APPENDIX E

Cushenbury Springs Hydogeologic Evaluation

TECHNICAL MEMORANDUM

Date:	July 17, 2013	**Project No.:**	093-91967-01
To:	David Rib	**Company:**	Mitsubishi Cement Corporation
From:	George Wegmann, William Fowler, P.G., C.E.G.	**Email:**	gwegmann@golder.com

RE: CUSHENBURY SPRINGS – HYDROGEOLOGIC EVALUATION

Golder Associates Inc. (Golder) conducted a limited hydrogeologic investigation at the Mitsubishi Cement Corporation (MCC) Cushenbury Mine and Plant Facility in Lucerne Valley, California (Figure 1). The work consisted of collecting water elevation data during different groundwater pumping scenarios to assess potential impacts on Cushenbury Springs from the anticipated increase in groundwater demand when the proposed South Quarry becomes operational. This technical memorandum summarizes activities completed and our findings.

1.0 BACKGROUND INFORMATION

Based on the 2012 Water Supply Assessment Report[1], it is estimated that 585 acre-ft per year of water will be consumed with the proposed South Quarry in operation. The 585 acre-ft per year represents an increase of approximately 21% over the site's average annual water use of 484 acre-ft per year as determined from 2000 through 2010 site data. During this timeframe, the site's annual water usage was above the future anticipated increased annual water usage of 585 acre-ft for one year (2007-2008); however, limited groundwater elevation data is available for that time period. Furthermore, while the reported potential increase in water usage as part of the proposed South Quarry expansion is still significantly below MCC's permitted water rights, there is only limited data available from the semi-annual groundwater monitoring regarding hydraulic connection and response between the site pumping wells, monitoring wells, and Cushenbury Springs.

Ron Barto Ground Water Consultant (Barto) indicated that, based on the groundwater data from the semi-annual monitoring program, several faults are present in the vicinity of Cushenbury Springs that act as effective barriers to groundwater flow. The east-west trending frontal faults result in "stair-steps" of groundwater levels as groundwater moves down the slope from south to north toward the valley.[2] Barto also indicated that the flow from Cushenbury Springs is widespread and is evidenced by high groundwater levels and seeps along the dirt road adjacent to the transmission pipeline from the off-site Lucerne Valley wells, similar to conditions observed in the spring of 2005 and 2010. The working

[1] Lilburn Corporation, Water Supply Assessment For the Proposed Mitsubishi Cement Corporation South Quarry, Revised December 2012.

[2] Ron Barto Ground Water Consultant, Fall 2011/Spring 2012 Semi-Annual Ground Water Monitoring Program for Cushenbury Mine, Lucerne Valley, May 30, 2012.

conceptual site model (CSM), therefore, consists of groundwater flow from the south that backs up against the Cushenbury fault and rises to the surface, resulting in spring flow at and just north of the fault.

The following table lists the well details for the on-site production and monitoring wells.

Table 1: Well Details

Well Name	Year Drilled	Elevation (ft)	Total Depth (ft bgs)	Screen Depth (ft bgs)
Well #1	1955	4410	600	301-598
Well #2	1956	4183	316	208-308
Well #3	1957	4445	546	335-546
Well #4	1959	4174	470	70-465
MW-1	1991	4242	144	124-144
MW-2	1991	4167	93	53-93
MW-3	1991	4134	33	13-33
MW-4	2000	4240	116	205-285

Notes:
Wells #2 and #3 are no longer operational and are not readily accessible.
Source of well detail data is Barto's May 2012 report
ft bgs = feet below ground surface

1.1 Site Reconnaissance

On June 6, 2013, Leah Feigelson and George Wegmann of Golder conducted a site visit and met with David Rib, MCC's environmental manager. The purpose of the site visit was to identify the status of existing wells and pumping capacities, observe flow at Cushenbury Springs, and develop and implement a plan to measure water levels and pumping rates at select wells. Figure 2 depicts the locations of MCC's on-site production and monitoring wells.

From the site visit, it was determined that the site generally operates Well #1 continually at approximately 150 gpm. Well #4 automatically cycles on and off during the day based on water usage. Well #4 pumps at approximately 450 gpm and cycles on for about 20 minutes per cycle. Wells #1 and #4 are 600 and 470 feet deep, respectively. Well #1 is screened from elevation 3812 to 4109 ft predominantly in bedrock and Well #4 is screened from elevation 3709 to 4104 ft in alluvium and bedrock.[3] On-site Well #2 and Well #3 are not currently operational. In addition to the on-site production wells, there are four monitoring wells installed on-site: MW-1 though MW-4.

[3] Ron Barto Ground Water Consultant, Hydrogeologic Update of the Cushenbury Mine and Plant Site, March 15, 2002.

