HYDRAULIC EVALUATION OF THE BARRIER WELL RECOVERY SYSTEM

FORMER 3M WOODBURY DISPOSAL SITE
WOODBURY, MN

SEPTEMBER 2007

Prepared for

3M Company

Submitted by

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TABLE OF CONTENTS

Section **Page**

LIST OF FIGURES

LIST OF TABLES

Title **Page**

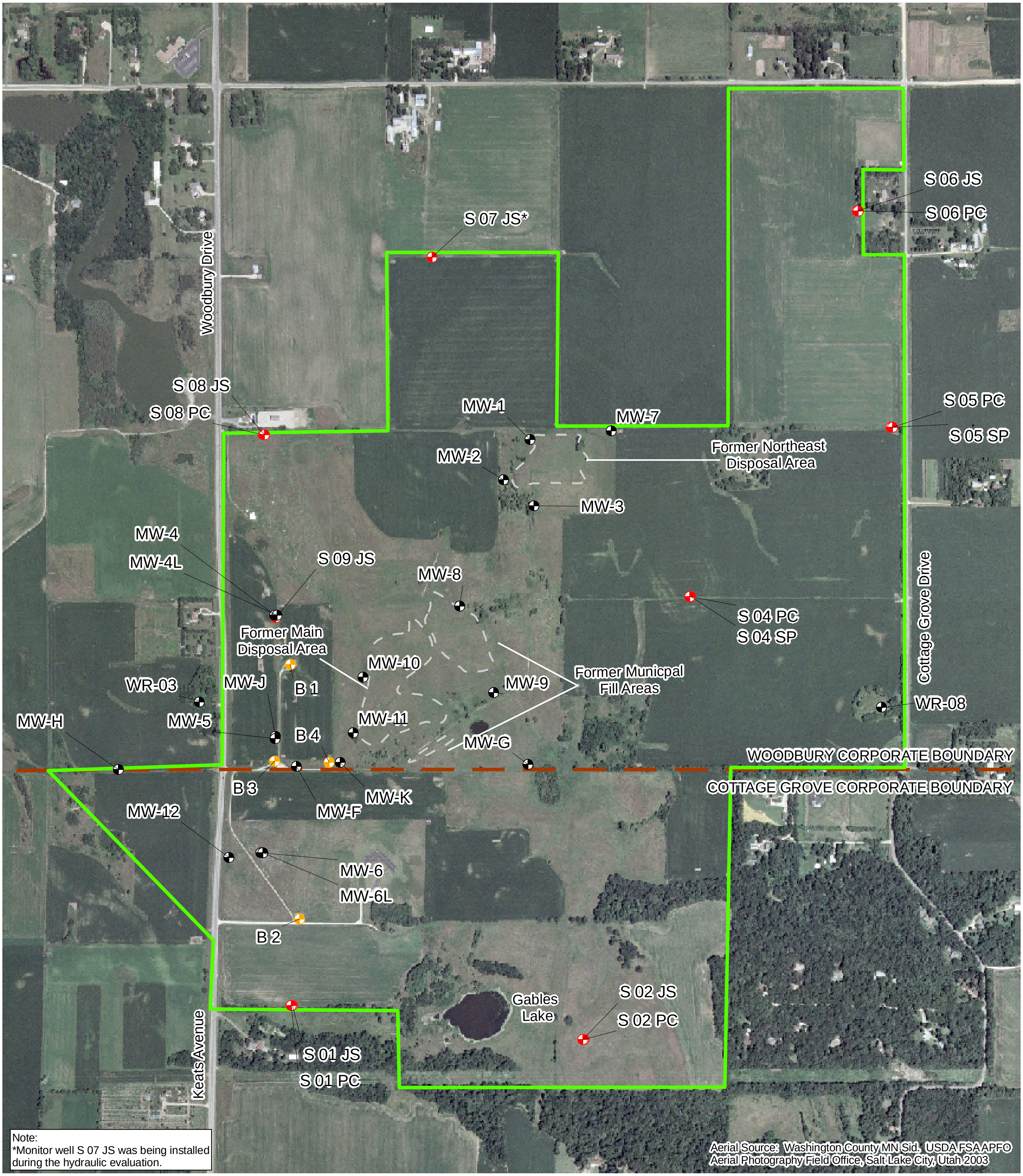
1. BACKGROUND

Since the late 1960s, the 3M Company (3M) has worked cooperatively with state and local authorities in the investigation and remediation of the former Woodbury disposal site (Site) in Woodbury, Minnesota. The Site consists of former waste disposal areas that had received industrial waste from the 3M St. Paul area facilities and the 3M Cottage Grove, Minnesota facility from 1960 to 1966. Municipal wastes from the cities of Woodbury and Cottage Grove were also disposed at the Site from 1960 to 1969.

Disposal of 3M materials occurred at two primary locations on the property, known as the Main Disposal Area and the Northeast Disposal Area. Residents of Woodbury and Cottage Grove disposed of municipal waste at separate locations on the Site. The locations of the former disposal areas are depicted in Figure 1.

In 1966, 3M conducted groundwater sampling at and near the Site. Volatile organic compounds (VOCs), primarily isopropyl ether (IPE), were detected in the groundwater samples from on-site wells and one off-site residential supply well (WR-03). Based on these results, 3M stopped all industrial disposal activities at the Site and initiated a groundwater monitoring program and remedial activities working with state and local authorities.

Four "barrier" pumping wells (B-1, B-2, B-3, and B-4) were installed downgradient of the former disposal areas between 1967 and 1973 and have been operated continuously since installation. The purpose of the barrier wells is to prevent migration of chemical constituents downgradient of the Site. The locations of these barrier wells are shown on Figure 1. Groundwater extraction was also conducted from 1969 until the early 1970s at four shallow wells (referred to as "removal wells") in the Main Disposal Area. The more shallow "removal wells" were abandoned after they went dry reportedly due to a lowering of the water table as a result of pumping of the barrier wells. The water withdrawn at the Site has been, and continues to be, conveyed in underground piping to the 3M Cottage Grove, Minnesota facility for use primarily as non-contact process water at the plant. VOC monitoring data collected from the barrier well have demonstrated



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Locations
- Approximate Disposal Area Boundaries
- Site Boundary

N
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WESTON SOLUTIONS

FIGURE 1

WOODBURY SITE AND
WELL LOCATION MAP
MAY 2007

WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\well_locations.mxd, 26-Sep-07 13:10, ricksc demonstrated effective removal of VOCs while maintaining hydraulic control in the Site vicinity.

Additional remedial activities conducted by 3M at the Site included a waste destruction program and installation of a soil cover over the former disposal areas. The waste destruction program consisted of controlled burning of Site wastes and was conducted in 1968 with approval from the Minnesota Pollution Control Agency (MPCA) and the cities of Woodbury and Cottage Grove. In 1995, 3M re-graded and covered the disposal areas with a 2-foot layer of soil. This activity was conducted under MPCA's Voluntary Investigation and Cleanup (VIC) Program.

More recently, 3M has been working cooperatively with the MPCA to examine the presence of fluorochemicals (FCs) at the Woodbury Site. A series of groundwater samples were collected in March, April, and May 2005 from the four barrier pumping wells and the combined discharge from these wells. These samples were submitted for analysis of four FCs (PFOA, PFOS, PFBS and PFHS). This work was completed as described in the MCPA-approved *Facility-wide Fluorochemical (FC) Investigation Work Plan* (FC Work Plan) for the 3M Cottage Grove, Minnesota facility (Weston Solutions, Inc. [WESTON®], 2004). The above four FCs were detected at low concentrations in three of the four barrier wells (barrier well B-2 had concentration less than laboratory limits of quantitation) and in the combined discharge from these wells. The sampling results were summarized and provided to the MPCA in the *Fluorochemical (FC) Data Assessment Report* for the 3M Cottage Grove, Minnesota Facility (WESTON, April 2006).

In a letter to 3M dated February 1, 2007, the MPCA requested that further assessment of FCs be conducted at the Woodbury Site and that 3M prepare a groundwater monitoring plan. Accordingly, 3M prepared the Fluorochemical (FC) Groundwater Monitoring Plan for the 3M Woodbury Site (Woodbury Site Groundwater Monitoring Plan) and the Fluorochemical (FC) Assessment Work Plan for the 3M Woodbury Site (Woodbury Site FC Work Plan) which addressed the MPCA's requests (WESTON, 2007a and 2007b).

In April 2007, 3M commenced discussions with the MPCA to formalize, under a Settlement Agreement and Consent Order (Consent Order), the process of conducting remedial investigations and response actions to address FCs present at three sites in Minnesota, namely, the Cottage Grove, Oakdale and Woodbury Sites. The Consent Order became effective on May 22, 2007 and requires that 3M conduct a Remedial Investigation/Feasibility Study (RI/FS) with respect to release or threatened release of FCs and VOCs at the Woodbury Site.

As part of the Woodbury Site Groundwater Monitoring Plan, an evaluation of the effectiveness of the barrier well system to maintain hydraulic control of groundwater in the vicinity of the disposal areas was performed. The results from this evaluation are presented in this document.

2. SITE SETTING

2.1 SITE LOCATION AND DESCRIPTION

The Site lies on the border of the Cottage Grove/Woodbury municipal boundary and in the area encompassed by Woodbury Drive (County Road 19) and Cottage Grove Drive, as shown in Figure 1. The property on which the Site is located consists of approximately 656 acres of land that 3M purchased between 1961 and 1992. The former Main Disposal Area is approximately 10 acres; the former Northeast Disposal Area is approximately 5 acres; and the former Municipal Fill Areas are approximately 5 acres.

The Site is currently undeveloped with portions of the property used for agricultural purposes. The surrounding properties are primarily used for agriculture with limited residential development in the area. The Site is fenced with no trespassing signs posted. Access is controlled through locked gates along Woodbury Drive and Keats Avenue to the west, and Cottage Grove Drive along the eastern Site boundary.

The Site is situated on an upland area between the Mississippi and St. Croix River valleys. The topography of the area consists of low rolling hills typical of glacially deposited terrain. Ground surface elevations at the Site range from approximately 850 to 990 feet above mean sea level (ft msl). The higher elevations occur in the north-central area of the property. Surface water features include an unnamed pond in the central Site area, and Gables Lake located near the southern boundary of the Site. There are no outlets for these surface water features.

2.2 SITE GEOLOGY

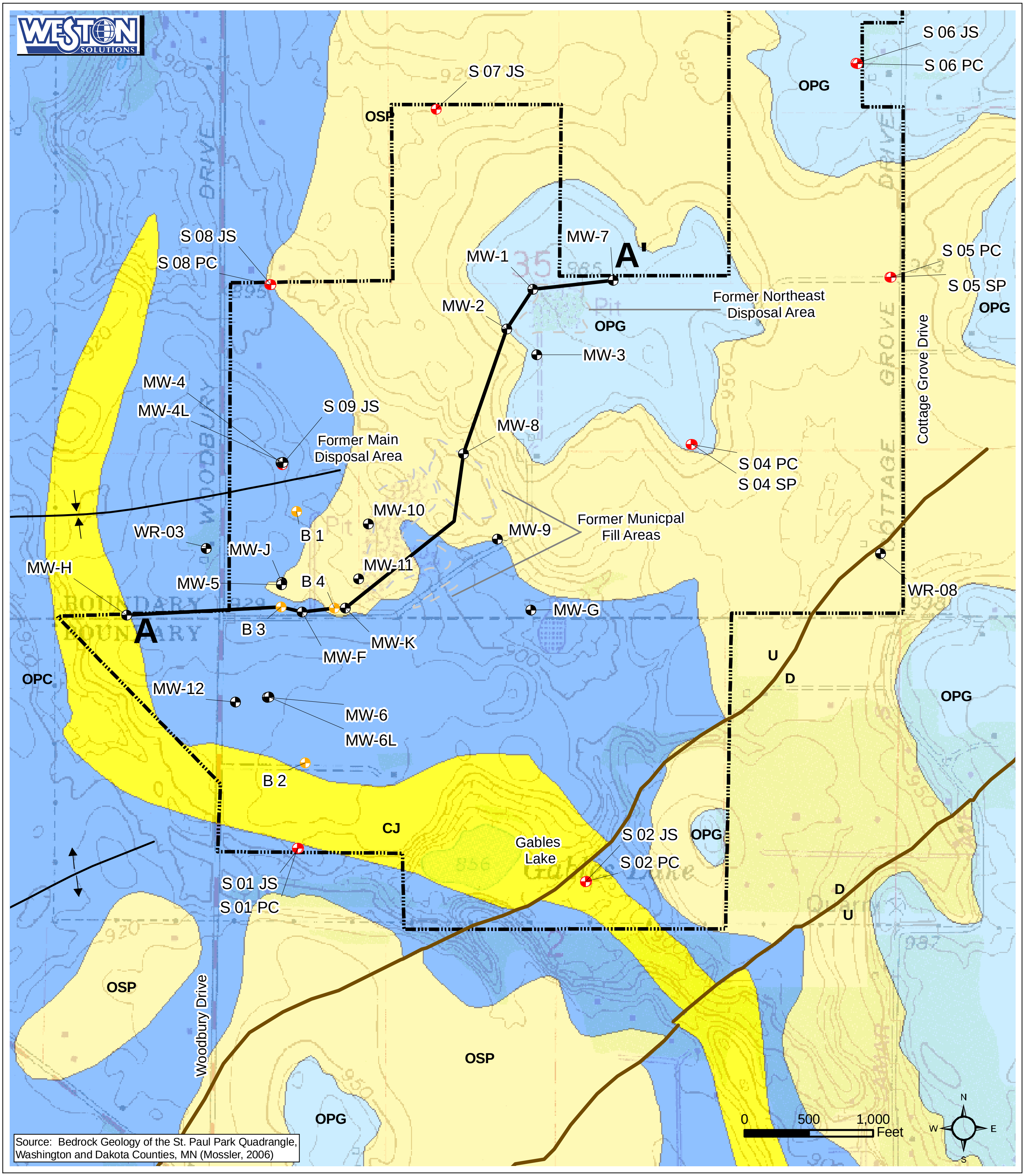
Southern Washington County is characterized by bedrock uplands that are dissected by preglacial stream valleys. The glacial sediments of southern Washington County were deposited primarily by glacial outwash from Superior lobe meltwater during the late Wisconsinan glaciation. The outwash consists primarily of sand, gravel, and cobbles. The uplands are generally mantled by a thin layer of glacial sediments; however, the stream valleys can be filled by glacial deposits up to 300 feet thick (Swanson and Meyer, 1990). Figure 2 is a bedrock geologic map of the Site and surrounding area, and Figure 3 presents a cross-section across the Site. As shown in these Figures, a bedrock valley intersects a portion of the western and southern Site area where a thick sequence of glacial deposits is present. The bedrock valley is shown in Figure 2 where the Jordan Sandstone is the subcropping bedrock unit. Also shown in Figure 2 is a northeast/southwest trending fault that intersects the southeast and eastern Site area. A number of northeast/southwest trending faults that offset the bedrock units are identified to be present in the Site vicinity in southern Washington County. These faults may connect water-bearing zones within one bedrock unit with another depending on the amount of vertical displacement of the fault.

Beneath the glacial drift deposits, regional bedrock units in this area are marine sedimentary rocks of the Paleozoic era. The uppermost bedrock units are the Platteville and Glenwood Formations, which are underlain by:

- St. Peter Sandstone;
- Prairie du Chien Group;
- Jordan Sandstone, and
- St. Lawrence Shale.

As shown in Figure 2, the Platteville Formation is encountered in the subsurface in the higher topographic areas. This unit is described as a thick- to medium-bedded dolostone overlying a thin-bedded limestone. A thin bed of sandy phosphatic dolostone is at the base of the formation. The Platteville Formation is up to 30 feet thick in the Site area.

The Platteville Formation is underlain by the Glenwood Formation, which is described as a green-gray or olive gray, fissile, fossiliferous shale containing scattered limestone beds. It has a sharp non-erosional contact with the overlying Platteville Formation, while its lower boundary grades into the underlying St. Peter Sandstone. The reported thickness of the Glenwood Shale is 3 to 5 feet in the Site area. Saturated conditions were not observed to be present in either the Platteville or Glenwood Formations at any of the drilling locations at the Site.



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Loca ions
- Approximate Woodbury Site Boundary
- A — A' Cross Section Location
- Fold - Line indicates axial trace of anticline or syncline
- U / D Fault - Letters represent vertical displacement U - Up, or D - Down
- OPG Platteville Formation and Glenwood Formation
- OSP St. Peter Sandstone
- CJ Jordan Sandstone
- OPC Prarie du Chien Group

FIGURE 2
WOODBURY WELL LOCATION
AND GEOLOGY MAP
WOODBURY, MINNESOTA

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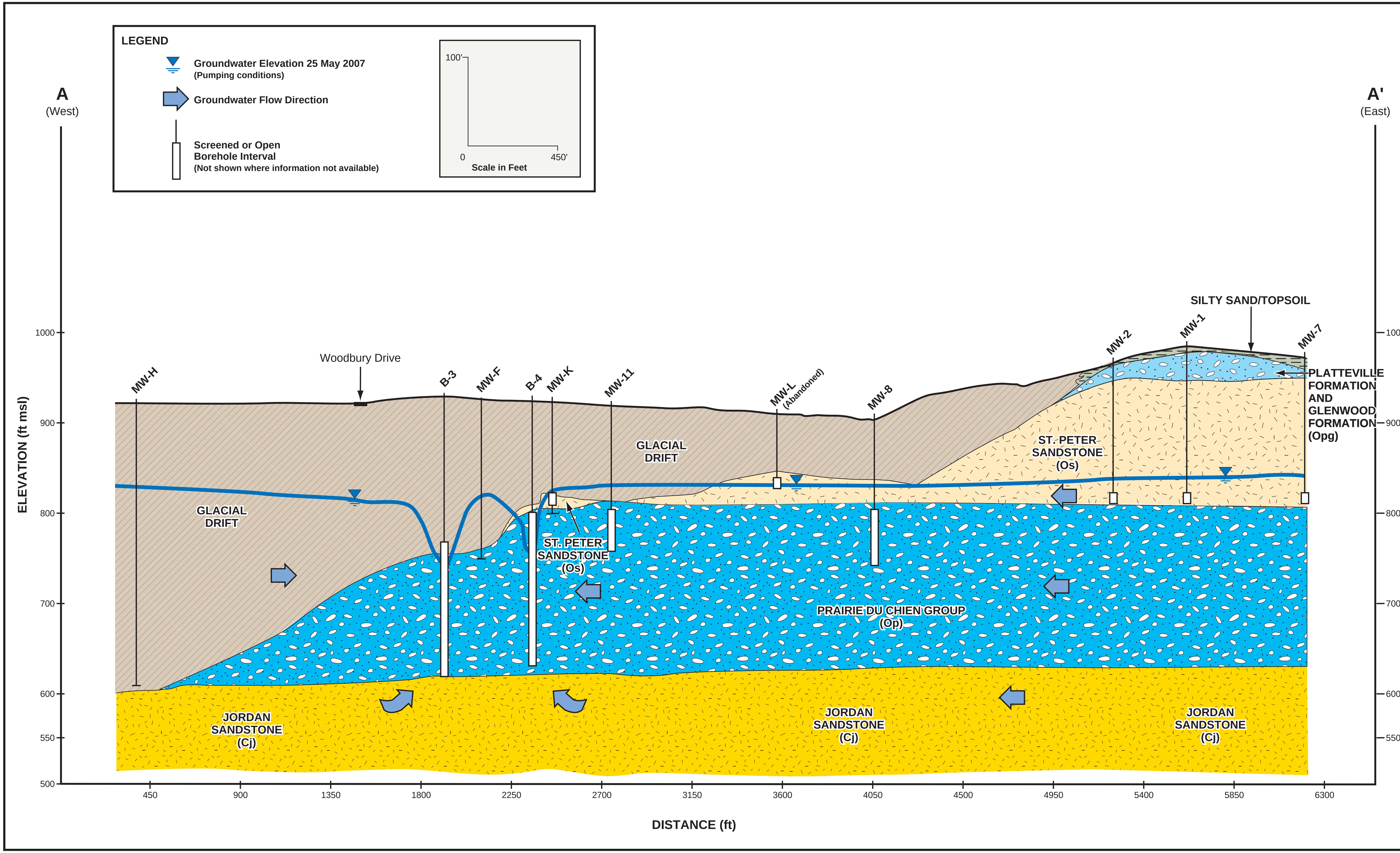

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FIGURE 3 GEOLOGIC CROSS SECTION A-A'
3M WOODBURY SITE
WOODBURY, MN

Underlying the Glenwood Formation is the St. Peter Sandstone. This unit is described as light yellow or white, well-sorted, friable, quartzose sandstone. It is an aquifer of importance in the Twin Cities area, but not in the immediate Site area as most wells are installed into underlying aquifers. Where not eroded, the St. Peter Sandstone is reported to be up to 165 feet thick in the Site vicinity (Mossler, 2006).

In lower lying areas, the Platteville Formation and St. Peter sandstone are eroded away and the Prairie du Chien Group is the first encountered bedrock unit (Figures 2 and 3). The Prairie du Chien Group underlies the St. Peter Sandstone and was observed to be up to 200 feet thick at some Site drilling locations. It is divided into the upper Shakopee formation and the underlying Oneota dolomite. The Shakopee Formation is a mixed carbonate-siliclastic unit that contains thin to medium beds of dolostone, sandy dolostone, and sandstone. The Oneota Dolomite is a thickly-bedded very fine-grained dolostone. Karst processes active early in the history of the Prairie du Chien initiated the development of a regionally extensive zone of high permeability both above and below the sequence boundary between the Shakopee Formation and Oneota Dolomite (Tipping, 2006).

The Prairie du Chien Group is underlain by the Jordan Sandstone, which is described as a coarse- to medium-grained quartzose sandstone. Though no site monitor wells have fully penetrated the Jordan Sandstone, it is reportedly 80 to 85 feet thick in the Site vicinity. The Prairie du Chien and Jordan units are important regional aquifers and most commonly used for municipal and residential water wells.

The St. Lawrence Formation is described as a light gray to yellowish-gray dolomitic siltstone and shale. The formation is up to 45 feet to 50 feet thick. In the Site vicinity, the St. Lawrence Formation is characterized as a unit that has low bulk hydraulic conductivity in a vertical direction and can therefore serve as a confining unit (Runkel et al, 2003).

2.3 SITE HYDROGEOLOGY

In the lower lying areas of the Site, groundwater exists within the unconsolidated glacial drift deposits. These lower lying areas exist in the western region of the site near the barrier well network, southern area near Gables Lake, and in the vicinity of the buried bedrock valley that intersects the southwestern and southern area of the Woodbury property. In general, the glacial drift sediments are less transmissive than the Jordan Sandstone aquifer and zones within the Prairie du Chien Group. In a regional model constructed for Washington County, a lower hydraulic conductivity value is input in the model for the glacial drift sediments than the hydraulic conductivity values for the Jordan Sandstone or Prairie du Chien aquifers (Barr, 2005).

In other areas of the Site, first encountered groundwater is within either the St. Peter Sandstone or the Prairie du Chien Group. The depth-to-groundwater across the Site varies from approximately 40 to 146 feet below ground surface (ft bgs). The greatest measured depth-to-groundwater is in the vicinity of the Northeast Disposal area which exists on a local topographic high. The shallowest depth-to-groundwater is near Gables Lake in the south-central area of the Site.

As shown in a regional hydrogeologic map (Kanivetsky and Cleland, 1990) presented in Figure 4, the groundwater flow direction within the Prairie du Chien-Jordan aquifer in the Site vicinity is toward the south-southwest. The Site is to the west of a regional groundwater divide mapped for the Prairie du Chien-Jordan aquifer. In areas further east and south of the site, groundwater flows east toward the St. Croix River and south toward the Mississippi River, respectively.

According to lithologic information collected during drilling activities performed on Site, the St. Peter Sandstone is a well sorted fine- to medium-grained friable sandstone, whereby groundwater flow occurs primarily through the pore spaces in the bedrock. In the Twin Cities area, the lower portion of the St. Peter Sandstone can be shaley and function as an aquitard over the Prairie du Chien Group (Palen, 1990).

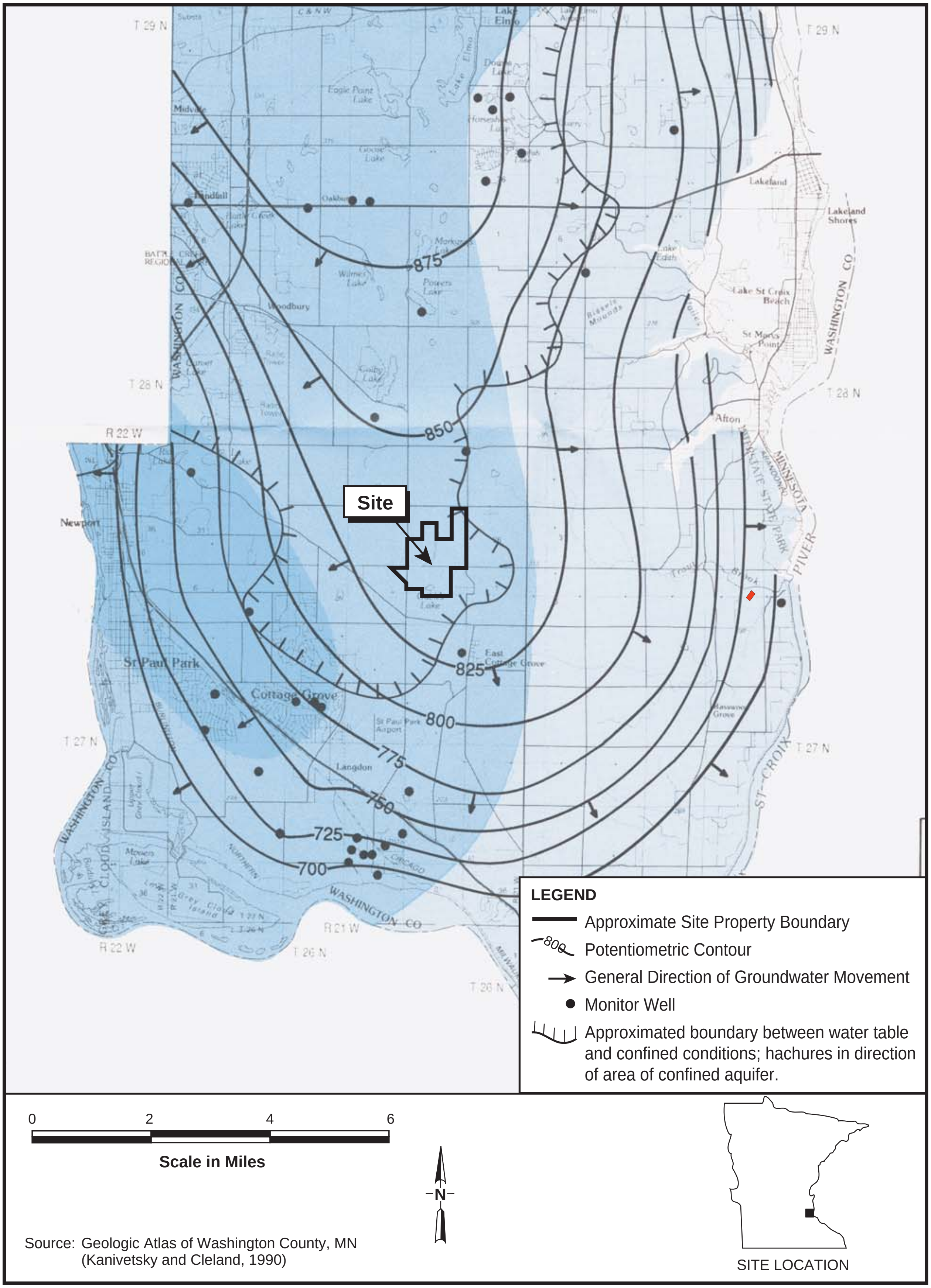

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FIGURE 4 PRAIRIE DU CHIEN – JORDAN AQUIFER POTENTIOMETRIC CONTOUR MAP WASHINGTON COUNTY, MN

Groundwater flow within the Prairie du Chien formation is controlled by secondary porosity features such as fractures and voids, while groundwater flow within the Jordan sandstone occurs between pore spaces within the rock matrix and may also occur along fractures (Runkel et al., 2003). Historically, the Prairie du Chien Group and Jordan Sandstone were often considered to be one hydrologic unit. Together, the two units form the primary bedrock aquifer in the Twin Cities area and are used as the source of water by most of the suburban communities that rely on groundwater. However, recent studies have divided the Prairie du Chien Group into an upper more transmissive unit comprised of the Shakopee Formation and the uppermost portion of the Oneota Dolomite, and a confining unit comprised of the remainder of the Oneota dolomite. These studies identified a high permeability zone near the contact of the Shakopee Formation and Oneota Dolomite as mentioned previously. In wells with open holes extending from the Shakopee Formation through the Oneota Dolomite and into the underlying Jordan Sandstone, head differences indicate that portions of the Oneota Dolomite act as a confining unit. Ambient flow measurements showed groundwater entering the borehole in the upper Shakopee and exiting through a series of fractures in the lower Shakopee Formation. In addition, water entered the borehole from the Jordan Sandstone and exited near the Shakopee Formation-Oneota Dolomite contact (Tipping, 2006).

Existing hydraulic data for the Site include single well slug tests that were performed by Conestoga-Rovers and Associates (CRA) at a number of site monitor wells, and a barrier well pumping test. Hydraulic conductivity values calculated by CRA for monitor wells MW-1 and MW-3, completed in the St. Peter Sandstone, were 3.1 and 4.8 feet per day (ft/day), respectively. The estimated hydraulic conductivity values for several Prairie du Chien aquifer wells (MW-9, MW-10, and MW-6L) were an order of magnitude higher than those values estimated for the monitor wells completed in the St. Peter Sandstone. Aquifer tests were performed on each of the four barrier wells in the early 1970s. The results of these tests yielded an average transmissivity of 12,500 ft^2/day (CRA, 1994) for the four barrier wells.

3. GROUNDWATER RECOVERY SYSTEM

3.1 DESCRIPTION

A groundwater recovery system has been in operation at the Site to capture groundwater impacted by chemical constituents since the installation of the well network between 1967 and 1971. As mentioned previously, the groundwater recovery network consists of four "barrier" wells (B-1, B-2, B-3, and B-4) operating at an average combined flow rate of 3,280 gallons per minute (gpm). Figure 1 presents the location of each well, and Table 1 summarizes well construction details and average pumping rate for each well. According to lithologic logs, barrier wells B-1, B-3, and B-4 are screened primarily across the Prairie du Chien Group. Barrier well B-1 extends into the Jordan Sandstone while the bottom of the well screens of barrier well B-3 and B-4 are near the contact between the Prairie du Chien Group and the Jordan Sandstone. Barrier well B-2 is screened across glacial drift sediments, the St. Peter sandstone, and a portion of the Prairie du Chien formation.

3.2 HYDRAULIC EVALUATION

An evaluation was performed by WESTON from 24 to 31 May 2007 to assess the effect of the groundwater recovery system on groundwater levels in the area. As shown in Table 2, groundwater levels were measured either manually or electronically using a submersible transducer equipped with a datalogger in 39 monitor or barrier wells. Depth-to-groundwater measurements were recorded in the barrier wells only during non-pumping periods. Measurements could not be recorded during pumping periods due to the risk of getting the probe stuck in the wells.

Figure 1 shows the well locations included in the monitoring program. Dataloggers were installed in 17 wells and programmed to collect water level data at one-minute intervals. Periodic manual depth-to-water measurements were recorded in these wells to confirm proper operation of the instruments. In addition, manual depth-to-groundwater

Table 1

Barrier Well Construction Summary
Woodbury Site
Woodbury, MN

	Well Construction[1]				Borehole Log[1]				
Well ID	Well Diameter (in.)	Total Depth (ft bgs)	Screened or Open Interval (ft bgs)	Average Pumping Rate (gpm)[2]	Borehole Depth (ft bgs)	Top Depth (ft bgs)	Bottom Depth (ft bgs)	Geologic Description	Geologic Unit
B-1	16	320	190-320	960	350	0	129	Glacial Drift	Drift
						129	320	Dolomite	OPDC
						320	350	Sandstone	CJDN
B-2	16	315	195-315	150	315	0	250	Glacial Drift	Drift
						250	293	Sandstone	OSTP
						293	315	Dolomite	OPDC
B-3	16	310	160-310	770	310	0	180	Glacial Drift	Drift
						180	310	Dolomite	OPDC
B-4	24	300	155-300	1400	300	0	122	Glacial Drift	Drift
						122	146	Sandy Dolomite	OPDC
						146	300	Dolomite	OPDC

[1]Information obtained from borehole/well completion reports
[2]As measured in May 2007.
in. = inches
ft bgs = feet below ground surface
gpm = gallons per minute
OPDC = Prairie du Chien Group
OSTP = St. Peter Sandstone
CJDN = Jordan Sandstone

Table 2

Summary of Groundwater Elevation Measurements
Hydraulic Evaluation
Woodbury Site - May 2007
Woodbury, MN

Well ID	Total Depth	Zone(s) Monitored	Method of Monitoring Water Level	Groundwater Elevation 25 May 2007 (Pumping Conditions)	Groundwater Elevation 28 May 2007 (Non-pumping Conditions)	Change in Water Level between Pumping and Non-Pumping Conditions
MW-1	173.8	St. Peter Sandstone	Manual	838.32	838.65	0.33
MW-2	161	St. Peter Sandstone	Manual	836.55	836.95	0.40
MW-3	161	St. Peter Sandstone	Manual	836.60	837.37	0.77
MW-4L	187	Middle PdC	Datalogger	829.59	835.07	5.48
MW-4	128	St. Peter Sandstone / Upper PdC	Manual	831.74	834.15	2.41
MW-5	245	Middle PdC	Datalogger	794.97	835.86	40.89
MW-6	178	St. Peter Sandstone	Datalogger	824.14	834.14	10.00
MW-6L	232.7[1]	PdC	Datalogger	826.44	833.50	7.06
MW-7	164.9	St. Peter Sandstone	Manual	838.94	839.58	0.64
MW-8	163	Upper PdC	Datalogger	830.17	836.49	6.32
MW-9	180	Upper PdC	Datalogger	831.21	835.13	3.92
MW-10	115.9[1]	Upper PdC	Datalogger	831.70	834.83	3.13
MW-11	160	Upper PdC	Datalogger	831.77	834.88	3.11
MW-12	205	Glacial Drift / Upper PdC	Datalogger	826.59	833.27	6.68
MW-F	128.7[1]	Glacial Drift	Datalogger	821.27	834.71	13.44
MW-G	226.6[1]	Jordan Sandstone	Manual	833.10	837.36	4.26
MW-H	310	Glacial Drift	Manual	828.24	833.00	4.76
MW-J	166.6	Upper PdC	Datalogger	821.31	834.33	13.02
MW-K	116	St. Peter Sandstone	Datalogger	830.27	831.24	0.97
S-01JDN	335	Jordan Sandstone	Datalogger	828.84	833.82	4.98
S-01PDC	145	Upper PdC	Datalogger	830.02	830.94	0.92
S-02JDN	297	Jordan Sandstone	Manual	834.77	836.93	2.16
S-02PDC	145	Upper PdC	Manual	835.83	837.64	1.81
S-04PDC	201	Upper PdC	Manual	837.94	839.21	1.27
S-04STP	145	St. Peter Sandstone	Manual	837.61	838.06	0.45
S-05PDC	170	Upper PdC	Manual	841.74	842.10	0.36
S-05STP	115	St. Peter Sandstone	Manual	841.92	842.06	0.14
S-06JDN	405	Jordan Sandstone	Manual	842.82	843.12	0.30
S-06PDC	255	Middle PdC	Manual	843.06	843.29	0.23
S-08JDN	322	Jordan Sandstone	Datalogger	835.55	838.75	3.20
S-08PDC	140	Upper PdC	Datalogger	838.11	839.95	1.84
S-09JDN	361	Jordan Sandstone	Datalogger	831.80	837.03	5.23
WR-03	390	Jordan Sandstone	Manual	830.18	835.65	5.47
WR-08	186.7	PdC	Manual	838.28	838.74	0.46

PdC = Prairie du Chien Group
[1] - Total depth measured in May 2007 shallower than reported well completion depth.

measurements were recorded periodically at all other existing Site wells during the monitoring period.

