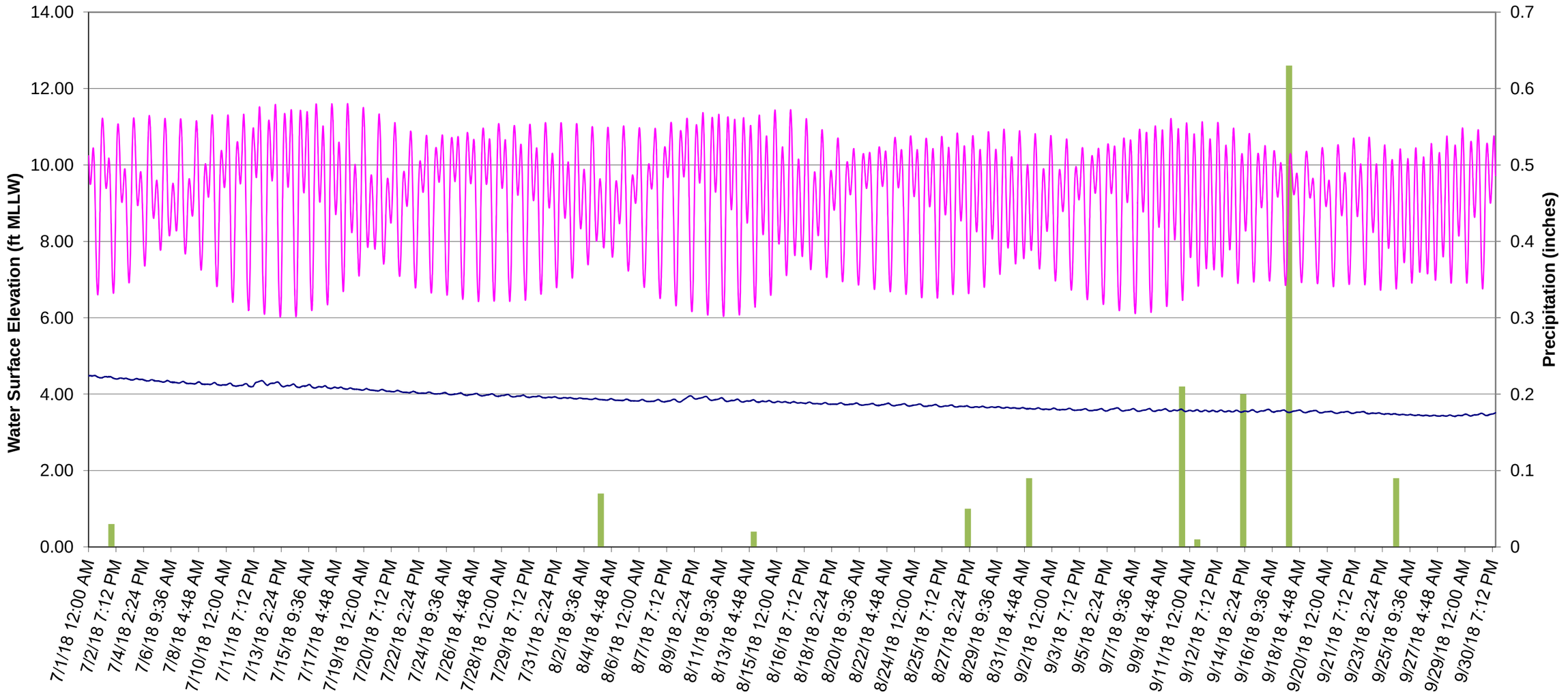


Figure 2c Well Pair Hydrographs
Upper Aquifer Well PO03 (Compartment 1) & Lower Aquifer Well 99CDMW02A
July 1 through September 30, 2018

Figure 2d Well Pair Hydrographs
Upper Aquifer Well CW03 (Compartment 2/3) & Lower Aquifer Well CW02
July 1 through September 30, 2018