During the site visit, Golder instrumented select wells with transducers to measure groundwater levels and record changes in the potentiometric surface over time. Water levels were measured with submerged INW® PT2X™ pressure transducer dataloggers programmed to record water pressure and temperature at five minute intervals. The following wells were instrumented: Well #4 and monitoring wells MW-1, MW-2, and MW-3. Additionally, depth to water measurements were made manually with an electric water level meter.

To measure the water levels in Cushenbury Springs, Golder installed two temporary 1-inch diameter PVC piezometers as shown on Figure 2 as Spring 1 and Spring 2. The temporary piezometers were instrumented with INW® PT2X™ pressure transducer dataloggers programmed to record measurements every 5 minutes. Spring 1 was set in the Cushenbury Springs located along the western side of the access road in an area where water was actively flowing. Spring 2 was set along the eastern side of the access road in a small wetlands area where water was ponded.

Golder performed site inspections on June 14, 2013 while the testing program was ongoing and then again on June 21, 2013 upon the completion of the testing program to retrieve data and the pressure transducers.

1.2 Test Conditions

Under the direction of Golder, MCC implemented several different pumping conditions. The various operating scenarios are summarized in the following table.

Table 2: Operating Scenarios

Scenario	Operation	Start Date	Finish Date	Approximate Duration	Notes
A	Well #1 on, Well #4 auto	June 6, 2013[1]	June 12, 2013	156 hours	Normal operating conditions
B	Well #1 and Well #4 both off	June 12, 2013	June 14, 2013	48 hours	Water supplied to the site from off-site Lucerne Valley wells
C	Well #1 off, Well #4 on	June 14, 2013	June 17, 2013	72 hours	Well #4 operating at constant rate
D	Well #1 and Well #4 both off	June 17, 2013	June 19, 2013	48 hours	Water supplied to the site from off-site Lucerne Valley wells
E	Well #1 on, Well #4 auto	June 19, 2013	June 21, 2013[2]	72 hours	Return to normal operating conditions

Notes:
1 = start date when Golder installed pressure transducers
2 = finish date when Golder removed pressure transducers

MCC collected daily well flowmeter readings from Well #1 and Well #4. The readings are summarized on Table 3. Scenarios A and E were conducted to establish baseline groundwater elevations and data as the site was operated under normal everyday working conditions. During Scenarios A and E, the Well #1 pumping rate averaged approximately 150 gpm and Well #4 averaged approximately 140 gpm.

Scenarios B and D were recovery phases to see how the groundwater system responded when none of the on-site wells were pumped. During the second recovery phase (Scenario D), Well #1 was operated for a short duration by MCC.

For Scenario C, Well #4 was pumped at a relatively constant rate while Well #1 remained off. During this Scenario, Well #4 was pumped at a daily rate that was over 21% greater than the average daily pumping rate from normal operating conditions based on data from Scenarios A and E (see Table 3) to match the projected demand from the proposed South Quarry operations. In addition, this Scenario assumes a worst-case scenario of Well #4 being the sole source of water, which is not how MCC currently operates or plans to operate their water supply system. Excess water generated while Scenario C was completed was discharged by the water storage tank south of the cement plant.

2.0 DATA COLLECTION SUMMARY

Hydrographs of the well and spring data are included as Figures 3 through 6. Included on the hydrograph figures as the secondary y-axis is the total average pumping rate from Well #4. The total average pumping rate is calculated based on the totalized flowmeter readings and dates provided to us by MCC. Transducer data from well MW-2 was not collected due to transducer error. However, Golder manually measured MW-2 groundwater elevations on 6/6/2013 and 6/21/2013. Raw transducer data from Well #4 and MW-1 was corrected to compensate for barometric pressure. The other transducers were vented to the atmosphere and therefore automatically compensate to barometric pressure changes.

2.1 Well Data

As noted on Figure 3, the groundwater elevation in well MW-1 is generally 100 feet higher than the water elevation in Well #4 during non-pumping conditions. The water elevation in Well #4 during non-pumping conditions is 10 to 30 feet higher in elevation than MW-2 and MW-3, respectively. The data for well MW-2 is from June 6, 2013 and June 21, 2013 as measured in the field by Golder. During pumping conditions of Well #4, the water level in Well #4 drops to below the water elevations noted for MW-2 and MW-3. Spring 1 and Spring 2 are approximately 140 feet lower in elevation than the water elevation observed at Well #4 during non-pumping conditions.

For Scenarios A and E, while the site was operating under normal circumstances, Well #4 is cycled on to provide make up water for extra demand numerous times throughout the day. The cycling of Well #4 is evident by the episodic change in water levels of approximately 37 feet throughout Scenarios A and E as noted on Figure 3. During Scenario B, water level at Well #4 recovered approximately 37 feet within the first 40 minutes of the pump being off and an additional two feet for the 3,000 minutes (2.1 days) that comprised the duration of the recovery phase. During Scenario C while Well #4 was solely pumping at an approximate constant rate of 350 gpm, approximately 35 feet of drawdown was observed in this well. During the constant rate test, a minor change in water level is evident for Well #4, which is likely the result of an adjustment or change in the pumping rate. Upon completion of Scenario C, the water level in Well #4 during Scenario D recovered similarly as to Scenario B.

