Final
SWMU 49 Monitored Natural Attenuation Sampling Year Two Report

Radford Army Ammunition Plant, Virginia

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Submitted to:

United States Army Corps of Engineers, Baltimore District

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Acronyms and Abbreviations

ºC	degrees Celsius
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
1,1-DCA	1,1-dichloroethane
1,1,1-TCA	1,1,1-trichloroethane
amsl	above mean sea level
bgs	below ground surface
BSEn	Bearing Sea Environmental, LLC
BTOC	below top of casing
cis-1,2-DCE	cis-1,2-dichloroethene
CB&I	CB&I Federal Services LLC
CCV	Continuing Calibration Verification
CMO	Corrective Measures Objective
COC	Contaminants of Concern
CoC	Chain-of-Custody
COD	Chemical Oxygen Demand
CT	Carbon Tetrachloride
DIUF	de-ionized ultra-filtered
DO	Dissolved Oxygen
DTW	Depth to Water
FD	Field Duplicate
Fe	Ferrous Iron
ft	feet/foot
HHRA	Human Health Risk Assessment
ICV	Initial Calibration Verification
IDW	Investigative Derived Waste
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LTM	Long-term Monitoring
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
mg/L	milligrams per liter

mL/min	milliliters per minute
MNA	Monitored Natural Attenuation
MRL	Method Reporting Limit
MS	Matrix Spike
mS/cm	millisiemens per centimeter
MSD	Matrix Spike Duplicate
mV	millivolt
NA	Not Applicable
ND	Not Detected
NT	Not Tested
NTU	Nephelometric Turbidity Unit
ORP	Oxidation Reduction Potential
Parsons	Parsons Engineering Science, Inc.
PCE	tetrachloroethene
PID	Photoionization Detector
POC	Point of Compliance
ppm	parts per million
PQL	practical quantitation limit
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFAAP	Radford Army Ammunition Plant
RFI	RCRA Facility Investigation
RG	Remedial Goal
RPD	Relative Percent Difference
Shaw	Shaw Environmental, Inc.
SU	Standard Unit
SWMU	Solid Waste Management Unit
TCE	trichloroethene
TCL	Target Compound List
TOC	Top of the casing or Total Organic Carbon
URS	URS Corporation
USACE	U.S. Army Corps of Engineers

USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USEPA	U.S. Environmental Protection Agency
VA	Virginia
VDEQ	Virginia Department of Environmental Quality
VI	Verification Investigation
VOC	Volatile Organic Compound

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1.0 Introduction

Bering Sea Environmental, LLC. (BSEn) has been contracted by the United States Army Corps of Engineers (USACE), Baltimore District, to perform the Year Two Long-Term Monitoring (LTM) and Monitored Natural Attenuation (MNA) sampling at Solid Waste Management Unit (SWMU) 49 (RAAP-013), Red Water Ash Burial #2, at Radford Army Ammunition Plant (RFAAP), Radford, Virginia (VA). This report provides a description of the groundwater sampling activities completed and analysis of results from the first through fourth quarterly rounds conducted in September 2016 through July 2017. Further, this report provides a summary of the second year sampling results.

1.1 Purpose and Scope

Groundwater at the SWMU 49 study area has been investigated from the mid-1990s through 2013 and has been fully characterized and delineated. Based on the contamination assessment and human health risk assessment (HHRA) performed and presented in the Draft SWMU 48/49 Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report (CB&I, 2014a), carbon tetrachloride (CT) and trichloroethene (TCE) were identified as the primary contaminants of concern (COCs). (Note: SWMU 49 used to be a combined study area with SWMU 48; however, previous investigations and sample data have determined that suspected contaminants reportedly disposed of at SWMU 48 were, in fact, likely disposed at SWMU 49. Therefore, this LTM report only concerns contamination associated with SWMU 49.) As such, CT and TCE were identified as the COCs that are contributing to potential future industrial and residential risk at the study area. Based on the MNA results presented in the SWMU 49 MNA Sampling Baseline Report (CB&I, 2015), MNA processes including biodegradation, sorption, dilution, dispersion, and chemical stabilization are occurring in groundwater at the SWMU 49 study area.

The second year MNA sampling program was developed and conducted in accordance with the U.S. Environmental Protection Agency (USEPA) and Virginia Department of Environmental Quality (VDEQ) approved Draft SWMU 48/49 RFI Report (CB&I, 2014a) and the Draft Final SWMU 49 MNA Groundwater Monitoring Work Plan (CB&I, 2014b). The corrective measures objectives (CMOs) and remedial goals (RGs) were developed and presented in the Draft SWMU 48/49 RFI Report (CB&I, 2014a). The site-specific CMO for SWMU 49 is to reduce COC (i.e., CT and TCE) concentrations to below RGs/maximum contaminant levels (MCLs) so as to not adversely impact future beneficial use of groundwater; and to the extent practicable, a goal of restoring site groundwater to the most beneficial use.

As such, the objectives of the MNA program are to measure and track the reduction of:

- CT and TCE to levels below the RGs as defined in **Table 1-1**.

- Monitor and evaluate the daughter products of the COCs to determine the progress (effectiveness and timeliness) of the degradation process.

Table 1-1 SWMU 48 & 49 Groundwater Remedial Goals

Chemical of Interest	Groundwater RG (µg/L)	Groundwater RG Source(*)
Carbon Tetrachloride	**5.0**	**MCL**
Trichloroethene	**5.0**	**MCL**

Notes:
** RGs are also the MCLs listed in the USEPA 2011 Edition of the Drinking Water Standards and Health Advisories (USEPA, 2011).*
µg/L = micrograms per liter
MCL = maximum contaminant level
RG = remedial goal

1.2 Site Description and Background

SWMU 49 is located in the southeastern portion of the RFAAP Horseshoe Area, east of the main bridge over the New River. As shown on **Figure 1-1**, the study area is situated on a bluff approximately 120 feet (ft) above and overlooking SWMU 13 and the New River. The SWMU 49 study area is approximately 75 ft long by 83 ft wide and situated adjacent to SWMUs 48, 50, and 59. Previously, SWMU 49 was combined with these three adjacent areas.

As presented in previous reports (CB&I, 2014a/2014b), SWMU 49 reportedly received 10 tons of red water ash during its active period. However, the results of environmental sampling to date indicate that the red water ash was likely disposed of in the disposal trenches associated with neighboring SWMU 48. Conversely, sampling indicates that the oily wastewater associated with SWMU 48 was disposed of in the SWMU 49 area.

Figure 1-1 SWMU 49 Site Location Map

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2.0 Physical Characteristics

2.1 Topography

The land surface at SWMU 49 slopes gently from 1,830 ft above mean sea level (amsl) on the north side of the site to approximately 1,816 ft amsl on the southeast side of the site. The southeast side ends abruptly at a bluff that rises approximately 120 ft above the Burning Grounds (SWMU 13) and the New River. In general, the topography is uneven and hummocky with several small draws and topographic highs. The topography at SWMU 49 is shown in **Figure 1-1**.

2.2 Surface Water

SWMU 49 is located on a bluff approximately 120 ft above the New River. Based on topography, surface water runoff is expected to flow approximately 700 ft south to the New River.

2.3 Geology

2.3.1 Regional Geology

SWMU 49 is located in the New River Valley, which crosses the Valley and Ridge Province approximately perpendicular to the regional strike of bedrock, and cross cuts Cambrian and Ordovician limestone or dolostone. Deep clay-rich residuum is prevalent in areas underlain by carbonate rocks. The valley is covered by river floodplain and terrace deposits; karst topography is dominant throughout the area. A more detailed description of the regional geology is presented in the *RFAAP Master Work Plan* (URS, 2003).

2.3.2 Site-Specific Geology

The lithology of the SWMU 49 subsurface was characterized during the advancement of soil borings and monitoring well borings at the site. One soil boring (48SB05) was advanced within SWMU 49 to 37 ft in depth. In addition to 48SB05, two monitoring wells were installed directly north and south of the target study area: 48MW1 and 48MW2, respectively. Plan and cross-section views of lines A-A’ and B-B’ that run through the adjacent sites of SWMU 48, SWMU 50, and SWMU 59 are presented on **Figures 2-1, 2-2**, and **2-3** respectively. Based on the borings, the subsurface geology consists of alluvium and residual deposits comprised of clay and silt with some sand and gravel overlying bedrock. Well 48MW1 was advanced to 154 ft below ground surface (bgs), with the bedrock elevation encountered at 72 ft bgs. Well 48MW2 was advanced to 133.7 ft bgs, with the bedrock elevation encountered at approximately 41 ft bgs. Depths to bedrock were directly measured at the monitoring well borings. Bedrock elevations ranged from approximately 1,745 to 1,776 ft amsl, with the bedrock surface sloping to the north.

Depth to competent bedrock at the site ranges from approximately 41 to 72 ft bgs. A saprolitic layer, formed from in situ weathering of the carbonate bedrock, immediately overlies the competent bedrock. The saprolite is up to 10 ft in thickness.

Bedrock consists of highly fractured interbedded siltstone, limestone, and dolostone of the Elbrook Formation. The Max Meadows Breccia is evident in outcrops along the slope leading to the river. In the outcrop along the slope, the tectonic breccias and the limestone and dolostone are highly weathered with many solution cavities. The unconsolidated sediment immediately overlying the saprolite consists of alluvial deposits.

Alluvial deposits, consisting primarily of silty sand, overly channel deposits of fine- to coarse-grained sand and gravel (river jack). These Paleo-channel deposits rest directly on the saprolite. Portions of the disposal areas contain fill material to depths of 9 to 10 ft bgs. A more detailed discussion of the geology and soil at RFAAP is presented in Sections 3.4 through 3.7 of the RFAAP Master Work Plan (URS, 2003) and in the Facility-Wide Background Study Report (IT, 2001).

2.4 Hydrogeology

2.4.1 Regional Hydrogeology

Geologically, the Appalachian Plateaus and Valley and Ridge Province encompass two major tectonic domains: the southern Appalachian Basin and the southeastern part of the Eastern Interior Basin. The hydrogeologic framework is based on generalized stratigraphic succession, with indurated sedimentary rocks of the Paleozoic age forming predominant units.

Groundwater flow paths are typically short, commonly extending no more than several miles in their longest dimension. The largest groundwater supplies are produced from the carbonate rocks, especially where they are associated with thick regolith, an important storage reservoir throughout the entire area. The regolith serves as a store of recharge that would otherwise be rapidly diverted to overland flow. It also slowly releases water to underlying carbonate aquifers. Because of the widespread distribution of carbonate rocks and associated regolith, abundant precipitation in a humid climate, and relatively steep hydraulic gradients, this region (and locality) is one of the major karstlands in the eastern United States.

Groundwater supplies in the Valley and Ridge Province are generally good quality compared to surface water supplies (Parsons Engineering Science, Inc. [Parsons], 1996). However, due to extended contact with minerals, many groundwater supplies contain higher levels of dissolved solids than the streams into which they discharge. Because of sinkholes and underground caverns in karst aquifers, there is a high potential for groundwater to be impacted by direct infiltration of contaminated surface water.