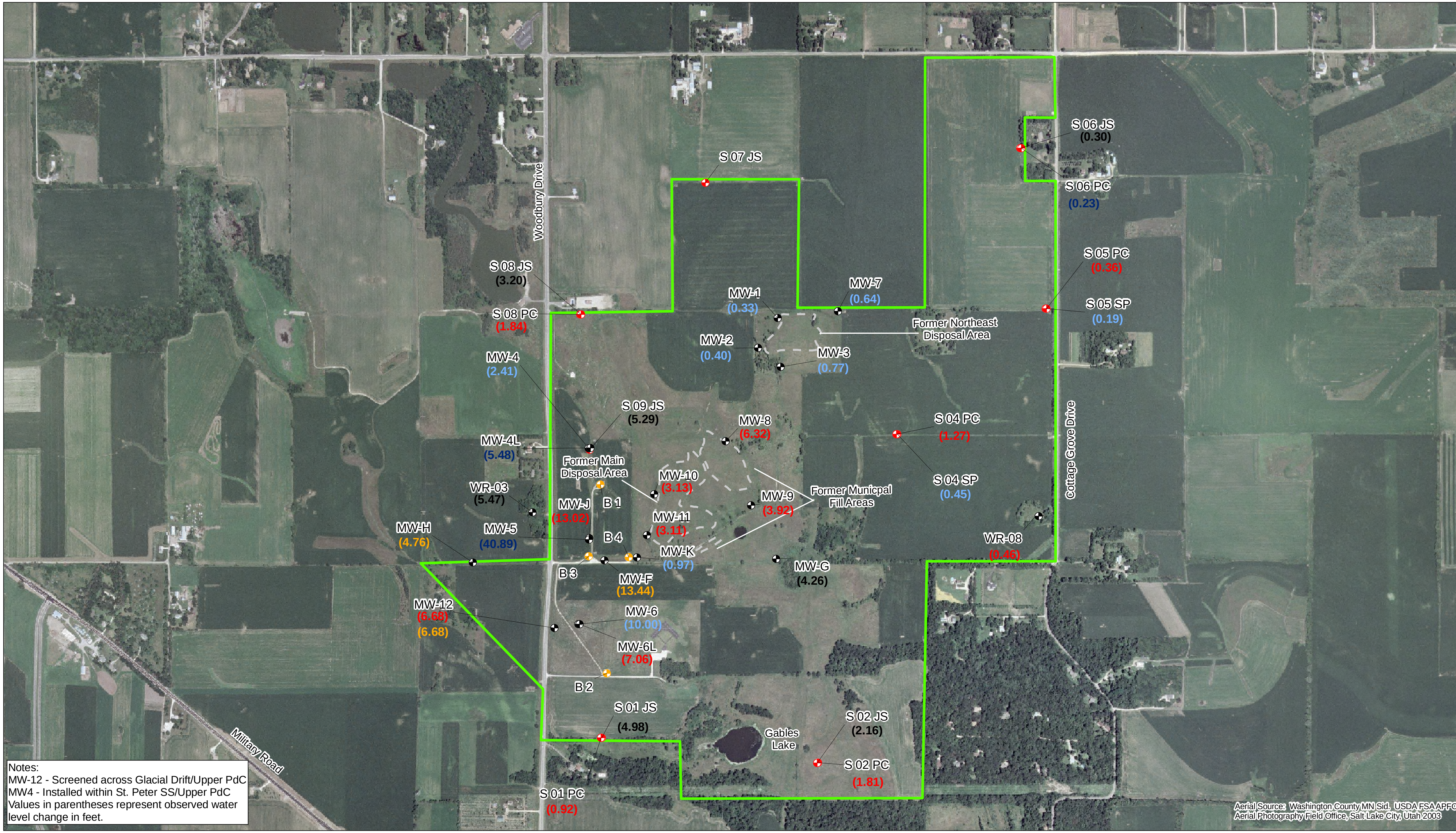
As part of the hydraulic evaluation, the groundwater recovery system was shutdown on the morning of 26 May 2007. The system remained off until 08:45 AM on 28 May 2007. This shutdown period coincided with maintenance activities being performed at the Cottage Grove facility during the Memorial Day weekend. After the plant shutdown, the pumping wells were turned on at a rate of one per hour from the lowest to highest yielding wells (i.e., B-2→B-3→B-1→B-4). This enabled the short term effect each barrier well has on groundwater levels in nearby observation wells to be assessed.

As mentioned previously, the discharge water generated at the Woodbury Site is routed to 3M's Cottage Grove facility where it is used primarily as non-contact cooling water. The barrier well system remained off for as long of a period as possible until the discharge water was required to resume normal plant operations at the Cottage Grove facility.

3.3 DATA ANALYSIS

3.3.1 Hydrographs

Hydrographs showing the groundwater elevation collected using the pressure transducers and groundwater temperature data plotted with the operational periods of the barrier wells are included in Attachment 1. Additional hydrographs showing groundwater elevation data collected manually are presented in Attachment 2. An examination of the hydrographs reveals a variable response in the water levels of the monitor wells across the site to the pumping of the barrier wells. Table 2 presents the calculated difference in water levels between pumping and non-pumping conditions during the hydraulic evaluation. The response in groundwater levels to the shutdown and restart of the groundwater recovery system across the area varied depending on the lithologic unit monitored and the distance from the groundwater recovery network. Figure 5 presents the measured difference in groundwater elevations between pumping conditions (25 May 2007) and non-pumping conditions (28 May 2007). A discussion of the observed response in monitor wells completed in the various hydrogeologic units at the site is



Notes:
MW-12 - Screened across Glacial Drift/Upper PdC
MW4 - Installed within St. Peter SS/Upper PdC
Values in parentheses represent observed water level change in feet.

Legend:

Monitoring Well Locations	(13.44)	Glacial Drift	(6.68)	Upper PdC
Sentinel Well Locations	(10.00)	St. Peter SS		
Barrier Well Locations	(5.48)	Middle PdC		
Site Boundary	(4.98)	Jordan SS		

N E S W

0 500 1,000 2,000
Feet

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FIGURE 5
OBSERVED WATER LEVEL CHANGE BETWEEN PUMPING AND NON-PUMPING CONDITIONS
WOODBURY SITE - MAY 2007

WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\Water_level_change.mxd, 27-Sep-07 09:14, ricksc provided in the following subsections. This discussion is limited to the site monitor wells that had been installed prior to the hydraulic evaluation being performed in late May 2007. Additional site monitor wells were installed after the hydraulic evaluation had been performed. As noted previously, the timing of the hydraulic evaluation coincided with the shutdown of plant activities over the Memorial Day weekend.

Glacial Drift Monitor Wells

Site monitor wells completed within the glacial drift sediments are completed between 116 to 310 feet below ground surface (ft bgs). The variation in depth is due to glacial and other geologic processes that eroded the bedrock surface, especially in the area near the bedrock valley that intersects the southeast and southern Site area. As shown in Table 2 and Figure 5, all monitor wells identified as completed within the glacial drift deposits displayed a response in water level to the operation of the barrier well network. For this set of wells, the largest change in water level (13.4 ft) between pumping and non-pumping conditions was observed in monitor well MW-F which is located between barrier wells B-3 and B-4. A change of approximately 6.7 and 4.8 feet between pumping and non-pumping conditions was observed in the water level data collected from monitor wells MW-12 and MW-H, respectively. Monitor well MW-12 is located along the western Site property boundary between barrier wells B-3 and B-2 and is screened partially across the glacial drift sediments. Monitor well MW-H is located to the west of Woodbury Drive/Keats Avenue, and is installed at 310 ft bgs within the buried bedrock valley.

St. Peter Sandstone Monitor Wells

Water level measurements were taken in seven site monitor wells completed within the St. Peter Sandstone, and one well (MW-4) screened partially across this unit. For these wells, the largest change in water level between pumping and non-pumping conditions was 10 feet in monitor well MW-6 which is located between barrier wells B-2 and B-3. Although the St. Peter Sandstone is not shown to be present in this area on the bedrock geologic map for the area (Figure 2), it is identified to be present at depth in the boring descriptions for monitor wells MW-6 and MW-6L. Glacial processes or faulting may have caused vertical displacement of the St. Peter Sandstone in this area.

In the remaining St. Peter Sandstone monitor wells located to the east and northeast of the barrier well network, the response to pumping of the barrier wells was minimal, or could not be ascertained relative to change due to the barrier well network or response to a precipitation event that occurred a few days prior to the test. As shown in Table 2, at locations where a well couplet exists (e.g. S-04 SP/PC and S-05 SP/PC), the observed change in water level in response to the operation of the barrier well network was greater in the Prairie du Chien monitor well than the adjacent St. Peter Sandstone monitor well. In addition, the water level in monitor well MW-K, located approximately 85 feet from barrier well B-4, showed minimal response to pumping. Regardless of the water level response to pumping at this well, the water level response at other St. Peter Sandstone wells indicate that the bottom of the St. Peter Sandstone appears to act as a semi-confining unit in this area limiting the amount of hydraulic communication between the St. Peter Sandstone and underlying units. Since the St. Peter Sandstone is not laterally continuous across the Site, groundwater within this unit ultimately discharges into either the glacial drift sediments or the Prairie du Chien that are in direct hydraulic communication with the barrier well network.

Upper Prairie du Chien Monitor Wells

Water level measurements were taken in ten site monitor wells identified to be installed within the upper Prairie du Chien aquifer at the Site, and an additional two monitor wells (MW-4 and MW-12) that are identified to be screened partially across this zone. As shown in Table 2 and presented in Figure 5, a response to the operation of the barrier well network was observed over a broad area. For these wells, the largest water level difference of slightly more than 13 feet was measured in monitor well MW-J located just to the north of barrier well B-3.

Monitor well MW-8 showed a change in water level between pumping and non-pumping conditions of almost twice that of nearby upper Prairie du Chien monitor wells (i.e., MW-9, MW-10, and MW-11). This greater change in water level is likely attributable to a greater degree of interconnectivity between fractures intercepted by the open borehole interval of monitor well MW-8 and those intersected by the barrier well network. A response to the pumping of the barrier well network was apparent in all wells monitoring the upper Prairie du Chien including sentinel well S-05 PC, located near the eastern site property boundary.

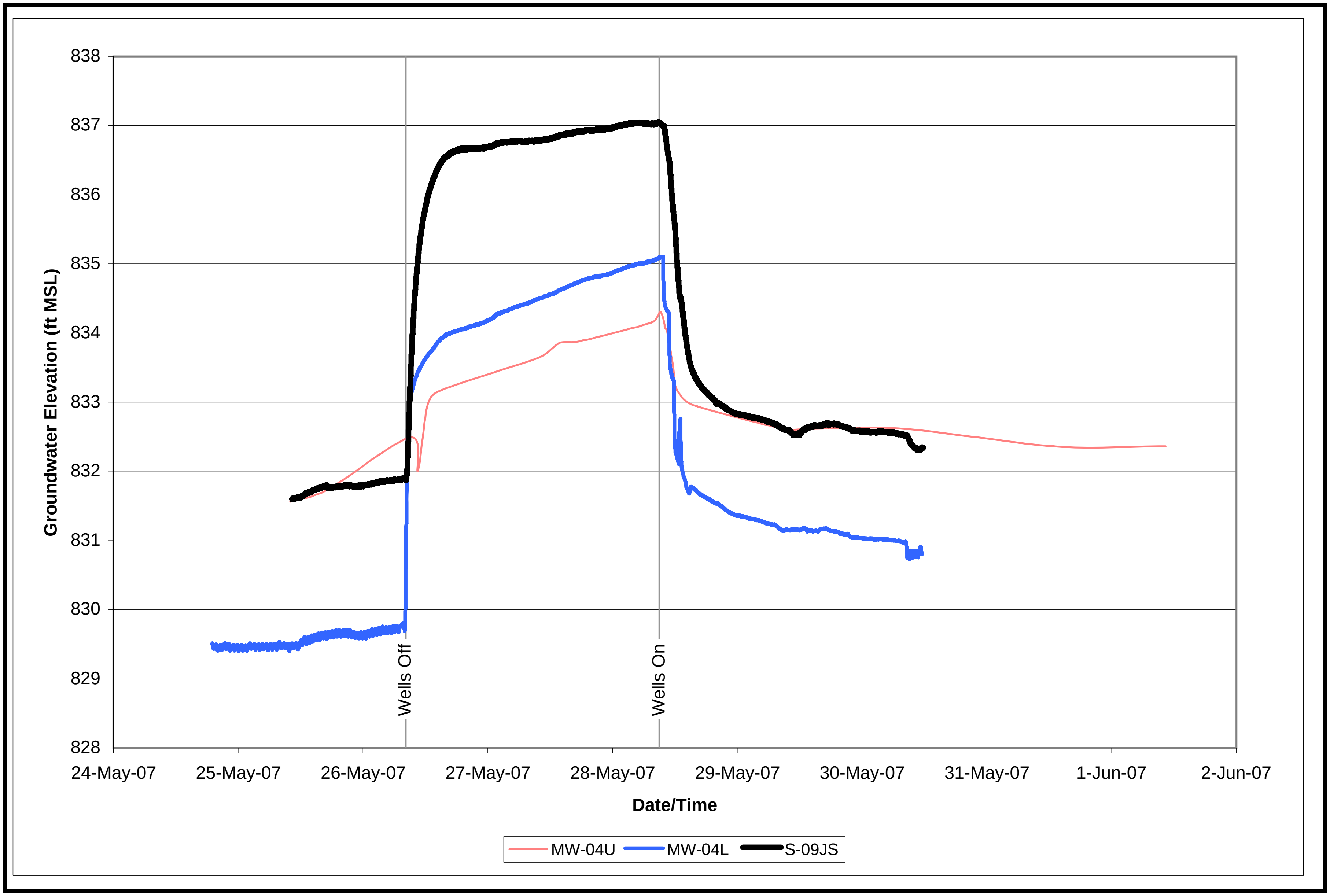
Middle Prairie du Chien Monitor Wells

Three monitor wells are installed near the middle of the Prairie du Chien Group. As shown in Table 2, the greatest change in groundwater levels measured between pumping and non-pumping conditions for all the wells in this evaluation was approximately 40.9 feet in monitor well MW-5. This monitor well is located approximately 200 feet north of barrier well B-3 and is screened across the central portion of the Prairie du Chien Group, likely intercepting the more permeable zone (as discussed in subsection 2.3) near the contact between the Shakopee Formation and the Oneota Dolomite. The water level difference between pumping and non-pumping conditions at monitor well MW-J, located adjacent to monitor well MW-5 and screened across the upper Prairie du Chien, was significantly less at approximately 13 feet. The difference in water level change at these two locations is likely not indicative of a lower transmissive unit intercepted by monitor well MW-5, but due to the fact that monitor well MW-5 is screened across the more permeable unit within the Prairie du Chien Group. This zone is likely providing the highest volume of groundwater being pumped by the barrier well network.

Further evidence supporting this interpretation is apparent in the water level data collected from the monitor well cluster of MW-4, S-09JS, and MW-4L. Shallow monitor well MW-4 is screened in the lower St. Peter Sandstone/upper Prairie du Chien Group (Shakopee Formation), monitor well S-09JS is screened in the Jordan Sandstone, and monitor well MW-4L is screened in the middle of the Prairie du Chien Group. As shown in Figure 6, during non-pumping conditions there is an upward vertical hydraulic gradient in this area. However, during pumping conditions monitor well MW-4L has the lowest groundwater elevation and the vertical gradient is downward from the lower St. Peter

Figure 6

Hydrographs for Monitor Wells MW-4, MW-4L and S-09JS
Woodbury Site, Woodbury, MN
May 2007



MW-4_-4L_S-09JRDFig06

Sandstone/upper Prairie du Chien Group (monitored by MW-4) and upward from the Jordan Sandstone toward the middle portion of the Prairie du Chien Group. This zone has been shown to have the highest porosity and permeability within the Prairie du Chien Group (Tipping et al., 2006).

No apparent water level change was present in the third monitor well (S-06PC) screened near the middle of the Prairie du Chien Group. This monitor well is approximately 5,500 feet away from the closest barrier well (B-1) so the expected response to pumping would be minimal.

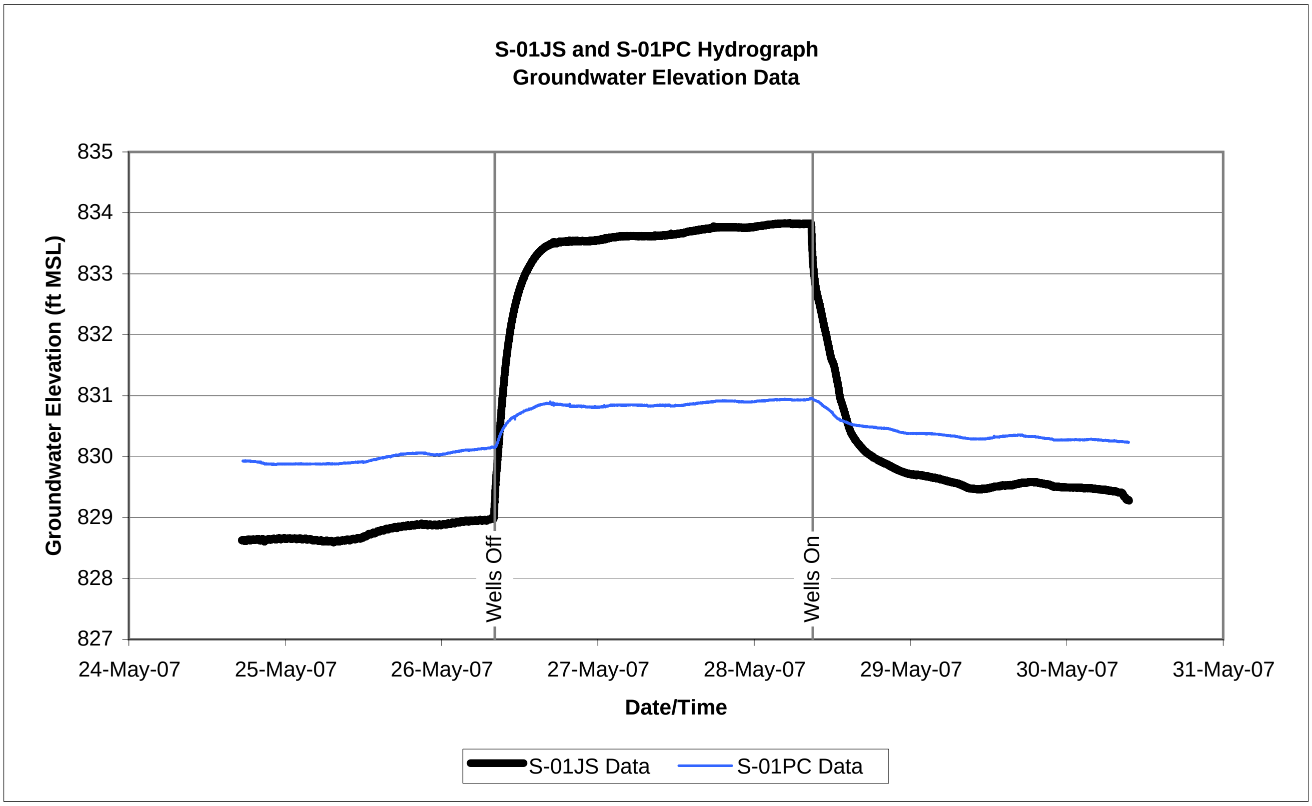
Jordan Sandstone Monitor Wells

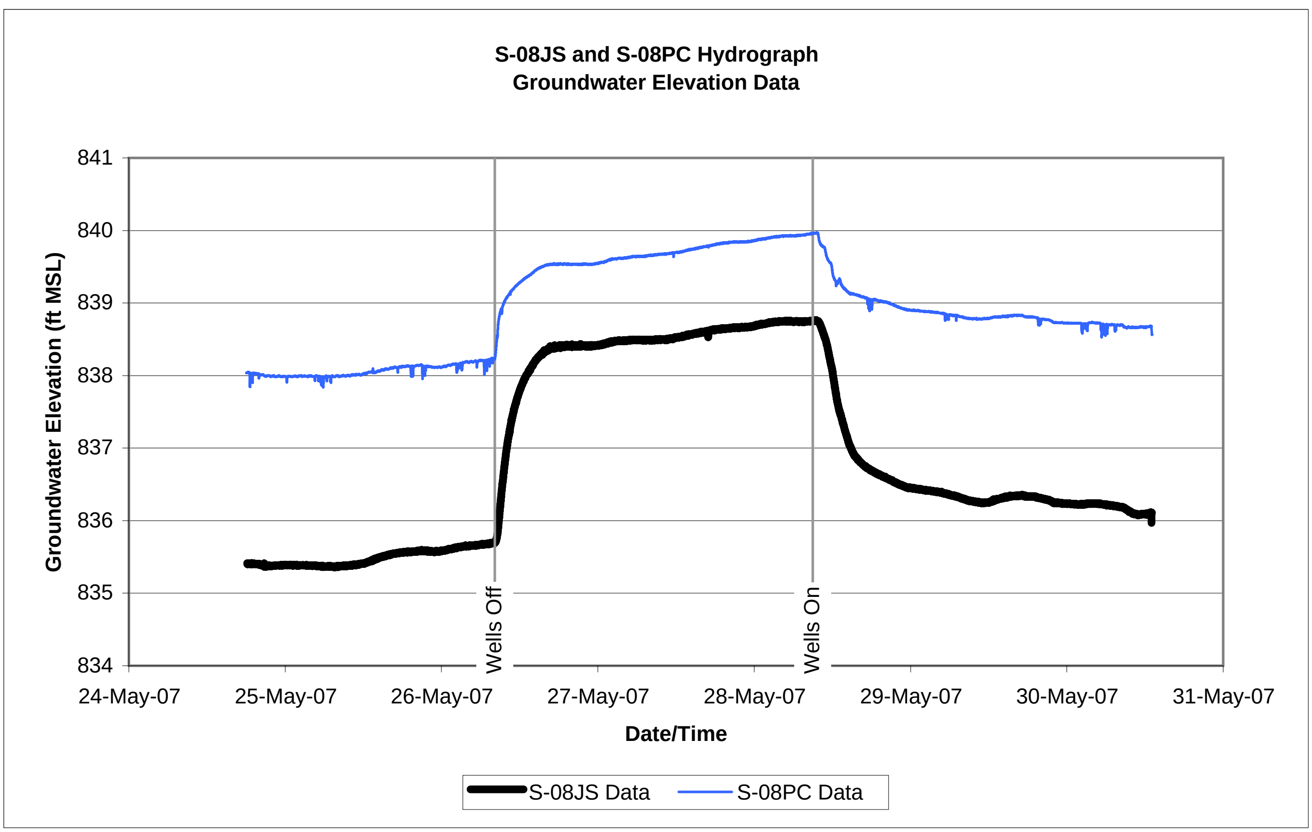
During the period that the hydraulic evaluation was performed, six monitor wells had been installed within the Jordan Sandstone unit. These wells consisted of five monitor wells installed during the drilling program performed on-site in early May 2007 and a former residential supply well (WR-03) to the west of the Site. A response to the operation of the barrier well network was observed in the water levels of all Jordan Sandstone monitor wells except for monitor well S-06 JS that is located in the northeast corner of the Site property approximately 5,500 feet from the closest barrier well (B-1). The greatest change in water level between pumping and non-pumping conditions (5.47 feet) was observed in the water level data collected from former residential supply well WR-03.

Figure 7 presents the hydrographs for monitor well pairs S-01JS/PC and S-08 JS/PC. These hydrographs show a greater response in water level in the Jordan Sandstone aquifer monitor wells than monitor wells completed in the shallow Prairie du Chien Group. An inspection of Table 2 indicates a similar response at other well pairs completed in these units (S-02 JS/PC and S-06 JS/PC). Since the Jordan Sandstone unit is more permeable than the shallow Prairie du Chien aquifer, it is likely supplying a higher volume of groundwater to the barrier well network. In addition, the construction of the barrier wells contribute to the difference in water level response between the two units since the bottom of the barrier wells extend into, or are very close to, the top of the Jordan Sandstone unit.

Figure 7

Hydrographs for Monitor Well Pairs S-01PC/JS and S-08PC/JS
Woodbury Site, Woodbury, MN
May 2007





The hydrograph for the S-01 JS/PC well pair clearly shows a response in water levels to the operation of the barrier well network. According to the geologic map for the area, the S-01 JS/PC well pair is on the south side of the buried bedrock valley while the barrier well network is located on the north side. Therefore, the buried bedrock valley does not limit the lateral extent of the barrier well network, and the Upper Prairie du Chien and Jordan Sandstone aquifers are in hydraulic communication with the barrier well network in this area.

3.3.2 Vertical Gradient Calculations

Table 3 provides a summary of the vertical gradients calculated at well pairs during pumping and non-pumping conditions during the monitoring period. The calculations presented in Table 3 are separated dependant on the zone monitored by the well couplets. An order of magnitude change in the vertical gradient was observed during the monitoring period at the S-04 SP/PC well pair, while no significant change was observed at the S-05 SP/PC location. The difference in response at these two locations is due to distance since the S-05 SP/PC well pair is located further from the barrier well network. The vertical gradient change at the S-04 SP/PC location produced less of an upward vertical gradient between non-pumping and pumping conditions (i.e., a greater response to pumping was observed in the water level in the well completed within the upper Prairie du Chien than the St. Peter Sandstone).

As discussed previously, the change in vertical gradient between well pairs monitoring the Upper Prairie du Chien and the Middle Prairie du Chien becomes more downward during pumping conditions. In addition, the vertical gradient between well couplets that monitor the Upper Prairie du Chien and Jordan Sandstone increase downward during pumping conditions. This does not imply that groundwater is flowing from the Upper Prairie du Chien to the Jordan Sandstone, instead groundwater flow occurs from both of these units toward the more permeable unit in the middle of the Prairie du Chien Group.

No significant change was observed in the vertical gradient between well pairs monitoring the middle Prairie du Chien and Jordan Sandstone. The vertical gradient

Table 3

Summary of Vertical Hydraulic Gradient Calculations
Woodbury Site, Woodbury, MN
May 2007

Well ID	Total Depth (ft bgs)	Screened Interval (ft bgs)			Zone(s) Monitored	Groundwater Elevation (Non-Pumping Conditions)	Vertical Gradient	Groundwater Elevation (Pumping Conditions)	Vertical Gradient
		Top	Bottom	Midpoint					
St. Peter Sandstone/Upper Prairie du Chien Well Couplets									
S-04STP	145	135	145	140	St. Peter SS	838.06	-0.023	837.61	-0.007
S-04PDC	201	180	200	190	Upper PdC	839.21	(Upward)	837.94	(Upward)
S-05STP	115	105	115	110	St. Peter SS	842.06	-0.001	841.92	0.004
S-05PDC	170	150	170	160	Upper PdC	842.10	(Upward)	841.74	(Downward)
Upper Prairie du Chien/Middle Prairie du Chien Well Couplets									
MW-04	128	93	128	110.5	St. Peter SS/Upper PdC	834.15	-0.021	831.74	0.048
MW-04L	190	120	190	155	Middle PdC	835.07	(Upward)	829.59	(Downward)
MW-J	166.6	143	165	154	Upper PdC	834.33	-0.026	821.31	0.454
MW-05	247	177	247	212	Middle PdC	835.86	(Upward)	794.97	(Downward)
Upper Prairie du Chien/Jordan Sandstone Well Couplets									
S-01PC	140	120	140	130	Upper PdC	830.94	-0.014	830.02	0.006
S-01JS	335	325	335	330	Jordan SS	833.82	(Upward)	828.84	(Downward)
S-02PC	139.5	119.5	139.5	129.5	Upper PdC	837.64	0.004	835.83	0.007
S-02JS	295	285	295	290	Jordan SS	836.93	(Downward)	834.77	(Downward)
S-08PC	140	120	140	130	Upper PdC	839.95	0.006	838.11	0.014
S-08JS	320	310	320	315	Jordan SS	838.75	(Downward)	835.55	(Downward)
Middle Prairie du Chien/Jordan Sandstone Well Couplets									
MW-04L	190	120	190	155	Middle PdC	835.07	-0.010	829.59	-0.011
S-09JS	360	350	360	355	Jordan SS	837.03	(Upward)	831.80	(Upward)
S-06PC	254	234	254	244	Middle PdC	843.29	0.001	843.06	0.002
S-06JS	400	390	400	395	Jordan SS	843.12	(Downward)	842.82	(Downward)

ft bgs = feet below ground surface
PdC = Prairie du Chien Formation
SS = Sandstone

between monitor wells MW-04L and S-09 JS is upward while the vertical gradient at the S-06 PC/JS well pair is slightly downward.

3.3.3 Aquifer parameters

Although a response to pumping was observed in the water level data collected from most wells monitored during the hydraulic evaluation, an accurate analysis to obtain aquifer parameters could not be performed due to well construction issues. Specifically, the barrier wells are screened across multiple aquifers withdrawing groundwater from more than one hydrogeologic unit (e.g., Upper Prairie du Chien, Middle Prairie du Chien, and Jordan Sandstone). While the construction of the barrier wells aids in creating groundwater capture in multiple aquifers, it limits the data that can be analyzed to determine estimates of hydraulic parameters since the exact groundwater flux being removed from each of the hydrogeologic units cannot be accurately quantified.

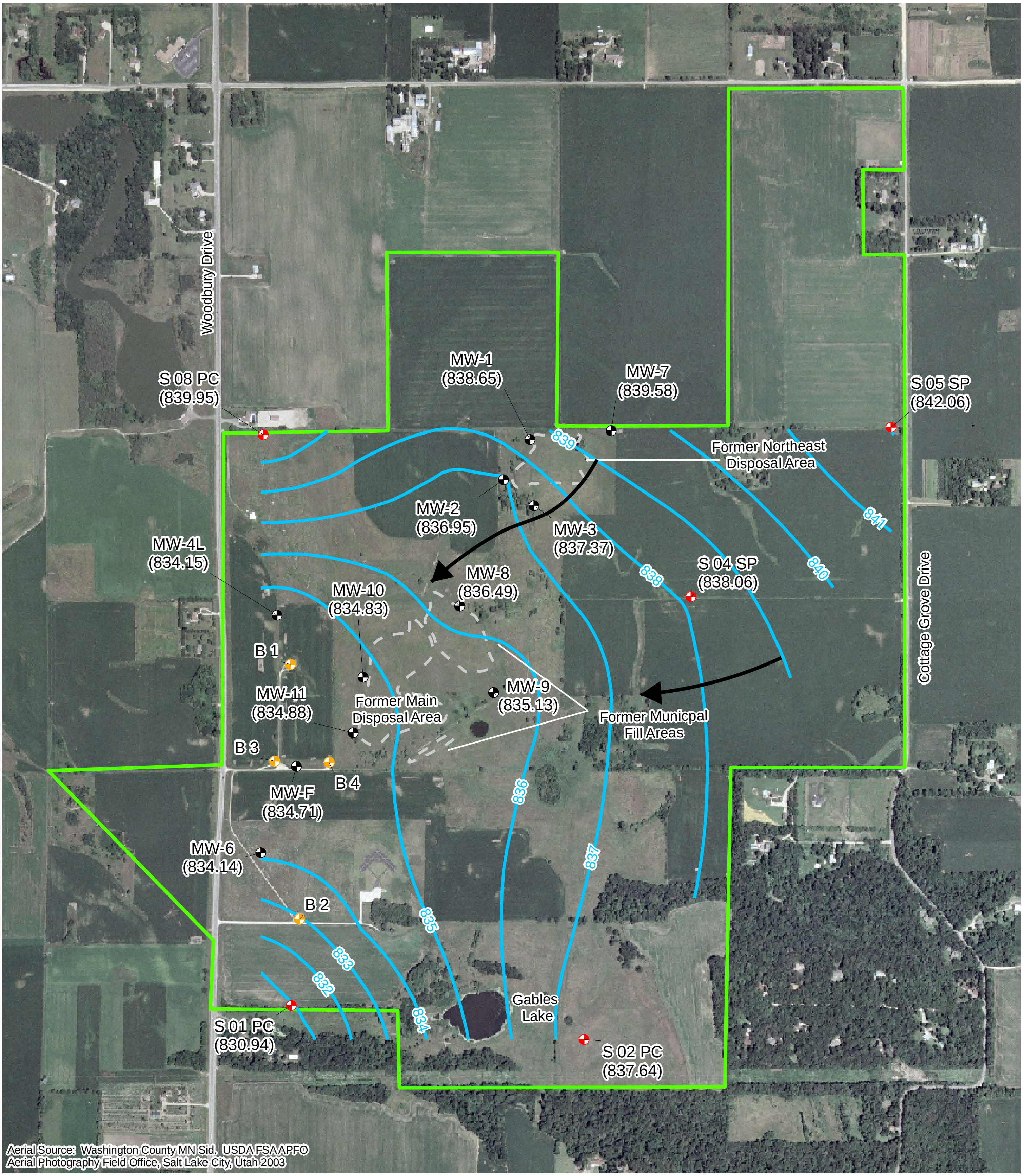
4. GROUNDWATER CONTOUR MAPS

Groundwater elevation contour maps were created using water level data collected from shallow site monitor wells and Jordan Sandstone monitor wells for 26 and 28 May 2007. The groundwater elevations used to develop the contour maps for 26 May were collected just prior to temporarily shutting down the groundwater recovery system (pumping conditions). The groundwater elevations used to construct the contour maps for 28 May 2007 were collected just prior to restarting the groundwater recovery system (non-pumping conditions).

