NOVEMBER 1, 2013

# SUMMARY REPORT
# TIME-SERIES GROUNDWATER SAMPLING
# CITY OF GOODYEAR WELL COG-01

## WESTERN AVENUE WQARF SITE
## AVONDALE AND GOODYEAR, ARIZONA

PREPARED FOR:
ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY • ENGINEERING

HARGIS + ASSOCIATES, INC.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ADEQ | Arizona Department of Environmental Quality |
| °C | degrees Celsius |
| DO | dissolved oxygen |
| EC | electrical conductivity |
| EPA | U.S. Environmental Protection Agency |
| gpm | gallons per minute |
| H+A | Hargis + Associates, Inc. |
| Nitrate-N | nitrate as nitrogen |
| mg/l | milligrams per liter |
| PCE | tetrachloroethene |
| QA/QC | quality assurance/quality control |
| REDOX | reduction-oxidation potential |
| the test | time-series groundwater sampling test |
| the City | City of Goodyear |
| the Site | Western Avenue WQARF Site |
| TDS | total dissolved solids |
| µg/l | micrograms per liter |
| µS/cm | microSiemens per centimeter |
| mV | millivolts |
| VOC | volatile organic compound |
| well COG-01 | City of Goodyear Well No. 1 |
| WQARF | Water Quality Assurance Revolving Fund |

SUMMARY REPORT

TIME-SERIES GROUNDWATER SAMPLING TEST
CITY OF GOODYEAR WELL COG-01

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# 1.0 INTRODUCTION

This report was prepared on behalf of the Arizona Department of Environmental Quality (ADEQ) to summarize the results of a time-series groundwater sampling test (the test) at City of Goodyear Well No. 1 (well COG-01). Well COG-01 is located within the Western Avenue Water Quality Assurance Revolving Fund (WQARF) Site (the Site) in Goodyear, Arizona (Figures 1 and 2). The Site was placed on the State of Arizona WQARF list based on the presence of tetrachloroethene (PCE) in shallow Subunit A groundwater.

## 1.1 OBJECTIVE

The objective of the test was to provide data to further develop the conceptual understanding of PCE at well COG-01. Specifically, the test was an effort to replicate the periodic occurrences of PCE that have been observed in well COG-01 during recent Site groundwater monitoring activities. The presence, absence, changes, or trends in PCE concentrations during the test were anticipated to provide information suggesting whether the PCE in well COG-01 occurs through leakage into the wellbore or by the downward vertical flow of impacted groundwater during pumping.

## 1.2 WORK PLAN AND ADDENDUM

A work plan outlining the scope of the test was prepared on January 17, 2013 (Hargis + Associates, Inc. [H+A], 2013a). The work plan addressed comments to the scope of the test from the City of Goodyear (the City) discussed during a meeting with ADEQ on January 3, 2013.

Additional input to the scope of the test was provided by the City on January 18, 2013. An addendum to the work plan was then prepared on January 22, 2013 to address the additional input (H+A, 2013b).

# 2.0 SCOPE OF TEST

The scope of the test consisted of:

- Allowing COG-01 to remain idle for a period of approximately two months prior to the time series sampling test;
- Pumping well COG-01 for a period of 24 hours;
- Collecting groundwater samples from well COG-01 for volatile organic compound (VOC), nitrate as nitrogen (nitrate-N), and perchlorate analyses at specified time intervals, and
- Measuring water levels in pumped well COG-01 and three designated observation wells.

Well COG-01 is reported to be screened in the lowermost portion of Subunit B and the uppermost portion of Subunit C (Brown & Caldwell, 2012). Monitor wells MW-1 and COG-MW3 served as Subunit A observation wells. Monitor well EMW-22LC served as a Subunit C observation well. These wells are the closest Subunit A and C monitor wells to well COG-01 (Figure 3). There are no wells screened exclusively in Subunit B at the Site. Well construction data for each test well is summarized in Table 1.

All test field work was conducted from January 21 through April 10, 2013. The test was conducted in accordance with the work plan and addendum (H+A, 2013a and 2013b). Copies of field forms, analytical laboratory reports, and tabulated water level pressure transducer data are provided in Appendices A through C, respectively.

The test activities were separated into three segments: pre-test, test, and post-test. Descriptions of each segment are discussed below.

## 2.1 PRE-TEST

Well COG-01 was deactivated by the City on January 21, 2013. The well remained inactive until the test date of March 25, 2013. This period of time was considered sufficient to allow any well-bore leakage of impacted Subunit A groundwater to enter and accumulate in the well COG-01 area.

Water level pressure transducers were installed in observation wells MW-1, COG-MW3, and EMW-22LC on March 18, 2013, approximately one week prior to starting the test. The transducers were installed prior to the test to characterize ambient water level conditions in Subunits A and C. The measurement frequency at each transducer was increased immediately prior to the start of the test to measure any early time responses created by well COG-01 pumping.

## 2.2 TEST

The test was started by activating well COG-01 at 0835 on March 25, 2013. The City directed the discharge from well COG-01 to the surrounding park during the first 30 minutes of pumping. This was done so that no sediment or other material that may have collected in the well during the preceding two months would enter and potentially damage the City water delivery system. The flow rate during the first 30 minutes of pumping could not be measured but was estimated to be greater than 600 gallons per minute (gpm). The flow rate was reduced to approximately 525 gpm when connected to the City system. This flow rate was maintained for the duration of the pumping portion of the test.

Eleven groundwater samples were collected from well COG-01. The samples were collected at the following times after the start of pumping:

- immediately after activation;
- five minutes;
- 10 minutes;
- 20 minutes;
- 30 minutes;
- one hour;
- two hours;
- four hours;
- six hours;
- eight hours, and
- 24 hours.

All groundwater samples were analyzed for VOCs using U.S. Environmental Protection Agency (EPA) method 8260B, nitrate-N using EPA method 300.0, and perchlorate using EPA method 314.0. Groundwater sampling included one duplicate sample collected at four hours and was analyzed for VOCs only. A trip blank accompanied the samples to the analytical laboratory and was also analyzed for VOCs only. All original, duplicate, and trip blank samples were analyzed by Test America, Inc., Phoenix, Arizona. Two split (or verification) samples were also collected at 30 minutes and six hours. Split samples were analyzed for VOCs only by Accutest Laboratories, Inc., Phoenix, Arizona.

The field parameters pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), reduction-oxidation potential (REDOX), and total dissolved solids (TDS) were measured in the well COG-01 discharge. Field parameter measurements were collected at the specified time intervals outlined in the work plan (H+A, 2013a). Water levels were measured in well COG-01 at the same frequency as the field parameter measurements.

## 2.3 POST-TEST

Post-test sampling was conducted at well COG-01. The purpose of the post-test sampling was to measure any rebound effect or other changes in VOC concentrations after pumping stopped. Post-test samples were collected at one, seven, and 14 days after pumping stopped. This corresponded to March 27, April 3, and April 10, 2013, respectively.

The post-test samples were analyzed by Test America, Inc. for VOCs only. A trip blank accompanied each sample to the laboratory. No other quality assurance/quality control (QA/QC) samples were collected. Each sample was collected after well COG-01 was re-activated for approximately five minutes. Well COG-01 was not operated at any other time during the post-test sampling period other than for the post-test sampling.

The transducers remained in observation wells MW-1, COG-MW3, and EMW-22L for approximately one week after pumping stopped. The water level data were reviewed prior to removal. The water level in each well had either recovered to pre-test levels or had stabilized at a lower level.

## 2.4 ADDITIONAL SAMPLING

Groundwater samples were collected from the three observation wells on April 16, 2013. This additional sampling was added to the scope of the test by ADEQ. The purpose of this sampling was to provide nitrate-N, perchlorate, and VOC concentration data from the observation wells to compare to concentrations of these chemicals in samples collected from well COG-01.

The additional sampling included collecting groundwater samples collected from wells MW-1, COG-MW3, and EMW-22LC using HydraSleeve® samplers. The samples collected from wells MW-1 and COG-MW3 were analyzed for nitrate-N and perchlorate. VOC data are readily available for these wells from the Site groundwater monitoring program. The groundwater sample from well EMW-22LC was analyzed for nitrate-N, perchlorate, and VOCs. To ADEQ's knowledge, no VOC data were available for well EMW-22LC. All samples were analyzed by Test America, Inc. using the same methods as above.

# 3.0 RESULTS

The following sections discuss the results of the test. Conclusions are presented in Section 4.0 and recommendations for additional work are presented in Section 5.0.

## 3.1 TETRACHLOROETHENE

PCE was detected in each groundwater sample collected during the test. PCE was detected at a concentration of 3.3 micrograms per liter (µg/l) in the sample collected immediately after well COG-01 was activated. PCE then increased slightly and fluctuated between 3.9 µg/l and 4.3 µg/l in the five minute to four hour samples. PCE concentrations then decreased steadily in the six, eight, and 24 hour samples to concentrations of 3.5 µg/l, 3.1 µg/l, and 1.6 µg/l, respectively. A summary of all PCE results are summarized in Table 2. PCE concentrations are illustrated in Figure 4.

During the post-test period, PCE concentrations increased to 4.4 µg/l, 3.9 µg/l, and 4.0 µg/l in the samples collected at one day, seven days, and 14 days, respectively. These post-test concentrations are very similar to those detected during the first four hours of pumping and greater than the concentrations observed after six hours to 24 hours of pumping (Table 2: Figure 4).

PCE was not detected above the limit of detection in the groundwater sample collected from well EMW-22LC on April 16, 2013 (Section 2.4). The limit of detection for PCE was 1.0 µg/l (Table 2).

## 3.2 NITRATE AS NITROGEN AND PERCHLORATE

Nitrate-N was detected in each groundwater sample collected during the test. Nitrate-N was detected at a concentration of 5.7 milligrams per liter (mg/l) in the sample collected immediately after well COG-01 was activated. Nitrate-N concentrations then increased slightly and were stable between 9.0 mg/l and 10 mg/l in the five minute to eight hour samples. Nitrate-N then increased to a concentration of 13 mg/l in the 24 hour sample. A summary of all nitrate-N results is provided in Table 2. Nitrate-N concentrations are illustrated in Figure 4.

Perchlorate was detected sporadically during the test. Perchlorate was detected above the limit of detection in seven of the 11 samples. When detected, perchlorate concentrations ranged from 2.0 µg/l to 3.7 µg/l. The highest concentration of perchlorate was detected in the 24 hour sample. A summary of all perchlorate results is provided in Table 2. Perchlorate concentrations are illustrated in Figure 4.

No samples were collected for nitrate-N or perchlorate during the post-test period. Post-test samples were only analyzed for VOCs per the work plan addendum (H+A, 2013b).

Nitrate-N was detected in the groundwater samples collected from the three observation wells on April 16, 2013 (Section 2.4). Nitrate-N was detected at concentrations of 9.5 mg/l and 11 mg/l in samples from wells MW-1 and COG-MW3, respectively. Nitrate-N was detected at a concentration of 4.0 mg/l in the sample from well EMW-22LC (Table 2).

Perchlorate was not detected in any of the three observation well samples on April 16, 2013. However these samples required dilution due to matrix interferences and detection limits were raised to 20 µg/l (Table2).

FIELD PARAMETERS

Field parameters were measured as outlined in the work plan (H+A, 2013a). Copies of the field forms presenting field parameter measurements are provided in Appendix A. Review of the field parameters indicates the following:

- Temperature was lowest (23.10 degrees Celsius [°C]) at the beginning of pumping, then increased and remained constant between approximately 25°C to slightly greater than 26°C until pumping stopped.
- pH was lowest (5.31 standard units) at the beginning of pumping, then increased and remained relatively constant at approximately 7 standard units through eight hours of pumping. pH then decreased to 6.04 and 6.74 standard units immediately before pumping stopped.
- EC and TDS were relatively constant at slightly less than 1,600 microSiemens per centimeter (µS/cm) and approximately 1,020 mg/l, respectively during the first four hours of pumping.

EC and TDS then steadily increased from four hours until pumping stopped. The highest concentrations of EC and TDS were measured at approximately 2,030 µS/cm and 1,290 mg/l, respectively, immediately prior to deactivation.

- DO fluctuated between 4.11 mg/l and 8.20 mg/l during pumping. No discernable trend was establish, however the highest DO was measured near the end of pumping.
- REDOX was measured at 115 millivolts (mV) at the beginning of pumping, and then steadily decreased to approximately 133 mV at 7.5 hours of pumping. REDOX then increased to measurements of greater than 60 mV immediately prior to ending the test.

Field parameters measured during post-test sampling were in good agreement with the five minutes values measured during pumping. However, REDOX measured during the April 10 (14 day) post-test sampling was not consistent with previous measurements. REDOX was measured at -333.2 mV. This value is outside the range of values previously measured. The cause of this anomalous value is not known and may have simply been an instrument malfunction.