A response in groundwater elevation was observed for the different scenarios of the testing program in monitoring well MW-1, located approximately 800 feet south of Well #4. As noted on Figure 4, during Scenario B when the on-site wells were not in operation, water levels recovered approximately 0.2 feet. While Well #4 was solely in operation during Phase C, water levels decreased approximately 0.6 feet. During Scenario D, when both wells were not in operation, the water level recovered approximately 0.3 feet before Wells #1 and #4 began operating as normal. These changes, while subtle, demonstrate that MW-1 and Well #4 are hydraulically connected.

The groundwater level in well MW-3 decreased approximately 0.5 feet through the course of the testing program at an average rate of 0.04 feet per day as shown on Figure 5. Even though MW-3 is closer to Well #4 as compared to MW-1, and the water elevation in Well #4 dropped to below the groundwater elevation in MW-3, a response to pumping Well #4 was not detected in MW-3. The 0.5 foot decrease in groundwater level is attributed to the antecedent (natural) groundwater decline as the rate of decline is consistent throughout non-pumping and pumping scenarios. Furthermore, a diurnal cyclical change in groundwater elevation is apparent for well MW-3 under all test scenarios. This also demonstrates that the water level in MW-3 was not influenced by pumping from Well #4.

2.2 Spring Data

The water level data for Spring 1 and Spring 2 are illustrated in Figure 6. The Spring 2 transducer was set in a small wetlands area in Cushenbury Springs where water was ponded. During baseline conditions under Scenario A, the water level was at first steady, and then began to decrease and display diurnal effects with water elevations cyclically increasing overnight and decreasing through the course of the day. The initial data and corresponding decrease in water elevations evident on Figure 6 is likely an artifact from installing the temporary piezometer and establishing a hydraulic connection between the standpipe and the piezometric surface. After June 13, 2103, which is the mid-point of Scenario B, the water level in the piezometer appears to have equilibrated with the Spring. From this time and on, the water elevation in the piezometer continued to decrease and display diurnal effects irrespective of the different testing scenarios.

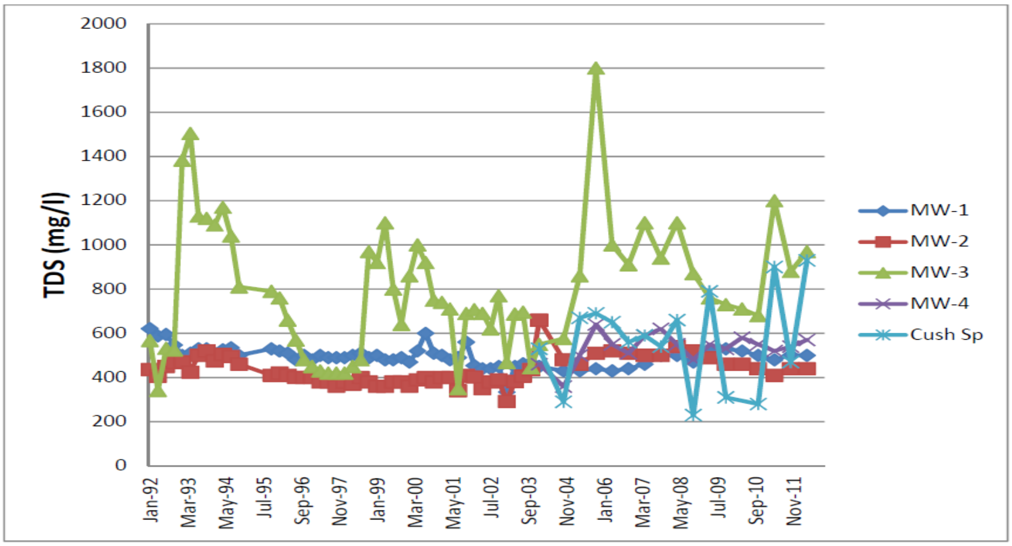
The Spring 1 transducer was set in Cushenbury Springs located along the western side of the access road in an area where water was actively flowing. However, because of low flow conditions and minimal water depth, the water elevation data is noisier when compared to Spring 2 data. During the background data collection period as part of Scenario A for Spring 1, the water level decreased 0.35 feet and then recovered. The water level never dropped to that level again during the remainder of Scenario A or any of the other test scenarios.