The groundwater elevation data collected during pumping conditions were contoured using KT3D (Tonkin and Larson, 2002), a software program designed to contour groundwater elevation data while taking into account one or more pumping centers. KT3D uses a linear-log kriging method that accounts for more tightly spaced groundwater elevation contours around pumping centers and is capable of performing particle-tracking to estimate capture zones for pumping centers. Traditional contouring packages utilize linear kriging methods that can overestimate predicted capture zones around pumping centers.

Shallow Groundwater Elevation Contour Maps

Monitor wells completed in different hydrostratigraphic units (e.g. glacial drift, St. Peter Sandstone, Upper Prairie du Chien Group) were used to construct the shallow groundwater elevation contour maps since the water table exists within different units across the Site. Figures 8 and 9 present the shallow groundwater elevation contours across the Site collected on 26 and 28 May 2007, respectively. A comparison of Figures 8 and 9 reveals that the groundwater recovery system is creating a large area of depression in the shallow groundwater surface across the Site. As discussed in subsection 3.3.1, the localized depression in the groundwater surface surrounding monitor well MW-08 shown in Figure 8, is likely due to a higher degree of interconnectivity between the zones intercepted by the screened interval of MW-08 and the barrier wells. Under non-pumping conditions (Figure 8) the direction of groundwater



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Locations
- Groundwater Elevation Contour (contour interval 1 foot)
- Interpreted Direction of Groundwater Flow
- (836.82) Groundwater Elevation (ft.msl)
- Site Boundary

N
W E
S

0 500 1,000
Feet

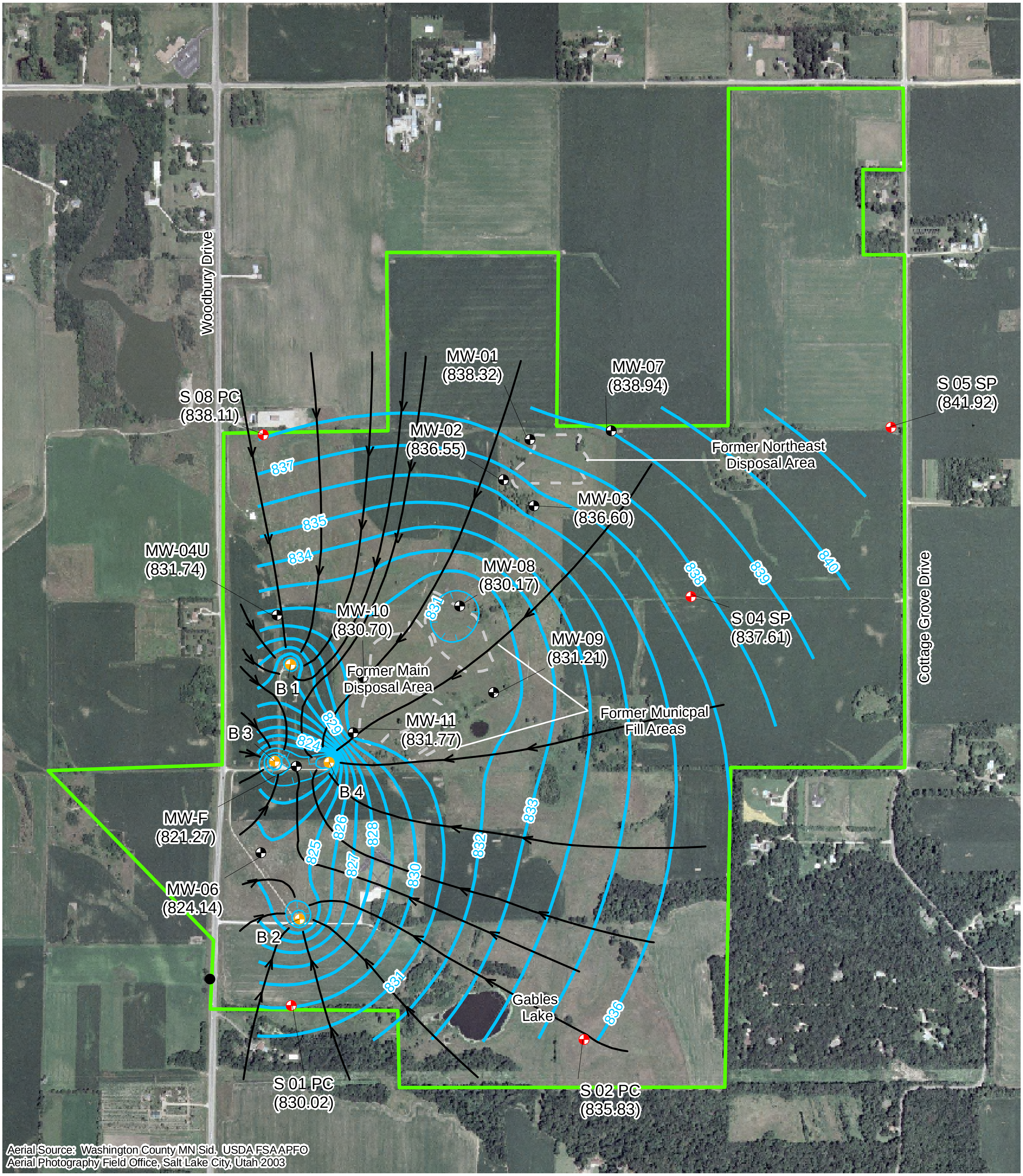
WESTON SOLUTIONS

FIGURE 8

GROUNDWATER ELEVATION CONTOUR MAP
SHALLOW MONITOR WELLS-NON PUMPING CONDITIONS
28 MAY 2007

WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\shallow_gw_elev_jordan_28_may_07.mxd, 26-Sep-07 13:42, ricksc



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Locations
- Groundwater Elevation Contour (contour interval 1 foot)
- Area of Predicted Groundwater Capture
- (836.82) Groundwater Elevation (ft.msl)
- Site Boundary

N W E S

0 500 1,000 Feet

WESTON SOLUTIONS

FIGURE 9

GROUNDWATER ELEVATION CONTOUR MAP
SHALLOW MONITOR WELLS-
PUMPING CONDITIONS
26 MAY 2007

WOODBURY, MINNESOTA

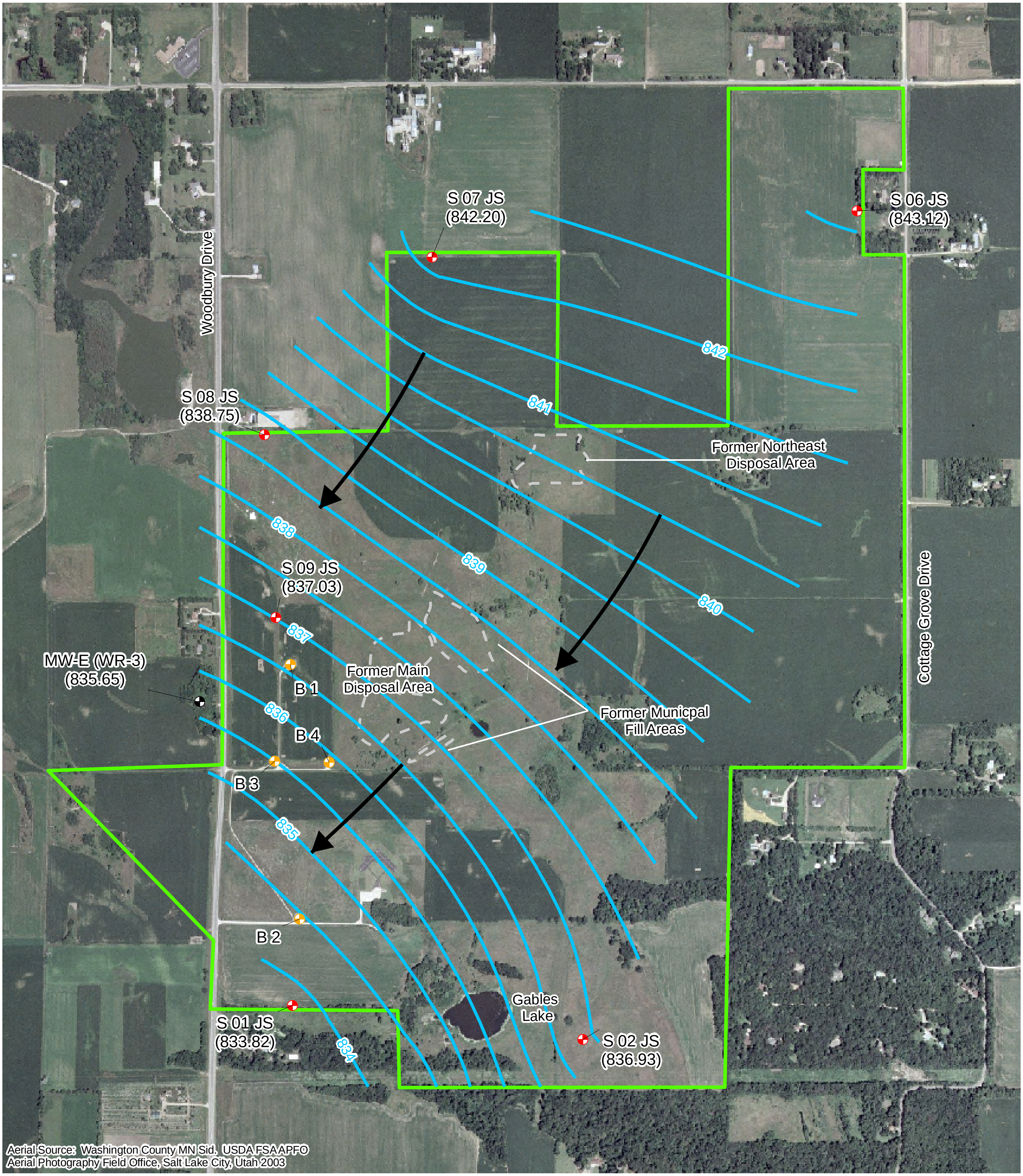
File: \\Fsfed01\TIG\3MWoodbury\MXD\shallow_gw_elev_jordan_26_may_07.mxd, 26-Sep-07 13:47, ricksc flow is westerly to southwesterly with a horizontal hydraulic gradient on the order of 0.003 ft/ft.

During pumping conditions, groundwater flow across the area of the Site depicted in Figure 9 is inward toward the barrier well network. As shown in Figure 9, barrier well B-4 is capturing shallow groundwater across the main and northeast disposal areas. Historical groundwater quality data confirms this conclusion as groundwater samples collected in early 2005 show that FC concentrations in barrier well B-4 are higher than in other barrier wells. The zone of capture for all barrier wells extends across the majority of the Site area.

The monitor wells in the northeast disposal area (MW-1, MW-2, MW-3, and MW-7) are all completed within the St. Peter Sandstone which is the uppermost water-bearing unit in this area. As shown in Figures 8 and 9, groundwater elevation data collected from these monitor wells, and monitor wells S-05SP and S-04SP shows that groundwater in the St. Peter Sandstone flows in a southwesterly direction. Water level data collected during this evaluation indicates that groundwater levels within the St. Peter Sandstone are not as impacted by the barrier well network as the other hydrostratigraphic units. However, groundwater within the St. Peter Sandstone beneath the northeast and main disposal areas flows southwesterly toward the barrier well network into the glacial drift sediments or the upper Prairie du Chien aquifer where the St. Peter Sandstone is not present (Figure 2). As shown in Figure 9, the capture zone for the barrier well network extends across the majority of the Site area and groundwater originating within the St. Peter Sandstone beneath the northeast and main disposal areas is ultimately captured by the recovery system.

Jordan Aquifer Maps

Figures 10 and 11 present the groundwater elevation contours constructed for the Jordan Aquifer collected on 26 and 28 May 2007, respectively. Figure 10 presents the groundwater elevation contours for the Jordan Aquifer under pumping conditions that was constructed using the KT3D software program, and Figure 11 displays the



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Loca ions
- Groundwater Elevation Contour (contour interval 0.5 feet)
- Interpreted Direction of Groundwater Flow
- (836.82) Groundwater Elevation (ft.msl)
- Site Boundary

N W E S

0 500 1,000 Feet

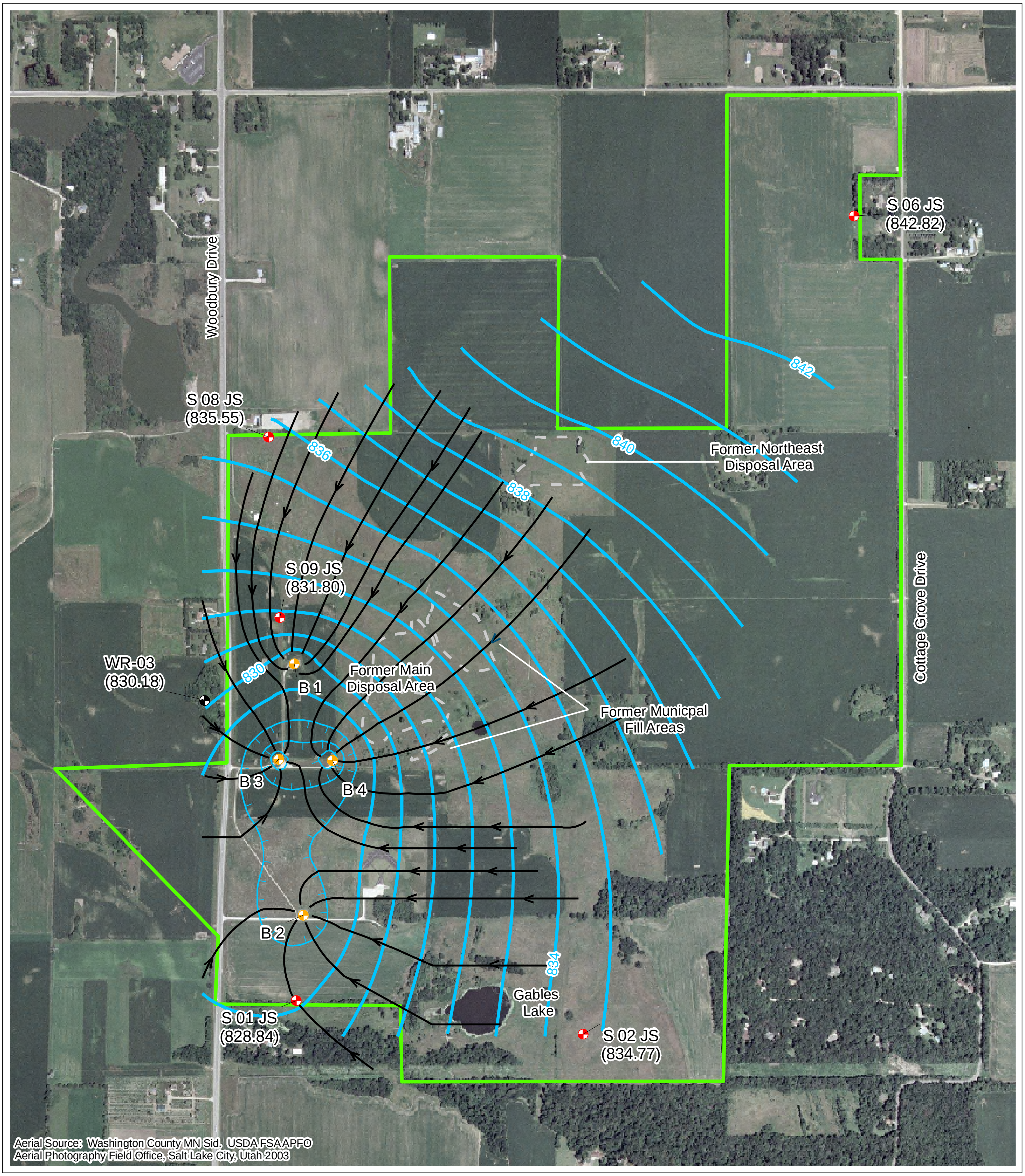
WESTON SOLUTIONS

FIGURE 10

GROUNDWATER ELEVATION CONTOUR MAP
JORDAN AQUIFER-
NON PUMPING CONDITIONS
28 MAY 2007

WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\gw_elev_jordan_28_may_07.mxd, 26-Sep-07 14:06, ricksc



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Locations
- Groundwater Elevation Contour (contour interval 2 feet)
- Area of Predicted Groundwater Capture
- (836.82) Groundwater Elevation (ft.msl)
- Site Boundary

N
W E
S

0 500 1,000
Feet

FIGURE 11

GROUNDWATER ELEVATION CONTOUR MAP
JORDAN AQUIFER-
PUMPING CONDITIONS
26 MAY 2007

WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\gw_elev_jordan_26_may_07.mxd, 26-Sep-07 14:14, ricksc groundwater elevation data after the barrier well system had been off for approximately 48 hours.

An inspection of Figure 10 indicates that the general direction of groundwater flow in the Jordan Sandstone at the Site under non-pumping conditions is toward the southwest. This is in agreement with the groundwater flow direction depicted in published literature (Swanson and Meyer, 1990) and indicates that the Site is to the west of a regional groundwater divide. The horizontal hydraulic gradient under non-pumping conditions is on the order of 0.0015.

A comparison of Figure 10 to 11 indicates that the barrier well system is creating a large depression in the groundwater surface during pumping conditions. As shown in Figure 11, the groundwater elevation data collected from monitor wells completed within the Jordan Sandstone unit indicate an inward hydraulic gradient toward the barrier well network during pumping conditions. Groundwater flowlines show that the barrier well system is capturing groundwater over a broad area of the Site. The predicted capture zones for barrier wells B-1 and B-4 extend beneath, and in the vicinity of, the northeast and main disposal areas. The capture zone for barrier well B-3 extends primarily across the western Site area while the barrier well B-2 capture zone is across the southern area of the Site.

5. JUNE 2007 GROUNDWATER ANALYTICAL DATA

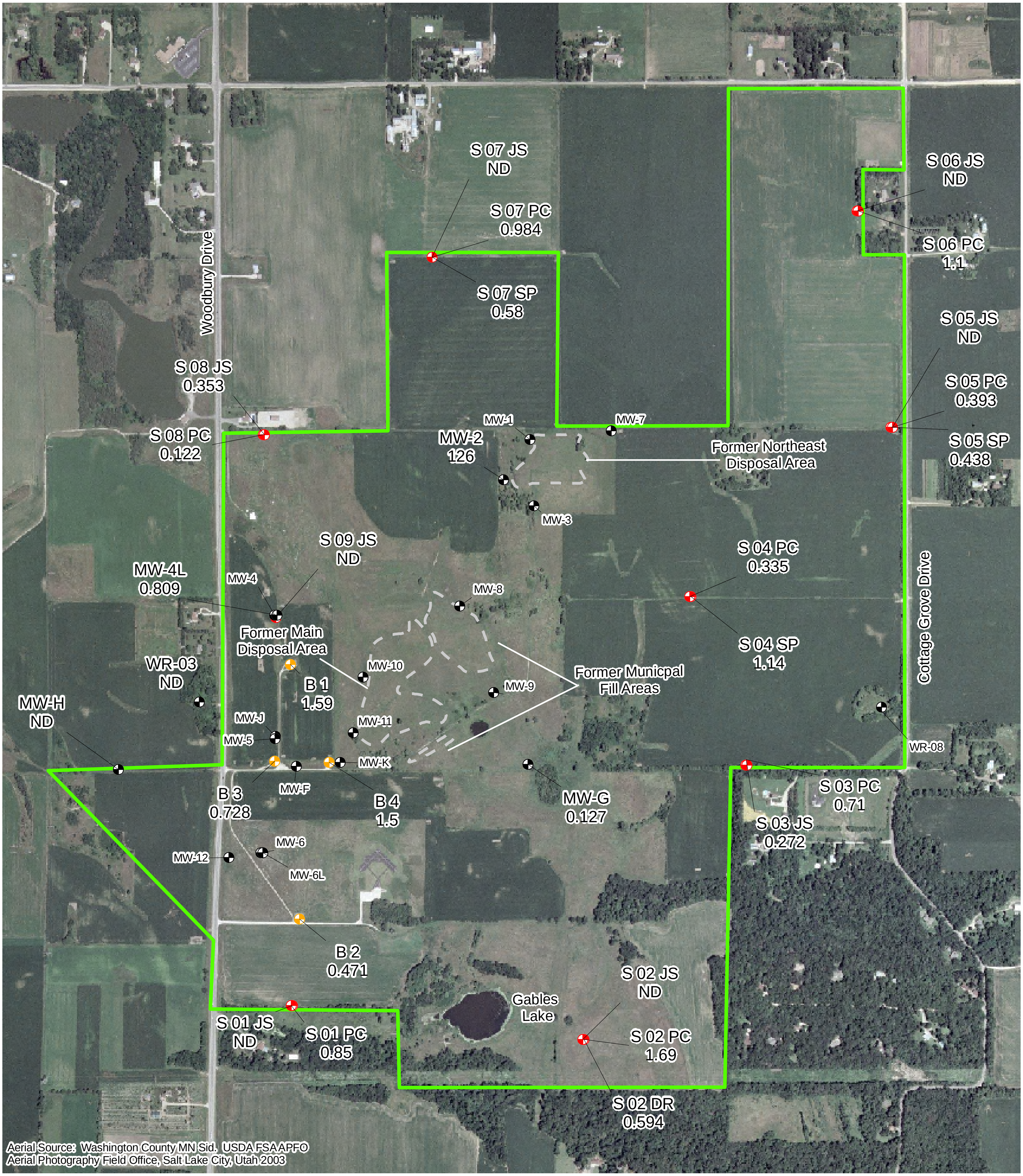
A complete round of groundwater samples were collected from twenty-nine Site well locations in June 2007. This sampling event represents the first quarterly round performed in accordance with the *Groundwater Monitoring Plan for the Woodbury Site* (WESTON, 2007), approved by MPCA in May 2007. The locations sampled include twenty new sentinel wells installed in May and June 2007, four barrier wells, four existing monitor wells, and one former residential well. The groundwater samples were collected in accordance with the groundwater sampling SOP and analyzed for FCs using analytical method protocol P2561. A summary of the groundwater analytical data is presented in Table 4 which lists the results for eight FCs.

As shown in Table 4, perfluorobutanoic acid (PFBA) is the most frequently detected FC compound. The distribution of PFBA in Site groundwater is shown in Figure 12, PFBA was detected in groundwater samples collected from sentinel wells located hydraulically upgradient (e.g. S05PC/SP, S06PC, S07PC/SP, and S08SP/JS) and downgradient (e.g. S01PC, S02DR, and S02PC) of the landfill. The range in PFBA concentrations upgradient (0.122 to 1.1 parts per billion (ppb)) were similar to the range in PFBA concentrations downgradient (0.85 to 1.69 ppb). Only two of the eight Jordan Sandstone sentinel wells had detectable levels of PFBA (S-03JS – 0.272 ppb; S-08JS – 0.353 ppb). No FCs were detected in former residential well WR03 or deep glacial drift monitor well MW-H located on the west side of Woodbury Drive/Keats Avenue. These wells are hydraulically downgradient of the former disposal areas under non-pumping conditions for the shallow and Jordan aquifers (see Figures 9 and 11). The former residential well WR03 was where groundwater was found to be impacted by volatile organic compounds (VOCs) in the late 1960s that initiated the installation of the barrier well network. The highest PFBA concentration was present in the groundwater sample collected from monitor well MW2, located near the former NE disposal area. The barrier wells appear to be effectively preventing the slightly higher levels of PFBA in groundwater beneath the former disposal area from migrating downgradient of the site based on the similar

Table 4

Summary of Groundwater Analytical Data
June 2007 Sampling Round
Woodbury Site, Woodbury, MN
Woodbury, MN

Well ID	PFBA	PFPeA	PFHA	PFHpA	PFOA	PFBS	PFHS	PFOS
Sentinel Wells								
S01JS	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S01PC	**0.85**	**0.0347**	**0.0367**	< .0248	< .0239	< .0252	< .0243	< .0256
S02DR	**0.594**	**0.0252**	< .023	< .0248	**0.033**	< .0252	**0.0373**	< .0256
S02JS	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S02PC	**1.69**	**0.0573**	**0.0255**	< .0248	**0.0286**	< .0252	**0.0526**	< .0256
S03JS	**0.272**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S03PC	**0.71**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S04PC	**0.335**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S04SP	**1.14**	**0.0557**	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S05JS	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S05PC	**0.393**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S05SP	**0.438**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S06JS	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S06PC	**1.1**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S07JS	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S07PC	**0.984**	**0.0317**	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S07SP	**0.58**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S08JS	**0.353**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S08PC	**0.122**	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
S09JS	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
Barrier Wells								
B-1	**1.59**	**0.487**	**0.974**	**0.143**	**1.44**	**1.73**	**1.52**	< .102
B-2	**0.471**	< .0382	< .0374	< .0385	< .025	< .0248	< .0248	< .102
B-3	**0.728**	**0.0738**	**0.119**	< .0385	**0.207**	**0.362**	**1.29**	**0.171**
B-4	**1.5**	**0.406**	**0.96**	**0.342**	**2.44**	**3.48**	**11.5**	**1.78**
Monitor Wells								
MW-2	**126**	**9.31**	**13**	NR	**4.92**	**14.4**	**4.65**	< .102
MW-4L	**0.809**	**0.062**	**0.0537**	**0.0357**	**0.0401**	**0.216**	**0.433**	**0.172**
MW-G	**0.127**	< .0382	< .0374	< .0385	< .025	< .0248	< .0248	**0.114**
MW-H	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256
Former Residential Well								
WR03	< .047	< .0241	< .023	< .0248	< .0239	< .0252	< .0243	< .0256



Legend:

	Monitoring Well Locations
	Sentinel Well Locations
	Barrier Well Locations
0.275	PFBA Concentation - ppb (ug/L)
	Site Boundary
ND	Not Detected at or above Limit of Quantitation (LOQ)

N
W E
S

0 500 1,000
Feet

WESTON SOLUTIONS

FIGURE 12

PFBA GROUNDWATER
SAMPLING RESULTS
JUNE 2007

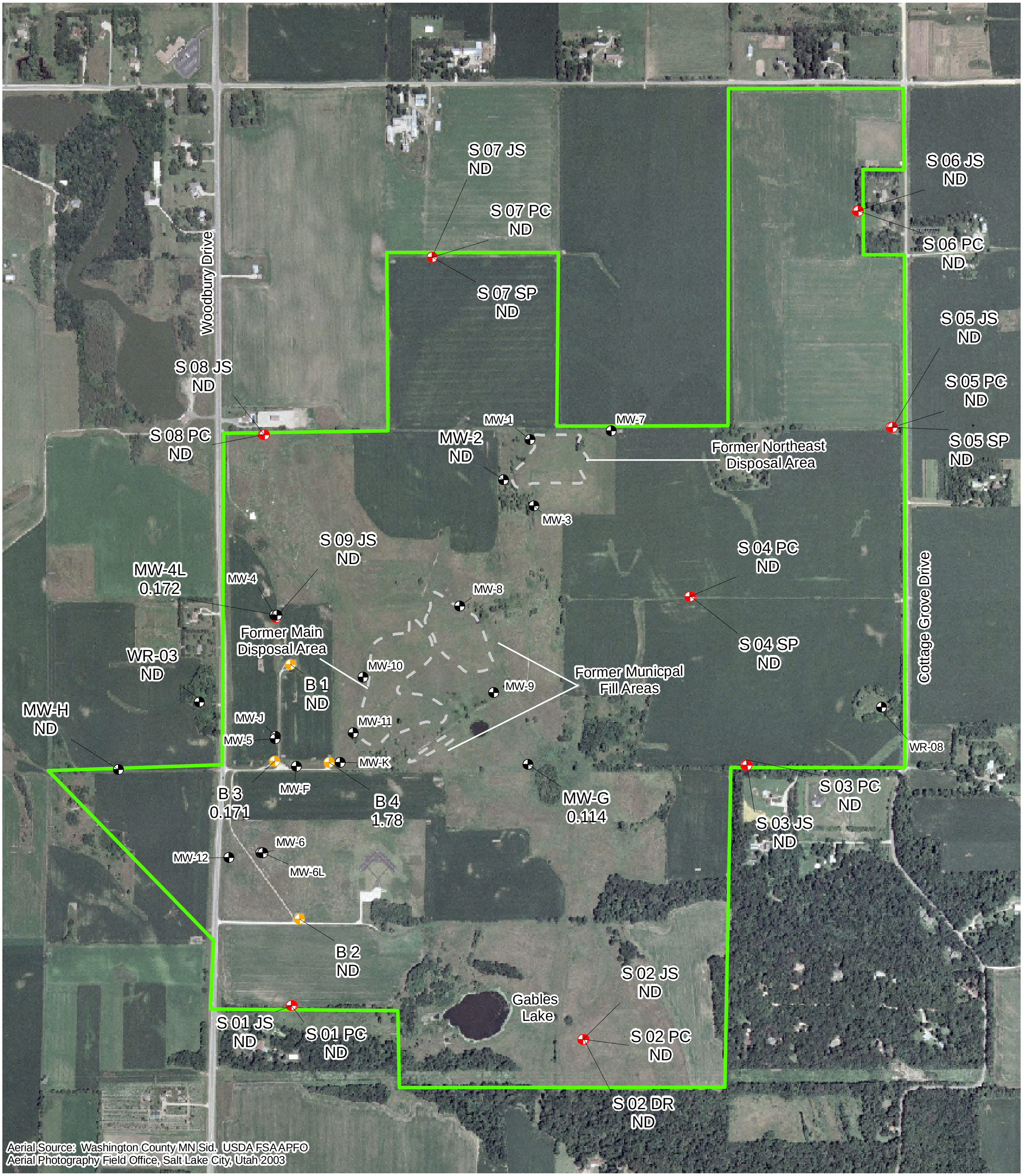
WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\PFBA_samples_june07.mxd, 22-Aug-07 16:01, ricksc levels of PFBA in the upgradient and downgradient sentinel wells, and the absence of PFBA in downgradient monitor well MW-H and former residential well WR03.

As shown in Table 4 and Figure 13, perfluorooctane sulfonate (PFOS) was not detected in any of groundwater samples collected from the sentinel wells constructed in May and June 2007. PFOS was detected in the groundwater samples collected from two of the site barrier wells (B-3 and B-4) and two site monitor wells (MW-4L and MW-G). The highest PFOS concentration was 1.78 ppb in the groundwater sample collected from barrier well B-4 (Figure 13). No PFOS was detected in barrier wells B-1 and B-2, or monitor well MW2 located near the former northeast disposal area.

Perfluorooctanoic acid (PFOA) was detected in two sentinel wells (S02DR and S02PC) slightly above the detection limit for this compound (Table 4 and Figure 14). PFOA was detected in monitor wells MW-2 and MW-4L, along with barrier wells B-1, B-3, and B-4. The concentration of PFOA detected in the groundwater sample from barrier well B-3 is an order of magnitude lower than that reported in the groundwater samples collected from barrier wells B-1 and B-4. PFOA was not present in the groundwater sample collected from barrier well B-2.

For the remaining FC compounds, Perfluoro-n-pentanoic acid (PFPeA), perfluorohexanoic acid (PFHA), and perfluorohexanesulfonate (PFHS) were detected at low levels (<0.055 ppb) in groundwater samples collected from a few sentinel wells. These compounds, and other FCs listed in Table 4, were present in the groundwater samples collected from barrier wells B-1, B-3, and B-4, and monitor wells MW-2 and MW-4L. No other FCs were detected in the groundwater sample collected from barrier well B-2. The only FC present in the sample collected from this barrier well was PFBA which was within the range reported for the upgradient sentinel wells. Therefore, groundwater being pumped by barrier well B-2 does not appear to be impacted by the former site disposal activities. Further, as mentioned in the discussion of the PFOA results previously, the FC concentrations detected in the groundwater sample from barrier well B-3 are generally an order of magnitude lower than the concentrations present in barrier wells B-1 and B-4.



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Locations
- 0.171 PFOS Concentration - ppb (ug/L)
- Site Boundary
- ND Not Detected at or above Limit of Quantitation (LOQ)

N W E S

0 500 1,000 Feet

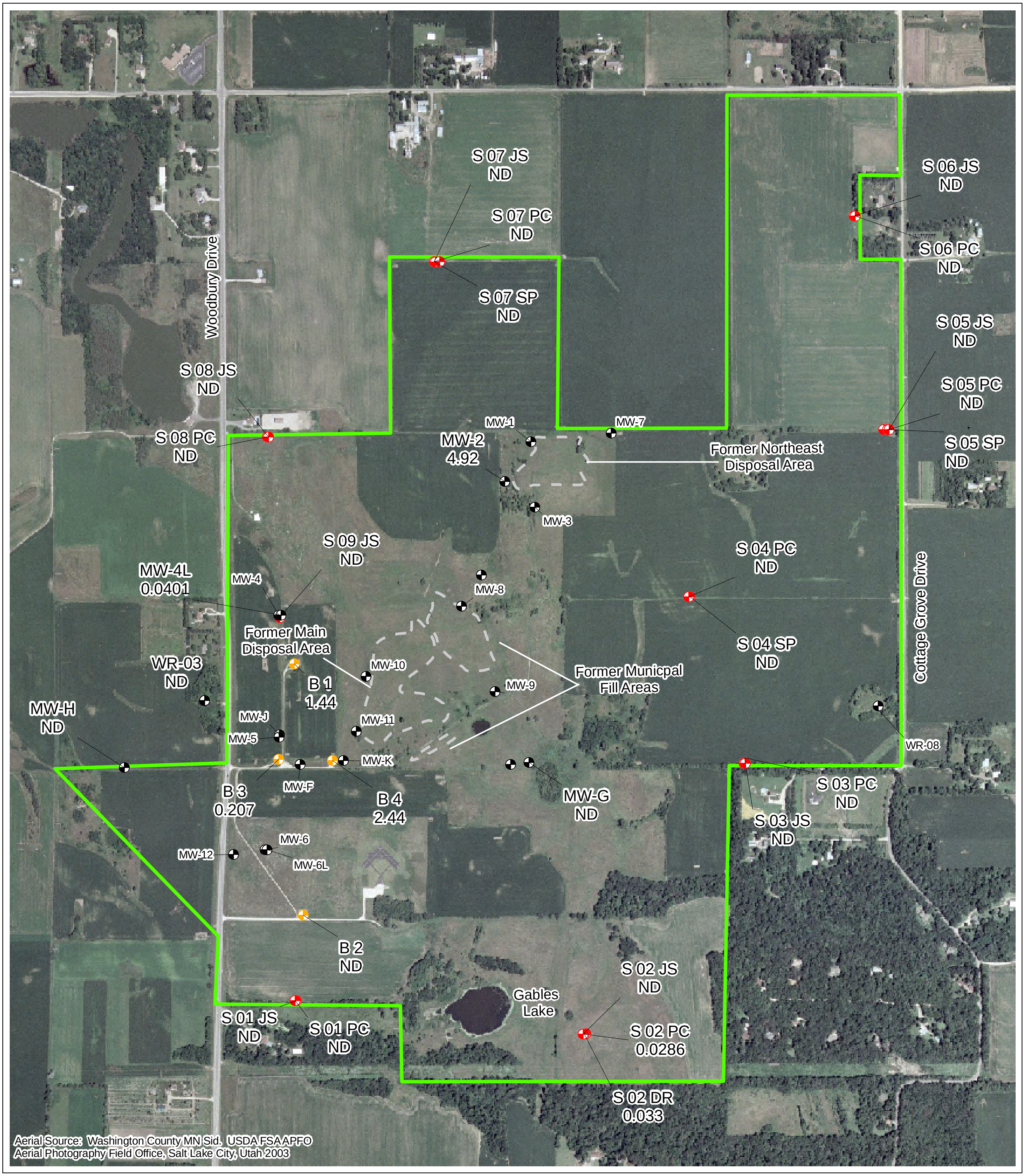
WESTON SOLUTIONS

FIGURE 13

PFOS GROUNDWATER SAMPLING RESULTS JUNE 2007

WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\PFOS_samples_june07.mxd, 26-Sep-07 14:23, ricksc



Legend:

- Monitoring Well Locations
- Sentinel Well Locations
- Barrier Well Locations
- 0.207 PFOA Concentration (ug/L)
- Site Boundary
- ND Not Detected at or above Limit of Quantitation (LOQ)

N
W E
S

0 500 1,000
Feet

WESTON SOLUTIONS

FIGURE 14

PFOA GROUNDWATER SAMPLING RESULTS JUNE 2007

WOODBURY, MINNESOTA

File: \\Fsfed01\TIG\3MWoodbury\MXD\PFOA_samples_june07.mxd, 10-Sep-07 12:08, ricksc

Figures 9 and 11 show the predicted area of capture for barrier wells B-2 and B-3. The area of predicted capture for barrier well B-2 is across the southern Site area and does not extend near either of the former disposal areas. Therefore, continued pumping of this barrier well (B-2) needs to be evaluated. The predicted area of capture for barrier well B-3 extends beyond Woodbury Drive to the west where groundwater samples collected from residential WR-3 and MW-H show no detectable levels of FCs. The pumping rate for barrier well B-3 could potentially be reduced to decrease the amount of nonimpacted groundwater being drawn in from the west.