Figure 2-1 SWMU 48 and SWMU 49 Geologic Cross Section Plan View

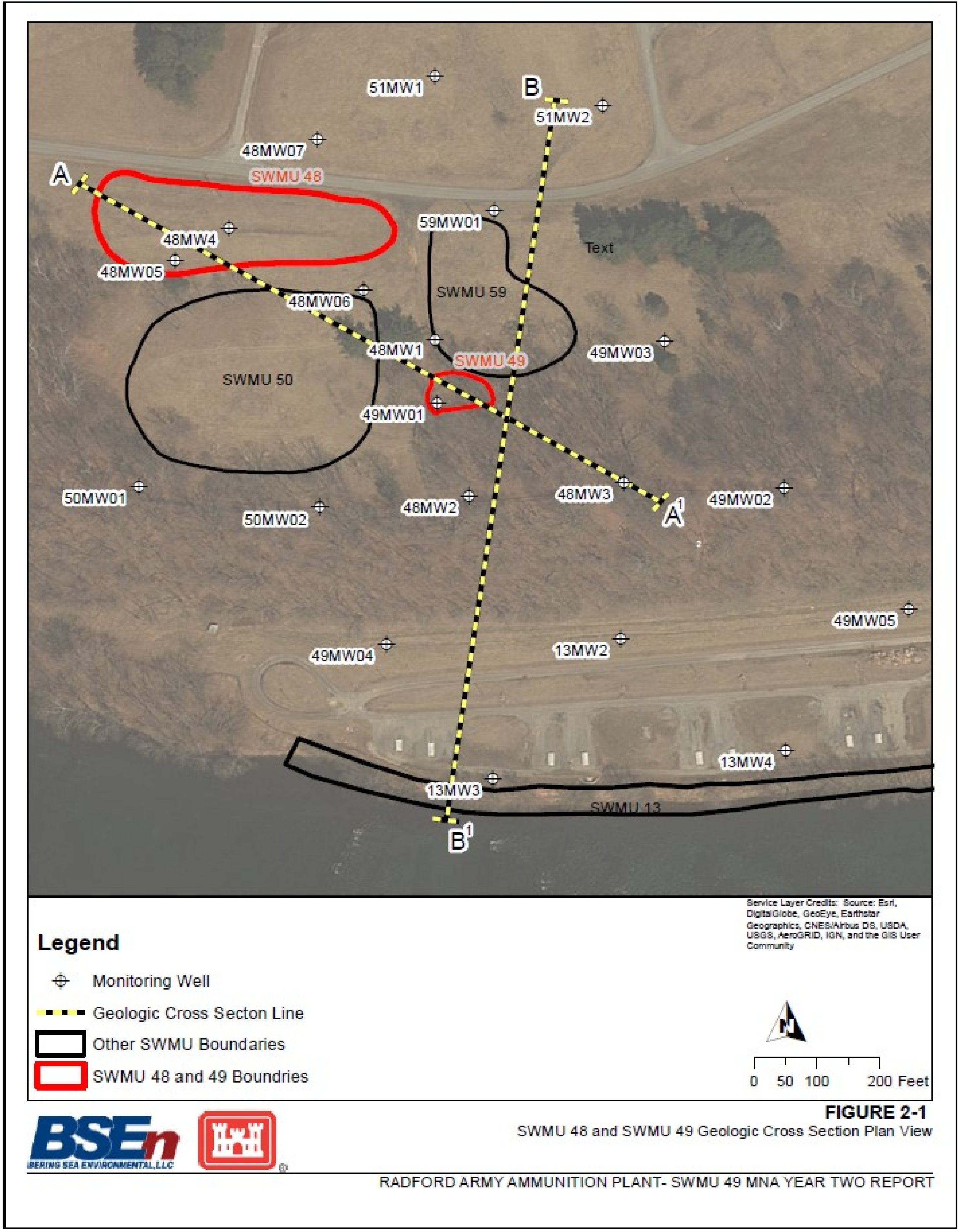

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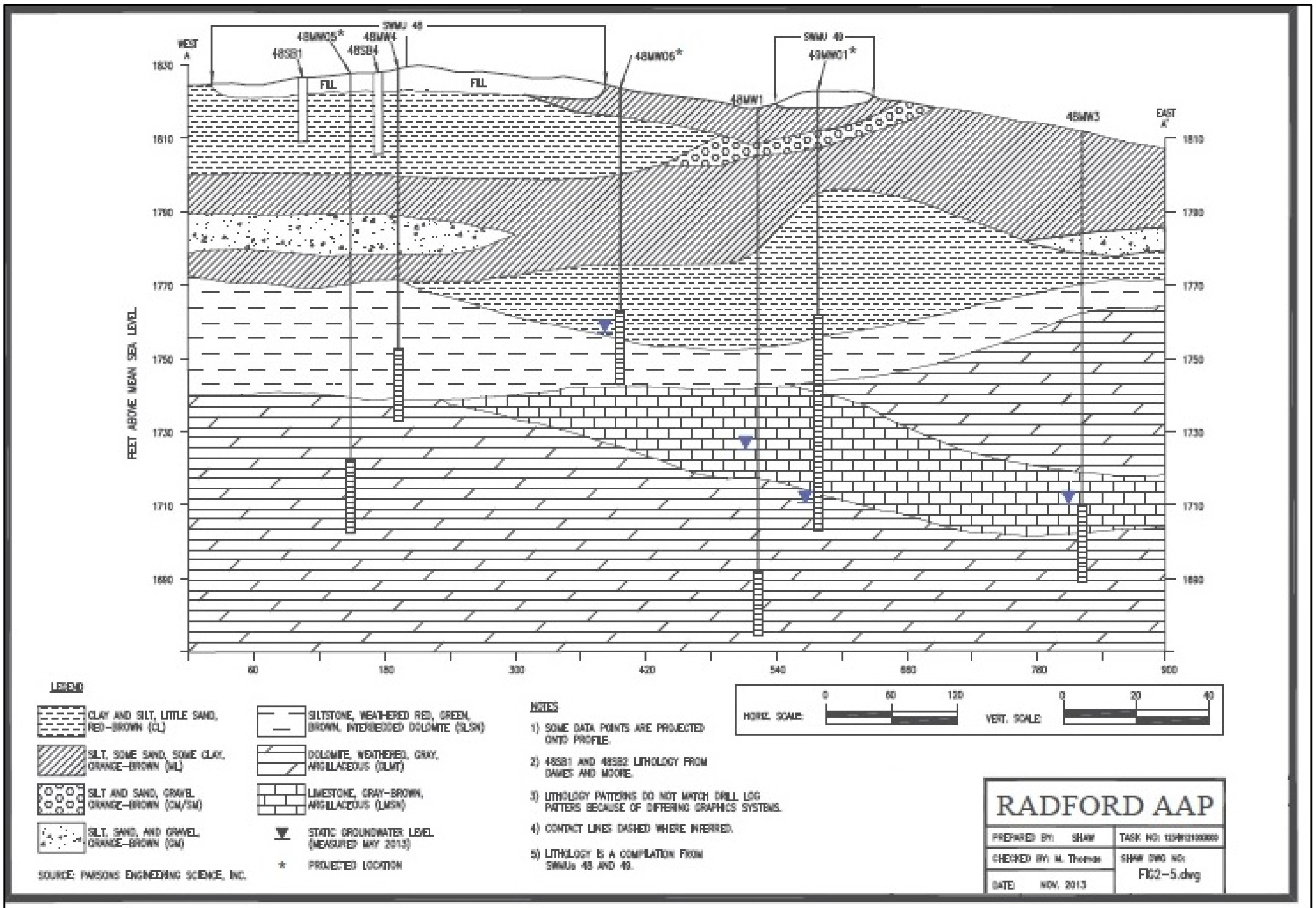
Figure 2-2 Geologic Cross-Section A-A' SWMU 48 and 49



SOURCE: PARSONS ENGINEERING SCIENCE, INC.

NOTES
1) SOME DATA POINTS ARE PROJECTED ONTO PROFILE.
2) 48SB1 AND 48SB2 LITHOLOGY FROM DAMES AND MOORE.
3) LITHOLOGY PATTERNS DO NOT MATCH DRILL LOG PATTERS BECAUSE OF DIFFERING GRAPHICS SYSTEMS.
4) CONTACT LINES DASHED WHERE INFERRED.
5) LITHOLOGY IS A COMPILATION FROM SWMUs 48 AND 49.

FIGURE 2-2

SWMU 48 and 49 Geologic Cross-Section A-A'

RADFORD ARMY AMMUNITION PLANT - SWMU 49 REPORT

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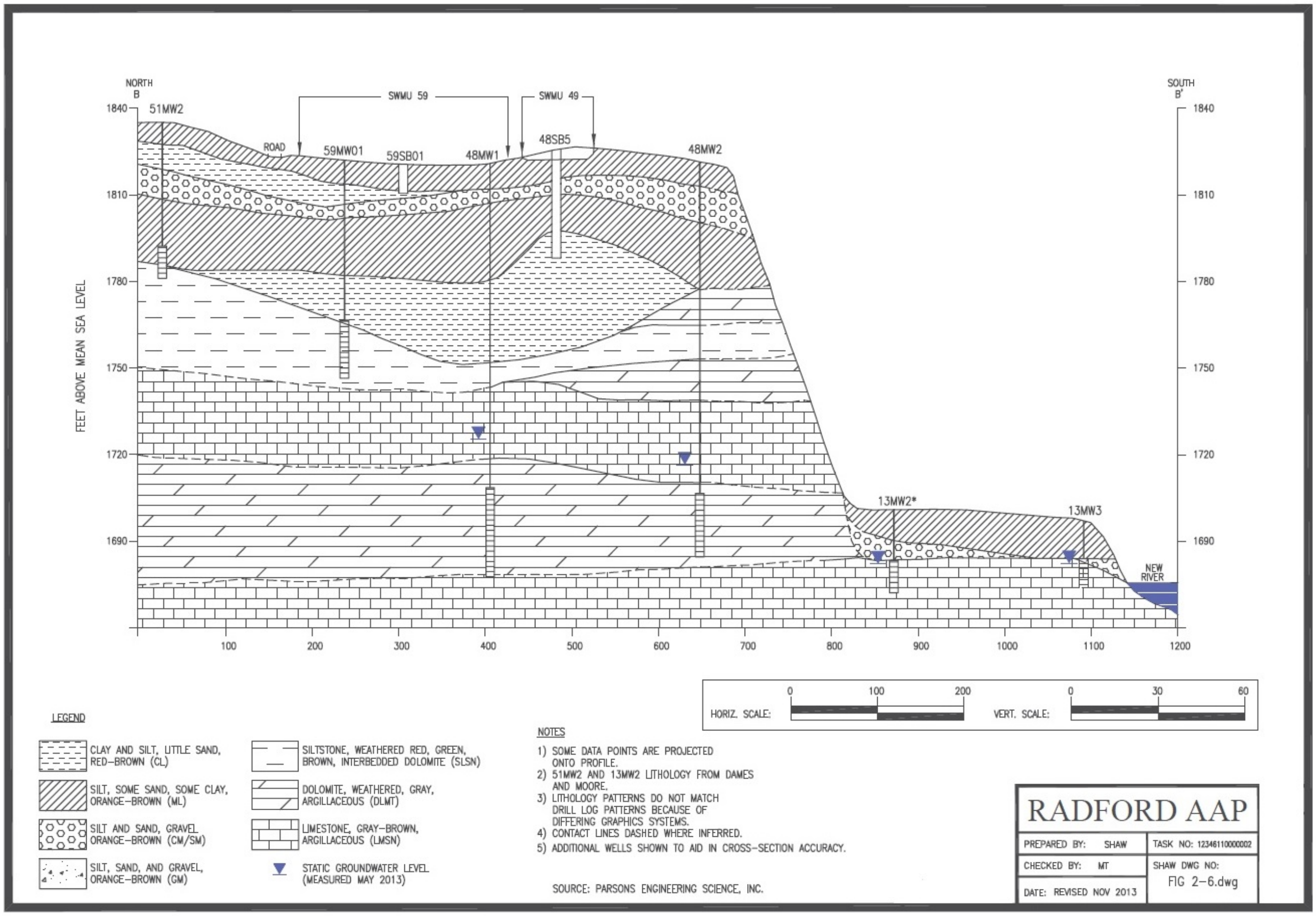
Figure 2-3 Geologic Cross-Section B-B’ SWMU 48 and 49



NOTES

1) SOME DATA POINTS ARE PROJECTED ONTO PROFILE.
2) 51MW2 AND 13MW2 LITHOLOGY FROM DAMES AND MOORE.
3) LITHOLOGY PATTERNS DO NOT MATCH DRILL LOG PATTERNS BECAUSE OF DIFFERING GRAPHICS SYSTEMS.
4) CONTACT LINES DASHED WHERE INFERRED.
5) ADDITIONAL WELLS SHOWN TO AID IN CROSS–SECTION ACCURACY.

SOURCE: PARSONS ENGINEERING SCIENCE, INC.

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FIGURE 2-3

SWMU 48 and 49 Geologic Cross-Section B- B'

RADFORD ARMY AMMUNITION PLANT - SWMU 49 REPORT

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2.4.2 Site-Specific Hydrogeology

Monitoring wells installed at SWMU 49 were screened in both the surficial unconsolidated deposits and in the underlying bedrock. Boring logs and well construction diagrams for the SWMU 49 study area wells are presented in the SWMU 49 MNA Sampling Baseline Report (CB&I, 2015). Water levels were measured in the wells to determine the groundwater flow direction at the site. A groundwater contour map prepared from the Baseline MNA monitoring completed in January 2015 is provided in **Figure 2-4**. A steep bluff separates SWMU 49 and SWMU 13 and, therefore, no monitoring wells are positioned between these sites. Contour lines shown on the figure represent lines of equal elevation of the water table; consequently, groundwater flow direction is always perpendicular to the contour lines. Groundwater at the site tends to flow south towards SWMU 13 and appears to discharge to the New River, south of the study area. Based on the Year Two groundwater elevations recorded, the flow direction did not change appreciably from quarter to quarter.

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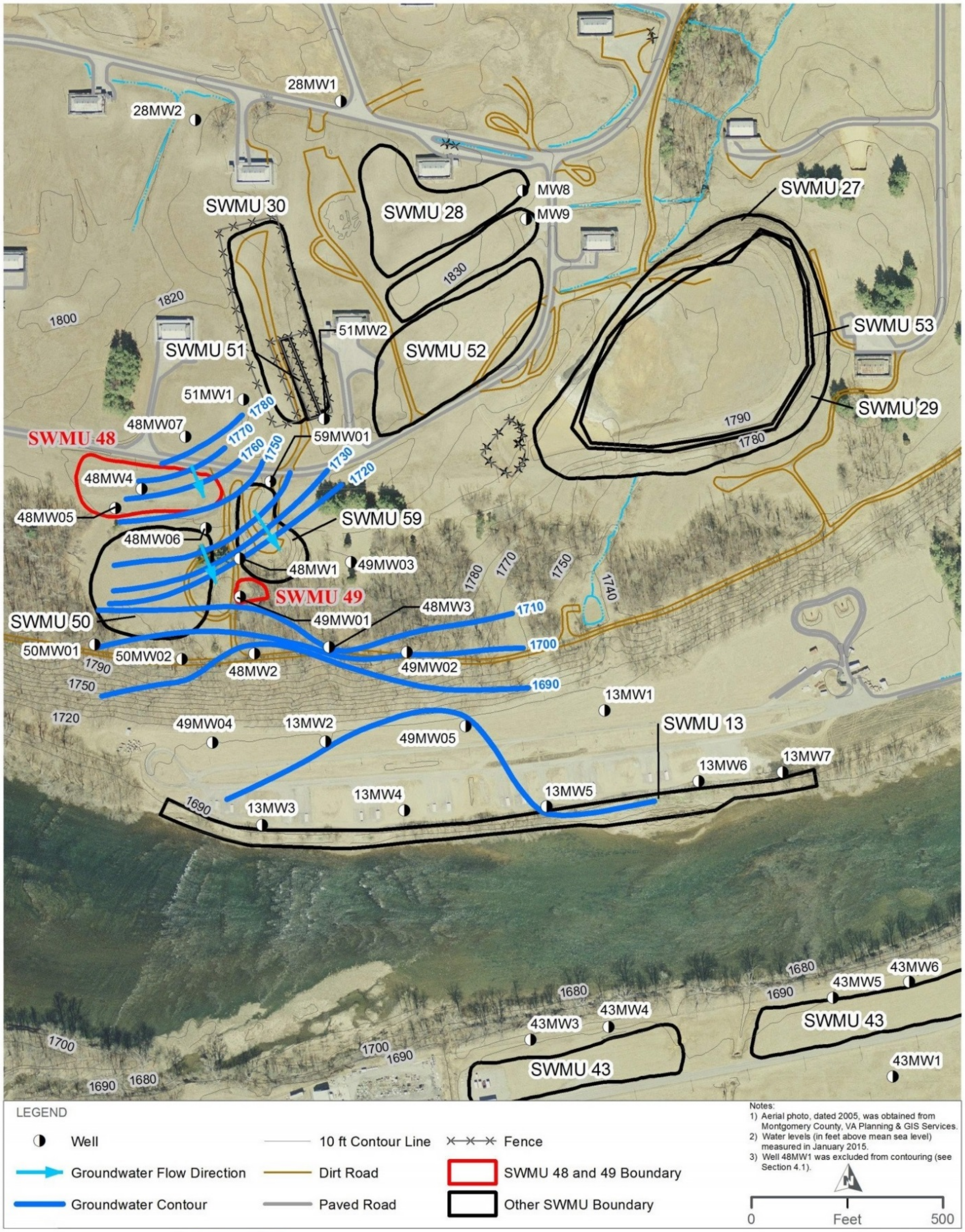
Figure 2-4 SWMU 49 January 2015 Potentiometric Surface Map



Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Water levels (in feet above mean sea level) measured in January 2015.
3) Well 48MW1 was excluded from contouring (see Section 4.1).

