VASQUEZ BOULEVARD/INTERSTATE 70 SUPERFUND SITE
OPERABLE UNIT 2, DENVER, COLORADO

GROUNDWATER DATA SUMMARY REPORT

MARCH 2013

DRAFT

Work Assignment Number: 125-RICO-089R

Prepared for the Environmental Protection Agency

Region VIII

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EXECUTIVE SUMMARY

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The Calendar Year (CY) 2012 Vasquez Boulevard/Interstate 70 (VB/I70), Operable Unit 2 (OU2) groundwater monitoring project was conducted by Pacific Western Technologies, Ltd. (PWT), under the authorization of, and in conjunction with, the U.S. Environmental Protection Agency (EPA), to evaluate the reproducibility of analytical results generated by the previous remedial investigation conducted by the City and County of Denver (CCoD). PWT has prepared this report for the CY 2012 sampling results. Sampling was conducted in accordance with the *Supplemental Sampling Program Quality Assurance Project Plan,* (QAPP) for OU2 (PWT 2012b) for CY 2012, in an effort to ensure that data of known quality are used for contamination assessment and decision-making purposes at OU2.

This Data Summary Report discusses the field sampling activities, analytical results, quality assessment and data evaluations conducted for volatile organic compounds (VOC), semivolatile organic compounds (SVOC) and total and dissolved metals in CY 2012, which encompasses the period from January, 2012, through December, 2012. CY 2012 sampling activities commenced in March, 2012. In addition, this document discusses any deviations from the QAPP that occurred during sample collection and handling, and provides supporting field sampling documentation and data review.

Review of the water table information discussed in Section 4.0 indicates that groundwater and any contaminants found in the groundwater would generally migrate from southeast to northwest within OU2. This would suggest that contaminated groundwater found in the downgradient wells may have come from an upgradient location either within OU2 or outside of OU2.

Upgradient Wells MW005 and MW006 are free from the types of contamination found in downgradient Wells MW001, MW002 and MW003. Well MW006 has low levels of chloroform that were not always above the CBSG, but chloroform above the CBSG was not found in the downgradient wells. Well MW001 has tetrachloroethene, trichloroethene and cis 1,2 dichloroethene above applicable groundwater standards but the other two downgradient wells do not. Likewise, Well MW002 has high arsenic values and occasional antimony values above applicable groundwater standards but the other two downgradient wells do not. Well MW003 has elevated chlorobenzene levels which are near to, but not above, standards but the other wells do not have similar levels of chlorobenzene. As a result, it is difficult to make any definitive statements about the source areas for the contamination seen in the downgradient wells other than to hypothesize that multiple sources for groundwater contamination migrating near these wells may exist.

Review of the monitoring data and trend plots for OU2 indicates that, even though each quarter's results were typically analyzed by a different Contract Laboratory Program (CLP) laboratory, the results were very consistent. Verification and validation of the analytical results indicates that the data quality resulting from the laboratory analysis was acceptable for decision making. The data also suggest that the ability for source area contamination to leach to the groundwater is not significantly affected by seasonal variations in the water table. Minor exceptions to this conclusion may be found in the chloroform results in MW006 and the antimony and arsenic results in MW002 which increased slightly in the dryer part of the year.

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To adequately assess the groundwater pathways within OU2 it is recommended that additional ~~piezometers~~ monitoring wells be installed to monitor water levels in areas midway between the

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upgradient and downgradient wells. This would provide better definition of the water table within OU2 and allow for better interpretation of groundwater flow directions.

One of the goals of the monitoring project was to assess whether a buried landfill under the Denver Coliseum parking lot was responsible for the contamination seen in downgradient wells. To this end, the analysis of organic compounds was included in the analyte suite because organics had been detected in boreholes drilled into the landfill during the remedial investigation conducted by CCoD (EMS 2009). However, due to the large distance between the upgradient wells and the downgradient wells it is difficult to pinpoint the landfill as the source of the contamination. In addition, recent groundwater results from other projects conducted in OU2 suggest that there may be other sources for groundwater contamination upgradient of the landfill. To adequately asses any landfill contribution to the groundwater contamination in downgradient wells, additional wells should be installed directly upgradient of the landfill. This should be done in conjunction with the piezometers recommended above to provide both an adequate water table map for OU2 and also to better interpret the contribution from the landfill to the groundwater contamination.

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Appendix A Quarterly Water Level Maps and Quarterly Analytical Result Maps
Appendix B Project Field Forms and Field Notes
Appendix C Chain-of-Custody Records
Appendix D Analytical Reports and Case Narratives
Appendix E Data Validation Reports, Data Review Worksheets, and RPD Calculations

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I would also recommend adding qualifier definitions to the analytical results figures.

I would recommend highlighting or bolding analytical results that are above the CBSG/MCL.

Consider adding the applicable water level contours to the analytical results maps (and maybe consolidate the number of figs?)

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LIST OF ACRONYMS

ASARCO	American Smelting and Refining Company
CBSG	Colorado Basic Standards for Groundwater
CCoD	City and County of Denver
CDPHE	Colorado Department of Public Health and Environment
COC	contaminant of concern
CLP	Contract Laboratory Program
CRQL	contract required quantitation limits
CY	calendar year
DCE	cis-1,2-dichloroethene
EDD	electronic data deliverables
EPA	U.S. Environmental Protection Agency
NFG	National Functional Guidelines
GDCC	Groundwater Data Collection/Compilation
HASP	health and safety plan
µg/L	microgram per liter
MCL	Maximum Contaminant Level
MDL	method detection limit
MRL	method reporting limit
MS/MSD	matrix spike/matrix spike duplicate
NAPL	non-aqueous phase liquids
OU	Operable Unit
PCE	tetrachloroethene
PPE	personal protective equipment
PWT	Pacific Western Technologies, Ltd.
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAC	Remedial Action Contract
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RPD	relative percent difference
RPM	Remedial Project Manager
ROD	Record of Decision
SOP	Standard Operating Procedure
TCE	trichloroethene
VB/I-70	Vasquez Boulevard/Interstate 70 Superfund Site
VOC	volatile organic compound
SVOC	semi-volatile organic compound

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1.0 INTRODUCTION

The Vasquez Boulevard / Interstate 70 Superfund Site (VB/I-70) is an area of approximately 4.5 square miles located in north-central Denver, Colorado (Figure 1-1). Historically, this area was a major smelting center for the Rocky Mountain West. Three smelting plants: Omaha & Grant, Argo, and Globe operated in the area for varying lengths of time, beginning as early as 1870, refining gold, silver, copper, lead, and zinc. The VB/I-70 Site is divided into three operable units (OU) which have been managed independently for the purposes of remedial investigation and remedial action.

OU 2, identified in Figure 2-1, is in the area where the Omaha & Grant Smelter was located. The U.S. Environmental Protection Agency (EPA) is concerned that wastes associated with historic smelter operations and a solid waste landfill may still exist and may have an impact on groundwater and soil. The initial Remedial Investigation (RI) was completed in December 2009 and focused on characterizing the nature and extent of surface soil, subsurface soil, and groundwater contamination (EMS 2009). After completion of the first phase of the RI, data gaps we identified with respect to the potential for contaminated groundwater associated with the historic landfill on the OU 2 Site. The objective of this groundwater monitoring project is to further assess potential groundwater contamination near the historic landfill on the OU 2 Site, and develop the amount of data necessary to support decisions with respect to the need for future site remediation.

Commented [aps6]: Perhaps we should say with limited focus on groundwater contamination given their level of effort and what is said in the order?

Pacific Western Technologies, Ltd. (PWT) received authorization from the EPA, Region VIII, under the Remedial Action Contract (RAC) to perform a groundwater monitoring project at Operable Unit 2 of the VB/I70 Superfund Site in Denver, Colorado on December 21, 2011. The goals of the project were to perform the following activities:

- Performance of well development and water level measurements
- Collection and analysis of groundwater samples
- Completion of data validation and verification of analytical data
- Submittal of a Data Summary Report

This document discusses the field sampling activities, analytical results, and data evaluations conducted for groundwater samples collected to support remedial investigation decisions for groundwater at Operable Unit 2 (OU2).

1.1. PROJECT SCOPE

Groundwater monitoring activities were conducted as prescribed by the *Supplemental Sampling Program Quality Assurance Project Plan,* (QAPP) for OU2 (PWT 2012b). Five existing groundwater monitoring wells installed during Phase I Remedial Investigation activities were developed (or re-developed) and monitored quarterly during calendar year (CY) 2012 to evaluate the groundwater quality in OU2. Three wells are considered to be located downgradient or cross gradient to a former landfill that is buried underneath the parking lot at the Denver Coliseum on land owned by the City and County of Denver (CCoD). Two other wells are located near the southeast edge of OU2 and have served as upgradient wells for the site. Figure 2-1 is the OU2 site location map that also shows the monitoring well locations. EPA initiated the groundwater sampling project to ensure that data of known quality was available for use in remedial investigation decision making at OU2. Additionally, EPA wanted to validate historic results for metals in the OU2 wells and also to assess if organic related contamination

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existed. The QAPP (PWT 2012b) was developed to support EPA's groundwater evaluation at OU2. Specifically, the QAPP directs the sampling and analysis of groundwater and includes data assessment activities to evaluate laboratory performance.

1.2. PROJECT OBJECTIVES

The objective of the groundwater sampling program is to evaluate the reproducibility (field and laboratory precision) of analytical results produced by quarterly groundwater samples from OU2 monitoring wells.

