TECHNICAL MEMORANDUM

# Evaluation of Wyckoff Groundwater Level Data April 1, 2018 through June 30, 2018

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|---|---|
| **PREPARED FOR:** | Hun Seak Park/Washington Dept. of Ecology |
| **PREPARED BY:** | Nicole Badon/CH2M<br>Ken Scheffler/CH2M |
| **COPIES** | Helen Bottcher/EPA Region 10<br>Richard Walker/CH2M<br>Keith Allers/CH2M<br>Richard Brooks/Suquamish Tribe<br>Perry Barrett/City of Bainbridge Island |
| **DATE:** | August 21, 2018 |

This memorandum summarizes the Wyckoff groundwater level results for the April 1 through June 30, 2018 (Quarter 2) 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, weather conditions, and maintenance.
- Hydraulic containment was maintained at all the well pairs over the 91-day monitoring period, with the lower aquifer to upper aquifer groundwater elevation ratios ranging from 1.08 to 1.78 for Quarter 2. 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 September 30, 2018 to maintain a quarterly data evaluation schedule consistent with that used in the definition of hydraulic containment.
- New transducer cables were installed at three locations during the first week of January 2018, following damage during vegetation clearing operations in September 2017. Transducer calibration was necessary after installation of the new transducer cables. All in-use transducers at the site were calibrated on March 1, 2018. Calibration events are conducted annually to confirm accurate water level measurements.

## Water Level Data Collection

The April 1 through June 30, 2018 period represents the next consecutive 91-day quarterly monitoring interval following the Quarter 1 (January 1 through March 30, 2018) evaluation presented in *Evaluation of Wyckoff Groundwater Level Data January 1, 2018 through March 31, 2018* (CH2M Memorandum, May 22, 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, April 1 through June 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 2, as conditions permitted. Several extraction well shutdowns occurred during the monitoring period due to low water levels, power outages, adverse weather conditions (e.g. wind/freeze), 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 2 monitoring period (April 1 through June 30, 2018), 5.92-inches of rainfall was recorded.

The total volume of water extracted from the upper aquifer was 4,581,975 gallons during the 91-day monitoring period, equating to an average pumping rate of approximately 35 gallons per minute (gpm) for the 91 days where all or portions of the wellfield were in operation. [Note, 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 (FPA) Extraction Well Pump Shutdown Periods Greater than 1 Day**

| Offline Dates | Wells | Reason |
|---|---|---|
| February 7 – April 12, 2018 | PW-9 | Low water level |
| March 9 – April 2, 2018 | EW-6 | Pump off for carbon change out |
| March 9 – May 11, 2018 | PW-6 | Pumps off for carbon change out |
| April 2 – April 9, 2018 | EW-2 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| April 6 – April 9, 2018 | PW-1, PW-2, PW-4, PW-5, PW-8 | Pumps off due to predicted wind storm |
| April 6 – April 16, 2018 | EW-6 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| April 13 – May 11, 2018 | PW-9 | Low water level |
| April 16 – 23, 2018 | EW-2 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| April 23 – April 30, 2018 | EW-6 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| April 30 – May 7, 2018 | EW-2 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| May 7 – May 14, 2018 | EW-6 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| May 14 – 21, 2018 | EW-2 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| May 22 – May 30, 2018 | EW-2 | Pump off due to air leak |
| May 30 – June 4, 2018 | EW-6 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| June 4 – June 18, 2018 | EW-2 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |
| June 18 – June 25, 2018 | EW-6 | Alternating EW-2 & EW-6 pumps on and off due to low water level in Pilot area |

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 the 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 gradients 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 91-day monitoring period (Quarter 2) from April 1 through June 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 the 10 well pairs for the 91-day monitoring period, indicating hydraulic containment was maintained at all the well pair locations.
- Negative vertical gradients were observed at 7 of the 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.
- Negative vertical gradients occurred in 7 of the 10 well pairs as a series of short-duration downward gradient periods. The average duration of the downward gradient periods was between 2 and 4 hours each at four well pair locations, and between 5 and 8 hours each at the remaining three well pair locations.
- At six of the seven locations where negative gradients were observed (MW14/CW05, PO03/99CDMW02A, VG-5U/VG-5L, PO13/VG-1L, CW13/VG-4L and CW08/P-4L), the upper aquifer well is screened in Compartment 1, and at the seventh location (CW03/CW02) the upper aquifer well is screened in Compartment 2/3. The remaining three well pairs (MW18/02CDMW01, VG-2U/VG-2L, and VG-3U/VG-3L) did not shown downward gradients during the current reporting period. The upper aquifer well at MW18/02CDMW01 is screened in Compartment 1 and the upper aquifer wells at the remaining two well pair locations (VG-2U/VG-2L, and VG-3U/VG-3L) are screened in Compartment 2/3.

**Table 3**
**Summary of Groundwater Elevation Data by Well Pair**
**April 1 through June 30, 2018**

| | | | | | Summary Statistics Short Term Comparison - Water Level Difference between the Upper and Lower Aquifer wells (ft) | | | Duration Analysis – Downward (neg.) Gradient | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Well Pair | Figure | Upper Aquifer Average Groundwater Elevation (ft. MLLW) | Lower Aquifer Average Groundwater Elevation (ft. MLLW) | Ratio (Avg Lower Aq WL / Avg Upper Aq WL)[a] | Average | Max | Min | Number of Neg Grad Events | Average Duration of Neg Grad (hours) | Total Duration of Neg Grad (days) | Percent Duration of 91-day Monitoring Period[b] |
| MW14/CW05 | 2a | 6.85 | 9.81 | 1.43 | 2.97 | 6.25 | -0.98 | 24 | 3 | 2.7 | 2.9% |
| MW18/02CDMW01 | 2b | 5.66 | 10.09 | 1.78 | 4.42 | 9.65 | 0.98 | none | | | |
| PO03/99CDMW02A | 2c | 6.04 | 9.88 | 1.64 | 3.85 | 7.03 | -0.54 | 6 | 3 | 0.7 | 0.8% |
| CW03/CW02 | 2d | 6.50 | 9.05 | 1.39 | 2.55 | 4.98 | -0.35 | 7 | 2 | 0.7 | 0.7% |
| VG-2U/VG-2L | 2e | 7.33 | 9.24 | 1.26 | 1.91 | 2.82 | 0.77 | none | | | |
| VG-3U/VG-3L | 2f | 6.24 | 10.33 | 1.66 | 4.09 | 5.86 | 1.82 | none | | | |
| VG-5U/VG-5L | 2g | 9.21 | 11.45 | 1.24 | 2.24 | 5.22 | -2.25 | 29 | 5 | 5.9 | 6.5% |
| PO13/VG-1L | 2h | 7.10 | 9.38 | 1.32 | 11.45 | 5.75 | -2.04 | 68 | 4 | 10.6 | 11.6% |
| CW13/VG-4L | 2i | 10.62 | 11.52 | 1.08 | 0.90 | 4.73 | -4.46 | 89 | 8 | 28.6 | 31.4% |
| CW08/P-4L | 2j | 8.25 | 9.27 | 1.12 | 1.02 | 4.78 | -3.49 | 118 | 5 | 25.8 | 28.4% |