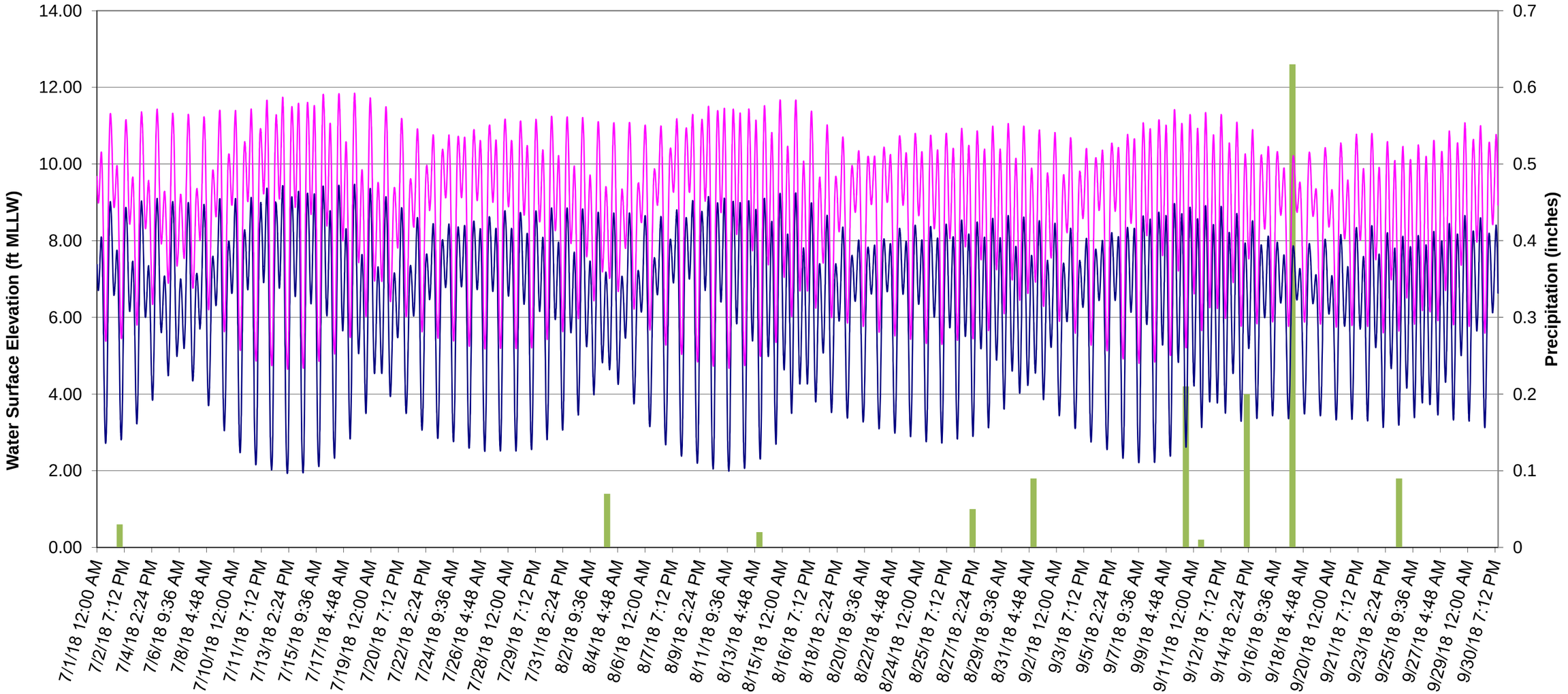


Figure 2e Well Pair Hydrographs
Upper Aquifer Well VG2U (Compartment 2/3) & Lower Aquifer Well VG2L
July 1 through September 30, 2018