6. SUMMARY

6.1 RESULTS

A hydraulic evaluation of the barrier well network at the Site in Woodbury, MN was completed by WESTON from 24 to 31 May 2007. The purpose of the program was to evaluate the effect of the current barrier well system on groundwater levels in the Site area, and to assess the groundwater capture area for the barrier well network. The effective area of groundwater capture for the recovery system was estimated using groundwater elevation data that was collected over the period. Groundwater elevations were monitored either manually or electronically at 39 monitor and recovery well locations during a period that the groundwater recovery system was operating, temporarily shut down, and then restarted. A summary of the results are as follows:

- The groundwater elevation data collected during the study were used to construct groundwater elevation contour maps for shallow monitor wells under pumping conditions (Figure 9) on 25 May and for non-pumping conditions (Figure 8) on 28 May 2007.

- The groundwater elevation data collected during the study were used to create groundwater elevation contour maps for the Jordan Sandstone aquifer under pumping conditions (Figure 11) on 25 May and for non-pumping conditions (Figure 10) on 28 May 2007.

- The general direction of groundwater flow under non-pumping conditions in the shallow subsurface beneath the Site is in a west to southwesterly direction. In the deeper Jordan Sandstone aquifer, groundwater flow under non-pumping conditions is in a southwesterly direction which is in agreement with published literature (Kanivetsky and Cleland, 1990).

- A response to pumping of the barrier well network was observed in all hydrostratigraphic units beneath the Site. The hydrostratigraphic units include: glacial drift sediments, St. Peter Sandstone, upper Prairie du Chien, middle Prairie du Chien, and the Jordan Sandstone.

The barrier well network is an effective hydraulic barrier that captures and prevents any downgradient migration of potentially impacted groundwater originating beneath the former disposal areas based on the following observations:

- A comparison of Figure 8 to Figure 9, and a comparison of Figure 10 to Figure 11, indicates that the barrier well network is creating a large depression in the shallow and deep groundwater system, respectively.

- As indicated in Figures 9 and 11, the hydraulic gradient under pumping conditions is inward toward the barrier well network across the majority of the Site property. This indicates that the area of groundwater capture zone for the barrier well network extends far beyond the limits of the former disposal areas at the Site.

- Within the Prairie du Chien Group, a zone of high permeability is present above and below the contact between the upper Shakopee formation and the underlying Oneota Dolomite. This more permeable unit within the Prairie du Chien Group is likely providing the highest volume of groundwater being pumped by the barrier well network. Groundwater elevation data showed that the pumping of the barrier well network induces flow upward from the underlying Jordan Sandstone unit and downward from the overlying hydrostratigraphic units toward this zone of higher permeability.

- Groundwater analytical data collected in June 2007 verify that the barrier well system is effectively preventing slightly higher PFBA levels in groundwater beneath the former disposal areas from migrating downgradient. The June 2007 groundwater analytical results show detected levels of FC compounds in the groundwater samples collected from the barrier wells B-1, B-3, and B-4. Detected levels were also present in monitor wells MW-2 and MW-4L. PFBA concentrations in sentinel wells downgradient of the Site were comparable to PFBA concentrations present in sentinel wells upgradient of the former disposal areas.

- No FC compounds were detected in the groundwater samples collected from monitor well MW-H or residential well WR-03 which are located downgradient of the Site under non-pumping conditions.

6.2 RECOMMENDATIONS

The following recommendations are made and are contingent upon MPCA review and approval:

- Perform redevelopment/rehabilitation activities at monitor well MW-K to determine whether the well screen is clogged at this location.

- Review quarterly groundwater sampling data collected at the Site and MPCA analytical data to compare PFBA concentrations in sentinel wells upgradient and downgradient of the Site.

- Assess the potential for reducing the pumping of barrier well B-2 as part of the groundwater recovery network. The FC sampling results obtained from barrier well B-2 in March, April, and May 2005 showed no FCs (PFBS, PFHS, PFOS, and PFOA) present. The groundwater sample collected from this location in December 2006 detected PFBA at 0.476 ppb. A similar PFBA concentration (0.471 ppb) was present in the groundwater sample collected in June 2007 and within the range (0.122 to 1.1 ppb) detected in sentinel wells located upgradient of the Site. Based on the results obtained from the VIC program, and this evaluation, this well has been shown to be redundant in terms of achieving effective capture of the affected groundwater on Site.

- Assess the potential for reducing the pumping rate at barrier well B-3 since it appears to be inducing groundwater flow from the west where FCs were not detected in a monitor well (MW-H) or former residential well (WR-3). Again, based on the results obtained from the VIC program, and this evaluation, this well has been shown to be redundant in terms of achieving effective capture of the affected groundwater on Site.

7. REFERENCES

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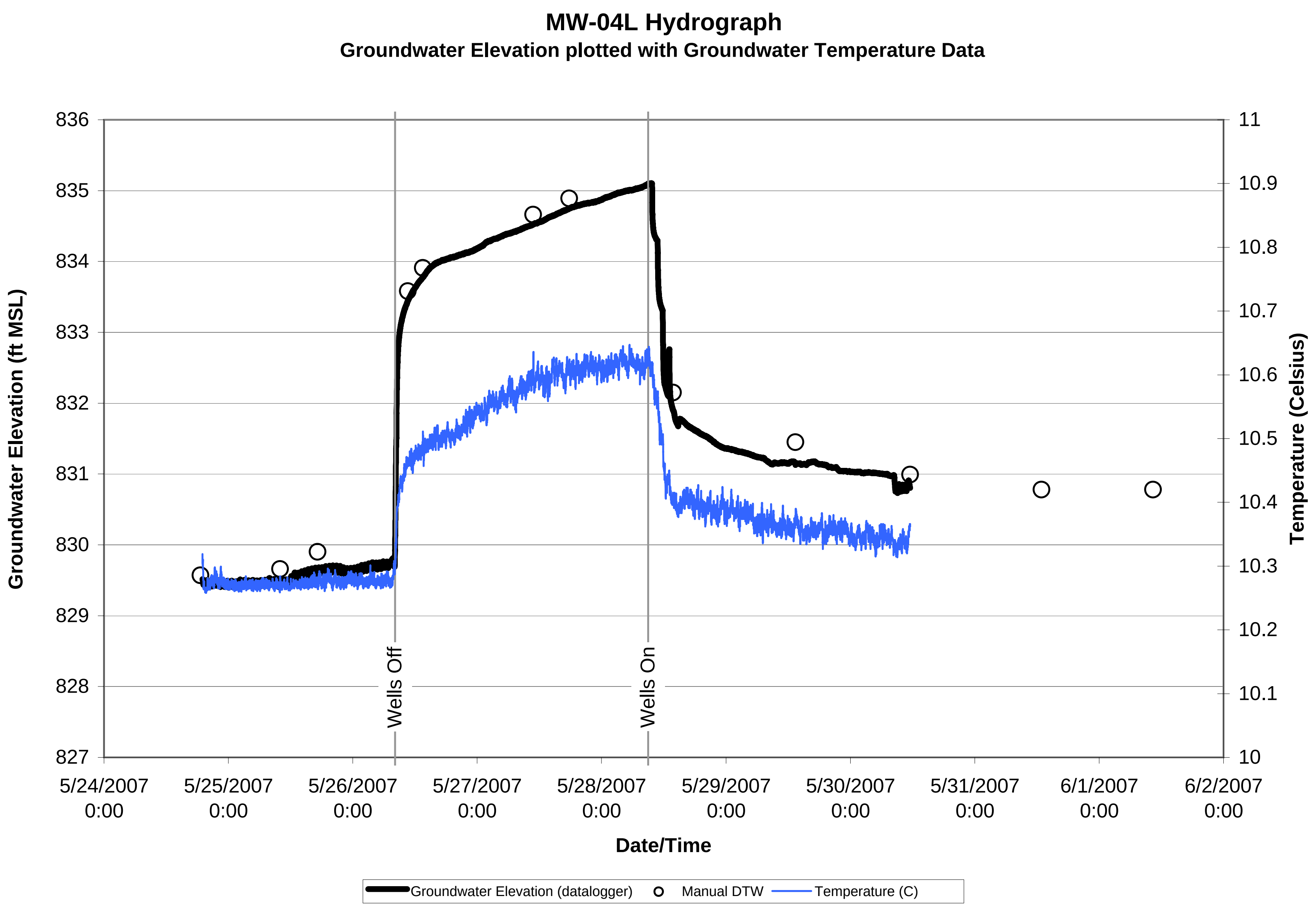
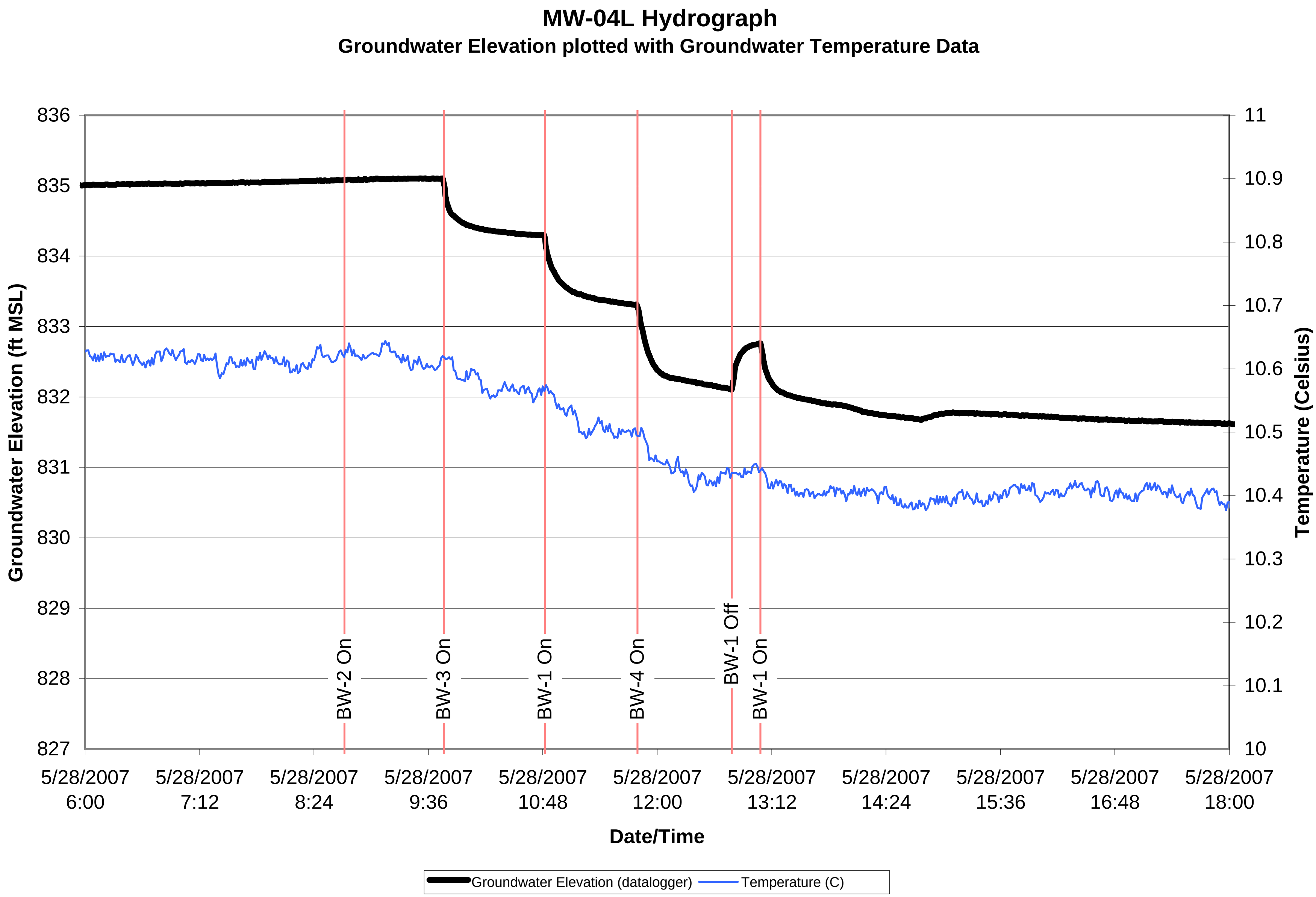
ATTACHMENT 1

Groundwater Hydrographs
Monitor and Sentinel Wells Monitored
with Submersible Dataloggers



MW-04L data MW04L_Chart



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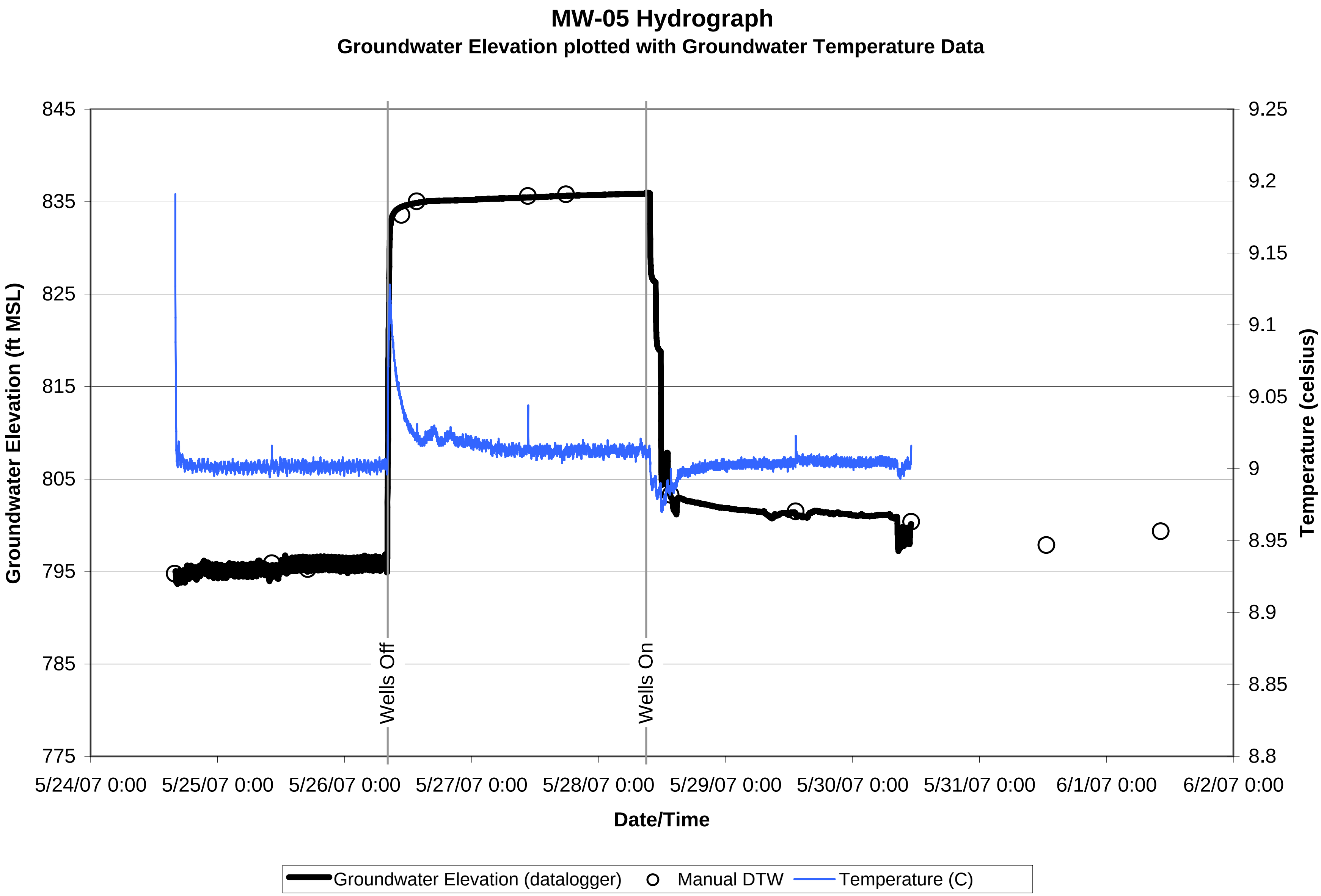
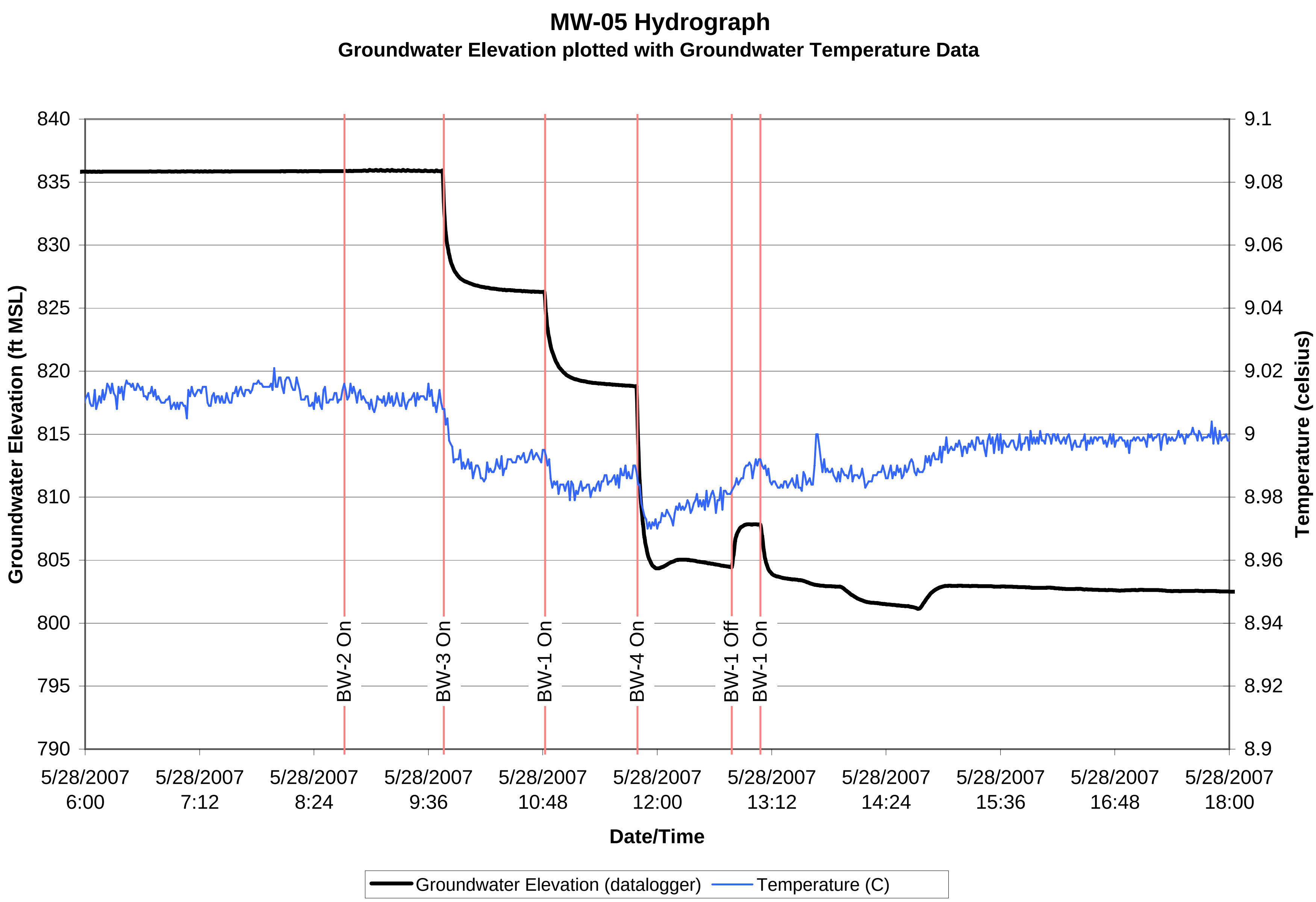


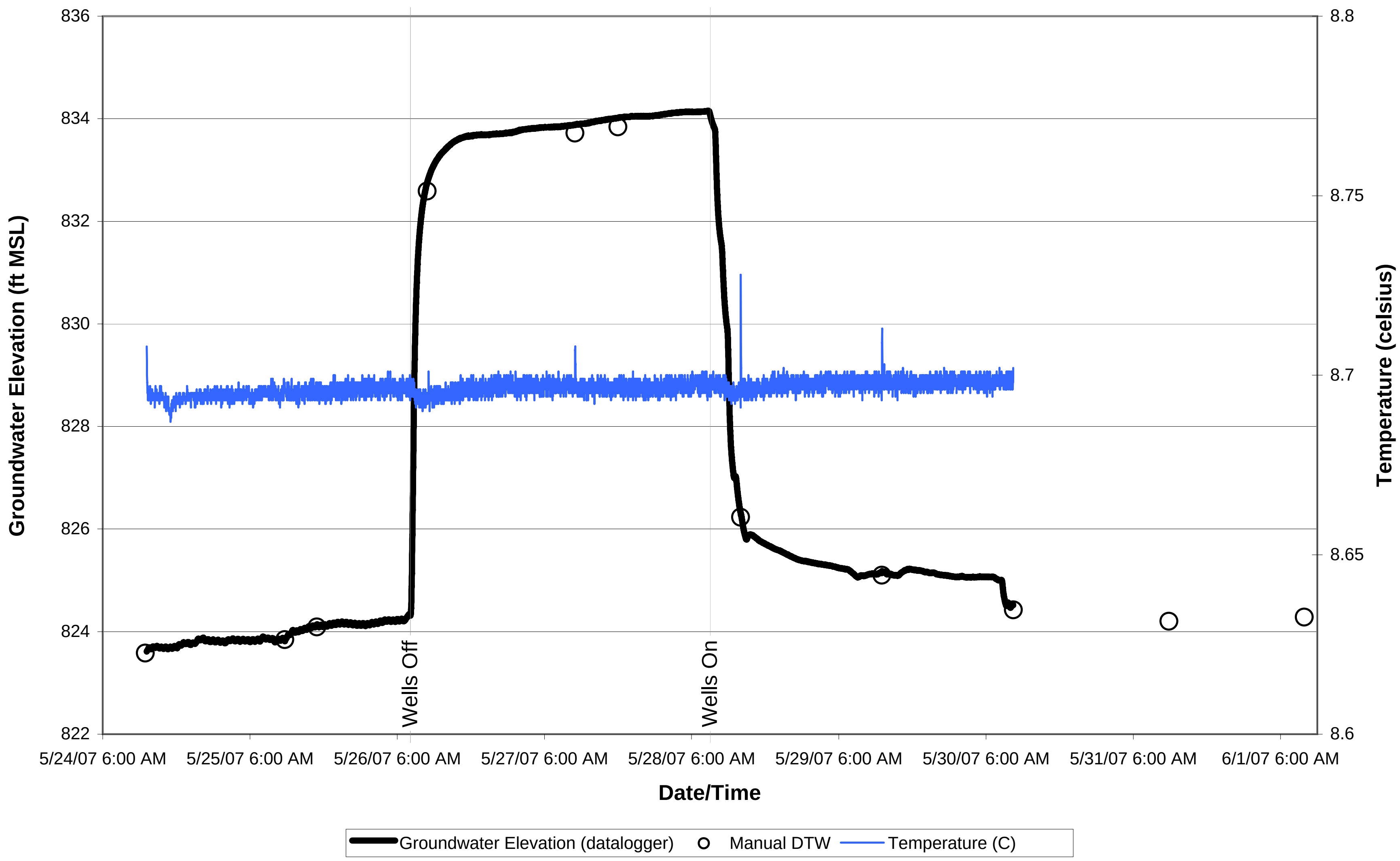
MW-05 Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
Groundwater Elevation (ft MSL)
Temperature (celsius)
845
835
825
815
805
795
785
775
9.25
9.2
9.15
9.1
9.05
9
8.95
8.9
8.85
8.8
Wells Off
Wells On
5/24/07 0:00
5/25/07 0:00
5/26/07 0:00
5/27/07 0:00
5/28/07 0:00
5/29/07 0:00
5/30/07 0:00
5/31/07 0:00
6/1/07 0:00
6/2/07 0:00
Date/Time
Groundwater Elevation (datalogger)
Manual DTW
Temperature (C)



MW-05 Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
Groundwater Elevation (ft MSL)
Temperature (celsius)
840
835
830
825
820
815
810
805
800
795
790
9.1
9.08
9.06
9.04
9.02
9
8.98
8.96
8.94
8.92
8.9
BW-2 On
BW-3 On
BW-1 On
BW-4 On
BW-1 Off
BW-1 On
5/28/2007 6:00
5/28/2007 7:12
5/28/2007 8:24
5/28/2007 9:36
5/28/2007 10:48
5/28/2007 12:00
5/28/2007 13:12
5/28/2007 14:24
5/28/2007 15:36
5/28/2007 16:48
5/28/2007 18:00
Date/Time
Groundwater Elevation (datalogger)
Temperature (C)

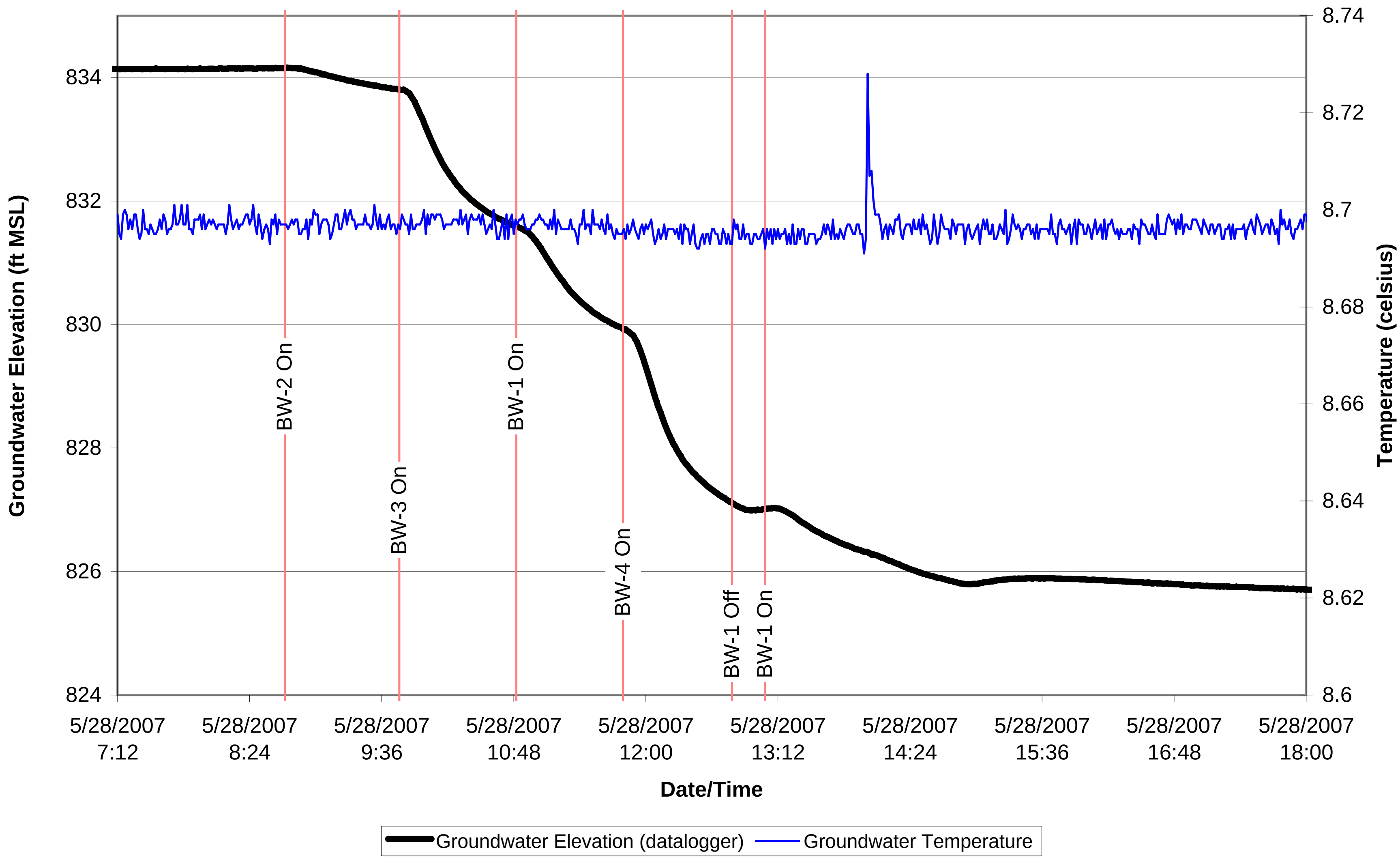
MW-6 Hydrograph

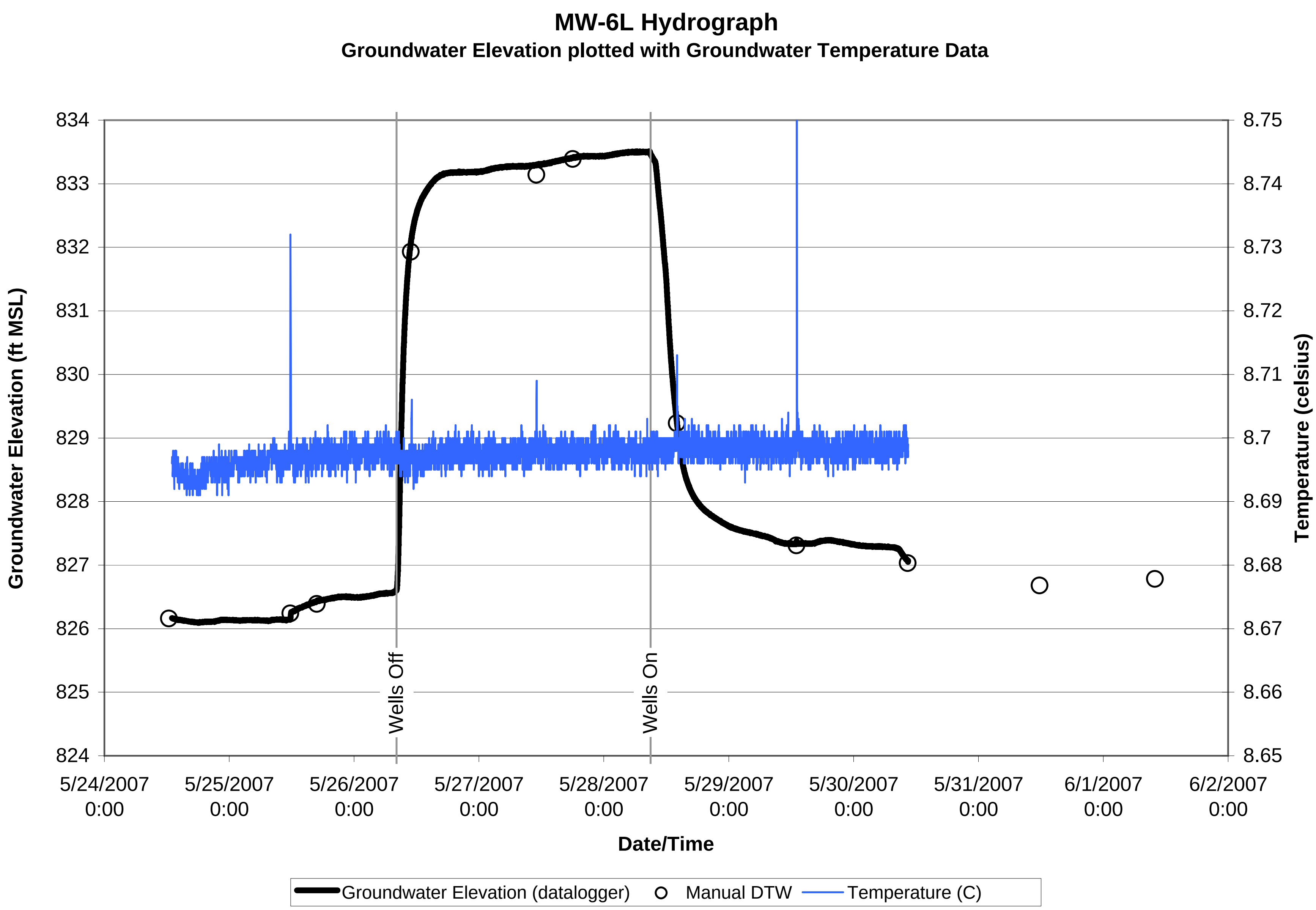
Groundwater Elevation plotted with Groundwater Temperature Data