Notes:

[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

- At 3 of the 10 well pairs (CW03/CW02, PO03/99CDMW02A, and MW14/CW05) the total negative gradient duration for the 91-day period was between 0.7% and 2.9% (0.7 to 2.7 days). Two of the 10 well pairs (VG-5U/VG-5L and PO13/VG-1L) had durations of 6.5% and 11.6% (5.9 and 10.6 days), and the remaining 2 well pairs had durations of 28.4% (CW08/P-4L; approximately 26 days) and 31.4% (CW13/VG-4L; approximately 29 days).
- While well pair CW08/P-4L did not have the highest negative gradient duration, it did have the highest number of negative gradient events for the 91-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 ft) from production well RPW2 as is VG-3U/VG-3L which had no negative gradient events.
- Maximum downward flow gradients occurred on April 17 through April 21, 2018 in all wells showing downward flow gradients. The maximum negative gradients occurred following a daily precipitation amount of 1.99 inches on April 16, 2018 and when all the extraction wells except PW-6, PW-9, and EW-2 were in operation. Minus tides of between -0.22 to -1.28 feet mean lower low water (MLLW) occurred from April 17, 2018 to April 20, 2018, respectively.

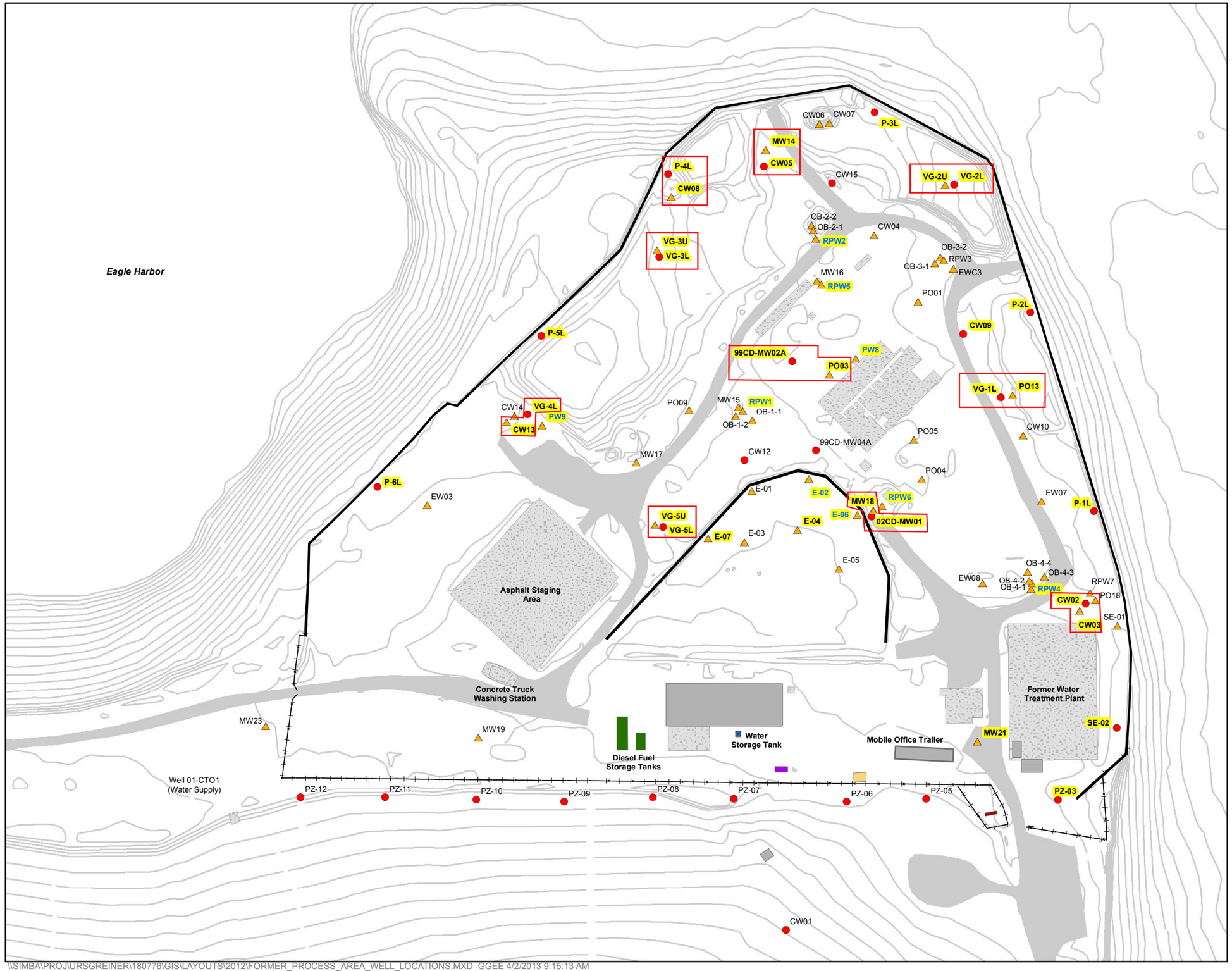
## Summary

During the Quarter 2 monitoring period, hydraulic containment was maintained at all ten well pairs.

