

Groundwater Level Monitoring Data
1996-2010
Devils Tower National Monument

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Groundwater level monitoring of the alluvial aquifer associated with the Belle Fourche River, Devils Tower National Monument

The Belle Fourche River flows through the southeast part of Devils Tower National Monument (Figure 1). Flow in the river is regulated by releases from Keyhole Reservoir, about 18 miles upstream from the park. As a result of the controlled streamflow through the park, natural recruitment of cottonwood trees and willows has been nearly eliminated in the associated riparian environment of Devils Tower National Monument. Hydrologic monitoring of the alluvial aquifer is being conducted to provide data necessary to develop a restoration plan for the area.

Ten shallow monitoring wells were constructed in the alluvium of the Belle Fourche River at Devils Tower National Monument in the summer of 1996. The primary purpose for installing the monitoring wells was to obtain groundwater level data needed to develop a plan for restoration of cottonwood and willows in the riparian corridor. Objectives for the monitoring include; 1) determine the depth to groundwater, 2) determine the seasonal variability of the water table, 3) determine the interaction between surface-water flow in the river and groundwater in the associated alluvial aquifer, and 4) facilitate testing the water chemistry of the alluvial groundwater.

Ten monitoring wells were constructed using a hand-powered soil augur. The wells were completed with 2-inch, Schedule 40 PVC. The bottom two feet of PVC in each well was perforated. Coarse sand was poured into the annular space to maintain hydraulic communication between the well and aquifer. The upper part of the borehole was sealed with bentonite pellets.

The wells were located in three areas (Figure 2). The four wells in the C-cluster are located on a large point bar extending southeasterly from the campground. The three wells in the M-cluster are located in association with an abandoned meander. The three wells in the P-cluster are located near the primitive campground, near the downstream boundary of the park. Table 1 provides a summary of the well construction.

Period of Record

Water levels in the monitoring wells were measured approximately monthly following construction of the wells in August 1996 until September 1999. Water levels were measured once in 2000; on July 13. No measurements were made in 2001 or 2002. Measurements were made in June and July of 2004. Beginning in 2005, measurements were made approximately biweekly from late-May through September. The frequency of measurements is illustrated by the locations of dots on the hydrographs (Figures 3-5).

Dataloggers were installed in two wells, P2 and P3, on November 30, 2006. The dataloggers record total pressure, which can be converted to depth of water after correcting for barometric pressure changes. Due to a variety of problems, the continuous record from November 2006 through mid-September 2009 is not as accurate as it could be. A better SOP (Standard Operating Procedure) was established in September 2009, resulting in more reliable data since then.

Manual Measurements

Prior to 2010, water level measurements were made by sticking a long piece of rebar to the bottom of the well. The distance from the end of the rebar to the wetted mark was measured, i.e., measuring the depth of water from the bottom of the well up. They then used the depth of the well to compute the depth to water below ground surface.

In 2010, DETO staff were provided a length of steel surveyor's tape and chalk and instructed to measure from the top down. This is the standard method for measuring water levels in wells.

Ed Eberhardy (DETO Biotech) compiled all of the water level measurements in a standard format in an Excel spreadsheet. Copies of the spreadsheet are at the park and with Larry Martin (Water Resources Division, Ft. Collins). A printout of the data is attached to this report.

Hydrographs of the data are provided in Figures 3-5. A separate figure is shown for each well cluster; C series, M series, and P series of wells. The recent data (2003-2010) for each well cluster is shown in Figures 6-8.

Continuous Data

HOB0® pressure transducer dataloggers were installed in Wells P2 and P3 in November 2006. The instruments measure total pressure, which varies depending on the depth of water in the well and barometric pressure. The pressure data can be converted to depth of water in the well by correcting for barometric pressure changes and providing an anchor measurement (a manual water level measurement that can be correlated to a specific pressure reading). Pressure data were recorded and stored hourly, providing a continuous record of water level in the two wells.

The dataloggers were programmed incorrectly from July 28, 2008 until September 18, 2009. We do not have reliable continuous data for that period.

Continuous record of water level data is available for the periods from November 30, 2006 to July 28, 2008 and from September 18, 2009 to September 3, 2010. Continuous monitoring of water levels at Wells P2 and P3 is ongoing. Hydrographs of water levels in Wells P2 and P3 for various time intervals are shown in Figures 9-14. The data are archived in an Excel spreadsheet. Copies of the spreadsheet are at the park and with Larry Martin (Water Resources Division, Ft. Collins).

Data Analysis

Figures 3-8 show that generally the water level in each well reaches about the same minimum level (depth below ground surface) each year. Peak water levels are more variable; depending on the streamflow in the Belle Fourche River.

Figures 9-14 show the correlation between water levels in Wells P2 and P3 and streamflow in the river. As we would expect, when the streamflow increases and the river stage rises, the water table in the alluvial aquifer also rises. We do not have a record of the elevation of the river stage in the park and can not quantify the correlation between river stage and the water table. The nearest USGS gaging station is near Alva, Wyoming, about 20 miles downstream (USGS Station

06428200). The gaging station is only operated from April 1 to September 30. There are no data available for the winter months.

Figures 9 and 10 show the continuous record of water levels in Wells P2 and P3, streamflow at the nearest USGS stream gaging station, and manual water level measurements. Correlation between the manual measurements during the summer of 2007 and the data computed from the pressure transducer is poor. I can't determine why the correlation is poor because the documentation for monitoring procedures during that time is almost nonexistent. Water level measurements during the summer of 2008 show a much better correlation with data from the pressure transducers. The continuous record of water levels in Wells P2 and P3 are closely correlated with streamflow in the river.

Figures 11 and 12 show the data for the period from September 2009 to September 2010; a period when there was better QA/QC for the monitoring data. Correlation between the manual measurements and the continuous data is very good. Water levels in the wells vary in direct correlation with streamflow in the river. Figures 13 and 14 show the same data set in greater detail for the summer of 2010.

Recommendations

1. Continue to use the steel tape and chalk method to measure water levels from the top down. Measuring water levels from the bottom up is not as accurate.
2. Make a few measurements during the winter months to provide better QA/QC for the data. Suggest adding a round of measurements in late-November, mid-February, and early-April.
3. Conduct a more critical review of field data as it is being collected. For example, between the manual measurements on July 28, 2010 and September 3, 2010 the water level in all of the wells decreased about a half foot; except Well P3 where the data shows the water level rose about a half foot. Recognizing these types of discrepancies in the field should have triggered remeasuring the water level to determine if an error had been made.