## 3.4 WATER LEVELS

Water levels were measured in pumped well COG-01, Subunit A observation wells MW-1 and COG-MW3, and Subunit C observation well EMW-22LC. Water level data for pumped well COG-01 are summarized in Table 3. Files containing the water level pressure transducer data for the observation wells are provided in Appendix C.

### 3.4.1 Pumped Well COG-01

Pre-test water levels were not able to be measured at well COG-01. The well surface completion is not equipped with an access port that accommodates the installation of a pressure transducer.

Water levels were measured in well COG-01 during pumping. Water levels were measured using an electronic sounder. A hydrograph illustrating water level drawdown is presented as Figure 5. Review of the data indicates that the water level in well COG-01 steadily declined approximately 26.7 feet after 30 minutes of pumping.

The water level recovered approximately four feet when the flow rate was reduced by redirecting the discharge from the surrounding park to the City system (Section 2.2). The water level began to decline again after approximately 20 minutes and continued to decline until pumping stopped. Drawdown was approximately 24.4 feet when pumping stopped (Table 3; Figure 5).

A hydrograph illustrating water level recovery is presented as Figure 5. Review of the data indicates that the water level in well COG-01 steadily recovered to approximately 0.8 feet below static during the three hours after pumping stopped. A measurement 24 hours after pumping stopped (March 27) indicated that the water level had recovered to a level above static (Table 3; Figure 5).

### 3.4.2 Subunit A Observation Wells

Pre-test water levels were measured at wells MW-1 and COG-MW3 for approximately one week prior to pumping. Hydrographs illustrating the pre-test water level data are presented as Figure 6. Review of the hydrographs indicates that water levels were stable at both wells. Water levels fluctuated less than 0.2 feet at well MW-1 and less than 0.1 feet at well COG-MW3 (Figure 6; Appendix C).

Water levels were measured at wells MW-1 and COG-MW3 during pumping. Hydrographs illustrating water level drawdown for both wells are presented as Figure 7. Review of the data indicates that water level responses are observable in both wells at approximately 30 minutes after pumping started. Water levels then declined in both wells until pumping stopped. Drawdown was approximately 0.1 feet at well MW-1 and approximately 0.3 feet at well COG-MW3 when pumping stopped (Figure 7; Appendix C).

Hydrographs illustrating water level recovery in wells MW-1 and COG-MW3 are presented as Figure 8. Review of the data indicates that neither well recovered to the static water level after one week after pumping stopped (Figure 8; Appendix C).

### 3.4.3 Subunit C Observation Well

Pre-test water levels were measured at well EMW-22LC for approximately one week prior to pumping. A hydrograph illustrating the pre-test water level data is presented as Figure 9. Review of the hydrograph indicates that the water level fluctuated but declined approximately two feet overall.

Water levels were measured in well EMW-22LC during pumping. A hydrograph illustrating water level drawdown is presented as Figure 10. Review of the data indicates that a water level response is observable in the first few minutes after pumping started. Water levels then declined until pumping stopped with a break in slope at approximately 12 hours of pumping. Drawdown was approximately 2.6 feet when pumping stopped (Figure 10; Appendix C).

Hydrographs illustrating water level recovery at well EMW-22LC is presented as Figure 11. Review of the data indicates that the water level recovered quickly after pumping stopped and reached static after approximately 400 minutes (Figure 11; Appendix C).

# 4.0 CONCLUSIONS

The test generated data that further supports leakage of PCE-impacted groundwater into the COG-01 wellbore. This leakage may be reaching well COG-01 through the well annulus and/or breaches in the casing. The following sections discuss the evidence from the test that support this conclusion. Uncertainties are discussed as well.

## 4.1 EVIDENCE OF LEAKAGE

A number of lines of evidence support leakage as the mechanism by which PCE enters well COG-01. Each is discussed below.

- Well COG-01 was not activated for approximately two months before pumping. Elevated concentrations of PCE were present in samples collected during the initial portions of pumping, similar to most elevated concentration detected to date (4.68 µg/l). A decreasing trend in PCE concentrations was then observed beginning between the four and six hour samples and continuing until pumping stopped (Figure 4). This suggests that PCE-impacted groundwater enters and accumulates in the well COG-01 area when the well is inactive and that the PCE is removed by pumping.
- PCE is known to be present at relatively low concentrations in Subunit A; specifically at observation well MW-1 located less than 500 feet east of well COG-01 (Figure 3). PCE concentrations have ranged from 3.5 µg/l to 12.0 µg/l during the period 2009 to the present; the more elevated concentrations collected using depth-specific passive diffusion bags (H+A, 2013c). This range of concentration is comparable to the PCE concentrations detected in samples from well COG-01 when first activated. The similarity of these PCE concentrations suggests that overlying Subunit A groundwater is the source of PCE to well COG-01.
- Water levels measured in the Subunit A and C observation wells indicate that pumping well COG-01 has a minimal impact in Subunit A and a more significant impact in Subunit C (Figure 12). Drawdown in Subunit A observation wells was less than 0.2 feet. Drawdown in the Subunit C observation well was between two and three feet. This indicates that a majority of the groundwater supplied to well COG-01 during pumping is from Subunit C.

- No VOCs, including PCE, were detected in the groundwater sample collected from Subunit C observation well EMW-22LC. This suggests that PCE is not present in the Subunit C groundwater that is supplied to well COG-01 during pumping. Subunit C groundwater would then be expected to have a diluting effect on the PCE present in well COG-01 as the well is pumped. This appears to be occurring based on the PCE concentrations in well COG-01 during pumping (Figure 4).
- The decreasing trend in PCE concentrations in well COG-01 was observed after approximately four to six hours of pumping (Figure 4). This equates to withdrawals of approximately 0.4 and 0.6 acre-feet, respectively. This suggests that PCE may not only be leaking directly into the well COG-01 wellbore, but that may be migrating through the well screen into the surrounding aquifer materials. As well COG-01 is pumped, the PCE present in the well casing is probably removed quickly; however, additional PCE that may have been introduced into the aquifer through the well screen and/or other holes or breaches in the casing or annulus may still be contributing PCE to the well. The delayed yield of fine-grained materials within the radius of influence of the well may also continue to contribute residual PCE for a period of time.
- PCE returned to the early pumping concentrations within 24 hours after pumping stopped. PCE concentrations in groundwater samples collected one and two weeks after pumping stopped were also similar in concentration to the early pumping concentrations (Figure 4). This suggests that local PCE-impacted groundwater from Subunit A and possibly portions of Subunit B contribute to water level recovery, as non-impacted Subunit C groundwater is no longer supplied to the well.
- PCE concentrations are elevated when well COG-01 is first activated. This is in agreement with previous data evaluation conducted by ADEQ (H+A, 2013a; Section 1.3). Data from Site monitoring events since 2010 indicate that PCE concentrations are the most elevated when well COG-01 is activated for sampling. PCE concentrations are lower or were not detected when well COG-01 was already operating upon arrival for sampling (Figure 13). Three samples were collected from well COG-01 during the November 2012 Site monitoring event. The samples were collected at activation, and after 10 and 30 minutes of pumping. Similar to this test, PCE concentrations ranged between 2.6 µg/l and 3.8 µg/l (H+A, 2013c).

The trend in PCE concentrations observed during pumping support this condition and may be used to predict PCE concentrations based on the operational status of the well. For example, groundwater samples collected within the first four or six hours of pumping can be expected to contain elevated concentrations of PCE. Whereas samples collected after six hours may have low to non-detectable concentrations (Figure 14).

- Information provided by the City indicates that there are holes and breaches in the COG-01 well casing. These holes and/or breaches would exacerbate leakage from the overlying Subunit A. Additionally, the construction history of well COG-01 is unclear. The well may have been altered an unknown number of times in the past; including the depth of the well and the condition and nature of the materials present in the well annulus, if any.

## 4.2 UNCERTAINTIES

There were some data generated during the test that do not necessarily support leakage as the source of PCE in the well COG-01 area. There are also some data gaps that create uncertainties in the conceptual understanding of well COG-01. Each is discussed below.

- Nitrate-N concentrations were relatively stable during pumping, and then increased slightly immediately before pumping stopped. Nitrate-N is generally believed to be lower in concentration in Subunit C compared to Subunit A. Sampling data collected during the test support this condition. Nitrate-N was detected at concentrations of 9.5 mg/l and 11 mg/l in samples from Subunit A wells MW-1 and COG-MW3, respectively (Table 2). Both of these concentrations are greater than the 4.0 mg/l that nitrate-N was detected at in the sample from Subunit C well EMW-22LC (Table 2).

  Therefore, if well COG-01 is mostly supplied by Subunit C groundwater during pumping (as evidenced by water level drawdown in observation wells), it could be expected that nitrate-N would decrease over time similar to PCE. This did not occur. The slight increase in nitrate-N might suggest an increase in the amount of Subunit A groundwater contributing to flow to well COG-01. Or, as the cone of depression expanded during pumping, an area within Subunit C with slightly more elevated concentrations of nitrate-N may have been encountered.

The range in nitrate-N concentrations observed during the test is also small and all concentrations may be considered essentially the same. Further understanding of the distribution of nitrate-N in Subunit A and C groundwater may be useful in providing and explanation for the data generated during the test.

- Perchlorate was sporadically detected during pumping, and then increased to a concentration slightly greater than the detection limit immediately before pumping stopped. Similar to nitrate-N, perchlorate concentrations are generally considered to be lower or not present in Subunit C compared to Subunit A. Perchlorate was not detected in any of the samples collected from the observation wells (Table 2). Further understanding of the distribution of perchlorate in Subunit A and C groundwater may be useful in providing and explanation for the data generated during the test.
- Changes in concentrations of field parameters, especially between initial and later measurements, can be expected in wells that have been inactive for extended periods of time. These changes can be seen in the measurements for most of the well COG-01 parameters (Appendix A). However, in general, EC and TDS concentrations slowly increased throughout pumping. The highest concentrations of EC and TDS were measured immediately before pumping stopped. Similar to nitrate-N and perchlorate, EC and TDS are generally believed to be lower in concentration in Subunit C compared to Subunit A. The increase in EC and TDS might suggest an increase in the amount of Subunit A groundwater contributing to flow at well COG-01. Or, as the cone of depression expanded during pumping, an area within Subunit C with slightly more mineralized groundwater may have been encountered. Additional information may be useful.
- No lithologic log is available for well COG-01. No other wells penetrate below Subunit A in the Site area. Therefore, the lithologic nature of Subunits B and C are unknown. The nature of the sediments in the well COG-01 area would be useful in further developing the conceptual understanding.
- No water quality data are available for Subunit B. The nature of PCE, if present in Subunit B, would be useful in further developing the conceptual understanding.

# 5.0 RECOMMENDATIONS

ADEQ believes that the test was effective in further characterizing PCE occurrences at well COG-01. The test results also support previous evaluation. The preponderance of data indicates that PCE is leaking into well COG-01 wellbore through the annulus and/or holes and breaches in the casing. The PCE may also be migrating to portions of Subunits B and/or C.

ADEQ recommends that additional work be conducted. Additional work could include longer-term (one to two week) pumping of well COG-01 with selected groundwater sampling. Long-term pumping may provide data to:

- Confirm or modify the results of this test and the understanding of PCE occurrence in well COG-01;
- Determine if PCE continues to decrease to and remain at concentrations less than the limit of detection when pumped for more than 24 hours;
- Determine if the delayed yield of fine-grained materials is occurring, and if so, its impact on PCE concentrations;
- Determine the potential for impacts created by downward vertical flow of Subunit A groundwater that may be enhanced during long-term pumping.
- Understand the slightly increasing nitrate-N, perchlorate, and EC and TDS concentrations observed during this test.

Routine Site monitoring events will also provide the opportunity to confirm the results of this study by comparing sample results with well COG-01 operation.

The scope of any additional work will be discussed with the City and other interested parties, as necessary.

# 6.0 REFERENCES CITED

Brown and Caldwell, 2012. COG-01 Well Diagram. November 19, 2012.

Hargis + Associates, Inc., 2013a. Work Plan for Time-Series Groundwater Sampling, City of Goodyear Well COG-01, Western Avenue WQARF Site, Avondale and Goodyear, Arizona. January 17, 2013.

_____, 2013b. Addendum to: Work Plan for Time-Series Groundwater Sampling, City of Goodyear Well COG-01, Western Avenue WQARF Site, Avondale and Goodyear, Arizona. January 22, 2013.

_____, 2013c. Semi-Annual Groundwater Monitoring Report, Second Half 2012, Western Avenue WQARF Site, Avondale and Goodyear, Arizona. March 27, 2013.