Negative hydraulic gradient events occurred at 7 of the 10 well pairs during the Quarter 2 monitoring period. The maximum observed negative gradients, for the 7 well pairs during the Quarter 2 period, occurred from April 17 to April 21, 2018 when all but three extraction wells were in operation, and following a daily precipitation total of 1.99 inches (Figure 3). The greatest minus tide, during the observed maximum negative gradient period, was -1.28 feet MLLW.

During extraction well shutdown events, when many pumps were off during the same period (April 6 through April 9, 2018), water levels in some of the upper aquifer well locations recovered quickly, showing a general increase between 0.85 to 2.7 feet (Figures 2a through 2j).

# 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

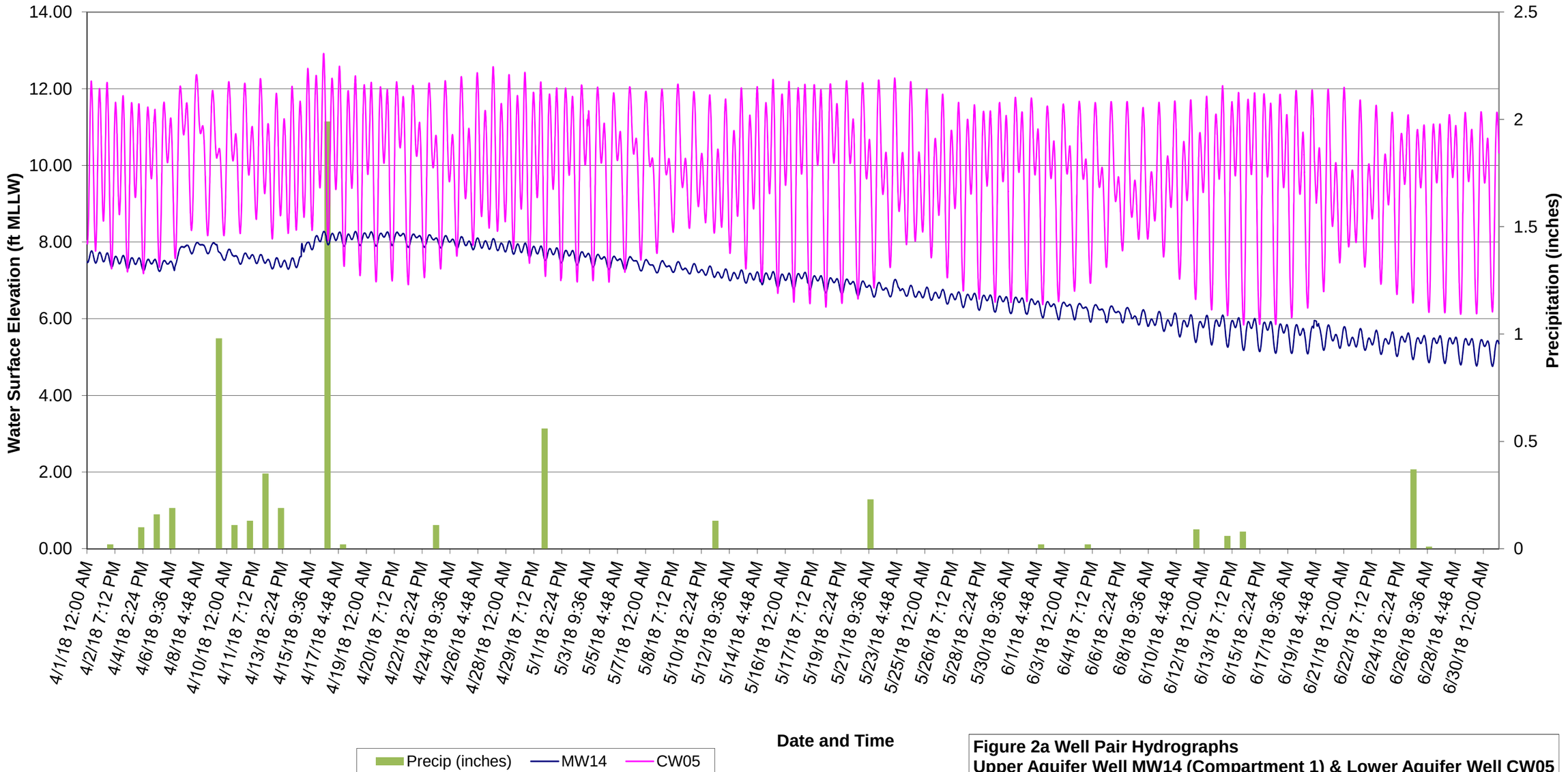



**Figure 2a Well Pair Hydrographs**
**Upper Aquifer Well MW14 (Compartment 1) & Lower Aquifer Well CW05**
**April 1 through June 30, 2018**