The most important observation is that no hydraulic response was observed in Spring 1 or Spring 2 during Scenario C, the period of high pumping for Well #4. Similar to monitoring well MW-3, an antecedent water decline is evident for the two Spring monitoring points. From June 13, 2013 until June 21, 2013, the water level at Spring 2 decreased approximately 0.0016 ft/day and at Spring 1 the water level decreased approximately 0.005 ft/day. The decrease in water elevations is apparent during non-pumping and pumping conditions. Additionally, a diurnal response is noted in the data. The water elevation decline and diurnal cycle appear to be natural evaporation as the gentle decline was present during non-pumping scenarios (Scenarios B and D) and generally consistent throughout the testing program under all operational scenarios. Furthermore, the lowest water levels for Spring 2 were consistently recorded around 2 to 3 PM and the highest water elevations were recorded around 1 to 2 AM.

2.3 Geochemical Data

While not part of this project, Barto previously collected total dissolved solids (TDS) data from the site wells and Cushenbury Springs. The following graph is from Barto's 2012 report.[2] The TDS concentrations detected in MW-3 and Cushenbury Springs over the past couple of years appear to be correlated, suggesting that the water at these locations is similar, and distinct from MW-1, MW-2, and MW-4 located to the south. This provides added evidence to the CSM whereby barriers to groundwater flow exist across the site.

Water Quality Changes
Plant Site Monitoring Wells



3.0 CONCLUSIONS

The hydraulic data collected by Golder during the present study generally supports Barto's conceptual site model that several east-west trending frontal faults act as boundaries between different hydraulic zones. While a response in water elevation to pumping in Well #4 was noted in monitoring well MW-1, no responses were noted in the closer and shallower monitoring well MW-3 or in the temporary piezometers (Spring 1 and Spring 2) installed in Cushenbury Springs. The water elevation decline and diurnal cycle noted for monitoring well MW-3 and Spring 1 and Spring 2 appear to be natural as they were evident during non-pumping scenarios (Scenarios B and D) and generally consistent throughout the testing program under all operational scenarios.

The groundwater and limited chemical data suggest that water from MW-3 and Cushenbury Springs is similar, and that groundwater being withdrawn from Well #4 is not in good hydraulic communication with MW-3 and Cushenbury Springs. Therefore, based on the available data and assuming average annual precipitation rates, an approximate 21% increase in withdrawal from on-site Wells #1 and #4 during operation of the proposed South Quarry is not anticipated to significantly impact Cushenbury Springs.

Attachments:

Table 3: Pumping Rate Summary
Figures 1 through 6

TABLES

Table 3: Pumping Rates

Date	Well #1 (meter reading)	Time	Date and Time	Total Gallons	Time Interval (minutes)	gpm	Well #4 (meter reading)	Time	Date and Time	Total Gallons	Time Interval (mins)	gpm	Cumulative gpm
06/03/13	186954	15:51	6/3/2013 15:51:00				87658	16:00	6/3/2013 16:00				
06/07/13	197666	15:51	6/7/2013 15:51:00	1071200	5760	186	95938	16:00	6/7/2013 16:00	828000	5760	144	330
06/10/13	205220	16:21	6/10/2013 16:21:00	755400	4350	174	99371	16:26	6/10/2013 16:26	343300	4346	79	253
06/11/13	207670	16:04	6/11/2013 16:04:00	245000	1423	172	101508	16:11	6/11/2013 16:11	213700	1425	150	322
06/12/13	209559	13:38	6/12/2013 13:38:00	188900	1294	146	102651	13:45	6/12/2013 13:45	114300	1294	88	234
06/13/13	209559	9:17	6/13/2013 9:17:00	0	1179	0	102651	9:11	6/13/2013 9:11	0	1166	0	0
06/14/13	209559	10:31	6/14/2013 10:31:00	0	1514	0	102651	11:20	6/14/2013 11:20	0	1569	0	0
06/15/13	209559	12:30	6/15/2013 12:30:00	0	1559	0	107378	12:05	6/15/2013 12:05	472700	1485	318	318
06/16/13	209559	13:41	6/16/2013 13:41:00	0	1511	0	113094	13:20	6/16/2013 13:20	571600	1515	377	377
06/17/13	209559	11:37	6/17/2013 11:37:00	0	1316	0	118004	11:44	6/17/2013 11:44	491000	1344	365	365
06/18/13	209796	16:02	6/18/2013 16:02:00	23700	1705	14	118004	16:08	6/18/2013 16:08	0	1704	0	14
06/19/13	209796	13:38	6/19/2013 13:38:00	0	1296	0	118004	13:30	6/19/2013 13:30	0	1282	0	0
06/20/13	212481	12:51	6/20/2013 12:51:00	268500	1393	193	120083	12:57	6/20/2013 12:57	207900	1407	148	341
06/21/13	214852	9:45	6/21/2013 9:45:00	237100	1254	189	122596	12:41	6/21/2013 12:41	251300	1424	176	366
			Total Gallons	2789800	25554	109			Total Gallons	3493800	25721	136	245

