Evaluation of Wyckoff Groundwater Level Data June 24, 2012 through September 21, 2012

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DATE: January 4, 2013

This memorandum summarizes the Wyckoff groundwater level results for the 90-day monitoring period of June 24 through September 21, 2012.

Summary/Recommendations

- Hydraulic containment was maintained in all 10 well pairs over the 90-day monitoring period: MW14/CW05, MW18/02CDMW01, PO03/99CDMW02A, CW03/CW02, VG-2U/VG-2L, VG-3U/VG-3L, VG-5U/VG-5L, PO13/VG-1L, CW13/VG4L, and CW08/P-4L.
- The groundwater elevation data from the new transducers in the 10 well pairs should be downloaded again in December 2012 to maintain a quarterly schedule consistent with the definition of hydraulic containment.

Water Level Data Collection

The June 24 through September 21, 2012 time period represents the next 90-day monitoring period in succession from the previous groundwater level data evaluation memorandum (March 26 - June 23, 2012). The locations of the wells are shown in Figure 1 and 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 calibrated in July 2012 during this monitoring period. The transducers were most recently calibrated on November 26, 2012. Several of the transducers showed minor out-of-calibration values. The required corrections ranged from 2 to 4 inches. The transducers were not recalibrated until the issue had been discussed with KPSI personnel.

All data are available in e-format upon request.

Table 1 – Wells with Transducers, June 24 – September 21, 2012

Upper Aquifer		Lower Aquifer	
CW03	PO13	02CDMW01	PZ03
CW08	RPW-1	99CDMW02A	SE02
CW13	RPW-2	CW02	VG-1L
E-02[1]	RPW-4	CW05	VG-2L
E-04[1]	RPW-5	CW09	VG-3L
E-06[1]	RPW-6	P-1L	VG-4L
E-07[1]	PW-8	P-2L	VG-5L
MW14	PW-9	P-3L	
MW18	VG-2U	P-4L	
MW21	VG-3U	P-5L	
PO03	VG-5U	P-6L	

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

Hydraulic Containment / Isolation Evaluation

The hydraulic containment/isolation performance at the Wyckoff site is evaluated based on water level data from 10 upper and lower aquifer well pairs: MW14/CW05, MW18/02CDMW01, PO03/99CDMW02A, CW03/CW02, VG-2U/VG-2L, VG-3U/VG-3L, VG-5U/VG-5L, PO13/VG-1L, CW13/VG-4L, and CW08/P-4L (See Figure 1 for these locations). The hydraulic containment at each well pair is evaluated by first calculating the average groundwater elevations of the upper and lower aquifers using the water elevation data recorded every 15 minutes during the 90-day monitoring period. Then the average groundwater elevations of the upper and lower aquifers at each well pair are compared relative to each other. If the average lower aquifer groundwater elevation is greater than that of the upper aquifer, an overall net upward gradient of groundwater is indicated and hydraulic containment is demonstrated. If a well pair meets the definition of hydraulic containment, the ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for that well pair is greater than 1. A secondary evaluation of hydraulic containment/isolation performance is conducted through examination of the short term periods when downward hydraulic gradients occur within well pairs. Hydrographs for each well pair are prepared (See Figures 2a through 2j). In addition, groundwater elevations for each well pair are compared at each 15 minute recording, and the summary statistics are evaluated. The maximum, average, and minimum change in groundwater elevation for each well pair is calculated, along with percent duration of the 90-day monitoring period when net downward gradients occur.

In previous memoranda, the primary and secondary hydraulic containment evaluation results were presented by individual well pair in text format. In an effort to streamline this discussion, the hydraulic evaluation data for the well pairs are summarized together in Table 2. This presents the average groundwater elevations for each well pair, the ratio of the average upper to lower aquifer groundwater elevation, and summary statistics on the short term vertical gradients.

- All ratios are greater than 1, indicating hydraulic containment is maintained.

- Short term vertical gradient data indicate that an upward gradient is sustained at all times during the 90-day monitoring period at two of the monitoring well pairs (VG-2U/VG-2L and VG-5U/VG-5L).
- A series of short duration downward gradient periods occur in the other eight monitoring well pairs. In seven of these eight well pairs, the percent duration of the 90-day period is 6.7 percent or less.
- One well pair (CW-08/P-4L at 18.9 percent) has a percent duration of the 90-day monitoring period greater than 10 percent.

Table 2

Summary of Groundwater Elevation Data by Well Pair

				Summary Statistics – Short Term Water Level Difference between the Upper and Lower Aquifer wells			Duration Analysis – Downward (neg) Gradient			
Well Pair	Upper Aquifer Average Groundwater Elevation (ft MLLW)	Lower Aquifer Average Groundwater Elevation (ft MLLW)	Ratio (Avg Lower Aq WL / Avg Upper Aq WL)*	Average	Max	Min	Number Neg Grad Events	Average Duration Neg Grad (hours)	Total Duration Neg Grad (days)	Percent Duration of 90-day monitoring period
MW14/CW05	6.57	9.43	1.44	2.86	6.07	-0.67	28	2.0	2.3	2.6%
MW18/02CDMW01	6.54	9.13	1.40	2.59	6.73	-1.10	30	3.0	3.7	4.1%
PO03/99CDMW02A	6.87	9.42	1.37	2.55	5.82	-1.23	37	3.2	4.9	5.4%
CW03/CW02	7.22	8.93	1.24	1.72	10.11	-0.82	46	3.2	6.1	6.7%
VG-2U/VG-2L	7.56	8.36	1.11	0.80	1.91	0.11	none			
VG-3U/VG-3L[1]	7.01	9.69	1.38	2.58	6.23	-0.36	14	2.5	1.5	1.6%
VG-5U/VG-5L	7.98	10.71	1.34	2.72	4.65	0.28	none			
PO13/VG-1L	6.53	9.17	1.40	2.64	5.88	-1.03	52	2.6	5.6	6.2%
CW13/VG-4L	8.40	10.83	1.29	2.43	4.94	-0.46	24	1.8	1.8	2.0%
CW08/P-4L	7.15	8.95	1.25	1.80	5.12	-2.14	94	4.3	17.0	18.9%

*** Ratio > 1 = Hydraulic Containment was Achieved**

[1]Evaluation of hydraulic containment is based on 90 days of groundwater level data. Due to a programming issue with the transducer in VG-3L, the water levels from June 29, 2012 at 09:14 through July 11, 2012 at 08:23 were not properly recorded. These data had to be eliminated from hydraulic containment calculations. Therefore, hydraulic containment is evaluated for less than 90-days for this well pair.

Treatment Plant Operations and Effects on Groundwater Flow

The treatment plant and extraction well systems were shut down for the majority of the monitoring period (June 24 through September 21, 2012) due to summer maintenance and low water levels, and then were operated 24 hours per day and 5 days per week during the monitoring period beginning in September 2012. The dates during which the extraction wells were shut down for periods greater than 24 hours are listed in Table 3. These periods are graphically overlaid with the precipitation records and are shown in Figure 3. The total volume of water pumped was 1,854,364 gallons during the 90-day monitoring period which equates to about 14 gpm over the entire period including all down time regardless of cause. [Note, when fully operating, the system can pump about 72 gpm.]

Table 3 – Former Process Area (FPA) Extraction Well Pump Shut down Periods Greater than 1 Day

Date	Wells Shut Down	Reason
April 21 –September 4, 2012	PW-6	Shutdown due to low water level
April 27 – September 4, 2012	PW-1	Shutdown for summer maintenance
July 6 – September 4, 2012	PW-9	Shutdown due to low water level and summer maintenance
July 26 – September 4, 2012	EW-2, EW-6	Shutdown for summer maintenance
July 27 – September 4, 2012	PW-2, PW-4, PW-5, PW-8	Shutdown for summer maintenance
September 7 – September 10, 2012	PW-1, PW-2, PW-4, PW-5, PW-6, PW-8, EW-2, EW-6	Weekend shutdown
September 7 – September 10, 2012	PW-9	Shutdown due to low water level
September 10, 2012 --	PW-9	Shutdown due to low water level
September 14 – September 17, 2012	PW-2, PW-4, PW-5, PW-8, EW-2, EW-6	Weekend shutdown
September 14 – September 19, 2012	PW-6	Shutdown due to low water level
September 14 – September 20, 2012	PW-1	Shutdown due to low water level
September 21 – September 24, 2012	PW-1, PW-2, PW-4, PW-5, PW-6, PW-8, EW-2, EW-6	Weekend shutdown

The effects of the hydraulic containment system on groundwater flow in the upper aquifer is difficult to determine, since groundwater elevations are influenced both by tidal fluctuation and groundwater extraction. The long term shutdown of the hydraulic containment system during this quarter allows for a more detailed evaluation of its affects. Two synoptic events were selected to represent different pumping conditions during the 90-day monitoring period. The first on July 25, 2012 at 12:55 PM

represents a moment in time when the tidal elevation was approximately 3 ft MLLW on an incoming tide. At that measurement time, six production wells were extracting groundwater (RPW-2 at 10.20 gallons per minute [gpm], RPW-4 at 7.46 gpm, RPW-5 at 9.22 gpm, PW-8 at 6.87 gpm, E-02 at 4.80 gpm, and E-06 at 5.60 gpm). The time selected for comparison was September 3, 2012 at 9:01 PM, representing a moment in time when the tidal elevation was also approximately 3 ft MLLW on an incoming tide, but when no production wells were extracting groundwater. Potentiometric surfaces were interpolated for the upper and lower aquifers using the pressure transducer water level data collection system, for each synoptic event.

Figures 4a and 4b present potentiometric surfaces for the July 25th synoptic event, showing groundwater flow direction arrows for both the upper and lower aquifers. The upper aquifer potentiometric surface demonstrates inward hydraulic gradients to the active production wells, while the lower aquifer potentiometric surface demonstrates hydraulic gradients toward Eagle Harbor and Puget Sound.

Figures 5a and 5b present potentiometric surfaces for the September 3rd synoptic event, showing groundwater flow direction arrows for the upper and lower aquifers. The upper aquifer potentiometric surface demonstrates a partial inward gradient to the production wells with some gradient reversal toward the sheet pile wall. The outward gradients along the sheet pile wall are an artifact of the potentiometric surface interpolation, which does not take into account the sheet pile wall as a hydraulic barrier to groundwater flow. The lower aquifer potentiometric surface demonstrates gradients and groundwater flow toward Eagle Harbor and Puget Sound.