1.3. PROJECT DESCRIPTION

The OU2 QAPP identifies the following tasks:

1. Perform well development on the five monitoring wells in OU2
2. Collect four quarters of water level measurements and groundwater samples from OU2 monitoring wells
3. Submit samples and appropriate QC samples (i.e., duplicate samples) for laboratory analysis
4. Review and validate analytical data, prepare a database of the results, and assess data to evaluate overall data reproducibility and groundwater quality.

This document discusses the field sampling activities, analytical results, and data evaluations conducted for the groundwater monitoring activities conducted in CY 2012. In addition, this document discusses any deviations from the QAPP (PWT 2012b) that occurred during sample collection and handling, and provides supporting field sampling documentation.

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FIGURE 1-1 VB/I70 SITE LOCATION MAP

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2.0 GROUNDWATER SAMPLING

This section describes the CY 2012 field activities for collecting groundwater samples. The goal of this sampling project was to collect and analyze samples for volatile organic, semivolatile organic and metals (total and dissolved) collected by PWT from OU2 groundwater wells. In CY 2012, field sampling activities were performed during the March 2012, May 2012, August 2012 and December 2012 quarterly sampling events. During each quarterly event, samples were collected from the following five OU2 groundwater wells:

- MW001
- MW002
- MW003
- MW005
- MW006

2.1. PRE-WATER SAMPLING ACTIVITIES

Prior to the March sampling activity PWT conducted well development in each well using procedure SOP *PWT/GW.106, Well Development*, which was included in the QAPP for OU2 (PWT 2012b). In general, a minimum of 5 casing volumes were purged from the wells and purging was continued until the field parameters stabilized.

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Prior to collecting groundwater samples during each of the quarterly sampling events, water level measurements were collected from each well using SOP *PWT/GW.102, Water Level Measurements in Wells and Piezometers*. Appendix A, Figures A-1 through A-4 present the quarterly water level maps for OU2. An interface probe was used for water level measurements so that any free product in the well could be detected. During both the well development and the initial water level measurement at Well MW003, a floating free product was identified. The free product discovery will be discussed in Section 4.0.

2.2. SAMPLE COLLECTION PROCEDURE

Water samples were collected using low-flow sampling procedures in accordance with SOP *PWT/GW.101, Groundwater Sampling* and SOP *PWT/GW.108, Measurement of Groundwater Field Parameters* included in the QAPP. Figure 2-1 shows the locations of the OU2 groundwater monitoring wells. The quarterly groundwater samples are identified in Table 2-1.

2.2.1. Field Documentation

Information for each groundwater sample, such as sample location, sample date, sample time, and sample identification, was documented in a field sampling form. The field sampling records, including field forms, copies of project field notes, and completed chain-of-custody records are provided in Appendices B, and C, respectively.

2.2.2. Health and Safety

PWT developed a Health and Safety Plan (HASP) for conducting the groundwater field sampling program (PWT 2012a). In general, the HASP directs field sampling personnel to

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conduct sampling in accordance with PWT corporate safety and health requirements. PWT sampling personnel conducted work in accordance with the HASP.

2.3. SAMPLE DESIGNATION

Water samples were identified through the use of a coding system to identify sample locations and sample types. This coding system ensures that samples are uniquely identified by well number and sampling month and year, and provides tracking numbers to facilitate data retrieval. Samples were numbered according to the following system:

Sample Number: MW001-1012-01

Where: MW = Groundwater monitoring well

001 = Well number

10 = Month of collection

12 = Year of collection (i.e., 2011)

01 = Unique sample designation number (01 = field sample, RN = rinsate sample, FT = filtered sample)

A special sample number was generated for field duplicate samples so as to send a blind sample to the laboratory. The field duplicate numbers are identified in Table 2-1. Field sampling forms were completed for each water sample. The field sampling forms present the water sample designation and field data including development parameters, water level measurements, and groundwater field sample parameters. The quarterly field sampling records are provided in Appendix B. Review of these records indicates that appropriate sample designations were used for all water sampling events.

2.4. SAMPLE ANALYSIS

In accordance with the QAPP, PWT submitted the CY 2012 quarterly water samples for laboratory analyses through the EPA CLP. Samples were analyzed for volatile organic compounds (VOCs) by EPA method 8260, semivolatile organic compounds (SVOCs) by EPA Method 8270 as well as dissolved (filtered) and total (unfiltered) metals by EPA Method 6020. Table 2-1 presents the chemicals of concern (COCs) proposed for analysis for each water sample and Table 2-2 presents the laboratory analytical methods conducted for the water sampling project. Appendix D contains copies of the CLP case narratives and analytical results. One opportunity sample consisting of potential light non-aqueous phase liquid (LNAPL) found floating in Well MW003 was sent to ALS Laboratory in Kelso, Washington for analysis by EPA Method 8015C.

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2.5. SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Chain-of-custody documentation provides an accurate written record of the possession of each sample from the time it is collected in the field through laboratory analysis. Field personnel completed a chain-of-custody form prior to sample shipment through the EPA Scribe database

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software. When the water samples arrived at the assigned CLP laboratory, the sample custodian compared the sample inventory with the chain-of-custody form to ensure accuracy. The chain-of-custody forms were then signed by the sample custodian to serve as written acknowledgement that the samples had been transferred intact to the laboratory sample custodian. Completed chain-of-custody records are provided in Appendix C. Review of the narrative for each sample shipment received indicated that all chain-of-custody records and sample shipment requirements were completed appropriately.

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TABLE 2-1

CALENDAR YEAR 2012 GROUNDWATER SAMPLES

Well	Month	Filtered/ Unfiltered	PWT Sample Number	Laboratory Analyses
MW001	March	Unfiltered	MW001-0312-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	March	Filtered	MW001-0312-FT	Metals by 6020/7470
	May	Unfiltered	MW001-0512-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	May	Filtered	MW001-0512-FT	Metals by 6020/7470
	September	Unfiltered	MW001-0512-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	September	Filtered	MW001-0912-FT	Metals by 6020/7470
	December	Unfiltered	MW001-1212-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	December	Filtered	MW001-1212-FT	Metals by 6020/7470
MW002	March	Unfiltered	MW002-0312-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	March	Filtered	MW002-0312-FT	Metals by 6020/7470
	May	Unfiltered	MW002-0512-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	May	Filtered	MW002-0512-FT	Metals by 6020/7470
	September	Unfiltered	MW002-0912-01 MW200-0912-01(Dup)	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	September	Filtered	MW002-0912-FT, MW200-0912-FT(Dup)	Metals by 6020/7470
	December	Unfiltered	MW002-1212-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	December	Filtered	MW002-1212-FT	Metals by 6020/7470
MW003	March	Unfiltered	MW003-0312-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	March	Filtered	MW003-0312-FT	Metals by 6020/7470
	May	Unfiltered	MW003-0512-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	May	Filtered	MW003-0512- FT	Metals by 6020/7470
	September	Unfiltered	MW003-0912-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	September	Filtered	MW003-0912- FT	Metals by 6020/7470
	December	Unfiltered	MW003-1212-01, MW300-1212-01(Dup)	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470

Well	Month	Filtered/ Unfiltered	PWT Sample Number	Laboratory Analyses
	December	Filtered	MW003-1212- FT, MW300-1212-FT(Dup)	Metals by 6020/7470
MW005	March	Unfiltered	MW005-0312-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	March	Filtered	MW005-0312-FT	Metals by 6020/7470
	May	Unfiltered	MW005-0512-01, MW555-0512-01(Dup)	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	May	Filtered	MW005-0512- FT MW555-0512-FT(Dup)	Metals by 6020/7470
	September	Unfiltered	MW005-0912-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	September	Filtered	MW005-0912- FT	Metals by 6020/7470
	December	Unfiltered	MW005-1212-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	December	Filtered	MW005-1212- FT	Metals by 6020/7470
MW006	March	Unfiltered	MW006-0312-01, MW333-0312-01(Dup)	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	March	Filtered	MW006-0312-FT, MW333-0312-FT(Dup)	Metals by 6020/7470
	May	Unfiltered	MW006-0512-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	May	Filtered	MW006-0512- FT	Metals by 6020/7470
	September	Unfiltered	MW006-0912-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	September	Filtered	MW006-0912- FT	Metals by 6020/7470
	December	Unfiltered	MW006-1212-01	VOCs by 8260, SVOCs by 8270, Metals by 6020/7470
	December	Filtered	MW006-1212- FT	Metals by 6020/7470

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TABLE 2-2

WATER SAMPLE ANALYTICAL METHODS

Analytical Method	Media	Analytes	MRL* (µg/L)	Instrumentation
Organic Methods				
EPA SW 846 8260	Water	Volatile Organics	0.5	Gas Chromatography/ Mass Spectroscopy
EPA SW-846 8270	Water	Semivolatile Organics	5.0	Gas Chromatography/ Mass Spectroscopy
Inorganic Methods				
EPA Method 6020	Water	Filtered Metals Unfiltered Metals	1.0**	ICP Mass Spectroscopy
EPA Method 7470	Water	Filtered Mercury Unfiltered Mercury	0.2	Cold Vapor Atomic Adsorption

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Commented [aps10]: See comment above.

* MRL – method reporting limit; µg/L – microgram per liter
** MRL for metals of interest

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FIGURE 2-1 VASQUEZ OU2 GROUNDWATER WELL LOCATIONS

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3.0 DATA QUALITY ASSESSMENT

PWT submitted groundwater samples to laboratories assigned by EPA through EPA's CLP for analysis. The organic samples and metals samples were assigned to two different laboratories for analysis. Each laboratory performed the analyses in accordance with the contract requirements of the CLP program. As a result, PWT did not provide oversight of the laboratories. The CLP laboratory assigned the samples to sample delivery groups (SDGs) according to sample collection date and the analytical batch number. Analyses were performed in accordance with analytical methods specified in the QAPP, and CLP requirements (PWT 2012b).