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FIGURE 2-4

SWMU 49 Potentiometric Surface Map – January 2015

RADFORD ARMY AMMUNITION PLANT - SWMU 49 MNA REPORT

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3.0 Previous Investigations

Seven previous investigations have been conducted at the previously combined study area including SWMUs 48 and 49. In 1987, a RCRA Facility Assessment was conducted to evaluate potential hazardous waste or hazardous constituent releases and implement corrective actions, as necessary (USATHAMA, 1987). In 1992, Dames and Moore performed a Verification Investigation (VI), which included surface and subsurface soil sampling and a soil gas survey to characterize the nature and extent of contamination (Dames and Moore, 1992). In 1996, Parsons conducted an RFI to further delineate the extent of contamination identified during the 1992 VI sampling (Parsons, 1996). ICF Kaiser Engineers also performed an RFI in 1998 to further refine the understanding of the nature and extent of contamination identified during the previous investigations. Additional RFI sampling was conducted by IT Corporation/Shaw Environmental, Inc. (Shaw) in 2002, 2006, 2007, and 2013 to collect sufficient data to complete human health and ecological risk assessments (CB&I, 2014a).

In 2014, the USEPA and VDEQ approved the Draft SWMU 48/49 RFI Report (CB&I, 2014a), which developed the CMOs and RGs for the MNA program. Direct push soil borings and the installation and sampling of new and existing monitoring wells were used to: characterize the nature and extent of constituents in soil and groundwater at the SWMU 48/49 combined study area, identify the lateral and vertical extent of impacted soil and chlorinated solvents in groundwater, and characterize soil lithology and depth to groundwater and bedrock. Details of these investigations are described in Section 3.0 (Field Investigation Program) of the approved Draft SWMU 48/49 RFI Report (CB&I, 2014a). A potentiometric map, portraying the May 2013 groundwater levels, is provided in **Figure 3-1**. Historical data presenting the SWMU 49 COC concentrations for CT and TCE in the study area wells can be found in **Tables 3-1** through **3-5**.

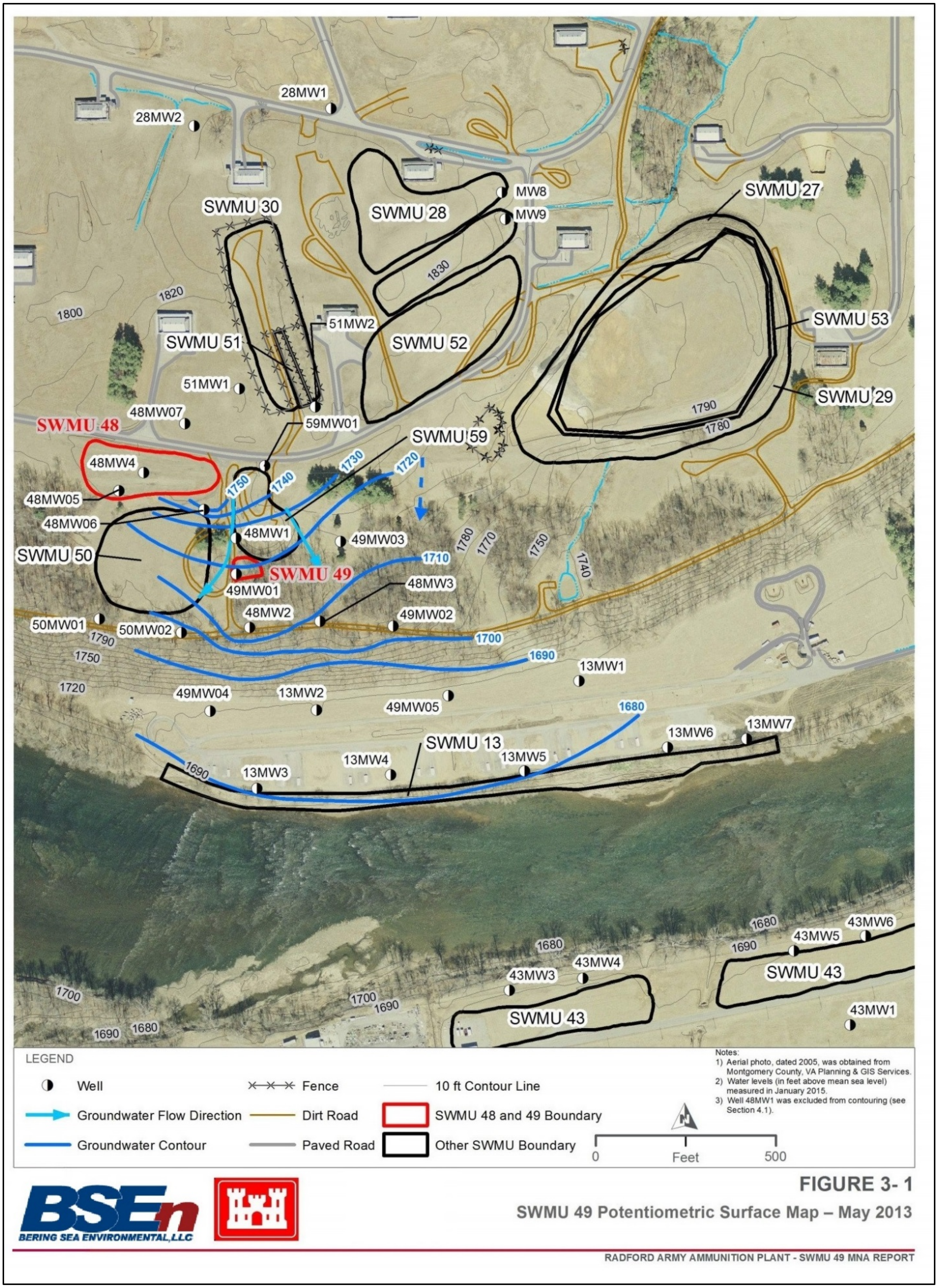
The nature and extent assessment identified several volatile organic compounds (VOCs) and metals in groundwater as elevated and contributing to potential future risks. Two of the VOCs associated with potential future industrial and residential risk in the HHRA (CT and TCE) were present above USEPA's MCLs (USEPA, 2011) during the multiple groundwater sampling events at the study area. A comparison of concentrations from the mid-1990s to 2013 indicates that the majority of the VOCs are no longer present in these sampled areas and have broken down through natural processes. Analysis of the groundwater data during this roughly 20-year period shows that concentrations of CT and TCE plume have: 1) decreased overall, 2) decreased to 1 microgram per liter (µg/L) surrounding the center of the plume, and 3) decreased at least by one half in the center of the plume. The presence of daughter products (i.e., chloroform and cis-1,2-dichloroethene [cis-1,2-DCE]) in groundwater at the study area indicates that limited biological degradation of the chlorinated solvents is occurring.

The HHRA determined that CT and TCE are the primary COCs in groundwater that are contributing potential future industrial and residential risk at the SWMU 49 study area. Because the RFI demonstrated that groundwater contamination is present at concentrations associated with unacceptable human health concerns, CMOs and RGs were developed to address the concerns.

The site-specific CMO for SWMU 49 is to reduce COC concentrations to below RGs/MCLs so as to not adversely impact future beneficial use of groundwater; and to the extent practicable, a goal of restoring site groundwater to the most beneficial use. The SWMU 49 groundwater COCs have been identified as CT and TCE. The groundwater RGs (displayed in **Table 1-1** of this report) will be used to compare results from groundwater monitoring wells to assess the progress of the MNA.

Table 3-6 provides the analytical results presented in the SWMU 49 MNA Sampling Baseline Report (CB&I, 2015). From the 2013 report, the highest concentrations of CT and TCE were observed in Wells 48MW2 and 48MW3. The plumes are small, appear to be isolated, and have not changed in dimension since 2013. Recommendations provided in the SWMU 49 MNA Sampling Baseline Report called for further monitoring of CT, TCE, and daughter products of these VOCs within the SWMU. The rationale of continued monitoring is to evaluate the effectiveness of the MNA processes.

Figure 3-1 SWMU 49 Potentiometric Surface Map – May 2013



Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Water levels (in feet above mean sea level) measured in January 2015.
3) Well 48MW1 was excluded from contouring (see Section 4.1).

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Table 3-1 COCs Detected in SWMU 48 & 49 Groundwater Samples – 1996 RFI

Analyte	**Sample ID Sample Date**	**48MW1 1/20/95**		**48MW1 7/20/95**		**48MW2 1/19/95**		**48MW2 7/19/95**		**48MW3 1/20/95**		**48MW3 7/21/95**		**48MW4 7/27/95**	
	RG	**Result**	**Lab Q**	**Result**	**Lab Q**	**Result**	**Lab Q**	**Result**	**Lab Q**	**Result**	**Lab Q**	**Result**	**Lab Q**	**Result**	**Lab Q**
VOCs (µg/L)															
Carbon tetrachloride	5	NT		1	U	NT		92		NT		100		1	U
Trichloroethene	5	NT		17		NT		11		NT		37		1	U

Notes:
RG = Remedial Goal
µg/L =micrograms per liter (parts per billion)
NT = Analyte not tested
VOC = Volatile Organic Compound

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.

▭ *Bold outline indicates an RG exceedance.*

Table 3-2 COCs Detected in SWMU 49 Groundwater Samples - 1998 RFI

Analyte	**Sample ID Sample**	**48MW1-2 4/8/98**					**48MW2-2 4/2/98**					**48MW3-2 4/2/98**					**48MW4-2 4/8/98**				
	RG	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**
VOCs (µg/L)																					
Carbon tetrachloride	5	5	U	U	5	5	140			5	5	180			5	5	5	U	U	5	5
Trichloroethene	5	8		J	5	5	18		J	5	5	33		J	5	5	5	U	U	5	5

Notes:
µg/L = micrograms per liter (parts per billion)
MDL = Method Detection Limit
MRL = Method Reporting Limit
RG = Remedial Goal

VOC = Volatile Organic Compound

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.
Val Q = Validation Data Qualifiers
J = Estimated concentration.
U = Analyte not detected.
-2 = Sample code signifies the second round of sampling conducted at these four wells. Original samples were collected during the 1996 RFI performed by ICF Kaiser.

☐ ***Bold outline indicates an RG exceedance.***
🟨 ***Shading in the MDL/MRL columns indicates the MDL/MRL is equal to or exceeds a criterion.***

Table 3-3 COCs Detected in SWMU 49 Groundwater Samples - 2006 Groundwater Data Report

Analyte	**Sample ID Sample Date**	**48MW1 4/13/06**					**48MW2 4/13/06**					**48MW3 4/13/06**					**48MW4 4/11/06**				
	RG	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**
VOCs (µg/L)																					
Carbon tetrachloride	5	1	U		0.5	1	29.2			0.5	1	51.2			0.5	1	1	U		0.5	1
Trichloroethene	5	5.5			0.5	1	3			0.5	1	7.4			0.5	1	1	U		0.5	1

Notes:
µg/L = micrograms per liter (parts per billion)
MDL = Method Detection Limit
MRL = Method Reporting Limit
RG = Remedial Goal
VOC = Volatile Organic Compound

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.

☐ ***Bold outline indicates an RG exceedance.***
🟨 ***Shading in the MDL/MRL columns indicates the MDL/MRL is equal to or exceeds a criterion.***

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Table 3-4 COCs Detected in SWMU 49 Study Area Groundwater Samples - 2007 RFI

Analyte	**Sample ID Sample Date**	**48MW1 8/29/07**					**48MW2 8/29/07**					**48MW3 8/29/07**					**48MW4 8/29/07**					**48MW05 8/30/07**					**48MW06 8/30/07**				
	RG	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**
VOCs (µg/L)																															
Carbon tetrachloride	5	1	U		0.29	1	94.6			0.29	1	60.3			0.29	1	1	U		0.29	1	1	U		0.29	1	1	U		0.29	1
Trichloroethene	5	1.6			0.38	1	11.2			0.38	1	10.1			0.38	1	1	U		0.38	1	1	U		0.38	1	3.7			0.38	1

Analyte	**Sample ID Sample Date**	**48MW07 8/30/07**					**49MW01 8/29/07**					**50MW01 8/30/07**					**50MW02 8/30/07**					**59MW01 8/29/07**				
	RG	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**
VOCs (µg/L)																										
Carbon tetrachloride	**5**	**1**	**U**		**0.29**	**1**	**3.8**			**0.29**	**1**	**1**	**U**		**0.29**	**1**	**2.7**			**0.29**	**1**	**1**	**U**		**0.29**	**1**
Trichloroethene	**5**	**1**	**U**		**0.38**	**1**	**1**	**U**		**0.38**	**1**	**1**	**U**		**0.38**	**1**	**3.4**			**0.38**	**1**	**1**	**U**		**0.38**	**1**

Notes:
µg/L = micrograms per liter (parts per billion)
MDL = Method Detection Limit
MRL = Method Reporting Limit
RG = Remedial Goal
VOC = Volatile Organic Compound

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.

