Evaluation of Wyckoff Groundwater Level Data December 27, 2011 through March 25, 2012

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The purpose of this memorandum is to summarize the Wyckoff groundwater level results for the 90-day monitoring period of December 27, 2011 through March 25, 2012.

Summary/Recommendations

- Hydraulic containment was maintained in 9 of the 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, and CW08/P-4L.
- Hydraulic containment was not maintained in well pair CW13/VG4L.
- The groundwater elevation data from the new transducers in the 10 well pairs should be downloaded again in July 2012 to maintain a quarterly schedule consistent with the definition of hydraulic containment.

Water Level Data Collection

New Model 705 KPSI™ Level and Pressure Transducers were installed in 22 upper aquifer wells and 18 lower aquifer wells in August 2011 and calibrated in September 2011 and March 2012. The new transducers are replacements for the Solinst Leveloggers that were installed in 10 upper aquifer wells and 18 lower aquifer wells. As a QC check, the Leveloggers and transducers recorded water level data concurrently for several months. Based on the recommendations presented in the CH2M HILL technical memorandum dated March 30, 2012 - *Comparison of Wyckoff Groundwater Elevation Data from Existing Leveloggers and new Transducers September 19 – November 29, 2011,* the Leveloggers have been removed from service and this and all subsequent groundwater level memoranda will be prepared using data from the new transducer system.

The December 27, 2011 through March 25, 2012 time period represents the next 90-day monitoring period in succession from the previous groundwater level data evaluation memoranda (September 28 – December 26, 2011). The locations of the wells are shown in Figure 1, wells formerly containing Leveloggers are listed in Table 1, and wells with transducers are listed in Table 2. All data are available in e-format upon request.

Table 1 – Wells formerly containing Leveloggers

Upper Aquifer		Lower Aquifer		
CW03	VG-2U	02CDMW01	VG-1L	P-3L
CW08	VG-3U	99CDMW02A	VG-2L	P-4L
CW13	VG-5U	CW01	VG-3L	P-5L
MW14		CW02	VG-4L	P-6L
MW18		CW05	VG-5L	
PO03		PZ03	P-1L	
PO13		PZ11	P-2L	

Table 2 – Wells with Transducers, December 27, 2011 – March 25, 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[1,2]	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.

[2] E-07 (not shown on the location map) is located west southwest of E-03

Hydraulic Containment / Isolation Discussion

The hydraulic containment/isolation performance at the Wyckoff site has been 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. The hydraulic containment at each well pair is evaluated in two steps. First, the average groundwater elevations of the upper and lower aquifers are calculated by averaging the water elevation data that was recorded every 60 minutes through March 8, 2012 at 8:30 am, then every 15 minutes through Mar 25, 2012 during the monitoring period. Second, the average groundwater elevations are compared. If the average lower aquifer groundwater elevation is greater than that of the upper aquifer, indicating an overall net upward movement of groundwater, then hydraulic containment is demonstrated. If a well pair meets the definition of hydraulic containment, then the ratio of the

average lower aquifer water elevation to the average upper aquifer water elevation for that well pair will be greater than 1.

Hydrographs from the 10 well pairs are shown in Figures 2 through 11 for the monitoring period.

Well Pair MW14/CW05

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair MW14/CW05 (Figure 2) shows that water levels in the lower aquifer were - at all times greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 9.07 feet MLLW in the lower aquifer (Well CW05) and 4.95 feet MLLW in the upper aquifer (Well MW14). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair MW14/CW05 was calculated to be 1.83, thus demonstrating hydraulic containment.

Over the 90-day monitoring period, there were no occurrences of downward flow potential for well pair MW14/CW05.

Well Pair MW18/02CDMW01

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair MW18/02CDMW01 (Figure 3) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 8.57 feet MLLW in the lower aquifer (Well 02CDMW01) and 2.72 feet MLLW in the upper aquifer (Well MW18). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair MW18/02CDMW01 was calculated to be 3.15, thus demonstrating hydraulic containment.

Over the 90-day period, 3 downward flow potential events occurred for well pair MW18/02CDMW01 (when upper aquifer water levels are greater than lower aquifer water levels). The sum of all downward flow potential events over the entire monitoring period was 7 hours. The average duration of an event was 2 hours and 20 minutes. The maximum duration of an event was 4 hours. The average downward flow potential was calculated to -0.25 feet (the average lower aquifer water elevation minus the average upper aquifer water elevation during the event, with negative value indicating downward flow potential). The maximum downward flow potential was calculated to be -0.53 feet and occurred on January 22, 2012 at 22:49.

Well Pair PO03/99CDMW02A

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair PO03/99CDMW02A (Figure 4) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 9.21 feet MLLW in the lower aquifer (Well 99CDMW02A) and 4.58 feet MLLW in the upper aquifer (Well PO03). The ratio

of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair PO03/99CDMW02A was calculated to be 2.01, thus demonstrating hydraulic containment.

Over the 90-day period, 2 downward flow potential events occurred for well pair PO03/99CDMW02A (when upper aquifer water levels are greater than lower aquifer water levels). The sum of all downward flow potential events over the entire monitoring period was 5 hours. The average duration of an event was 2 hours and 30 minutes. The maximum duration of an event was 3 hours. The average downward flow potential was calculated to -0.30 feet (the average lower aquifer water elevation minus the average upper aquifer water elevation during the event, with negative value indicating downward flow potential). The maximum downward flow potential was calculated to be -0.63 feet and occurred on January 23, 2012 at 23:49.

Well Pair CW03/CW02

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair CW03/CW02 (Figure 5) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 8.55 feet MLLW in the lower aquifer (Well CW02) and 5.40 feet MLLW in the upper aquifer (Well CW03). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair CW03/CW02 was calculated to be 1.58, thus demonstrating hydraulic containment.

Over the 90-day period, 2 downward flow potential events occurred for well pair CW03/CW02 (when upper aquifer water levels are greater than lower aquifer water levels). The sum of all downward flow potential events over the entire monitoring period was 7 hours. The average duration of an event was 3 hours and 30 minutes. The maximum duration of an event was 4 hours. The average downward flow potential was calculated to be -0.24 feet (the average lower aquifer water elevation minus the average upper aquifer water elevation during the event, with negative value indicating downward flow potential). The maximum downward flow potential was calculated to be -0.38 feet and occurred on January 21, 2012 at 21:49.

Well Pair VG-2U/VG-2L

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair VG-2U/VG-2L (Figure 6) shows that water levels in the lower aquifer were at all times greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 8.22 feet MLLW in the lower aquifer (Well VG-2L) and 6.34 feet MLLW in the upper aquifer (Well VG-2U). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair VG-2U/VG-2L was calculated to be 1.30, thus demonstrating hydraulic containment.

Over the 90-day period, there were no occurrences of downward flow potential for well pair VG-2U/VG-2L.