3.1. GROUNDWATER SAMPLE VALIDATION AND VERIFICATION

The QAPP indicates that data verification should be completed on 90 percent of the analytical records and Level 3.0 data validation be conducted on 10 percent of the results. Because data verification on a set of records should occur prior to data validation, 100 percent of the results are subject to verification, which equates to a Level 2b validation. Guidance documents utilized for the data validation and verification include:

- *EPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA 2008)
- *EPA Contract Laboratories Program National Functional Guidelines for Inorganic Data Review* (EPA 2010b)
- *EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846)* (EPA 1996)
- *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (EPA-540-R-08-005)*(EPA 2009).

Data validation and verification techniques include accepting or rejecting the analytical data based on data quality acceptance criteria and requirements specified by the method, the laboratory, the QAPP, and the EPA National Functional Guidelines. The precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters were used to evaluate the quality of analytical data and determine whether the data quality objectives (DQOs) of the project were met. Table 3-1 summarizes the data quality control evaluation in terms of PARCC parameters. PARCC parameters are discussed below. The detailed data verification/validation evaluation is provided in Appendix E.

3.1.1. Precision

Precision is the reproducibility of measurements under a given set of conditions. For duplicate or replicate measurements, precision is expressed as the relative percent difference (RPD) of a data pair. In general, analytical laboratory precision is assessed using the calculated RPD between the following data:

- Field replicate or duplicate sample pairs
- Matrix spike/matrix spike duplicate sample pairs (MS/MSD)
- Investigative/matrix duplicate sample pairs

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The RPD is calculated according to the following formula, where A and B are the reported concentrations for duplicate sample analysis:

$$RPD = \frac{|A - B|}{\frac{(A + B)}{2}} \times 100$$

Field Precision

Field precision of the sampling procedures was evaluated with field duplicate samples. Four duplicate groundwater samples were collected in CY 2012 (Table 2-1). Quarterly field duplicate pairs were analyzed for all organic analyses and for the total and dissolved metals in the ground water samples. The QAPP indicates that the RPD is to be calculated only for results greater than the method reporting limit (MRL) (PWT 2012b). All organic analytes with concentrations greater than the MRLs for the duplicate water samples met the field precision goal with an RPD of less than 25 percent difference. For the metals analyses the following compounds were above the field precision goal of 25 percent difference:

Well MW006: There was a discrepancy between the March field and duplicate sample results for manganese which returned an RPD of 32.51 percent in the unfiltered sample pair.

Well MW005: There was a discrepancy between the May field and duplicate sample results for zinc which returned an RPD of 33.40 percent in the unfiltered sample pair. There was a discrepancy between the May field and duplicate sample results for nickel which returned an RPD of 101.37 percent, and zinc which returned an RPD of 87.24 percent, in the filtered sample pair.

Laboratory Precision

Evaluation of analytical laboratory precision was conducted using calculated RPDs of MS/MSD samples in organic analyses. Specifically, MS/MSD samples were used to assess the influence of the sample media (media interference) on the analyses. For the quarterly sampling, one MS/MSD was analyzed for the organic analyses and a sample pair was analyzed for the filtered and the unfiltered metals (with mercury) analyses. A total of eight organic MS/MSD samples and eight metals MS samples out of 80 monitoring well analyses by method were used to assess media interference. Appendix F contains the RPD results for MS/MSD samples. An RPD of 30 percent was used for evaluation. All of the MS/MSD RPDs for groundwater samples were below the 30 percent evaluation criterion for the VOCs. The RPD for the SVOC 4-nitrophenol in Sample MW001-0312-01 was the only compound that exceeded the 30 percent evaluation criteria with and RPD of 30.77 percent.

3.1.2. Accuracy

Accuracy is the degree of agreement between a measurement, or an average of measurements, and an accepted reference or "true" value, and is a measure of bias in the system. Accuracy is evaluated using percent recovery as calculated below:

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$$\text{Percent Recovery} = \frac{|A - B|}{C} \times 100$$

Where:

A is the target analyte concentration determined analytically from the spiked sample

B is the background level determined by a separate analysis of the unspiked sample

C is the concentration of spike added

Analytical laboratory accuracy was assessed quantitatively through the analysis of MS/MSD samples, deuterated performance compound spikes, surrogate spikes, laboratory control samples (LCSs), and response factors for calibration standards and internal standard recoveries. Specific accuracy criteria, such as acceptable percent recovery values, are presented in the QAPP (PWT 2012b).

Accuracy from MS/MSDs, deuterated performance compound spikes, and LCSs was evaluated as part of the data verification discussed in Appendix E. In general, recoveries were good to excellent. Data were rarely qualified as rejected for accuracy, and data was only rarely qualified as estimated. The data are considered to be accurate.

3.1.3. Representativeness

Representativeness is a qualitative expression of the degree to which sample data accurately and precisely represent a characteristic of a population, a sampling point, or an environmental condition. Representativeness criteria for specific parameters are presented in the QAPP.

Representativeness of the field data was achieved by following the QAPP and SOPs during sample collection. Laboratory data were evaluated for representativeness by assessing whether the laboratory followed the specified analytical criteria in the QAPP and the SOPs, and by reviewing the holding time criteria and the results of the method blanks. The laboratories noted several temperature excursions when receiving the metals samples and some data was rejected because of the high temperatures. However, only metals that were non-detect were rejected due to temperature issues so there was no impact. Holding times were met. Several analytes were seen in the VOC blanks but only at the lowest levels. Several metals were detected in the metals preparation and method blanks but never above the CRQL. Detections were not at a frequency or level that would suggest the data are not representative.

Evaluation of trip blanks, equipment blanks, and field replicate or duplicate samples is also commonly used for assessing representativeness. Trip blanks are submitted only when VOCs are to be analyzed in the sample. Trip blanks were not used because the CLP Program does not provide trip blanks. Equipment blanks were also not collected because dedicated tubing and bladders were used for the sampling. The results from the duplicate/replicate samples discussed in the previous sections suggest that the water samples are representative.

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3.1.4. Comparability

Comparability is a qualitative parameter that expresses the confidence with which one data set may be compared to another. Comparability is dependent on similar QA objectives and is achieved through the use of standardized methods for sample collection and analysis, the use of standardized units of measure, normalization of results to standard conditions, and the use of standard and comprehensive reporting forms as defined by the QAPP.

For this data review report, laboratory data were evaluated for comparability by assessing whether the laboratory followed the required analytical methods and provided the appropriate units of measure. The OU2 laboratory data were found to be comparable.

3.1.5. Completeness

Completeness is a measure of the amount of relative valid data obtained from a measurement system compared to the amount expected under correct, normal conditions. Laboratory data completeness is a quantitative measure of the percentage of valid data for all analytical data as determined by the precision, accuracy, and holding time criteria evaluation. Relative valid data is calculated using the equation below:

$$\text{Relative Valid Data} = \frac{n_{\text{acceptable data points}}}{n_{\text{total measurements}}} \times 100$$

In CY 2012, all of the Vasquez OU-2 data were considered valid with the exception of sample results from a single cooler from the first quarter samples. Non-detected metals compounds were rejected for high temperatures. Beryllium, thallium, silver and mercury that were not detected in the samples were qualified "R", rejected. These compounds were usually not detected in significance in the samples. Of all the individual analytes examined, these rejections represent less than 5% of the total and completeness was still above the completeness goal of 95 percent for CY 2012 and for the program as a whole was met.

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TABLE 3-1

CHEMICAL DATA QUALITY CONTROL EVALUATION IN TERMS OF PARCC PARAMETERS

PARCC*	Quality Control Program	Evaluation Criteria
Precision	Field Duplicate/Replicate Sample Pairs Matrix Spike/Matrix Spike Duplicate Sample Pairs Investigative/Matrix Duplicate Sample Pairs Laboratory Control Sample/Laboratory Control	Relative Percent Difference Relative Percent Difference Relative Percent Difference Relative Percent Difference
Accuracy	Surrogate Spikes Matrix Spikes Matrix Spike Duplicates Laboratory Control Sample Laboratory Control Sample Duplicate Standard Reference Materials	Percent Recovery Percent Recovery Percent Recovery Percent Recovery Percent Recovery Percent Recovery
Representativeness	Holding Times Method Blanks Trip Blanks Equipment Blanks Temperature Blanks Field Duplicates	Qualitative, Degree of Confidence Qualitative, Degree of Confidence Qualitative, Degree of Confidence Qualitative, Degree of Confidence Qualitative, Degree of Confidence Qualitative, Degree of Confidence
Comparability	Standard Field Procedures Standard Analytical Procedures Standard Units of Measure	Qualitative, Degree of Confidence Qualitative, Degree of Confidence Qualitative, Degree of Confidence
Completeness	Valid Data	Relative Valid Data

3.2. QAPP REQUIREMENTS

Selected requirements of the QAPP for evaluation of water samples are discussed below.

The QAPP requires a quarterly groundwater sample frequency for the five OU2 wells. Twenty water samples for VOCs, SVOCs and filtered/unfiltered metals were collected during the March, May, September and December quarterly sampling rounds (Table 2-1). In addition, a sample of the floating free product was collected during the May sample round. This satisfied the QAPP specified frequency.