To evaluate the spatial effects of the hydraulic containment system on the upper aquifer, the July 25th potentiometric surface was subtracted from the September 3rd potentiometric surface. This difference, shown in Figure 6, reflects the approximate displacement of the upper aquifer water table resulting from shutting down the hydraulic containment system in late July, as well as any seasonal changes, over this period. All the wells except for PW9 and CW13 are located within the area where displacement is estimated at greater than 1 foot. This suggests that most, if not all of the Former Process Area is within the hydraulic radius of influence of the extraction wells (RPW-2, RPW-4, RPW-5, PW-8, E-02, and E-06) active on July 25th. It should be noted that this radius of influence evaluation is applicable to the low water levels consistent with summer - dry season conditions. The hydraulic effects of groundwater extraction may differ for winter - wet season conditions.

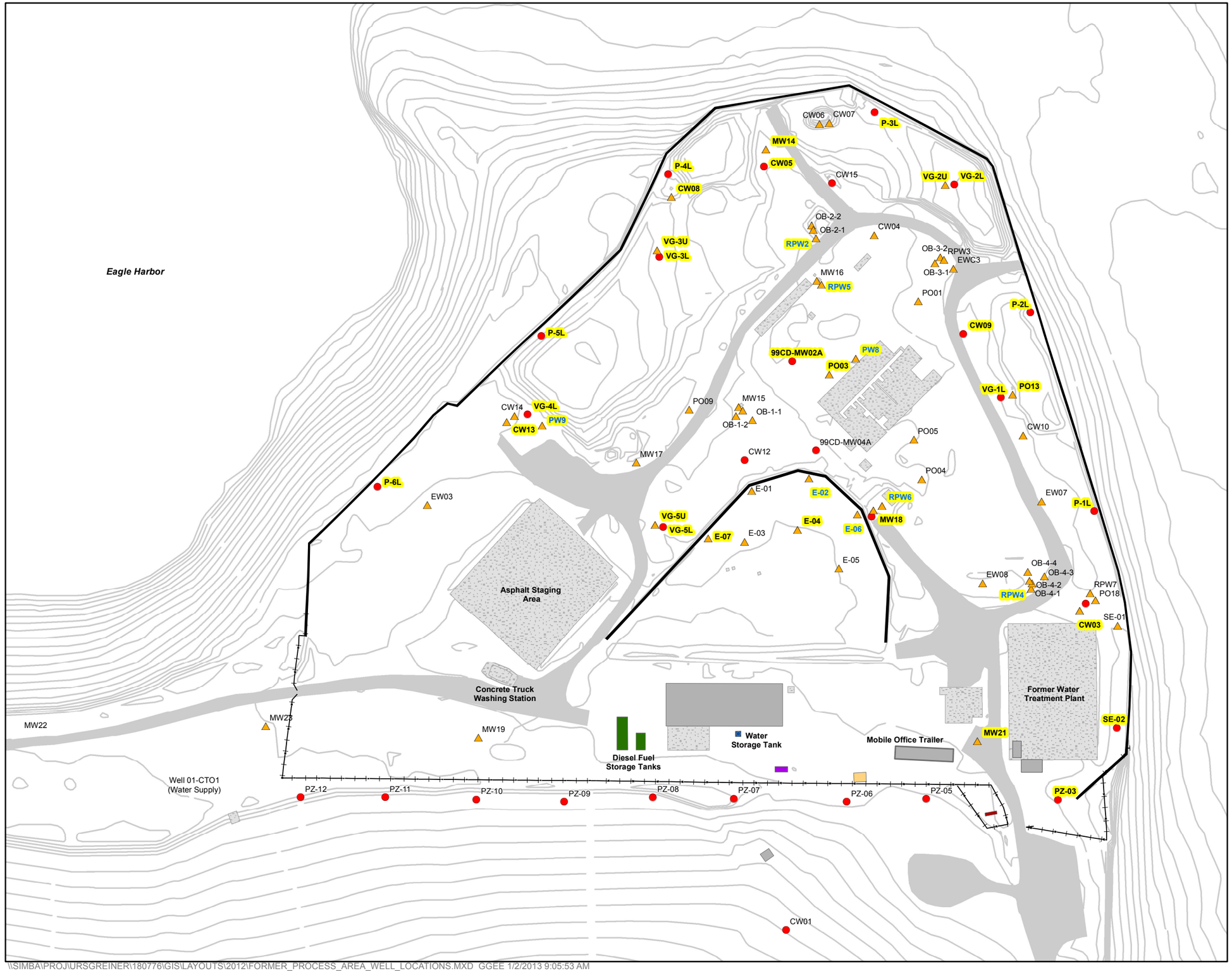
Summary and Conclusion

Hydraulic containment and the effects of treatment plant operations on groundwater flow are evaluated using groundwater level data monitored using pressure transducers installed in 22 upper aquifer wells and 18 lower aquifer wells. Results of the evaluation indicate the following:

- Hydraulic containment was maintained in all 10 well pairs for the duration of the 90-day monitoring period with minimal pumping of the extraction wells during the summer dry season.
- The long term shutdown of the hydraulic containment system allowed for comparison of two synoptic events, which suggests that the majority of the Former Process Area is within the radius of influence of the extraction wells in operation on July 25, 2012. Displacement of water levels in the upper aquifer is estimated at greater than 1 foot for all well locations except PW-9 and CW-13.

Because of the limited displacement estimated at PW-9 and CW-13, as well as a history of pump cycling at PW-9 and its limited influence on nearby observation wells, effects of groundwater extraction in this area should be thoroughly reviewed during evaluation of the next 90-day monitoring period. Enhancing the influence of groundwater extraction during the dry season in this area may require well development or modification of the pump equipment.

This memorandum represents a change in the historical format of the document to provide a streamlined discussion of results. If this is acceptable, future 90-day monitoring period reports will be prepared using this new format.



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

N

0 50 100 Feet

FIGURE 1

Former Process Area Well Locations

WYCKOFF/EAGLE HARBOR SUPERFUND SITE

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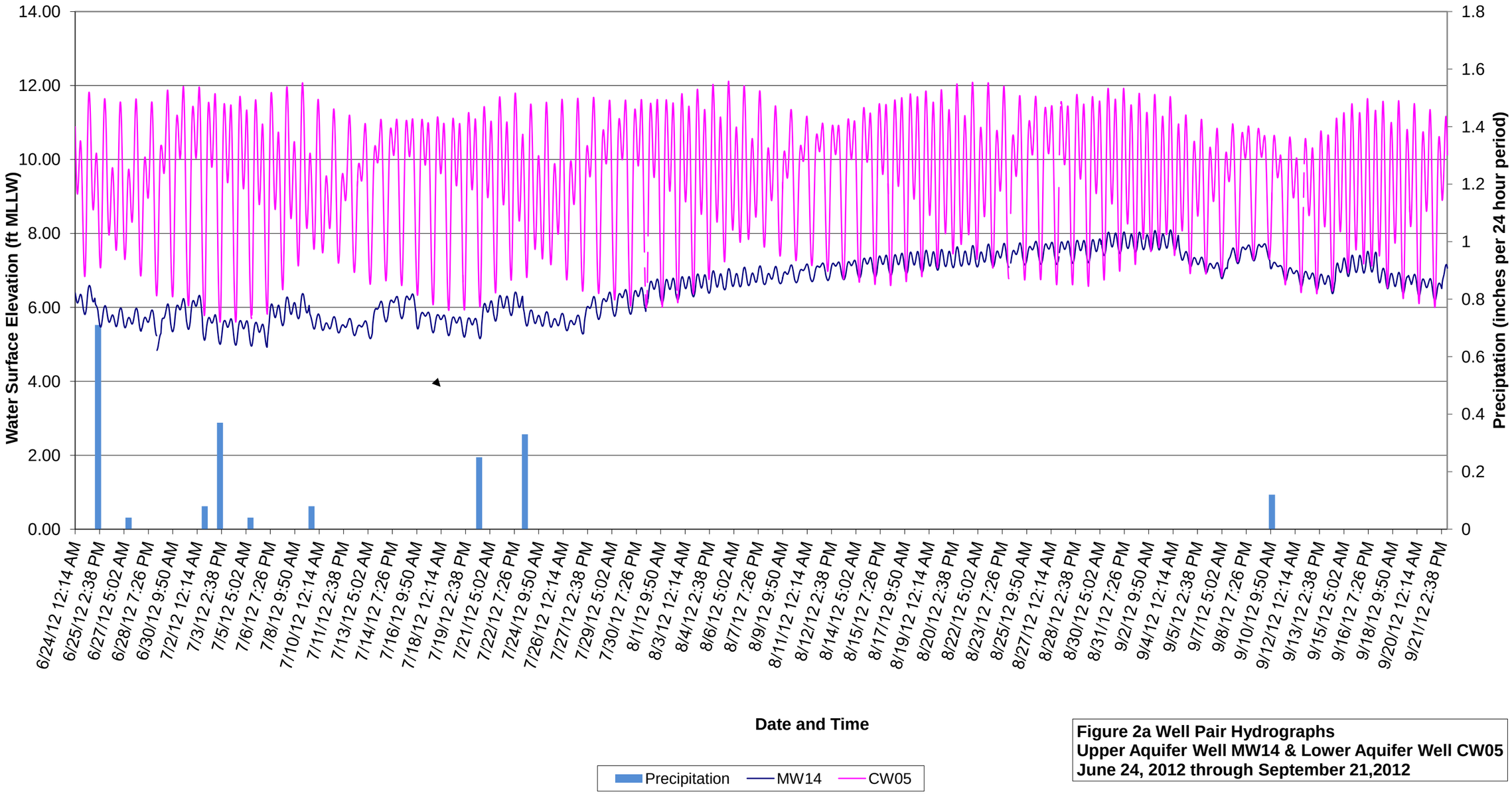

Figure 2a Well Pair Hydrographs
Upper Aquifer Well MW14 & Lower Aquifer Well CW05
June 24, 2012 through September 21,2012