Well Pair VG-3U/VG-3L

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair VG-3U/VG-3L (Figure 7) shows that water levels in the lower aquifer were at all times greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 10.08 feet MLLW in the lower aquifer (Well VG-3L) and 4.74 feet MLLW in the upper aquifer (Well VG-3U). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair VG-3U/VG-3L was calculated to be 2.13, thus demonstrating hydraulic containment.

Over the 90-day period, there were no occurrences of downward flow potential for well pair VG-3U/VG-3L.

Well Pair VG-5U/VG-5L

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair VG-5U/VG-5L (Figure 8) shows that water levels in the lower aquifer were at all times greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 10.86 feet MLLW in the lower aquifer (Well VG-5L) and 7.83 feet MLLW in the upper aquifer (Well VG-5U). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair VG-5U/VG-5L was calculated to be 1.39, thus demonstrating hydraulic containment.

Over the 90-day period, there were no occurrences of downward flow potential for well pair VG-5U/VG-5L.

Well Pair PO13/VG-1L

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair PO13/VG-1L (Figure 9) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 8.81 feet MLLW in the lower aquifer (Well VG-1L) and 5.48 feet MLLW in the upper aquifer (Well PO13). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair PO13/VG-1L was calculated to be 1.61, thus demonstrating hydraulic containment.

Over the 90-day monitoring period, 7 downward flow potential events occurred for well pair PO13/VG-1L (when upper aquifer water levels are greater than lower aquifer water levels). The sum of all downward flow potential events over the monitoring period was 15 hours. The average duration of an event was approximately 2 hours and 8 minutes. The maximum duration of an event was 3 hours. The average downward flow potential was calculated to be –0.15 feet (the average lower aquifer water elevation minus the average upper aquifer water elevation during the event, with negative value indicating downward flow potential). The maximum downward flow potential was calculated to be -0.44 feet and occurred on January 21, 2012 at 21:49.

Well Pair CW13/VG-4L

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair CW13/VG4L (Figure 10) shows that water levels in the lower aquifer were on average lower than the water levels in the upper aquifer, thus not meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 8.62 feet MLLW in the lower aquifer (Well VG-4L) and 10.72 feet MLLW in the upper aquifer (Well CW13). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair CW13/VG4L was calculated to be 0.80, thus demonstrating non-hydraulic containment.

Over the 90-day monitoring period, 95 downward flow potential events occurred for well pair CW13/VG4L (when upper aquifer water levels are greater than lower aquifer water levels). The sum of all downward gradient events over the monitoring period was 688 hours and 15 minutes (approximately 28.6 days). The average duration of an event was approximately 7 hours and 14 minutes. The maximum duration of an event was 22 hours and 30 minutes. The average downward flow potential was calculated to be –1.30 feet (the average lower aquifer water elevation minus the average upper aquifer water elevation during the event, with negative value indicating downward flow potential). The maximum downward flow potential was calculated to be -4.39 feet and occurred on January 21, 2012 at 21:49.

Discussion related to loss of containment for well pair CW13/VG4L is included in section *Treatment Plant Operations and Precipitation Effects on Vertical Gradients* below.

Well Pair CW08/P-4L

90-Day Monitoring Period (December 27, 2011 through March 25, 2012)

The hydrograph for well pair CW08/P-4L (Figure 11) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 11.28 feet MLLW in the lower aquifer (Well P-4L) and 6.70 feet MLLW in the upper aquifer (Well CW08). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair CW08/P-4L was calculated to be 1.68, thus demonstrating hydraulic containment.

Over the 90-day monitoring period, 79 downward flow potential events occurred for well pair CW08/P-4L (when upper aquifer water levels are greater than lower aquifer water levels). The sum of all downward gradient events over the monitoring period was 317 hours and 45 minutes (approximately 13 days). The average duration of an event was approximately 4 hours. The maximum duration of an event was 7 hours. The average downward flow potential was calculated to be -0.67 feet (the average lower aquifer water elevation minus the average upper aquifer water elevation during the event, with negative value indicating downward flow potential). The maximum downward flow potential was calculated to be –2.26 feet and occurred on February 5, 2012 at 22:48.

Treatment Plant Operations and Precipitation Effects on Vertical Gradients

During the December 27, 2011 through March 25, 2012 monitoring period, Former Process Area (FPA) groundwater extraction well pumps were periodically shut down due to well maintenance, winter storms, or scheduled weekend shut downs. Shut downs of the extraction well pumps that occurred for

periods of one day or longer (as noted in CH2M HILL operation records) are listed in Table 3. These periods are graphically overlaid with the precipitation records and are shown in Figure 12.

The treatment plant and extraction well systems were operated 24 hours per day and 7 days per week during the monitoring period, with the exception of the dates listed in Table 3, when several extraction wells were shut down for periods greater than 24 hours. The total volume of water pumped was 7,104,599 gallons during the 90-day monitoring period which equates to about 58 gpm over the entire period including all down time regardless of cause. [Note, when fully operating, the system can pump about 57 to 60 gpm.]

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

Date	Wells Shut Down	Reason
January 6 – January 9, 2012	PW-9	Weekend shutdown
January 17 – January 23, 2012	RPW-1, RPW-2, RPW-4, RPW-5, RPW-6, PW-8, PW-9, E-02, E-06	Shutdown due to heavy winter storm/snow
March 3 – March 5, 2012	PW-8	High pressure trip
March 7 – March 12, 2012	PW-9	Pump offline due to low water level

During the December 27, 2011 through March 25, 2012 monitoring period, downward flow potentials were associated with precipitation events and treatment plant and extraction well system shut downs. Figure 12 shows the cumulative precipitation of 13.18 inches at the site for the monitoring period, with the heaviest precipitation occurring in January. Downward flow potentials were observed in 6 of the monitored well pairs during the monitoring period. The maximum downward flow potential observed for 5 of the 6 well pairs, MW18/02CDMW01, PO03/99CDMW02, CW03/CW02, PO13/VG1L, and CW13/VG4L occurred on January 21 through January 23, 2012, during a 7-day shutdown period and a winter storm where 1.65 inches of precipitation were recorded on January 23, 2012 (the date of the greatest single day precipitation during the monitoring period). The maximum downward flow potential observed for the remaining well pair CW08/P4L occurred on February 5, 2012, 13 days after the heavy precipitation on January 23, 2012, and following 3.34 inches of cumulative precipitation from January 23 through February 1, 2012. All of the extraction well pumps were in operation following the heavy precipitation event on January 23, 2012, with all pumps brought back into operation from 9:30 am to 10:34 am on January 23.