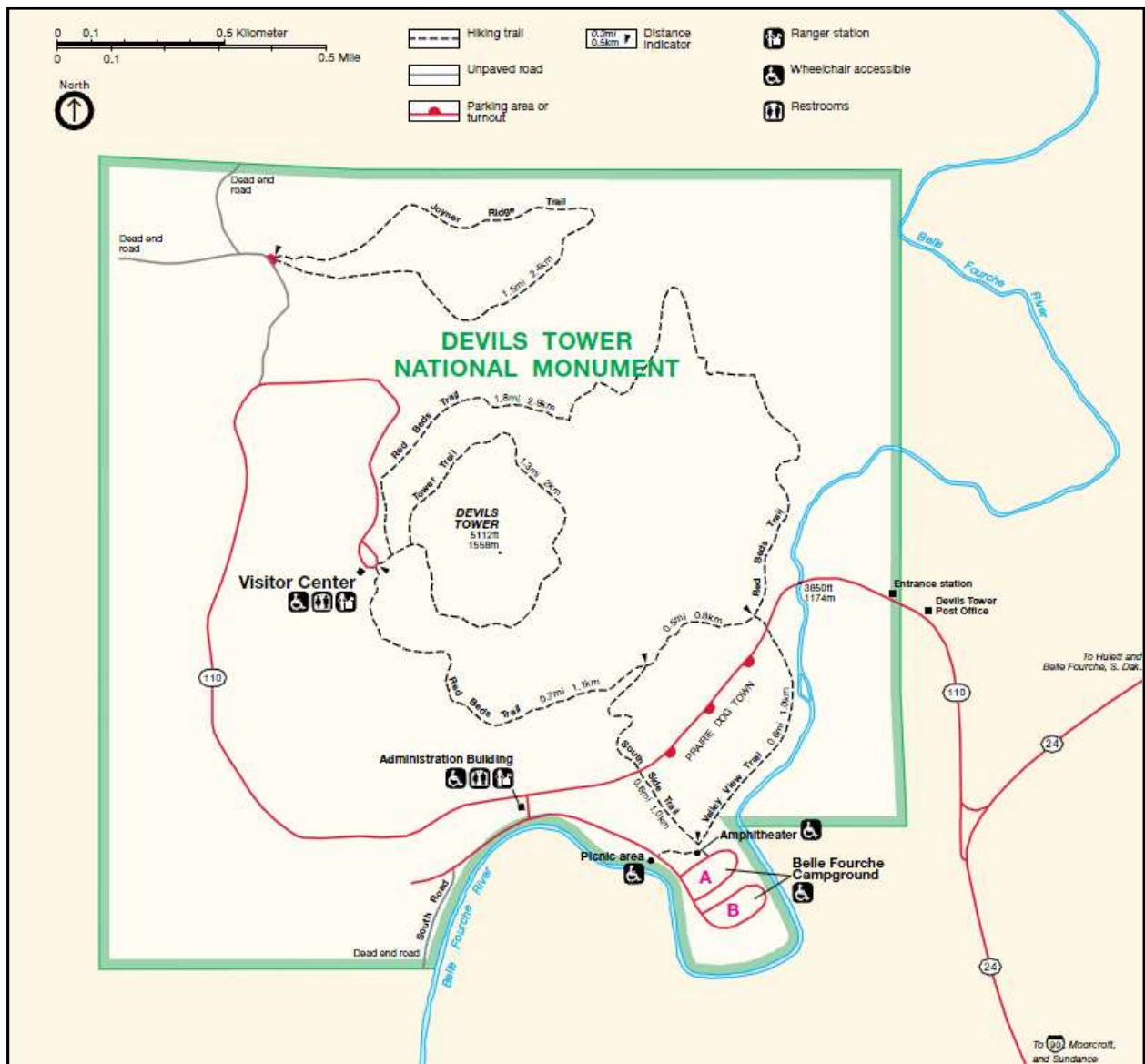


Figure 1. Map of Devils Tower National Monument, WY.

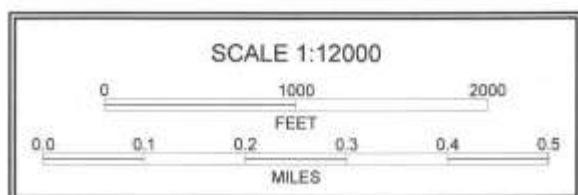
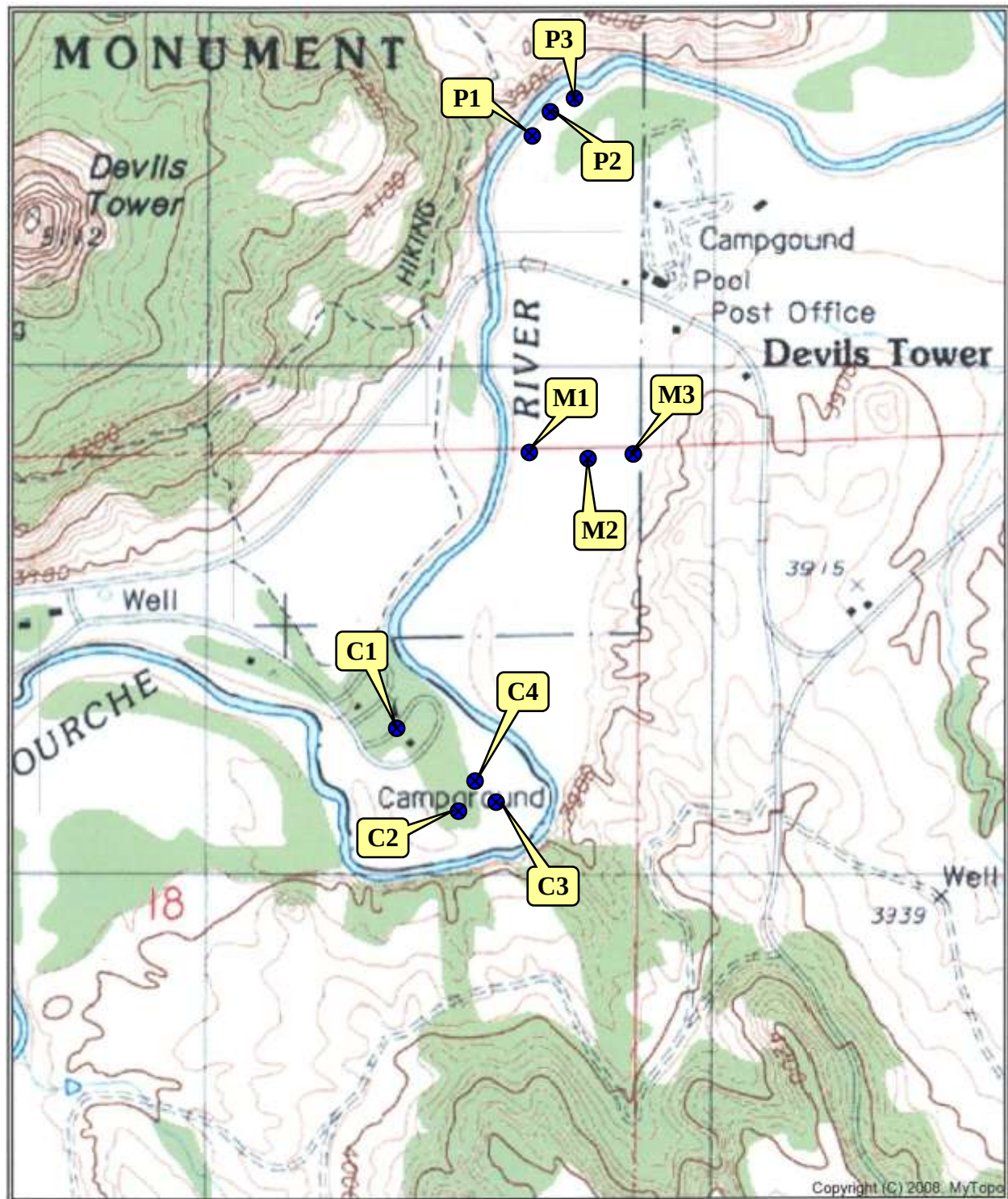


Figure 2. Locations of monitoring wells along the Belle Fourche River, Devils tower National Monument.

Table 1. Alluvial groundwater monitoring wells at Devils Tower National Monument.

Well Location		Name/#	Elevation Feet TOC	Depth Feet BGS	Stickup Feet	Easting Feet	Northing Feet
Campground	Near campground host site, Loop A	C1	88.65	10.0	0.21	11494.9	7257.9
Campground	On point bar, most upstream	C2	85	8.2	0.24	12258.1	7298.9
Campground	On point bar, midway between C2 and C4	C3	85.33	7.1	1.33	12401.5	7494.6
Campground	On point bar, most downstream	C4	83.78	6.3	0.48	12227.3	7569.6
Oxbow	Nearest river	M1	77.41	2.6	1.15	11233.2	9201.8
Oxbow	Midway between M1 and M3	M2	77.45	2.7	1.42	11505.0	9600.7
Oxbow	Furthest from river, 20 ft from property boundary	M3	77.51	3.4	1.08	11601.1	9687.6
Primitive Camp	Most upstream	P1	77.08	6.4	0.25	9762.6	10872.6
Primitive Camp	Midway between P1 and P3	P2	74.49	5.1	0.56	9752.7	11126.7
Primitive Camp	Most downstream	P3	73.22	5.1	0.79	9845.7	11354.2

Note: X, Y, Z data (elevation, northing, and easting) are relative to an arbitrary datum.