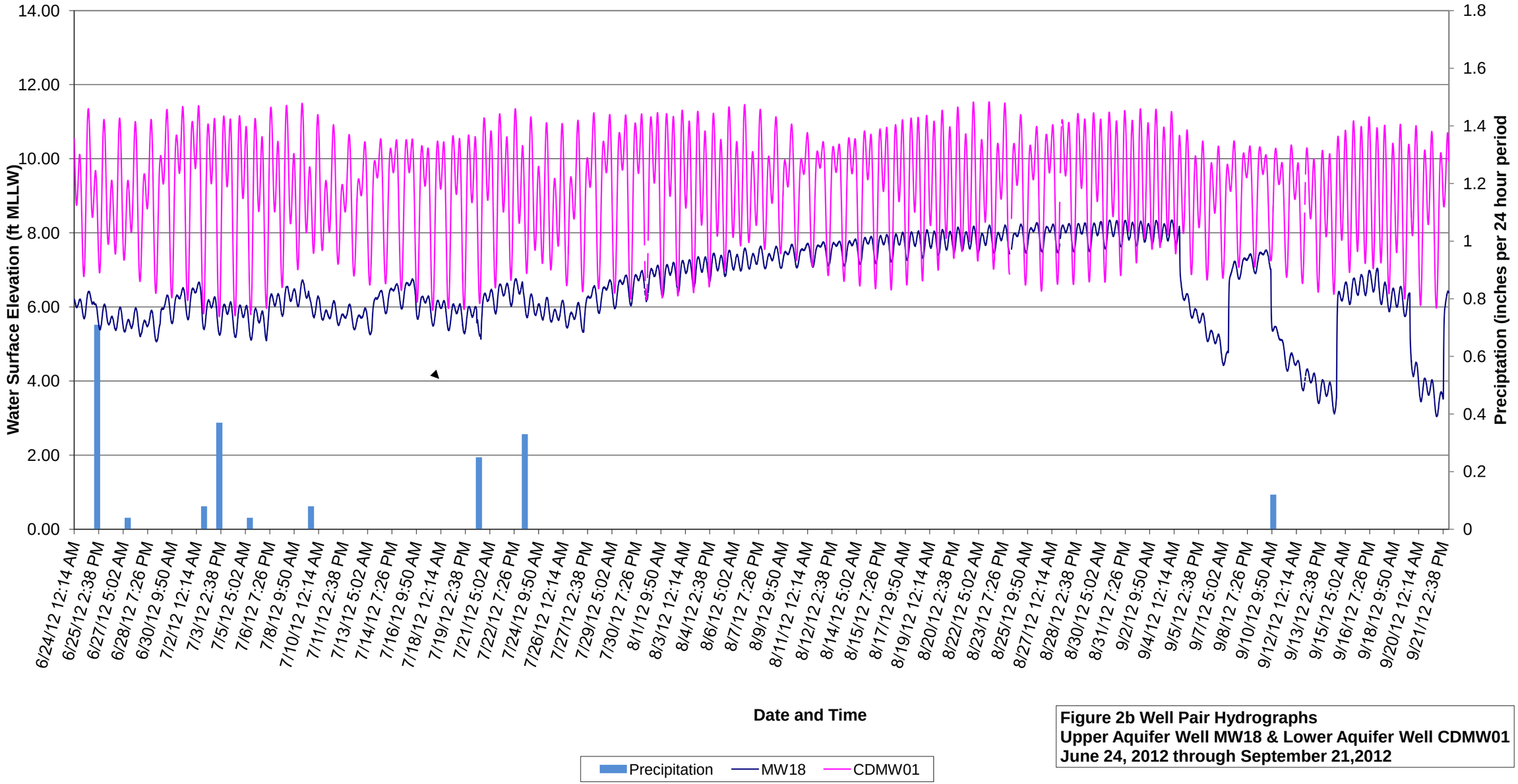

Figure 2b Well Pair Hydrographs
Upper Aquifer Well MW18 & Lower Aquifer Well CDMW01
June 24, 2012 through September 21,2012

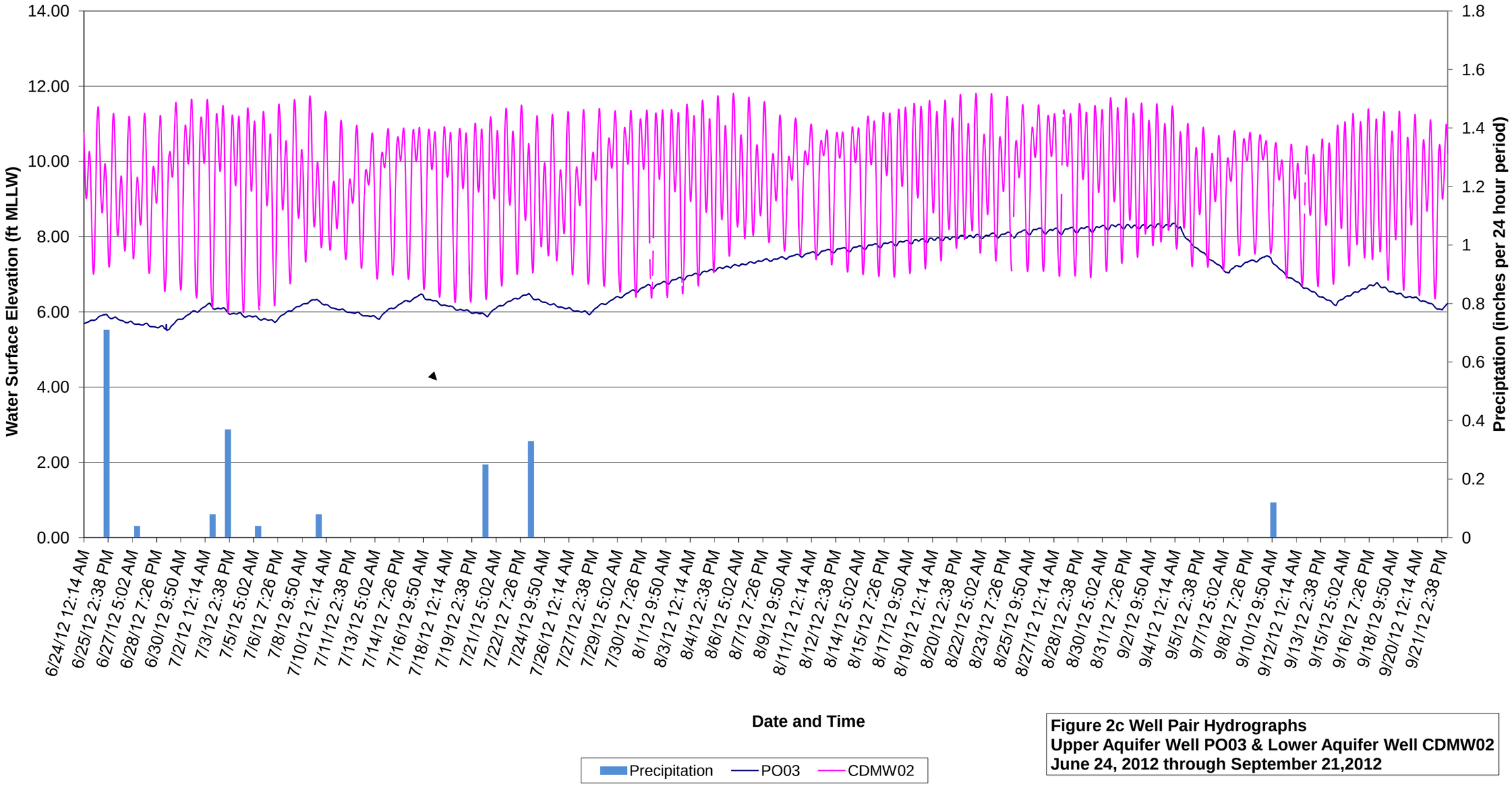

Figure 2c Well Pair Hydrographs
Upper Aquifer Well PO03 & Lower Aquifer Well CDMW02
June 24, 2012 through September 21,2012

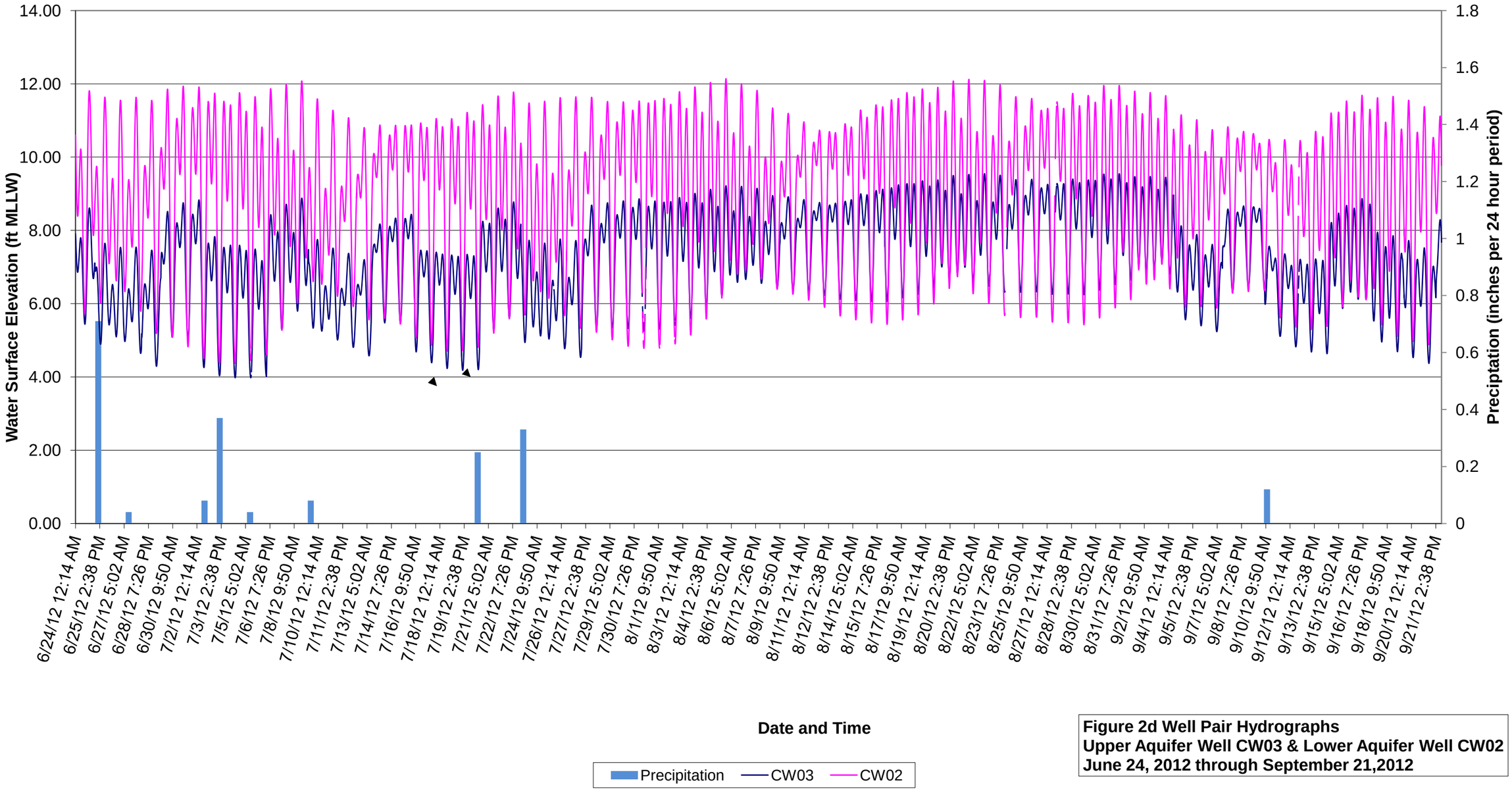

Figure 2d Well Pair Hydrographs
Upper Aquifer Well CW03 & Lower Aquifer Well CW02
June 24, 2012 through September 21,2012