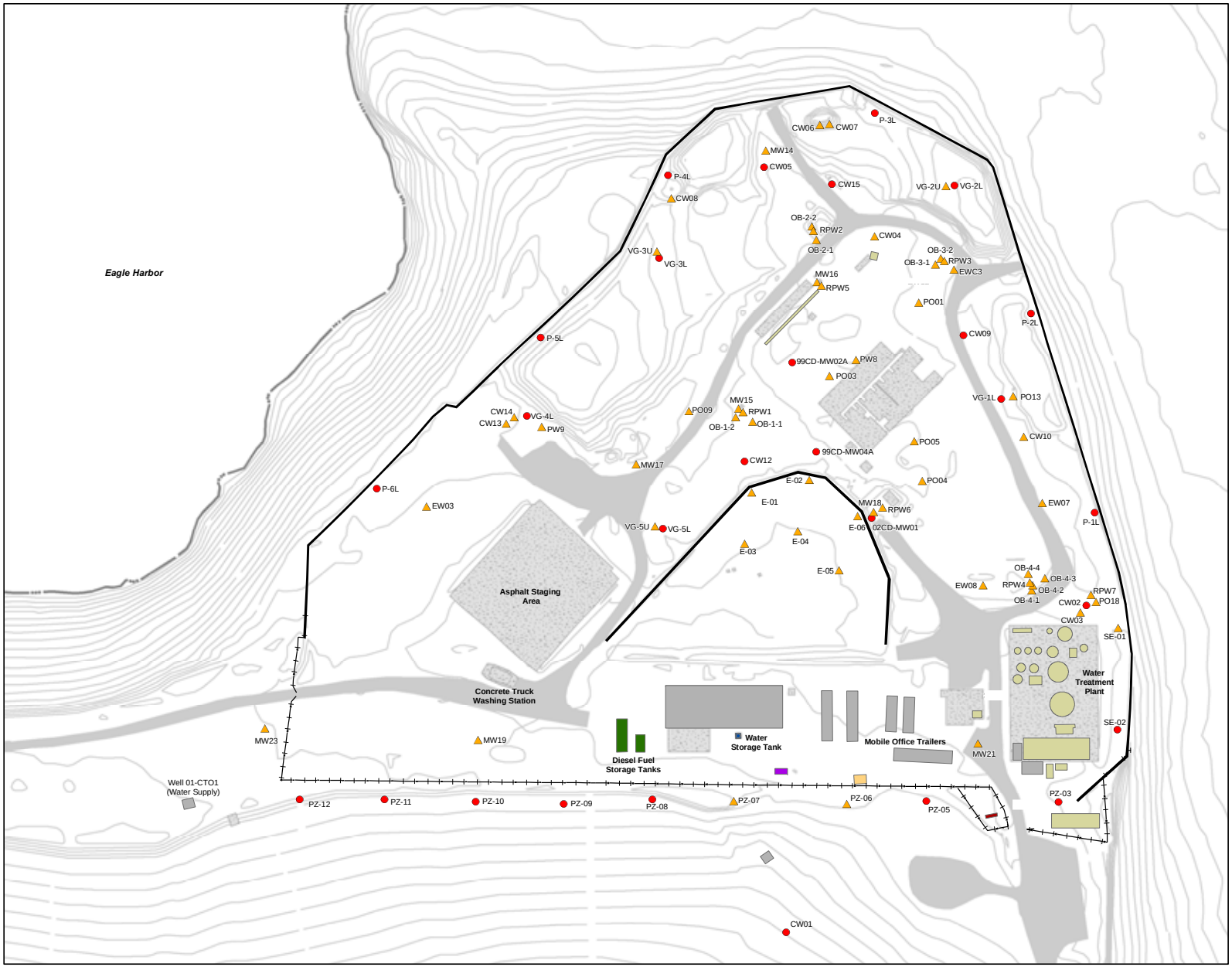
All of the upper aquifer hydrographs show a rise in groundwater levels following the 1.65-inch precipitation event on January 23, 2012, and during 3.85 inches of cumulative precipitation from March 12 – March 20, 2012. However, with the extraction and treatment system operating 24/7 for the majority of the monitoring period, the water levels in all except one of the upper aquifer wells (CW13) were maintained at levels lower than those in lower aquifer wells for the majority of the monitoring period. This demonstrates that maximizing upper aquifer “recharge storage potential” by keeping the extraction operations at full capacity before and during the wet season allows hydraulic containment to be maintained when the heavy rains begin in the late fall through spring.

Well pair CW13/VG4L was the only well pair that did not meet the definition of hydraulic containment for this monitoring period. Because the well pair is in the immediate vicinity of extraction well PW-9, CH2M HILL reviewed historical precipitation records and water extraction volumes from PW-9 to evaluate the effects on CW13/VG4L hydraulic containment performance. The summary from the

previous three winter seasons is shown in Table 4. As shown, in addition to the current quarter the well pair has not met the definition of hydraulic containment for the previous two winter quarters. Although the current quarter's precipitation was as little less and volume of extracted water was a little greater compared to the data from the previous winter quarters, hydraulic containment was still not maintained. Therefore, the loss of hydraulic containment cannot be attributed to lack of pumping or excess rainfall. The situation will continue to be evaluated.

Table 4 – Historical Pumping, Precipitation and Hydraulic Containment Records for CW13/VG4L

Monitoring Period	Total Recorded Precipitation (inches)	Approximate PW-9 Water Volume Extracted (gallons)	Ratio (Avg lower aquifer gw elevation / Avg upper aquifer gw elevation)
Dec. 27, 2011 to March 25, 2012	13.18	484,000	0.8
Jan. 1, 2011 to March 31, 2011	15.91	412,000	0.92
Jan 6, 2010 to April 5, 2010	15.85	418,000	0.87



Lower Aquifer Well
Upper Aquifer Well
Fence
Sheetpile Wall
Roads
Buildings
Concrete Slab
Structures