Meter readings in 100 gallon increments

gpm = gallons per minute as calculated by dividing total gallons by time interval minutes

The start time on 6/3/13 is assumed

FIGURES

2 0 2 Miles

LEGEND

☆ Mitsubishi Cement Corporation

REFERENCES

1) Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community
2) Coordinate System: NAD 1983 StatePlane California V FIPS 0405

PROJECT MITSUBISHI CEMENT CORPORATION
CUSHENBURY SPRINGS HYDROGEOLOGIC INVESTIGATION
SAN BERNARDINO COUNTY, CA

TITLE

REGIONAL SETTING

Golder Associates

PROJECT No.		093-91967-01	FILE No.	SiteVicinity.mxd
DESIGN	MM	7/9/2013	SCALE: AS SHOWN	REV. 0
GIS	MM	7/9/2013	**Figure 1**	
CHECK	GW	7/9/2013		
REVIEW	GW	7/9/2013		

Map Document: G:\GIS\Sites\MitsubishiCementCorporation\Maps\SiteVicinity.mxd / Modified 7/9/2013 5:28:06 PM by MMaguire / Exported 7/9/2013 5:28:16 PM by MMaguire

750 0 750 Feet

LEGEND

- Monitor Well
- Production Well
- Temporary Piezometer

NOTES

1) Spring 1 and Spring 2 locations are approximate as measured in field with hand-held GPS unit.

REFERENCES

1) Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
2) Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet

PROJECT
MITSUBISHI CEMENT CORPORATION
CUSHENBURY SPRINGS HYDROGEOLOGIC INVESTIGATION
SAN BERNARDINO COUNTY, CA

TITLE

WELL LOCATIONS

Golder Associates

PROJECT No.		093-91967-01	FILE No.	WellLocations.mxd
DESIGN	MM	7/9/2013	SCALE: AS SHOWN	REV. 0
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REVIEW	GW	7/17/2013		