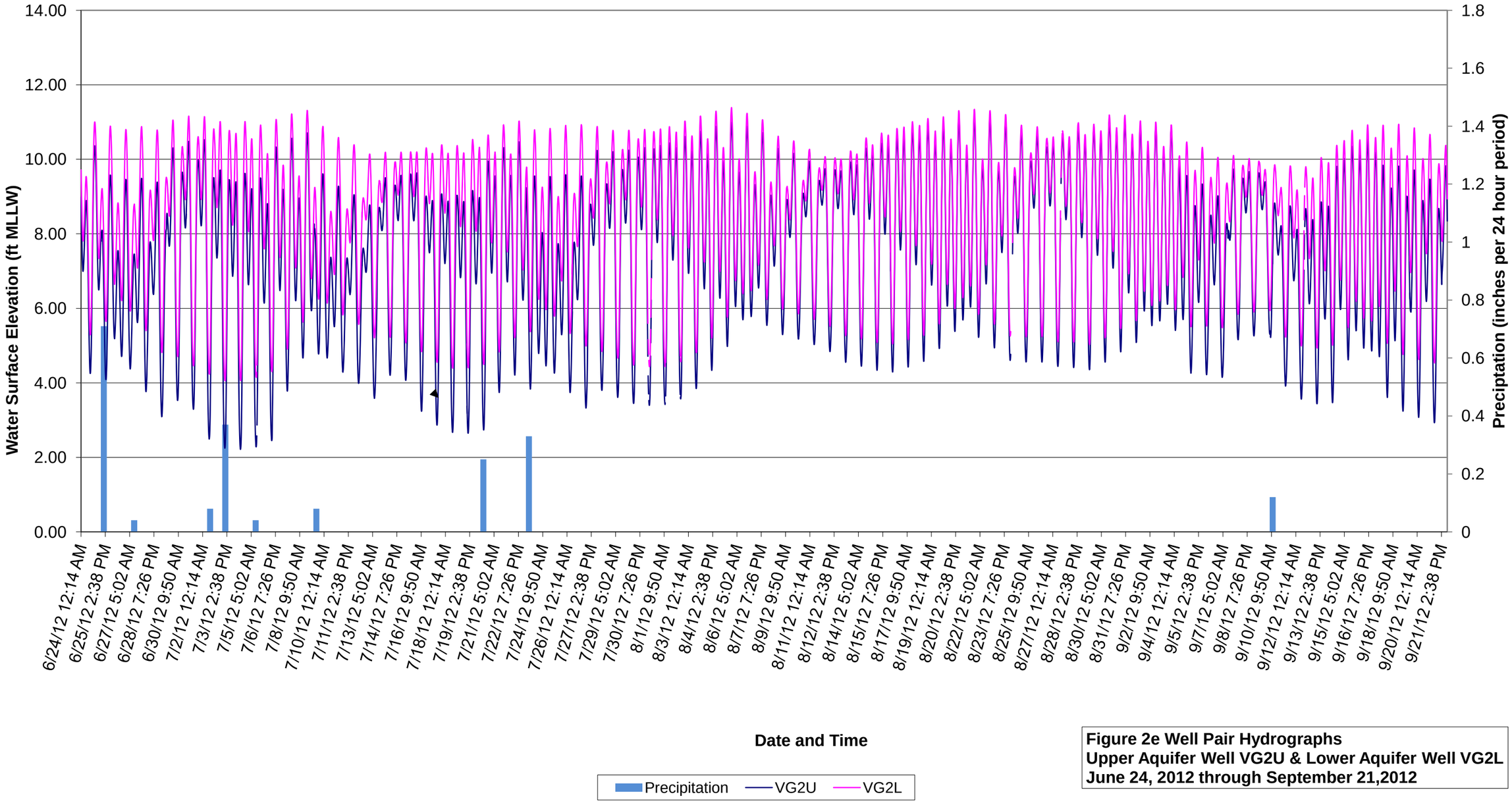

Figure 2e Well Pair Hydrographs
Upper Aquifer Well VG2U & Lower Aquifer Well VG2L
June 24, 2012 through September 21,2012

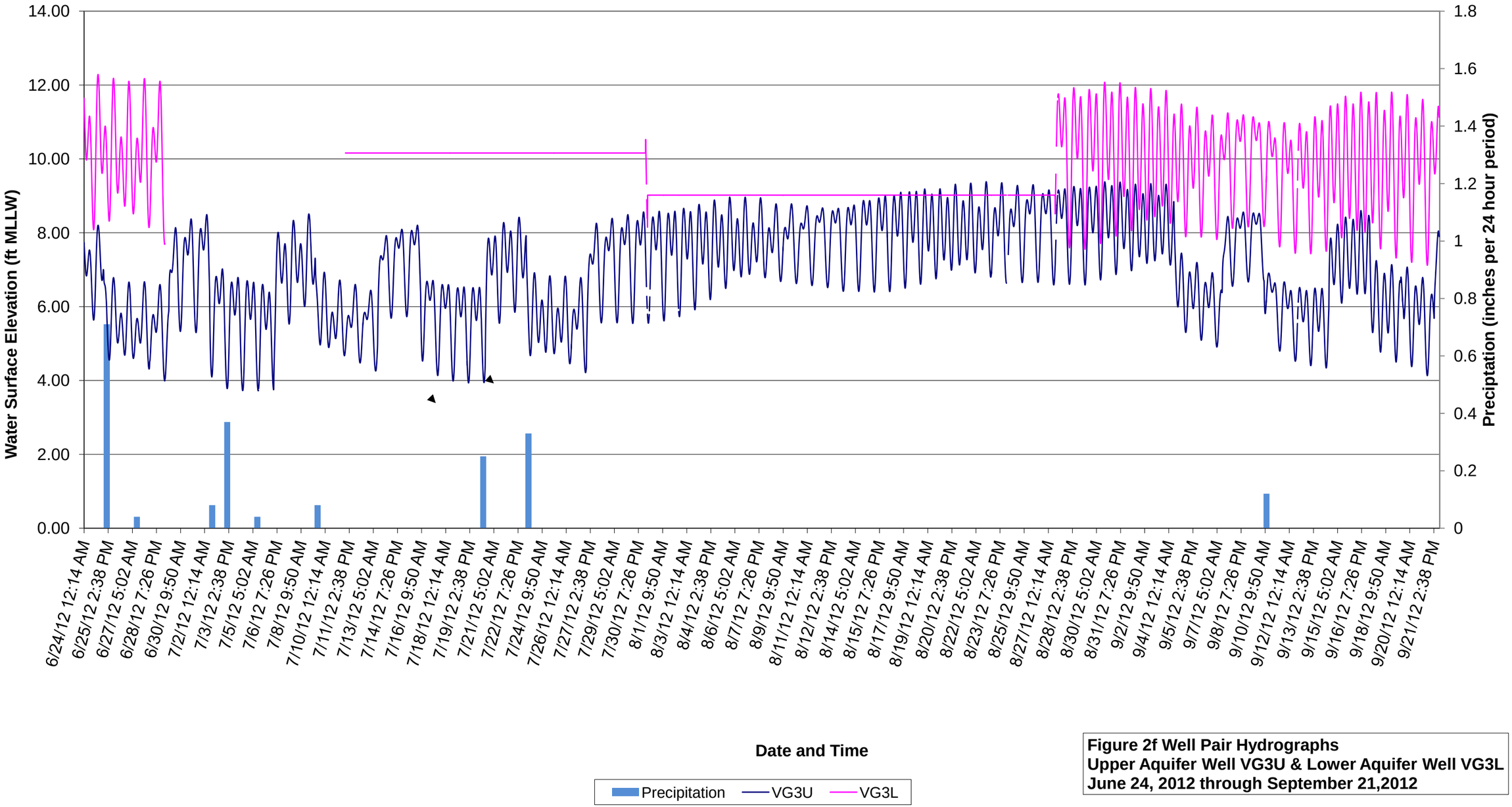

Figure 2f Well Pair Hydrographs
Upper Aquifer Well VG3U & Lower Aquifer Well VG3L
June 24, 2012 through September 21,2012