# TABLES

# TABLE 1

## WELL CONSTRUCTION DATA

| Well Identifier | Subunit | Easting (feet) | Northing (feet) | Measuring Point Elevation (feet msl) | Date Drilled (mo/yr) | Drilling Method | ADWR Registration Number | Total Depth of Well (feet bls) | Screened Interval (feet bls) | Casing Diameter (inches) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COG-01 | B/C | 566083.0 | 886341.0 | NA | NA | NA | 55-609571 | 200 | 175-195 | 10 | 8-Inch Diameter Screen |
| MW-1 | A | 566607.3 | 886242.6 | 965.36 | 07/95 | HSA | 55-550228 | 97 | 37 - 97 | 4 | |
| COG-MW3 | A | 565762.3 | 885989.0 | 966.37 | 02/93 | Air Rotary | 55-537835 | 83 | 43-83 | 4 | |
| EMW-22LC | C | 565666.49 | 886297.01 | 966.12 | 07/87 | NA | 55-517112 | 315 | 280-310 | 5 | |

NOTES

Easting and Northing are State Plane Arizona Central Zone NAD 83.

Original table from GeoTrans, Inc., 2009.

Draft well COG-1 construction data provided by Brown & Caldwell on November 20, 2012.

FOOTNOTES

msl = Mean sea level
mo/yr = Month/year
ADWR = Arizona Department of Water Resources
bls = Below land surface
HSA = Hollow stem auger
N/A = Information not available

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# TABLE 2

## WATER QUALITY DATA

All detections are **bolded**

| | | | Detected Constituents* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | Chloroform | Dibromochloromethane | Tetrachloroethene | Trichloroethene | Nitrate | Perchlorate |
| | | reporting units > | ug/l | ug/l | ug/l | ug/l | ug/l | mg/l | ug/l |
| Well | Sample Identifier | Date Sampled | | | | | | | |
| COG-01 | COG-01-032513-0 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **3.3** | <1.0 | **5.7** | <2.0 |
| | COG-01-032513-5 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **4.2** | <1.0 | **9.0** | <2.0 |
| | COG-01-032513-10 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **3.9** | <1.0 | **9.6** | **2.1** |
| | COG-01-032513-20 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **4.2** | <1.0 | **9.6** | **2** |
| | COG-01-032513-30 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **3.9** | <1.0 | **9.6** | <2.0 |
| | COG-01-032513-30 (split) | 3/25/2013 | **0.26J** | **0.26J** | **0.27J** | **4.3** | **0.44J** | NA | NA |
| | COG-01-032513-60 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **4.3** | <1.0 | **9.6** | <2.0 |
| | COG-01-032513-120 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **4.2** | <1.0 | **9.6** | <2.0 |
| | COG-01-032513-240 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **4.2** | <1.0 | **9.7** | **2** |
| | WA-101-032513 (duplicate) | 3/25/2013 | <1.0 | <1.0 | <1.0 | **4.0** | <1.0 | NA | NA |
| | COG-01-032513-360 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **3.5** | <1.0 | **10** | **2** |
| | COG-01-032513-360 (split) | 3/25/2013 | <1.0 | **0.22J** | **0.23J** | **3.5** | **0.38J** | NA | NA |
| | COG-01-032513-480 | 3/25/2013 | <1.0 | <1.0 | <1.0 | **3.1** | <1.0 | **10** | **2.1** |
| | COG-01-032613-1440 | 3/26/2013 | <1.0 | <1.0 | <1.0 | **1.6** | <1.0 | **13** | **3.7** |
| | COG-01-032713 | 3/27/2013 | <1.0 | <1.0 | <1.0 | **4.4** | <1.0 | NA | NA |
| | COG-01-040313 | 4/3/2013 | <1.0 | <1.0 | <1.0 | **3.9** | <1.0 | NA | NA |
| | COG-01-041013 | 4/10/2013 | <1.0 | <1.0 | <1.0 | **4.0** | <1.0 | NA | NA |
| MW-1 | MW-1-75.2-041613 | 4/16/2013 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | **9.5** | <20 |
| COG-MW3 | COG-MW3-76.4-041613 | 4/16/2013 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | **11** | <20 |
| EMC-22LC | EMW-22LC-295-041613 | 4/16/2013 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | **4.0** | <20 |

NOTES:

J = Estimated Value

NA = Not Analyzed

< = compound was not detected above the detection limit

* All samples were analyzed for VOCs (EPA 8260B), perchlorate(EPA 314.0) and Nitrate (EPA 300.0) unless noted

VOC = volatile organic compounds

# TABLE 3

## WATER LEVEL DATA

| COG-01* | | |
|---|---|---|
| Elapsed Time (in minutes from pump test start) | Depth to Water (ft bmp) | Drawdown (ft) |
| 0 | 79.3 | 0.00 |
| 0.25 | 90.9 | 11.60 |
| 0.5 | 98.64 | 19.34 |
| 0.75 | 101.15 | 21.85 |
| 1 | 101.93 | 22.63 |
| 1.5 | 102.75 | 23.45 |
| 2 | 103.44 | 24.14 |
| 2.5 | 103.78 | 24.48 |
| 3 | 104.04 | 24.74 |
| 3.5 | 104.28 | 24.98 |
| 4 | 104.35 | 25.05 |
| 5 | 104.54 | 25.24 |
| 6 | 104.71 | 25.41 |
| 7 | 104.84 | 25.54 |
| 8 | 104.95 | 25.65 |
| 9 | 105.04 | 25.74 |
| 10 | 105.11 | 25.81 |
| 12 | 105.24 | 25.94 |
| 14 | 105.38 | 26.08 |
| 16 | 105.48 | 26.18 |
| 18 | 105.6 | 26.30 |
| 19 | 105.69 | 26.39 |
| 23 | 105.72 | 26.42 |
| 25 | 105.82 | 26.52 |
| 30 | 106.03 | 26.73 |
| 32 | 105.51 | 26.21 |
| 33 | 104.22 | 24.92 |
| 34 | 102.65 | 23.35 |
| 35 | 102.39 | 23.09 |
| 36 | 102.2 | 22.90 |
| 38 | 102.14 | 22.84 |
| 40 | 102.11 | 22.81 |
| 45 | 102.17 | 22.87 |
| 50 | 102.11 | 22.81 |
| 55 | 102.2 | 22.90 |
| 60 | 102.2 | 22.90 |
| 70 | 102.23 | 22.93 |
| 90 | 102.3 | 23.00 |
| 120 | 102.75 | 23.45 |
| 150 | 102.9 | 23.60 |
| 180 | 102.97 | 23.67 |
| 210 | 103.04 | 23.74 |
| 240 | 103.11 | 23.81 |
| 270 | 103.14 | 23.84 |
| 300 | 103.21 | 23.91 |

# TABLE 3

## WATER LEVEL DATA

| COG-01* | | |
|---|---|---|
| Elapsed Time (in minutes from pump test start) | Depth to Water (ft bmp) | Drawdown (ft) |
| 330 | 103.23 | 23.93 |
| 360 | 103.25 | 23.95 |
| 390 | 103.26 | 23.96 |
| 420 | 103.32 | 24.02 |
| 450 | 103.3 | 24.00 |
| 480 | 103.35 | 24.05 |
| 1420 | 103.65 | 24.35 |
| 1439 | 103.65 | 24.35 |
| Pump turned off 1440 minutes after start | | |
| 1440.17 | 94.4 | 15.10 |
| 1440.33 | 87.52 | 8.22 |
| 1440.5 | 85.99 | 6.69 |
| 1440.67 | 85.16 | 5.86 |
| 1440.83 | 84.66 | 5.36 |
| 1441 | 84.32 | 5.02 |
| 1441.17 | 84.12 | 4.82 |
| 1441.33 | 83.91 | 4.61 |
| 1441.5 | 83.72 | 4.42 |
| 1441.67 | 83.49 | 4.19 |
| 1441.83 | 83.35 | 4.05 |
| 1442 | 83.22 | 3.92 |
| 1442.5 | 82.81 | 3.51 |
| 1443 | 82.75 | 3.45 |
| 1443.5 | 82.6 | 3.30 |
| 1444 | 82.43 | 3.13 |
| 1444.5 | 82.36 | 3.06 |
| 1445 | 82.23 | 2.93 |
| 1446 | 82.08 | 2.78 |
| 1447 | 81.95 | 2.65 |
| 1448 | 81.85 | 2.55 |
| 1449 | 81.76 | 2.46 |
| 1451 | 81.61 | 2.31 |
| 1453 | 81.48 | 2.18 |
| 1455 | 81.41 | 2.11 |
| 1458 | 81.26 | 1.96 |
| 1463 | 81.17 | 1.87 |
| 1465 | 81.13 | 1.83 |
| 1470 | 81.04 | 1.74 |
| 1475 | 80.94 | 1.64 |
| 1480 | 80.85 | 1.55 |
| 1490 | 80.72 | 1.42 |
| 1500 | 80.62 | 1.32 |

# TABLE 3

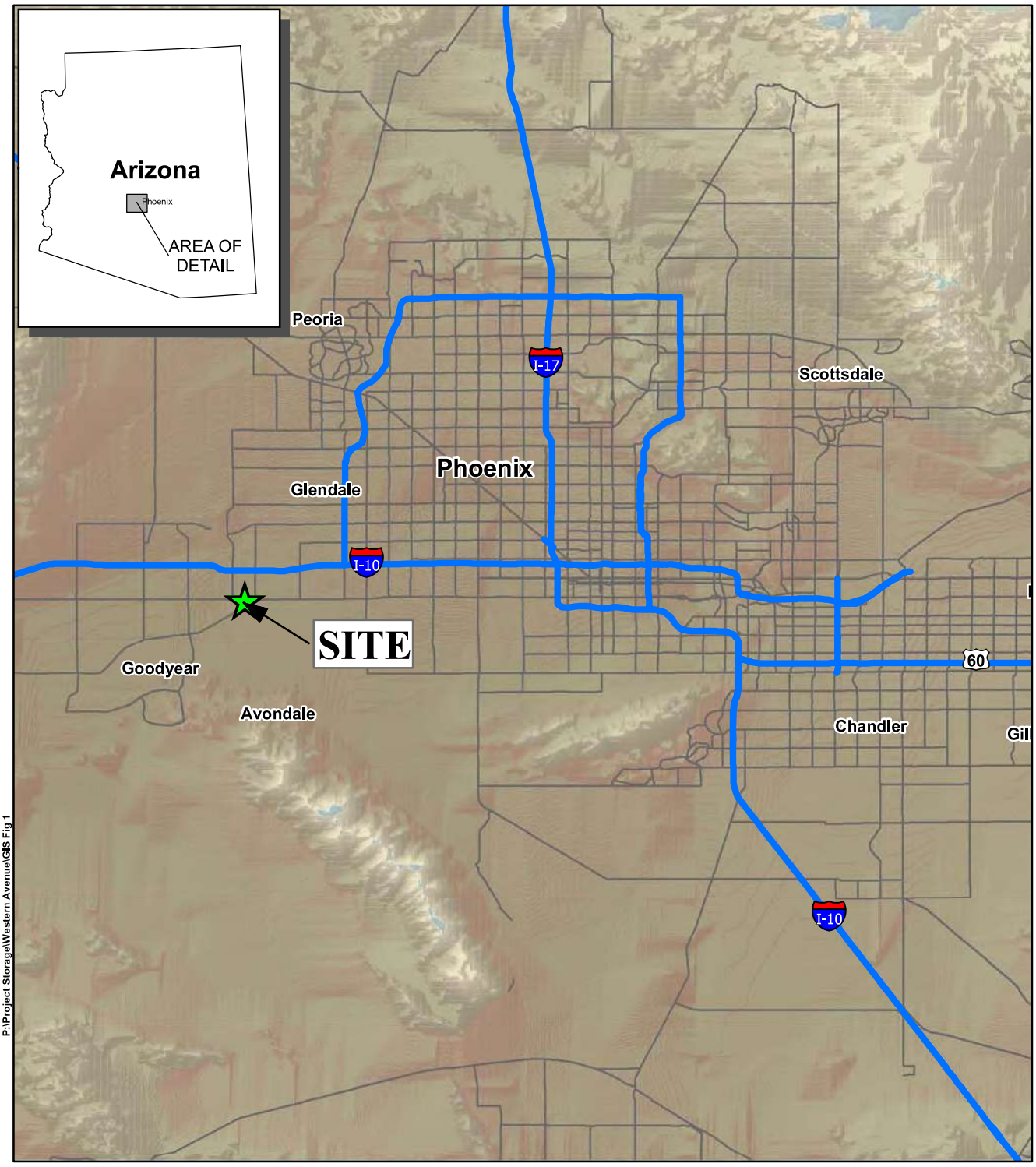
## WATER LEVEL DATA

| COG-01* | | |
|---|---|---|
| Elapsed Time (in minutes from pump test start) | Depth to Water (ft bmp) | Drawdown (ft) |
| 1510 | 80.56 | 1.26 |
| 1520 | 80.45 | 1.15 |
| 1530 | 80.38 | 1.08 |
| 1540 | 80.34 | 1.04 |
| 1550 | 80.29 | 0.99 |
| 1560 | 80.29 | 0.99 |
| 1600 | 80.1 | 0.80 |
| 1620 | 80.06 | 0.76 |
| 2845 | 78.55 | -0.75 |

NOTES:

*Water level data recorded by tranducers in observation wells can be found in Appendix C on the accompanying CD.