N

0 50 100 200 Feet

FIGURE 1

Former Process Area Well Locations

WYCKOFF/EAGLE HARBOR SUPERFUND SITE

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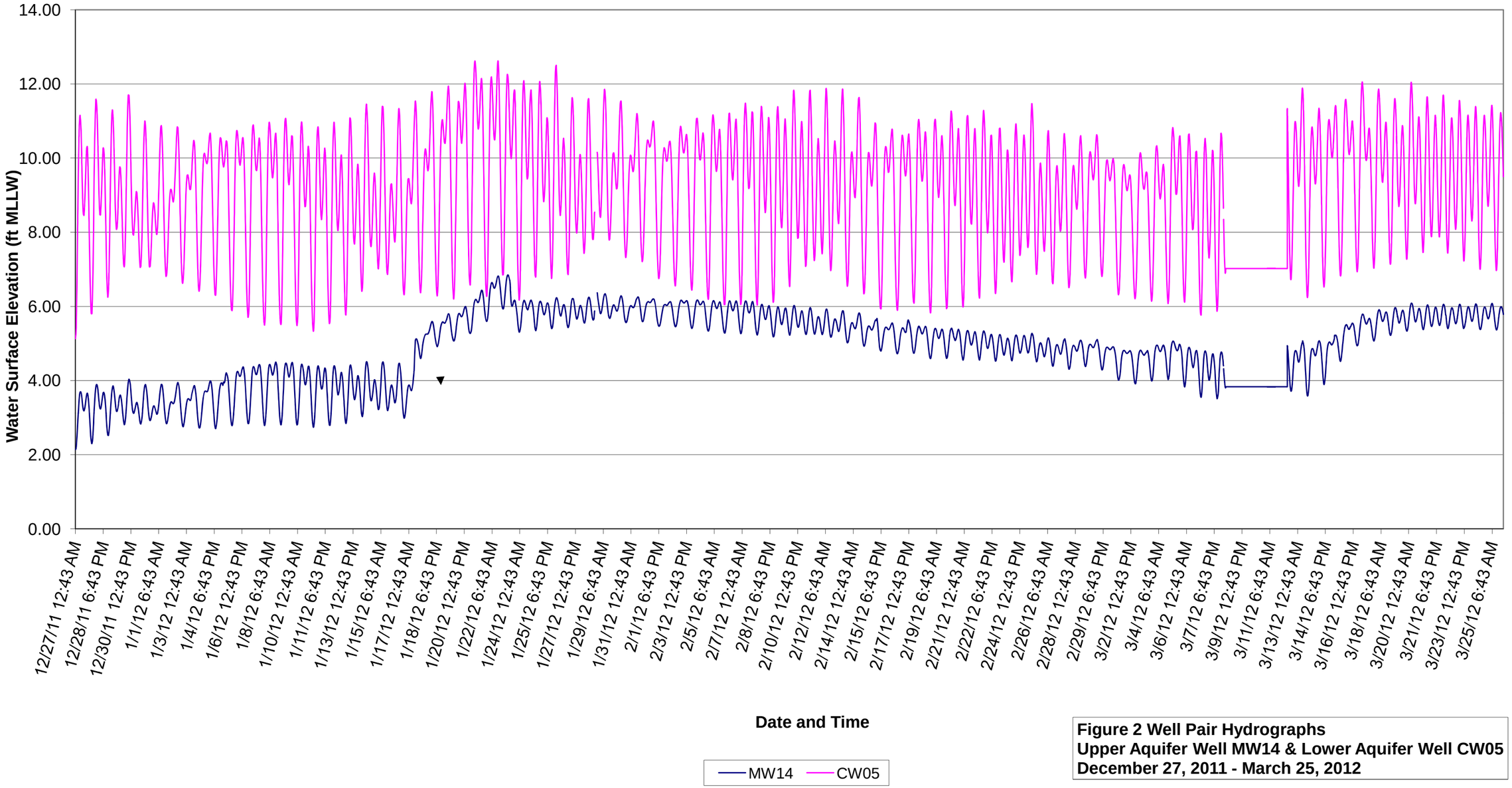

Figure 2 Well Pair Hydrographs
Upper Aquifer Well MW14 & Lower Aquifer Well CW05
December 27, 2011 - March 25, 2012

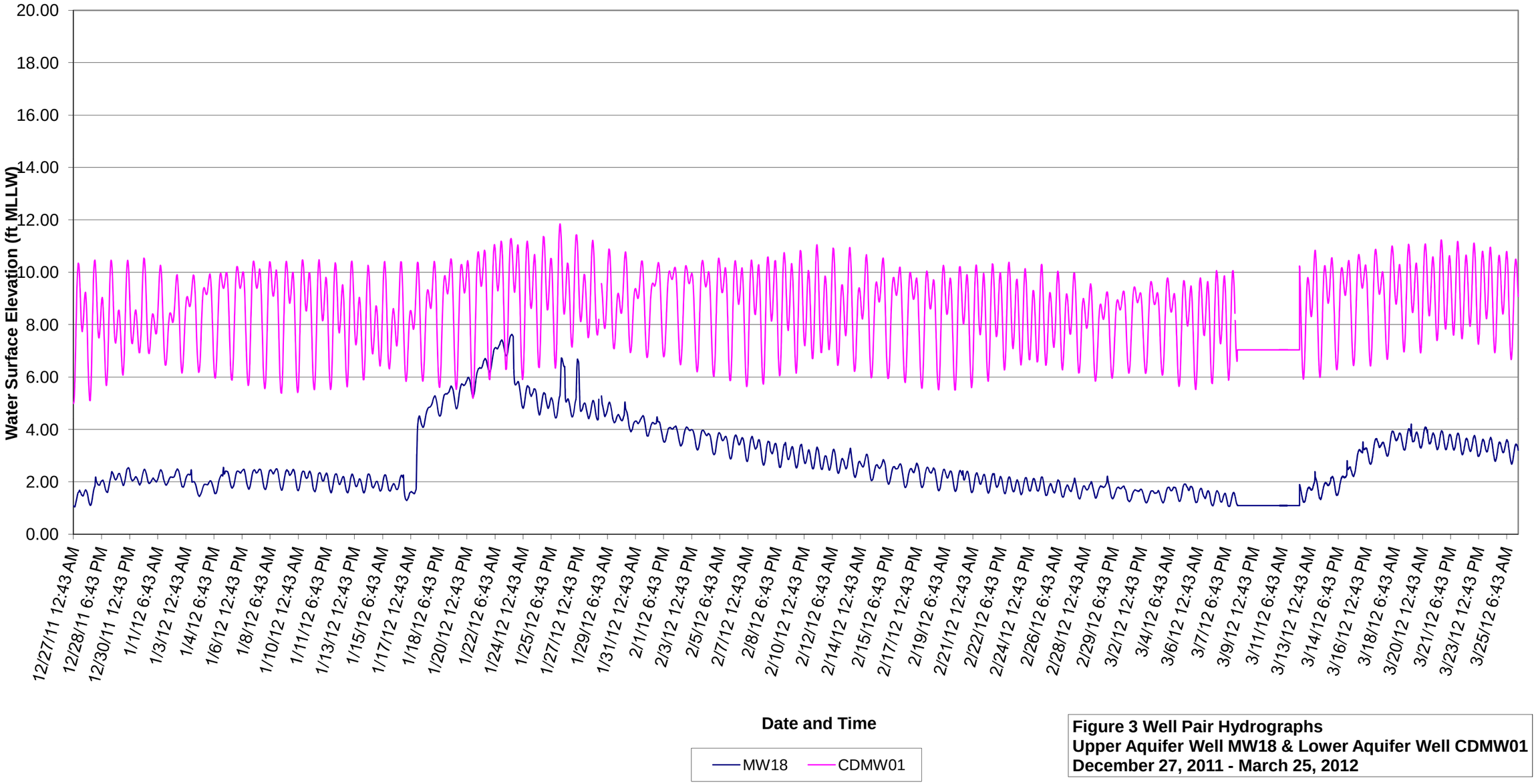

Figure 3 Well Pair Hydrographs
Upper Aquifer Well MW18 & Lower Aquifer Well CDMW01
December 27, 2011 - March 25, 2012