MW-6 dataMW-6_CHART

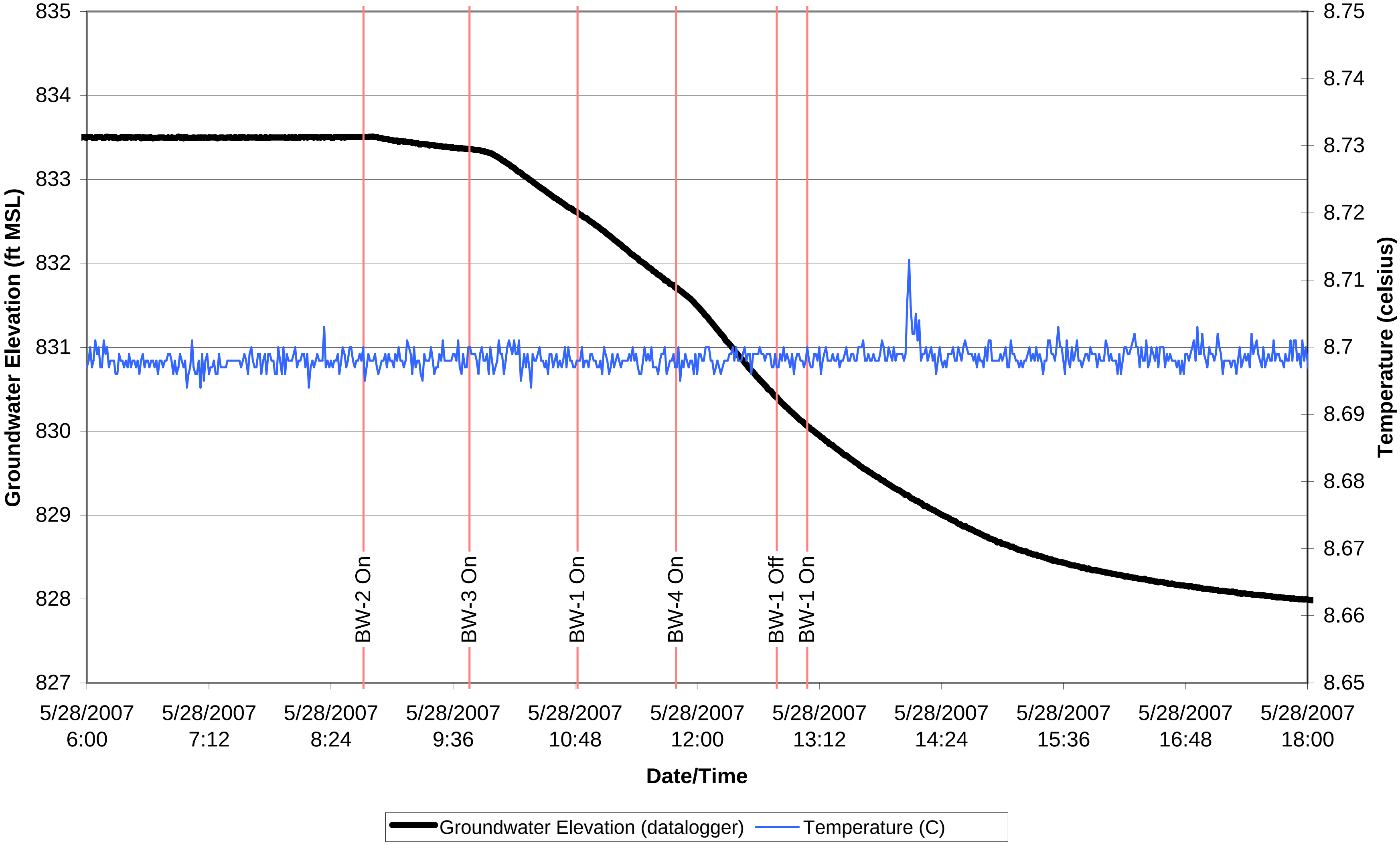
MW-6 Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data





MW-6L dataMW-6L_Chart1

MW-6L Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data



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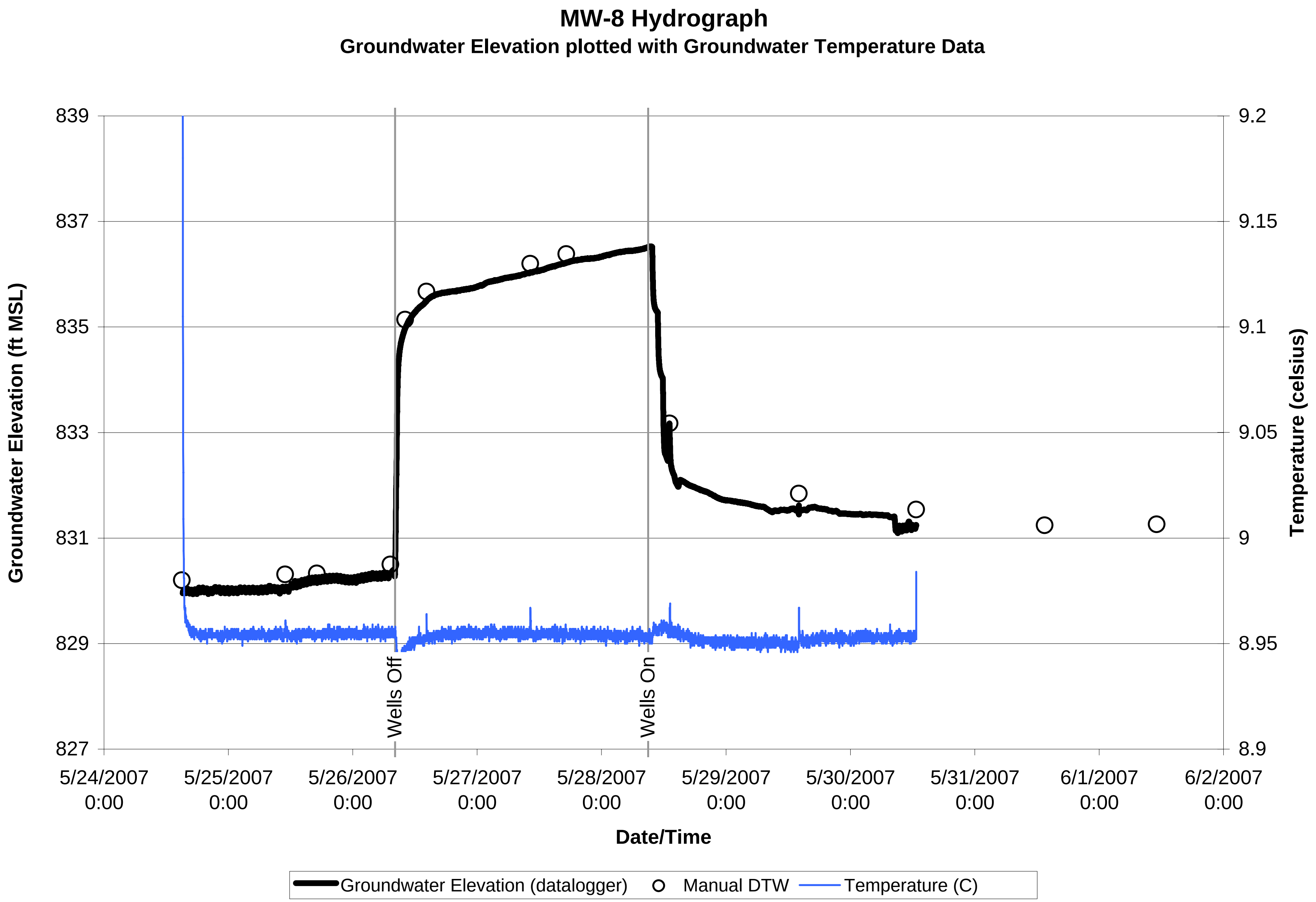
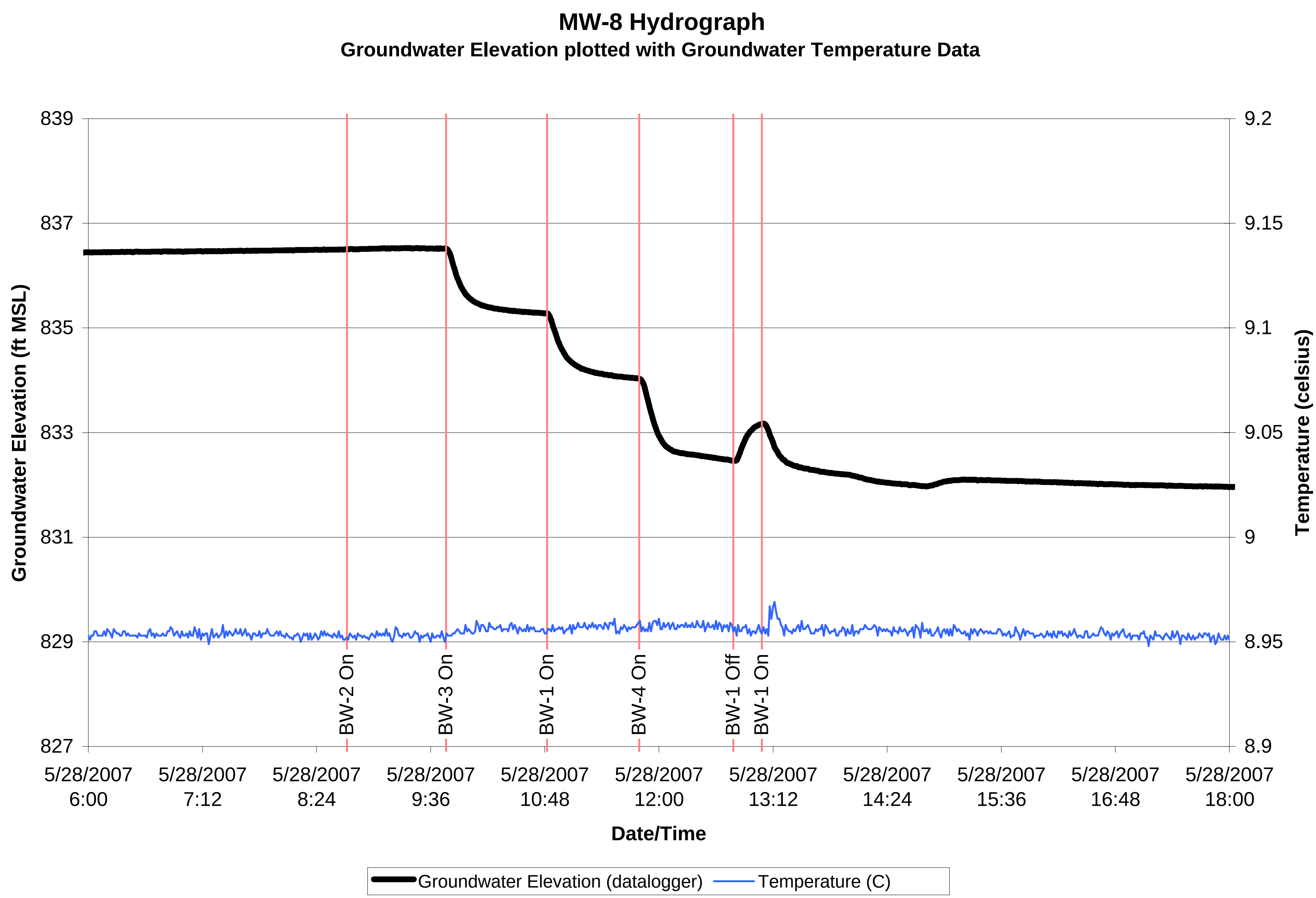
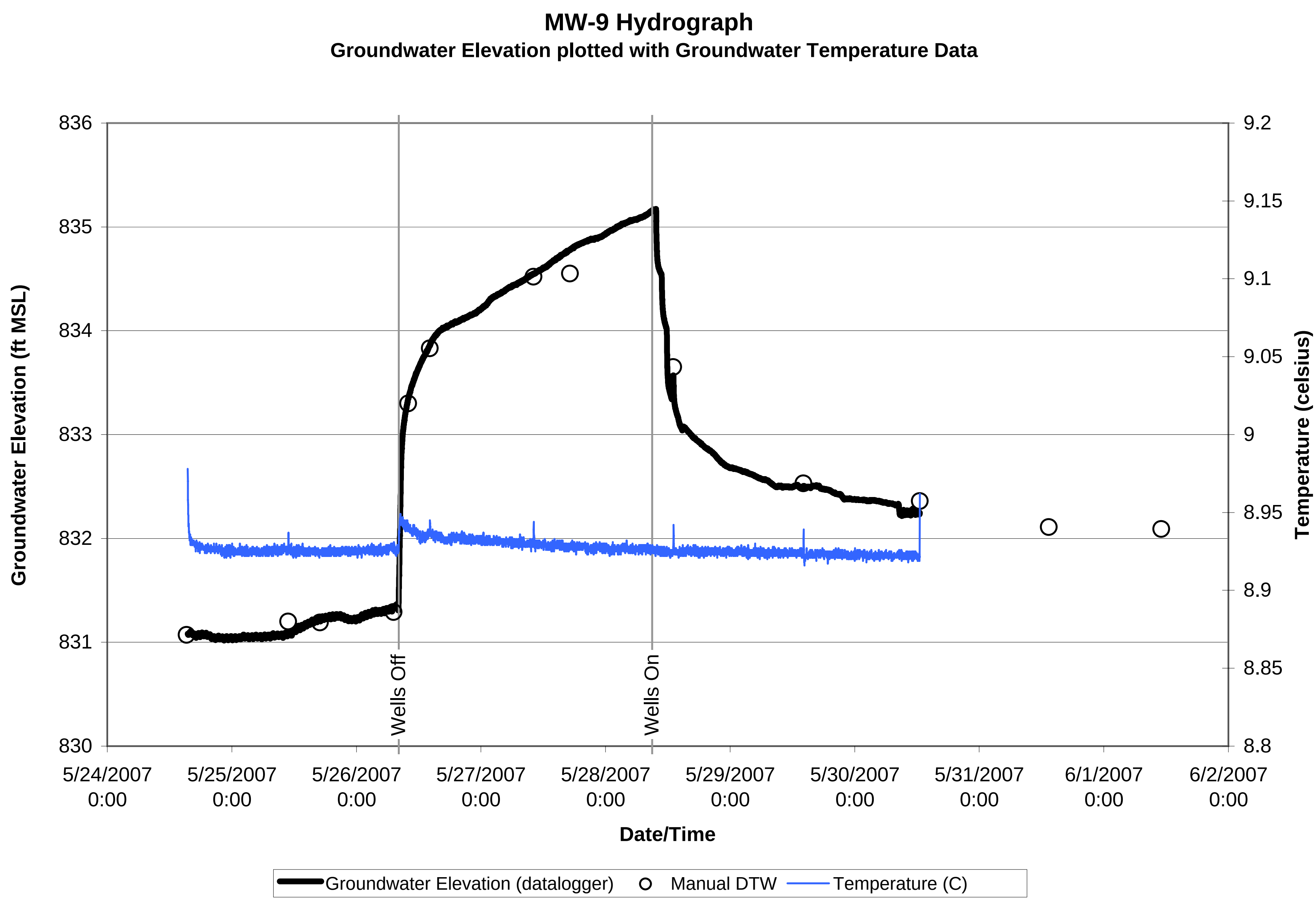


MW-8 Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
839
837
835
833
831
829
827
9.2
9.15
9.1
9.05
9
8.95
8.9
Groundwater Elevation (ft MSL)
Temperature (celsius)
Wells Off
Wells On
5/24/2007 0:00
5/25/2007 0:00
5/26/2007 0:00
5/27/2007 0:00
5/28/2007 0:00
5/29/2007 0:00
5/30/2007 0:00
5/31/2007 0:00
6/1/2007 0:00
6/2/2007 0:00
Date/Time
Groundwater Elevation (datalogger)
Manual DTW
Temperature (C)



MW-8 Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
Groundwater Elevation (ft MSL)
839
837
835
833
831
829
827
Temperature (celsius)
9.2
9.15
9.1
9.05
9
8.95
8.9
BW-2 On
BW-3 On
BW-1 On
BW-4 On
BW-1 Off
BW-1 On
5/28/2007 6:00
5/28/2007 7:12
5/28/2007 8:24
5/28/2007 9:36
5/28/2007 10:48
5/28/2007 12:00
5/28/2007 13:12
5/28/2007 14:24
5/28/2007 15:36
5/28/2007 16:48
5/28/2007 18:00
Date/Time
Groundwater Elevation (datalogger)
Temperature (C)



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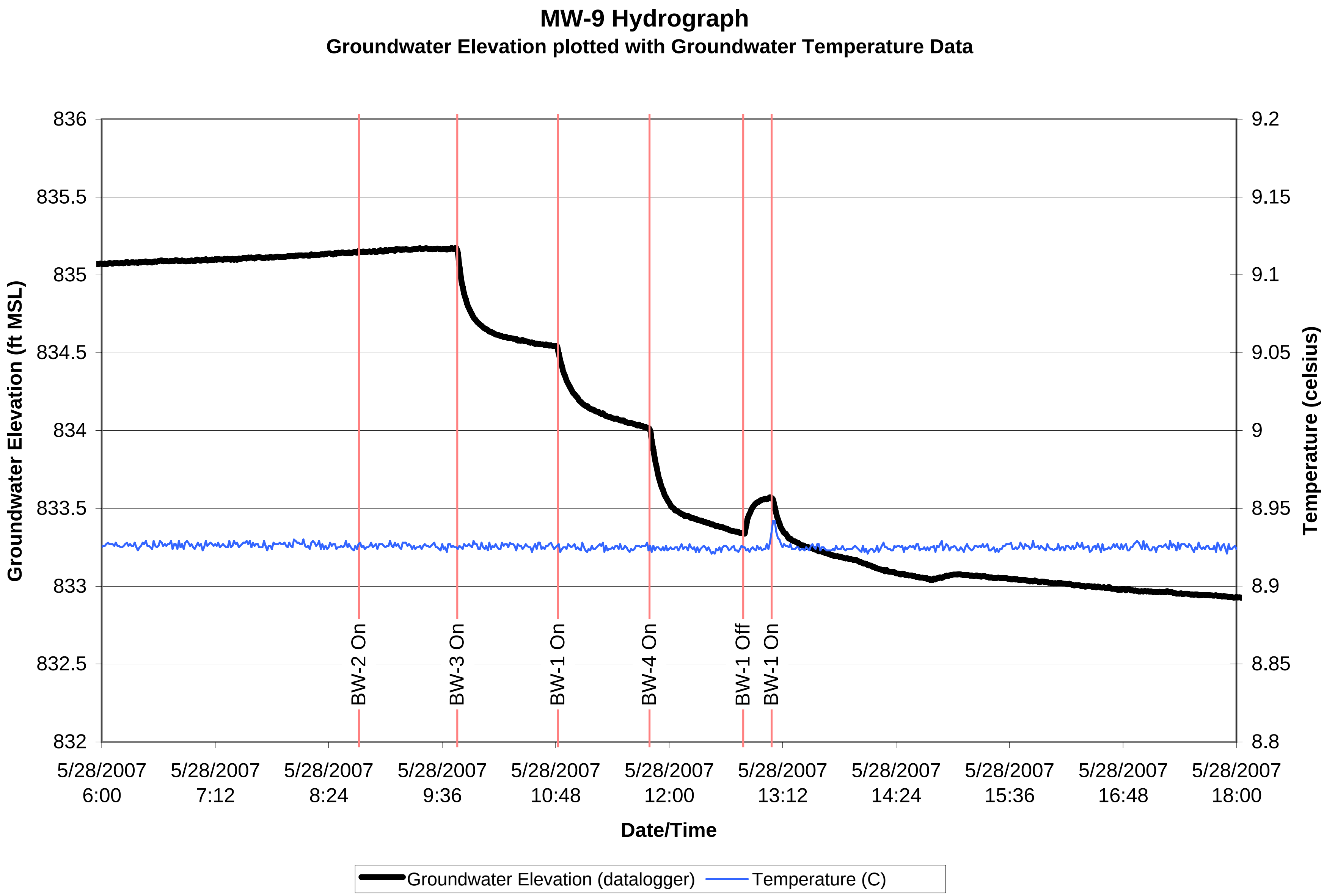

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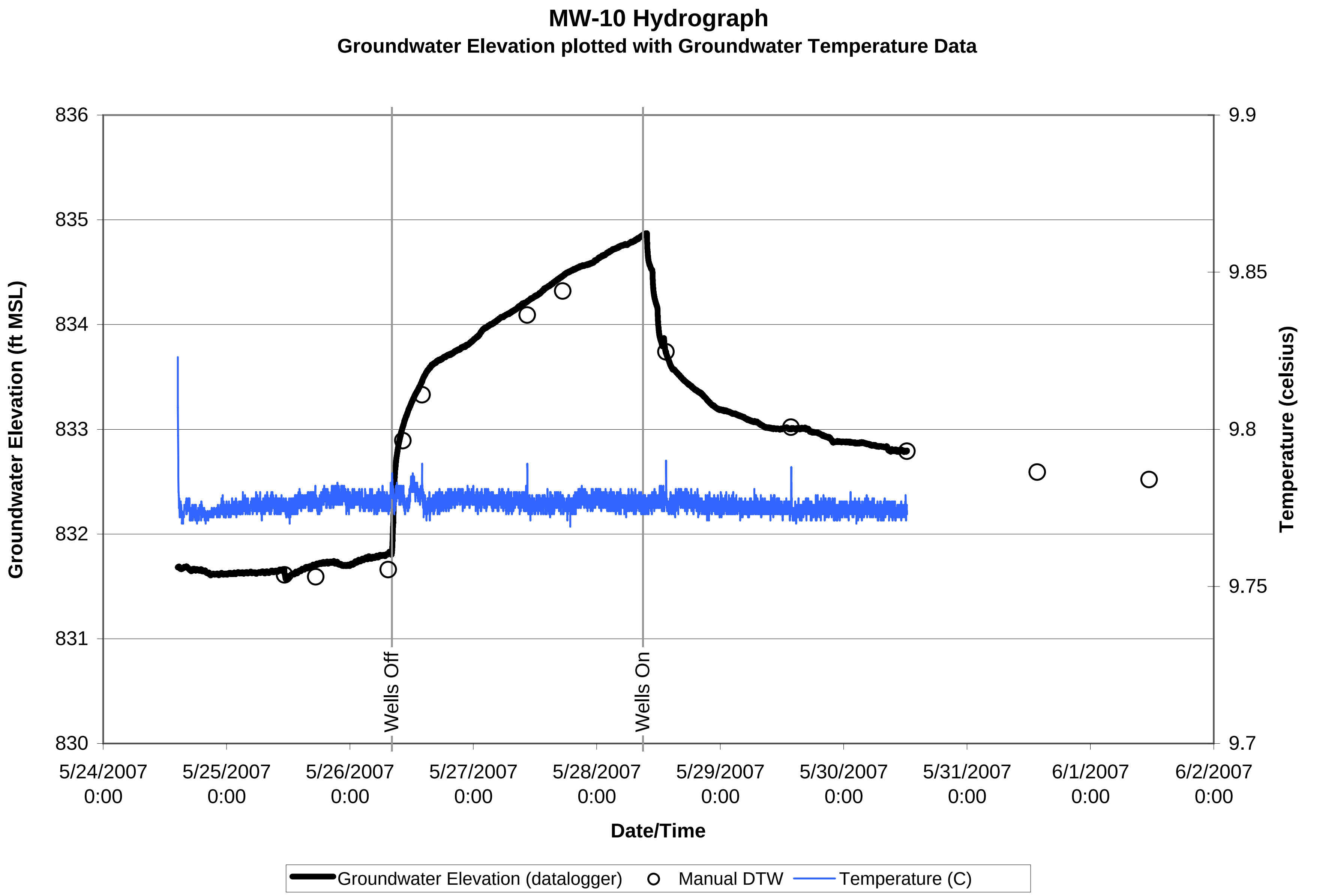
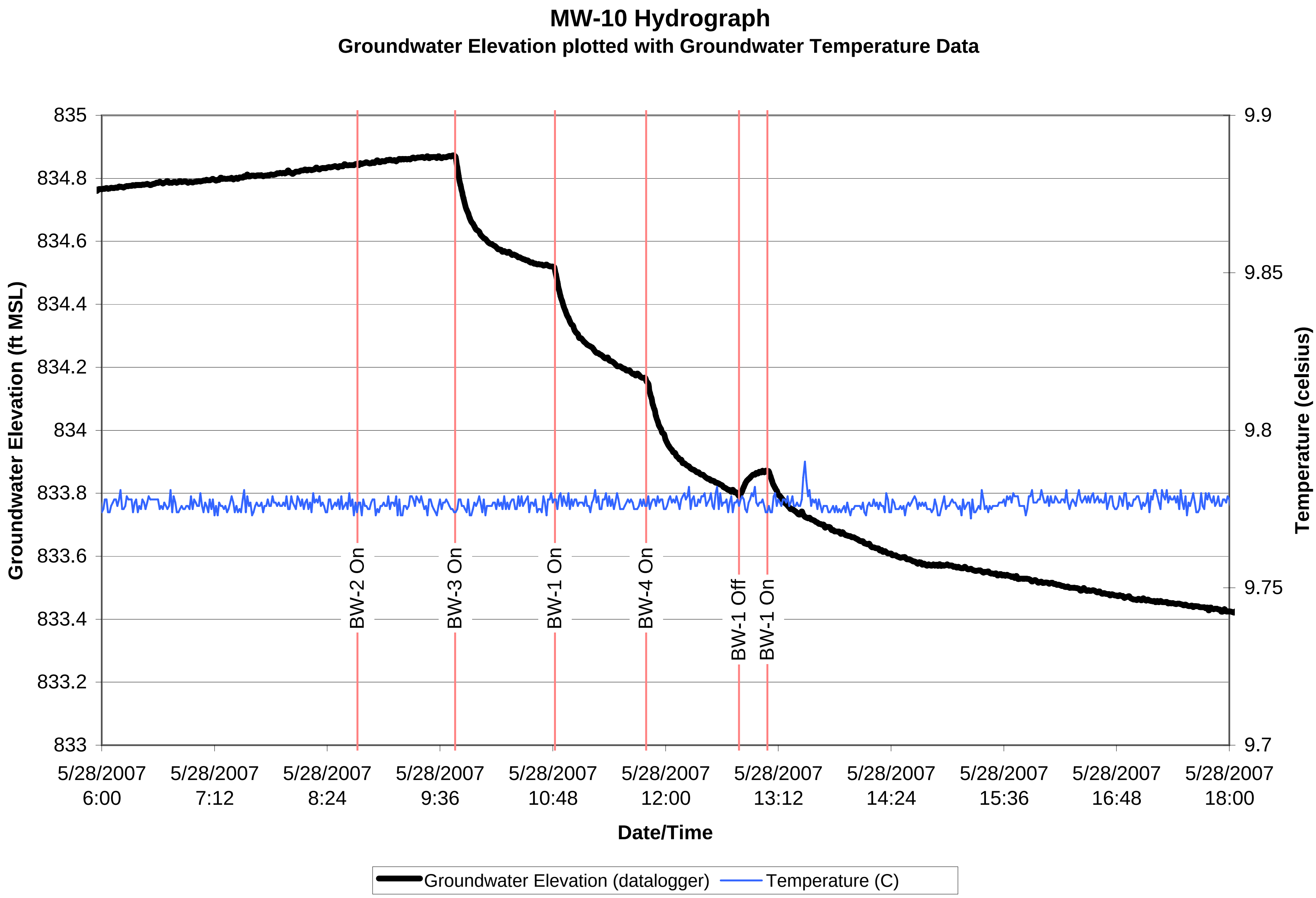


MW-10 data MW-10_Chart1



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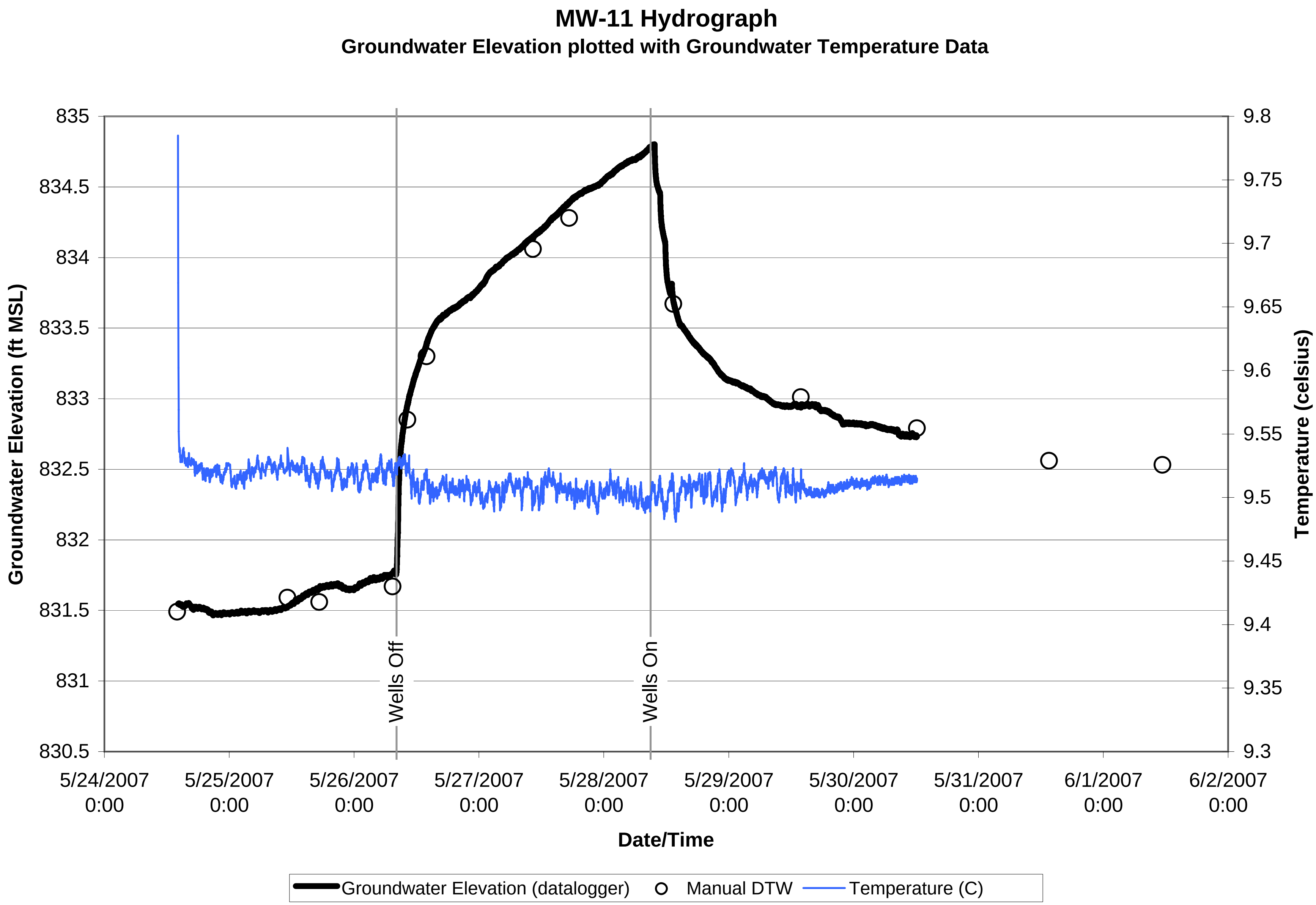
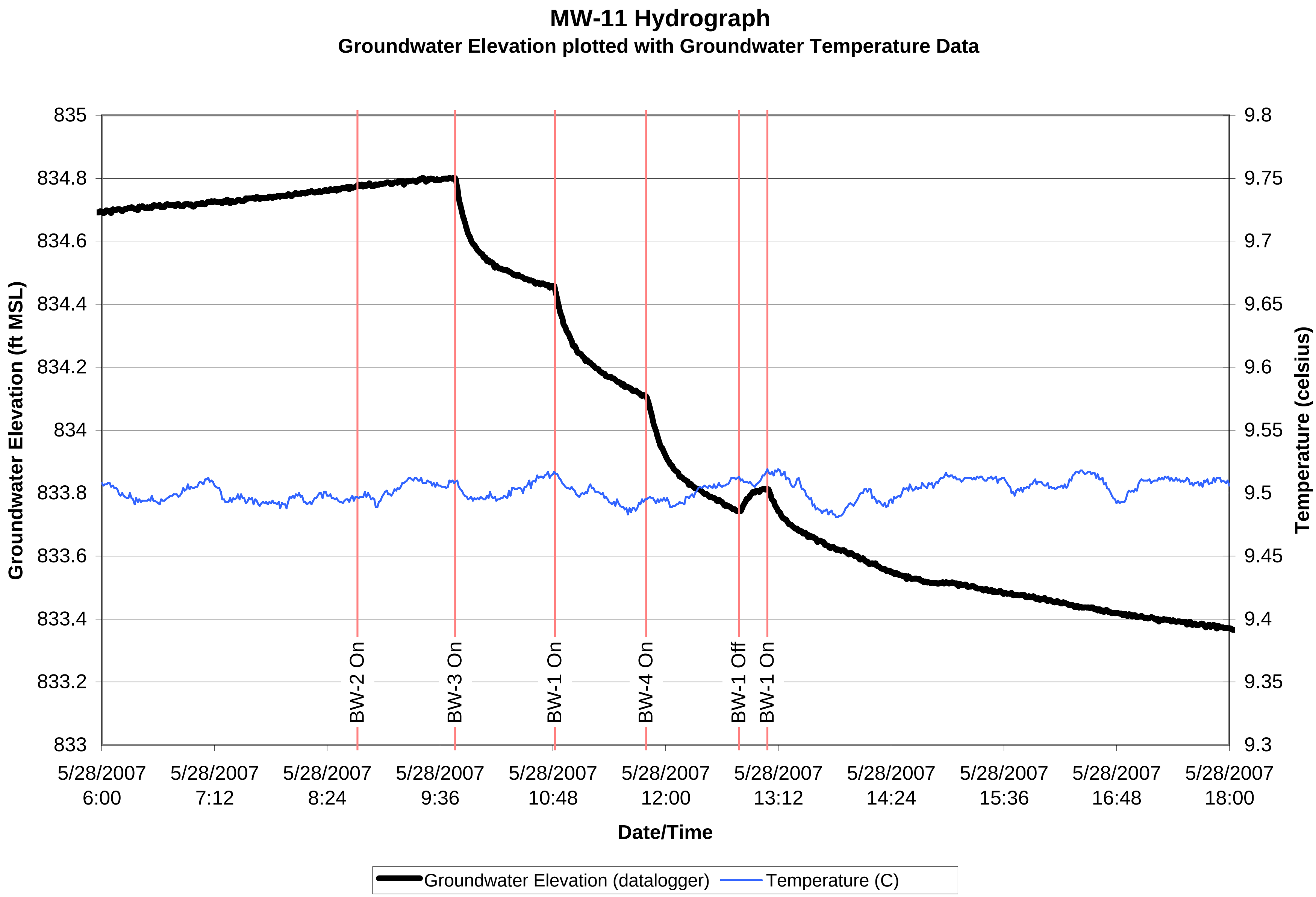
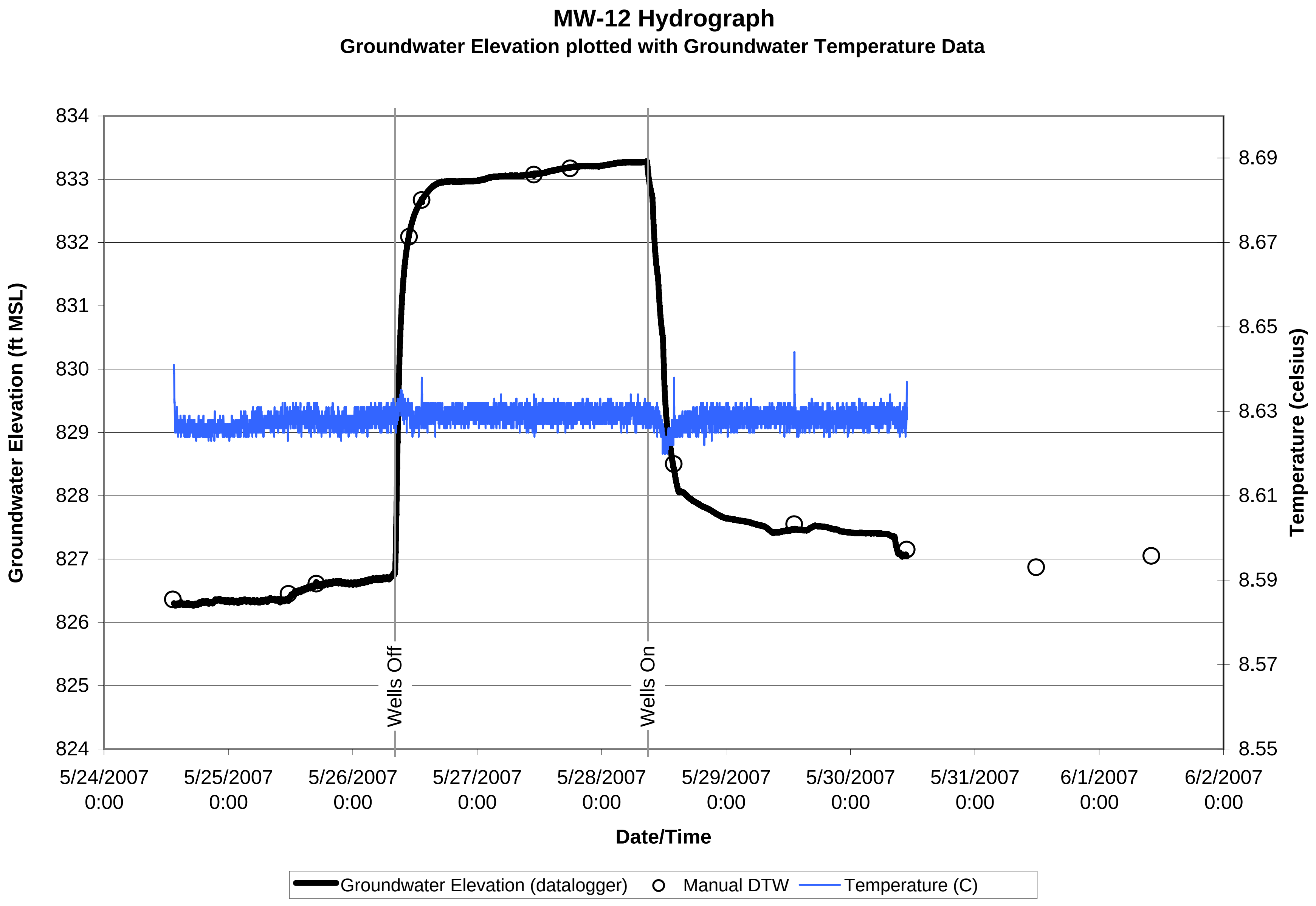