For CY 2012, 4 duplicate samples were collected in conjunction with the 20 regular groundwater samples, which equates to a sample/duplicate frequency of 20 percent, which exceeds the frequency required by the QAPP of 5%.

The QAPP requirements for the laboratory to perform and analyze MS/MSDs, LCSs, and method blanks were met.

3.3. DATA VERIFICATION AND VALIDATION SUMMARY

Each sample delivery group (SDG) was reviewed to verify that the data meets the acceptance criteria of the QAPP and EPA guidance (USEPA 1996, 1999, 2010, 2008).

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The QAPP indicates that data verification should be completed on 90 percent of the analytical records and data validation should be conducted on 10 percent of the results. Because data verification on a set of records should occur prior to data validation, 100 percent of the results are subject to verification. Data verification is discussed below for each data package.

3.3.1. Data Verification

The QAPP indicates that the following elements will be reviewed for compliance as part of data verification:

- Temperature
- Methodology
- Holding Times
- Calibration
- Blanks
- Spikes
- Duplicates

Data verification and validation for the QAPP is performed by a chemist qualified to evaluate laboratory data. The data packages are reviewed for completeness for the list of analytes, list of analytical methods, method holding times, and MDLs; for MRLs; for detections in method blanks; for acceptable range of spike recoveries for the matrix spike, surrogate, and LCSs; and correct units. The calibration QC check is conducted by the laboratory for each data package. The lab data qualifiers in the data packages were also reviewed, to determine whether to accept, reject or provide additional qualification of the data. In some cases, it was necessary to apply PWT-specified flags to the data.

The data reports in Appendix D may show two sets of data qualifiers which are separated by a semicolon. The first qualifier set, which may contain more than one qualifier, was provided by the lab with the data package. The second data qualifier set is added by PWT after quality review of the data packages and supporting documentation. In most cases PWT used unique data qualifiers. The QAPP (PWT 2012b) supersedes all other reference materials where differences in qualifier definitions exist. Data verification and validation reports for analytical results from the VB/I70 OU2 groundwater sampling project are provided in Appendix E.

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4.0 DATA ASSESSMENT

This section discusses the data assessment for samples collected from OU2 groundwater wells during the CY2012 monitoring period.

4.1. WATER LEVEL DATA EVALUATION

Water levels were measured in the wells during each quarter of monitoring. Figures A-2 through A-4 in Appendix A provide the quarterly water table elevations in the vicinity of OU2. The water table maps are generally similar for all quarters and indicate that the water table is lowest at Well MW001and proceeds to rise slightly to the east as evidenced in water table elevations in Wells MW002 and MW003. Water table elevations in upgradient Wells MW005 and MW006 indicate that the water table rises by approximately eight to nine feet southeast of Well MW001. All water level contours on the figures are dashed because the locations of the monitoring wells are at the edges of OU2 such that the actual water table configuration within OU2 can only be approximated. However, it can be concluded from the water table maps that groundwater in OU2 generally migrates from the southeast to the northwest and towards the Platte River.

Commented [aps11]: Although the contours are inferred, it would be helpful to provide a flow gradient.

4.2. WATER QUALITY DATA EVALUATION

The results obtained from the five wells monitored in OU2 will be reviewed with respect to the action levels listed in the Colorado Basic Standards for Groundwater (CBSGs) (WQCC 2013), which may be different than the Maximum Concentration Limits (MCLs) identified in the Safe Drinking Water Act. The water quality results were compared to the CBSGs corresponding to the Human Health Standards for Domestic Water Supplies unless otherwise indicated. The results will be discussed based on the analytical methods that were used. Table 4-1 summarizes the most significant analytical results from the wells and Figures A-5 through A-6 in Appendix A show the same results posted at the respective wells. Appendix D presents all of the analytical results obtained from the groundwater monitoring.

4.2.1. Volatile Organic Compounds

VOCs were analyzed using the standard CLP trace VOCs analysis method corresponding to EPA Method 8260. In Well MW001, tetrachloroethene, trichloroethene and cis-1,2 dichloroethene were detected above the CBSGs for all four quarters. Tetrachlorethene averaged 42 ug/L, and is above the CBSG of 5 ug/L. Trichloroethene averaged 14.25 ug/L and is above the CBSG of 5 ug/L, while cis-1,2 dichloroethene averaged 52 ug/L and is above the CBSG of 14 ug/L. Figure 4-1 shows a trend plot of cis-1,2 dichloroethene, tetrachloroethene, and trichloroethene for MW001. In general, the concentrations of these compounds vary within a limited range.

In Well MW003, chlorobenzene averaged 78.75 ug/L with the highest detection at 99 ug/L. However, the CBSG for chlorobenzene is 100 ug/L so the groundwater standard was not exceeded. Figure 4-3 is a trend plot of chlorobenzene concentrations in MW003.

In upgradient Well MW006 the average chloroform concentration was 3.8 ug/L which exceeds CBSG of 3.5 ug/L. The chloroform concentration was below the CBSG in the first two quarters

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of the year and above the CBSG in the last two quarters of the year. Figure 4-4 is a trend plot of chloroform concentrations in MW006.

4.2.2. Semivolatile Organic Compounds

SVOCs were analyzed using the standard CLP analysis method corresponding to EPA Method 8270. There were no exceedances of the CBSGs for semivolatile organic compounds in OU2 wells during the four quarters of monitoring.

Commented [aps12]: We should note that there are some SVOCs for which the MRL > CBSG.

4.2.3. Unfiltered Metals

CLP standard metals analyses were performed on total (unfiltered) groundwater using EPA Method 6020. In MW002 the average concentration of arsenic was 115 ug/L which exceeds the CBSG of 10 ug/L. Figure 4-2 is a trend plot showing total arsenic concentrations and Figure 4-5 is a trend plot that includes the Remedial Investigation (RI) data as well as the current data for MW002. Review of Figure 4-5 indicates that the total arsenic concentrations have not significantly changed with time. The antimony concentration in MW002 averaged 4.95 ug/L which is below the CBSG of 6 ug/L, however the September sample exceeded the CBSG at 6.15 (average of sample and duplicate).

Commented [aps13]: Is this a typical procedure?

There were no other exceedances of the CBSGs corresponding to the Human Health Standards for Domestic Water Supplies for unfiltered metals during the four quarters of monitoring. However, iron exceeded the Domestic Water Supply Drinking Water Standard of 300 ug/L in all five monitoring wells, except for the December samples in Wells MW001 and MW005. Also, the Agricultural Standard for iron of 5,000 ug/L was exceeded in Wells MW002 and MW003. Iron values in Well MW003 averaged 21,450 ug/L. Manganese also exceeded the Domestic Water Supply Drinking Water Standard of 50 ug/L and the Agricultural Standard of 200 ug/L in wells MW001, MW002 and MW003.

Commented [aps14]: Should we discuss or mention surface water standards for metals (and VOCs/SVOCs) in addition to CBSGs since this groundwater likely discharges to the S.Platte?

The CBSGs for metals are intended to be applied to filtered groundwater samples. However, the footnote in the CBSG document states "The total concentration (not filtered) may be required on a case by case basis if deemed necessary to characterize the pollution caused by the activity" (CWCC 2013). Given that the monitoring results for OU2 are not specifically being used to achieve groundwater compliance with drinking water standards, the unfiltered results have been discussed.

4.2.4. Filtered Metals

CLP standard metals analyses were performed on dissolved (filtered) groundwater using EPA Method 6020. In MW002 the average concentration of arsenic was 115 ug/L which exceeds the CBSG of 10 ug/L. Figure 4-2 is a trend plot showing total arsenic concentrations, and Figure 4-5 is a trend plot that includes the RI data as well as the current data for MW002. Review of Figure 4-5 indicates that the dissolved arsenic concentrations have not significantly changed with time. The antimony concentration in MW002 averaged 5.22 ug/L which is below the CBSG of 6 ug/L. However the September and December samples exceeded the CBSG at 6.3 (average of sample and duplicate) and 6.7 ug/L respectively.

Commented [aps15]: Filtered results are higher than unfiltered results? The discrepancy should be discussed further in the text.

There were no other exceedances of the CBSGs for Human Health Standards for Domestic Water for unfiltered metals during the four quarters of monitoring. However, iron exceeded both the Domestic Water Supply Drinking Water Standard of 300 ug/L in all five monitoring wells.

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Also, the Agricultural Standard for iron of 5,000 ug/L was exceeded in Wells MW002 and MW003. Figure 4-3 is a trend plot of the dissolved iron concentration in MW003. Manganese exceeded the Domestic Water Supply Drinking Water Standard of 50 ug/L and the Agricultural Standard of 200 ug/L in Wells MW001, MW002 and MW003 (except for the September sample result for Well MW001 which was 182 ug/L).

4.2.5. Free Product Evaluation

During well development and sampling activities a floating free product was discovered in Well MW003. In the field, the free product consisted of black globules of sticky, tar-like material that gave off a tar-like odor. There was a significant amount of this substance encountered in the initial well purging but the presence of this material diminished rapidly in subsequent well purges. The only organic compound that was found at elevated concentrations in this well was chlorobenzene with concentrations of around 80 ug/L. However, chlorobenzene has a specific gravity greater than water ~~so that it~~and thus would not characteristically ~~not~~ float on the groundwater surface.