Devils Tower C Wells

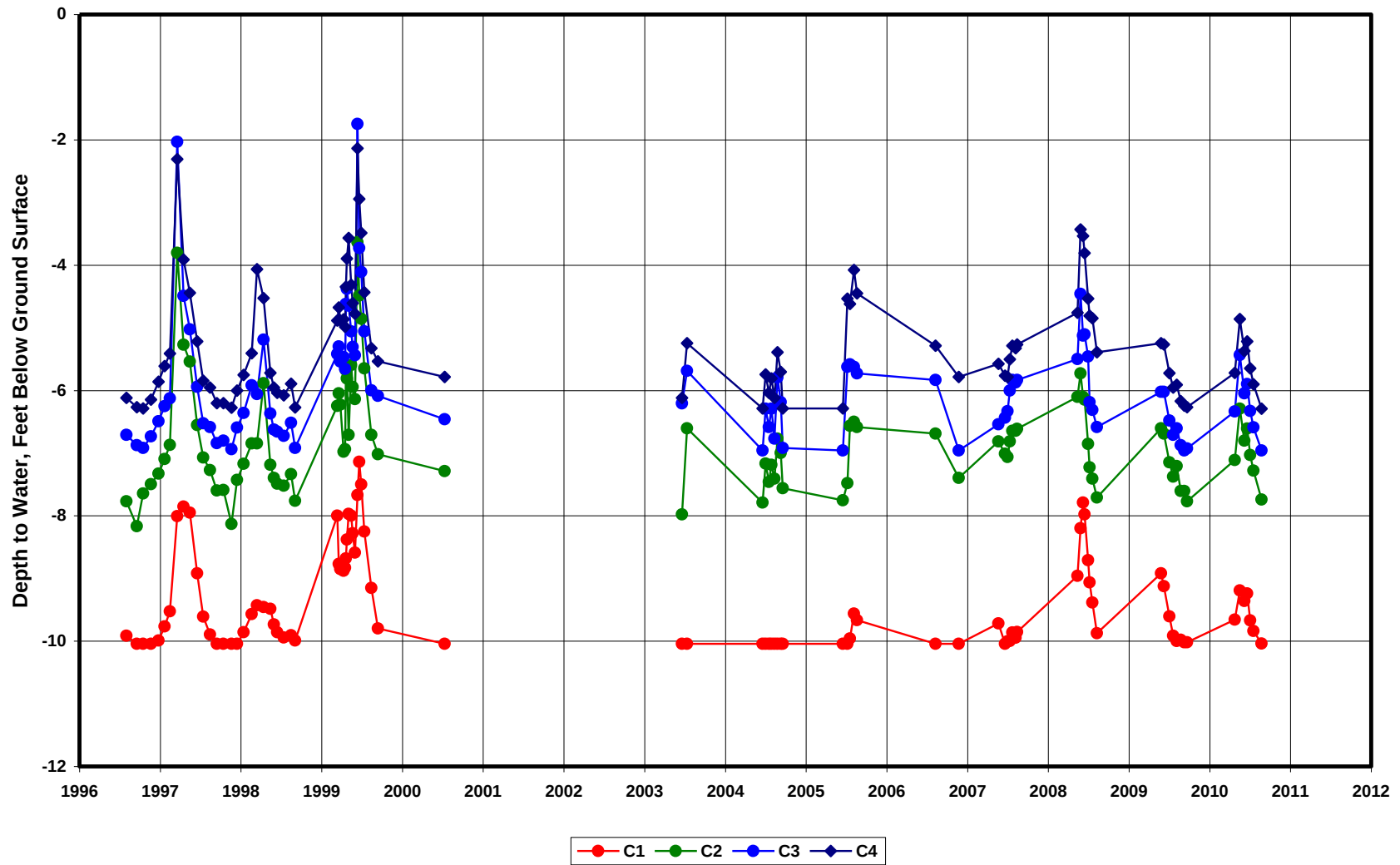


Figure 3. Hydrographs of wells in the C-cluster, Devils Tower National Monument.

Devils Tower M Wells

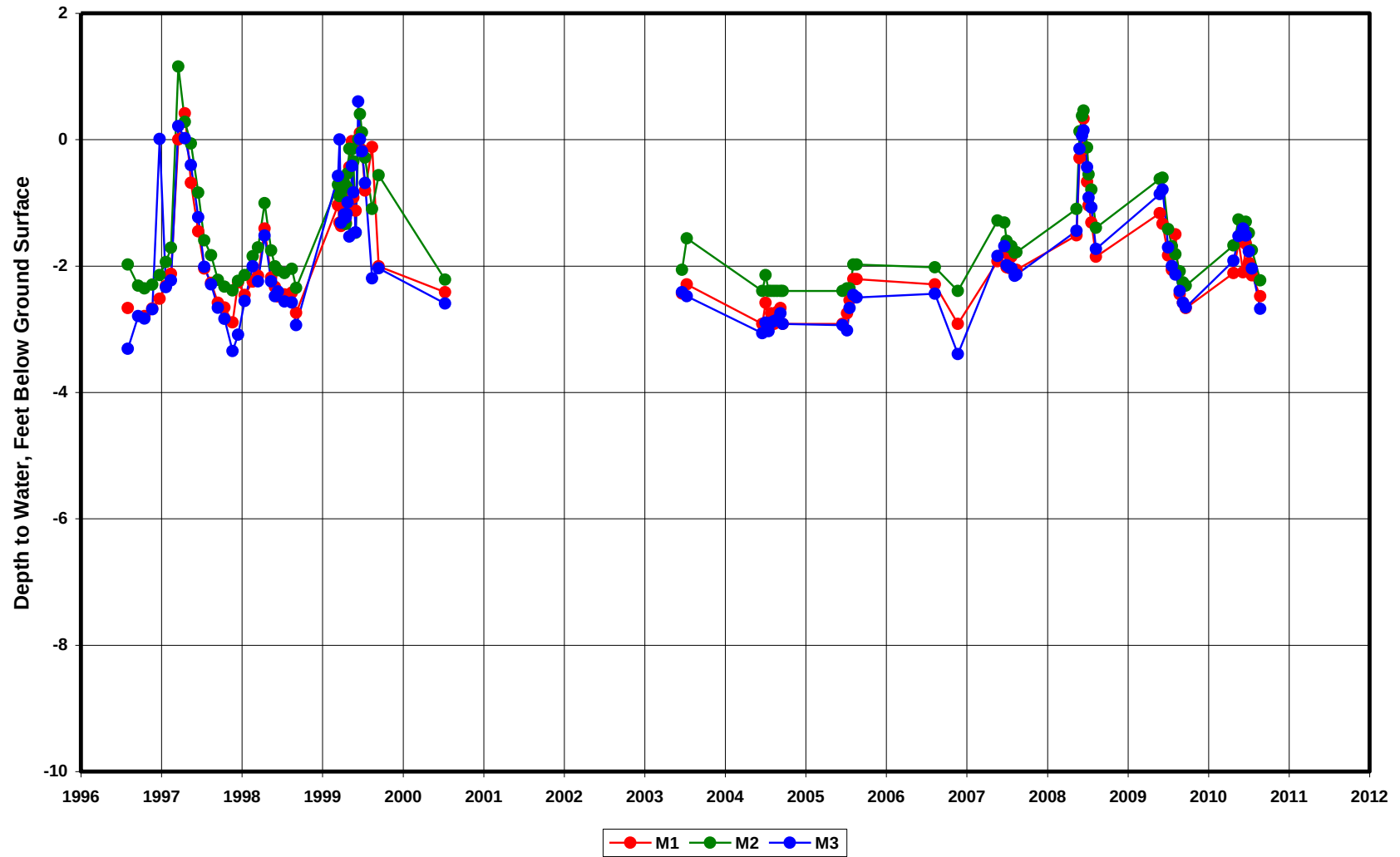


Figure 4. Hydrographs of wells in the M-cluster, Devils Tower National Monument.