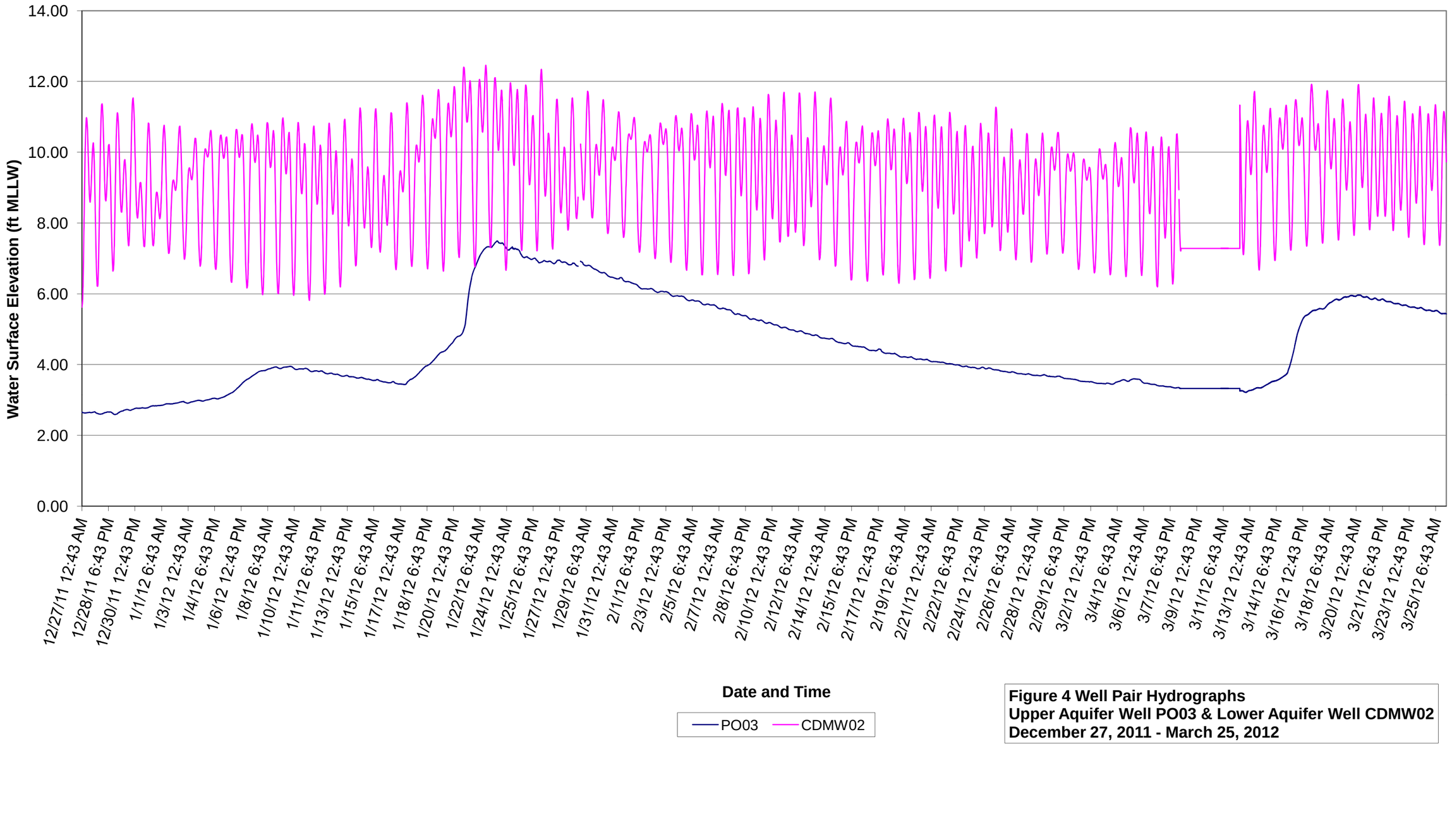

Figure 4 Well Pair Hydrographs
Upper Aquifer Well PO03 & Lower Aquifer Well CDMW02
December 27, 2011 - March 25, 2012

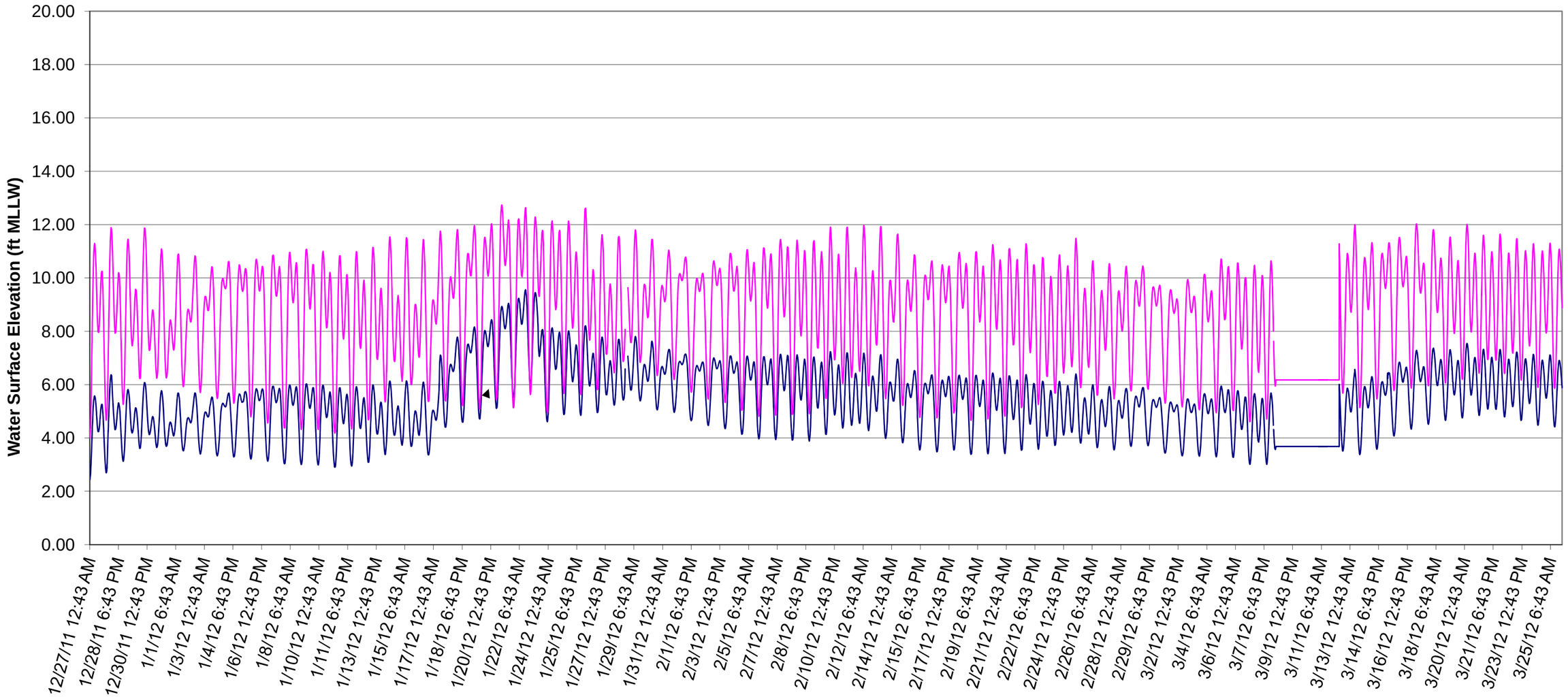

Figure 5 Well Pair Hydrographs
Upper Aquifer Well CW03 & Lower Aquifer Well CW02
December 27, 2011 - March 25, 2012