~~Based on the physical characteristics of the free product it was probable that it was composed of organic compounds in the lubricating oil/grease range.~~ At EPA's request, a sample of the free product was collected during the May sampling round and shipped to ALS Laboratory in Kelso, Washington for analysis by EPA Method 8015C. Method 8015C provides analysis of long chain hydrocarbon compounds at both the diesel range (12 to 20 carbons in the molecule chain) and the residual range (20 to 34 carbons in the molecule chain). ~~Lubricating oils contain a mixture of C_{20}—C_{34} hydrocarbons and are made from the more viscous portion of crude oil by removing the lighter hydrocarbon components through distillation.~~ The analysis provides the concentration for compounds that fit into each of these hydrocarbon compound ranges but does not provide specific analytes that compose the material. The result for the diesel range organics was 20,000 ug/L and the result for the residual range was 200,000 ug/L. Based on the analytical results, it can be concluded that the majority of the free product is in the range for lubricating oils or greases. Since no groundwater standards exist for residual range organic compounds, PWT was not directed to conduct further testing.

4.3. EVALUATION OF SOURCES FOR GROUNDWATER CONTAMINATION

Based on the location of the landfill as depicted in Figure 27 of the RI Report (EMS 2009), the three downgradient wells (MW001, MW002, MW003) should be outside of, and downgradient of, the landfill waste. The soil data from the RI was reviewed to shed light on whether contamination found in the downgradient wells was observed in soil borings that were done in the landfill materials. Some of the borehole soils were analyzed for VOCs and poly-aromatic hydrocarbons (PAHs) in addition to the eight RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver) (EMS 2009). Most of the soil samples were non-detect for organic constituents. The largest number of organic constituents detected were~~as~~ in the 12-14 foot depth interval from Borehole SB 4-2 which is located at the northwest boundary of the Coliseum parking lot and generally between Wells MW001 and MW002. The organic constituents listed below were identified in this soil interval and are typically associated with petroleum hydrocarbon related compounds. The analytes in bold were analyzed in the recent groundwater samples that were collected:

Commented [aps16]: I would recommend identifying the location of this boring on a figure.

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- **1,2,4-Trichlorobenzene** **84 J ug/Kg**
- 1,2,4-Trimethylbenzene 6,400 ug/Kg
- 1,3,5-Trimethylbenzene 2,800 ug/Kg
- 2-Methylnaphthalene 680 ug/Kg
- 4-Isopropyltoluene 1,000 ug/Kg
- **Ethyl benzene** **230 J ug/Kg**
- **Isopropylbenzene** **280 J ug/Kg**
- **m & p Xylenes** **600 ug/Kg**
- **Naphthalene** **770 ug/Kg**
- n-Butylbenzene 1,200 ug/Kg
- n-Propylbenzene 680 ug/Kg
- **o-Xylene** **560 ug/Kg**
- sec-Butylbenzene 1,100 ug/Kg
- tert-Butylbenzene 94 J ug/Kg
- **Fluoranthene** **300 J ug/Kg**
- **Fluorene** **250 J ug/Kg**
- **Phenanthrene** **440 J ug/Kg**
- **Pyrene** **280 J ug.Kg**

Commented [aps17]: Many of these analytes are on the normal 8260 list, why were they not analyzed for this project? Especially given the higher concentrations of 1,2,4 and 1,35-trimethylbenzene?

Review of the groundwater results for the three downgradient wells indicates that the wells had no detections for these compounds above the reporting limit except for MW003 which had concentrations of isopropylbenzene slightly above the reporting limit. Given that tetrachloroethene, trichloroethene and cis 1,2 dichloroethene are the contaminants of concern in MW001 and chlorobenzene is the contaminant detected above applicable standards in MW003, there does not appear to be a direct correlation between the organic contaminants found in the soil boreholes in the landfill and the organic contaminants found in the wells.

Commented [aps18]: Clarify that this based on those constituents that were analyzed for in groundwater (i.e. as above, not all detected constituents in soil were analyzed in groundwater samples).

The RI Report used background values to evaluate concentrations of metals related contamination in soils, and used 15 mg/Kg for arsenic and 400 mg/Kg for lead (EMS 2009). Review of the metals results from the soil boreholes in the landfill indicates that there are numerous detections of arsenic and lead above background which ranged between 17 mg/Kg to 96 mg/Kg (arsenic) and between 780 mg/Kg and 3600 mg/Kg (lead). The Protection of Groundwater Soil Screening Levels in ~~Table soil2gw~~ the Soil to Groundwater Protection Table updated November 2012) ,from EPA Publication 9355.4-23 (EPA 1996) indicates that the groundwater protection risk based soil screening level for arsenic is 0.0013 mg/Kg and the MCL based soil screening level is 0.29 mg/Kg. Therefore soil intervals with arsenic levels above this range of values can leach arsenic to groundwater sufficient to produce exceedance of the MCL (10 ug/L). The MCL based soil screening level for lead is 14 mg/Kg (there is no risk based soil screening level reported). There are lead concentrations above this level reported from borehole intervals in the RI Report such that leaching of lead to groundwater sufficient to cause exceedance of the MCL (15 ug/L) is possible.

Commented [aps19]: I'm assuming this is the Regional Screening Level Soil to Groundwater Protection Table? If so, I would recommend referencing it in that manner

Review of the lead concentrations in downgradient wells indicates that Well MW002 had one unfiltered lead result above the MCL of 15 ug/L and MW003 had one filtered and one unfiltered result above the MCL. The borehole for MW002 showed a lead soil concentration of 3600 mg/Kg in the 5.0-5.5 foot interval. The borehole for MW003 showed a lead soil concentration of 950 mg/Kg in the 0.0-8.0 foot interval. Given that the groundwater lead concentrations were not consistent with respect to the MCL and that two out of the three lead concentrations above the MCL were unfiltered samples, the lead values may represent localized soil contamination rather

Commented [aps20]: What does this mean exactly? Not consistently above or below?

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than emission from the landfill. The lead values in the downgradient wells were all below the CBSG of 50 ug/L.

Commented [aps21]: Smelter waste?

Review of arsenic results in downgradient monitoring wells indicates that arsenic is only in significant concentrations in Well MW002 and the other two downgradient wells have concentrations below the MCL/CBSG of 10 ug/L. Review of borehole soil results for MW002 indicates an arsenic soil concentration of 59 mg/Kg in the 5.0-5.5 foot interval where elevated lead concentrations were also found. However, boreholes located near Well MW002 did not show similar arsenic soil concentrations. Borehole soils data for MW001 indicates that arsenic at a concentration of 31 ug/Kg was found at 6.0 feet and arsenic at a concentration of 27 ug/Kg was found at a depth of 19 feet. Borehole soils data for MW003 indicates that an arsenic concentration of 23 ug/Kg was found at 1.8 feet and arsenic at a concentration of 96 ug/Kg was found at a depth of 19.5 feet. However, neither of these latter two wells showed significant arsenic concentrations in groundwater. The fact that both the filtered and unfiltered results for arsenic in MW002 have very similar concentrations suggests that the arsenic may truly be in solution and not related to localized soil contamination, and may represent emission from the landfill or other upgradient sources.

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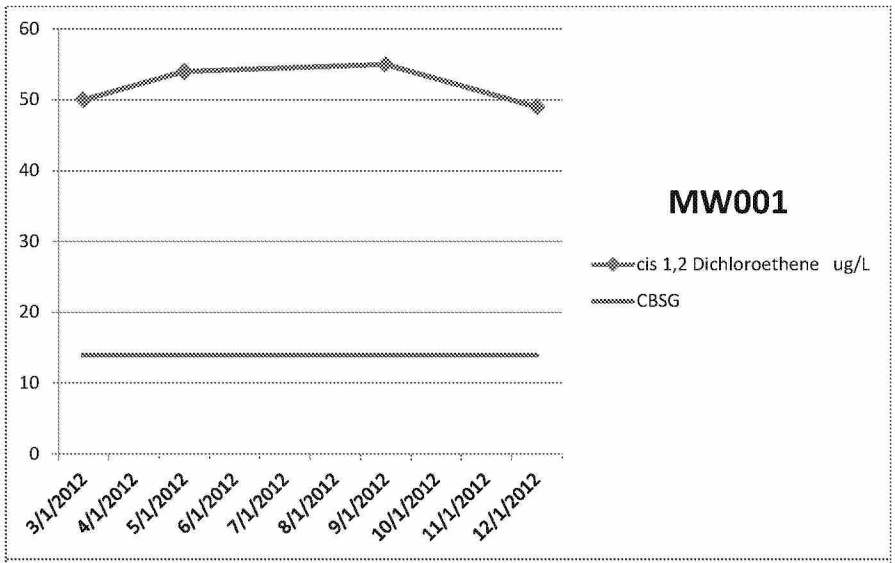
FIGURE 4-1: Trend Plots for Selected Analytes in MW001

Commented [aps22]: If it doesn't make it too busy, I would recommend plotting water level elevation on Figures 4-*