▭ ***Bold outline indicates an RG exceedance.***

Table 3-5 VOCs Detected in SWMU 49 Study Area Groundwater Samples - 2013 Supplemental RFI

Analyte	Sample ID Sample Date	13MW2 5/6/13					13MW3 5/6/13					13MW4 5/6/13					13MW5 5/6/13					48MW1 5/8/13					48MW2 5/9/13					48MW3 5/9/13				
	RG	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (µg/L)																																				
1,1,1-Trichloroethane	**na**	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.432	J	J	0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2
1,1-Dichloroethane	**na**	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	1.03			0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2
1,1-Dichloroethene	**na**	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5
Acetone	**na**	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1
Carbon tetrachloride	**5**	0.5	U		0.248	0.5	5.63			0.248	0.5	0.5	U		0.248	0.5	0.5	U		0.248	0.5	0.5	U		0.248	0.5	82.7			0.248	0.5	73.1			0.248	0.5
Chloroform	**na**	0.2	U		0.155	0.2	0.453	J	J	0.155	0.2	0.2	U		0.155	0.2	0.2	U		0.155	0.2	0.2	U		0.155	0.2	5.97			0.155	0.2	7.89			0.155	0.2
cis-1,2-Dichloroethene	**na**	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.817	J	J	0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2
Methylene chloride	**na**	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5
Tetrachloroethene	**na**	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5
Toluene	**na**	0.2	U		0.122	0.2	0.2	U		0.122	0.2	0.2	U		0.122	0.2	0.2	U		0.122	0.2	2.1			0.122	0.2	1.18			0.122	0.2	0.291	J	J	0.122	0.2
Trichloroethene	**5**	0.2	U		0.161	0.2	1.08			0.161	0.2	1.08			0.161	0.2	0.2	U		0.161	0.2	1.9			0.161	0.2	9.75			0.161	0.2	10.7			0.161	0.2

Analyte	Sample ID Sample Date	48MW06 5/7/13					49MW01 5/8/13					49MW02 5/9/13					49MW03 5/7/13					49MW04 5/6/13					49MW05 5/6/13					50MW02 5/8/13				
	RG	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (µg/L)																																				
1,1,1-Trichloroethane	**na**	1.66			0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.2	U	UL	0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.251	J	J	0.123	0.2
1,1-Dichloroethane	**na**	5.86			0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.2	U	UL	0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.344	J	J	0.171	0.2
1,1-Dichloroethene	**na**	0.301	J	J	0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U	UL	0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5
Acetone	**na**	1	U		0.193	1	1	U		0.193	1	2.41	J	B	0.193	1	1	U	UL	0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1
Carbon tetrachloride	**5**	0.5	U		0.248	0.5	4.61			0.248	0.5	5.36			0.248	0.5	0.5	U	UL	0.248	0.5	0.664	J	J	0.248	0.5	0.5	U		0.248	0.5	0.919	J	J	0.248	0.5
Chloroform	**na**	0.2	U		0.155	0.2	0.193	J	J	0.155	0.2	7.79			0.155	0.2	0.2	U	UL	0.155	0.2	1.25			0.155	0.2	0.2	U		0.155	0.2	0.2	U		0.155	0.2
cis-1,2-Dichloroethene	**na**	9.21			0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.2	U	UL	0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.373	J	J	0.103	0.2
Methylene chloride	**na**	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	2.3	J	L	0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5
Tetrachloroethene	**na**	0.801	J	J	0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U	UL	0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.255	J	J	0.193	0.5
Toluene	**na**	0.2	U		0.122	0.2	0.765	J	J	0.122	0.2	1.52			0.122	0.2	0.2	U	UL	0.122	0.2	0.2	U		0.122	0.2	0.2	U		0.122	0.2	0.726	J	J	0.122	0.2
Trichloroethene	**5**	6.25			0.161	0.2	0.2	U		0.161	0.2	0.934	J	J	0.161	0.2	0.2	U	UL	0.161	0.2	0.2	U		0.161	0.2	0.2	U		0.161	0.2	2.31			0.161	0.2

Notes:
RG = Remedial Goal developed for carbon tetrachloride and trichloroethene in CB&I, 2014.
µg/L = micrograms per liter (parts per billion)
MDL = Method Detection Limit
MRL = Method Reporting Limit
VOC = Volatile Organic Compound

Lab Q = Lab Data Qualifiers
J = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
UL = Estimated concentration non-detect bias low

Bold outline indicates an RG exceedance.

Table 3-6 Analytes Detected in Baseline Monitoring

Analyte	Sample ID Sample Date	13MW2 1/26/15					13MW3 1/26/15					13MW4 1/26/15					13MW5 1/26/15					48MW1 1/28/15					48MW2 1/28/15					48MW3 1/27/15					48MW06 1/29/15				
	RG	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (µg/L)																																									
1,1,1-Trichloroethane	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.454	J	J	0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.691	DJ	J	0.5	1
1,1-Dichloroethane	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.908	J	J	0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	4.28	D		0.5	1
Acetone	na	5	U		2.5	5	5	U		2.5	5	5	U		2.5	5	5	U		2.5	5	5	U		2.5	5	5	U		2.5	5	5	XU		2.5	5	27.8	D	B	5	10
Bromoform	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	XU		0.5	1
Bromomethane	na	1	U		0.5	1	1	U		0.5	1	1	U		0.5	1	1	U		0.5	1	1	U		0.5	1	1	U		0.5	1	1	NU		0.5	1	2	U		1	2
Carbon tetrachloride	5	0.5	U		0.25	0.5	4.62			0.25	0.5	0.592	J	J	0.25	0.5	0.5	U		0.25	0.5	0.5	XU		0.25	0.5	118	X	J	0.25	0.5	77.4			0.25	0.5	1	XU		0.5	1
Chloroform	na	0.5	U		0.25	0.5	0.47	J	J	0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	7.46			0.25	0.5	8.37			0.25	0.5	1	U		0.5	1
cis-1,2-Dichloroethene	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.914	J	J	0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	4.86	D		0.5	1
Dibromochloromethane	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	XU		0.25	0.5	1	U		0.5	1
Ethylbenzene	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.469	J	J	0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1
m- & p-Xylene	na	1	U		0.5	1	1	U		0.5	1	1	U		0.5	1	1	U		0.5	1	0.535	J	J	0.5	1	1.32	J	J	0.5	1	0.736	J	J	0.5	1	2	U		1	2
o-Xylene	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.285	J	J	0.25	0.5	0.919	J	J	0.25	0.5	0.495	J	J	0.25	0.5	1	U		0.5	1
Tetrachloroethene	na	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.5	U		0.25	0.5	0.709	DJ	J	0.5	1
Trichloroethene	5	0.5	U		0.25	0.5	0.883	J	J	0.25	0.5	0.5	U		0.25	0.5	1.42			0.25	0.5	1.91			0.25	0.5	10.5			0.25	0.5	12.4			0.25	0.5	3.29	D		0.5	1
Misc. (µg/L)																																									
Total Organic Carbon	na	2500	U		1250	2500	2500	U		1250	2500	2500	U		1250	2500	NT					2500	U		1250	2500	2500	U		1250	2500	2500	U		1250	2500	1640	J	J	1250	2500
Chloride	na	2750			170	330	3880			170	330	11500			170	330	NT					3100			170	330	2650			170	330	2220			170	330	9360	D		340	660
Nitrate (as N)	na	71.5	J	J	33	100	1660			33	100	100	U		33	100	NT					1350			33	100	754			33	100	6400			33	100	5880			33	100
Sulfate	na	45900			330	1000	126000			330	1000	23800			330	1000	NT					58000			330	1000	16800			330	1000	29800			330	1000	275000	D		660	2000
Methane	na	2	U		1	2	2	U		1	2	2	U		1	2	NT					2	U		1	2	2	U		1	2	2	U		1	2	2	U		1	2
Ethene	na	2	U		1	2	2	U		1	2	2	U		1	2	NT					2	U		1	2	2	U		1	2	2	U		1	2	2	U		1	2

Table 3-6 Analytes Detected in Baseline Monitoring (Continued)

Analyte	Sample ID Sample Date	48MW07 1/29/15					49MW01 1/28/15					49MW02 1/27/15					49MW03 1/28/15					49MW04 1/26/15					49MW05 1/26/15					50MW02 1/27/15				
	RG	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**	**Result**	**Lab Q**	**Val Q**	**MDL**	**MRL**
VOCs (µg/L)																																				
1,1,1-Trichloroethane	**na**	0.5	U		0.25	0.5	0.262	J	J	0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5
1,1-Dichloroethane	**na**	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.313	J	J	0.25	0.5
Acetone	**na**	5	U		2.5	5	5	U		2.5	5	14	XDJ	B	5	10	5	U		2.5	5	5	U		2.5	5	18.6	DJ	B	5	10	5	XU		2.5	5
Bromoform	**na**	0.5	XU		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5
Bromomethane	**na**	1	U		0.5	1	1	U		0.5	1	2	U		1	2	1	U		0.5	1	1	U		0.5	1	2	U		1	2	1	U		0.5	1
Carbon tetrachloride	**5**	0.5	XU		0.25	0.5	4.97	X	J	0.25	0.5	5.05	D		0.5	1	0.5	XU		0.25	0.5	0.662	J	J	0.25	0.5	1	U		0.5	1	1.62			0.25	0.5
Chloroform	**na**	0.5	U		0.25	0.5	0.404	J	J	0.25	0.5	1.55	DJ	J	0.5	1	0.5	U		0.25	0.5	1.46			0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5
cis-1,2-Dichloroethene	**na**	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.384	J	J	0.25	0.5
Dibromochloromethane	**na**	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	XU		0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	XU		0.25	0.5
Ethylbenzene	**na**	0.5	U		0.25	0.5	0.262	J	J	0.25	0.5	1.13	DJ	J	0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5
m- & p-Xylene	**na**	1	U		0.5	1	0.69	J	J	0.5	1	4.06	D		1	2	1	U		0.5	1	1	U		0.5	1	2	U		1	2	0.804	J	J	0.5	1
o-Xylene	**na**	0.5	U		0.25	0.5	0.544	J	J	0.25	0.5	2.91	D		0.5	1	0.296	J	J	0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.542	J	J	0.25	0.5
Tetrachloroethene	**na**	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	0.311	J	J	0.25	0.5
Trichloroethene	**5**	0.5	U		0.25	0.5	0.5	U		0.25	0.5	.0501	DJ	J	0.5	1	0.5	U		0.25	0.5	0.5	U		0.25	0.5	1	U		0.5	1	2.08			0.25	0.5
Misc. (µg/L)																																				
Total Organic Carbon	**na**	NT					2500	U		1250	2500	2500	U		1250	2500	NT					2500	U		1250	2500	NT					2500	U		1250	2500
Chloride	**na**	NT					6030			170	330	3450			170	330	NT					5160			170	330	NT					7270			170	330
Nitrate (as N)	**na**	NT					303			33	100	47.6	J	J	33	100	NT					249	J	J	33	100	NT					2060			33	100
Sulfate	**na**	NT					1000	U		330	1000	26600			330	1000	NT					53600			330	1000	NT					73200			330	1000
Methane	**na**	NT					2	U		1	2	1.54	J	J	1	2	NT					2	U		1	2	NT					2	U		1	2
Ethene	**na**	NT					2	U		1	2	1.4	J	J	1	2	NT					2	U		1	2	NT					2	U		1	2

Notes:
RG = Remedial Goal developed for carbon tetrachloride and trichloroethene in CB&I, 2014.
µg/L = micrograms per liter (parts per billion)
CCV = Continuing Calibration Verification
ICV = Initial Calibration Verification
MDL = Method Detection Limit
MRL = Method Reporting Limit
na = not applicable
NT = Analyte not tested
VOC = Volatile Organic Compound

Lab Q = Lab Data Qualifiers
D = Sample was run at a dilution.
J = Value <MRL and >MDL and is considered estimated.
N = Matrix Spike/Matrix Spike Duplicate accuracy and/or precision were outside criteria
U = Analyte not-detected at the method reporting limit.
X = The associated ICV/CCV exceeded the upper control limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.

▭ ***Bold outline indicates an RG exceedance.***

4.0 Field Activities

The following sections provide a discussion of field activities conducted by BSEn in the second year of MNA monitoring at SWMU 49.

The second year of groundwater monitoring consisted of four sampling events conducted in October 2016 (fifth quarter), January 2017 (sixth quarter), April 2017 (seventh quarter), and July 2017 (eighth quarter). Fifteen monitoring wells were included in the monitoring well network, of which eleven were sampled on a quarterly basis and four on an annual basis. The year two MNA groundwater monitoring consisted of a synoptic water level measurement, the results of which are included in Table 4-1, and sampling of the 15 point of compliance (POC) monitoring wells for Target Compound List (TCL) VOCs and dissolved gases (methane, ethane, ethene). In addition, the following indicator parameters were collected: Total Organic Carbon (TOC), dissolved ferrous iron, and the anions chloride, nitrate, and sulfate. Water quality parameters collected during low flow sampling included pH, temperature, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity. The list of monitoring wells and sample frequency is provided in **Table 4-2**. Field activities were conducted in accordance with the Draft Final SWMU 49 MNA Groundwater Monitoring Work Plan (CB&I, 2014b). Copies of the groundwater sample forms are presented in **Appendix A**.