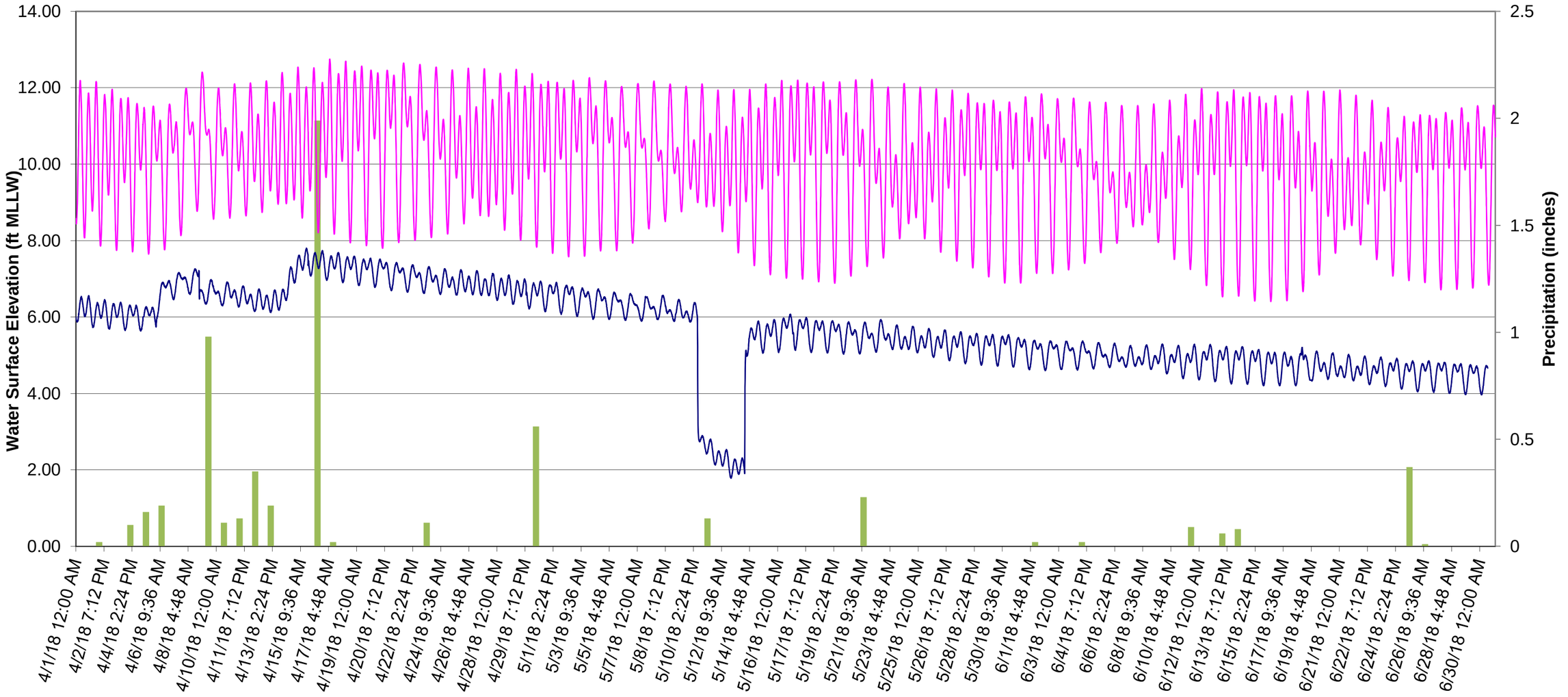



**Figure 2b Well Pair Hydrographs**
**Upper Aquifer Well MW18 (Compartment 1) & Lower Aquifer Well 02CDMW01**
**April 1 through June 30, 2018**

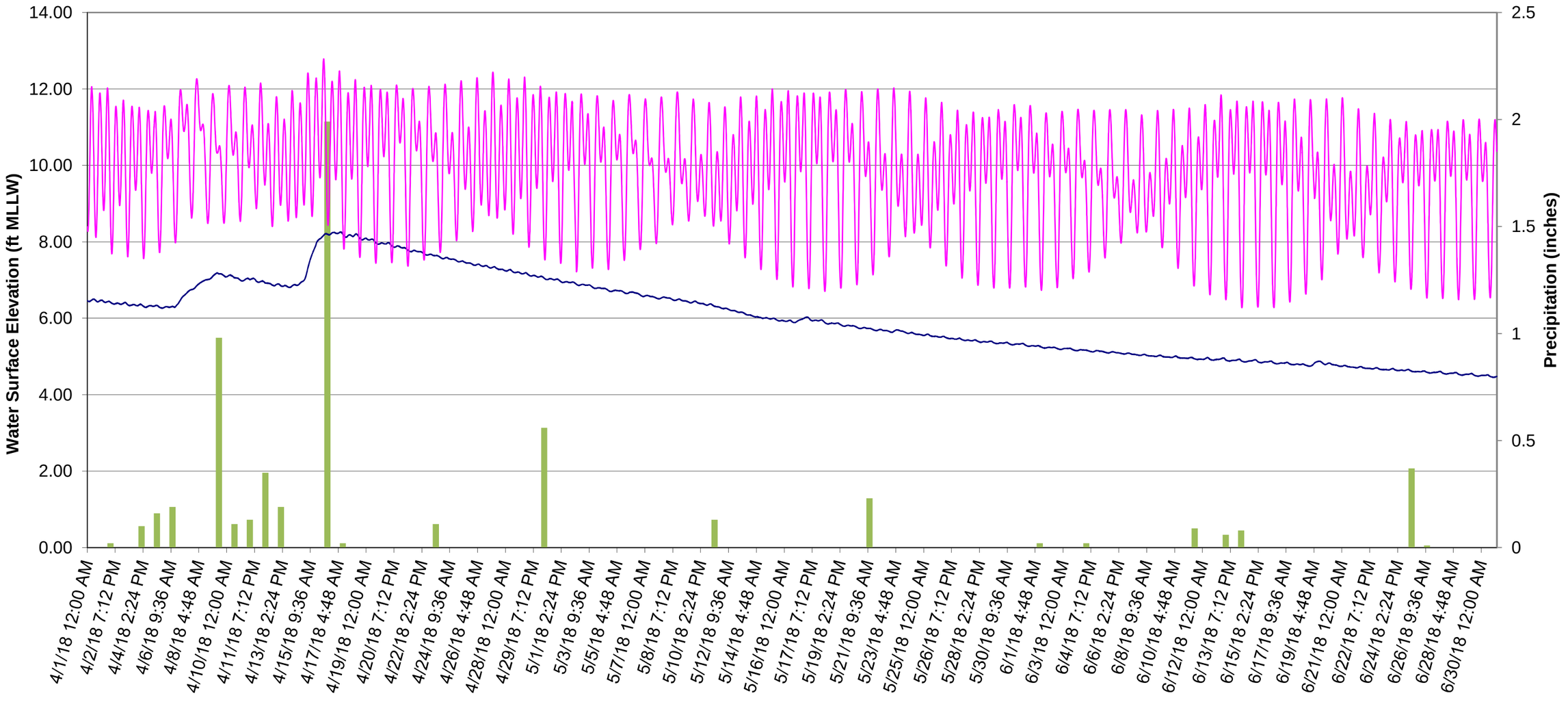



**Figure 2c Well Pair Hydrographs**
**Upper Aquifer Well PO03 (Compartment 1) & Lower Aquifer Well 99CDMW02A**
**April 1 through June 30, 2018**