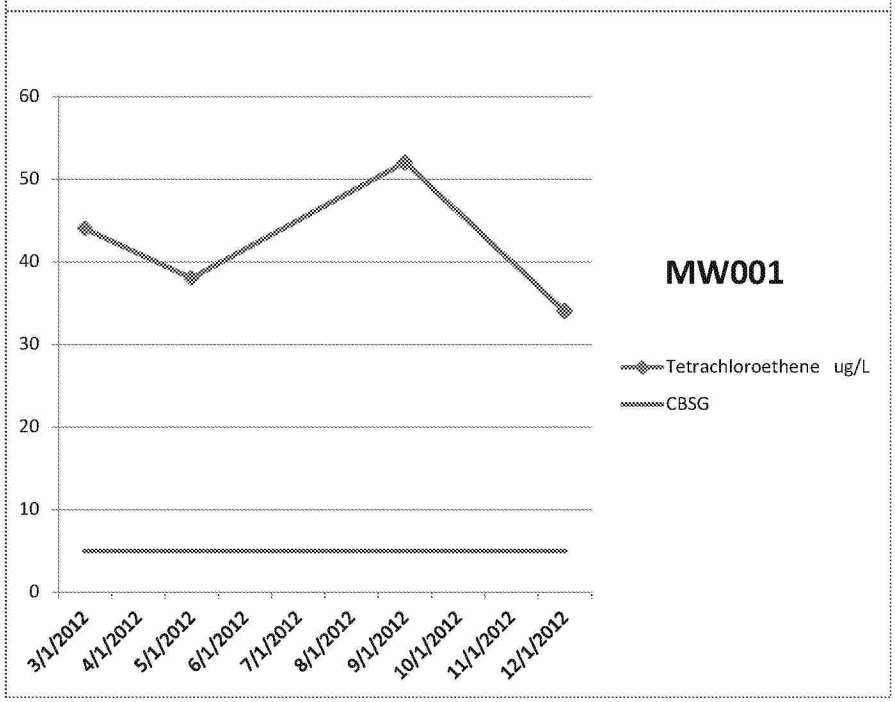


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FIGURE 4-1: Trend Plots for Selected Analytes in MW001

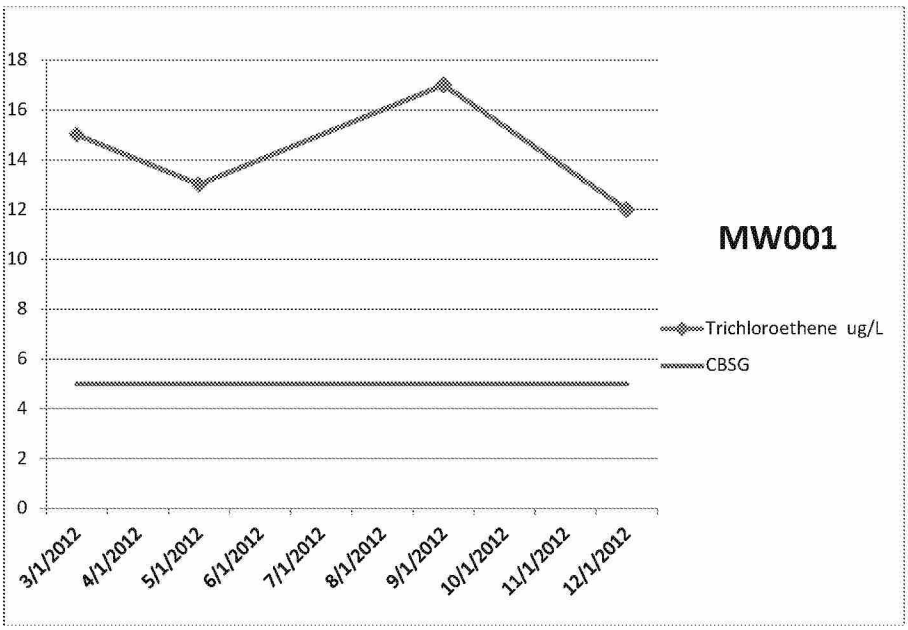
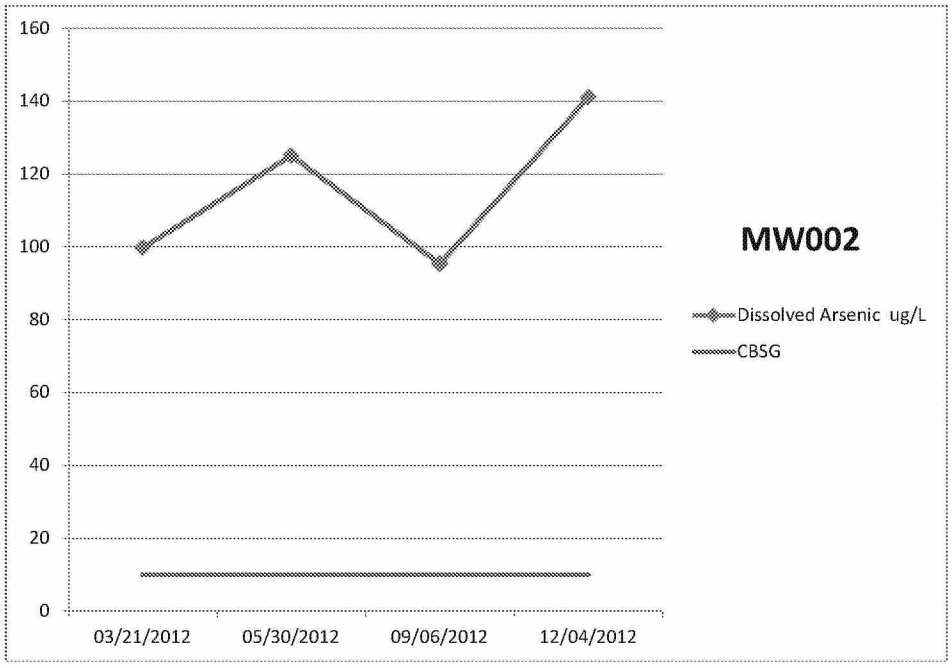
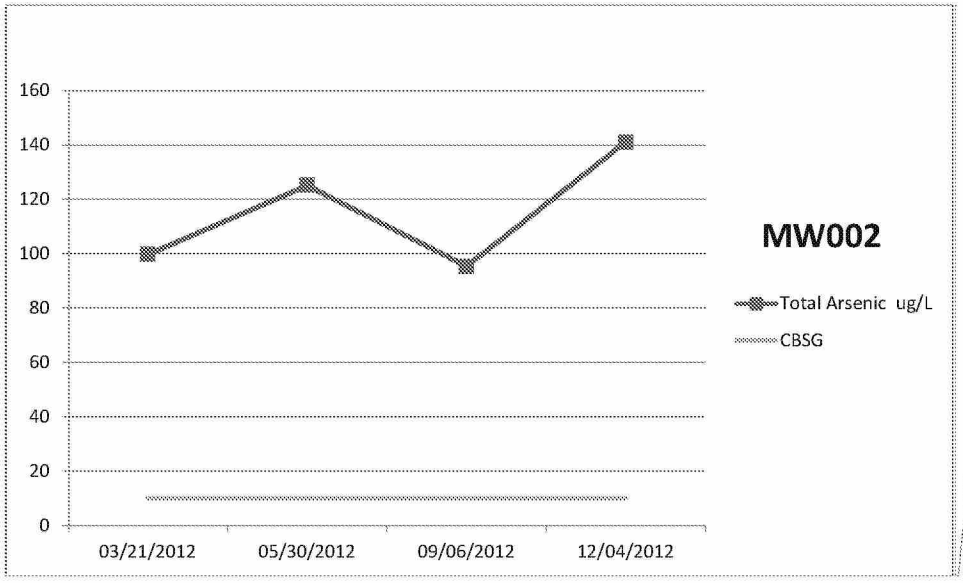


FIGURE 4-2: Trend Plots for Selected Analytes in MW002





Commented [aps23]: Why do we change trend line colors for this plot?

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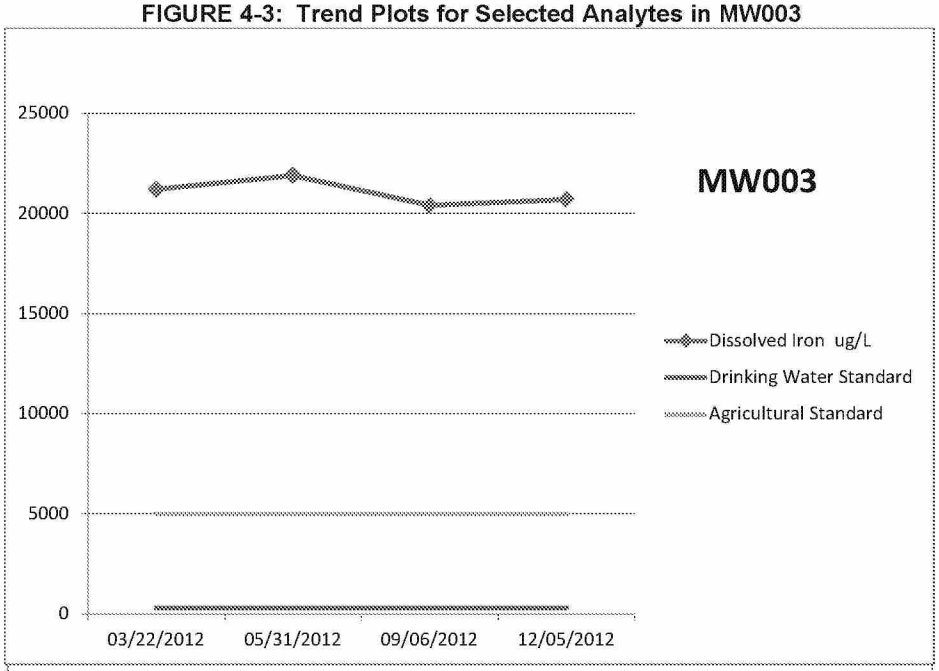
FIGURE 4-3: Trend Plots for Selected Analytes in MW003