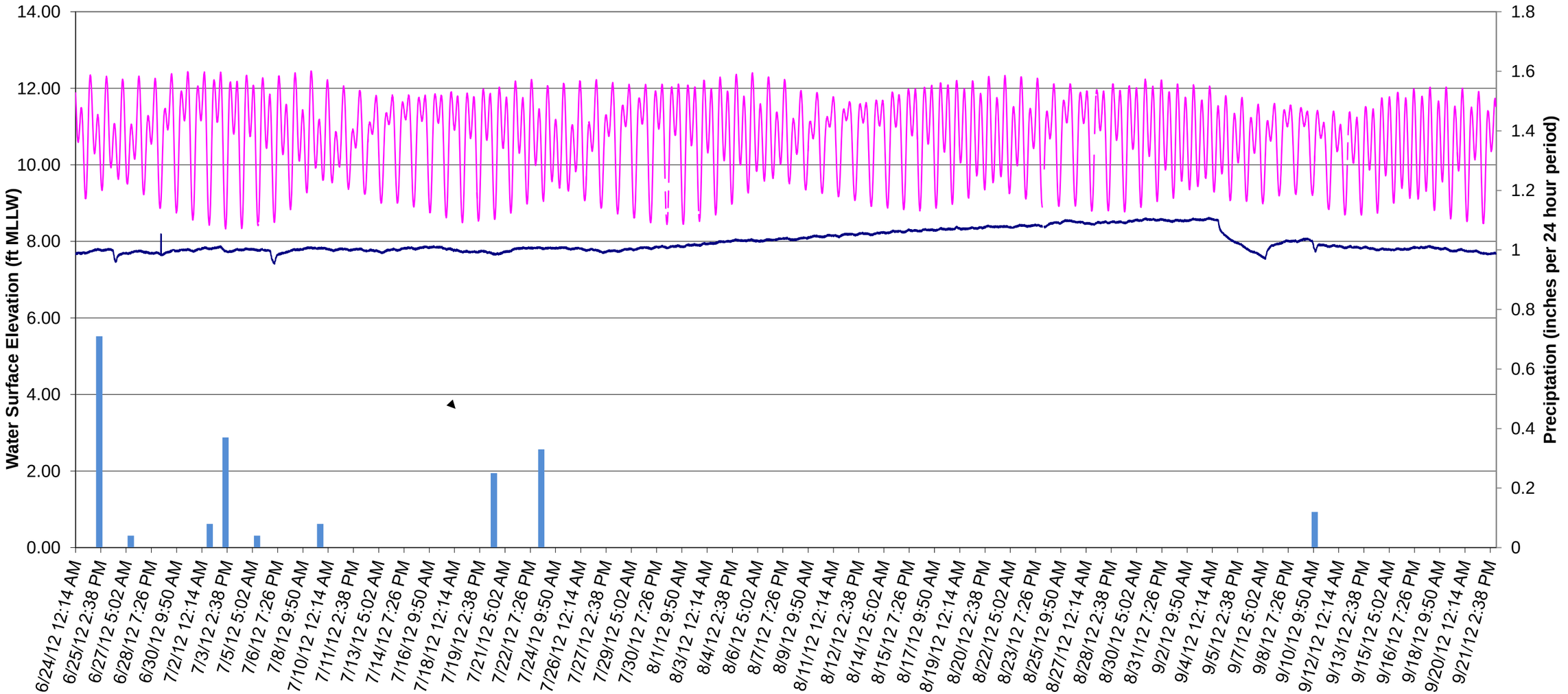

Figure 2g Well Pair Hydrographs
Upper Aquifer Well VG5U & Lower Aquifer Well VG5L
June 24, 2012 through September 21, 2012

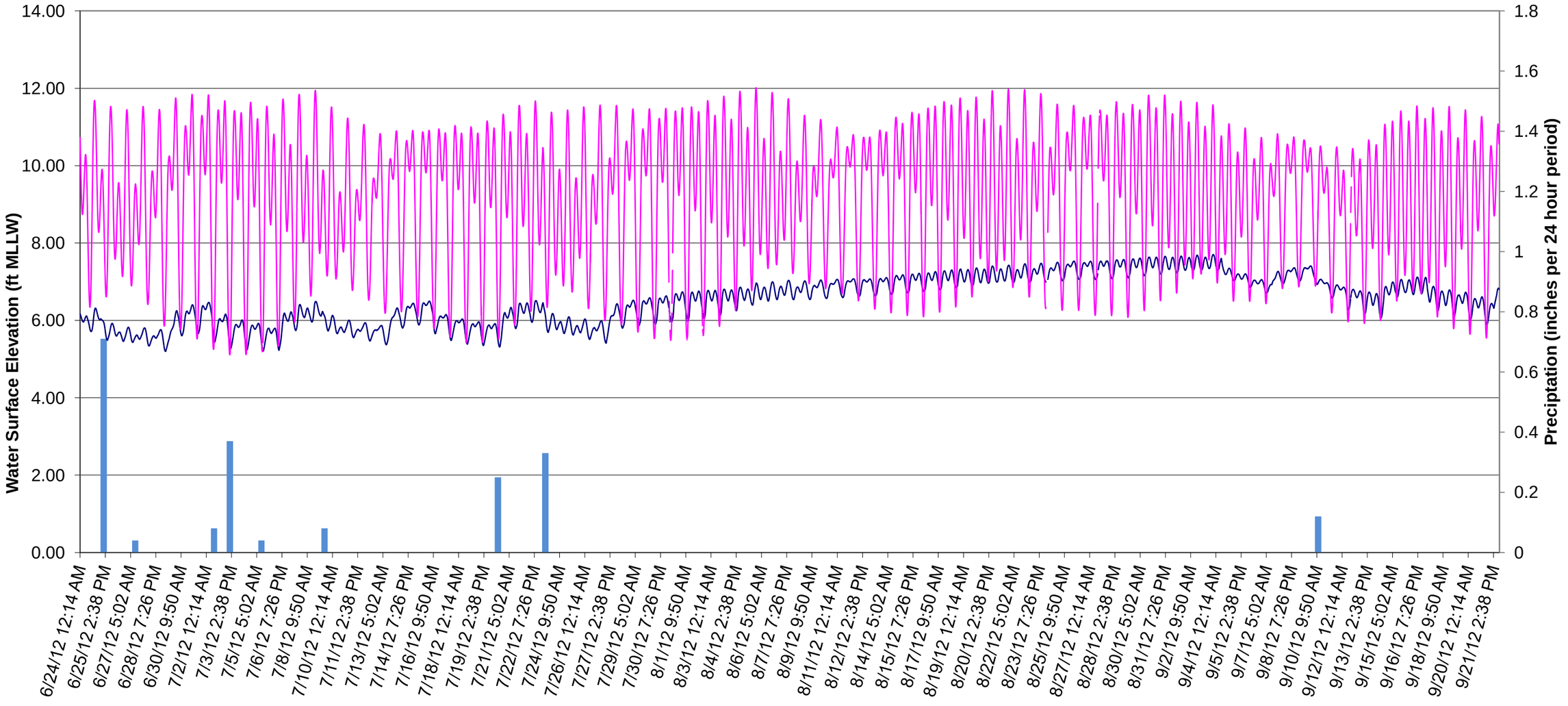

Figure 2h Well Pair Hydrographs
Upper Aquifer Well PO13 & Lower Aquifer Well VG1L
June 24, 2012 through September 21, 2012

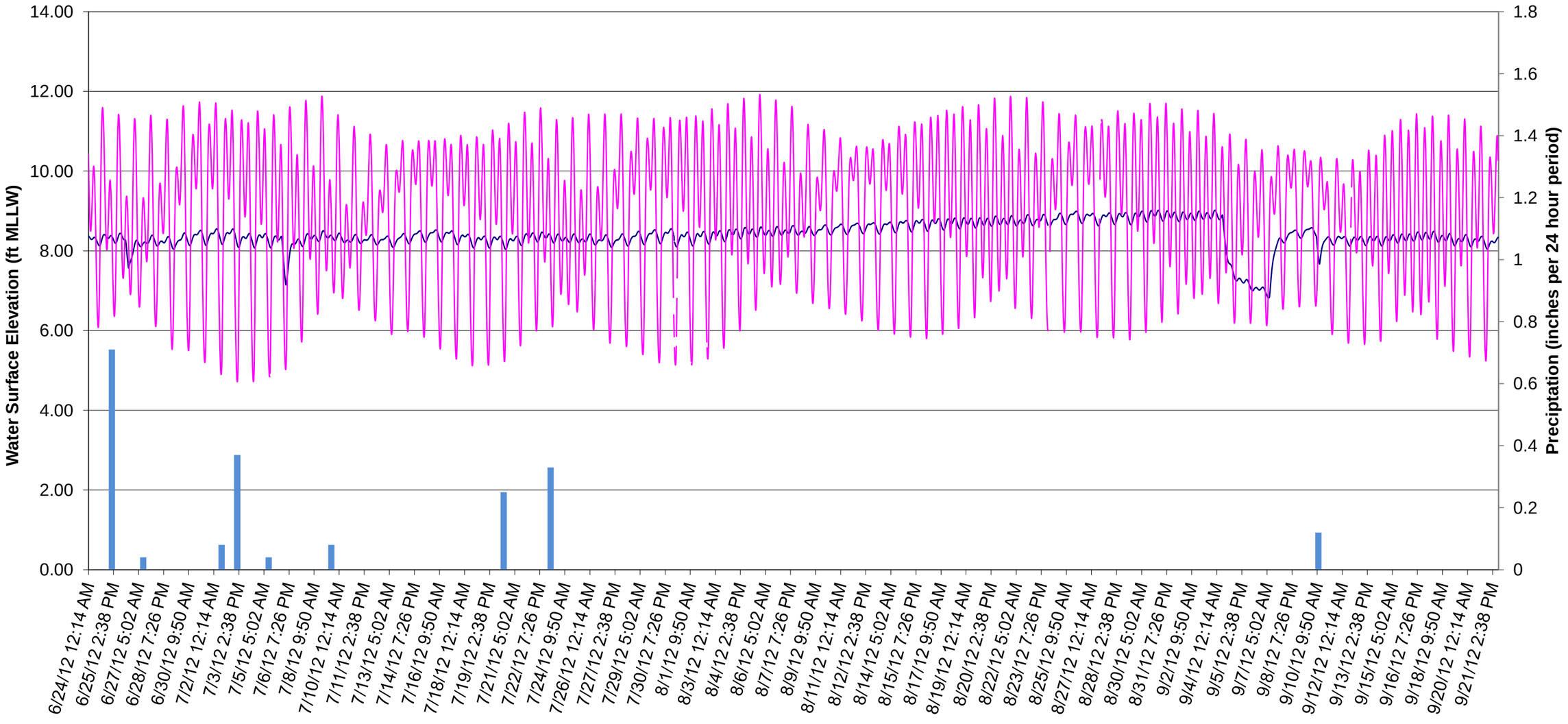

Figure 2i Well Pair Hydrographs
Upper Aquifer Well CW13 & Lower Aquifer Well VG4L
June 24, 2012 through September 21, 2012