FIGURES




P:\Project Storage\Western Avenue\GIS Fig 1

N

0 4 8 Miles

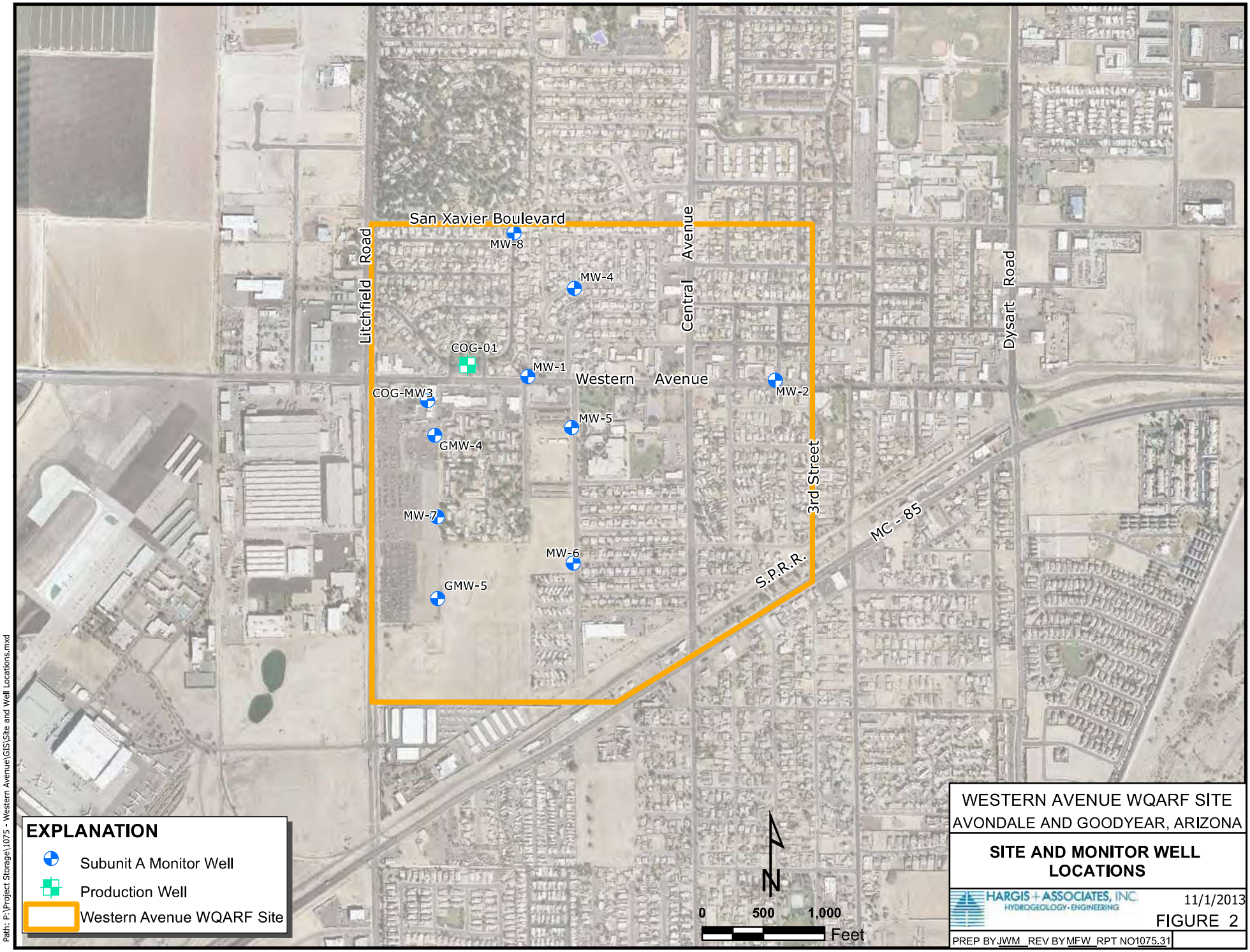
WESTERN AVENUE WQARF SITE
AVONDALE AND GOODYEAR, ARIZONA

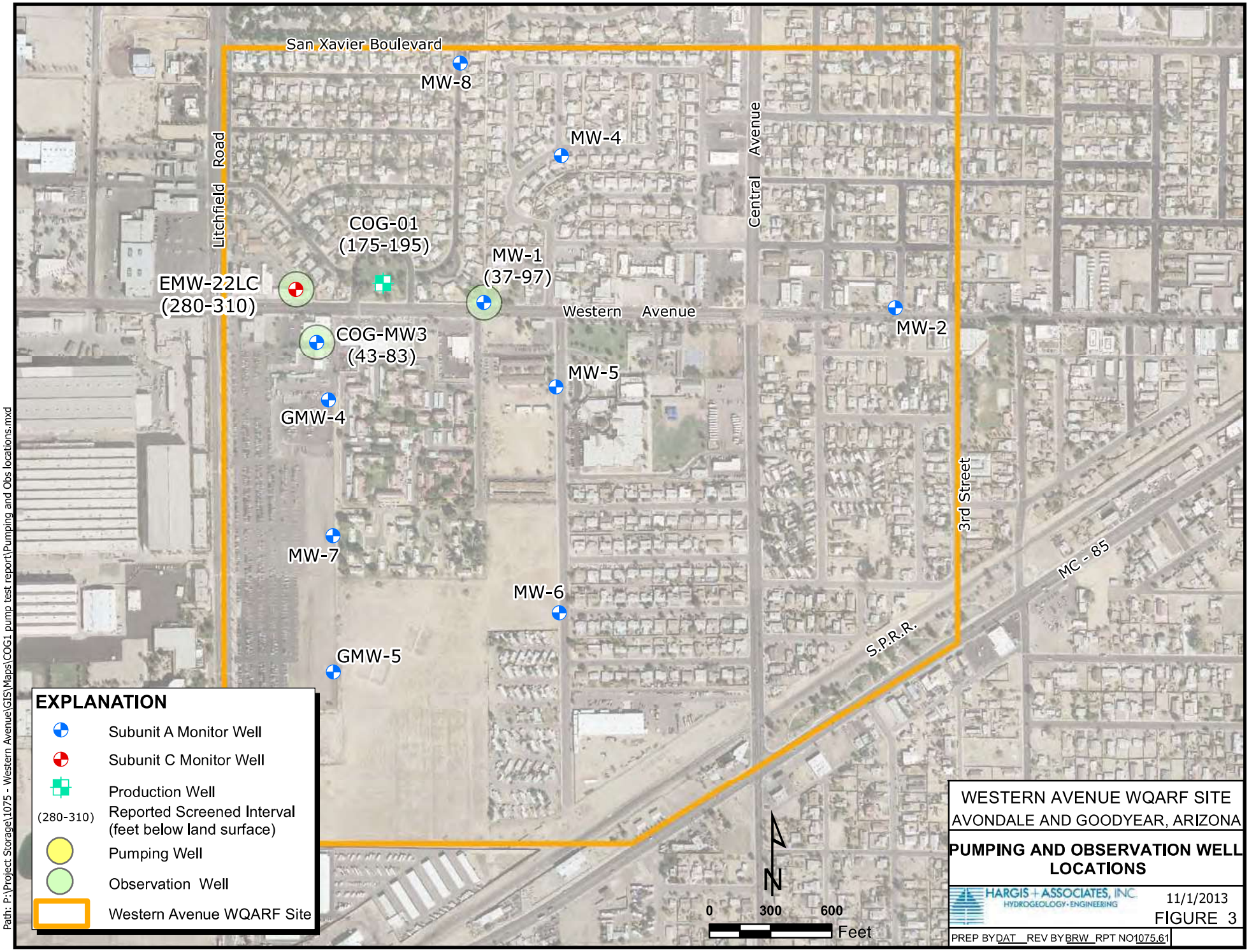
**SITE LOCATION**

HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY · ENGINEERING

FIGURE 1

| | | |
|---|---|---|
| PREP BY: JWM<br>REV BY: MFW | DATE: 6/21/2010<br>FILE: Fig 1.mxd | PROJECT: 1075.31 |


San Xavier Boulevard
Litchfield Road
Central Avenue
Dysart Road
Western Avenue
3rd Street
S.P.R.R.
MC - 85
MW-8
MW-4
COG-01
MW-1
MW-2
COG-MW3
MW-5
GMW-4
MW-7
MW-6
GMW-5
EXPLANATION
Subunit A Monitor Well
Production Well
Western Avenue WQARF Site
N
0
500
1,000
Feet
WESTERN AVENUE WQARF SITE
AVONDALE AND GOODYEAR, ARIZONA
SITE AND MONITOR WELL LOCATIONS
HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY · ENGINEERING
11/1/2013
FIGURE 2
PREP BY JWM REV BY MFW RPT NO 1075.31
Path: P:\Project Storage\1075 - Western Avenue\GIS\Site and Well Locations.mxd


San Xavier Boulevard
MW-8
MW-4
Litchfield Road
Central Avenue
COG-01
(175-195)
MW-1
(37-97)
EMW-22LC
(280-310)
Western Avenue
MW-2
COG-MW3
(43-83)
MW-5
GMW-4
3rd Street
MC - 85
MW-7
MW-6
S.P.R.R.
GMW-5
EXPLANATION
Subunit A Monitor Well
Subunit C Monitor Well
Production Well
(280-310)
Reported Screened Interval
(feet below land surface)
Pumping Well
Observation Well
Western Avenue WQARF Site
N
0
300
600
Feet
WESTERN AVENUE WQARF SITE
AVONDALE AND GOODYEAR, ARIZONA
PUMPING AND OBSERVATION WELL LOCATIONS
HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY · ENGINEERING
11/1/2013
FIGURE 3
PREP BY DAT REV BY BRW RPT NO 1075.61
Path: P:\Project Storage\1075 - Western Avenue\GIS\Maps\COG1 pump test report\Pumping and Obs locations.mxd