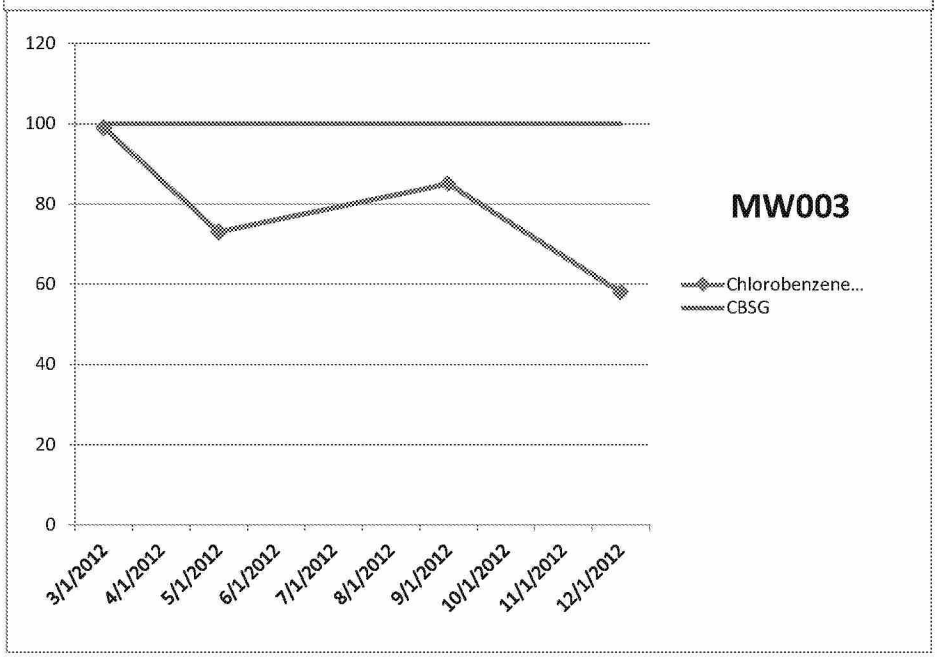


FIGURE 4-4: Trend Plots for Selected Analytes in MW006

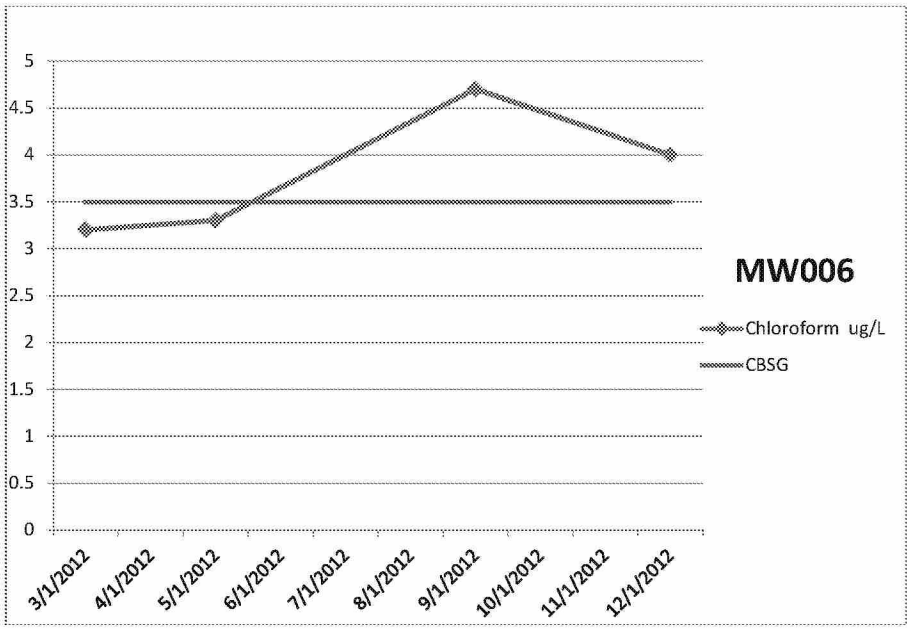


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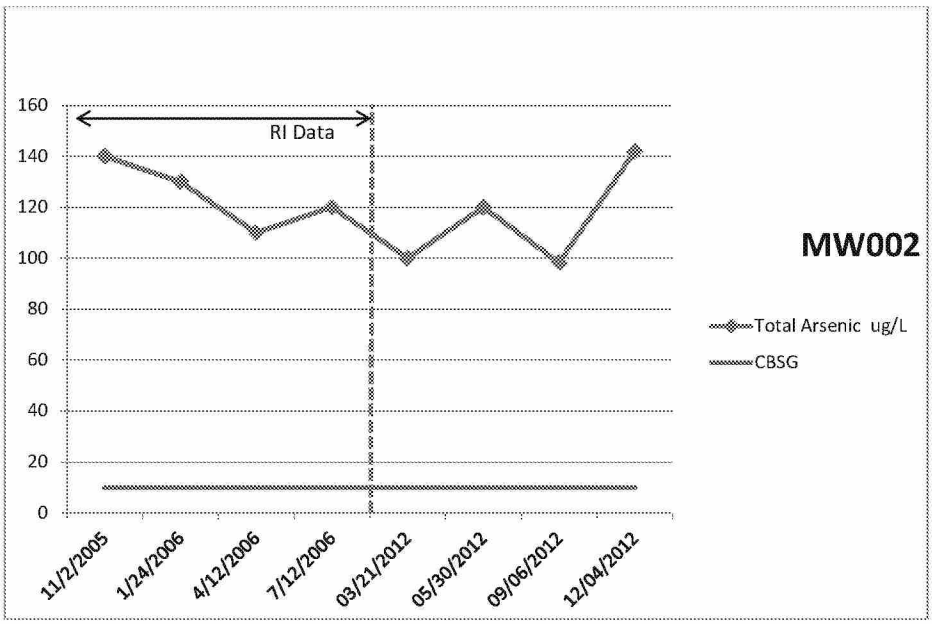
FIGURE 4-5: Cumulative Trend Plots for Arsenic in MW002



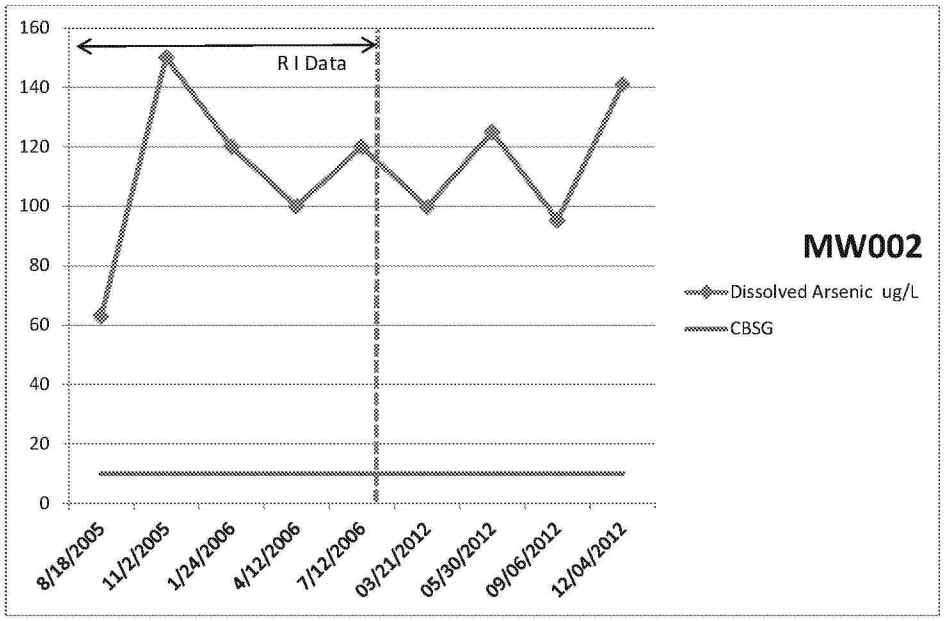


Table 4-1: Quarterly Results for Selected Analytes

Commented [aps24]: A notes section should be added at the bottom of the table with definitions (e.g. qualifiers).

Well Number	Sample Date	Sample Type	Chemical Name	Result	Qualifier	CBSG	MCL	Reporting Limit
MW001	03/21/2012	Trace VOC	cis-1,2-Dichloroethene	50	D	14	70	0.50
MW001	03/21/2012	Trace VOC	Tetrachloroethene	44	D	5	5	0.50
MW001	03/21/2012	Trace VOC	Trichloroethene	15		5	5	0.50
MW001	03/21/2012	Total Metals	Manganese	902	J-	200	NA	1.0
MW001	03/21/2012	Dissolved Metals	Manganese	910	J-	200	NA	1.0
MW002	03/21/2012	Total Metals	Antimony	4.2	J-	6	6	2.0
MW002	03/21/2012	Dissolved Metals	Antimony	3.7	J-	6	6	2.0
MW002	03/21/2012	Total Metals	Arsenic	100	J-	10	10	1.0
MW002	03/21/2012	Dissolved Metals	Arsenic	99.7	J-	10	10	1.0
MW002	03/21/2012	Total Metals	Iron	9960	J-	5000	NA	200
MW002	03/21/2012	Dissolved Metals	Iron	9130	J-	5000	NA	200
MW002	03/21/2012	Total Metals	Manganese	1190	J-	200	NA	1.0
MW002	03/21/2012	Dissolved Metals	Manganese	1180	J-	200	NA	1.0
MW003	03/22/2012	Trace VOC	Chlorobenzene	99	D	100	100	0.50
MW003	03/22/2012	Total Metals	Iron	22000	J-	5000	NA	200
MW003	03/22/2012	Dissolved Metals	Iron	21200	J-	5000	NA	200
MW003	03/22/2012	Total Metals	Manganese	507	J-	200	NA	1.0
MW003	03/22/2012	Dissolved Metals	Manganese	502	J-	200	NA	1.0
MW006	03/20/2012	Trace VOC	Chloroform	3.2		3.5	80	0.50
MW001	05/30/2012	Trace VOC	cis-1,2-Dichloroethene	54	D	14	70	0.50
MW001	05/30/2012	Trace VOC	Tetrachloroethene	38	D	5	5	0.50
MW001	05/30/2012	Trace VOC	Trichloroethene	13		5	5	0.50
MW001	05/30/2012	Total Metals	Manganese	629		200	NA	1.0
MW001	05/30/2012	Dissolved Metals	Manganese	608		200	NA	1.0
MW002	05/30/2012	Total Metals	Antimony	4.8		6	6	2.0
MW002	05/30/2012	Dissolved Metals	Antimony	4.8		6	6	2.0
MW002	05/30/2012	Total Metals	Arsenic	120		10	10	1.0
MW002	05/30/2012	Dissolved Metals	Arsenic	125		10	10	1.0
MW002	05/30/2012	Total Metals	Iron	9440		5000	NA	200

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Table 4-1: Quarterly Results for Selected Analytes

Commented [aps24]: A notes section should be added at the bottom of the table with definitions (e.g. qualifiers).