4.1 Fifth Quarter Groundwater Sampling

Groundwater elevation measurements were collected from all 15 POC monitoring wells, while samples were collected from 11 of the 15 wells. The fifth quarter of groundwater sampling was conducted 12 October through 14 October 2016. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.1.1 Groundwater Elevation Measurements

Water level elevations were collected during each second year quarterly event from the 15 monitoring wells at SWMU 49 prior to the collection of groundwater samples. **Table 4-1** provides the measured depth to water levels (from the top of the casing [TOC]) and groundwater elevations amsl collected on 10 October 2016. **Figure 4-2** presents a groundwater elevation contour map developed from the elevation data collected during this quarterly monitoring event. Groundwater contours were derived using Esri ArcGIS Desktop Spatial Analyst 10.5.1 software and creating a spline interpolated continuous surface based on limited groundwater data collected in the field. The surface model was executed using default values in most cases and forced to cover an area inclusive of all wells using the extent polygon to define the area of interest. Contour lines were then constructed from the output splined surface at 10-foot and 2-foot intervals, depending on the site, with zero base contour. The results of the automated processing were then reviewed by subject knowledge experts and manually adjusted to accurately represent ground conditions.

Table 4-1 SWMU 49 Fifth Quarter Groundwater Elevations

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (BTOC)	Elevation (TOC)	Water Level (ft amsl)	PID Readings (ppm)
48MW07	62 - 82	20	82	47.63	1833.69	1786.06	PID = 0.1
13MW5	14 - 25	19	25	16.30	1696.40	1680.10	PID = 0.0
49MW03	77 - 117	40	117	104.76	1811.82	1707.06	PID = 0.0
49MW05	16 - 37	19	36.8	20.27	1699.74	1679.47	PID = 0.0
48MW06	58 - 78	20	78	65.56	1822.85	1757.29	PID = 0.0
48MW1	110 - 140	30	140	107.52	1816.42	1708.90	PID = 0.0
48MW2	113 - 134	20	133.7	124.15	1816.27	1692.12	PID = 0.0
48MW3	100 - 120	20	120	97.02	1808.56	1711.54	PID = 0.0
49MW01	90 - 121	31	121	115.37	1826.42	1711.05	PID = 0.0
49MW02	103 - 133	30	133	94.30	1806.29	1711.99	PID = 0.0
50MW02	89 - 119	30	119	115.30	1809.63	1694.33	PID = 0.0
13MW2	19 - 29	10	29	21.33	1702.62	1681.29	PID = 0.0
13MW3	9 - 19	10	19	15.00	1694.47	1679.47	PID = 0.1
13MW4	14 - 24	10	24	16.11	1696.40	1680.29	PID = 0.1
49MW04	50 - 70	20	72	20.59	1703.00	1682.41	PID = 0.0

Notes:

amsl = above mean sea level
bgs = below ground surface
BTOC = below top of casing
ft = feet/foot
ppm = parts per million
TOC = Top of casing
DTW = Depth to water
PID = Photoionization detector

4.1.2 Groundwater Sampling

Groundwater samples were collected from 11 of the 15 POC monitoring wells from 12 October through 14 October 2016 and analyzed for the analytical suites covering TCL VOCs and the dissolved gases methane, ethane, and ethene. In addition, the following indicator parameters were collected: TOC, dissolved ferrous iron, chloride, nitrate, and sulfate. Water quality parameters collected during low flow sampling included pH, temperature, specific conductance, DO, ORP, and turbidity. These parameters are discussed in Section 6.2 regarding the potential for biodegradation in the groundwater at SWMU 49. **Table 4-2** presents the suite of analytes collected for analysis during the fifth quarterly monitoring event.

Figure 4-1 SWMU 49 Monitoring Well Sample Locations

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Figure 4-2 SWMU 49 October 2016 Groundwater Contour Map

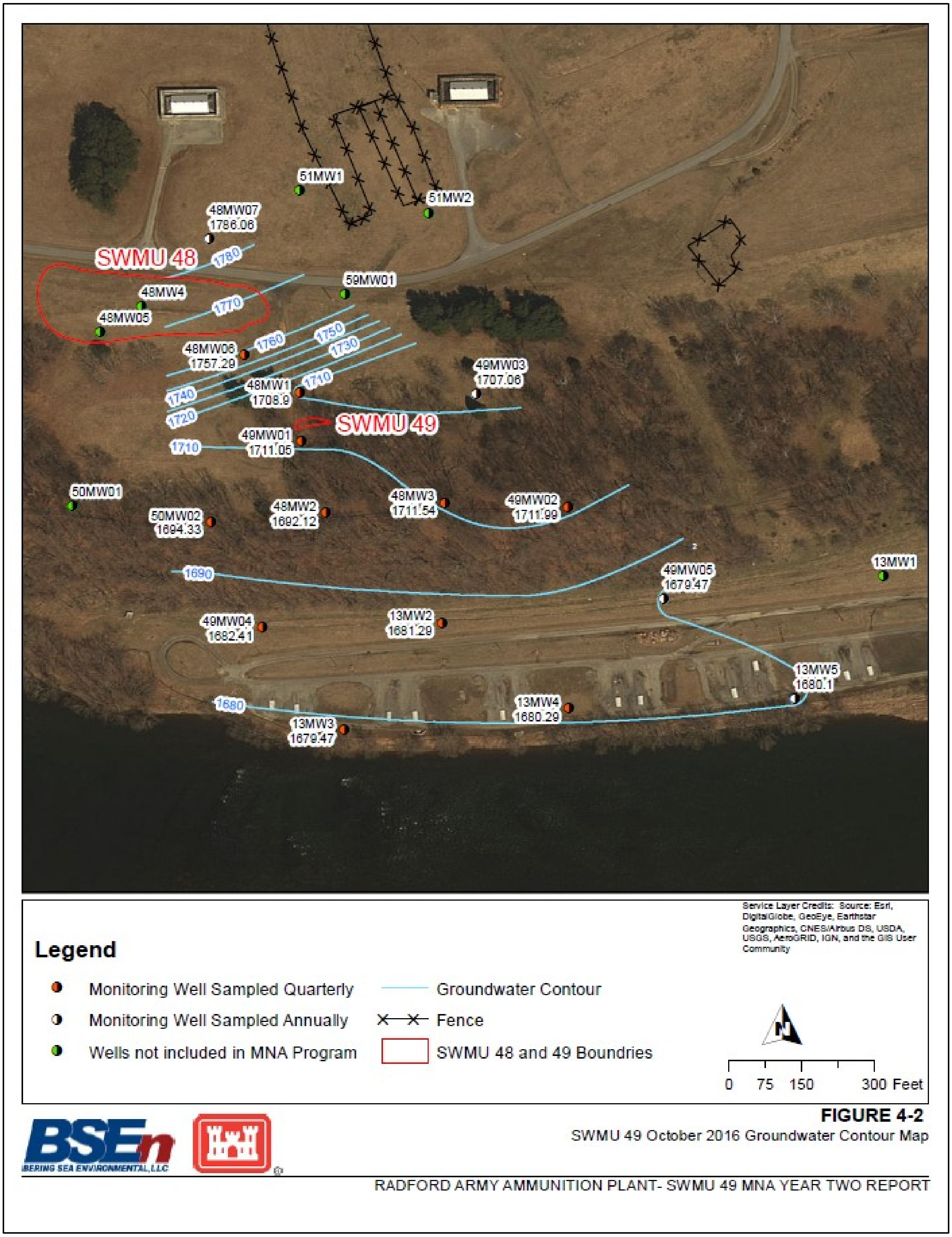

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Table 4-2 SWMU 49 Year Two Quarterly Monitoring Analytical Suite

Well/Sample ID	Frequency	TCL VOCs	Dissolved Gases (Methane, Ethane, Ethene)	MNA Indicator Parameters	Water Quality Parameters
13MW2	**Quarterly**	**X**	**X**	**X**	**X**
13MW3	**Quarterly**	**X**	**X**	**X**	**X**
13MW4	**Quarterly**	**X**	**X**	**X**	**X**
13MW5	**Annual**	**X**	**X**	**X**	**X**
48MW1	**Quarterly**	**X**	**X**	**X**	**X**
48MW2	**Quarterly**	**X**	**X**	**X**	**X**
48MW3	**Quarterly**	**X**	**X**	**X**	**X**
48MW06	**Quarterly**	**X**	**X**	**X**	**X**
48MW07	**Annual**	**X**	**X**	**X**	**X**
49MW01	**Quarterly**	**X**	**X**	**X**	**X**
49MW02	**Quarterly**	**X**	**X**	**X**	**X**
49MW03	**Annual**	**X**	**X**	**X**	**X**
49MW04	**Quarterly**	**X**	**X**	**X**	**X**
49MW05	**Annual**	**X**	**X**	**X**	**X**
50MW02	**Quarterly**	**X**	**X**	**X**	**X**

Notes:
MNA = Monitored Natural Attenuation
TCL =Target compound list
VOC = Volatile organic compound

Groundwater samples were collected via low-flow bladder pumps to obtain representative groundwater samples and to minimize investigative derived waste (IDW) purge water. The following procedures were followed during all quarterly groundwater monitoring events:

1. A photoionization detector (PID) reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sand pack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to ensure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI 556 water quality flow cell.
4. Monitoring wells were pumped at a rate of approximately 200 milliliters per minute (mL/min). Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO,

ORP, turbidity, and specific conductivity. Turbidity was measured using a Hach 2100Q turbidity meter, while concentrations of dissolved ferrous iron were measured in the field using a Hach DR900 test kit via Method 8146.

5. **Table 4-3** presents a summary of the final (stabilized) water quality readings for each well from the fifth quarter.

Based on the fifth quarter DO data, aerobic groundwater conditions exist at SWMU 49 (i.e., DO >1 parts per million [ppm]). The DO levels ranged from a low of 1.67 milligrams per liter (mg/L) at monitoring well 48MW04 to a high of 6.12 mg/L at monitoring well 48MW2. ORP measurements ranged from a low of 9.41 millivolts (mV) in monitoring well 13MW3 to a high of 192.7 mV at monitoring well 48MW2. Measurements of pH ranged from a low of 7.99 standard units (SU) at monitoring well 13MW3 to a high of 13.42 at monitoring well 48MW1. As evidenced in **Table 4-3**, only one pH measurement was below 8.0, the remainder range from 8.6 to 13.42. Measuring the suitability of the groundwater to support microbial species is accomplished via pH readings. Microbial activity tends to be reduced outside of pH range of 5 to 9, and anaerobic microorganisms are typically sensitive to pH extremes (ITRC, 1999). These elevated pH readings (> 9) from the fifth quarter are observed as a single event anomaly, as such elevated readings were not observed in the Year 1 MNA water quality readings which ranged from 6.24 to 8.49, nor were they observed in remaining Year 2 MNA water quality readings which ranged from 6.68 to 7.84. Measurements of specific conductance ranged from a low of 427 microsiemens per centimeter (µS/cm) at monitoring well 48MW1 to a high of 742 µS/cm at monitoring well 13MW2.

Table 4-3 SWMU 49 Fifth Quarter Water Quality Parameters

Well ID	Temperature (°C)	Specific Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	ORP (mV)	Turbidity (NTU)	Fe (mg/L)
48MW06	13.18	559	11.74	2.10	171.1	55.10	0.90
48MW1	13.21	427	13.42	4.3	186.3	2.02	0.00
48MW2	14.38	504	9.74	6.12	192.7	42	0.21
48MW3	13.62	740	10.14	3.75	179.6	1.46	0.00
49MW01	15.23	479	10.39	5.98	191.3	97.2	0.92
49MW02	13.02	550	9.17	2.21	138.1	10.6	0.27
50MW02	12.80	711	9.25	3.57	144.4	15.9	0.06
13MW2	15.04	742	9.3	4.6	99.5	1.79	0.04
13MW3	16.84	584	7.99	2.29	9.41	1.52	0.00
13MW4	16.0	472	9.32	3.36	74.6	1.43	0.01
49MW04	15.3	646	8.6	1.67	165.3	-	0.00

Notes:
°C = degrees Celsius
µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
mV = millivolts
NTU = Nephelometric turbidity unit
ORP = Oxidation-reduction potential
Fe = Ferrous iron

The groundwater flow rate was maintained during sample collection. Samples were collected, labeled, and packed in ice until shipment to the laboratory. Chain-of-custody (CoC) forms were filled out and shipped with the samples. Copies of the CoC forms are provided in **Appendix B** along with the raw analytical data packages.

4.1.3 Quality Control Samples

Quality control (QC) samples including a duplicate sample and trip, equipment, and temperature blanks were collected during the fifth monitoring event.

One duplicate sample was collected during the first monitoring event at 48MW3 (duplicate as 49TM01) and analyzed for the full suite of compounds as the parent sample. Further, one matrix spike/matrix spike duplicate (MS/MSD) was collected at monitoring well 13MW4 and analyzed for the full suite of compounds as the parent sample.

One equipment rinse blank sample (101416R1) was collected during the fifth quarter sampling event. The equipment rinse blank was collected by pouring de-ionized ultra-filtered (DIUF) water over decontaminated sampling equipment and into laboratory supplied bottles. The rinse blank was analyzed for the full suite of compounds as the samples.

One IDW purge water sample (49ADW01) was collected and analyzed for pH, chemical oxygen demand (COD), and total metals.

Results of the quality assurance (QA)/QC samples are presented in the raw analytical data package provided in **Appendix B-2.**

4.2 Sixth Quarter Groundwater Sampling

Groundwater elevation measurements and samples were collected from all 15 POC monitoring wells. The sixth quarter of groundwater sampling was conducted 11 January through 13 January 2017. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.2.1 Groundwater Elevation Measurements

Water level elevations were collected during each second year quarterly event from the 15 monitoring wells at SWMU 49 prior to the collection of groundwater samples. **Table 4-4** provides the measured depth to water levels (from the TOC) and groundwater elevations amsl collected on 10 January 2017. **Figure 4-3** presents a groundwater elevation contour map developed from the elevation data collected during this quarterly monitoring event.