Devils Tower P Wells

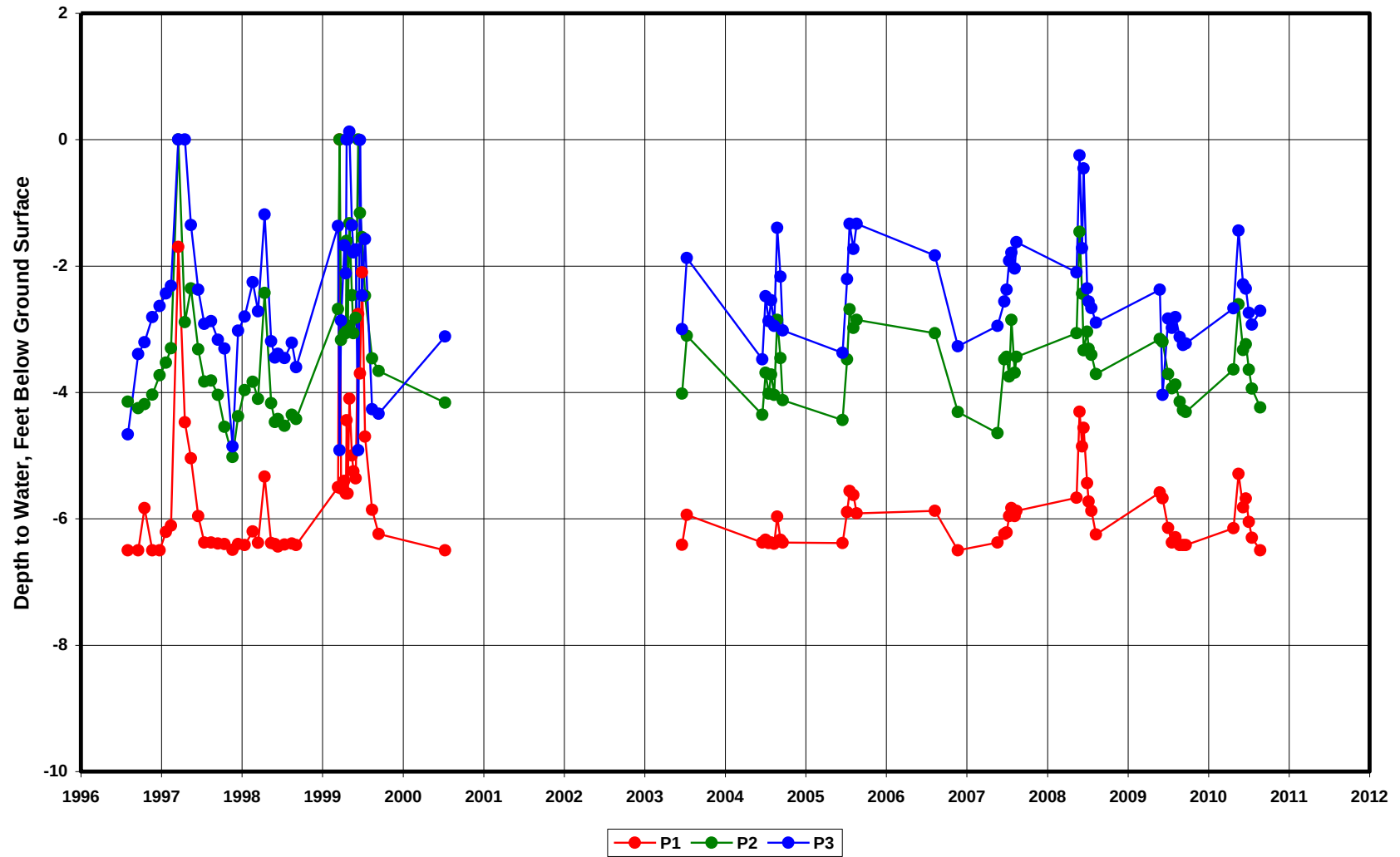


Figure 5. Hydrographs of wells in the P-cluster, Devils Tower National Monument.

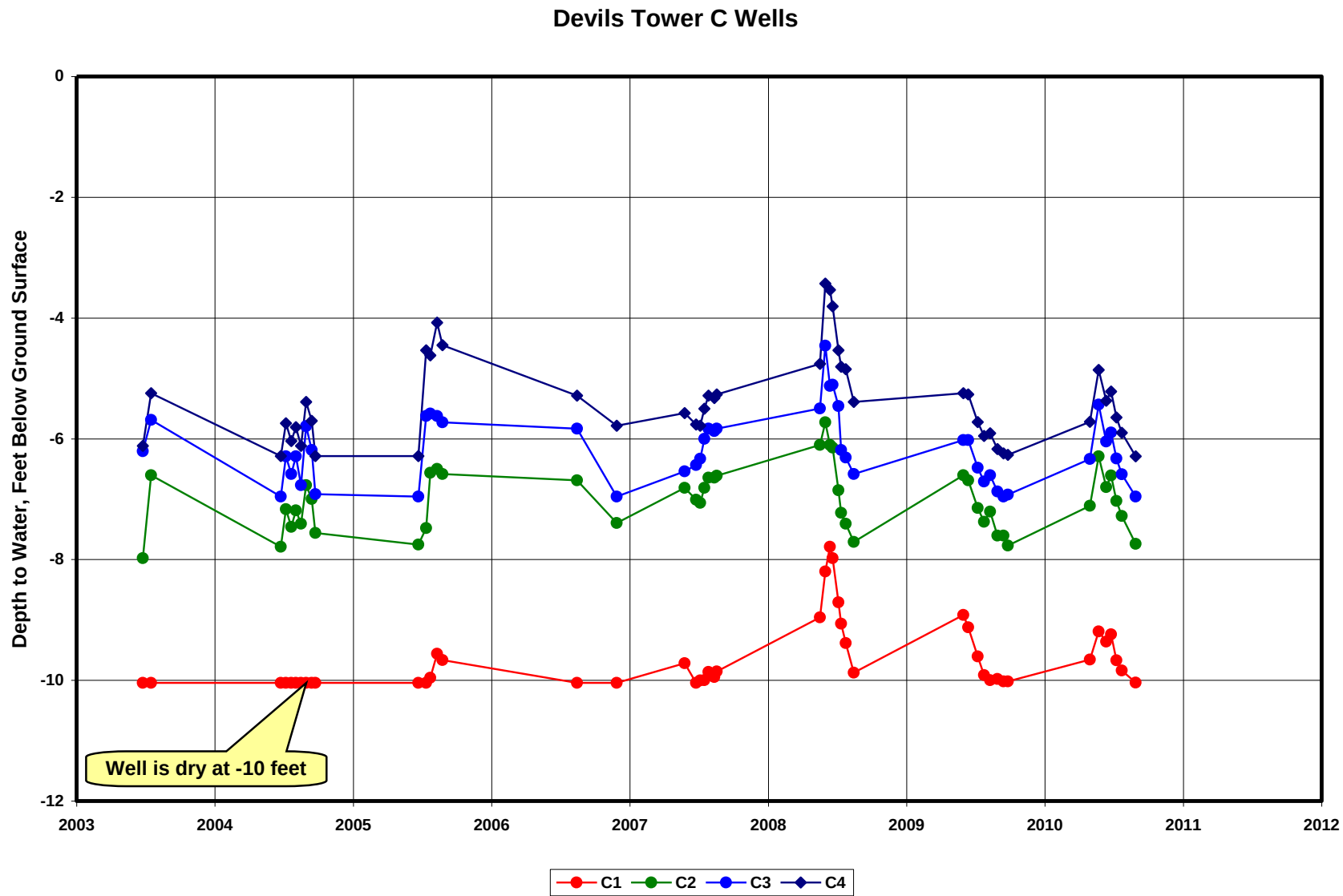


Figure 6. Hydrographs of wells in the C-cluster, 2003-2010, Devils Tower National Monument