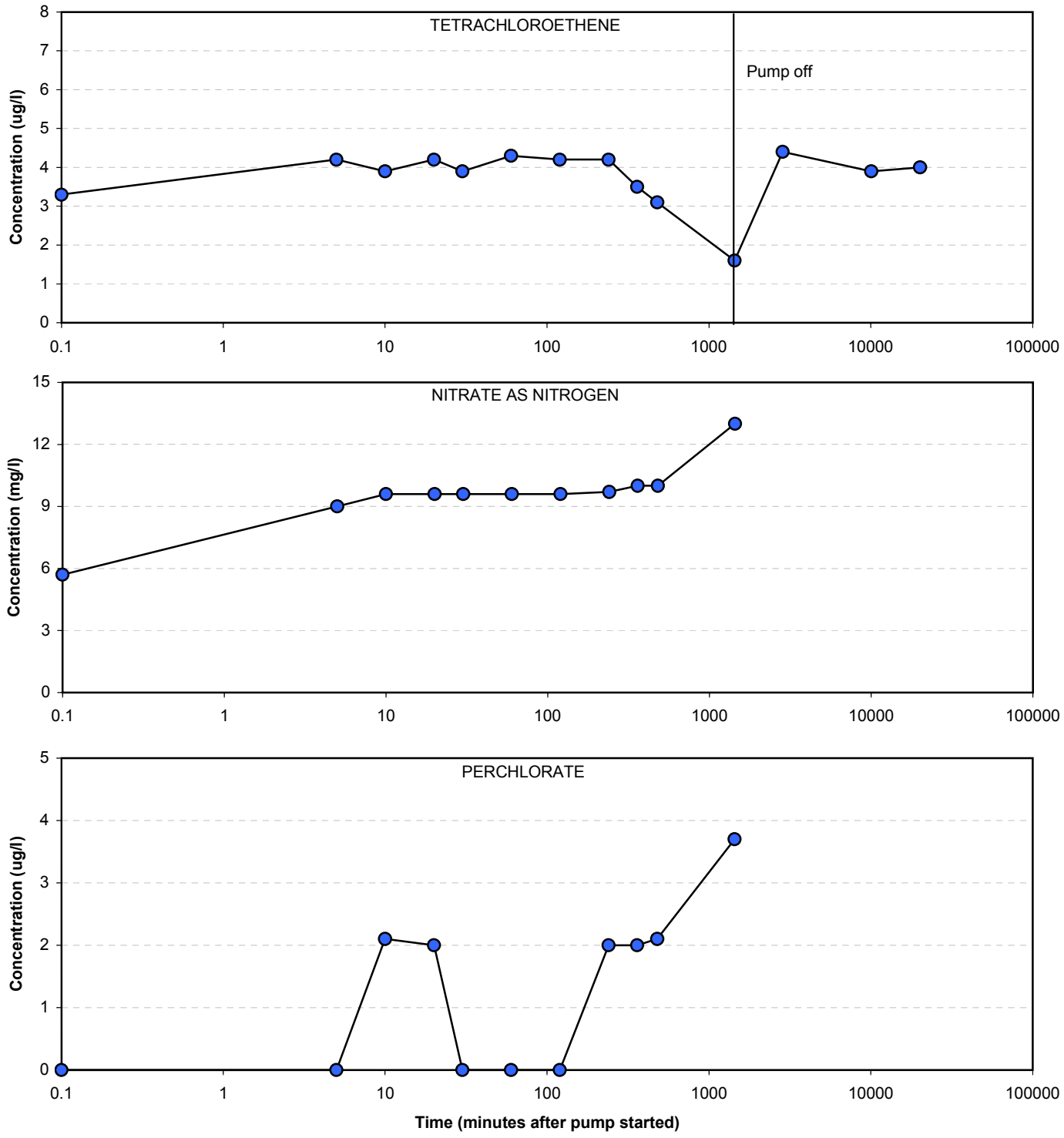
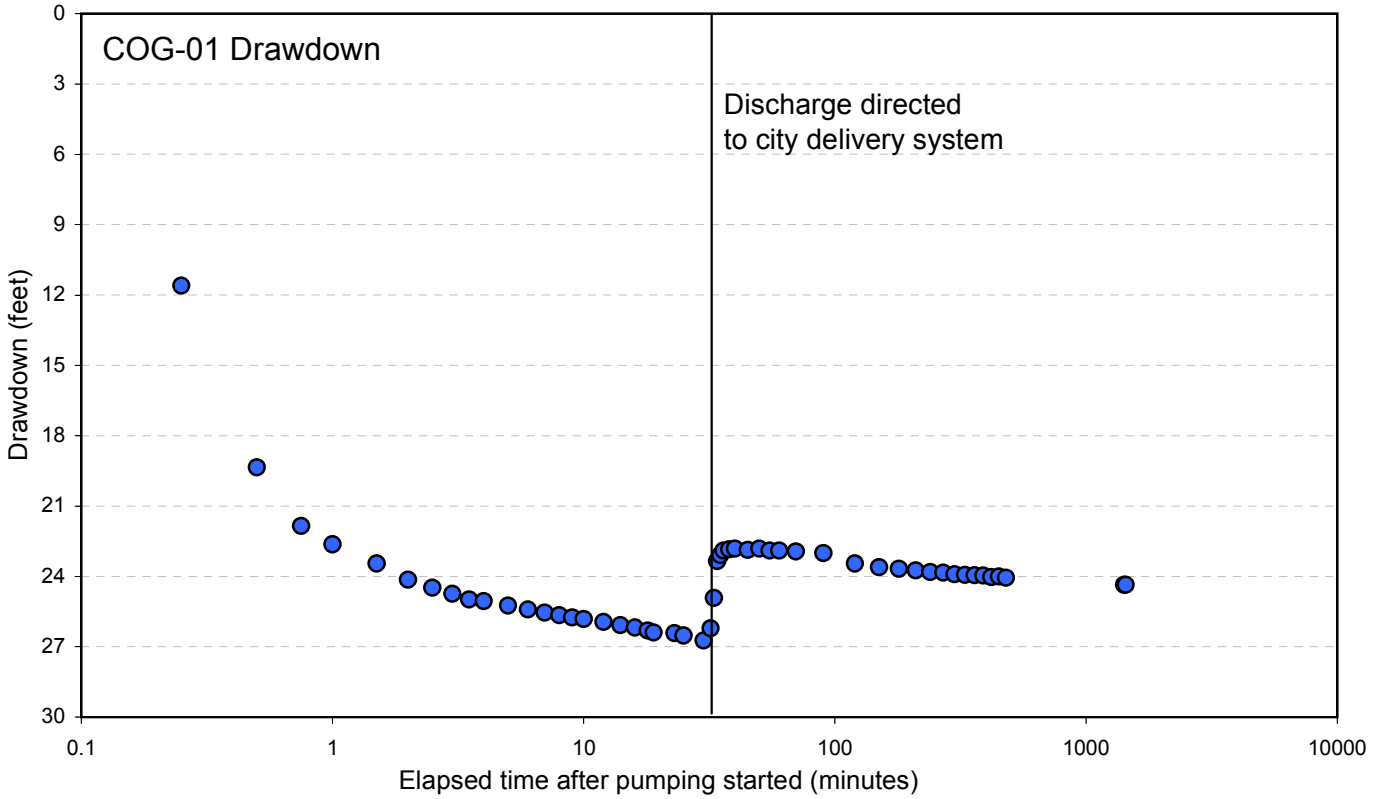



FIGURE 4.
TETRACHLOROETHENE, NITRATE AS NITROGEN, AND PERCHLORATE CONCENTRATIONS
PUMPED WELL COG-01

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering



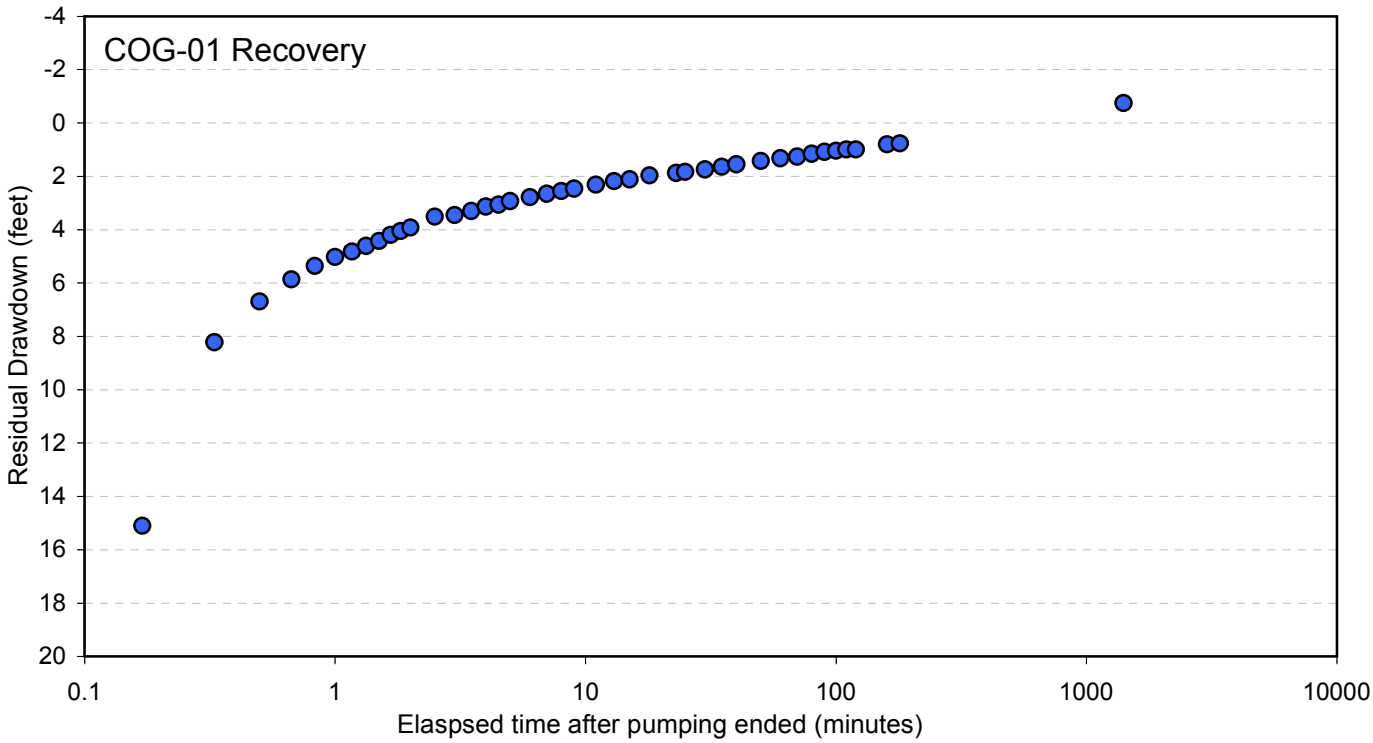
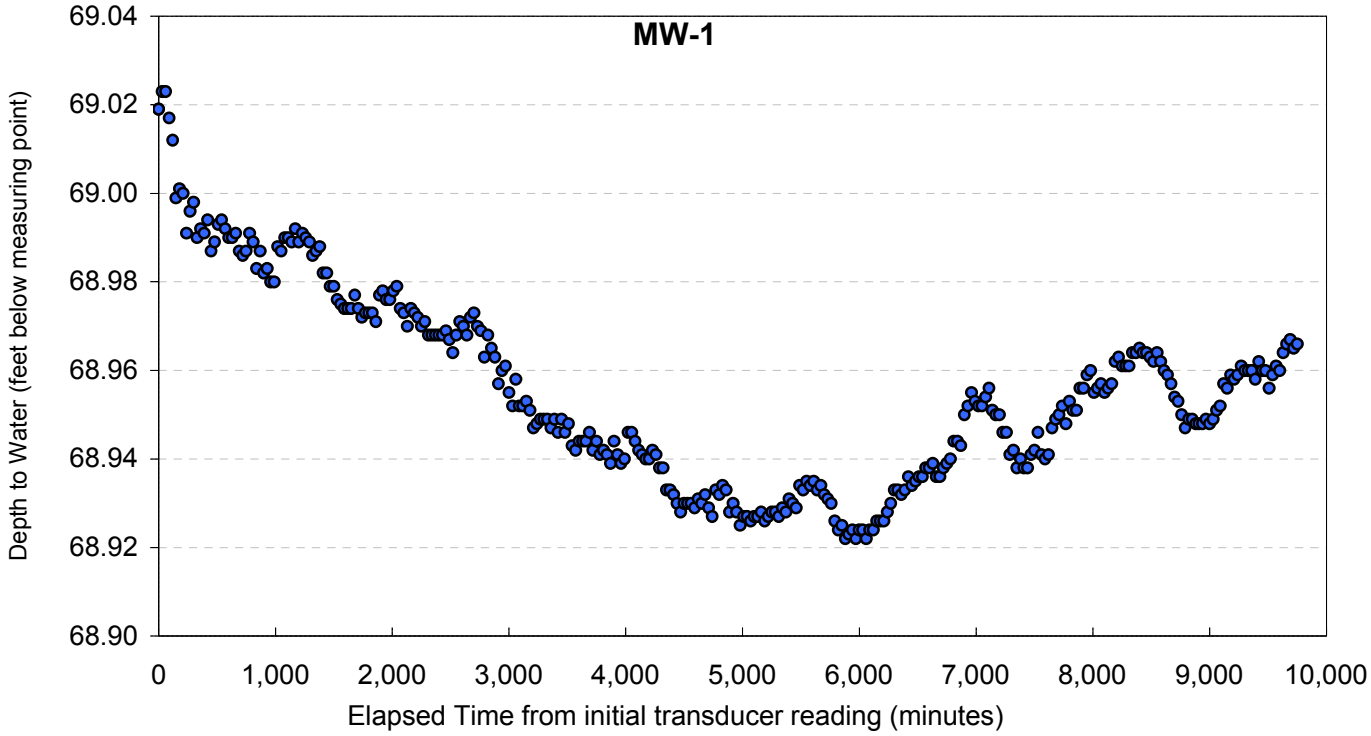