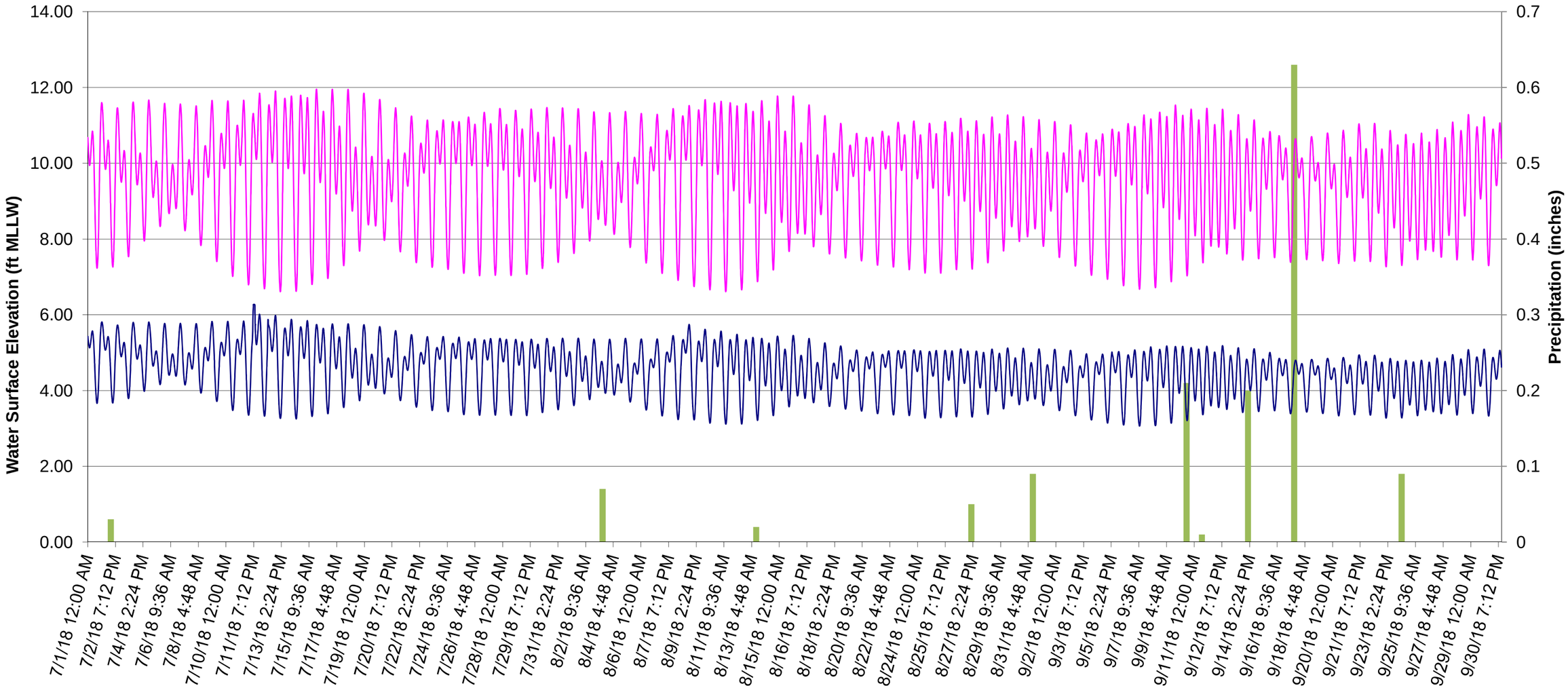


Figure 2f Well Pair Hydrographs
Upper Aquifer Well VG3U (Compartment 2/3) & Lower Aquifer Well VG
July 1 through September 30, 2018