Table 4-4 SWMU 49 Sixth Quarter Groundwater Elevations

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (BTOC)	Elevation (TOC)	Water Level (ft amsl)	PID Readings (ppm)
48MW07	62 - 82	20	82	48.57	1833.69	1785.12	PID = 0.0
13MW5	14 - 25	19	25	17.40	1696.40	1679.00	PID = 0.0
49MW03	77 - 117	40	117	105.25	1811.82	1706.57	PID = 0.0
49MW05	16 - 37	19	36.8	20.32	1699.74	1679.42	PID = 0.0
48MW06	58 - 78	20	78	65.63	1822.85	1757.22	PID = 0.0
48MW1	110 - 140	30	140	109.29	1816.42	1707.13	PID = 0.0
48MW2	113 - 134	20	133.7	124.78	1816.27	1691.49	PID = 0.0
48MW3	100 - 120	20	120	97.27	1808.56	1711.29	PID = 0.0
49MW01	90 - 121	31	121	115.49	1826.42	1710.93	PID = 0.0
49MW02	103 - 133	30	133	94.27	1806.29	1712.02	PID = 0.0
50MW02	89 - 119	30	119	116.04	1809.63	1693.59	PID = 0.0
13MW2	19 - 29	10	29	21.72	1702.62	1680.90	PID = 0.0
13MW3	9 - 19	10	19	15.63	1694.47	1678.84	PID = 0.0
13MW4	14 - 24	10	24	17.25	1696.40	1679.15	PID = 0.0
49MW04	50 - 70	20	72	21.11	1703.00	1681.89	PID = 0.0

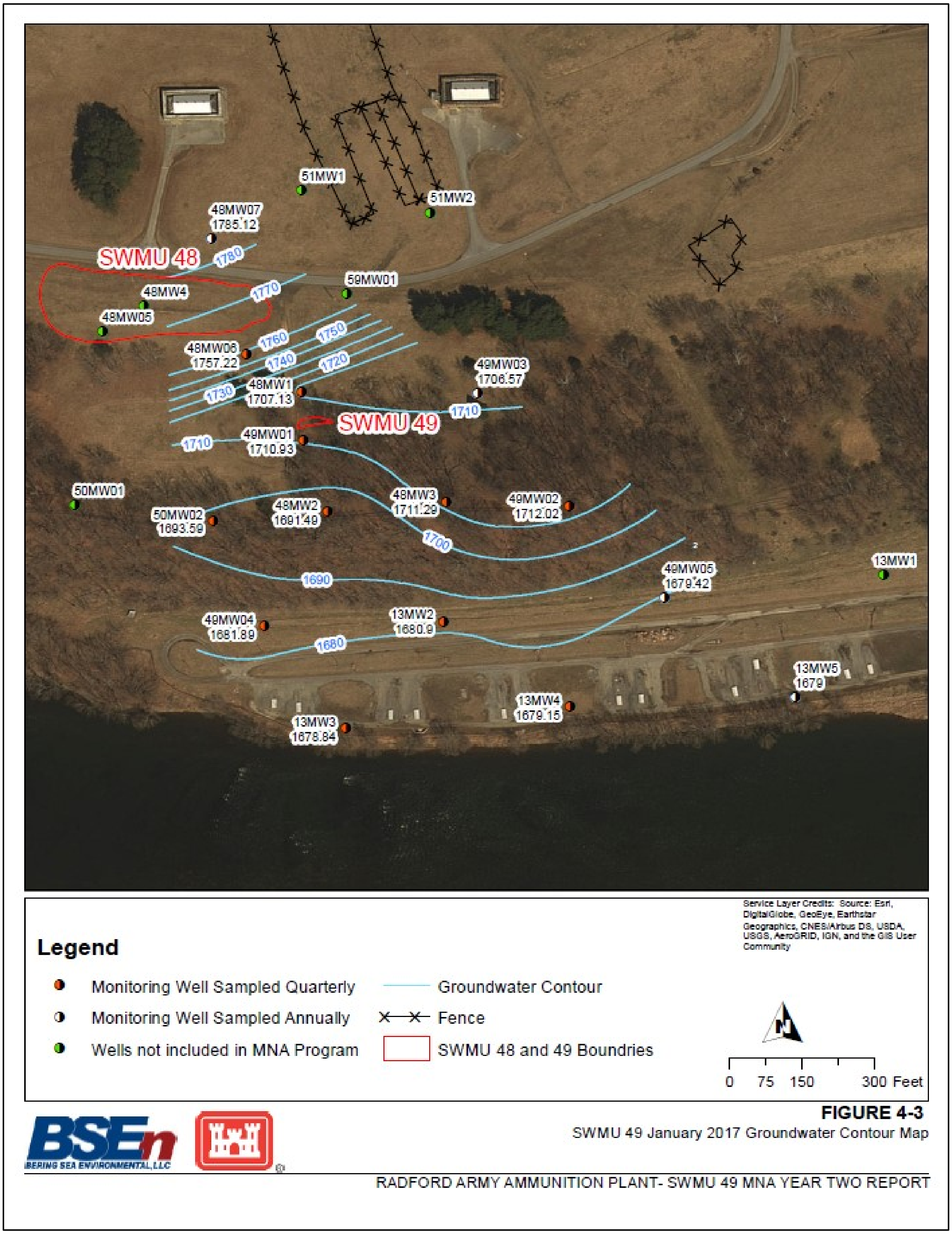
Notes:

amsl = above mean sea level
bgs = below ground surface
BTOC = below top of casing
ft = feet/foot
ppm = parts per million
TOC = Top of casing
DTW = Depth to water
PID = Photoionization detector

4.2.2 Groundwater Sampling

Groundwater samples were collected from all 15 POC monitoring wells from 11 January through 13 January 2017. The sixth quarter monitoring samples were tested for the same analytes as the fifth quarter, which are presented in **Table 4-2**. In addition, the same MNA indicator parameters were collected in the sixth quarter as were collected in the fifth quarter: TOC, dissolved ferrous iron, chloride, nitrate, and sulfate. Water quality parameters collected during low flow sampling included pH, temperature, specific conductance, DO, ORP, and turbidity. These parameters are discussed in Section 6.2 regarding the potential for biodegradation in the groundwater at SWMU 49.

Figure 4-3 SWMU 49 January 2017 Groundwater Contour Map



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Groundwater samples were collected applying the same method and approach used during the fifth quarterly monitoring event: specifically, via low-flow bladder pumps. The sample procedures are provided below.

1. A PID reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sandpack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to insure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI Professional Plus water quality flow cell.
4. Monitoring wells were pumped at a rate of approximately 200 mL/min. Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO, ORP, turbidity, and specific conductivity. Turbidity was measured using a Hach 2100Q turbidity meter, while concentrations of dissolved ferrous iron were tested in the field using a Hach DR900 test kit via Method 8146.
5. **Table 4-5** presents a summary of the final (stabilized) water quality readings for each well from the sixth quarter.

Based on the sixth quarter DO data, aerobic groundwater conditions exist at SWMU 49 (i.e., DO > 1 ppm). The DO levels ranged from a low of 1.37 mg/L at monitoring well 49MW02 to a high of 8.27 mg/L at monitoring well 48MW07. ORP measurements ranged from a low of 63.8 mV in monitoring well 49MW05 to a high of 134.0 mV at monitoring well 50MW02. Measurements of pH ranged from a low of 6.68 SU at monitoring well 13MW4 to a high of 7.84 SU at monitoring well 48MW07. Measurements of specific conductance ranged from a low of 203.4 µS/cm at monitoring well 48MW07 to a high of 878 µS/cm at monitoring well 49MW05. Copies of the CoC forms are provided in **Appendix B-2** along with the raw analytical data packages.

Table 4-5 SWMU 49 Sixth Quarter Water Quality Parameters

Well ID	Temperature (ºC)	Specific Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	ORP (mV)	Turbidity (NTU)	Fe (mg/L)
48MW07	12.1	203.4	7.84	8.27	76.1	1.30	0.00
13MW5	11.4	835	7.08	4.57	74.8	0.67	0.04
49MW03	11.6	378.4	7.58	7.70	81.1	57.4	0.42
49MW05	13.8	878	7.16	2.52	63.8	35.4	0.16
48MW06	12.3	722	7.30	2.51	90.1	43.1	0.29
48MW1	11.8	521.5	7.72	2.82	81.7	2.91	0.00
48MW2	10.0	555.2	7.37	7.36	103.9	35.8	0.40
48MW3	9.8	810	7.17	4.70	81.0	0.40	0.14
49MW01	12.6	502.6	7.58	5.79	66.4	38	0.33
49MW02	9.6	619.2	7.32	1.37	66.4	4.31	0.18
50MW02	11.8	818	6.77	5.29	134.0	78.5	0.45
13MW2	14.3	761	7.04	4.34	71.6	1.41	0.02
13MW3	14.1	599.6	6.89	3.45	103.1	3.45	0.05
13MW4	14.9	539.2	6.68	3.75	88.5	1.56	0.07
49MW04	13.3	660	7.34	1.51	75.9	3.01	0.04

Notes:
°C = degrees Celsius
µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
mV = millivolts
NTU = Nephelometric turbidity unit
ORP = Oxidation-reduction potential
Fe = Ferrous iron

4.2.3 Quality Control Samples

QC samples including a duplicate sample and trip, equipment, and temperature blanks were collected during the sixth monitoring event.

One duplicate sample was collected during the fifth monitoring event at 48MW07 (duplicate as 49TM1) and analyzed for the full suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 48MW2 and analyzed for the full suite of compounds as the parent sample.

One equipment rinse blank sample (011217R1) was collected during the sixth quarter sampling event. The equipment rinse blank was collected by pouring DIUF water over decontaminated sampling equipment into laboratory supplied bottles. The rinse blank was analyzed for the full suite of compounds as the samples.

One IDW purge water sample (49ADW01) was collected and analyzed for pH, COD, and total metals.

Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B-2**.

4.3 Seventh Quarter Groundwater Sampling

Groundwater elevation measurements were collected from all 15 POC monitoring wells, while samples were collected from 11 of the 15 wells. The seventh quarter of groundwater sampling was conducted 11 April through 13 April 2017. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.3.1 Groundwater Elevation Measurements

Water level elevations were collected during each second year quarterly event from the 15 monitoring wells at SWMU 49 prior to the collection of groundwater samples. **Table 4-6** provides the measured depth to water levels (from the TOC) and groundwater elevations amsl collected on 10 April 2017. **Figure 4-4** presents a groundwater elevation contour map developed from the elevation data collected during this quarterly monitoring event.

Table 4-6 SWMU 49 Seventh Quarter Groundwater Elevations

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (BTOC)	Elevation (TOC)	Water Level (ft amsl)	PID Readings (ppm)
48MW07	62 - 82	20	82	46.81	1833.69	1786.88	PID = 0.0
13MW5	14 - 25	19	25	16.19	1696.40	1680.21	PID = 0.0
49MW03	77 - 117	40	117	104.93	1811.82	1706.89	PID = 0.0
49MW05	16 - 37	19	36.8	19.45	1699.74	1680.29	PID = 0.0
48MW06	58 - 78	20	78	65.35	1822.85	1757.50	PID = 0.0
48MW1	110 - 140	30	140	105.89	1816.42	1710.53	PID = 0.0
48MW2	113 - 134	20	133.7	124.24	1816.27	1692.03	PID = 0.0
48MW3	100 - 120	20	120	97.56	1808.56	1711.00	PID = 0.0
49MW01	90 - 121	31	121	115.63	1826.42	1710.79	PID = 0.0
49MW02	103 - 133	30	133	94.35	1806.29	1711.94	PID = 0.0
50MW02	89 - 119	30	119	115.35	1809.63	1694.28	PID = 0.0
13MW2	19 - 29	10	29	20.98	1702.62	1681.64	PID = 0.0
13MW3	9 - 19	10	19	15.09	1694.47	1679.38	PID = 0.0
13MW4	14 - 24	10	24	16.36	1696.40	1680.04	PID = 0.0
49MW04	50 - 70	20	72	20.53	1703.00	1682.47	PID = 0.0

Notes:

amsl = above mean sea level
bgs = below ground surface
BTOC = below top of casing
ft = feet/foot
ppm = parts per million
TOC = Top of casing
DTW = Depth to water
PID = Photoionization detector

4.3.2 Groundwater Sampling

Groundwater samples were collected from 11 of the 15 POC monitoring wells from 11 April through 13 April 2017. The seventh quarter monitoring samples were tested for the same analytes as the fifth quarter, which are presented in **Table 4-2**. In addition, the following MNA indicator parameters were collected: TOC, dissolved ferrous iron, chloride, nitrate, and sulfate. Water quality parameters collected during low flow sampling included pH, temperature, specific conductance, DO, ORP, and turbidity. These parameters are discussed in Section 6.2 regarding the potential for biodegradation in the groundwater at SWMU 49.

Groundwater samples were collected applying the same method and approach used during the fifth quarterly monitoring event: specifically, via low-flow bladder pumps. The sample procedures are provided below.

1. A PID reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sandpack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to insure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI Professional Plus water quality flow cell.
4. Monitoring wells were pumped at a rate of approximately 200 mL/min. Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO, ORP, turbidity, and specific conductivity. Turbidity was measured using a Hach 2100Q turbidity meter, while concentrations of dissolved ferrous iron were tested in the field using a Hach DR900 test kit via Method 8146.
5. **Table 4-7** presents a summary of the final (stabilized) water quality readings for each well from the seventh quarter.

Based on the seventh quarter DO data, aerobic groundwater conditions exist at SWMU 49 (i.e., DO > 1 ppm) at all but one monitoring well (49MW04). The DO levels ranged from a low of 0.94 mg/L at monitoring well 49MW04 to a high of 6.56 mg/L at monitoring well 48MW02. ORP measurements ranged from a low of 97.4 mV in monitoring well 48MW3 to a high of 138.1 mV at monitoring well 50MW02. Measurements of pH ranged from a low of 6.84 SU at monitoring well 13MW4 to a high of 7.65 SU at monitoring well 48MW1. Measurements of specific conductance ranged from a low of 441 µS/cm at monitoring well 49MW01 to a high of 730 µS/cm at monitoring well 48MW06. Copies of the CoC forms are provided in **Appendix B-2** along with the raw analytical data packages.