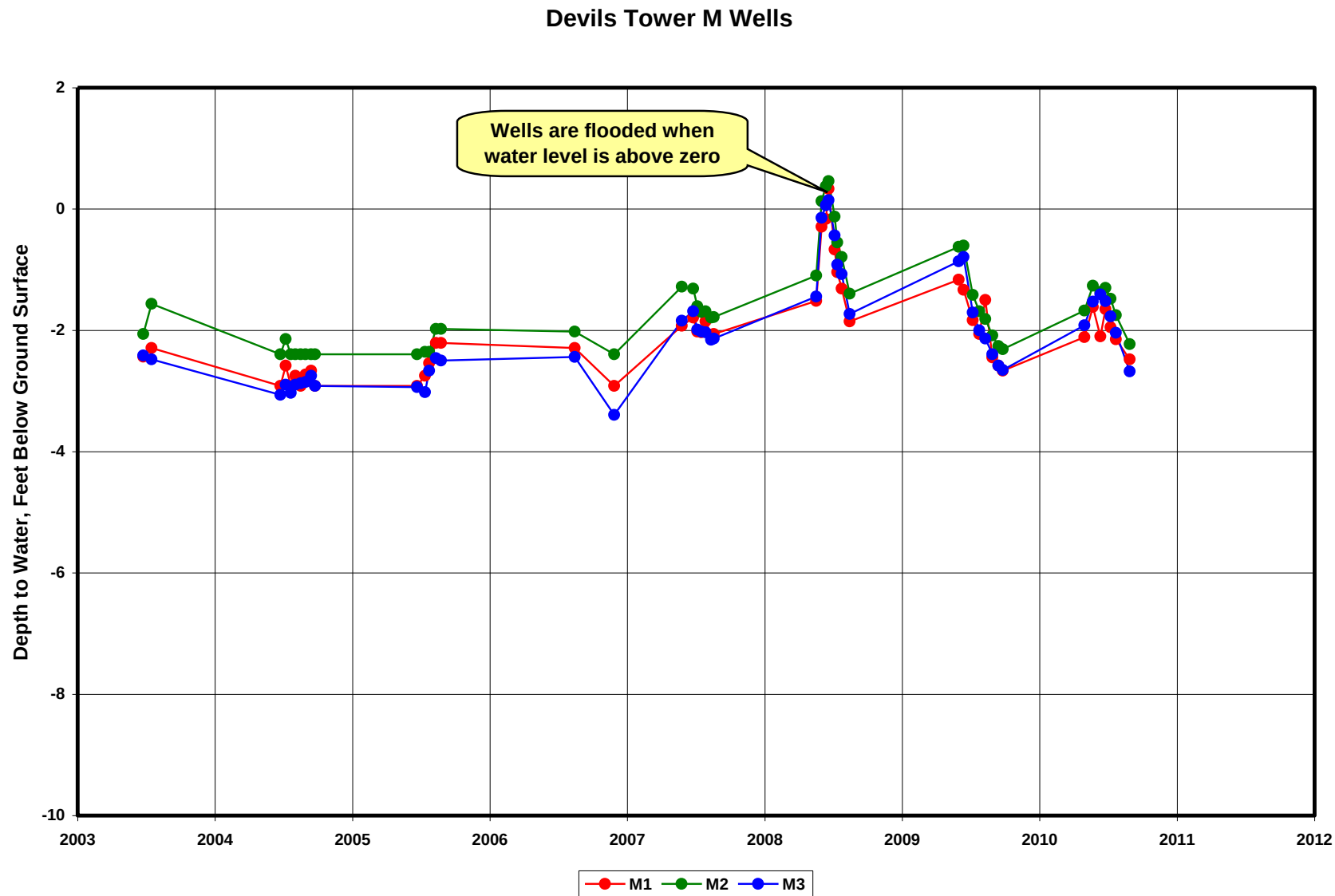


Figure 7. Hydrographs of wells in the M-cluster, 2003-2010, Devils Tower National Monument

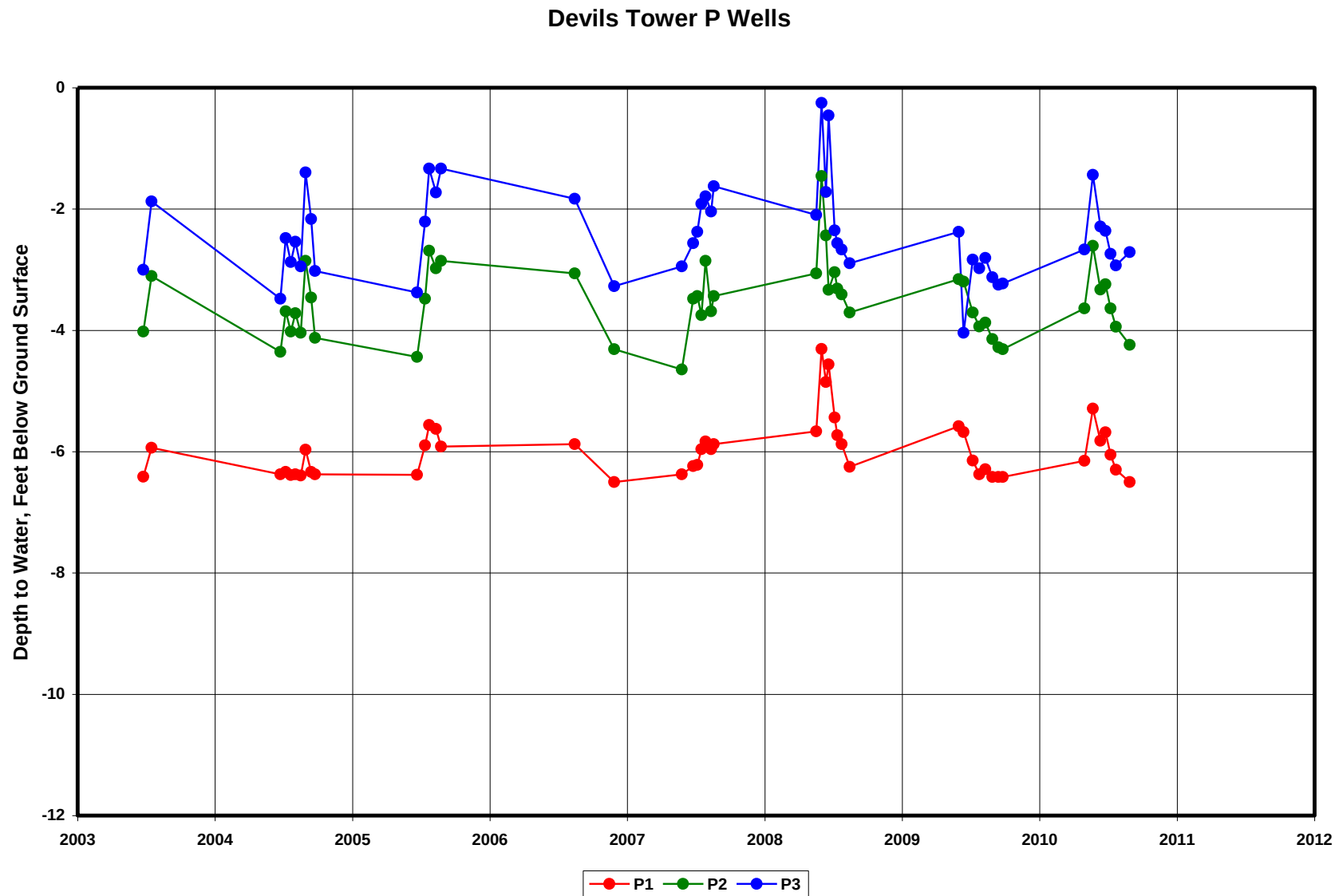


Figure 8. Hydrographs of wells in the P-cluster, 2003-2010, Devils Tower National Monument