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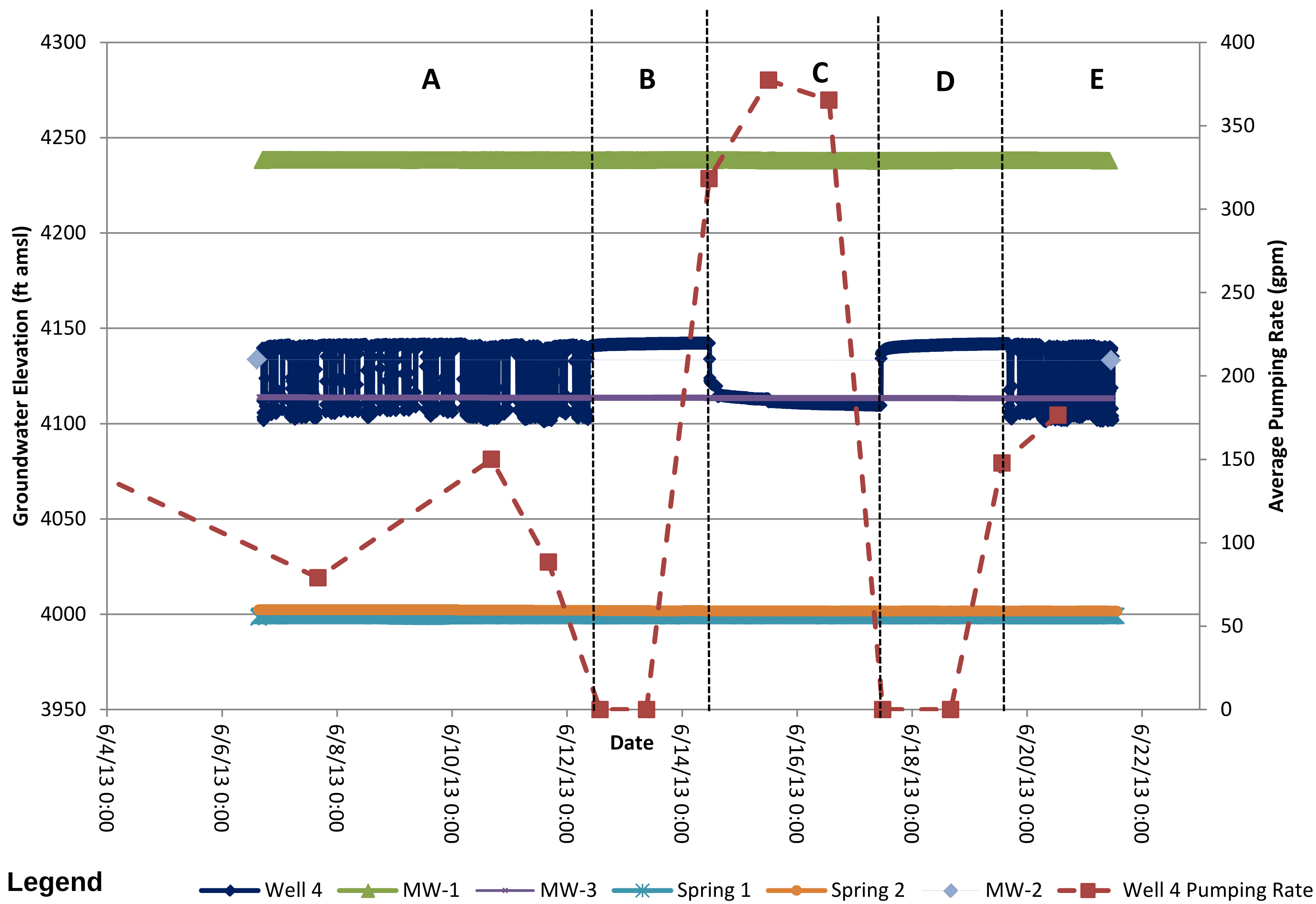
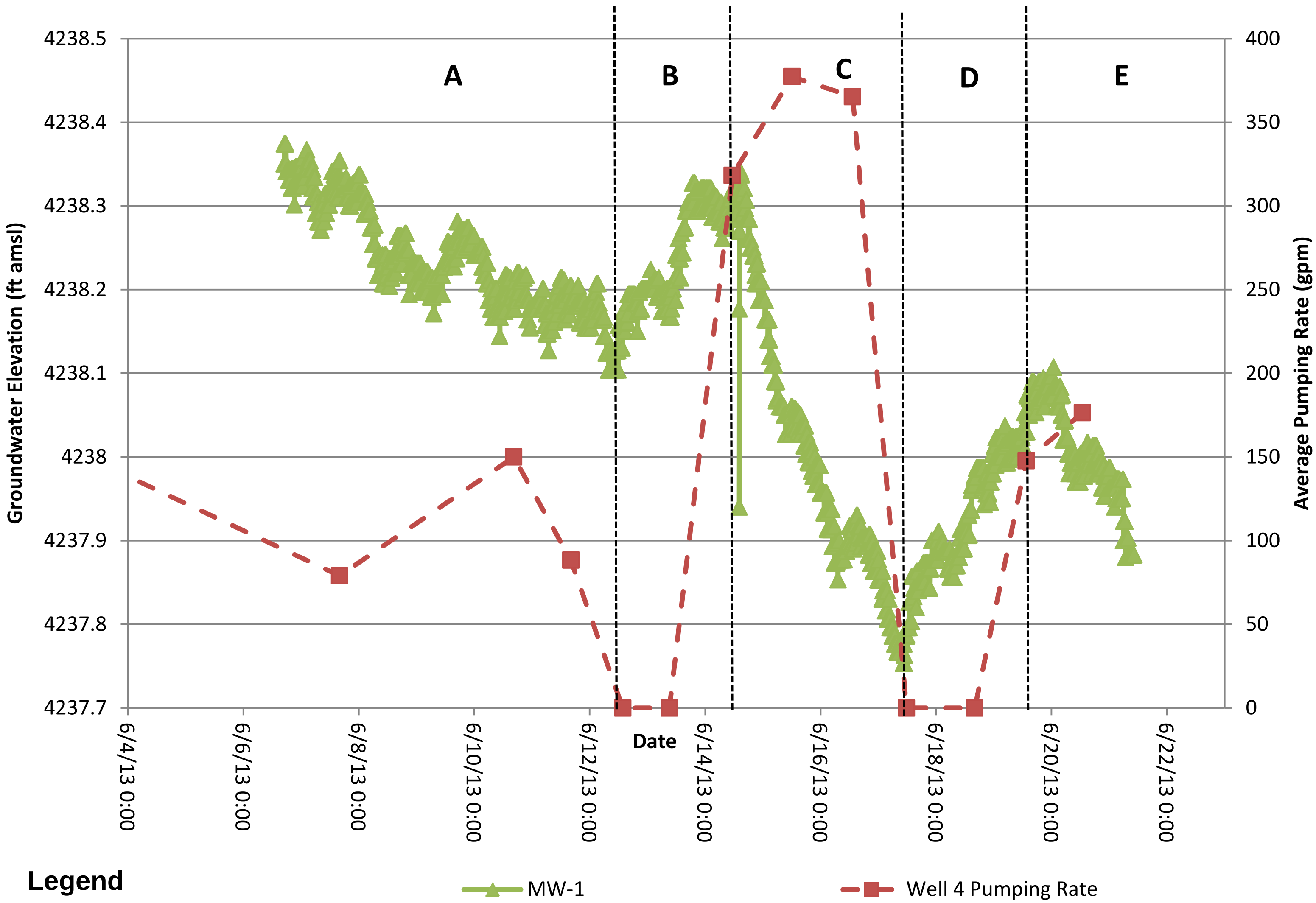