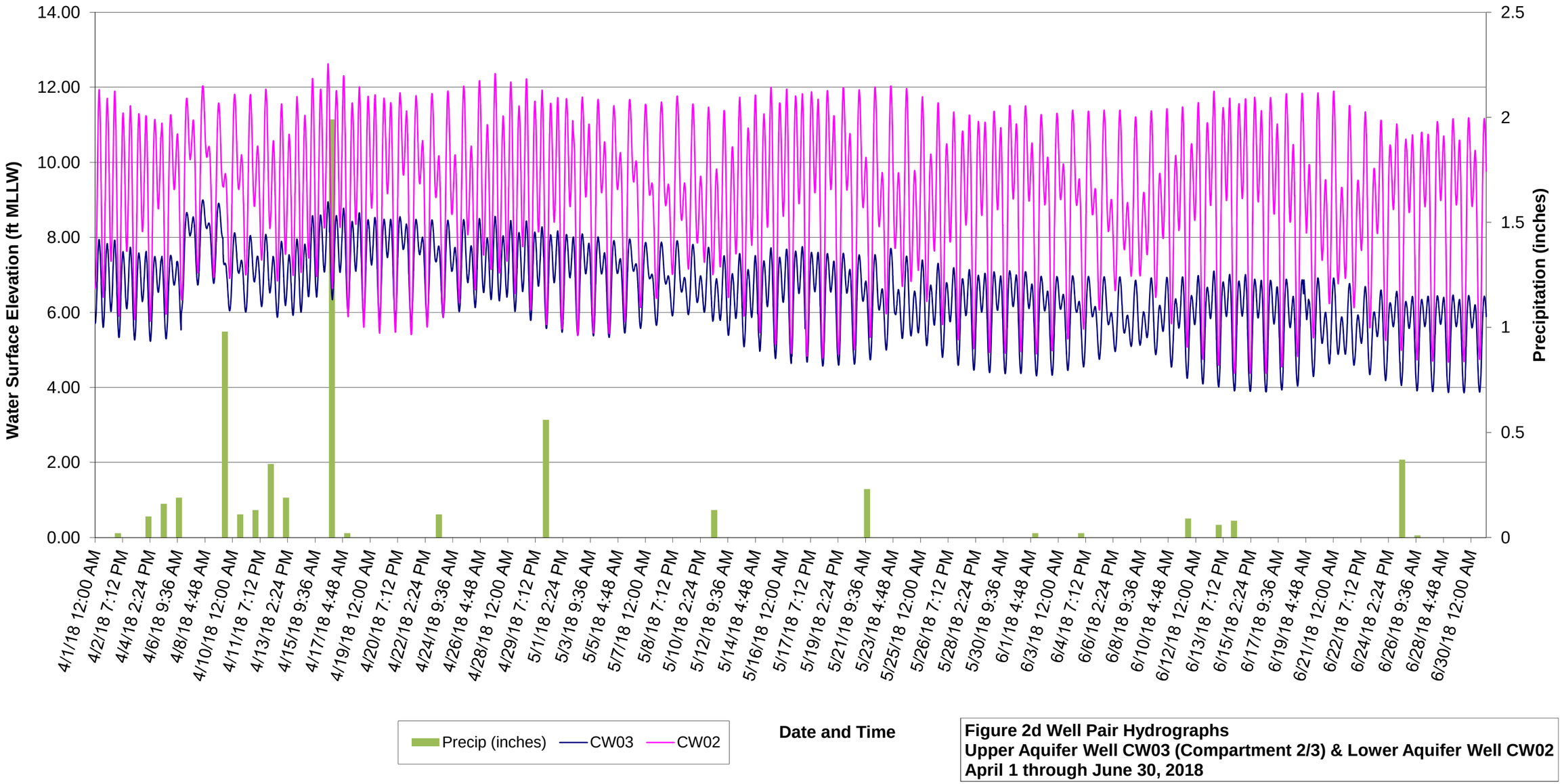



**Figure 2d Well Pair Hydrographs**
**Upper Aquifer Well CW03 (Compartment 2/3) & Lower Aquifer Well CW02**
**April 1 through June 30, 2018**