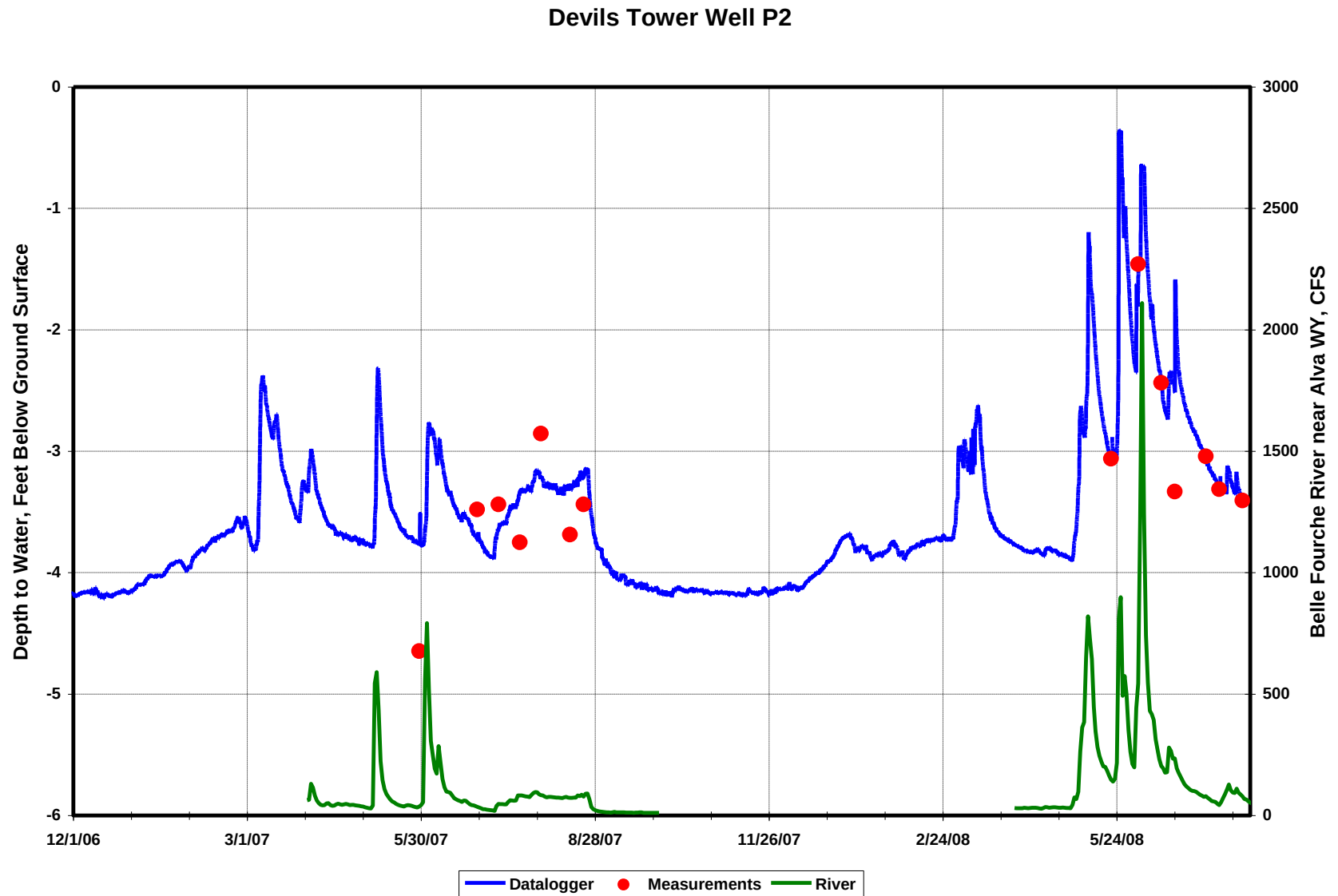


Figure 9. Continuous record and manual measurements of water levels in Well P2; December 2006 to September 2008.

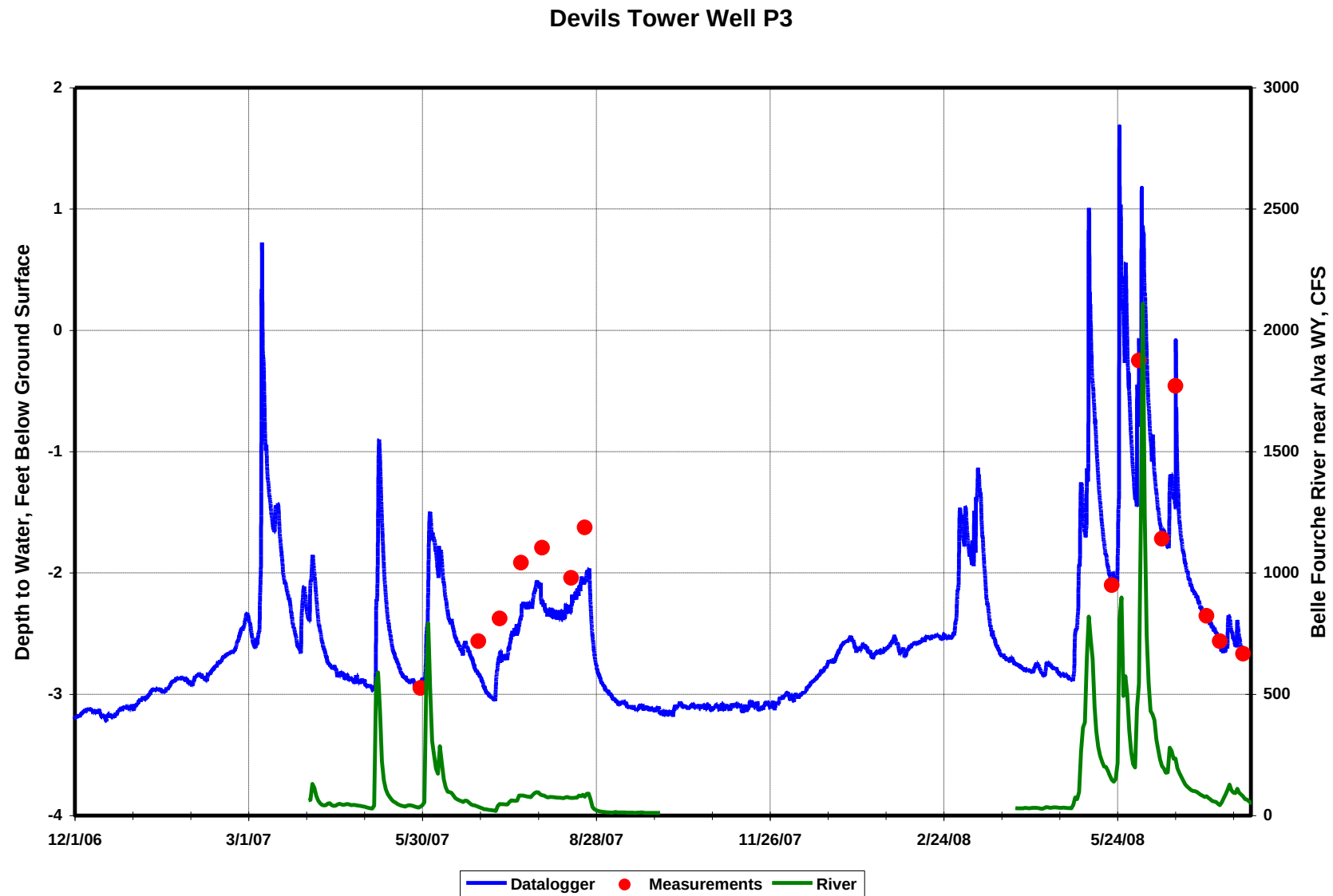


Figure 10. Continuous record and manual measurements of water levels in Well P3; December 2006 to September 2008.