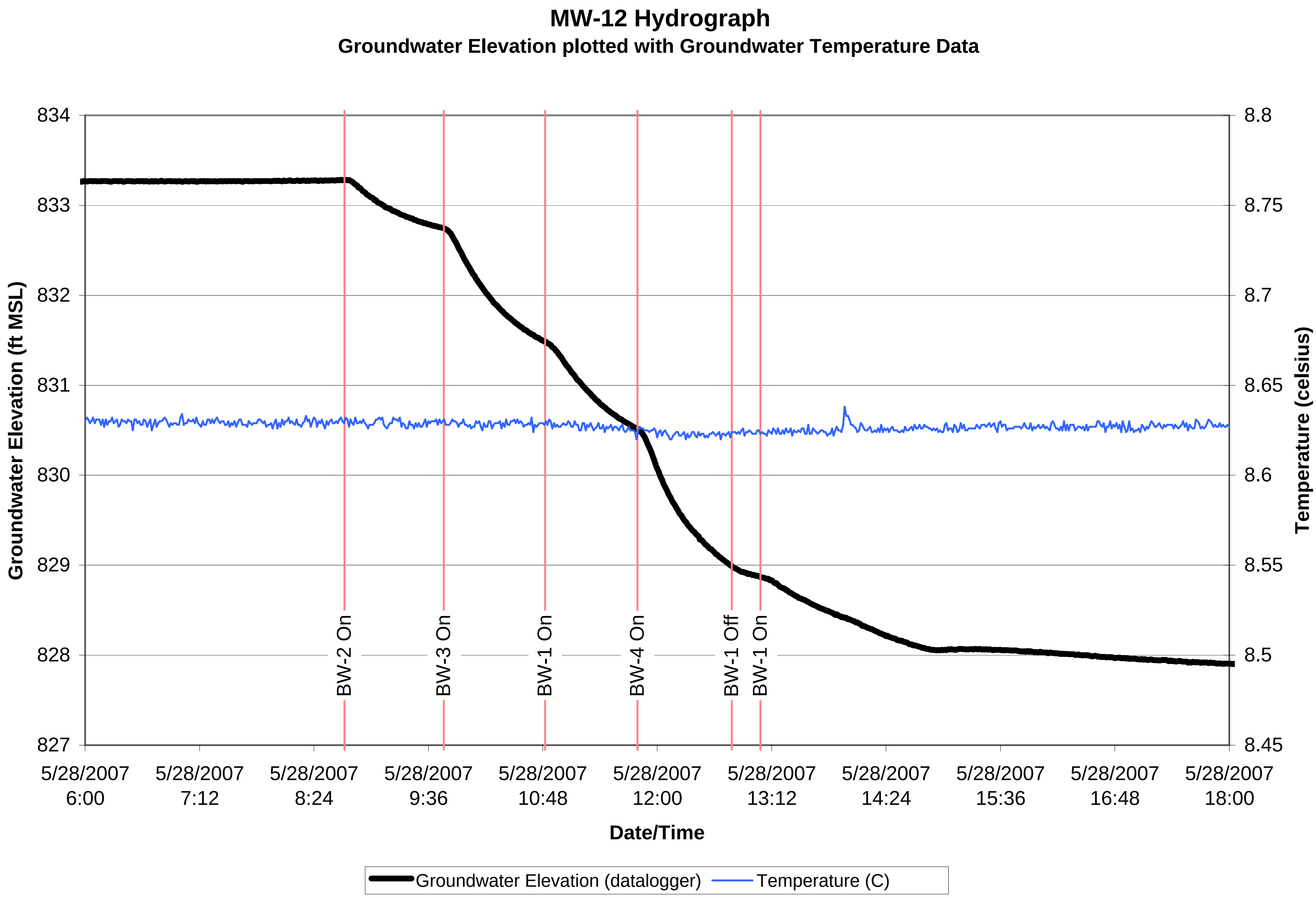
MW-11 data MW-11_Chart1

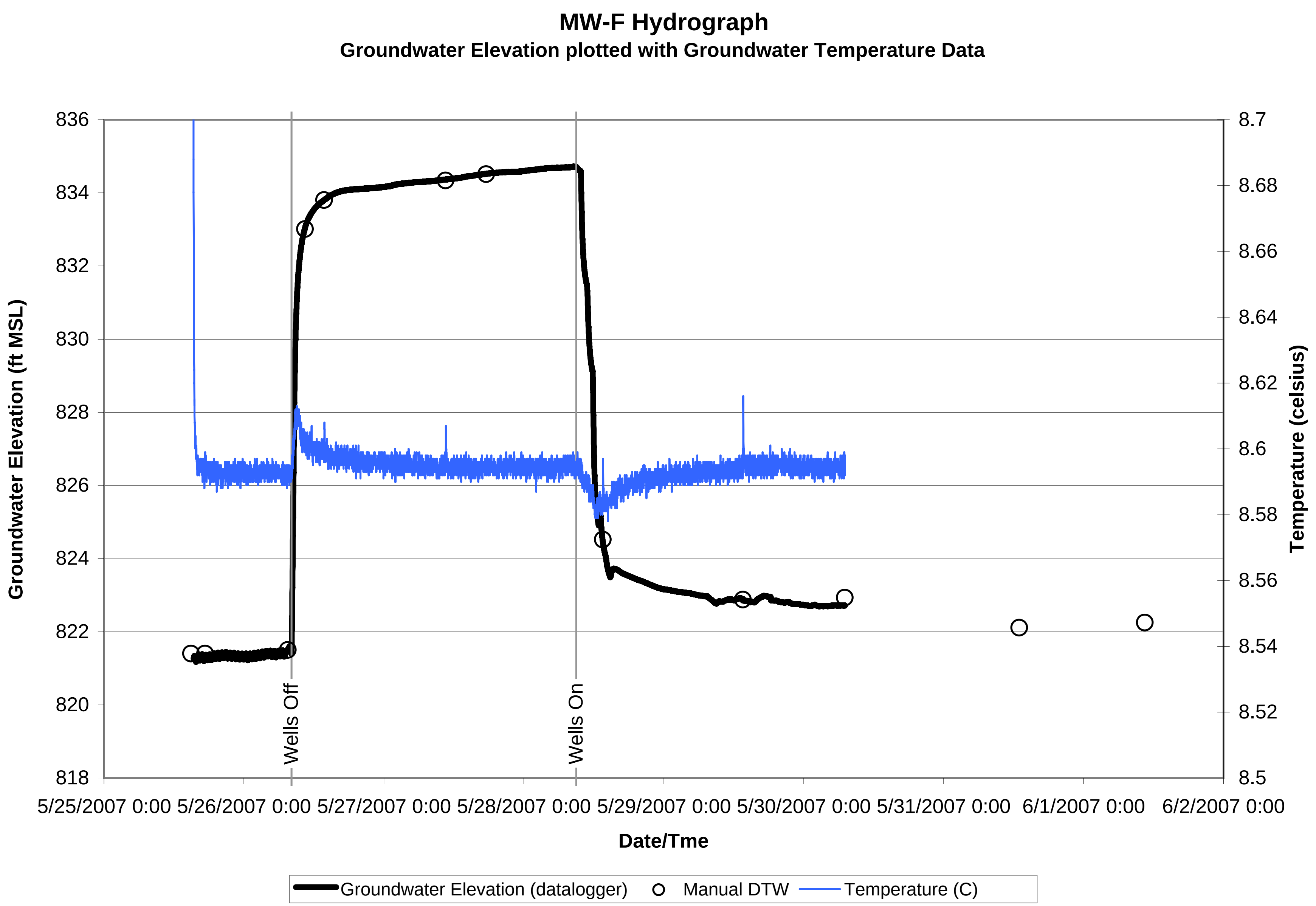


MW-11 Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
Groundwater Elevation (ft MSL)
Temperature (celsius)
835
834.8
834.6
834.4
834.2
834
833.8
833.6
833.4
833.2
833
9.8
9.75
9.7
9.65
9.6
9.55
9.5
9.45
9.4
9.35
9.3
BW-2 On
BW-3 On
BW-1 On
BW-4 On
BW-1 Off
BW-1 On
5/28/2007 6:00
5/28/2007 7:12
5/28/2007 8:24
5/28/2007 9:36
5/28/2007 10:48
5/28/2007 12:00
5/28/2007 13:12
5/28/2007 14:24
5/28/2007 15:36
5/28/2007 16:48
5/28/2007 18:00
Date/Time
Groundwater Elevation (datalogger)
Temperature (C)

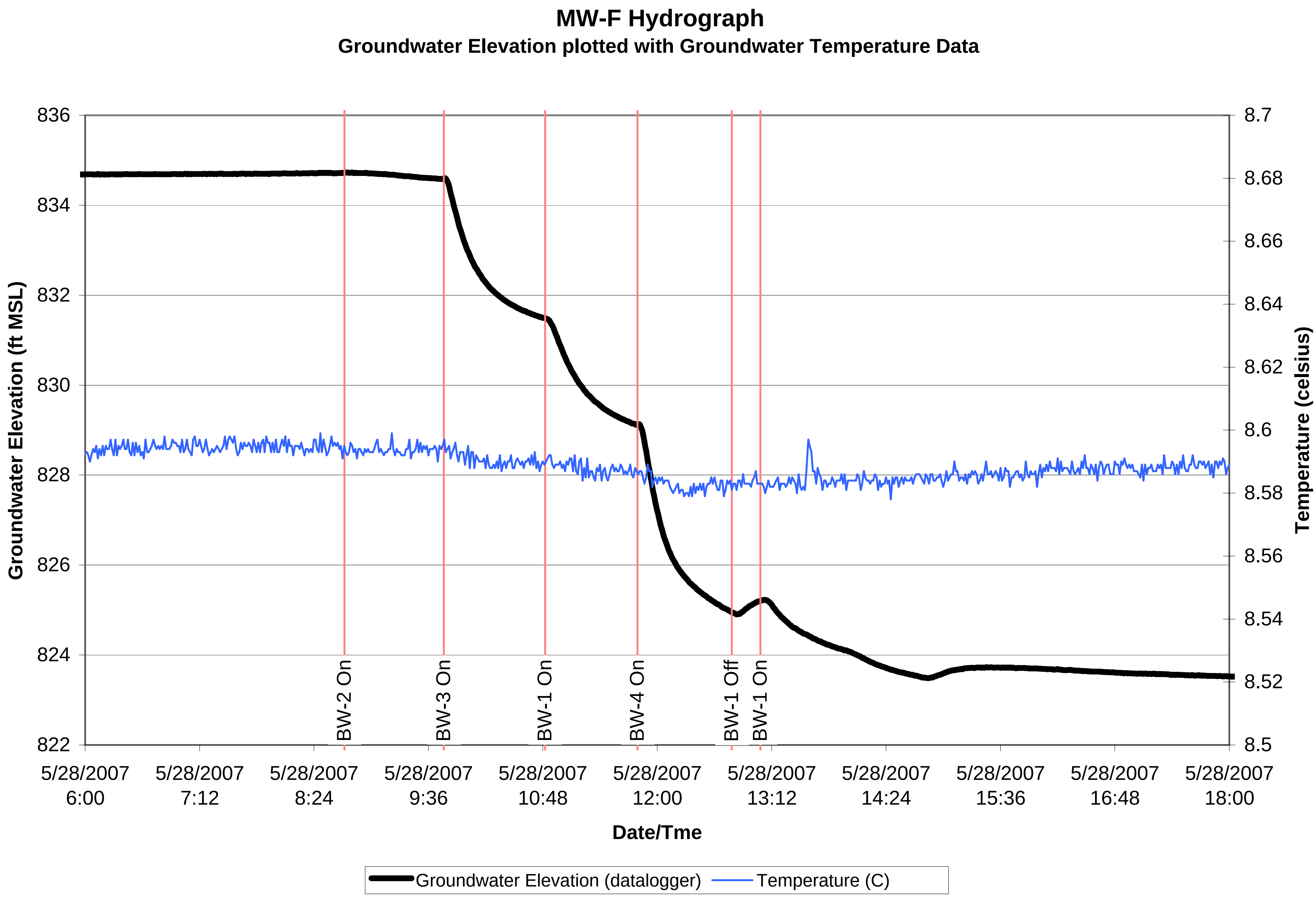


MW-12 data MW-12_Chart1

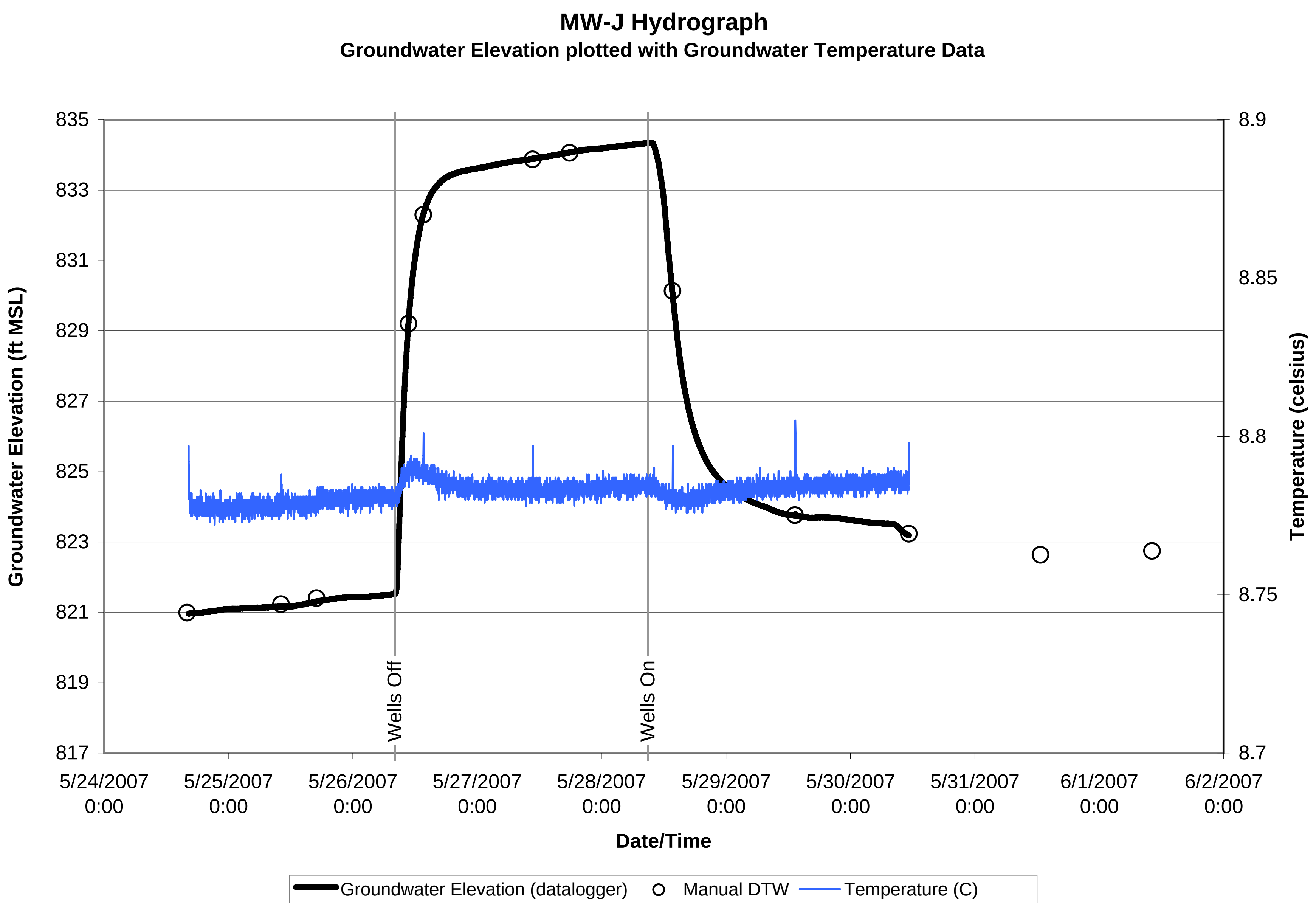

MW-12 Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
834
833
832
831
830
829
828
827
8.8
8.75
8.7
8.65
8.6
8.55
8.5
8.45
Groundwater Elevation (ft MSL)
Temperature (celsius)
BW-2 On
BW-3 On
BW-1 On
BW-4 On
BW-1 Off
BW-1 On
5/28/2007 6:00
5/28/2007 7:12
5/28/2007 8:24
5/28/2007 9:36
5/28/2007 10:48
5/28/2007 12:00
5/28/2007 13:12
5/28/2007 14:24
5/28/2007 15:36
5/28/2007 16:48
5/28/2007 18:00
Date/Time
Groundwater Elevation (datalogger)
Temperature (C)



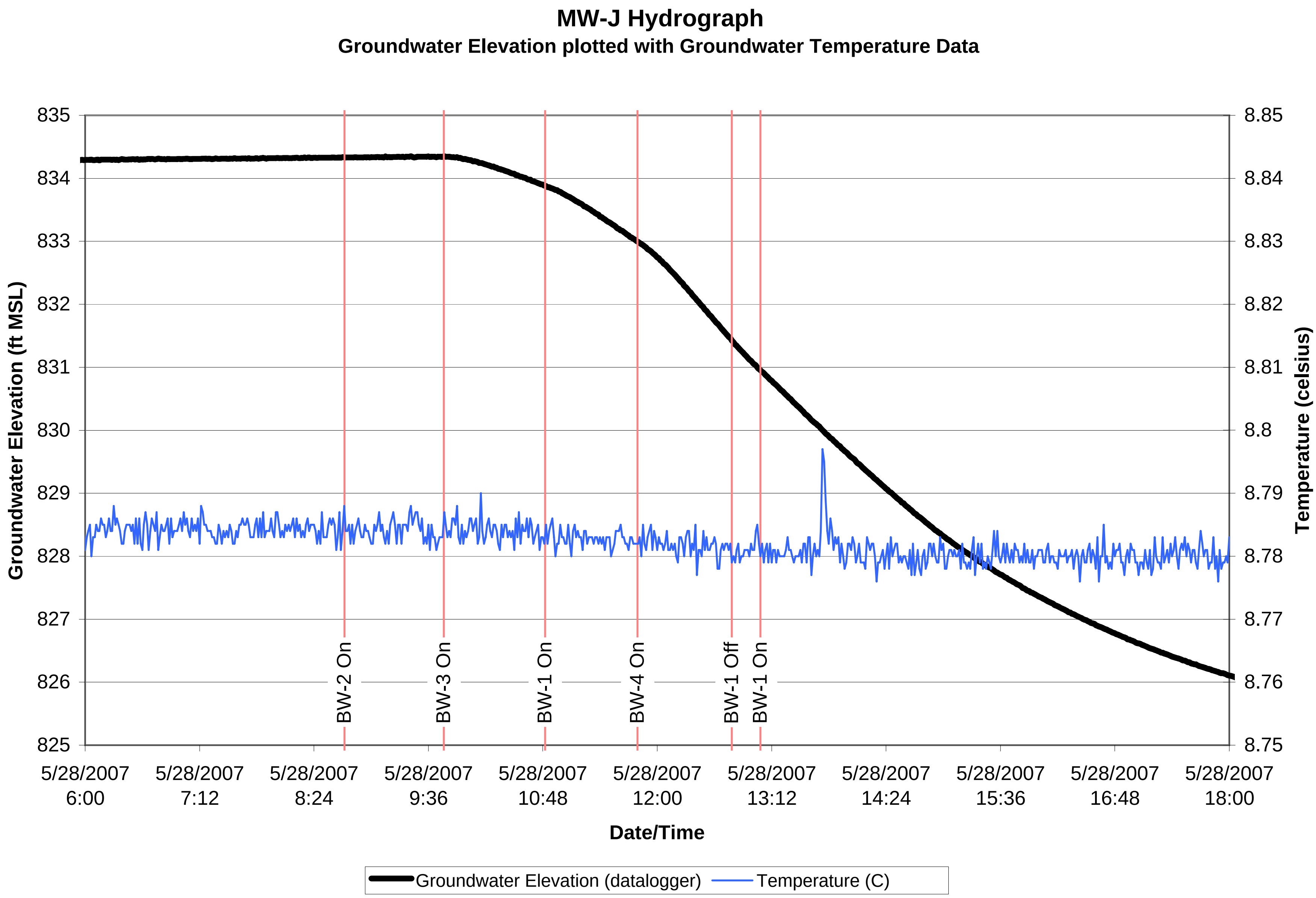
MWF data MW-F_Chart1



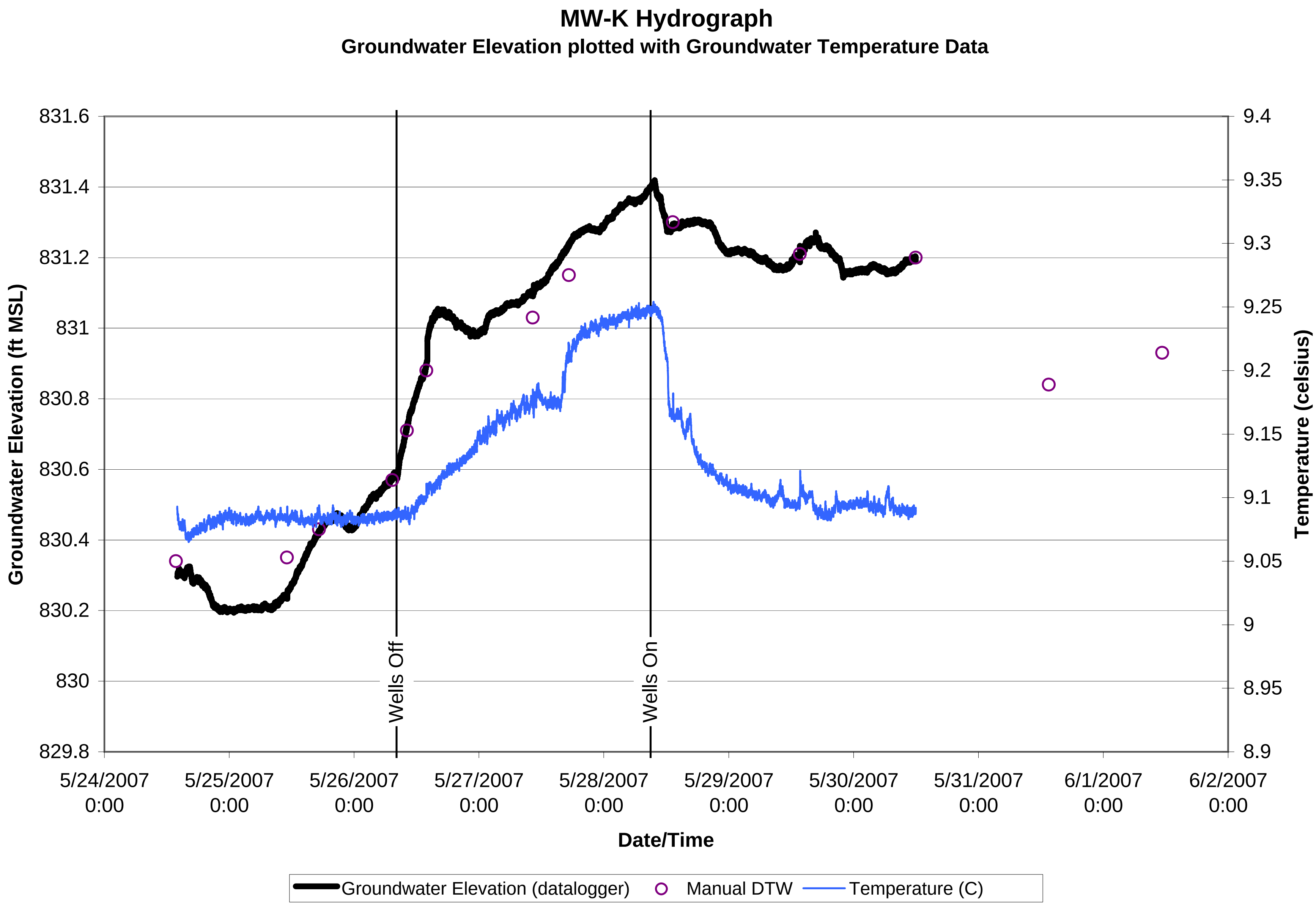
MWF data MW-F_Drdn_CH

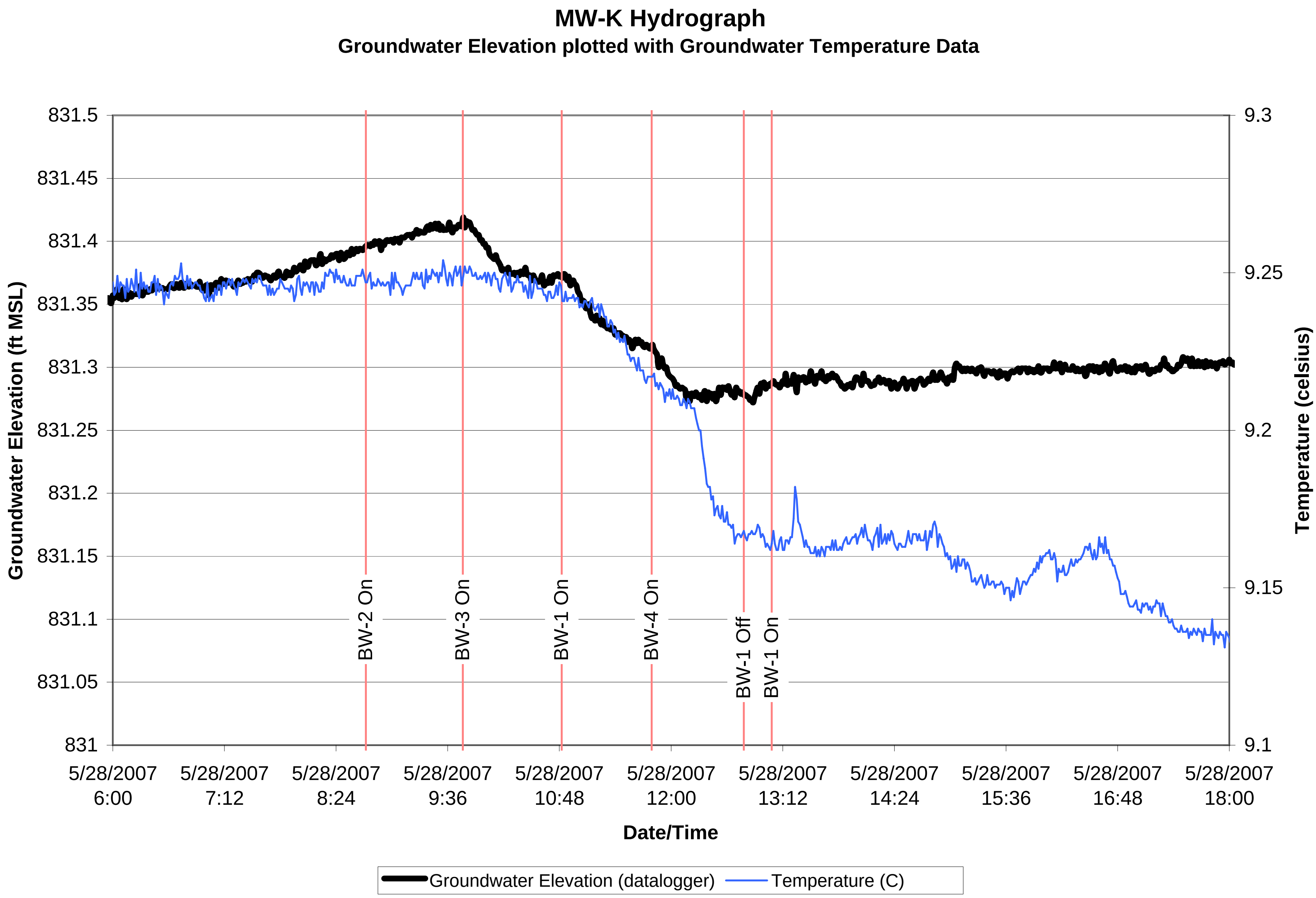


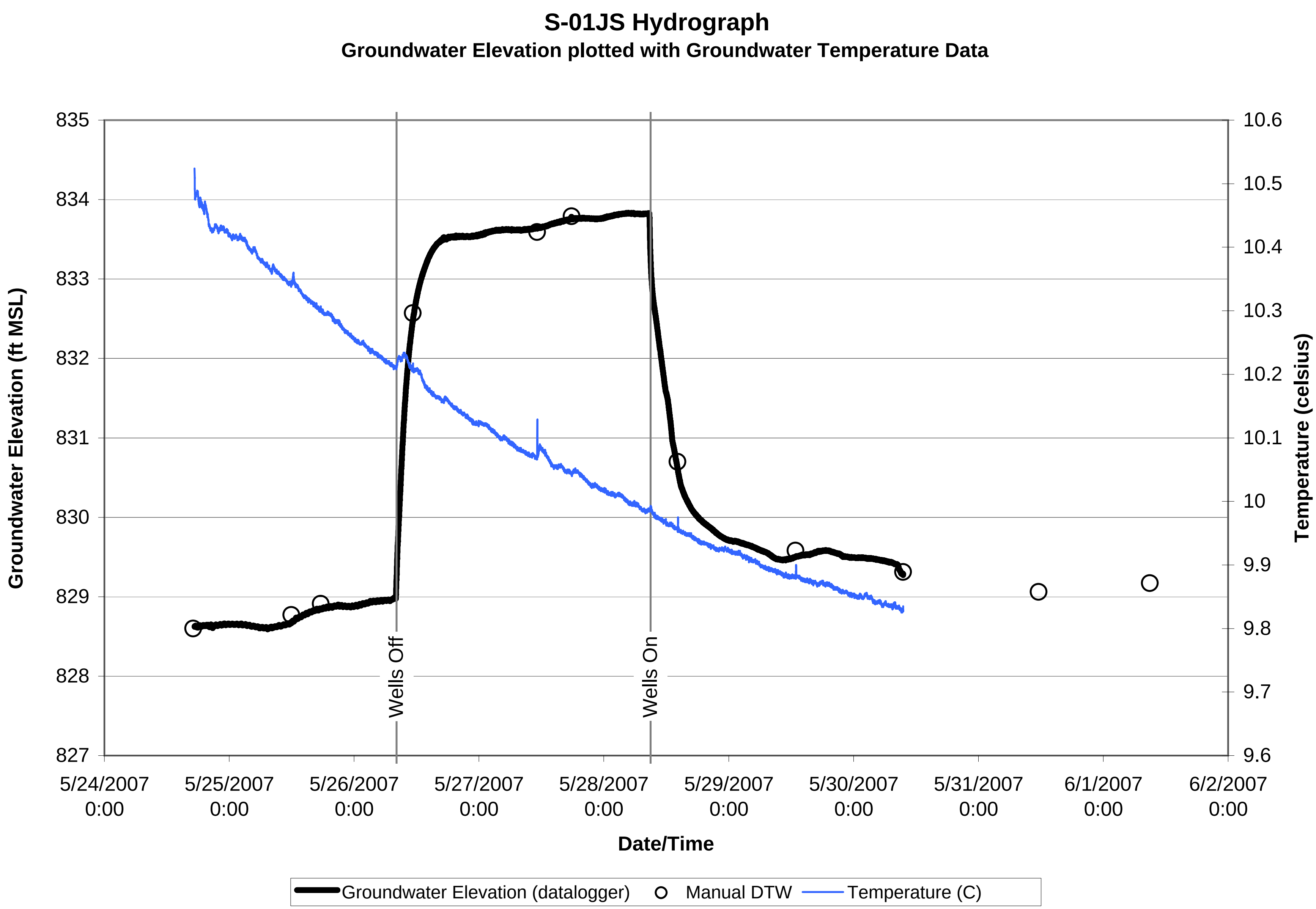
MWJ data MW-J_Chart1



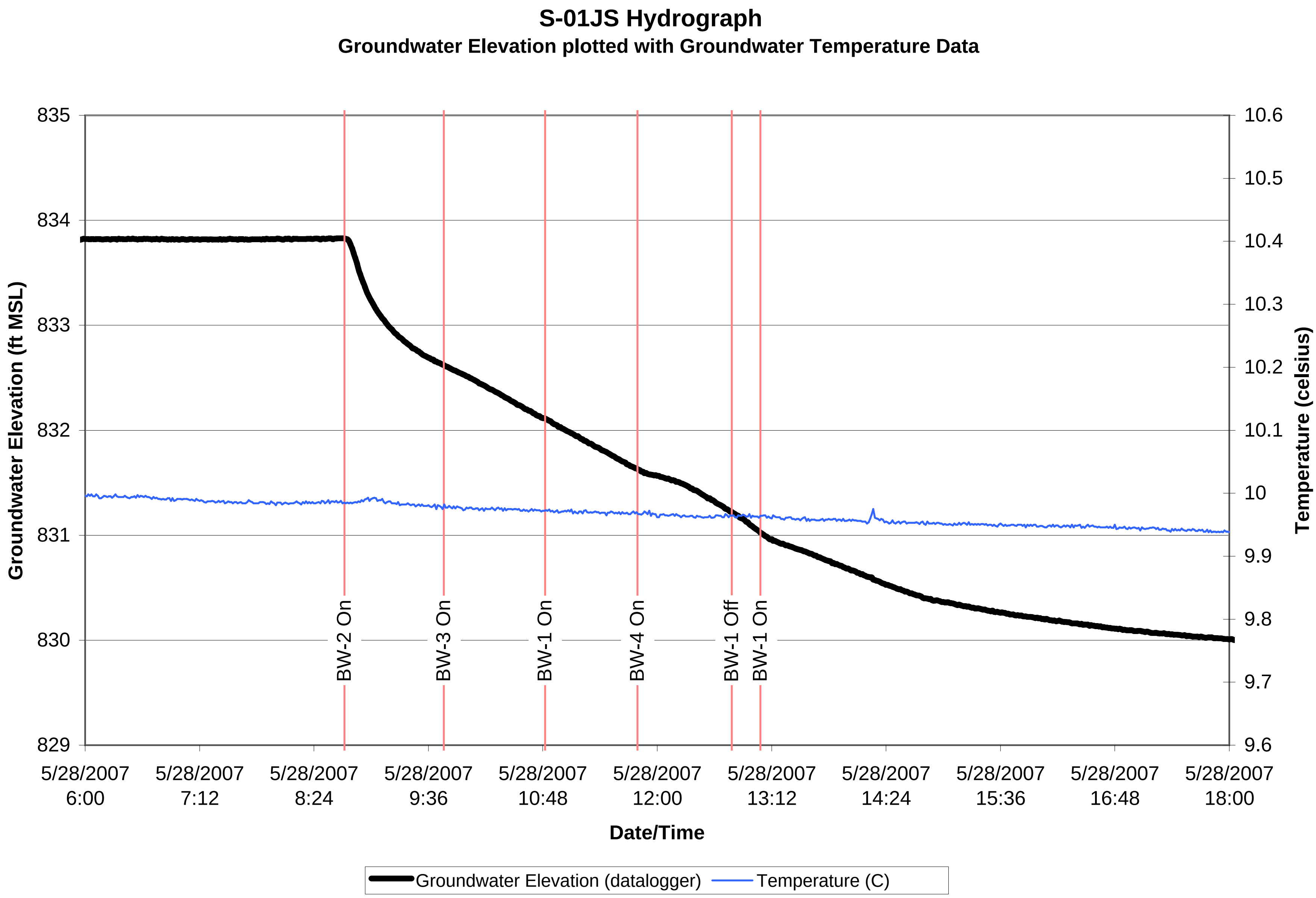
MWJ data MW-J_Ch_Drdn


MW-K Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
Groundwater Elevation (ft MSL)
Temperature (celsius)
831.6
831.4
831.2
831
830.8
830.6
830.4
830.2
830
829.8
9.4
9.35
9.3
9.25
9.2
9.15
9.1
9.05
9
8.95
8.9
Wells Off
Wells On
5/24/2007 0:00
5/25/2007 0:00
5/26/2007 0:00
5/27/2007 0:00
5/28/2007 0:00
5/29/2007 0:00
5/30/2007 0:00
5/31/2007 0:00
6/1/2007 0:00
6/2/2007 0:00
Date/Time
Groundwater Elevation (datalogger)
Manual DTW
Temperature (C)