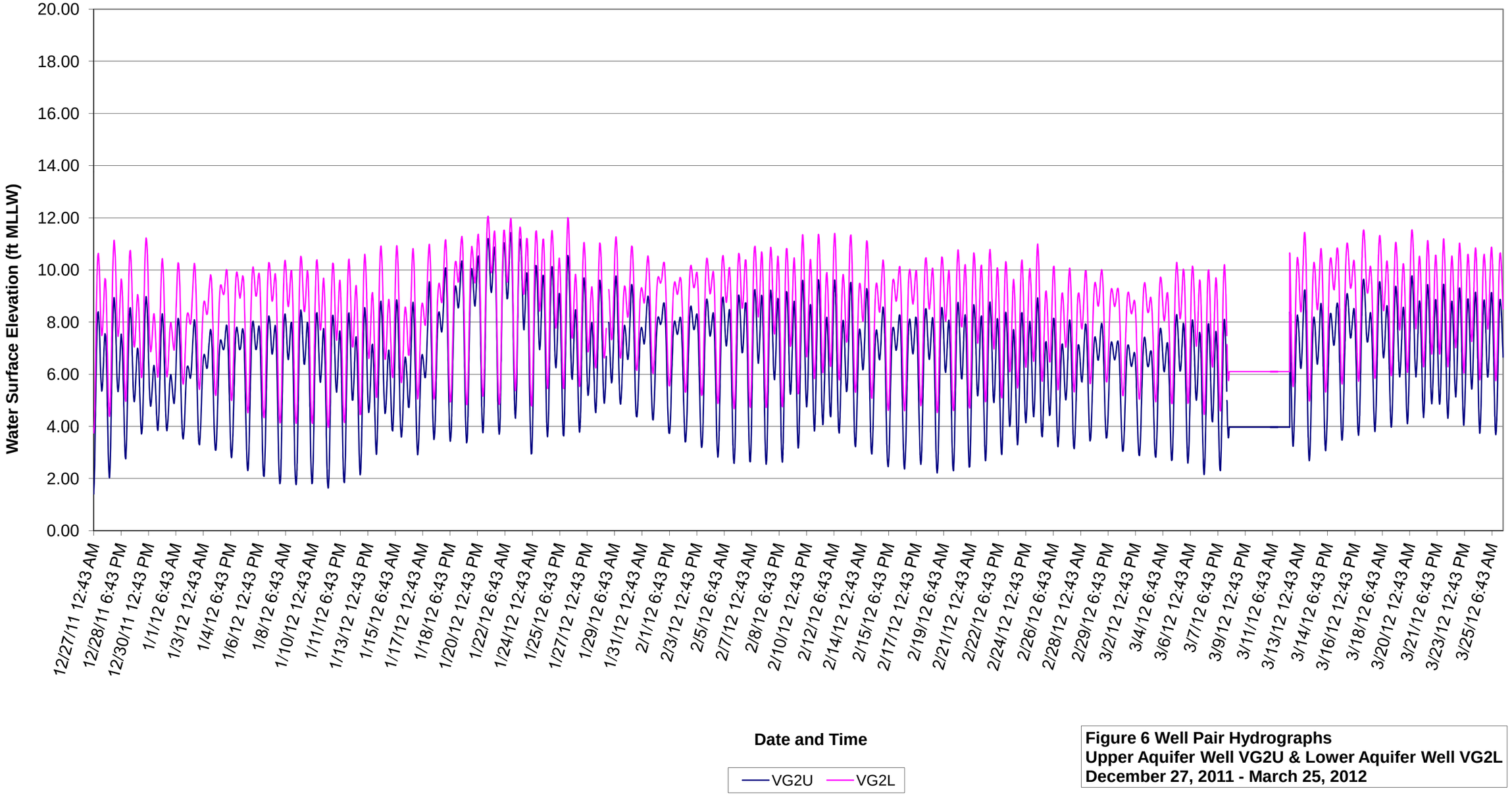

Figure 6 Well Pair Hydrographs
Upper Aquifer Well VG2U & Lower Aquifer Well VG2L
December 27, 2011 - March 25, 2012

Figure 7 Well Pair Hydrographs
Upper Aquifer Well VG3U & Lower Aquifer Well VG3L
December 27, 2011 - March 25, 2012