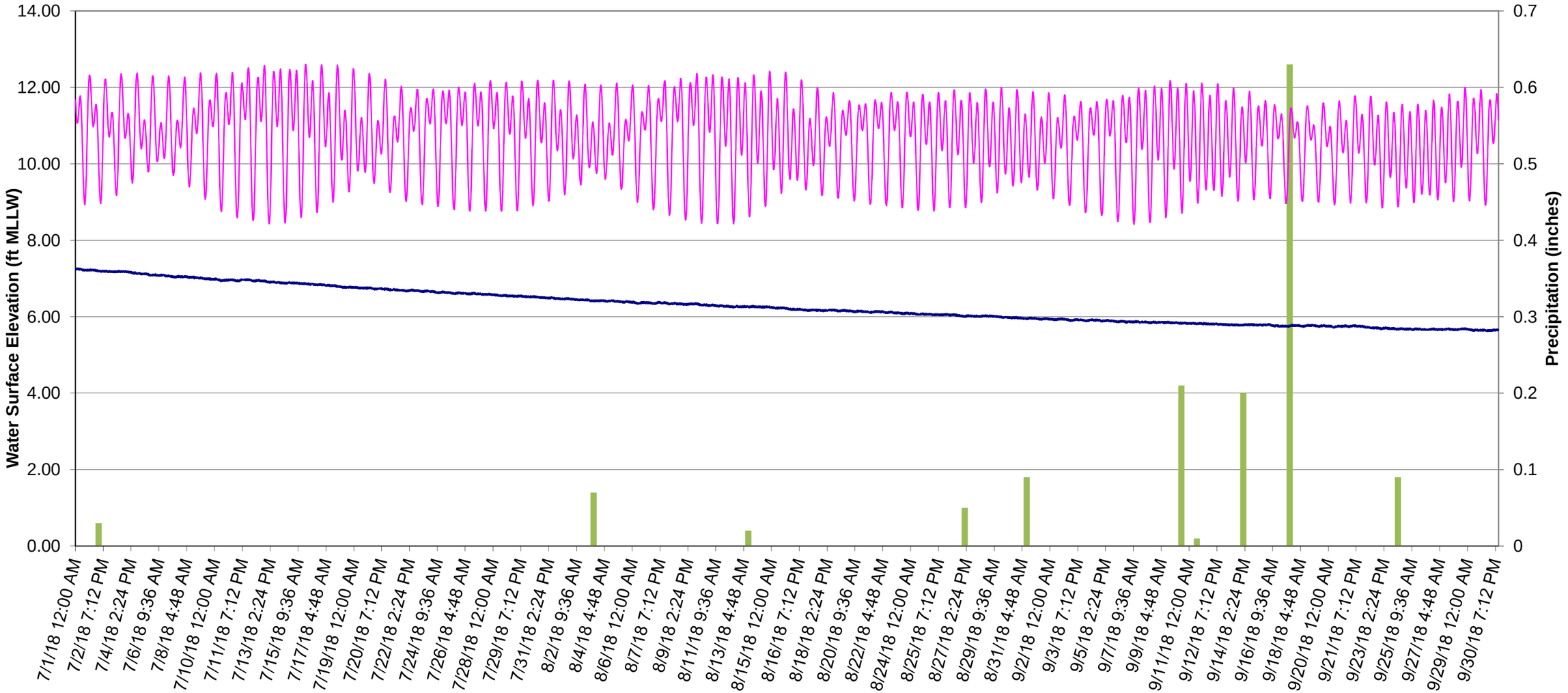


Figure 2g Well Pair Hydrographs
Upper Aquifer Well VG5U (Compartment 1) & Lower Aquifer Well VG5L
July 1 through September 30, 2018