FIGURE 5.
WATER LEVEL DRAWDOWN AND RECOVERY
PUMPED WELL COG-01

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering



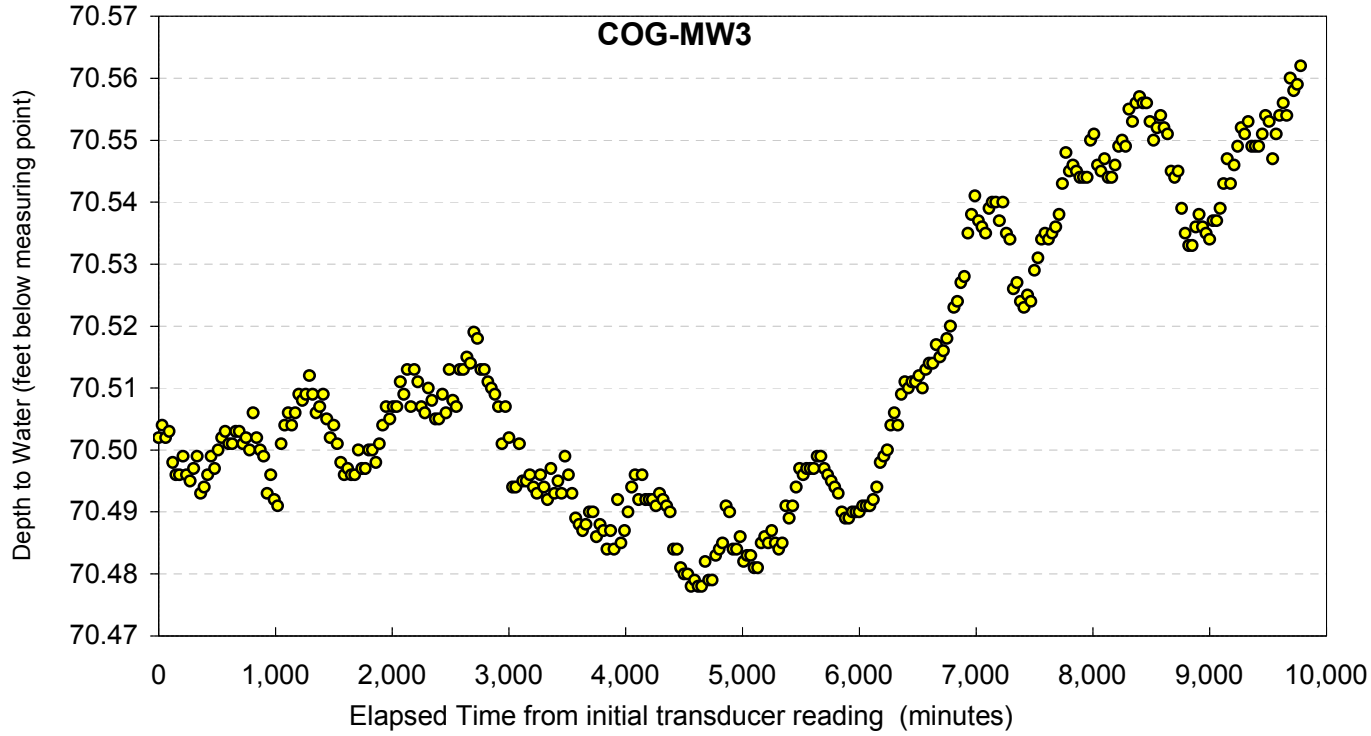
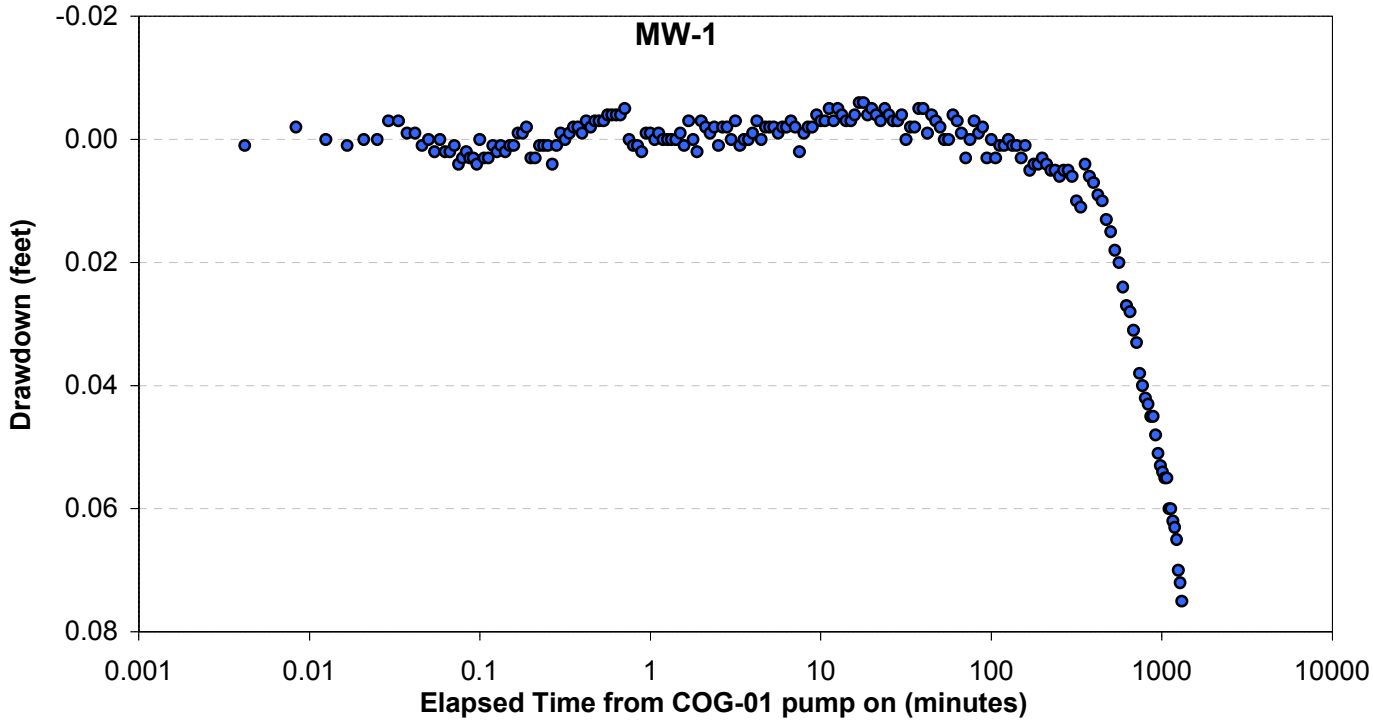




FIGURE 6.
PRE-TEST (AMBIENT) WATER LEVELS
SUBUNIT A OBSERVATION WELLS

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering



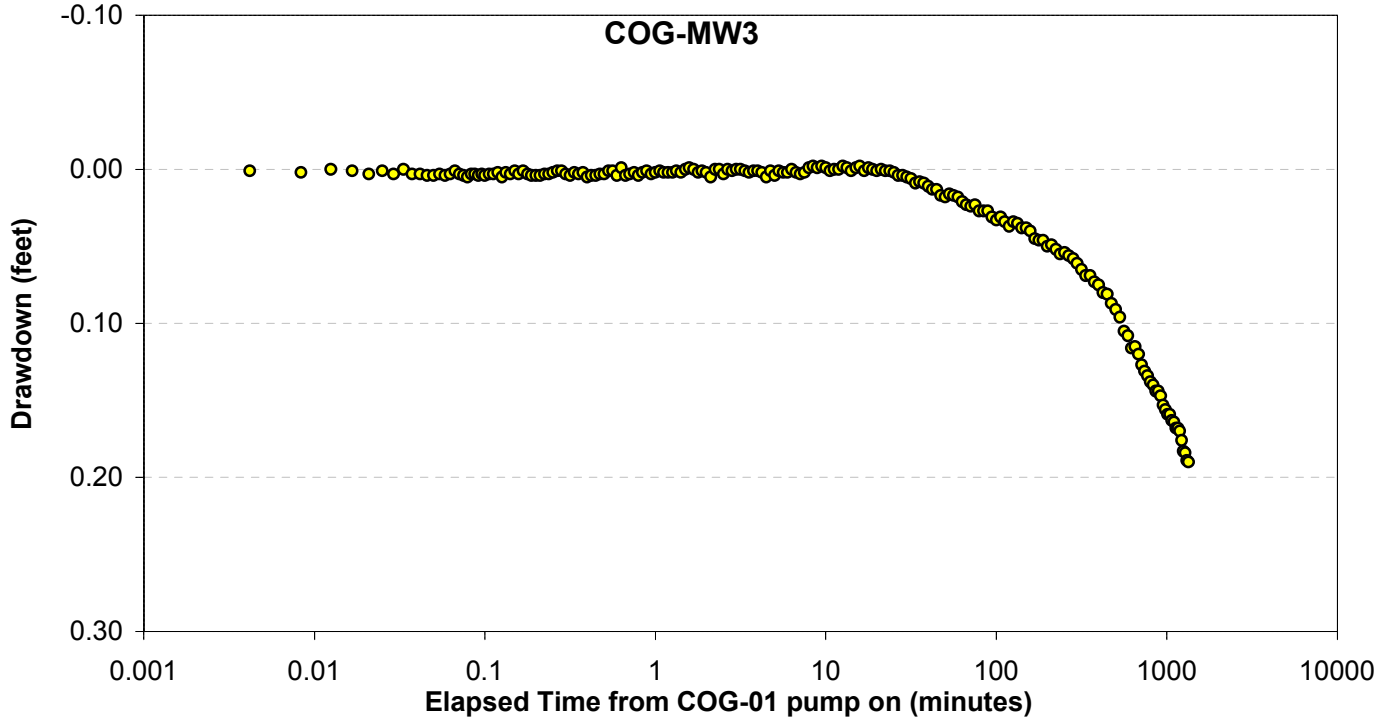
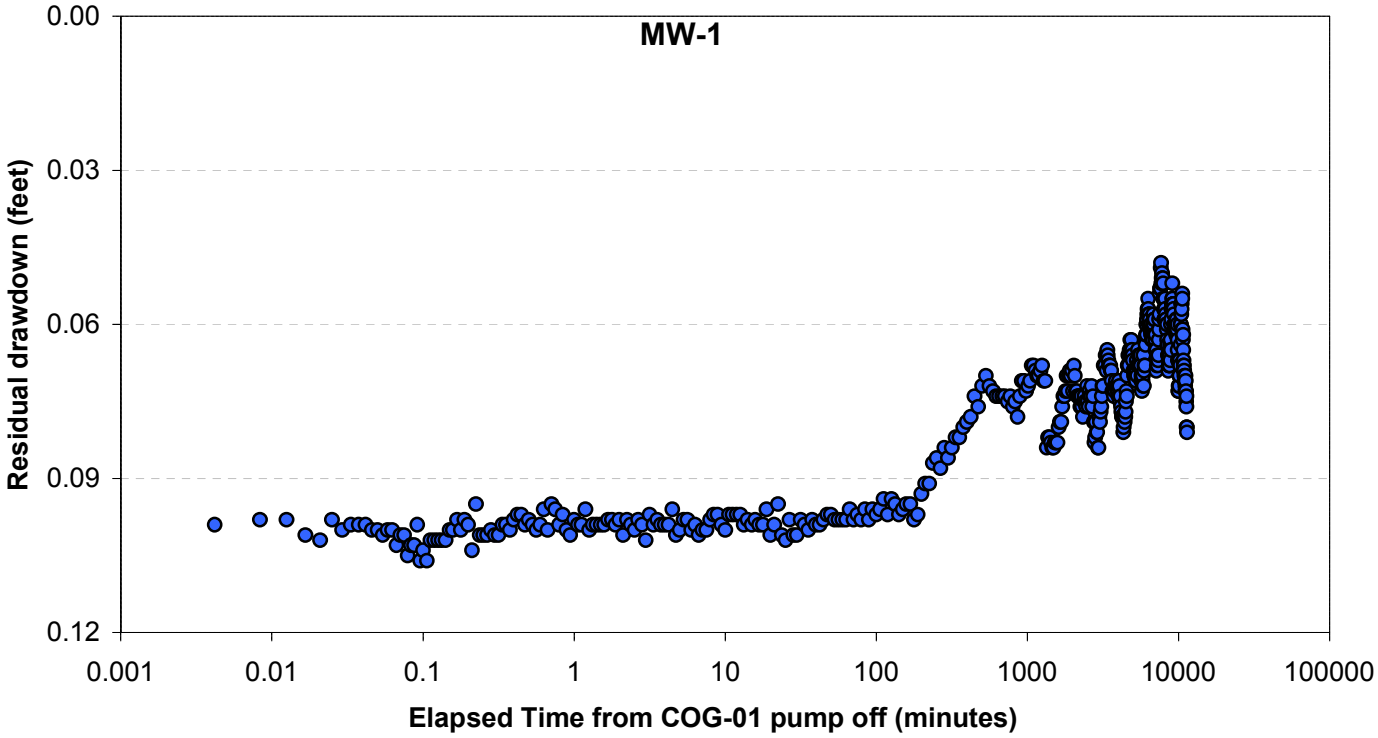