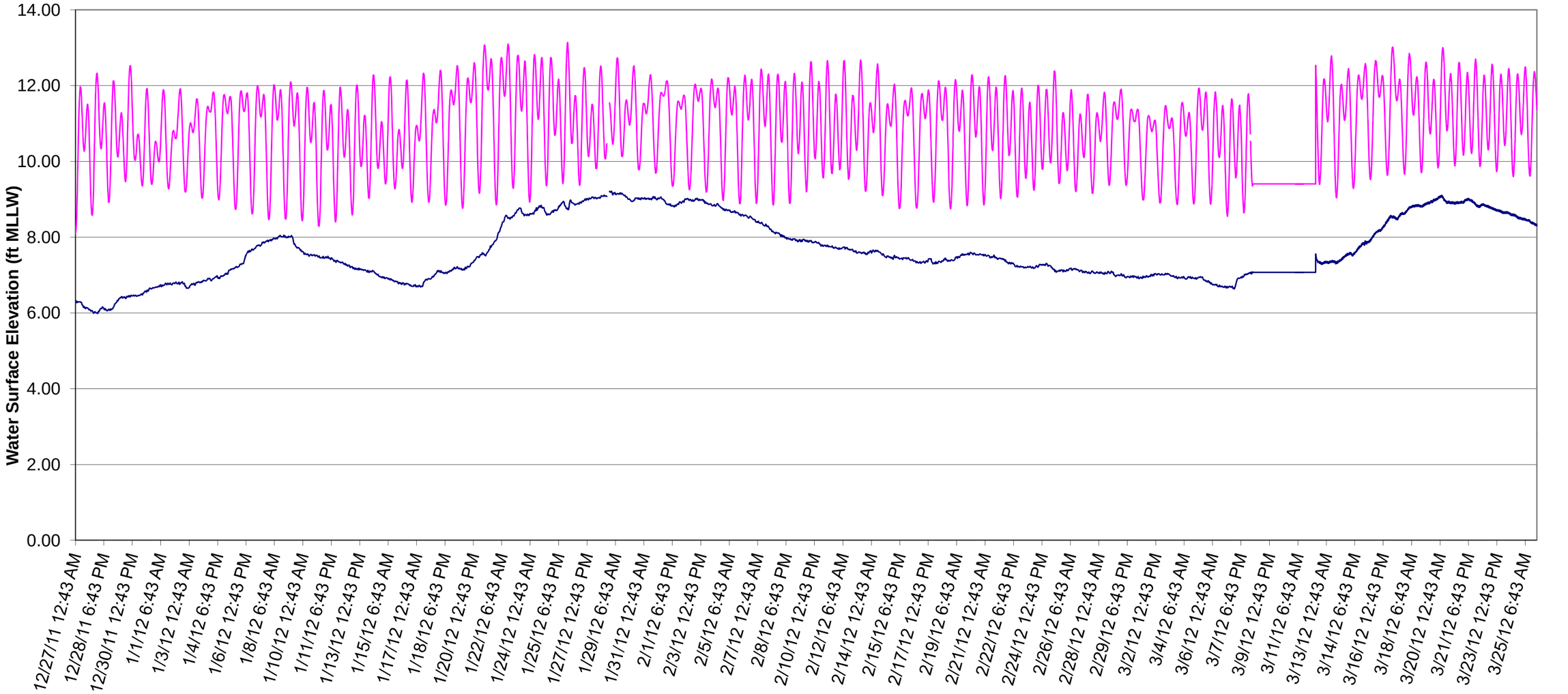

Figure 8 Well Pair Hydrographs
Upper Aquifer Well VG5U & Lower Aquifer Well VG5L
December 27, 2011 - March 25, 2012

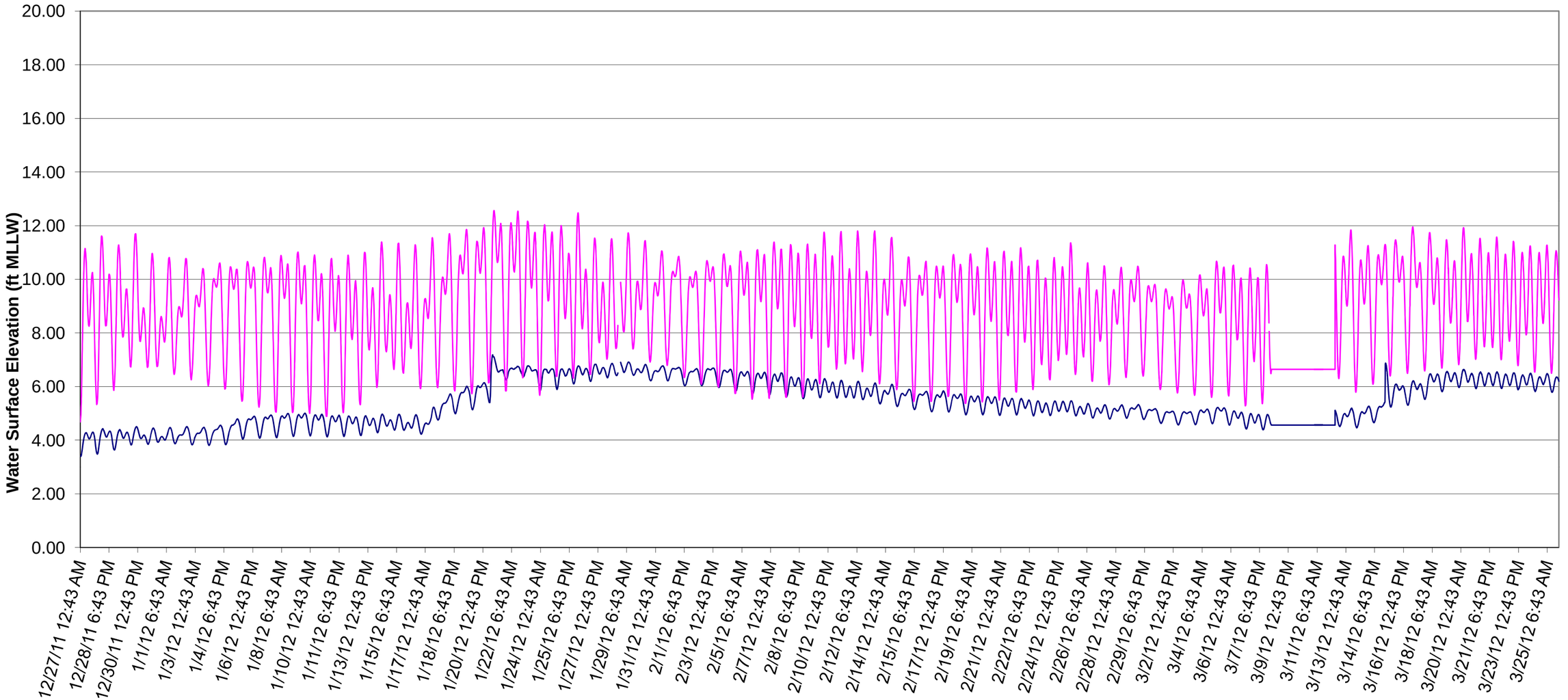

Figure 9 Well Pair Hydrographs
Upper Aquifer Well PO13 & Lower Aquifer Well VG1L
December 27, 2011 - March 25, 2012