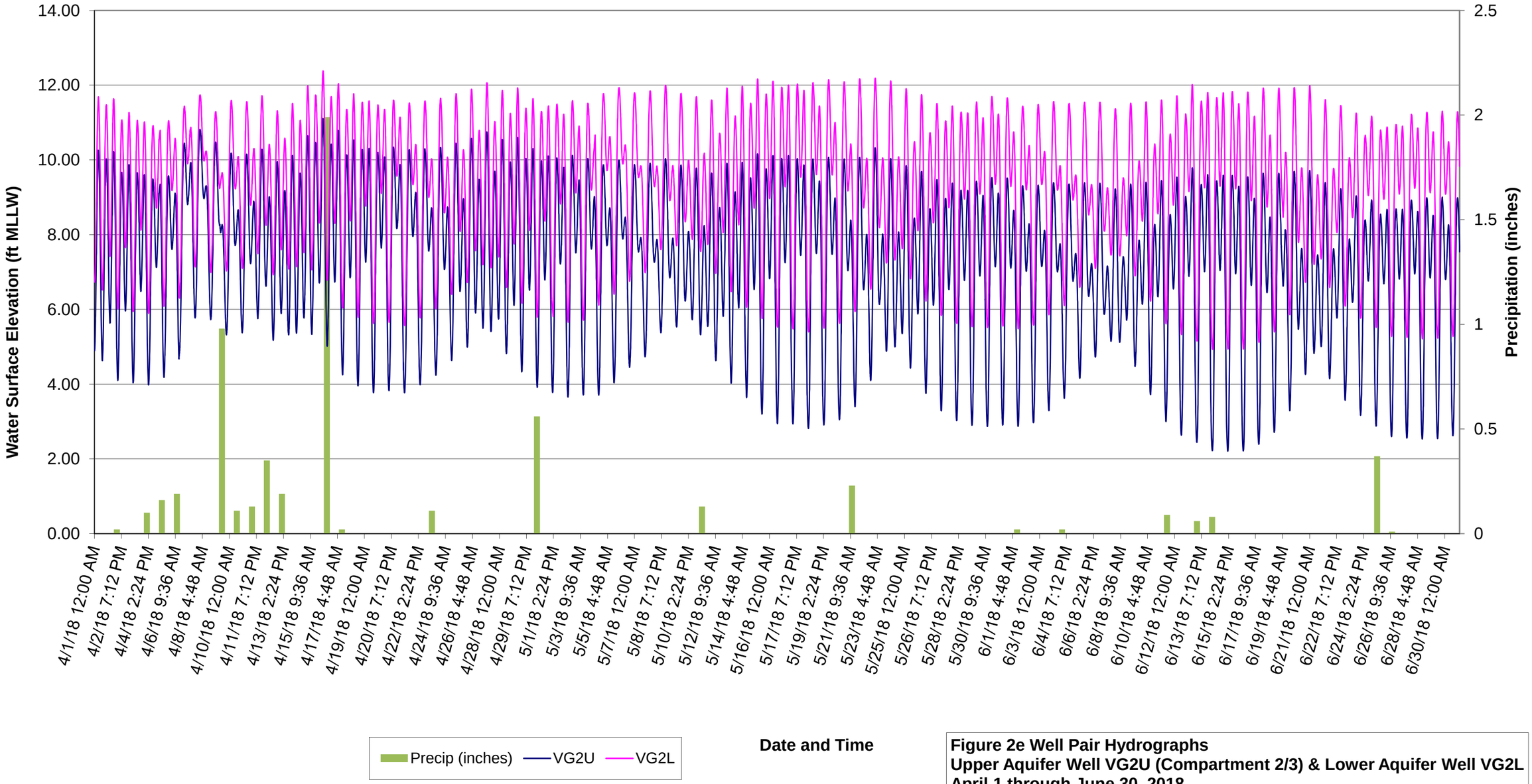



**Figure 2e Well Pair Hydrographs**
**Upper Aquifer Well VG2U (Compartment 2/3) & Lower Aquifer Well VG2L**
**April 1 through June 30, 2018**

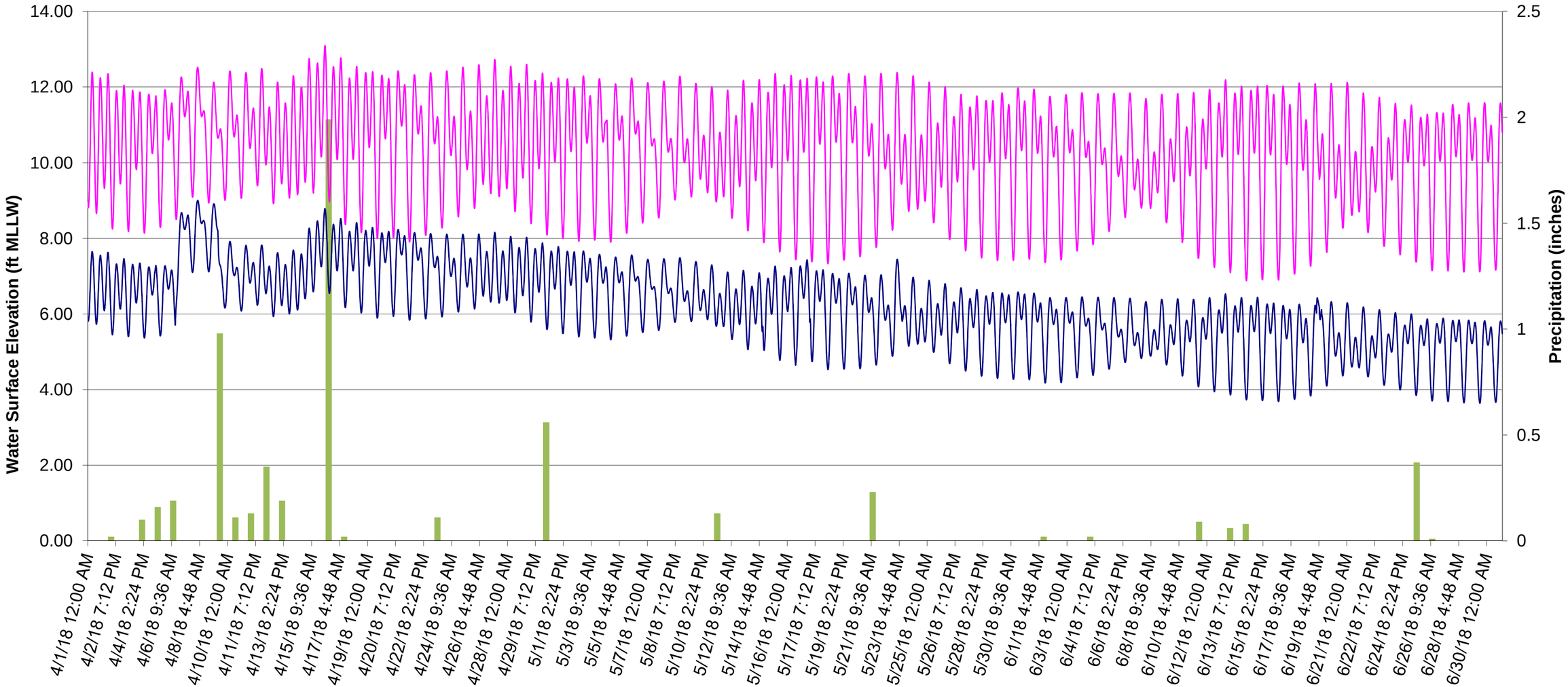



**Figure 2f Well Pair Hydrographs**
**Upper Aquifer Well VG3U (Compartment 2/3) & Lower Aquifer Well VG**
**April 1 through June 30, 2018**