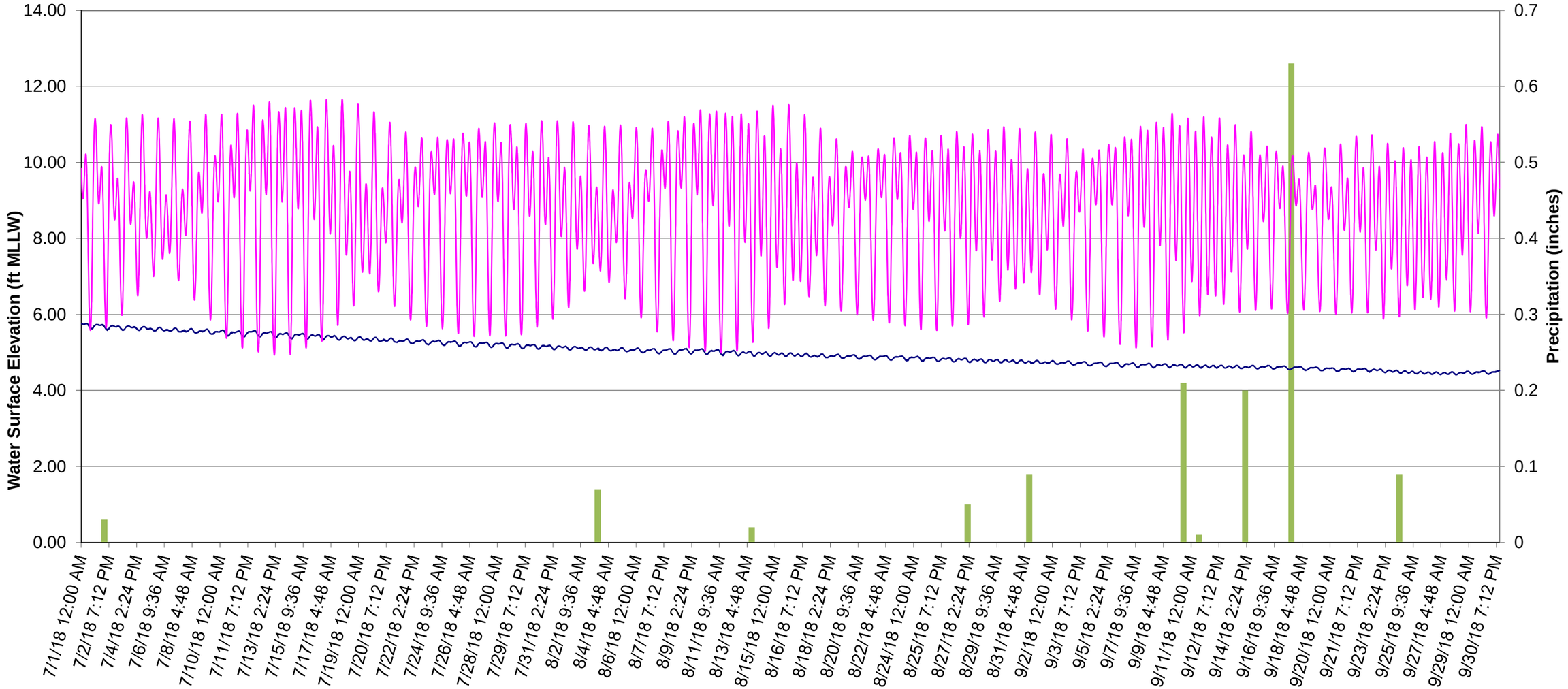


Figure 2h Well Pair Hydrographs
Upper Aquifer Well PO13 (Compartment 1) & Lower Aquifer Well VG1L
July 1 through September 30, 2018