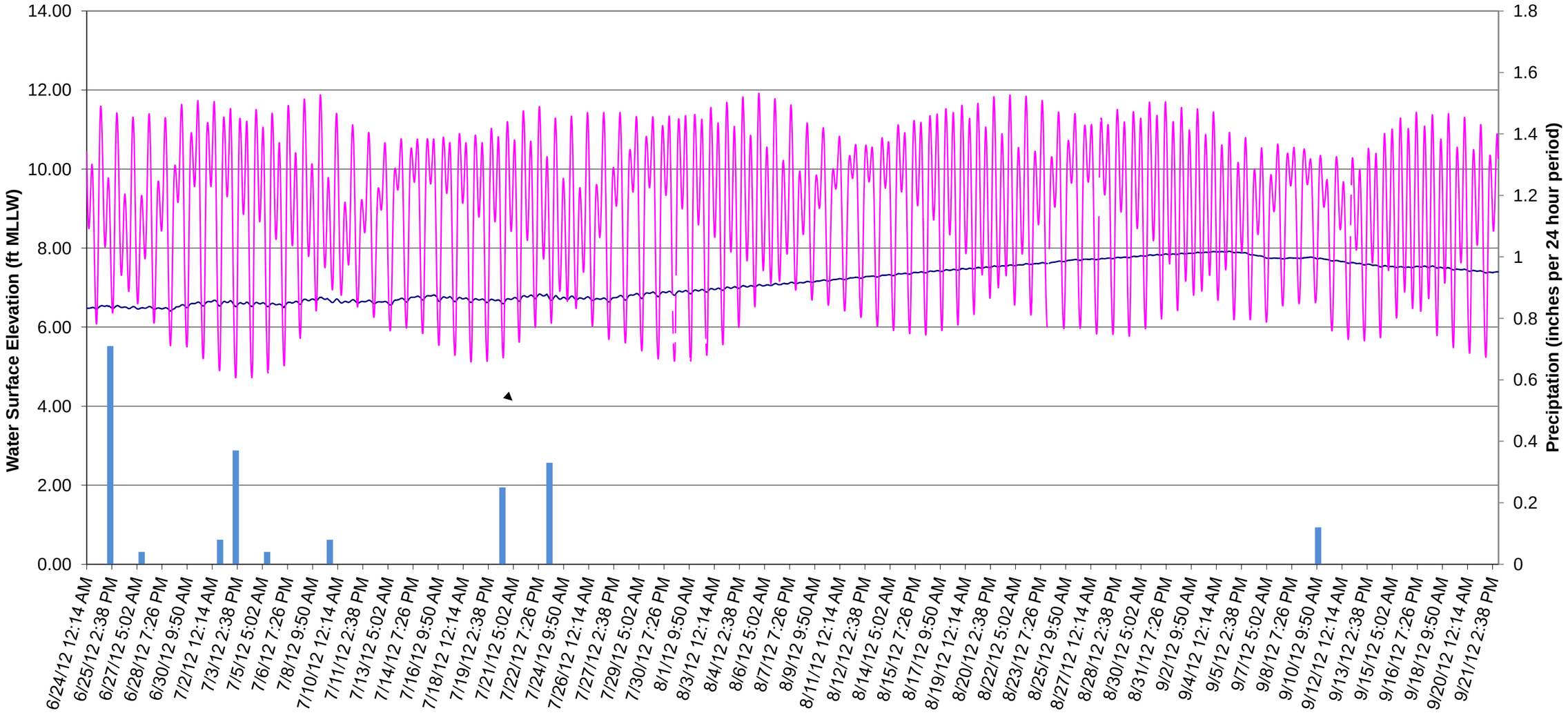

Figure 2j Well Pair Hydrographs
Upper Aquifer Well CW08 & Lower Aquifer Well P4L
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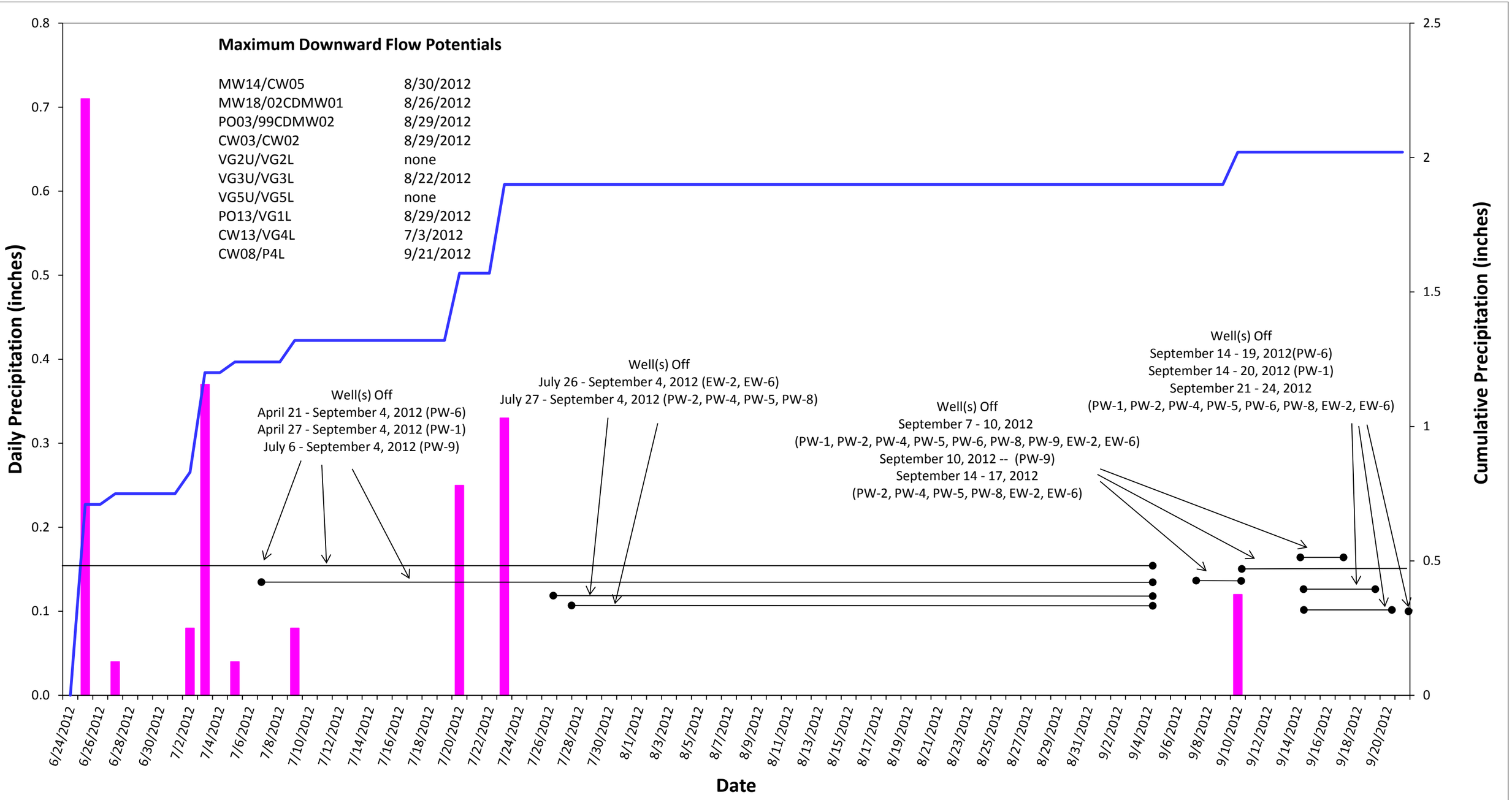
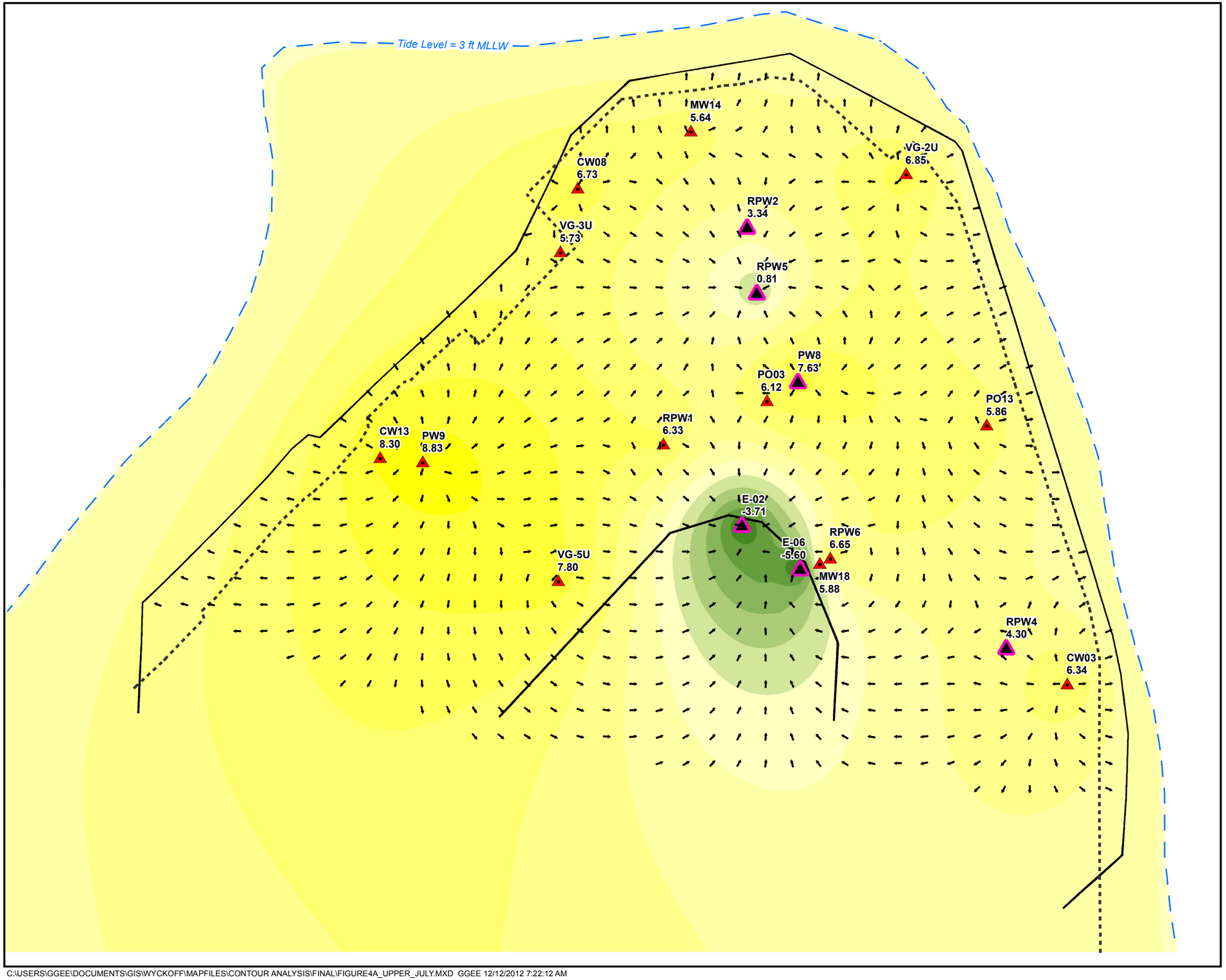


Figure 3 Wyckoff Site Precipitation, Well Field Shutoff, and Max Downward Flow Potential Summary June 24, 2012 through September 21, 2012



LEGEND

- Upper Aquifer Well (Well ID, Groundwater Elevation ft MLLW)
- Wells Pumping at the Time of Measurement
- Groundwater Flow Direction
- Bulk Head Prior to Current Sheet Pile Wall
- Tide Level (3 ft MLLW)
- Current Sheet Pile Wall