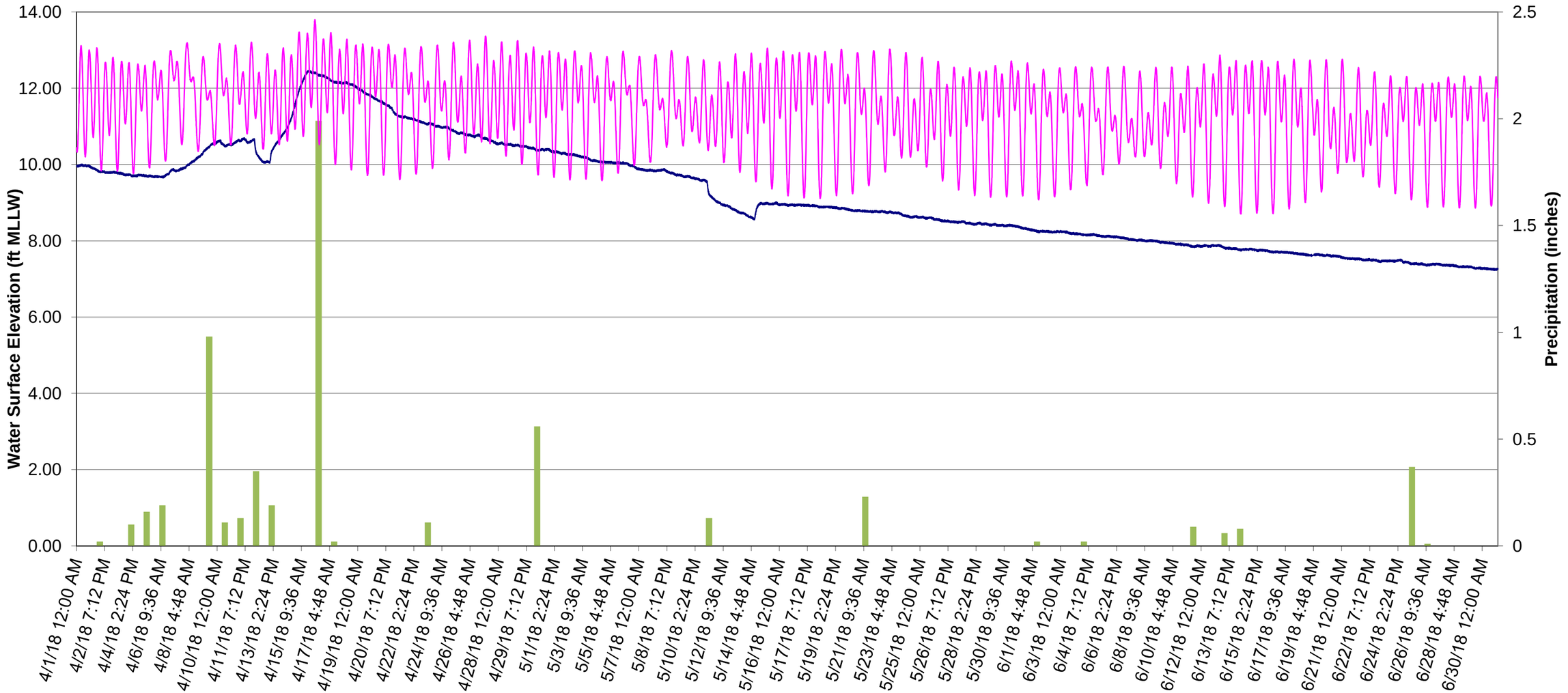



**Figure 2g Well Pair Hydrographs**
**Upper Aquifer Well VG5U (Compartment 1) & Lower Aquifer Well VG5L**
**April 1 through June 30, 2018**

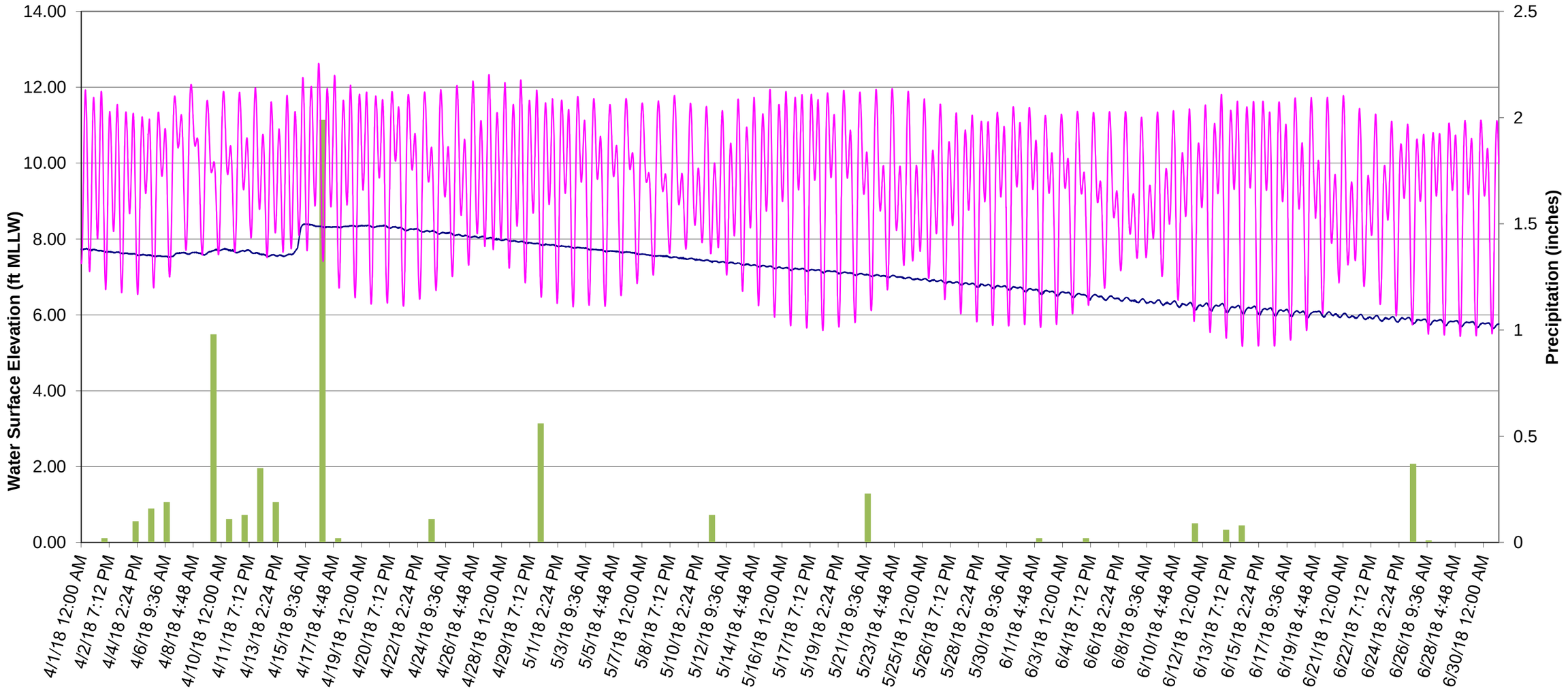



**Figure 2h Well Pair Hydrographs**
**Upper Aquifer Well PO13 (Compartment 1) & Lower Aquifer Well VG1L**
**April 1 through June 30, 2018**