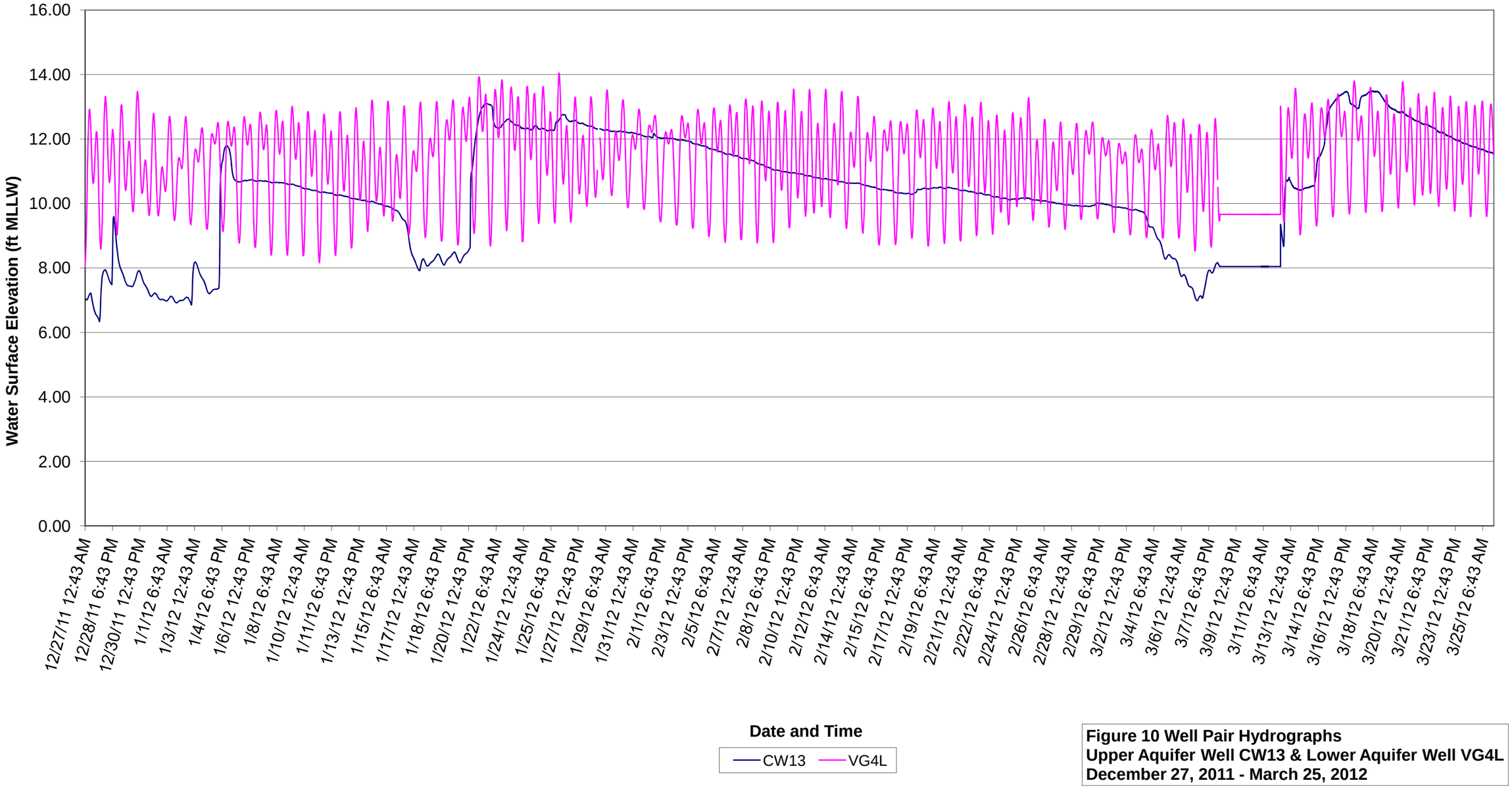

Figure 10 Well Pair Hydrographs
Upper Aquifer Well CW13 & Lower Aquifer Well VG4L
December 27, 2011 - March 25, 2012

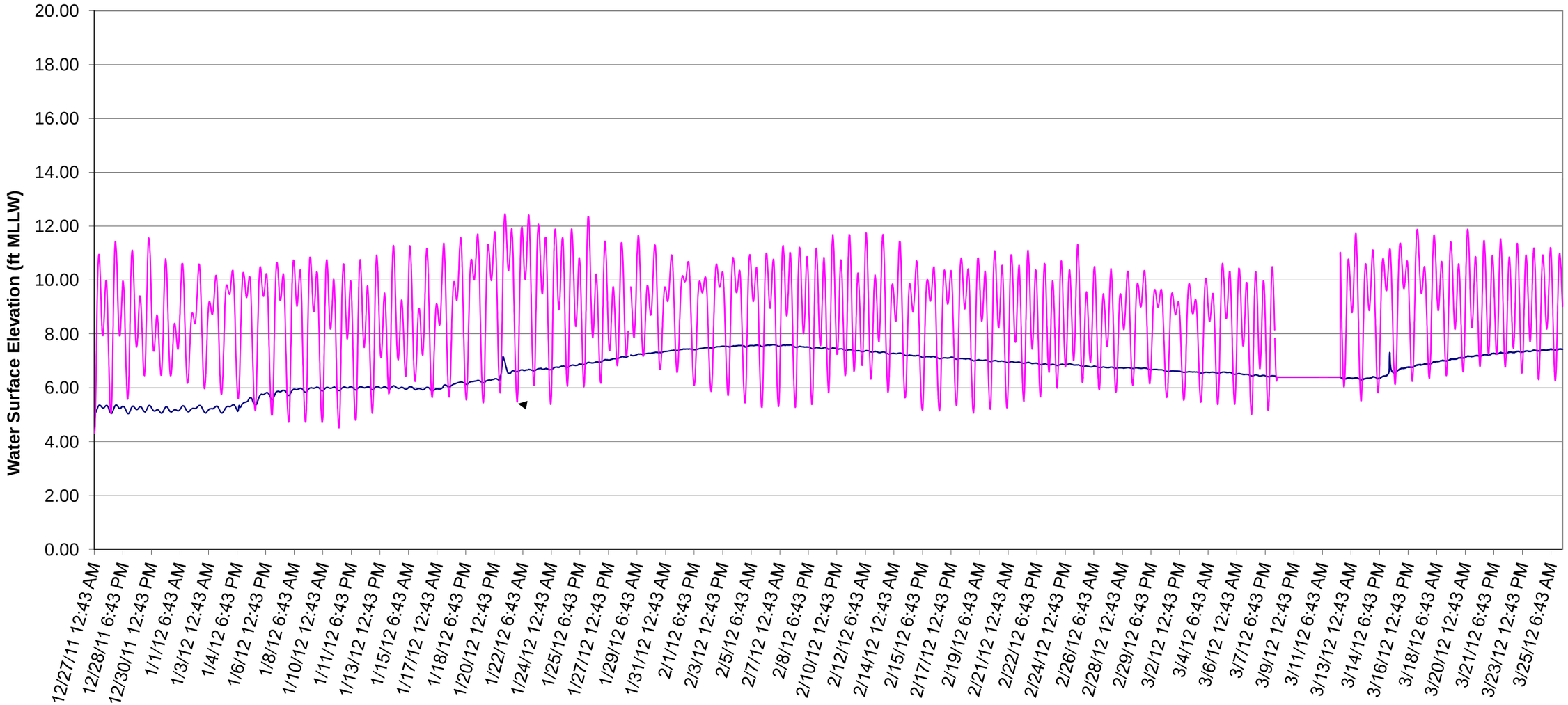

Figure 11 Well Pair Hydrographs
Upper Aquifer Well CW08 & Lower Aquifer Well P4L
December 27, 2011 - March 25, 2012

Maximum Downward Flow Potentials

MW14/CW05	none
MW18/02CDMW01	1/22/2012
PO03/99CDMW02	1/23/2012
CW03/CW02	1/21/2012
VG2U/VG2L	none
VG3U/VG3L	none
VG5U/VG5L	none
PO13/VG1L	1/21/2012
CW13/VG4L	1/21/2012
CW08/P4L	2/5/2012

Well(s) Off
Jan. 6 - 9, 2012 (PW-9)
Jan. 17 - 23, 2012
(RPW-1, RPW-2, RPW-4, RPW-5, RPW-6, PW-8, PW-9, E-02, E-06)

Well(s) Off
Mar. 3 - 5, 2012 (PW-8)
Mar. 7 - 12, 2012 (PW-9)

Daily Precipitation (inches)

Cumulative Precipitation (inches)

Date

Daily Precipitation
Cumulative Precipitation

Figure 12 Wyckoff Site Precipitation, Well Field Shutoff, and Max Downward Flow Potential Summary December 27, 2011 - March 25, 2012