Groundwater Elevation (ft MLLW)

- -3.5 - -3
- -2.9 - -2
- -1.9 - -1
- -0.9 - 0
- 0.1 - 1
- 1.1 - 2
- 2.1 - 3
- 3.1 - 4
- 4.1 - 5
- 5.1 - 6
- 6.1 - 7
- 7.1 - 8
- 8.1 - 9

Displayed Data:
Tidal Data - Incoming Tide; July 25, 2012 at 1248
Surface water level = 2.96 MLLW
Well Transducer Data - July 25, 2012 at 1255

Pumping Data:
RPW1 (off)
RPW2 = 10.20 gpm
RPW4 = 7.46 gpm
RPW5 = 9.22 gpm
RPW6 (off)
PW8 = 6.87 gpm
PW9 (off)
E-02 = 4.80 gpm
E-06 = 5.60 gpm

N

0 50 100 200 Feet

Figure 4a
Water Elevation Measurements (ft MLLW)
July 25, 2012, Pumping Wells Active
Upper Aquifer Wells
Wyckoff/Eagle Harbor Superfund Site

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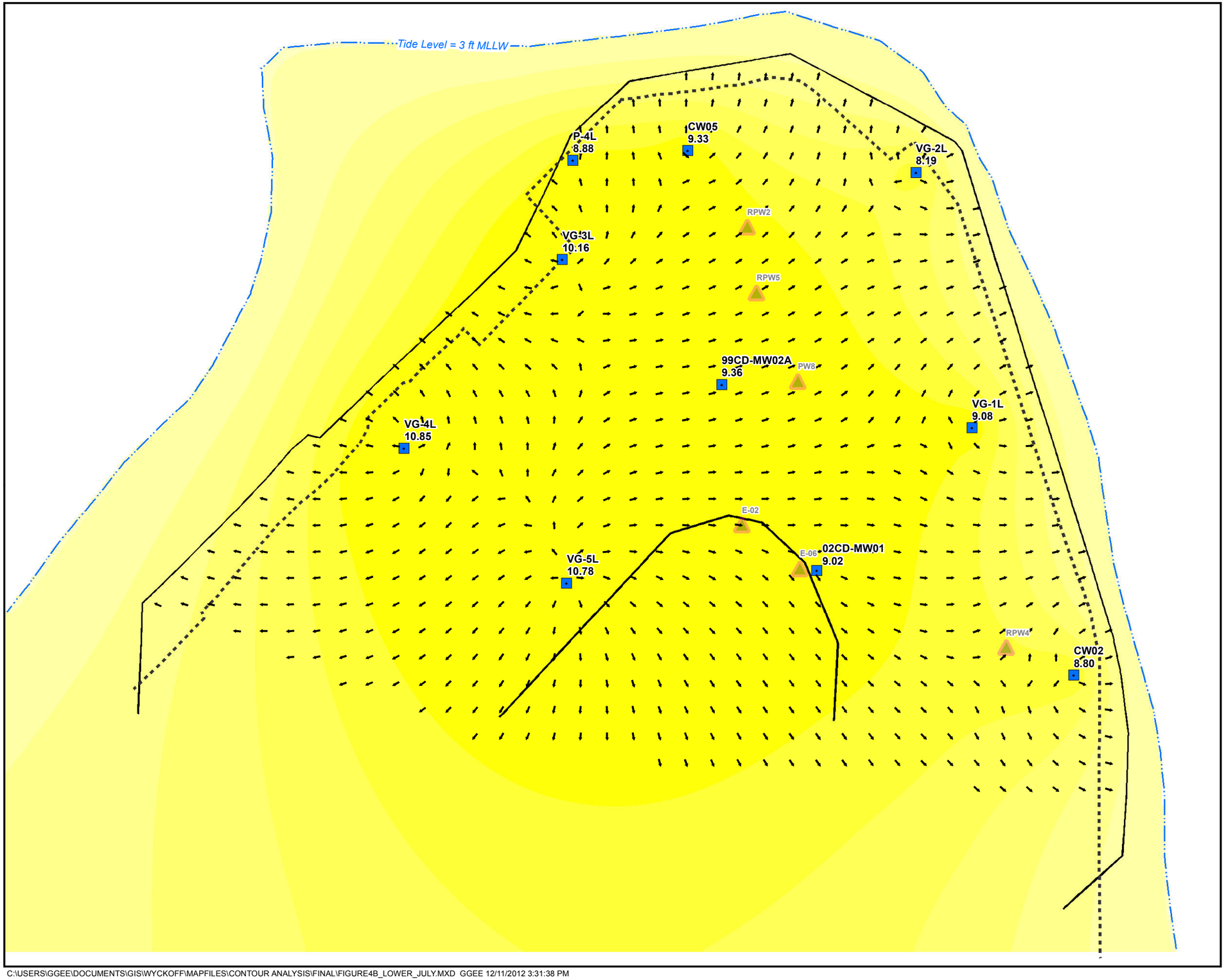

LEGEND

- Lower Aquifer Well (Well ID, Groundwater Elevation ft MLLW)
- Wells Pumping at the Time of Measurement
- Groundwater Flow Direction
- Tide Level (3 ft MLLW)
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall

Groundwater Elevation (ft MLLW)

- -3.5 - -3
- -2.9 - -2
- -1.9 - -1
- -0.9 - 0
- 0.1 - 1
- 1.1 - 2
- 2.1 - 3
- 3.1 - 4
- 4.1 - 5
- 5.1 - 6
- 6.1 - 7
- 7.1 - 8
- 8.1 - 9

Displayed Data:
Tidal Data - Incoming Tide; July 25, 2012 at 1248
Surface water level = 2.96 MLLW
Well Transducer Data - July 25, 2012 at 1255

Pumping Data (Upper Aquifer):
RPW1 (off)
RPW2 = 10.20 gpm
RPW4 = 7.46 gpm
RPW5 = 9.22 gpm
RPW6 (off)
PW8 = 6.87 gpm
PW9 (off)
E-02 = 4.80 gpm
E-06 = 5.60 gpm

N

0 50 100 200 Feet

Figure 4b
Water Elevation Measurements (ft MLLW)
July 25, 2012, Pumping Wells Active
Lower Aquifer Wells
Wyckoff/Eagle Harbor Superfund Site

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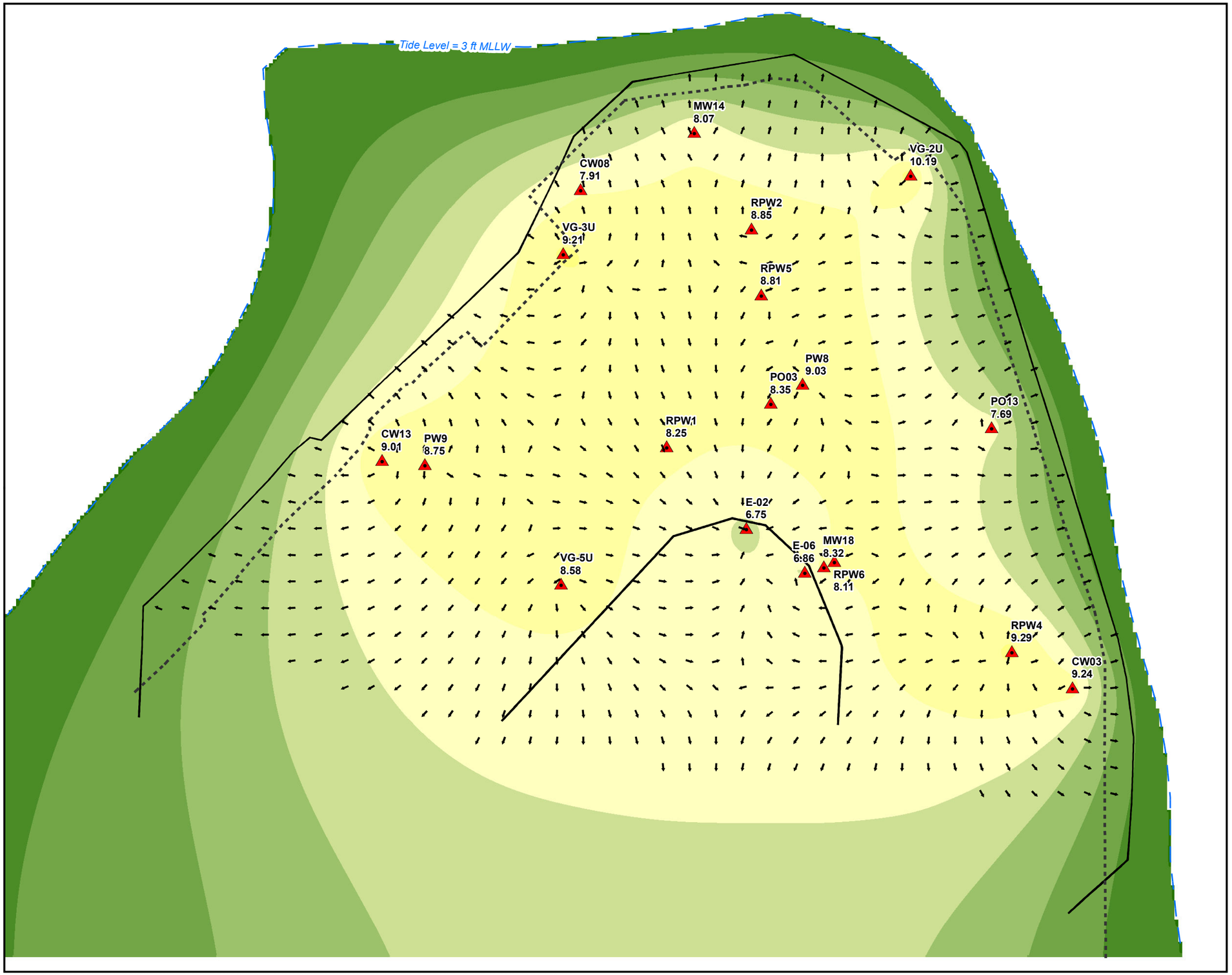

LEGEND

- Upper Aquifer Well (Well ID, Groundwater Elevation ft MLLW)
- Groundwater Flow Direction
- Tide Level (3 ft MLLW)
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall

Groundwater Elevation (ft MLLW)

- 2.95 - 3.00
- 3.01 - 4.00
- 4.01 - 5.00
- 5.01 - 6.00
- 6.01 - 7.00
- 7.01 - 8.00
- 8.01 - 9.00
- 9.01 - 10.00
- 10.01 - 11.00
- 11.01 - 12.00
- 12.01 - 13.00