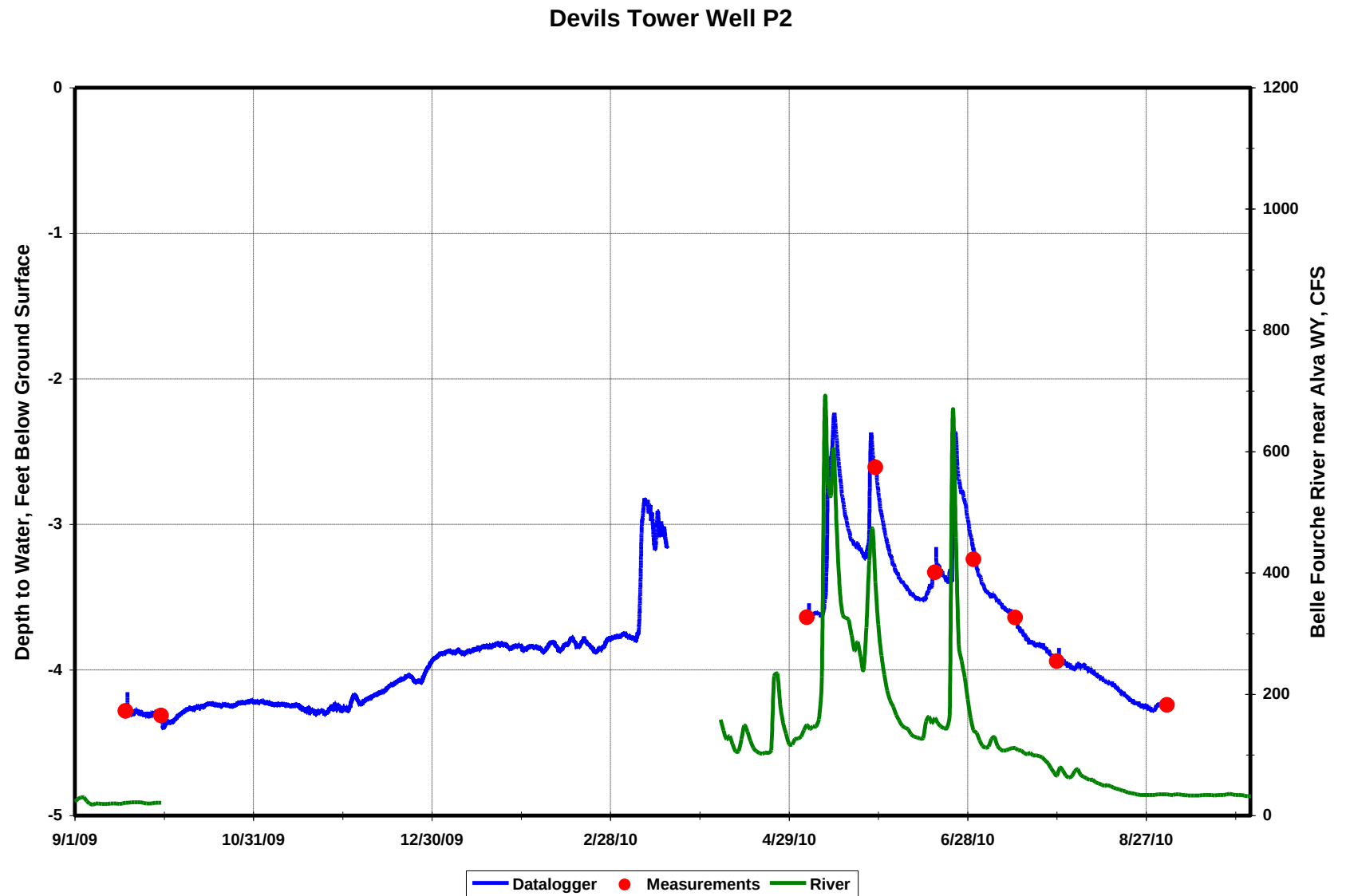


Figure 11. Continuous record and manual measurements of water levels in Well P2; September 2009 to September 2010.

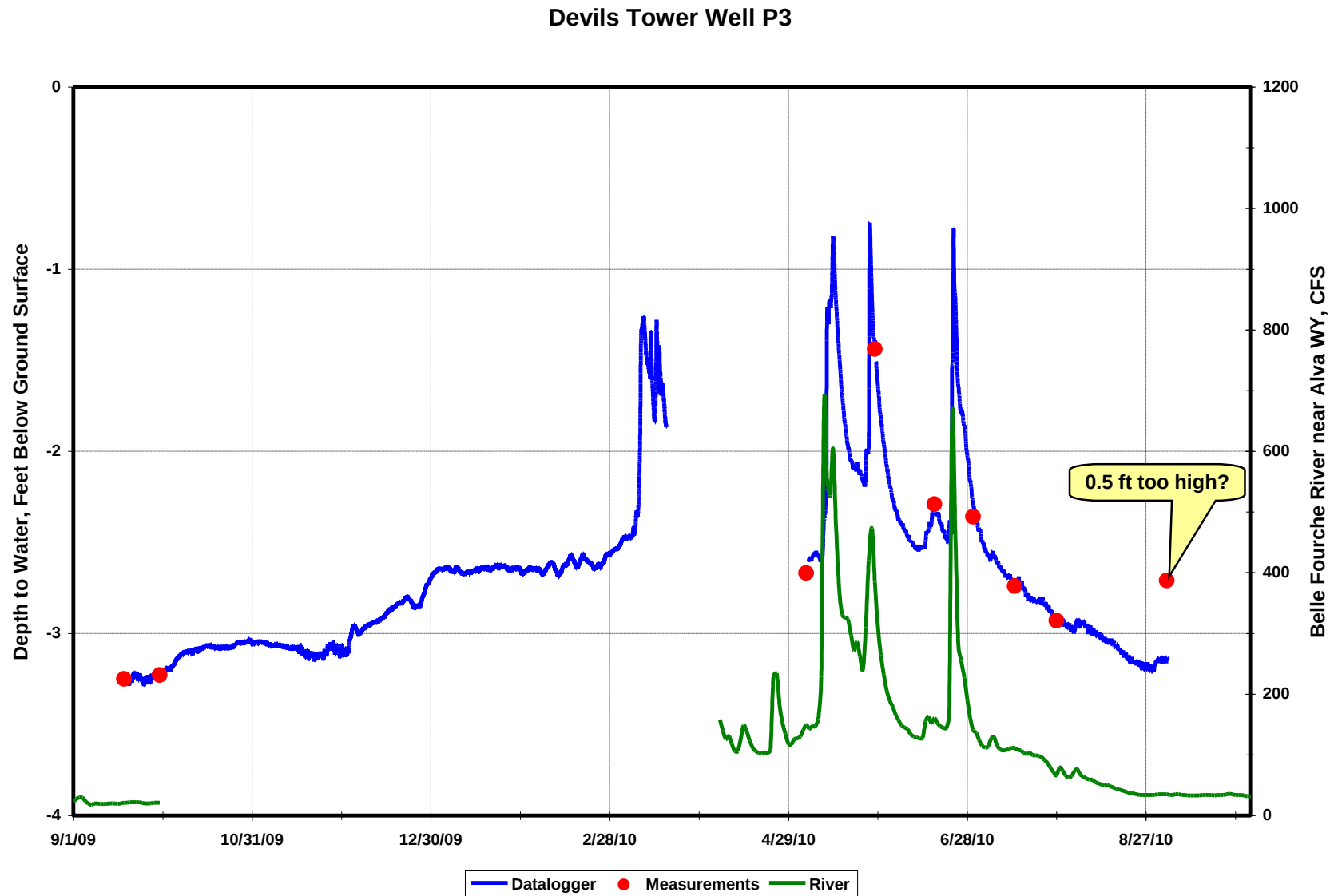


Figure 12. Continuous record and manual measurements of water levels in Well P3; September 2009 to September 2010.