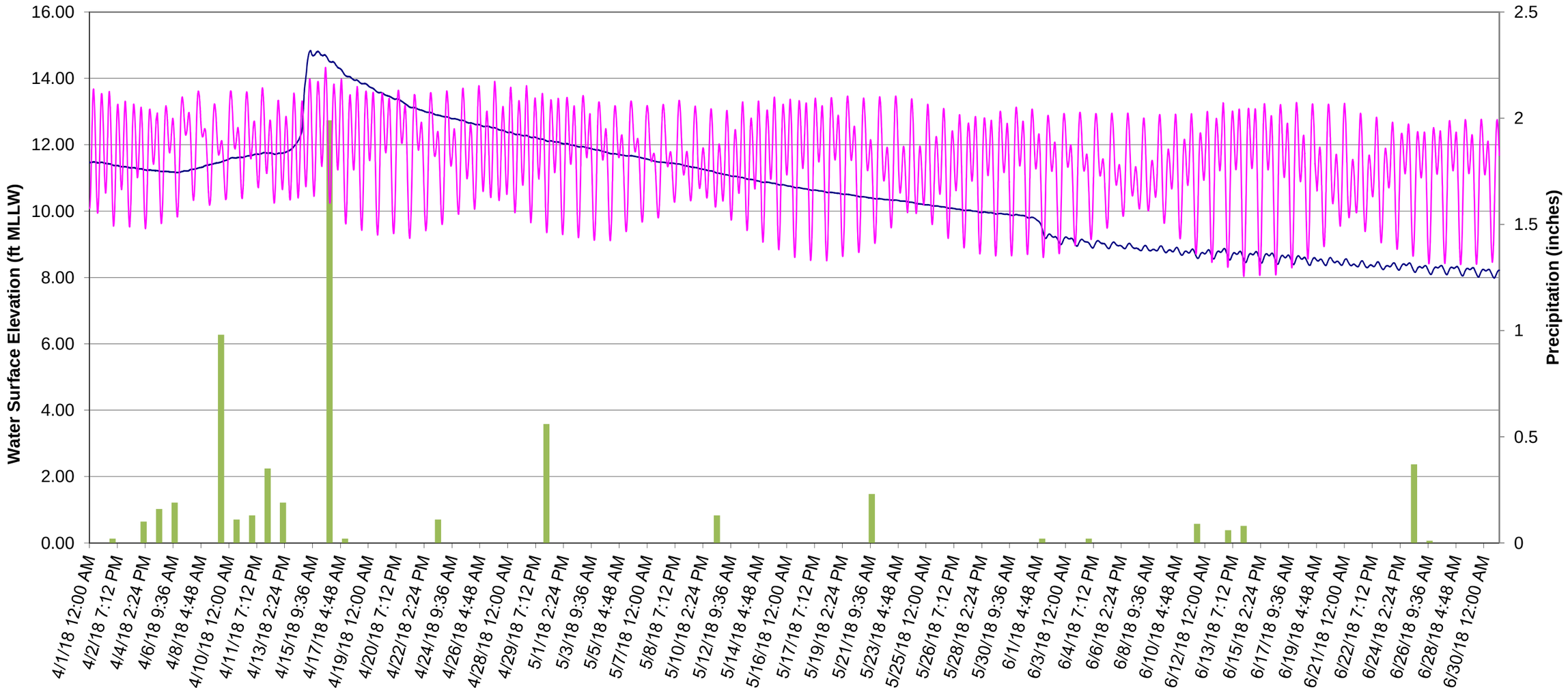



**Figure 2i Well Pair Hydrographs**
**Upper Aquifer Well CW13 (Compartment 1) & Lower Aquifer Well VG4L**
**April 1 through June 30, 2018**

**Maximum Downward Flow Gradients**

| | |
|---|---|
| MW14/CW05 | 4/21/2018 |
| MW18/02CDMW01 | None |
| PO03/99CDMW02 | 4/19/2018 |
| CW03/CW02 | 4/19/2018, 4/20/2018, 4/21/2018 |
| VG2U/VG2L | None |
| VG3U/VG3L | None |
| VG5U/VG5L | 4/18/2018 |
| PO13/VG1L | 4/19/2018 |
| CW13/VG4L | 4/17/2018 |
| CW08/P4L | 4/21/2018 |

Well(s) Off
Feb. 7 – Apr. 12, 2018
(PW-9)

Mar. 9 -- Apr. 2, 2018
(EW-6)

Well(s) Off
Mar. 9 – May 11, 2018
(PW-6)

Well(s) Off
Apr. 2 -- Apr. 9, 2018
(EW-2)

Apr. 6 -- Apr. 9, 2018
(PW-1, PW-2, PW-4,
PW-5, PW-8)

Apr. 6 - Apr. 16, 2018
(EW-6)

Well(s) Off
Apr. 13 -- May 11, 2018
(PW-9)

Apr. 16 - 23, 2018
(EW-2)

Apr.23 - Apr 30, 2018
(EW-6)

Well(s) Off
Apr. 30 - May 7, 2018
(EW-2)

May 7 - May 14, 2018
(EW-6)

May 14 - May 21, 2018
(EW-2)

Well(s) Off
May 22 - May 30, 2018
(EW-2)

May 30 - Jun. 4, 2018
(EW-6)

Jun. 4 - Jun. 18, 2018
(EW-2)

Well(s) Off
Jun. 18 - Jun. 25, 2018
(EW-6)

Daily Precipitation (inches)

Cumulative Precipitation (inches)

Date

Daily Precipitation
Cumulative Precipitation

**Figure 3 Wyckoff Site Precipitation, Well Field Shutdown, and Max Downward Flow Potential Summary April 1 through June 30, 2018**