Displayed Data:
Tidal Data - Incoming Tide; September 3, 2012 at 2106
Surface water level = 2.99 MLLW
Well Transducer Data - September 3, 2012 at 2101
No wells pumping

N

0 50 100 200 Feet

Figure 5a
Water Elevation Measurements (ft MLLW)
September 3, 2012, Pumping Wells Inactive
Upper Aquifer Wells
Wyckoff/Eagle Harbor Superfund Site

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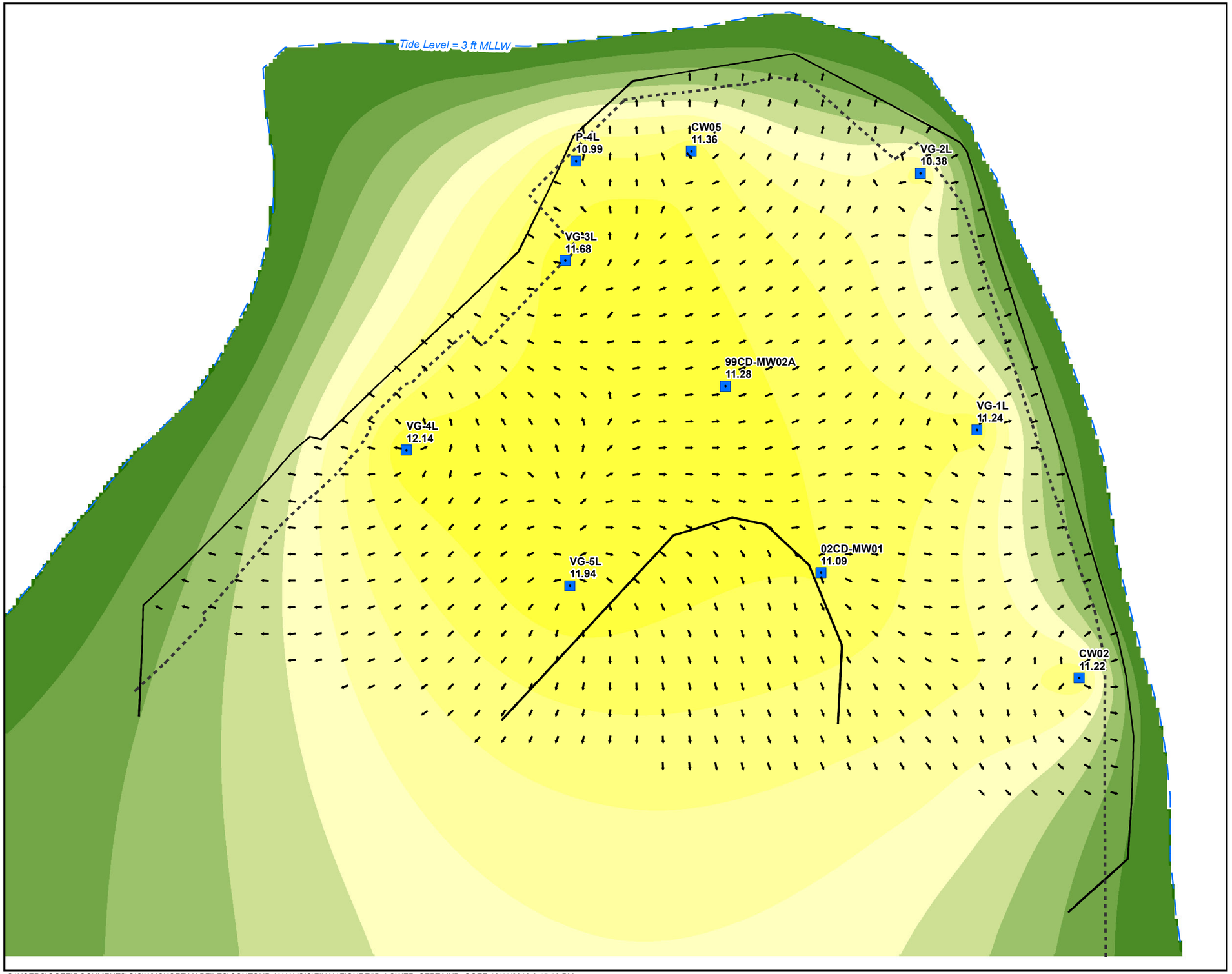

LEGEND

- Lower Aquifer Well (Well ID, Groundwater Elevation ft MLLW)
- Groundwater Flow Direction
- Tide Level (3 ft MLLW)
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall

Groundwater Elevation (ft MLLW)

- 2.95 - 3.00
- 3.01 - 4.00
- 4.01 - 5.00
- 5.01 - 6.00
- 6.01 - 7.00
- 7.01 - 8.00
- 8.01 - 9.00
- 9.01 - 10.00
- 10.01 - 11.00
- 11.01 - 12.00
- 12.01 - 13.00

Displayed Data:
Tidal Data - Incoming Tide; September 3, 2012 at 2106
Surface water level = 2.99 MLLW
Well Transducer Data - September 3, 2012 at 2101
No wells pumping

N

0 50 100 200 Feet

Figure 5b
Water Elevation Measurements (ft MLLW)
September 3, 2012, Pumping Wells Inactive
Lower Aquifer Wells
Wyckoff/Eagle Harbor Superfund Site

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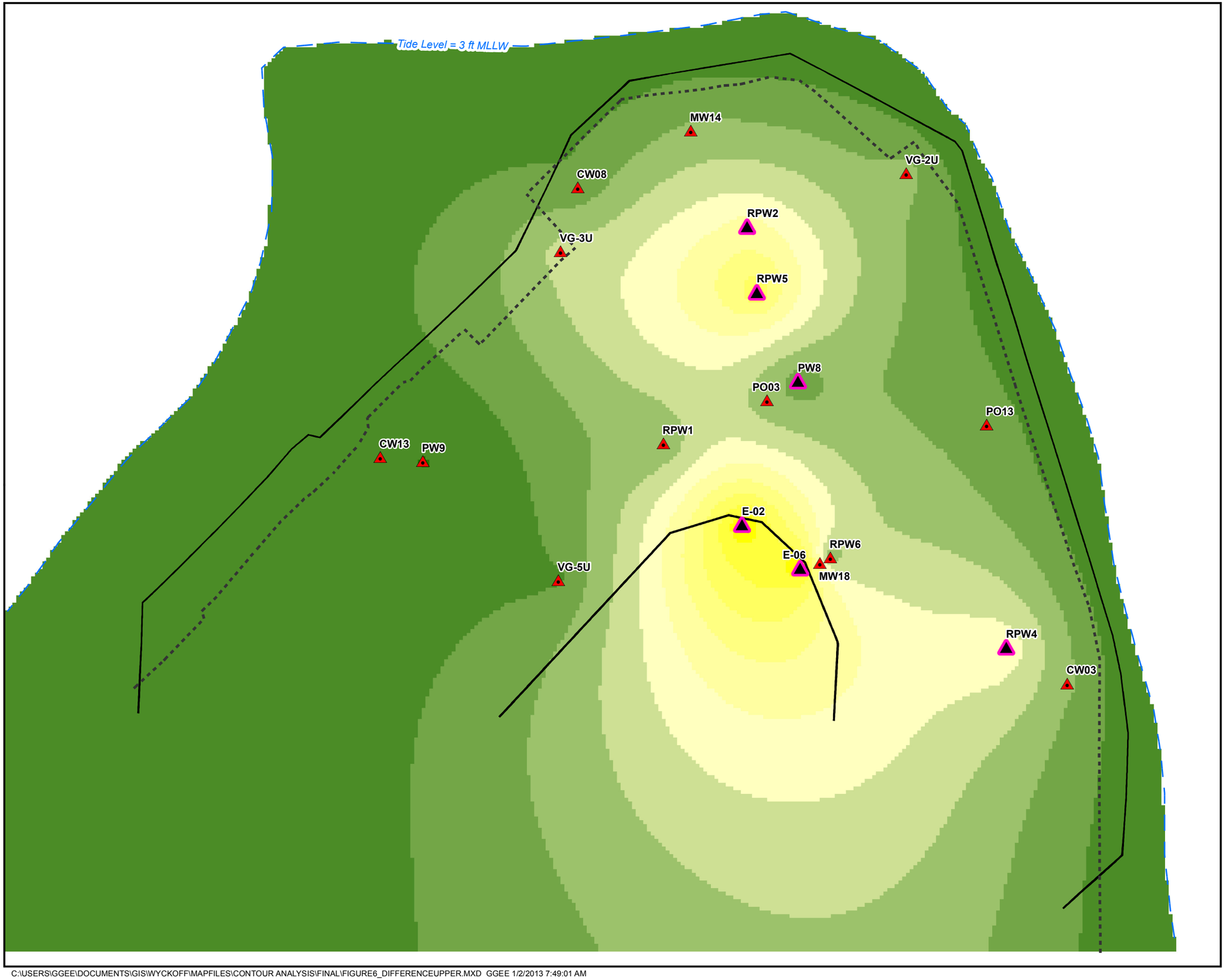

LEGEND

- Upper Aquifer Well (Well ID)
- Wells Pumping (July 25, 2012)
- Bulk Head Prior to Current Sheet Pile Wall
- Tide Level (3 ft MLLW)
- Current Sheet Pile Wall

Difference in Groundwater Elevation (ft MLLW)

- -0.3 - 0
- 0.1 - 1
- 1.1 - 2
- 2.1 - 3
- 3.1 - 4
- 4.1 - 5
- 5.1 - 6
- 6.1 - 7
- 7.1 - 8
- 8.1 - 9
- 9.1 - 10

July 25, 2012 Data:
Tidal Data - Incoming Tide; July 25, 2012 at 1248
Surface water level = 2.96 MLLW
Well Transducer Data - July 25, 2012 at 1255

Pumping Data (July 25):
RPW1 (off)
RPW2 = 10.20 gpm
RPW4 = 7.46 gpm
RPW5 = 9.22 gpm
RPW6 (off)
PW8 = 6.87 gpm
PW9 (off)
E-02 = 4.80 gpm
E-06 = 5.60 gpm

September 3, 2012 Data:
Tidal Data - Incoming Tide; September 3, 2012 at 2106
Surface water level = 2.99 MLLW
Well Transducer Data - September 3, 2012 at 2101
No wells pumping

N

0 50 100 200 Feet

Figure 6
Difference in Water Elevation Measurements (ft MLLW) Between Pumping and Non-Pumping Scenarios
Upper Aquifer Wells
Wyckoff/Eagle Harbor Superfund Site

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