Well Number	Sample Date	Sample Type	Chemical Name	Result	Qualifier	CBSG	MCL	Reporting Limit
MW002	05/30/2012	Dissolved Metals	Iron	9240		5000	NA	200
MW002	05/30/2012	Total Metals	Manganese	1180		200	NA	1.0
MW002	05/30/2012	Dissolved Metals	Manganese	1210		200	NA	1.0
MW003	05/31/2012	Trace VOC	Chlorobenzene	73	D	14	70	0.50
MW003	05/31/2012	Total Metals	Iron	24200		5000	NA	200
MW003	05/31/2012	Dissolved Metals	Iron	21900		5000	NA	200
MW003	05/31/2012	Total Metals	Manganese	559		200	NA	1.0
MW003	05/31/2012	Dissolved Metals	Manganese	518		200	NA	1.0
MW006	05/29/2012	Trace VOC	Chloroform	3.3		3.5	80	0.50
MW001	09/06/2012	Trace VOC	cis-1,2-Dichloroethene	55	D	14	70	0.50
MW001	09/06/2012	Total Metals	Manganese	207	J	200	NA	1.0
MW001	09/06/2012	Dissolved Metals	Manganese	182	J	200	NA	1.0
MW001	09/06/2012	Trace VOC	Tetrachloroethene	52	D	5	5	0.50
MW001	09/06/2012	Trace VOC	Trichloroethene	17		5	5	0.50
MW002	09/06/2012	Total Metals	Antimony	6		6	6	2.0
MW002	09/06/2012	Dissolved Metals	Antimony	6.2		6	6	2.0
MW002	09/06/2012	Total Metals	Arsenic	98.3		10	10	1.0
MW002	09/06/2012	Dissolved Metals	Arsenic	95.3		10	10	1.0
MW002	09/06/2012	Total Metals	Iron	6080	J	5000	NA	200
MW002	09/06/2012	Dissolved Metals	Iron	5780	J	5000	NA	200
MW002	09/06/2012	Total Metals	Manganese	966	J	200	NA	1.0
MW002	09/06/2012	Dissolved Metals	Manganese	966	J	200	NA	1.0
MW003	09/06/2012	Trace VOC	Chlorobenzene	85	D	14	70	0.50
MW003	09/06/2012	Total Metals	Iron	19200	J	5000	NA	200
MW003	09/06/2012	Dissolved Metals	Iron	20400	J	5000	NA	200
MW003	09/06/2012	Total Metals	Manganese	450	J	200	NA	1.0
MW003	09/06/2012	Dissolved Metals	Manganese	461	J	200	NA	1.0
MW006	09/04/2012	Trace VOC	Chloroform	4.7		3.5	80	0.50
MW001	12/04/2012	Trace VOC	cis-1,2-Dichloroethene	49	D	14	70	0.50

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Table 4-1: Quarterly Results for Selected Analytes

Commented [aps24]: A notes section should be added at the bottom of the table with definitions (e.g. qualifiers).

Well Number	Sample Date	Sample Type	Chemical Name	Result	Qualifier	CBSG	MCL	Reporting Limit
MW001	12/04/2012	Total Metals	Manganese	593		200	NA	1.0
MW001	12/04/2012	Dissolved Metals	Manganese	595		200	NA	1.0
MW001	12/04/2012	Trace VOC	Tetrachloroethene	34	D	5	5	0.50
MW001	12/04/2012	Trace VOC	Trichloroethene	12		5	5	0.50
MW002	12/04/2012	Total Metals	Antimony	4.8		6	6	2.0
MW002	12/04/2012	Dissolved Metals	Antimony	6.7		6	6	2.0
MW002	12/04/2012	Total Metals	Arsenic	142		10	10	1.0
MW002	12/04/2012	Dissolved Metals	Arsenic	141		10	10	1.0
MW002	12/04/2012	Total Metals	Iron	8600		5000	NA	200
MW002	12/04/2012	Dissolved Metals	Iron	8420		5000	NA	200
MW002	12/04/2012	Total Metals	Manganese	1190		200	NA	1.0
MW002	12/04/2012	Dissolved Metals	Manganese	1190		200	NA	1.0
MW003	12/05/2012	Trace VOC	Chlorobenzene	58	D	100	100	0.50
MW003	12/05/2012	Total Metals	Iron	20400		5000	NA	200
MW003	12/05/2012	Dissolved Metals	Iron	20700		5000	NA	200
MW003	12/05/2012	Total Metals	Manganese	508		200	NA	1.0
MW003	12/05/2012	Dissolved Metals	Manganese	484		200	NA	1.0
MW006	12/03/2012	Trace VOC	Chloroform	4.0		3.5	80	0.50

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5.0 CONCLUSIONS AND RECOMMENDATIONS

Review of the water table information discussed in Section 4.0 indicates that groundwater and any contaminants found in the groundwater would generally migrate from southeast to northwest within OU2. This would suggest that contaminated groundwater found in the downgradient wells may have come from an upgradient location either within OU2 or outside of OU2. Upgradient Wells MW005 and MW006 are free from the types of contamination found in Downgradient Wells MW001, MW002 and MW003. Well MW006 has low levels of chloroform that were not always above the CBSG, but chloroform above the CBSG was not found in the downgradient wells. Well MW001 has tetrachloroethene, trichloroethene and cis 1,2 dichloroethene above standards but the other two downgradient wells do not. Likewise, Well MW002 has high arsenic values and occasional antimony values above standards but the other two downgradient wells do not. Well MW003 has elevated chlorobenzene levels which are near to, but not above, standards but the other wells do not have similar levels of chlorobenzene. As a result, it is difficult to make any definitive statements about the source areas for the contamination seen in the downgradient wells other than to hypothesize that multiple sources may exist for groundwater contamination migrating near these wells.

Review of the monitoring data and trend plots for OU2 indicates that, even though each quarter's results were typically analyzed by a different CLP laboratory, the results were very consistent. Verification and validation of the analytical results indicates that the data quality resulting from the laboratory analysis was acceptable for decision making. The data also suggest that the ability for source area contamination to leach to the groundwater is not significantly affected by seasonal variations in the water table. Minor exceptions to this conclusion may be found in the chloroform results in MW006 and the antimony and arsenic results in MW002 which increased slightly in the dryer part of the year.

To adequately assess the groundwater pathways within OU2 it is recommended that additional ~~piezometers~~ monitoring wells be installed in areas midway between the upgradient and downgradient wells. This would provide better definition of the water table within OU2 and allow for better interpretation of groundwater flow directions.

One of the goals of the monitoring project was to assess whether a buried landfill under the Denver Coliseum parking lot was responsible for the contamination seen in downgradient wells. To this end, the analysis of organic compounds was included in the analyte suite because organics had been detected in boreholes drilled into the landfill during the RI (EMS 2009). However, due to the large distance between the upgradient wells and the downgradient wells it is difficult to pinpoint the landfill as the source of the contamination. In addition, recent groundwater results from other projects conducted in OU2 suggest that there may be other sources for groundwater contamination upgradient of the landfill. To adequately asses the landfill contribution to the groundwater contamination in downgradient wells, additional wells should be installed directly upgradient of the landfill. This should be done in conjunction with the ~~piezometers~~ monitoring wells recommended above to provide both an adequate water table map for OU2 and also to better interpret the contribution from the landfill to the groundwater contamination.

Commented [aps25]: I think it might be better if we consolidate our monitoring well recommendations in one place/paragraph. In addition, it might be worthwhile to include a figure with proposed locations.

Should we recommend deeper monitoring wells due to the presence of chlorinated solvents? Or should we wait until we have further information?

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6.0 REFERENCES

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APPENDIX A

QUARTERLY WATER LEVEL MAPS AND QUARTERLY ANALYTICAL RESULT MAPS

APPENDIX B

PROJECT FIELD FORMS AND FIELD NOTES

APPENDIX C

CHAIN-OF-CUSTODY RECORDS

APPENDIX D

ANALYTICAL REPORTS AND CASE NARRATIVES

APPENDIX E

DATA VALIDATION REPORTS, DATA REVIEW WORKSHEETS AND RPD CALCULATIONS