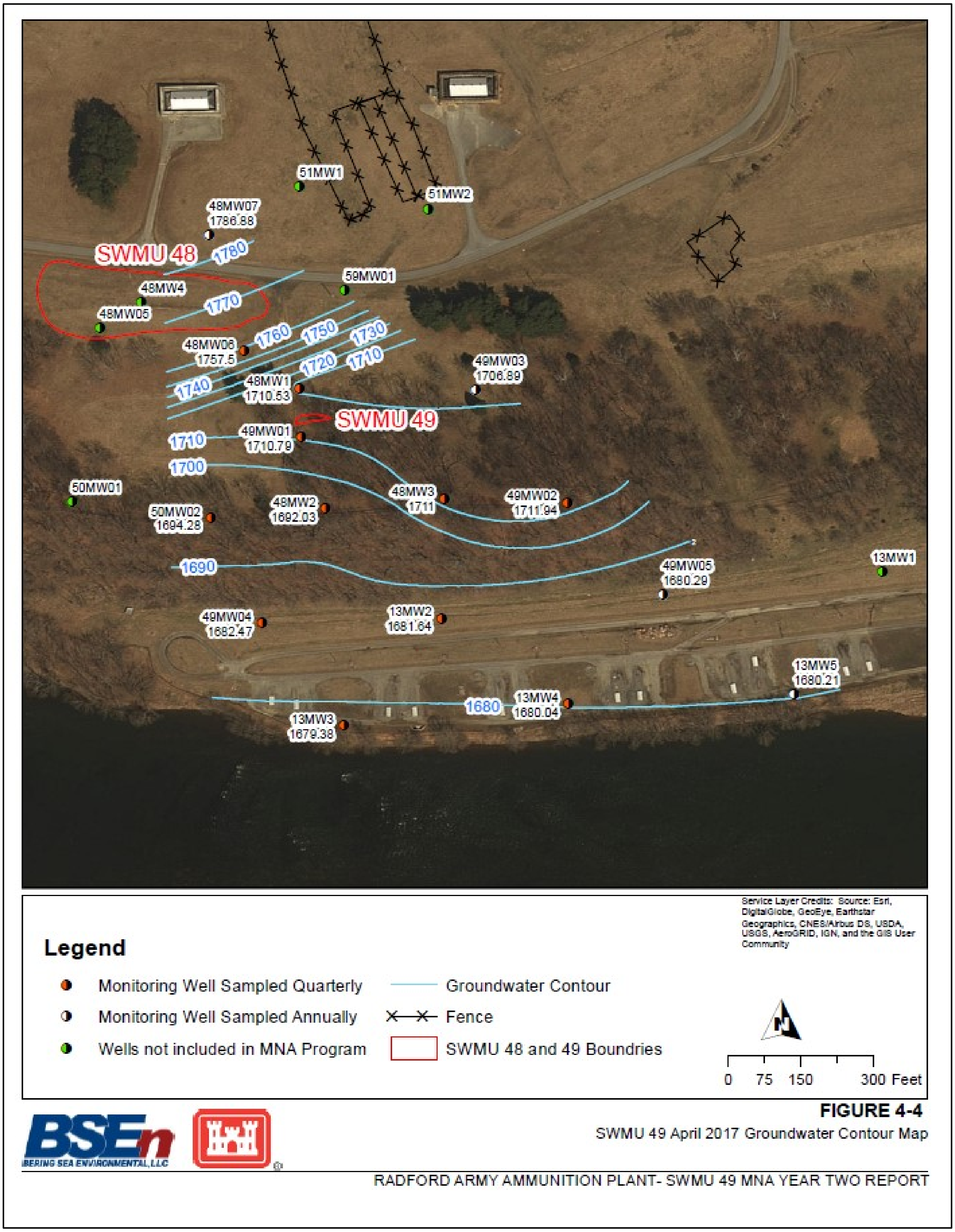
Table 4-7 SWMU 49 Seventh Quarter Water Quality Parameters

Well ID	Temperature (ºC)	Specific Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	ORP (mV)	Turbidity (NTU)	Fe (mg/L)
48MW06	14.1	730	7.15	2.12	124.6	39.1	0.30
48MW1	12.8	475	7.65	2.72	116.7	1.47	0.06
48MW2	13.3	482	7.42	6.56	115.0	17.1	0.15
48MW3	12.5	700	7.20	3.57	97.4	0.57	0.03
49MW01	13.0	441	7.63	5.16	131.3	18.7	0.26
49MW02	12.7	526	7.37	1.37	107.4	3.84	0.17
50MW02	13.0	680	7.02	3.09	138.1	34.2	1.83
13MW2	15.1	680	7.05	5.63	105.1	1.76	0.05
13MW3	14.4	567	6.94	3.94	109.2	1.14	0.03
13MW4	14.1	445	6.84	5.36	105.7	0.52	0.00
49MW04	14.9	610	7.31	0.94	135.3	1.35	0.08

Notes:

°C = degrees Celsius
µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
mV = millivolts
NTU = Nephelometric turbidity unit
ORP = Oxidation-reduction potential
Fe = Ferrous iron

Figure 4-4 SWMU 49 April 2017 Groundwater Contour Map



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4.3.3 Quality Control Samples

QC samples including a duplicate sample and trip, equipment, and temperature blanks were collected during the seventh quarterly monitoring event.

One duplicate sample was collected during the seventh monitoring event at 48MW06 (duplicate as 49TM1) and analyzed for the full suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 48MW3 and analyzed for the full suite of compounds as the parent sample.

One equipment rinse blank sample (041317R1) was collected during the seventh quarter sampling event. The equipment rinse blank was collected by pouring DIUF water over decontaminated sampling equipment into laboratory supplied bottles. The rinse blank was analyzed for the full suite of compounds as the samples.

One IDW purge water sample (49ADW01) was collected and analyzed for pH, COD, and total metals.

Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B-2**.

4.4 Eighth Quarter Groundwater Sampling

Groundwater elevation measurements were collected from all 15 POC monitoring wells, while samples were collected from 11 of the 15 wells. The eighth quarter of groundwater sampling was conducted 11 July through 13 July 2017. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.4.1 Groundwater Elevation Measurements

Water level elevations were collected during each second year quarterly event from the 15 monitoring wells at SWMU 49 prior to the collection of groundwater samples. **Table 4-8** provides the measured depth to water levels (from the TOC) and groundwater elevations amsl collected on 10 July 2017. **Figure 4-5** presents a groundwater elevation contour map developed from the elevation data collected during this quarterly monitoring event.

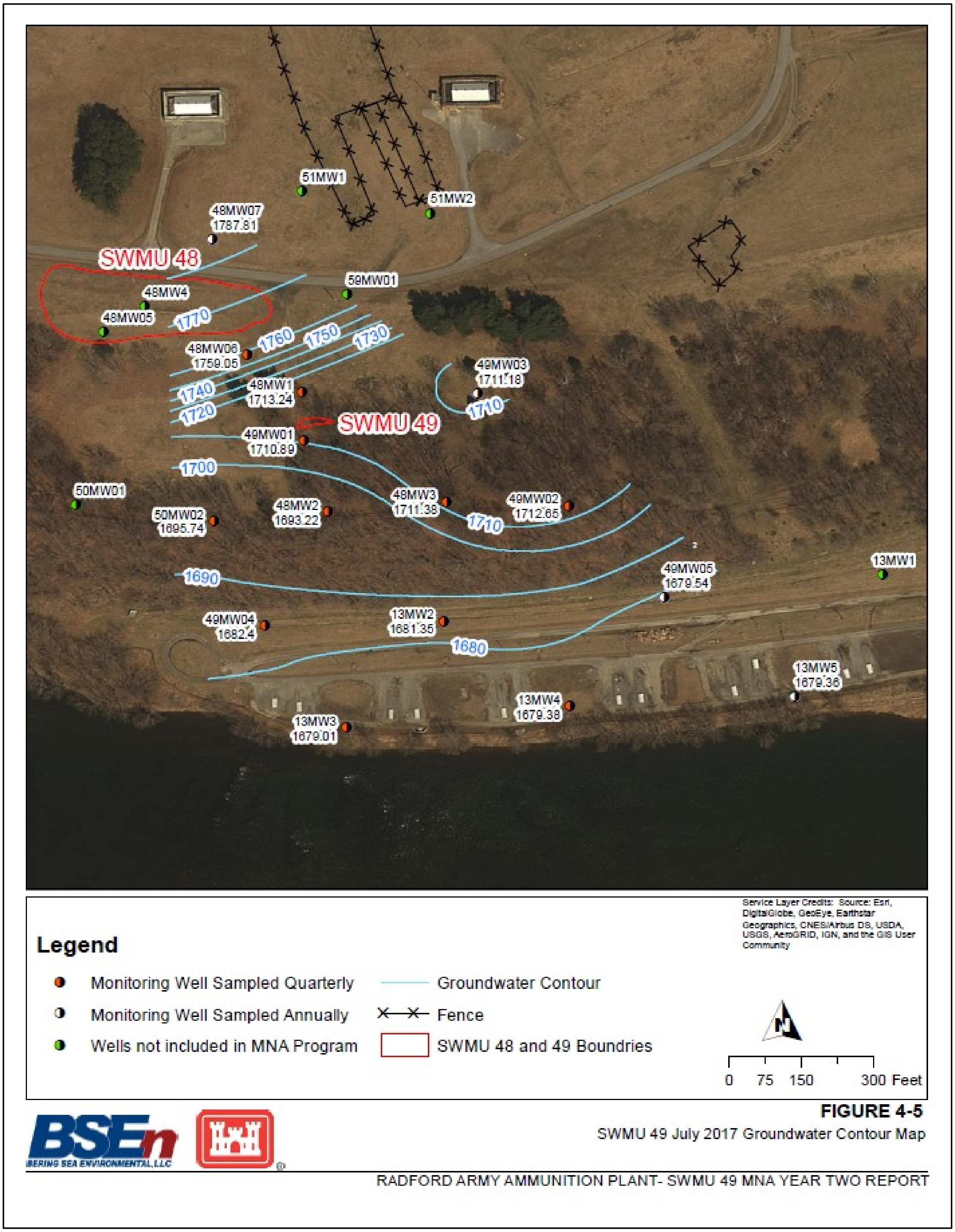
Table 4-8 SWMU 49 Eighth Quarter Groundwater Elevations

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (BTOC)	Elevation (TOC)	Water Level (ft amsl)	PID Readings (ppm)
48MW07	62 - 82	20	82	45.88	1833.69	1787.81	PID = 0.0
13MW5	14 - 25	19	25	17.04	1696.40	1679.36	PID = 0.0
49MW03	77 - 117	40	117	100.64	1811.82	1711.18	PID = 0.0
49MW05	16 - 37	19	36.8	20.20	1699.74	1679.54	PID = 0.0
48MW06	58 - 78	20	78	63.80	1822.85	1759.05	PID = 0.0
48MW1	110 - 140	30	140	103.18	1816.42	1713.24	PID = 0.0
48MW2	113 - 134	20	133.7	123.05	1816.27	1693.22	PID = 0.0
48MW3	100 - 120	20	120	97.18	1808.56	1711.38	PID = 0.0
49MW01	90 - 121	31	121	115.53	1826.42	1710.89	PID = 0.0
49MW02	103 - 133	30	133	93.64	1806.29	1712.65	PID = 0.0
50MW02	89 - 119	30	119	113.89	1809.63	1695.74	PID = 0.0
13MW2	19 - 29	10	29	21.27	1702.62	1681.35	PID = 0.0
13MW3	9 - 19	10	19	15.46	1694.47	1679.01	PID = 0.0
13MW4	14 - 24	10	24	17.02	1696.40	1679.38	PID = 0.0
49MW04	50 - 70	20	72	20.60	1703.00	1682.40	PID = 0.0

Notes:

amsl = above mean sea level
bgs = below ground surface
BTOC = below top of casing
ft = feet/foot
ppm = parts per million
TOC = Top of casing
DTW = Depth to water
PID = Photoionization detector

Figure 4-5 SWMU 49 July 2017 Groundwater Contour Map



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4.4.2 Groundwater Sampling

Groundwater samples were collected from 11 of the 15 POC monitoring wells from 11 July through 13 July 2017. The eighth quarter monitoring samples were tested for the same analytes as the fifth quarter, which are presented in **Table 4-2**. In addition, the following MNA indicator parameters were collected: TOC, dissolved ferrous iron, chloride, nitrate, and sulfate. Water quality parameters collected during low flow sampling included pH, temperature, specific conductance, DO, ORP, and turbidity. These parameters are discussed in Section 6.2 regarding the potential for biodegradation in the groundwater at SWMU 49.

Groundwater samples were collected applying the same method and approach used during the fifth quarterly monitoring event: specifically, via low-flow bladder pumps. The sample procedures are provided below.

1. A PID reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sandpack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to insure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI Professional Plus water quality flow cell.
4. Monitoring wells were pumped at a rate of approximately 200 mL/min on average. Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO, ORP, turbidity, and specific conductivity. Turbidity was measured using a Hach 2100Q turbidity meter, while concentrations of dissolved ferrous iron were tested in the field using a Hach DR900 test kit via Method 8146.
5. **Table 4-9** presents a summary of the final (stabilized) water quality readings for each well from the sixth quarter.

Based on the eighth quarter DO data, aerobic groundwater conditions exist at SWMU 49 (i.e., DO >1 ppm) at all but two monitoring well (49MW02 and 48MW06). The DO levels ranged from a low of 0.01 mg/L at monitoring well 48MW06 to a high of 6.37 mg/L at monitoring well 48MW2. ORP measurements ranged from a low of 26.8 mV in monitoring well 48MW06 to a high of 121.5 mV at monitoring well 49MW01. Measurements of pH ranged from a low of 6.92 SU at monitoring well 13MW4 to a high of 7.72 SU at monitoring well 48MW1. Measurements of specific conductance ranged from a low of .90 µS/cm at monitoring well 48MW06 to a high of 760 µS/cm at monitoring well 48MW3.