MW-K Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
Groundwater Elevation (ft MSL)
Temperature (celsius)
831.5
831.45
831.4
831.35
831.3
831.25
831.2
831.15
831.1
831.05
831
9.3
9.25
9.2
9.15
9.1
BW-2 On
BW-3 On
BW-1 On
BW-4 On
BW-1 Off
BW-1 On
5/28/2007 6:00
5/28/2007 7:12
5/28/2007 8:24
5/28/2007 9:36
5/28/2007 10:48
5/28/2007 12:00
5/28/2007 13:12
5/28/2007 14:24
5/28/2007 15:36
5/28/2007 16:48
5/28/2007 18:00
Date/Time
Groundwater Elevation (datalogger)
Temperature (C)



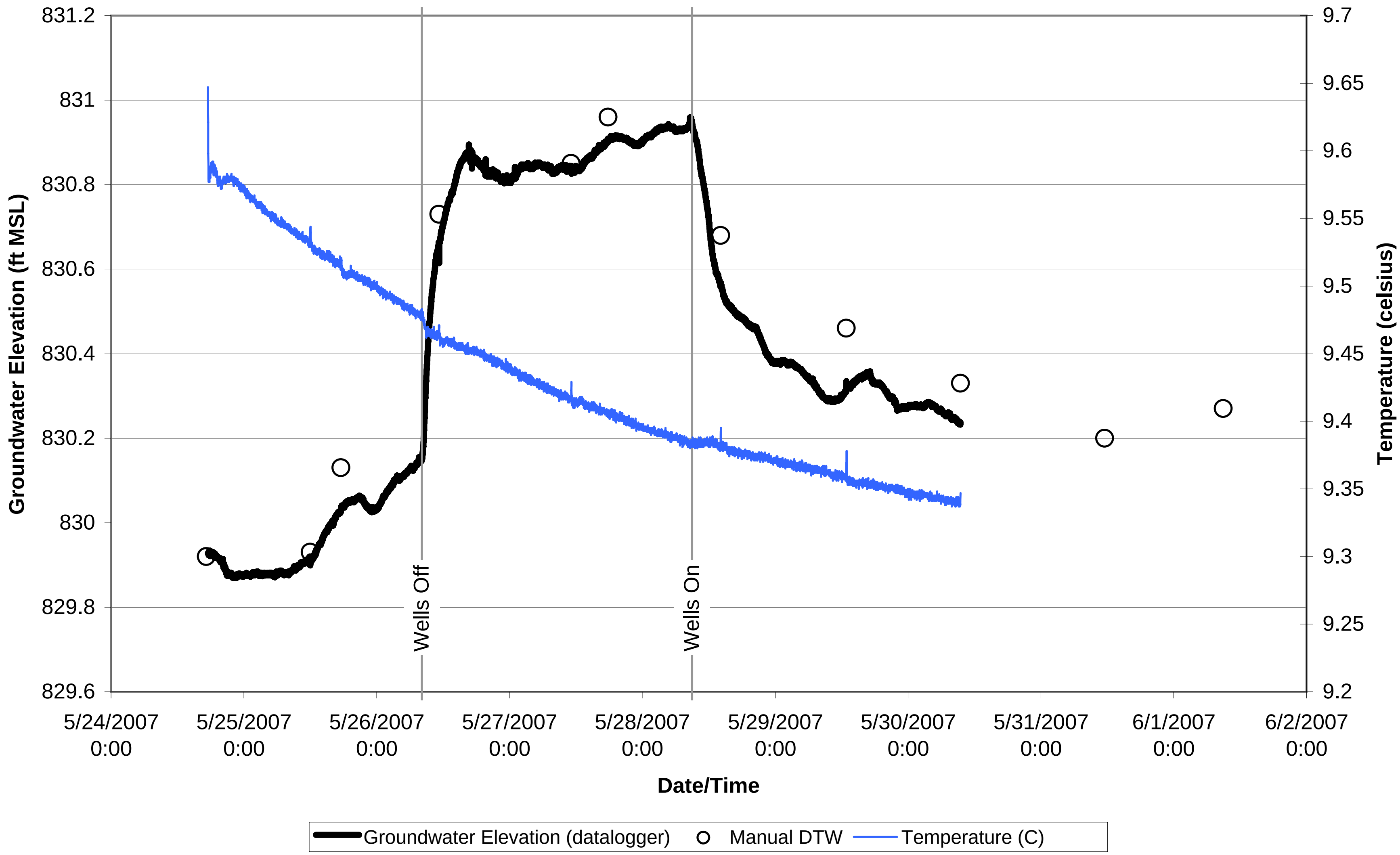
S-01JRD_data S-01JRD_CH

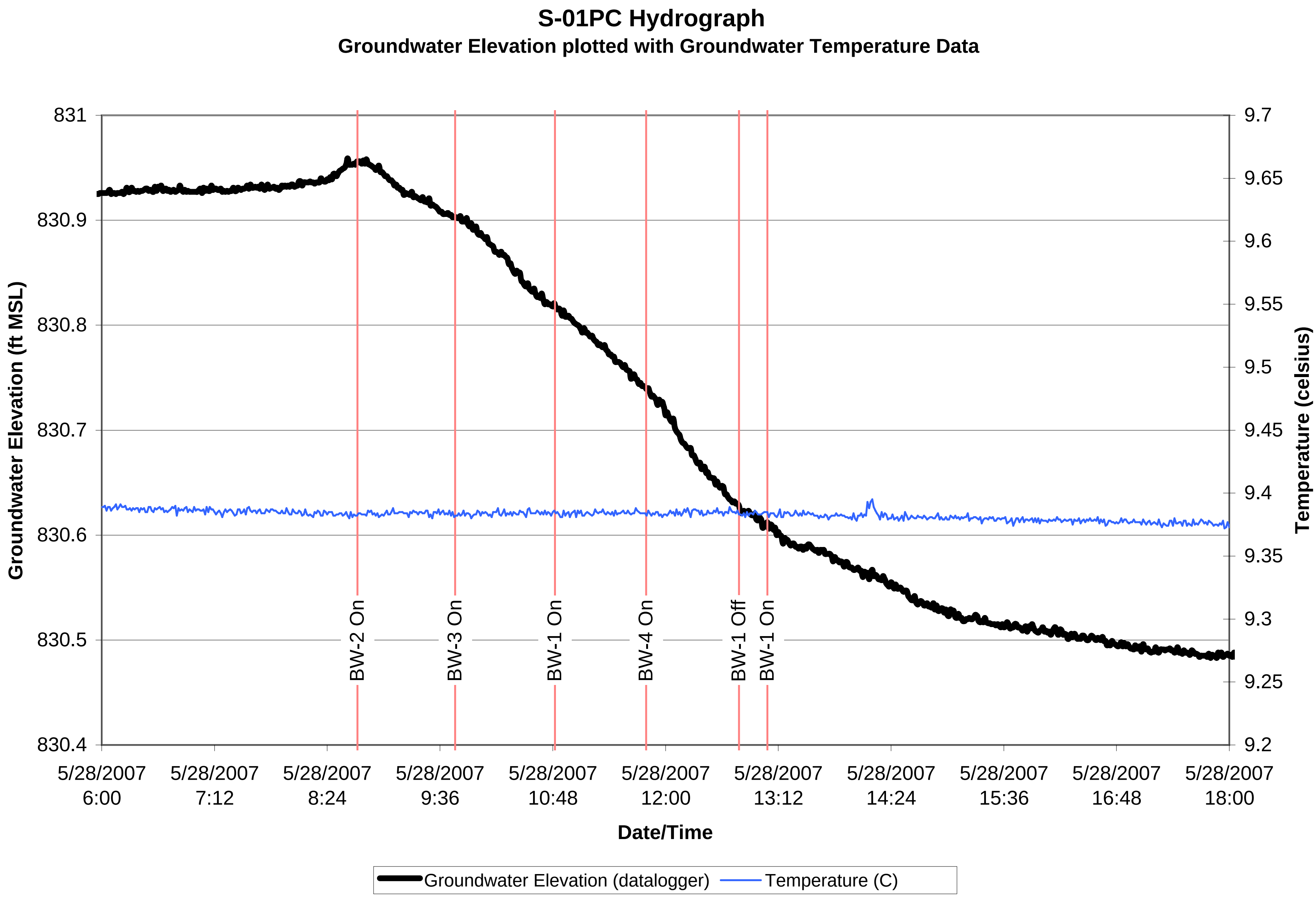


S-01JRD_data S-01JRD_CH_Drdn

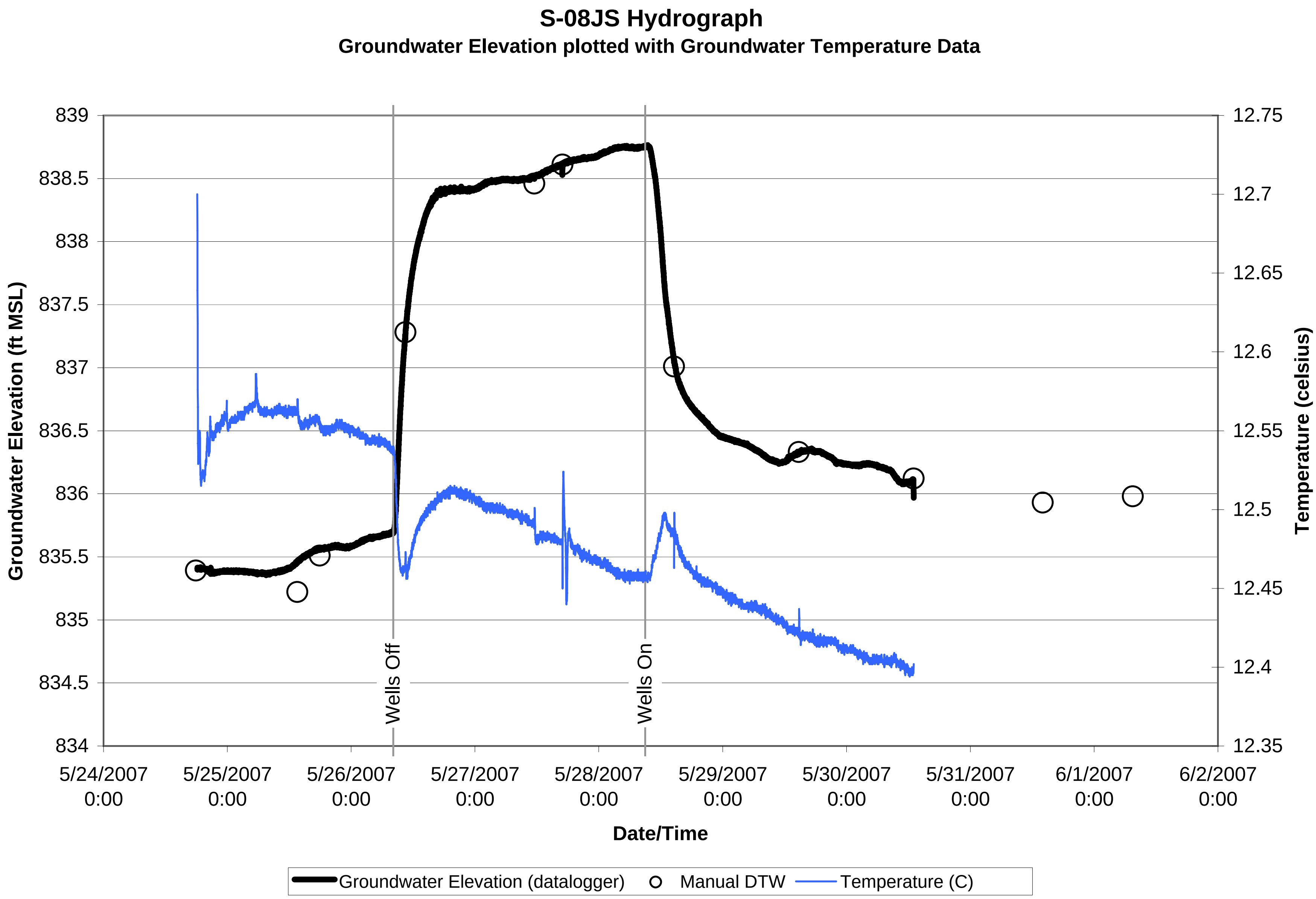
S-01PC Hydrograph

Groundwater Elevation plotted with Groundwater Temperature Data

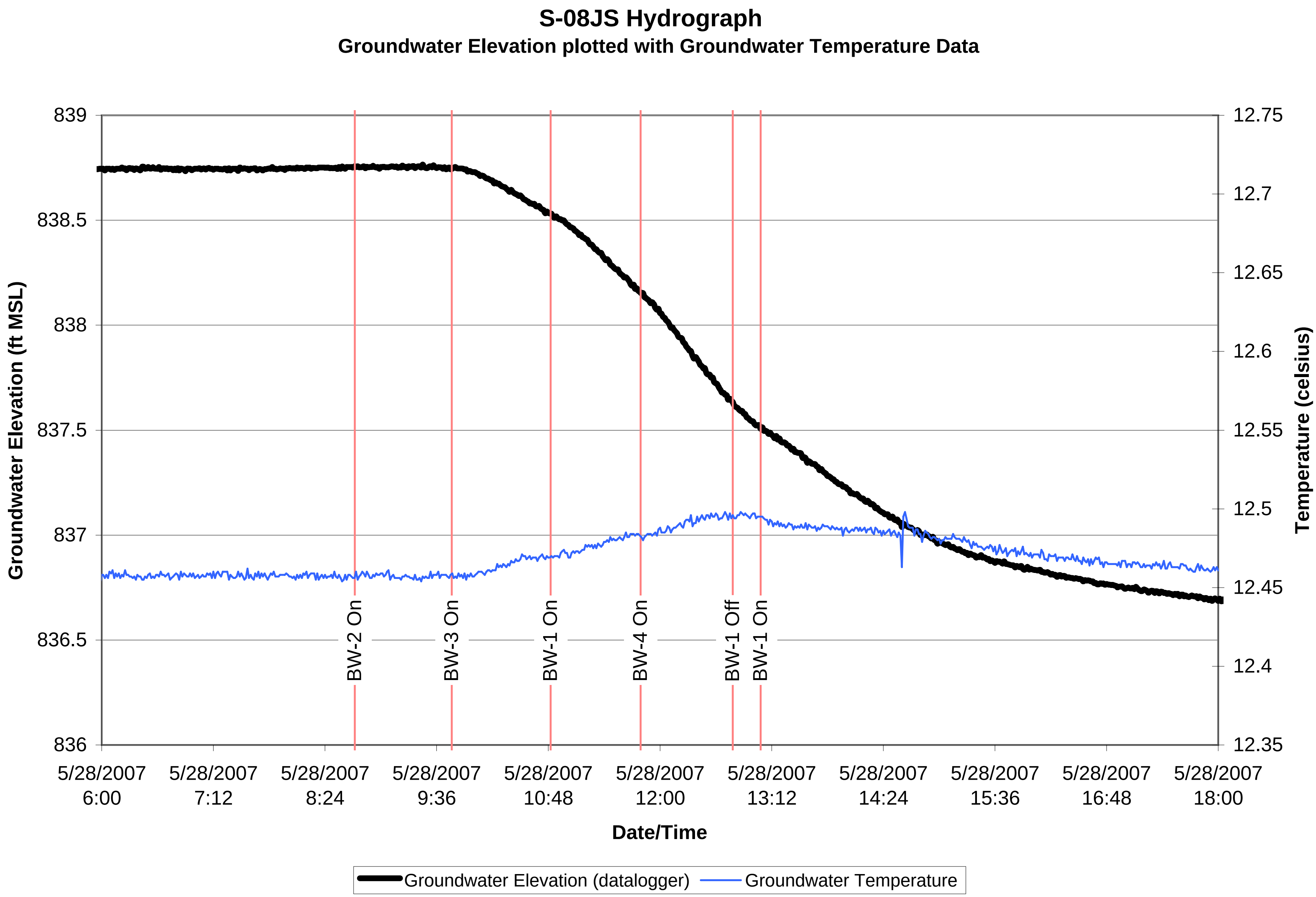


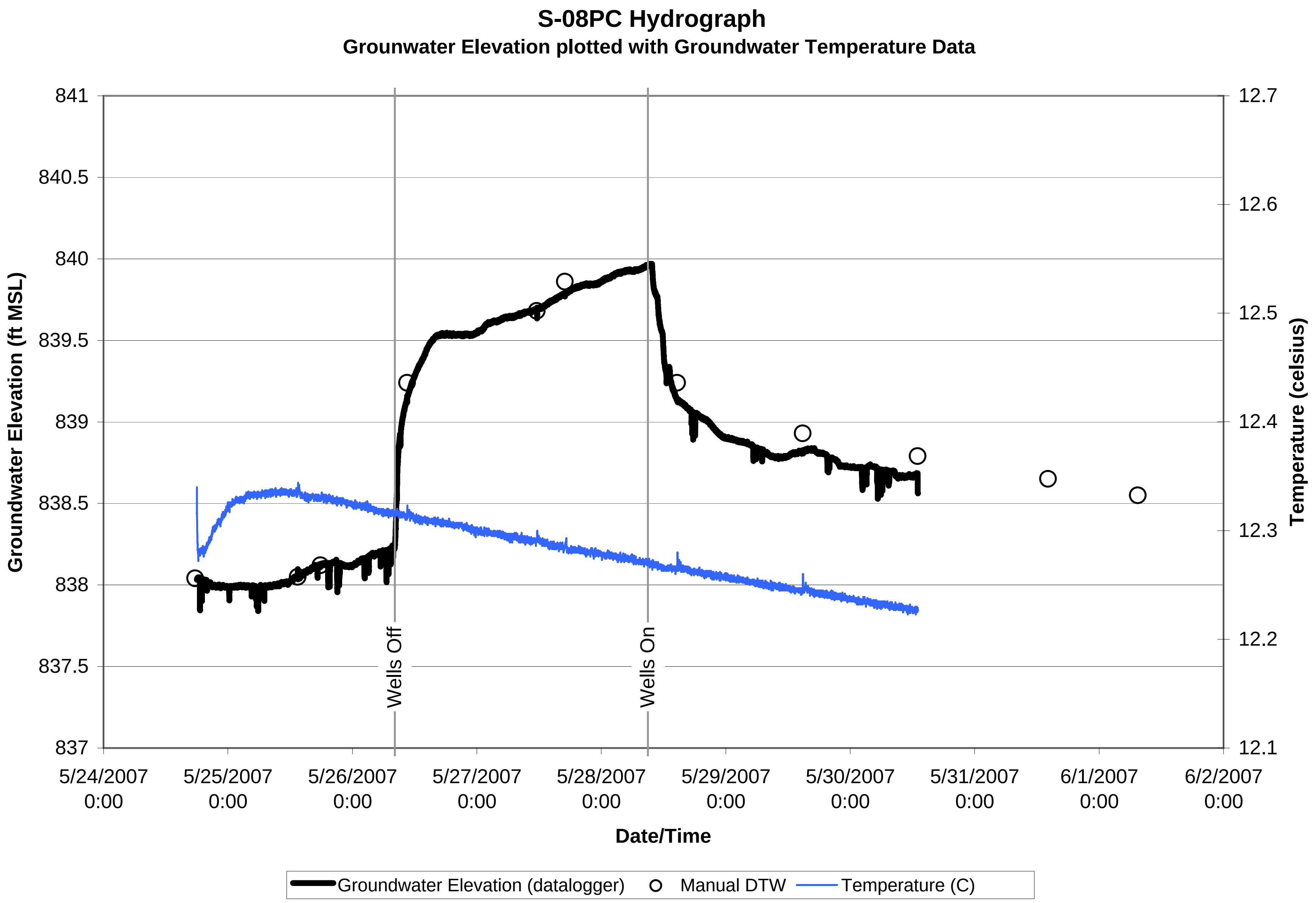


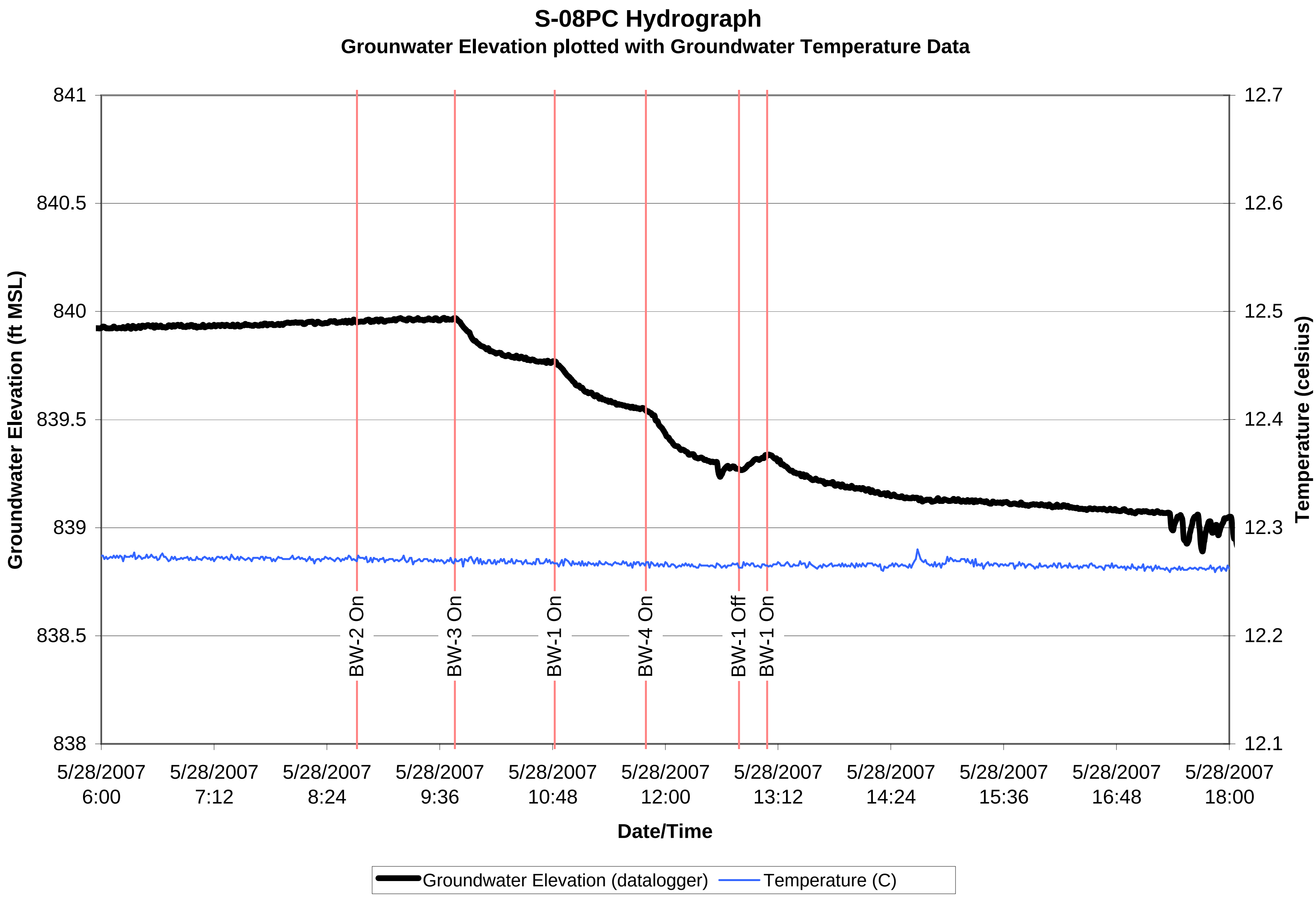
S-01PC data S-01PC_Ch_Drdn



S-08JRD_data S-08JRD_CHT


S-08JS Hydrograph
Groundwater Elevation plotted with Groundwater Temperature Data
839
838.5
838
837.5
837
836.5
836
12.75
12.7
12.65
12.6
12.55
12.5
12.45
12.4
12.35
Groundwater Elevation (ft MSL)
Temperature (celsius)
BW-2 On
BW-3 On
BW-1 On
BW-4 On
BW-1 Off
BW-1 On
5/28/2007 6:00
5/28/2007 7:12
5/28/2007 8:24
5/28/2007 9:36
5/28/2007 10:48
5/28/2007 12:00
5/28/2007 13:12
5/28/2007 14:24
5/28/2007 15:36
5/28/2007 16:48
5/28/2007 18:00
Date/Time
Groundwater Elevation (datalogger)
Groundwater Temperature

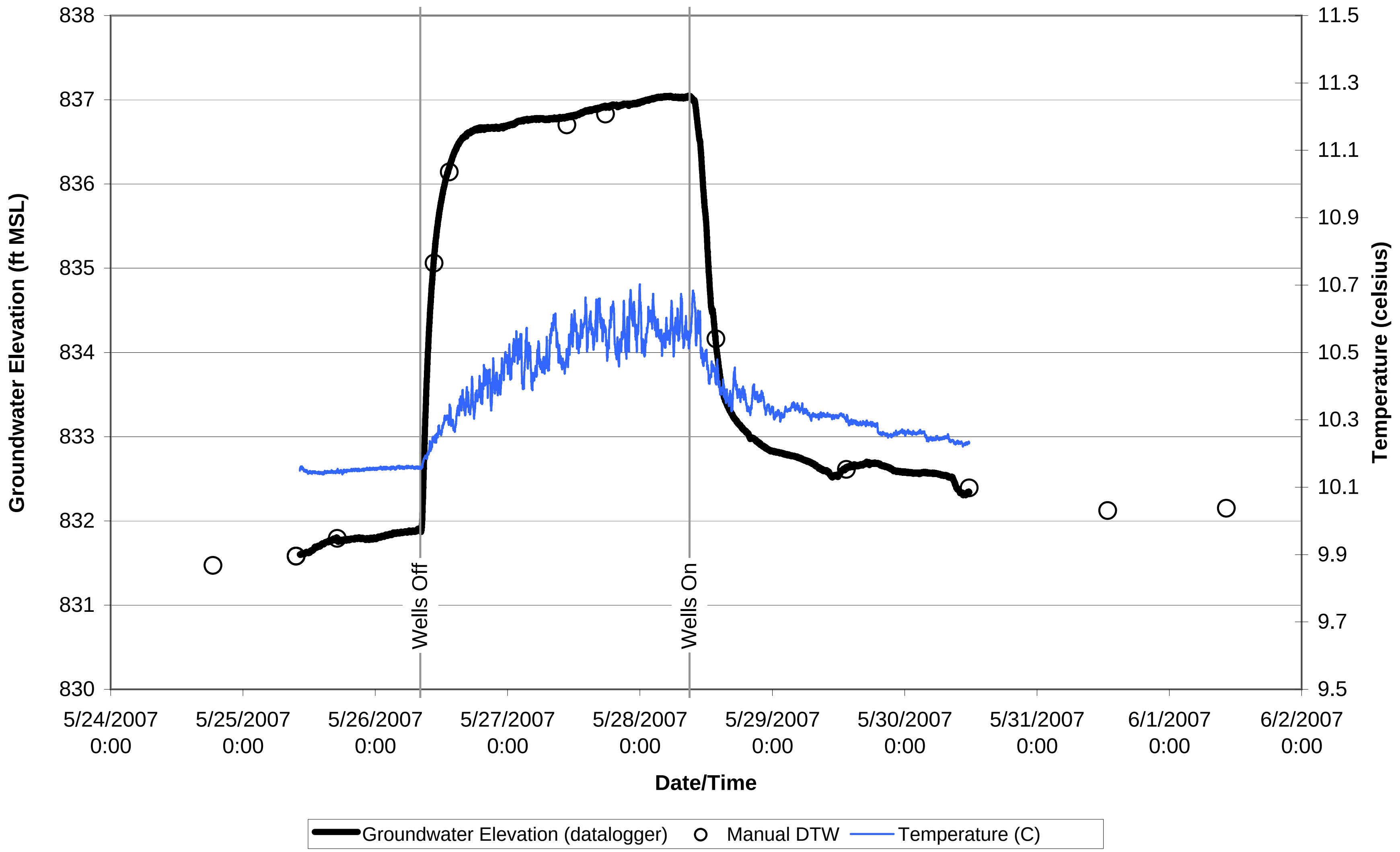

S-08PC Hydrograph
Grounwater Elevation plotted with Groundwater Temperature Data
841
840.5
840
839.5
839
838.5
838
837.5
837
12.7
12.6
12.5
12.4
12.3
12.2
12.1
Groundwater Elevation (ft MSL)
Temperature (celsius)
Wells Off
Wells On
5/24/2007 0:00
5/25/2007 0:00
5/26/2007 0:00
5/27/2007 0:00
5/28/2007 0:00
5/29/2007 0:00
5/30/2007 0:00
5/31/2007 0:00
6/1/2007 0:00
6/2/2007 0:00
Date/Time
Groundwater Elevation (datalogger)
Manual DTW
Temperature (C)