Devils Tower Well P2
Summer 2010

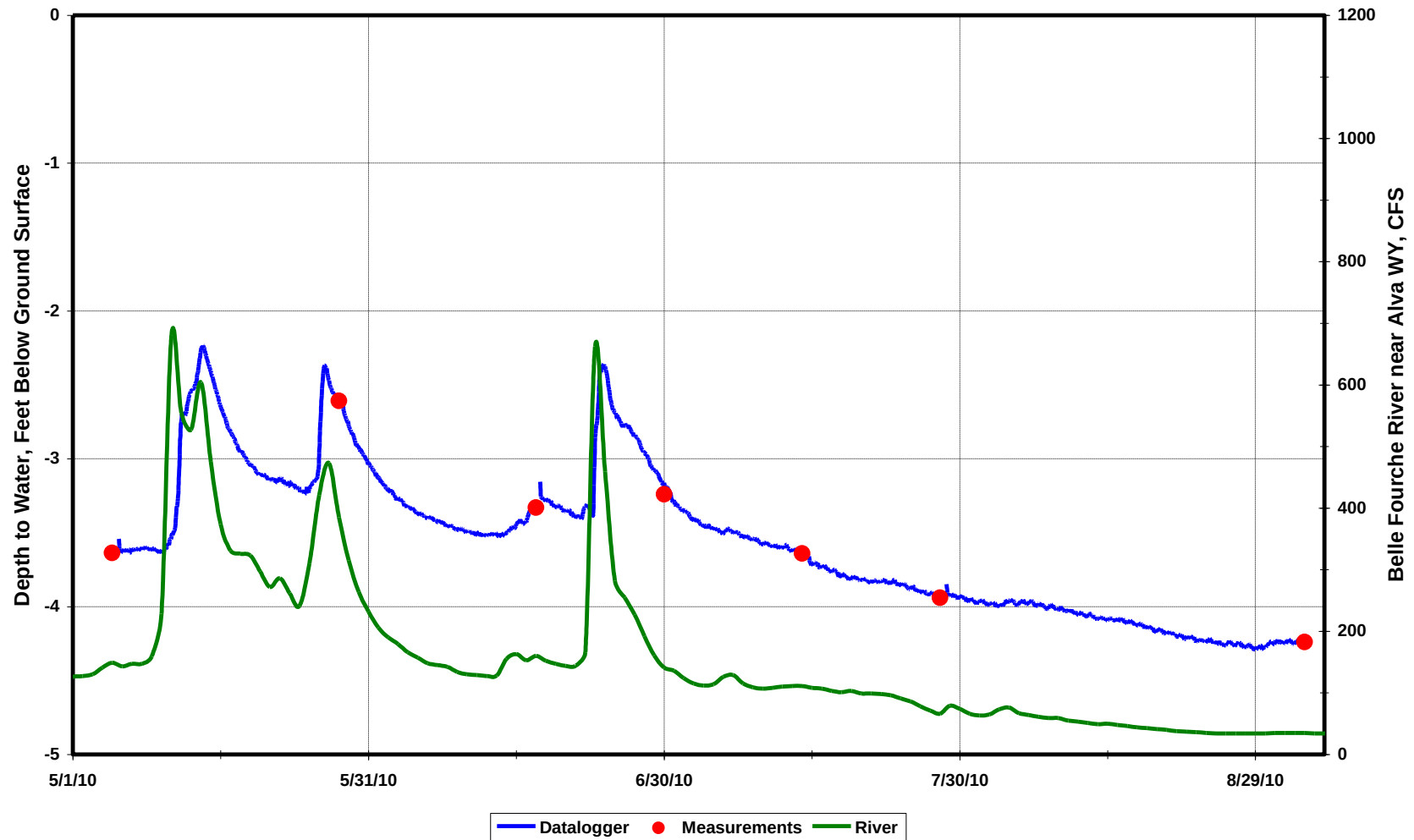


Figure 13. Continuous record and manual measurements of water levels in Well P2; Summer 2010.

Devils Tower Well P3
Summer 2010

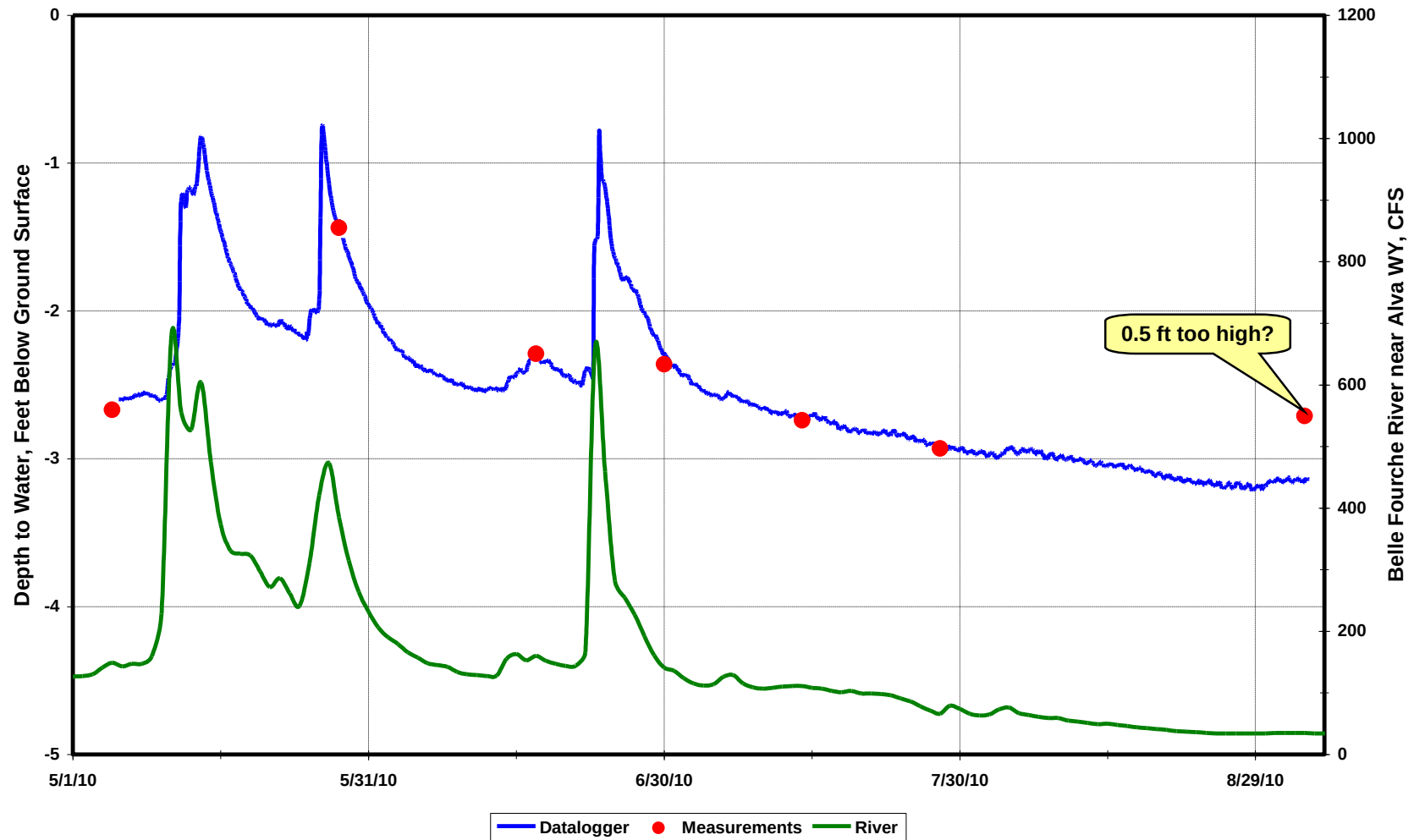


Figure 14. Continuous record and manual measurements of water levels in Well P3; Summer 2010.