FIGURE 7.
WATER LEVEL DRAWDOWN
SUBUNIT A OBSERVATION WELLS

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering



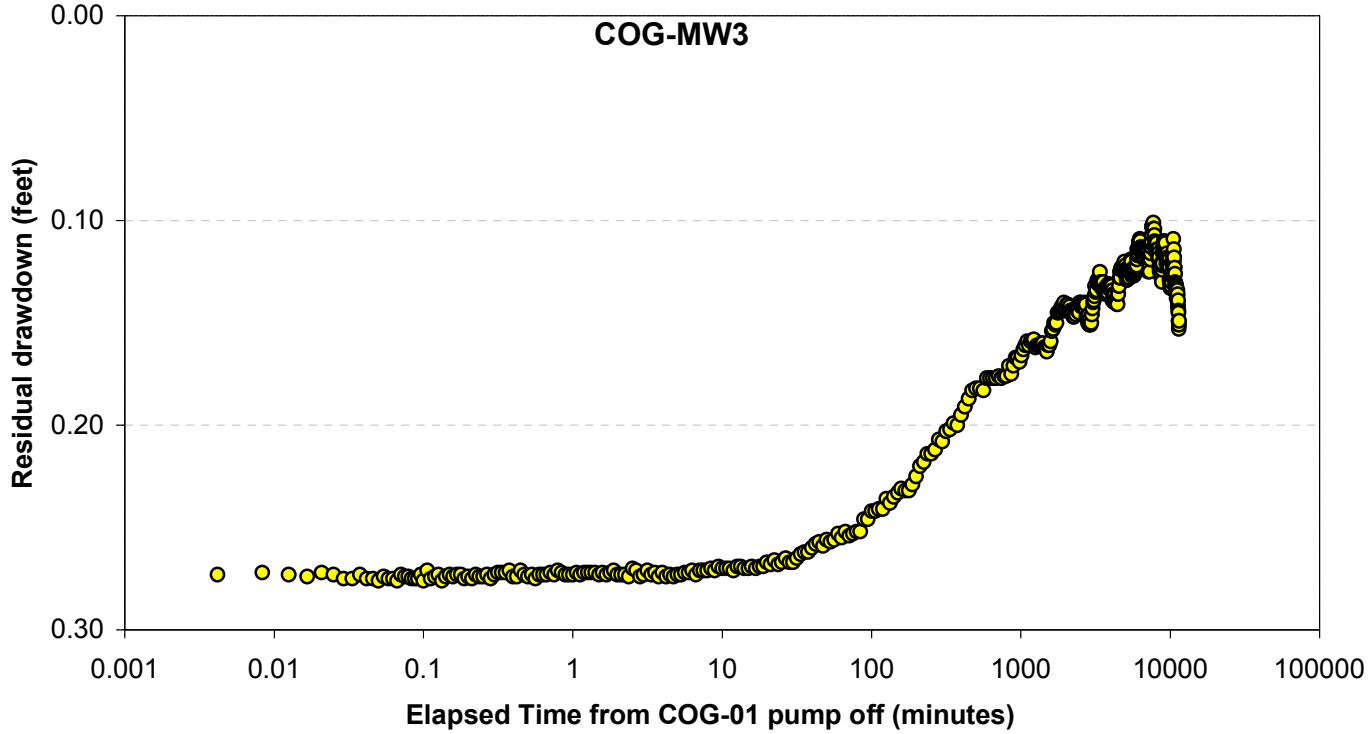




FIGURE 8.
WATER LEVEL RECOVERY
SUBUNIT A OBSERVATION WELLS

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering

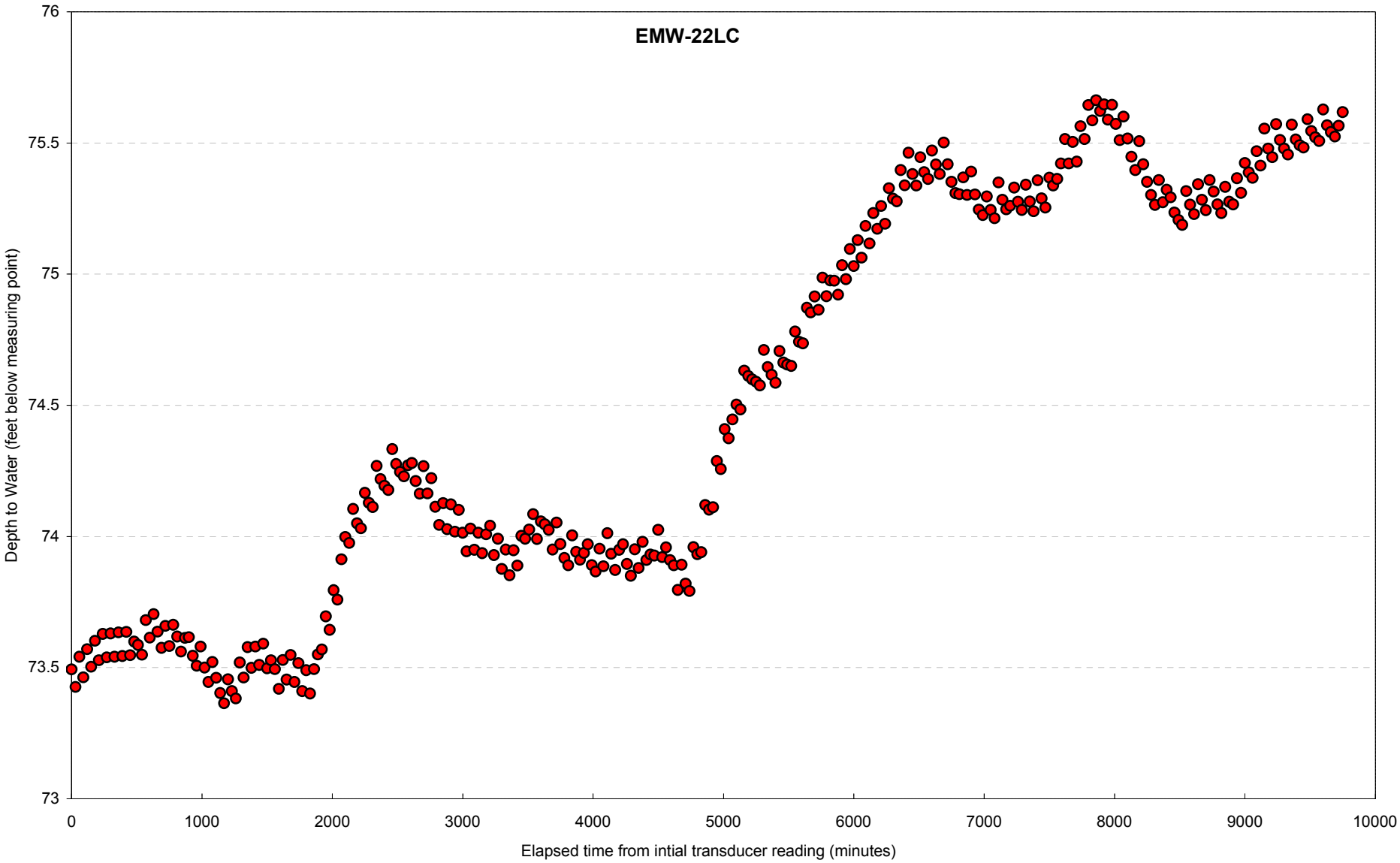



FIGURE 9.
PRE-TEST (AMBIENT) WATER LEVELS
SUBUNIT C OBSERVATION WELL

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering

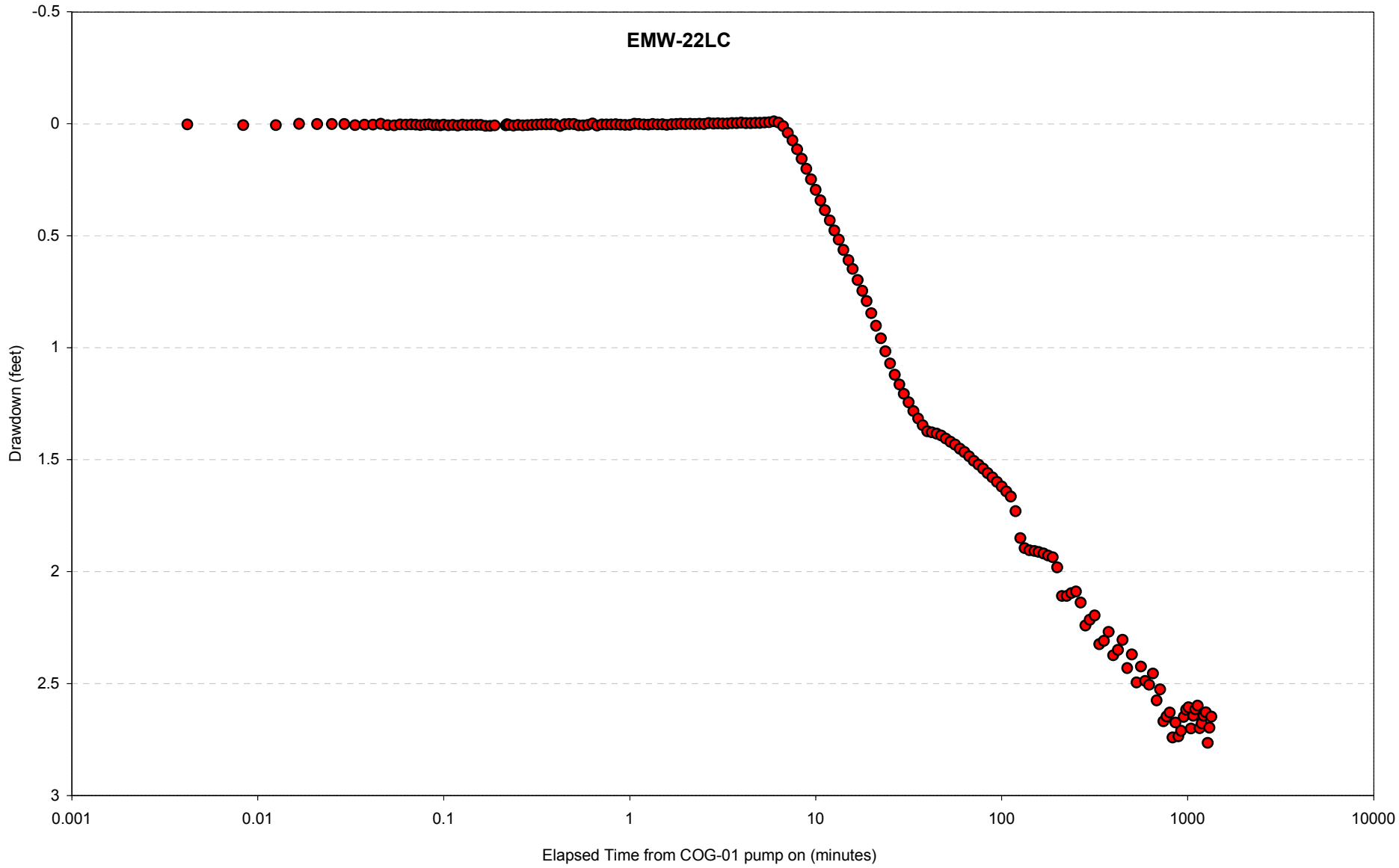



FIGURE 10.
WATER LEVEL DRAWDOWN
SUBUNIT C OBSERVATION WELL

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering

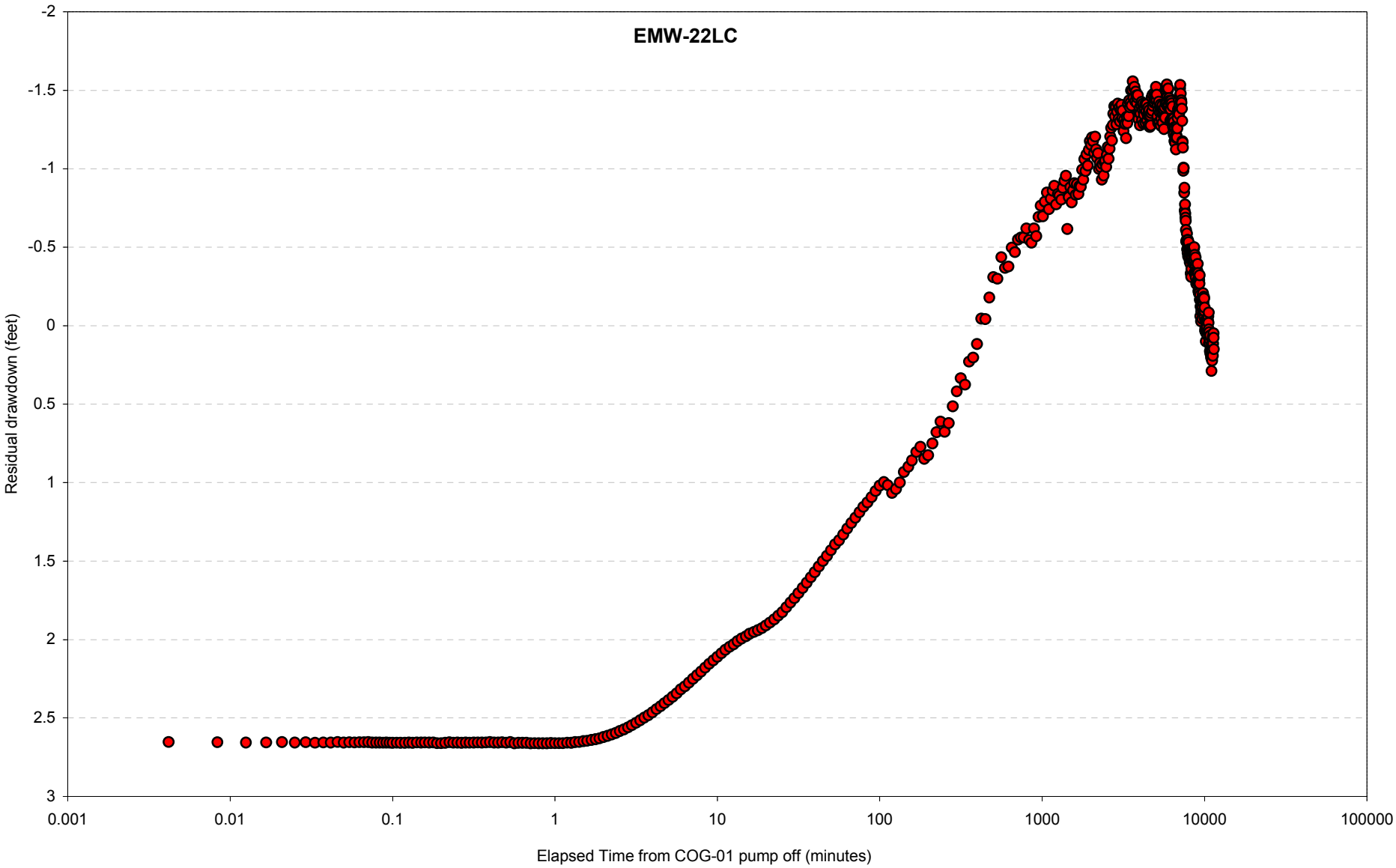



FIGURE 11.
WATER LEVEL RECOVERY
SUBUNIT C OBSERVATION WELL