PROJECT/REPORT	MCC - Cushenbury Springs Hydrogeologic Evaluation	PLOTTED BY GW	JOB NO. 093-91967-01
TITLE	**Hydrograph - All Data**	CHECKED BY GW REVIEWED BY WLF	FIGURE 3

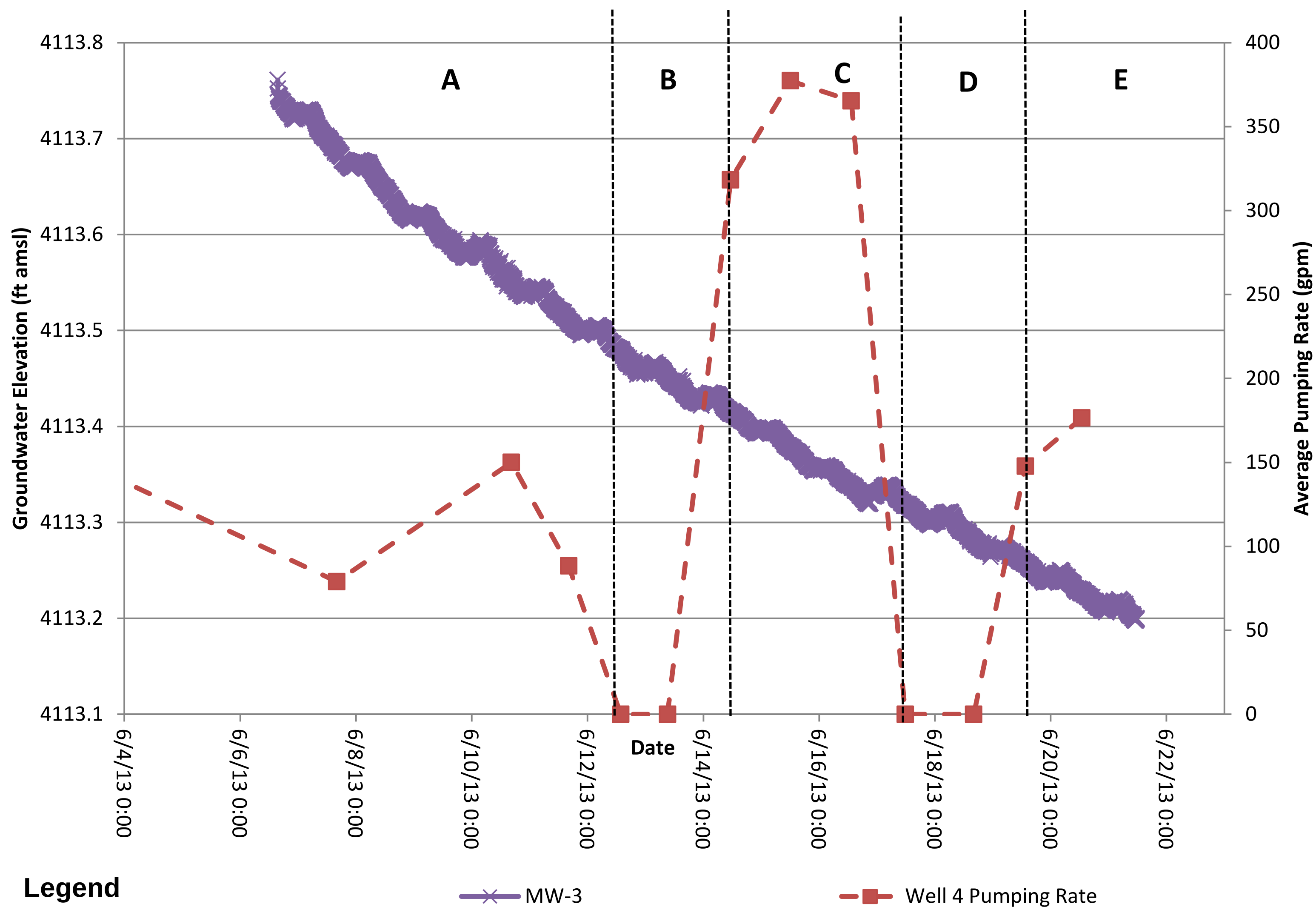
Golder Associates

Spring 1.xlsx CH all



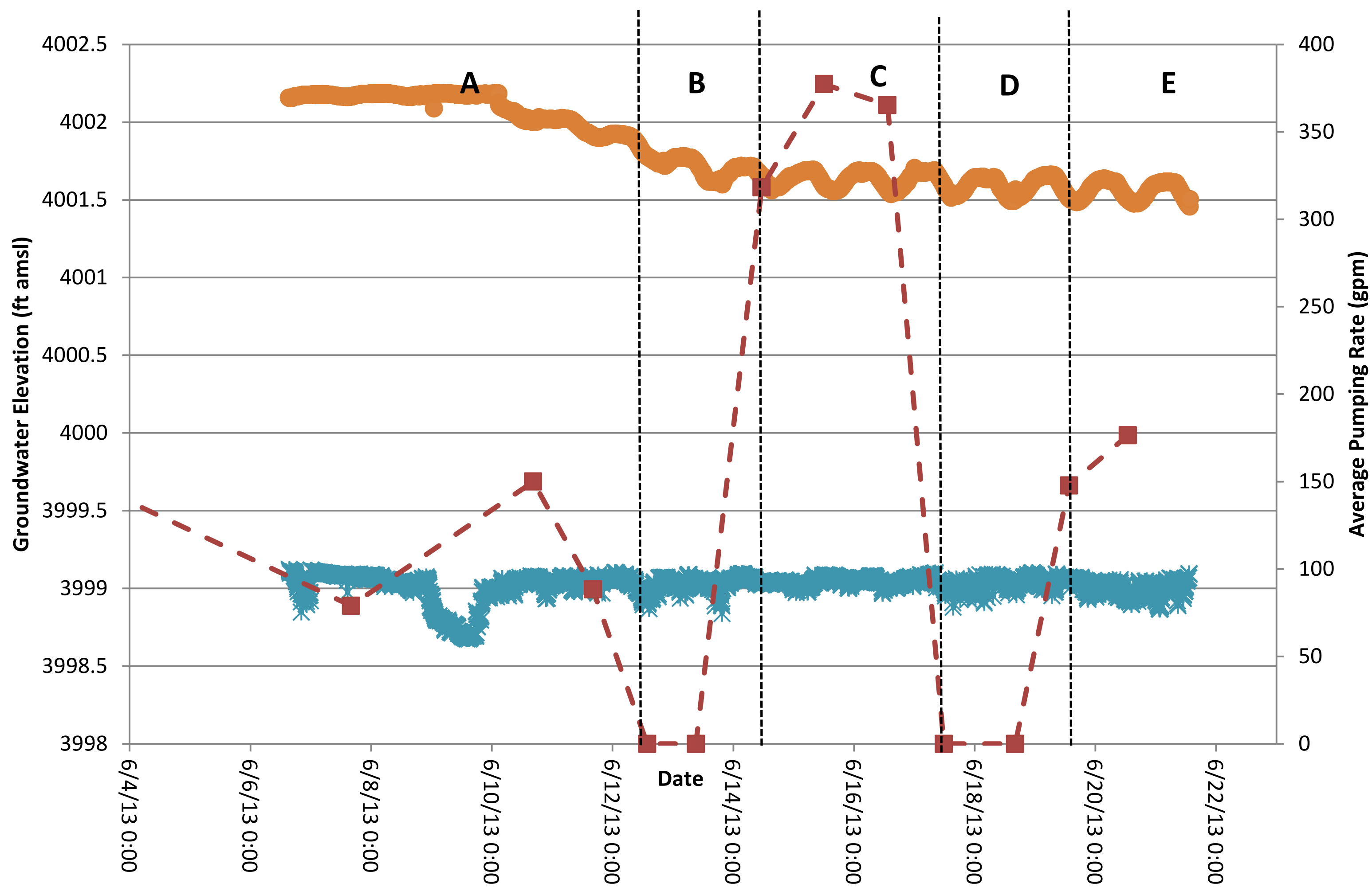
Golder Associates	PROJECT/REPORT MCC - Cushenbury Springs Hydrogeologic Evaluation	PLOTTED BY GW	JOB NO. 093-91967-01
		CHECKED BY GW	
	TITLE **Hydrograph - MW-1**	REVIEWED BY WLF	FIGURE 4

Spring 1.xlsx CH mw1



Golder Associates	PROJECT/REPORT: MCC - Cushenbury Springs Hydrogeologic Evaluation	PLOTTED BY: GW	JOB NO.: 093-91967-01
		CHECKED BY: GW	
	TITLE: **Hydrograph - MW-3**	REVIEWED BY: WLF	FIGURE: 5

Spring 1.xlsx CH mw3



Legend

Spring 1 | Spring 2 | Well 4 Pumping Rate

Golder Associates	PROJECT/REPORT MCC - Cushenbury Springs Hydrogeologic Evaluation	PLOTTED BY GW	JOB NO. 093-91967-01
		CHECKED BY GW	
	TITLE **Hydrograph - Spring-1 and Spring-2**	REVIEWED BY WLF	FIGURE 6