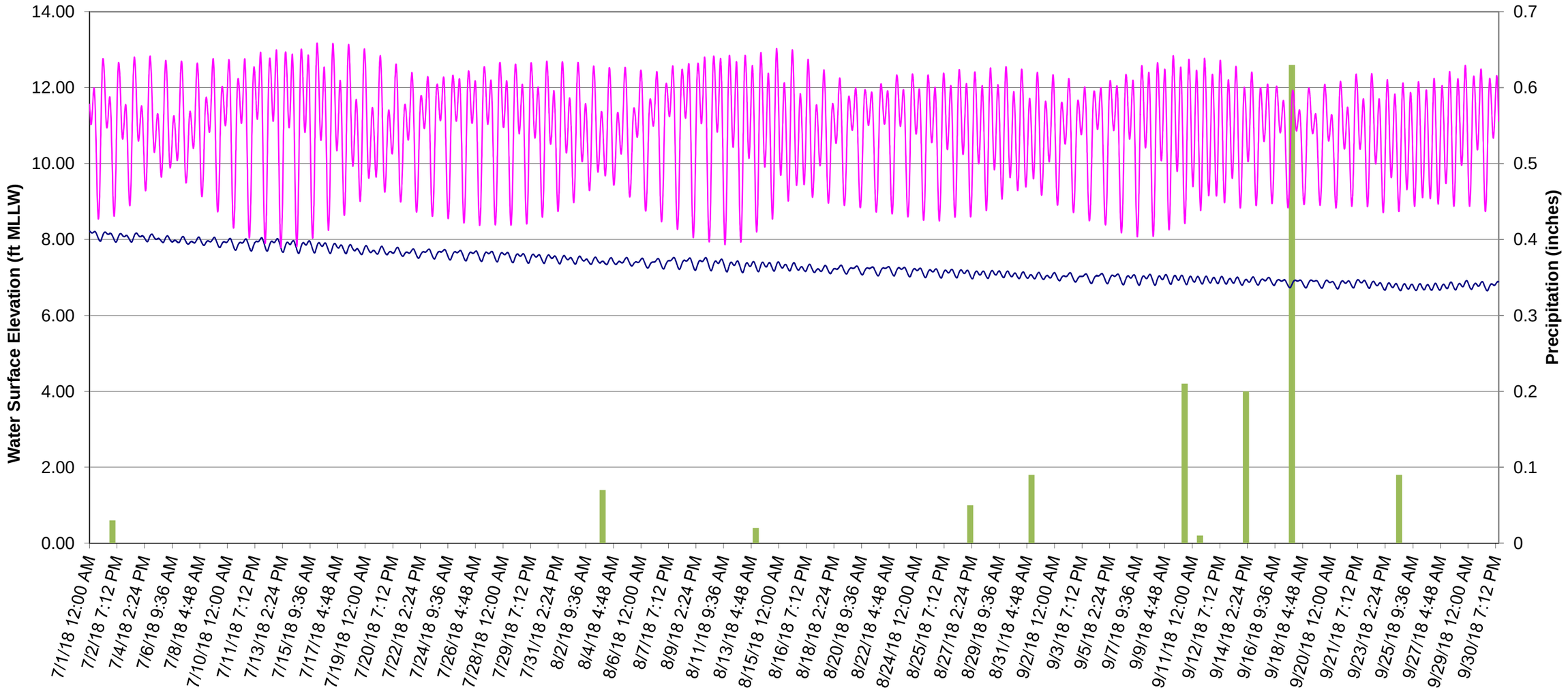


Figure 2i Well Pair Hydrographs
Upper Aquifer Well CW13 (Compartment 1) & Lower Aquifer Well VG4L
July 1 through September 30, 2018

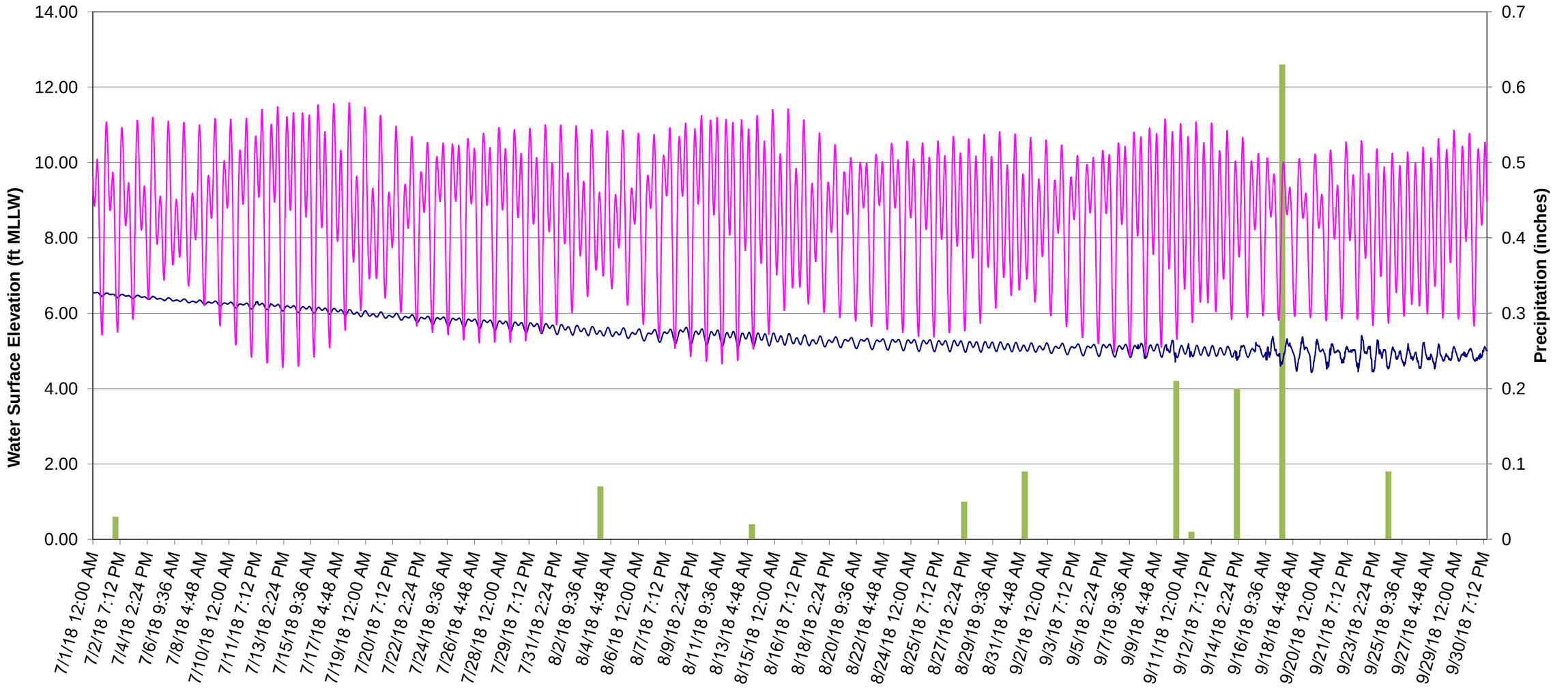


Figure 2j Well Pair Hydrographs
Upper Aquifer Well CW08 (Compartment 1) & Lower Aquifer Well P4L
July 1 through September 30, 2018