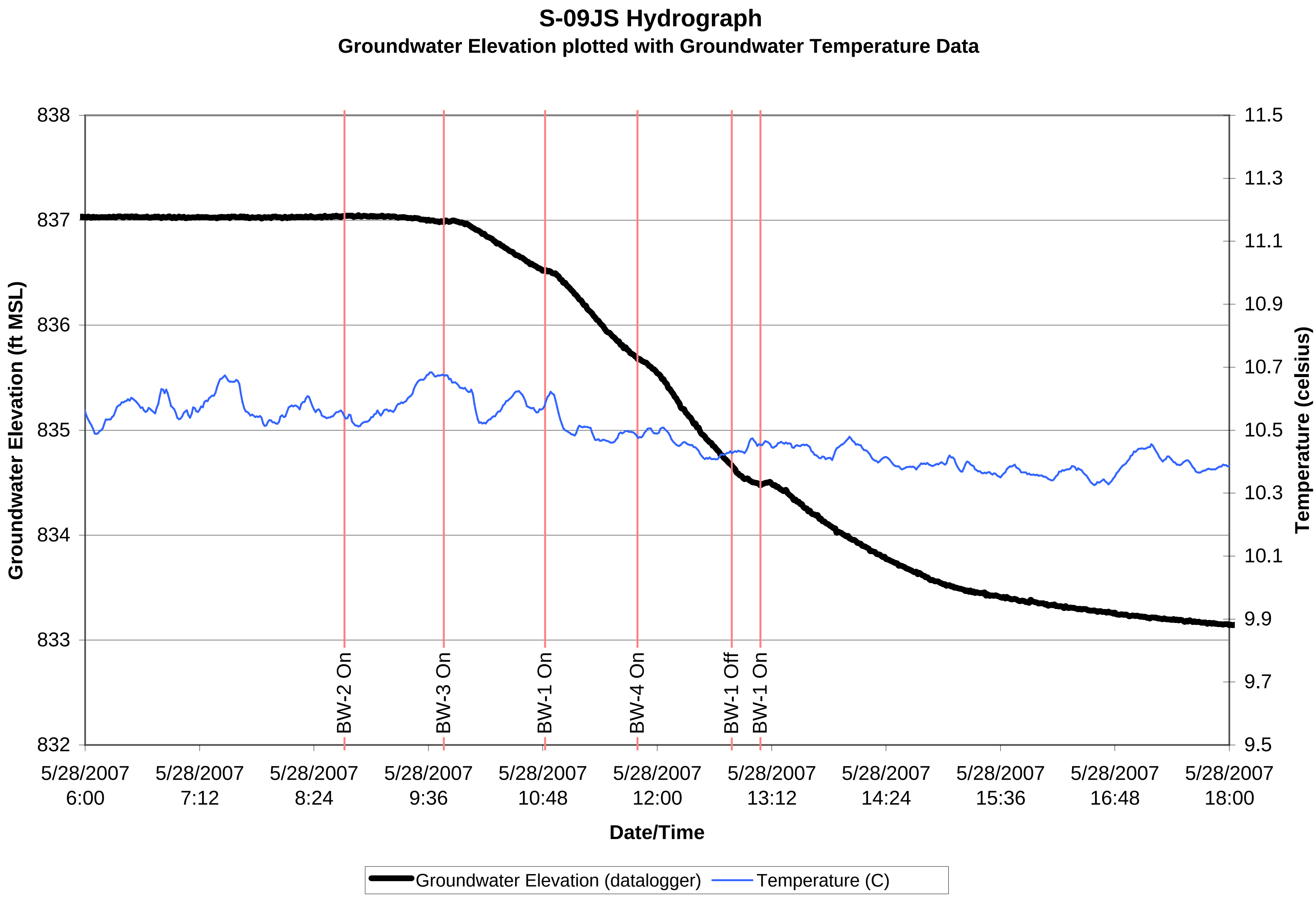


S-08PC data S-08PC_Ch_DRDN

S-09JS Hydrograph

Groundwater Elevation plotted with Groundwater Temperature Data

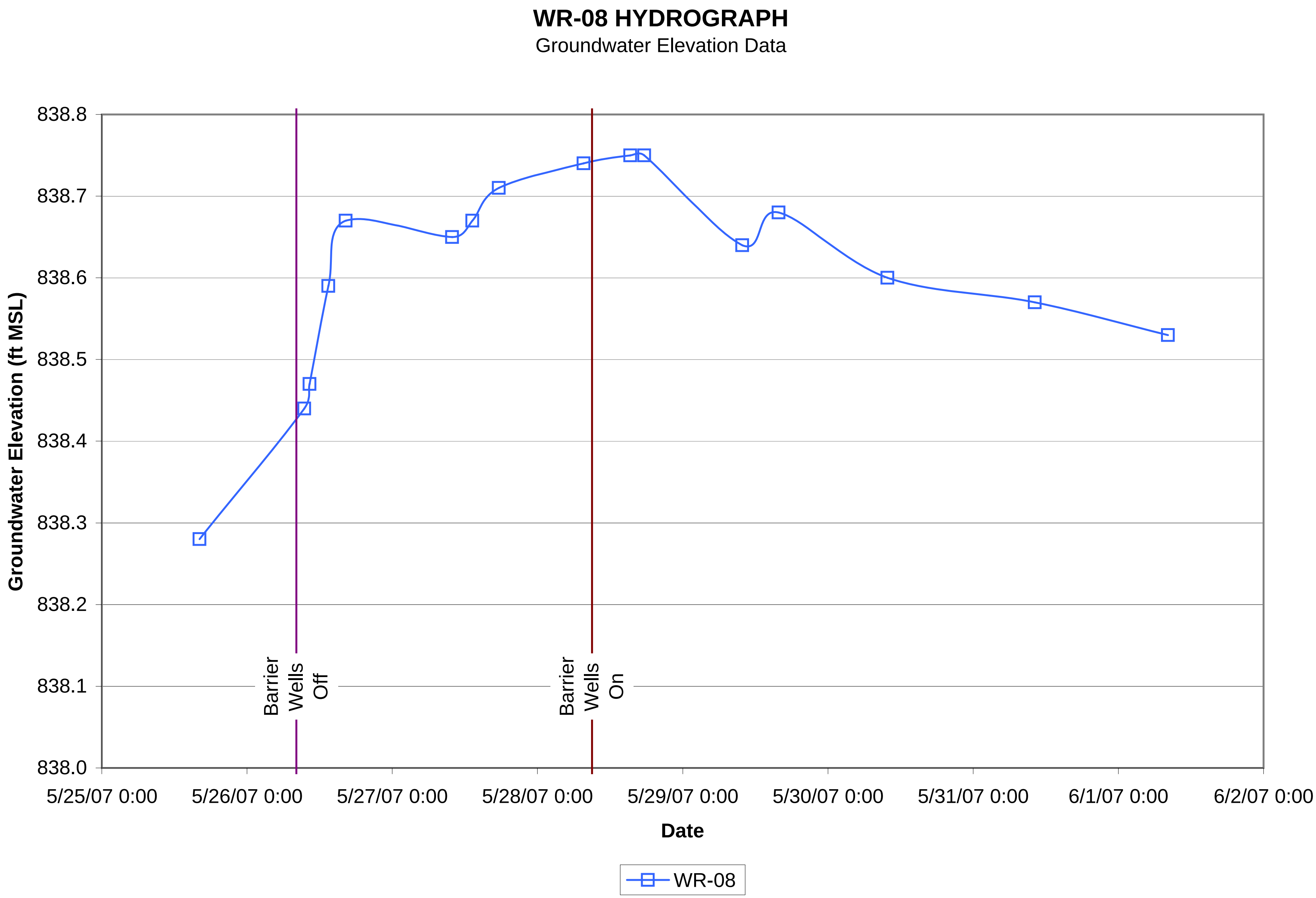




S-09JRD data S-09JRD_CH_DRDN

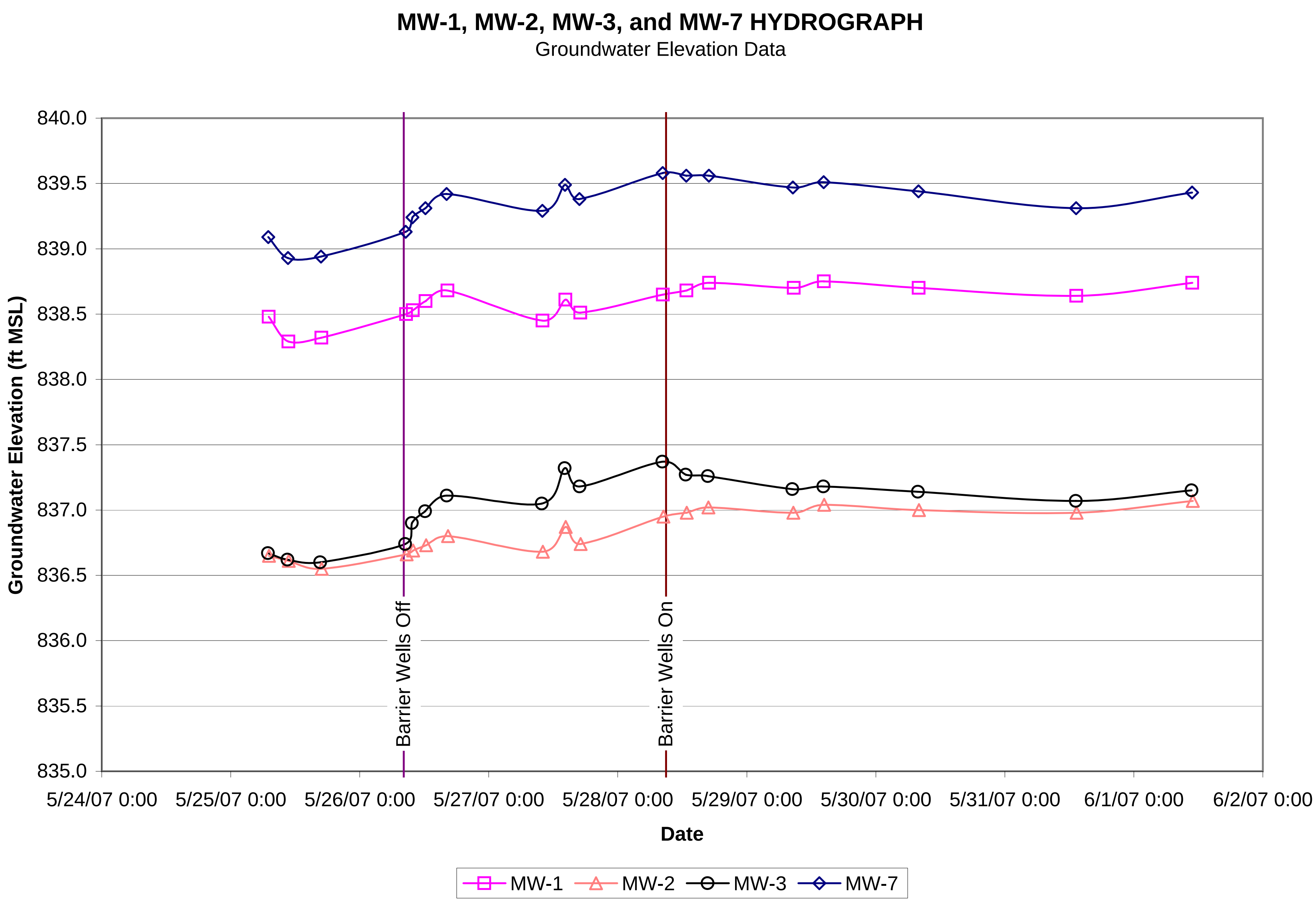
ATTACHMENT 2

Groundwater Hydrographs
Monitor and Recovery Wells
Monitored Manually



Former residential well on Cottage Grove Drive.

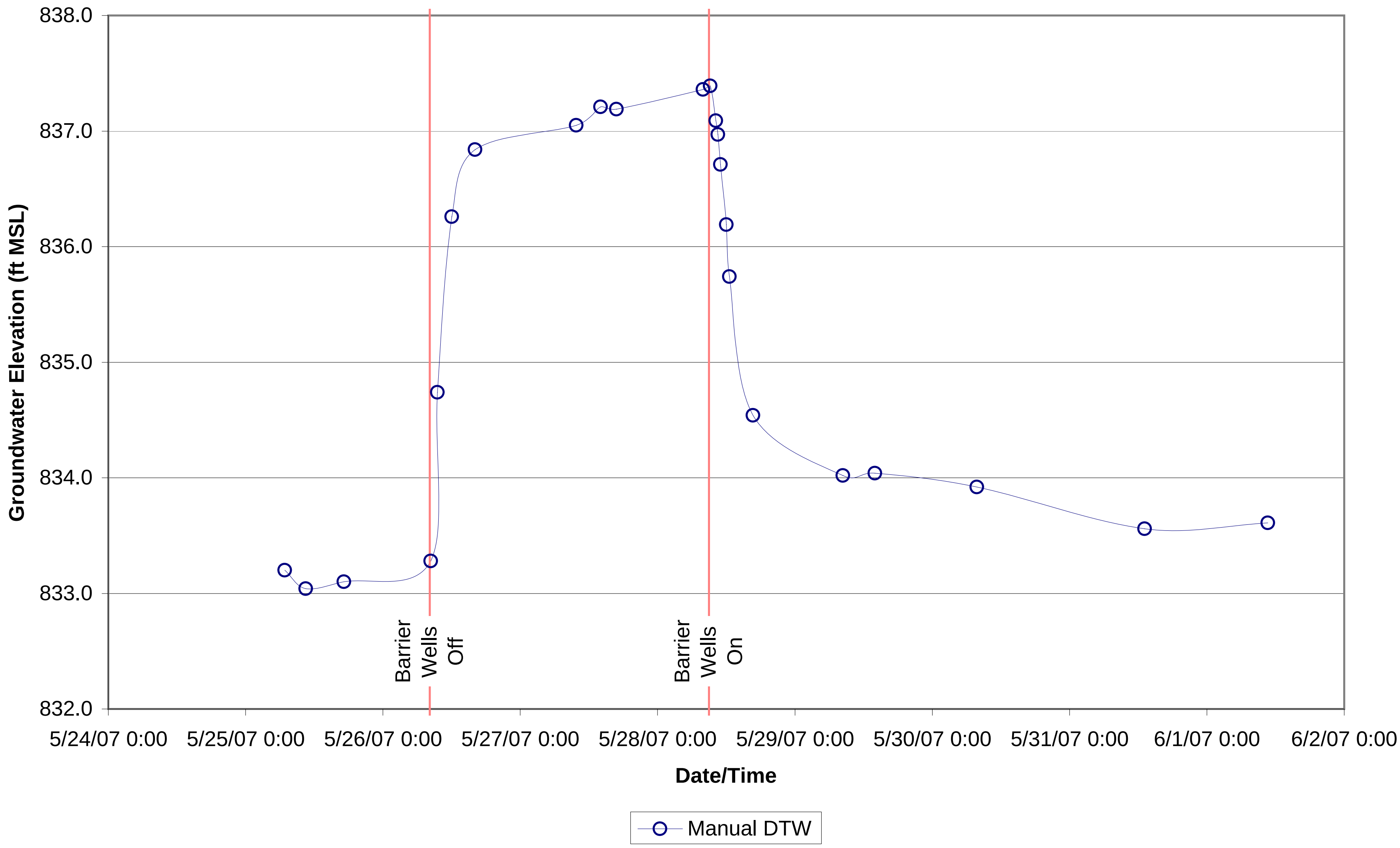
Manuals_daveWR-08_CHART

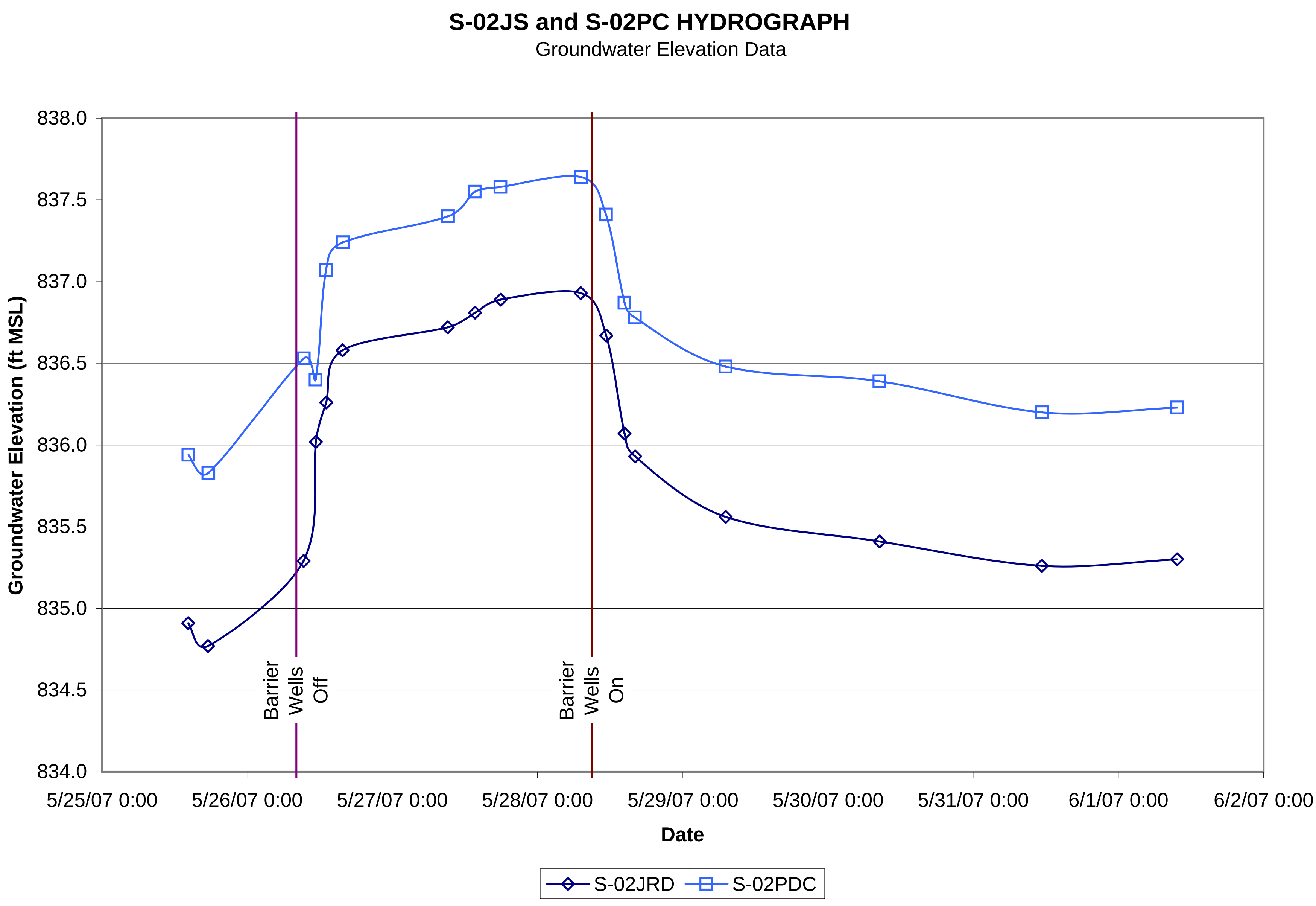


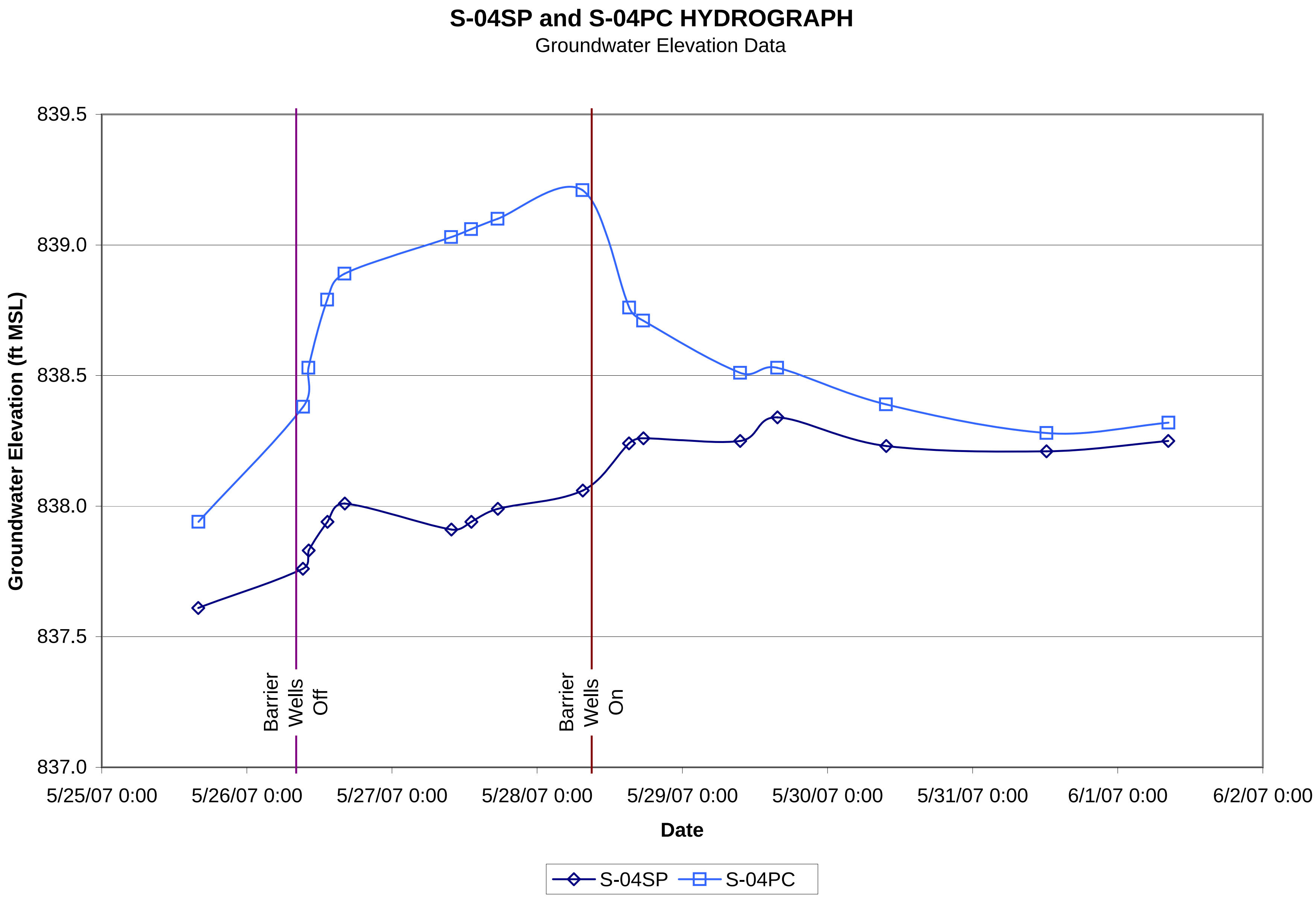
Manuals_daveMW-1,-2,-3,-7_CHART

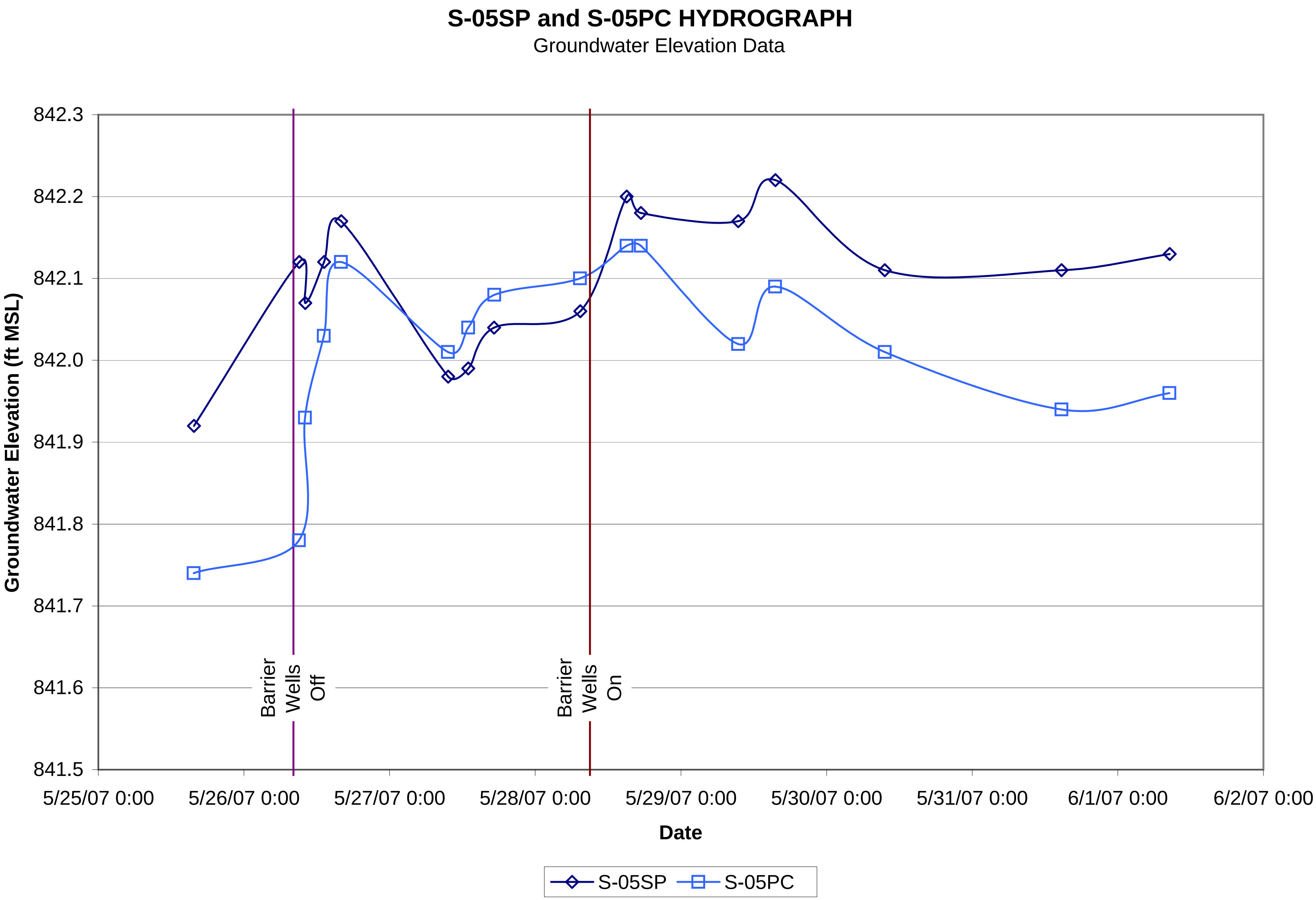
MW-G Hydrograph

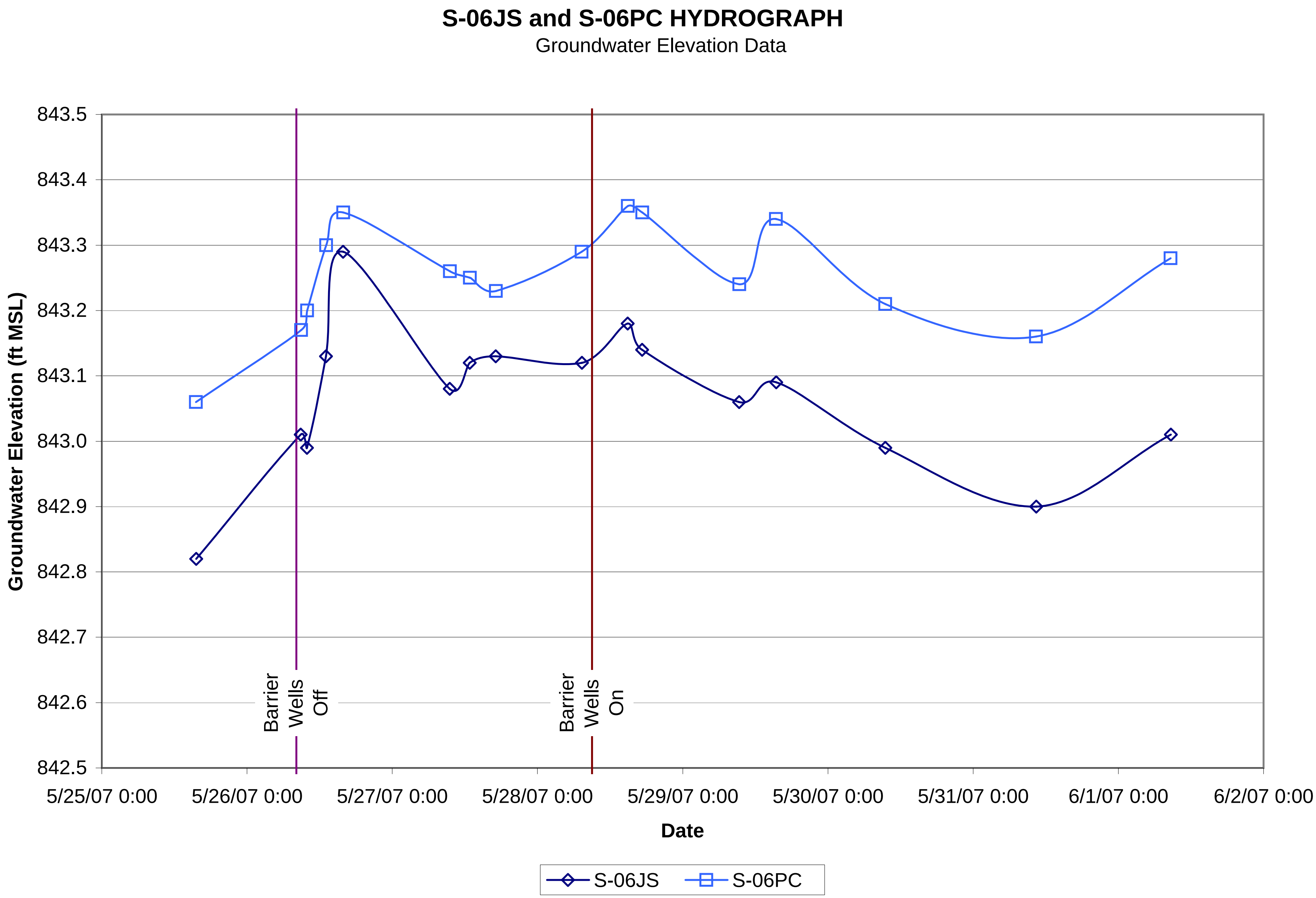
Groundwater Elevation Data

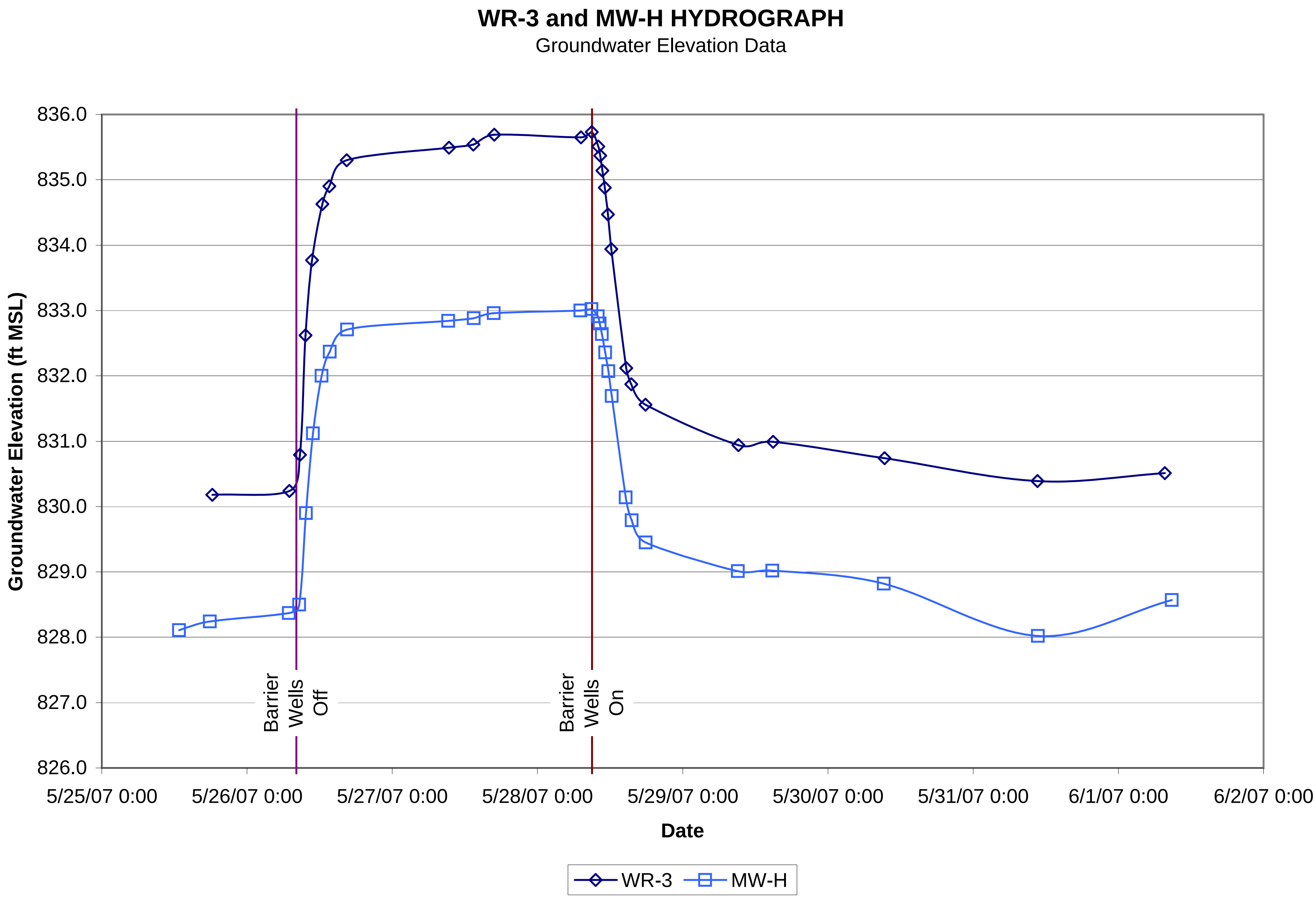



S-02JS and S-02PC HYDROGRAPH
Groundwater Elevation Data
Groundwater Elevation (ft MSL)
838.0
837.5
837.0
836.5
836.0
835.5
835.0
834.5
834.0
Barrier Wells Off
Barrier Wells On
5/25/07 0:00
5/26/07 0:00
5/27/07 0:00
5/28/07 0:00
5/29/07 0:00
5/30/07 0:00
5/31/07 0:00
6/1/07 0:00
6/2/07 0:00
Date
S-02JRD
S-02PDC


S-04SP and S-04PC HYDROGRAPH
Groundwater Elevation Data
Groundwater Elevation (ft MSL)
839.5
839.0
838.5
838.0
837.5
837.0
Barrier Wells Off
Barrier Wells On
5/25/07 0:00
5/26/07 0:00
5/27/07 0:00
5/28/07 0:00
5/29/07 0:00
5/30/07 0:00
5/31/07 0:00
6/1/07 0:00
6/2/07 0:00
Date
S-04SP
S-04PC


S-05SP and S-05PC HYDROGRAPH
Groundwater Elevation Data
Groundwater Elevation (ft MSL)
842.3
842.2
842.1
842.0
841.9
841.8
841.7
841.6
841.5
Barrier Wells Off
Barrier Wells On
5/25/07 0:00
5/26/07 0:00
5/27/07 0:00
5/28/07 0:00
5/29/07 0:00
5/30/07 0:00
5/31/07 0:00
6/1/07 0:00
6/2/07 0:00
Date
S-05SP
S-05PC


S-06JS and S-06PC HYDROGRAPH
Groundwater Elevation Data
Groundwater Elevation (ft MSL)
843.5
843.4
843.3
843.2
843.1
843.0
842.9
842.8
842.7
842.6
842.5
Barrier Wells Off
Barrier Wells On
5/25/07 0:00
5/26/07 0:00
5/27/07 0:00
5/28/07 0:00
5/29/07 0:00
5/30/07 0:00
5/31/07 0:00
6/1/07 0:00
6/2/07 0:00
Date
S-06JS
S-06PC


WR-3 and MW-H HYDROGRAPH
Groundwater Elevation Data
Groundwater Elevation (ft MSL)
836.0
835.0
834.0
833.0
832.0
831.0
830.0
829.0
828.0
827.0
826.0
Barrier Wells Off
Barrier Wells On
5/25/07 0:00
5/26/07 0:00
5/27/07 0:00
5/28/07 0:00
5/29/07 0:00
5/30/07 0:00
5/31/07 0:00
6/1/07 0:00
6/2/07 0:00
Date
WR-3
MW-H