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering

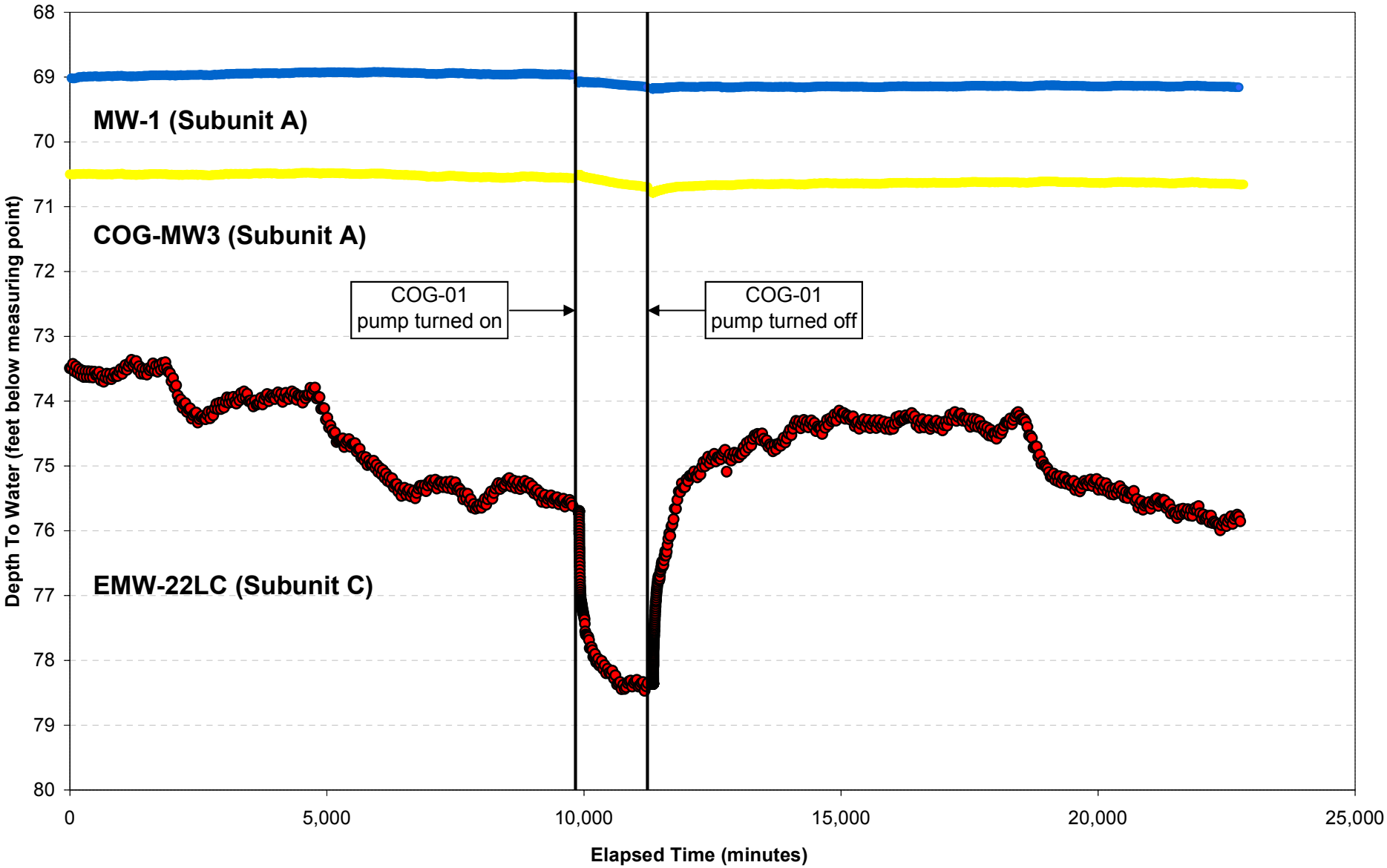



FIGURE 12.
WATER LEVEL RESPONSES
SUBUNIT A AND C OBSERVATION WELLS

HARGIS + ASSOCIATES, INC.
Hydrogeology/Engineering

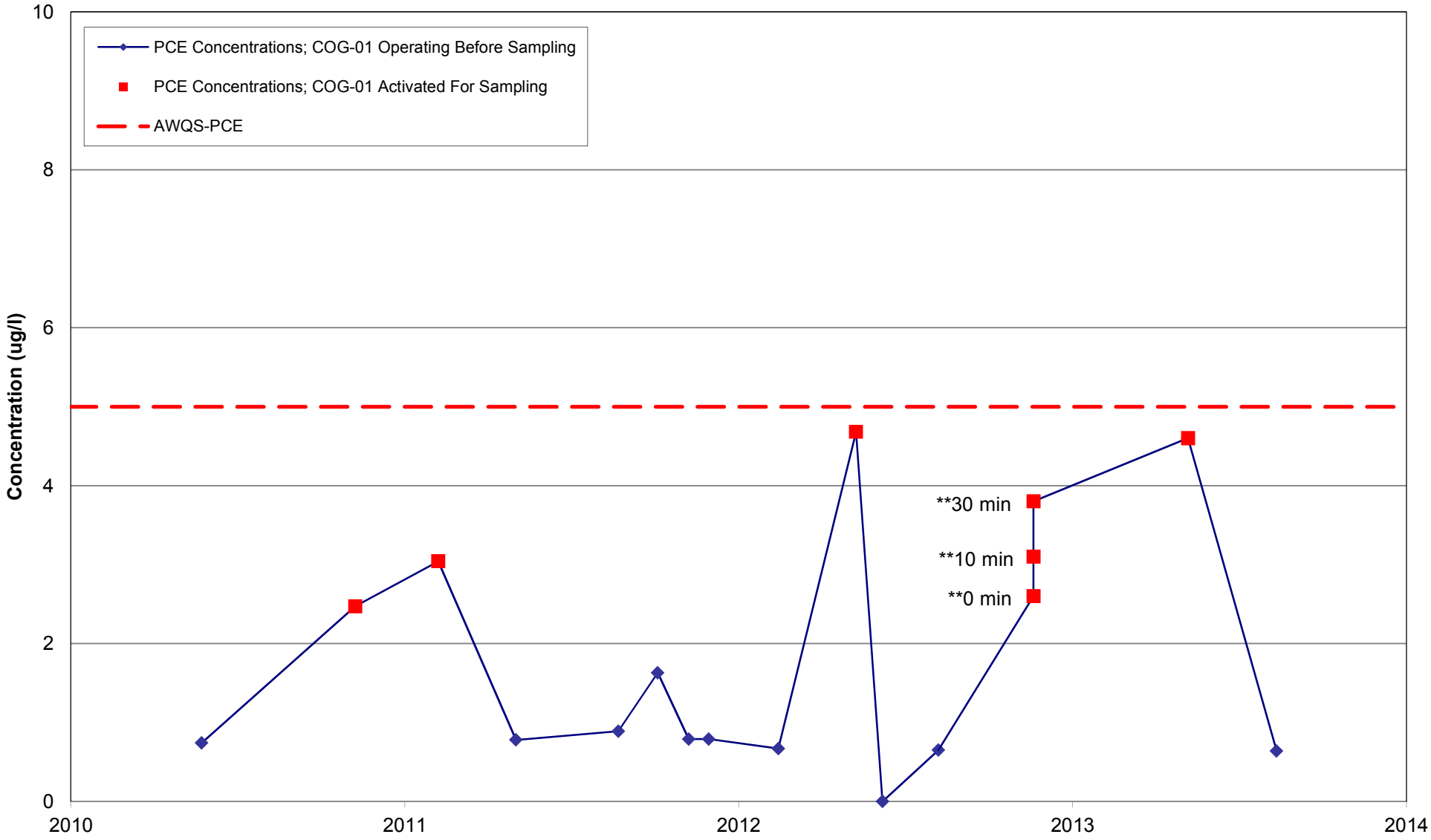



FIGURE 13. WELL COG-01 OPERATION AND TETRACHLOROETHENE CONCENTRATIONS

Notes:
ug/L = micrograms per liter
AWQS = Aquifer Water Quality Standard
Non detects are plotted at zero
**Groundwater samples in November 2012 collected immediately upon activation and at 10 and 30 minutes after activation.

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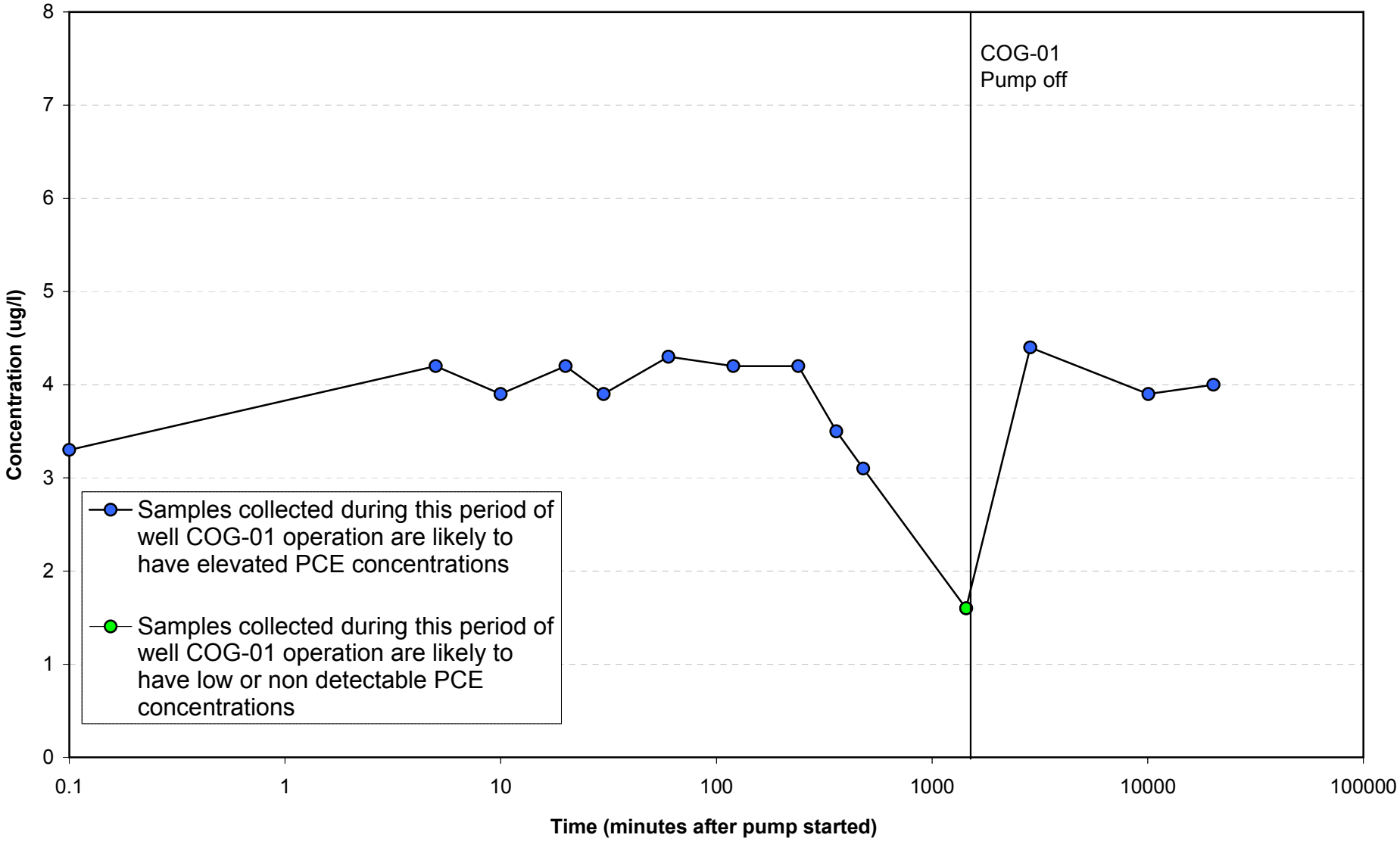


FIGURE 14.
TETRACHLOROETHENE CONCENTRATIONS
PUMPED WELL COG-01

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