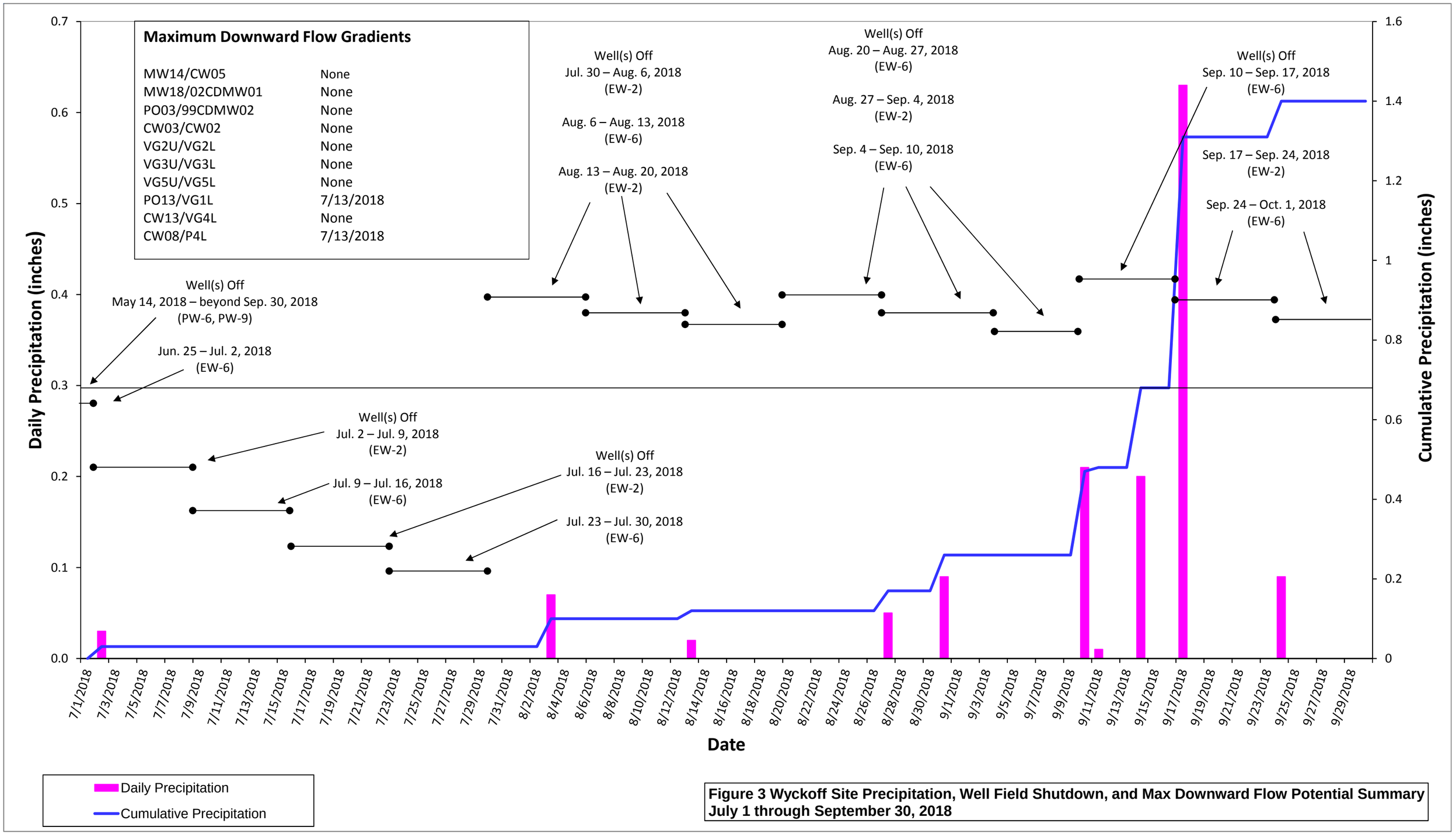


Figure 3 Wyckoff Site Precipitation, Well Field Shutdown, and Max Downward Flow Potential Summary July 1 through September 30, 2018