Table 4-9 SWMU 49 Eighth Quarter Water Quality Parameters

Well ID	Temperature (ºC)	Specific Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	ORP (mV)	Turbidity (NTU)	Fe (mg/L)
48MW06	14.5	0.90	7.08	0.01	26.8	21.2	0.23
48MW1	14.2	499.0	7.72	3.70	94.1	9.11	0.13
48MW2	14.1	532.7	7.54	6.37	115.0	675	2.31
48MW3	13.8	760	7.27	3.12	115.7	0.40	0.11
49MW01	14.2	487.2	7.57	4.30	121.5	18.7	0.21
49MW02	14.6	584.0	7.38	0.67	102.7	3.93	0.16
50MW02	14.2	702	7.14	2.64	108.0	6.53	0.19
13MW2	15.3	751	7.14	6.04	93.0	3.13	0.15
13MW3	18.9	615	7.10	4.53	98.3	0.52	0.12
13MW4	14.8	445.4	6.92	3.02	91.1	0.75	0.06
49MW04	14.3	664	7.39	4.29	114.3	2.35	0.10

Notes:
°C = degrees Celsius
µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
mV = millivolts
NTU = Nephelometric turbidity unit
ORP = Oxidation-reduction potential
Fe = Ferrous iron

4.4.3 Quality Control Sampling

QC samples including a duplicate sample and trip, equipment, and temperature blanks were collected during the eighth monitoring event.

Two duplicate samples were collected during the eighth monitoring event at 48MW06 (duplicate as 49TM1) and 49MW02 (duplicate 49TM2) and analyzed for the full suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 48MW3 and analyzed for the full suite of compounds as the parent sample.

One equipment rinse blank sample (071317R1) was collected during the eighth quarter sampling event. The equipment rinse blank was collected by pouring DIUF water over decontaminated sampling equipment and into laboratory supplied bottles. The rinse blank was analyzed for the full suite of compounds as the samples.

One IDW purge water sample (49ADW01) was collected and analyzed for pH, COD, and total metals.

Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B-2**.

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5.0 Chemical Analytical Results

5.1 Selection of Comparison Criteria

The chemical data collected during the second year MNA groundwater monitoring investigation were compared to RGs selected in the approved Draft SWMU 48/49 RFI Report (CB&I, 2014a). **Tables 5-1** through **5-8** present the analytical results and summaries of the fifth through eighth quarterly monitoring data, including number of results that exceeded the RGs, frequency of detection, the minimum and maximum detected concentrations, and the location of the maximum concentration.

5.2 Fifth Quarter Groundwater Results

Eleven groundwater monitoring wells were sampled during this quarterly monitoring event including wells 13MW2, 13MW3, 13MW4, 48MW1, 48MW2, 48MW3, 48MW06, 49MW01, 49MW02, 49MW04, and 50MW02, while a duplicate sample was collected from monitoring well 48MW3 (duplicate as 49TM01). Sample locations are provided in **Figure 4-1**.

Samples were submitted for TCL VOC, dissolved gases (methane, ethane, and ethene), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-1**, while the results are presented in **Table 5-2**. The potential for biodegradation in the groundwater at SWMU 49 is discussed in Section 6.2.

TCL VOCs

Six VOCs were detected in groundwater samples including 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), CT, chloroform, cis-1,2-DCE, and TCE. Nine monitoring wells had one or more detections of the VOCs listed above. Monitoring wells 13MW2 and 49MW02 did not have detected concentrations of VOCs.

The VOC 1,1,1-TCA was detected at monitoring wells 48MW1 and 50MW02 at estimated concentrations ranging from a low of 0.22 µg/L (48MW1) to a high of 0.23 µg/L (50MW02). An RG for 1,1,1-TCA has not been established for SWMU 49. However, the USEPA MCL for 1,1,1-TCA is 200 µg/L (USEPA, 2011).

The VOC 1,1-DCA was detected at monitoring wells 48MW1, 48MW06, and 50MW02 at concentrations ranging from an estimated value of 0.33 µg/L (50MW02) to a high of 1.5 µg/L (48MW06). An RG for 1,1-DCA has not been established for SWMU 49. There is no USEPA MCL for 1,1-DCA (USEPA, 2011); however, the Tapwater RSL is 2.8 µg/L (USEPA, 2017).

The VOC CT was detected at six monitoring wells including 13MW3, 48MW2, 48MW3 (and field duplicate 49TM01), 49MW01, 49MW04, and 50MW02. Two wells contained CT concentrations that exceeded the RG of 5 µg/L; monitoring wells 48MW2 (42 µg/L) and 48MW3 (63 µg/L). CT concentrations also exceeded the RG in the field duplicate 49TM01 (62 µg/L), collected at 48MW3. The range of concentrations detected during this quarter went from a low of an estimated value of 0.86 µg/L (49MW04) to a high of 63 µg/L (48MW3). The CT plume is shown on **Figure 5-1**. Both the CT and TCE isopleths (included as Figures 5-1 through 5-8) were derived by creating a spline interpolated continuous surface based on limited observed values collected in the field. This surface model was executed using default values in most cases and forced to cover an area inclusive of all wells using an extent polygon to define the area of interest. The results of the spline were then reclassified into predefined bins, one series for each chemical, to create discrete regions of concentration. The resulting reclassified raster was then converted to vector polygons. The results of the automated processing were then reviewed by subject knowledge experts and then manually adjusted to accurately represent ground conditions.

Chloroform was detected in six monitoring wells including 48MW2, 48MW3 (and associated field duplicate 49TM01), 49MW01, 50MW02, 49MW04, and 13MW3. Concentrations ranged from an estimated value of 0.21 µg/L (49MW01) to a high of 7.3 µg/L (48MW3). An RG for chloroform has not been established for SWMU 49. However, the USEPA MCL for chloroform is 80 µg/L (USEPA, 2011).

The VOC cis-1,2-DCE was detected in three monitoring wells including 48MW1, 48MW06, and 50MW02 at concentrations ranging from an estimated value of 0.25 µg/L (48MW1) to a high of 2.2 µg/L (48MW06). An RG for cis-1,2-DCE has not been established for SWMU 49. However, the USEPA MCL for cis-1, 2-DCE is 70 µg/L (USEPA, 2011).

The VOC TCE was detected at seven monitoring wells including 13MW3, 13MW4, 48MW1, 48MW2, 48MW3 (and associated field duplicate 49TM01), 48MW06, and 50MW02. Monitoring well 48MW3 (and associated field duplicate 49TM01) contained a concentration of TCE that exceeded the RG of 5 µg/L. The range of concentrations detected during this quarter went from a low of an estimated value of 0.58 µg/L (13MW3) to a high of 9.2 µg/L (48MW3). The TCE plume is shown on **Figure 5-2**.

Miscellaneous Analytes

Groundwater samples were also analyzed for MNA indicators (TOC, dissolved ferrous iron, dissolved gases, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed levels of TOC in the 11 monitoring wells ranged from non-detect in nine monitoring wells to an estimated high concentration of 0.78 mg/L (48MW06). Dissolved ferrous iron levels ranged from a low of 0.0 mg/L (non-detect) to a high of 0.92 mg/L (49MW01). Chloride concentrations ranged from a low of 1.9 mg/L (48MW2) to a high of 10 mg/L (48MW06). Detected concentrations of nitrate ranged from an estimated low of 0.15 mg/L (13MW2) to a high of 6.9 mg/L (49TM01, field duplicate of 48MW3). Sulfate concentrations ranged from a low of 0.0 (non-detect) mg/L (49MW01) to a high of 95 mg/L (13MW3). Methane, ethane, and ethene went largely undetected during this quarterly monitoring event, with the exception of the samples collected from 13MW3 and 13MW4. Sample 13MW3 had an estimated methane concentration of 0.42 µg/L, and sample 13MW4 had an estimated concentration of 0.31 µg/L. **Table 5-2** presents the MNA indicator parameters sample results.

Table 5-1 SWMU 49 Summary of Fifth Quarter Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples[1]	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs								
1,1,1-Trichloroethane	**µg/L**	**na**	**na**	2	12	0.22	0.23	50MW02
1,1-Dichloroethane	**µg/L**	**na**	**na**	3	12	0.33	1.5	48MW06
Acetone	**µg/L**	**na**	**na**	0	12	ND	ND	na
Bromoform	**µg/L**	**na**	**na**	0	12	ND	ND	na
Bromomethane	**µg/L**	**na**	**na**	0	12	ND	ND	na
Carbon tetrachloride	**µg/L**	**5**	3	7	12	0.86	63	48MW3
Chloroform	**µg/L**	**na**	**na**	7	12	0.21	7.3	48MW3
cis-1,2-Dichloroethene	**µg/L**	**na**	**na**	3	12	0.25	2.2	48MW06
Dibromochloromethane	**µg/L**	**na**	**na**	0	12	ND	ND	na
Ethylbenzene	**µg/L**	**na**	**na**	0	12	ND	ND	na
m- & p-Xylene	**µg/L**	**na**	**na**	0	12	ND	ND	na
o-Xylene	**µg/L**	**na**	**na**	0	12	ND	ND	na
Tetrachloroethene	**µg/L**	**na**	**na**	0	12	ND	ND	na
Trichloroethene	**µg/L**	**5**	2	8	12	0.58	9.2	48MW3
Misc.								
Chloride	**mg/L**	**na**	**na**	12	12	1.9	10	48MW06
Ethane	**µg/L**	**na**	**na**	0	12	ND	ND	na
Ethene	**µg/L**	**na**	**na**	0	12	ND	ND	na
Methane	**µg/L**	**na**	**na**	2	12	0.31	0.42	13MW3
Nitrate (as N)	**mg/L**	**na**	**na**	12	12	0.15	6.9	49TM01 (field duplicate of 48MW3)
Sulfate	**mg/L**	**na**	**na**	11	12	3.8	95	13MW3
Total Organic Carbon	**mg/L**	**na**	**na**	2	12	0.51	0.78	48MW06

Notes:
1 = Includes one Duplicate Sample
µg/L = micrograms per liter
mg/L = milligrams per liter
na = not applicable
ND = non-detect
RG = Remedial Goal

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Table 5-2 SWMU 49 Detected Analytes In Fifth Quarter Groundwater Samples

Sample ID			48MW06					48MW1					48MW2					48MW3					49TM01 (Field Duplicate of 48MW3)					49MW01				
Date Collected			10/14/2016					10/14/2016					10/13/2016					10/13/2016					10/13/2016					10/13/2016				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.5	U	U	1	0.21	0.22	J	J	1	0.21	0.5	U	U	1	0.21	0.5	U	U	1	0.21	0.5	U	U	1	0.21	0.5	U	U	1	0.21
1,1-Dichloroethane	ug/L	na	1.5			1	0.2	0.38	J	J	1	0.2	0.5	U	U	1	0.2	0.5	U	U	1	0.2	0.5	U	U	1	0.2	0.5	U	U	1	0.2
Acetone	ug/L	na	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5
Bromoform	ug/L	na	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22
Bromomethane	ug/L	na	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5
Carbon tetrachloride	ug/L	5	0.5	U	U	1	0.23	0.5	U	U	1	0.23	**42**			1	0.23	**63**			1	0.23	**62**			1	0.23	2.7			1	0.23
Chloroform	ug/L	na	0.25	U	U	0.5	0.15	0.25	U	U	0.5	0.15	3.3			0.5	0.15	7.3			0.5	0.15	6.9			0.5	0.15	0.21	J	J	0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	2.2			1	0.25	0.25	J	J	1	0.25	0.5	U	U	1	0.25	0.5	U	U	1	0.25	0.5	U	U	1	0.25	0.5	U	U	1	0.25
Dibromochloromethane	ug/L	na	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19
Ethylbenzene	ug/L	na	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22
m & p-Xylene	ug/L	na	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5
o-Xylene	ug/L	na	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24
Tetrachloroethene	ug/L	na	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3
Trichloroethene	ug/L	5	1.9			1	0.21	0.97	J	J	1	0.21	2.8			1	0.21	**9.2**			1	0.21	**8.8**			1	0.21	0.5	U	U	1	0.21
Misc.																																
Ethane	ug/L	na	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4
Ethene	ug/L	na	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5
Methane	ug/L	na	0.6	U	U	0.7	0.3	0.6	U	U	0.7	0.3	0.6	U	U	0.7	0.3	0.6	U	U	0.7	0.3	0.6	U	U	0.7	0.3	0.6	U	U	0.7	0.3
Chloride	mg/L	na	10			4	1.1	2.8	J	J	4	1.1	1.9	J	J	4	1.1	3.3	J	J	4	1.1	3	J	J	4	1.1	6			4	1.1
Nitrate (as N)	mg/L	na	1.3	H	J	0.4	0.08	0.72	H		0.4	0.08	0.72			0.4	0.08	6.6			0.4	0.08	6.9			0.4	0.08	0.4			0.4	0.08
Sulfate	mg/L	na	76			20	5.2	37			10	2.6	3.8	J	J	5	1.3	28			5	1.3	28			5	1.3	2.5	U	U	5	1.3
Total Organic Carbon	mg/L	na	0.78	J	J	3	0.5	1.5	U	U	3	0.5	1.5	U	U	3	0.5	1.5	U	U	3	0.5	1.5	U	U	3	0.5	1.5	U	U	3	0.5
MNA																																
Dissolved Fe^{2+}	mg/L	na	0.90					0.00					0.21					0.00					0.00					0.92				

Table 5-2 SWMU 49 Detected Analytes In Fifth Quarter Groundwater Samples (Continued)

Sample ID			**49MW02**					**50MW02**					**13MW2**					**13MW3**					**13MW4**					**49MW04**				
Date Collected			**10/13/2016**					**10/13/2016**					**10/12/2016**					**10/12/2016**					**10/12/2016**					**10/12/2016**				
Analyte	**Units**	**Remedial Goals [(1)]**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.5	U	U	1	0.21	0.23	J	J	1	0.21	0.5	U	U	1	0.21	0.5	U	U	1	0.21	0.5	U	U	1	0.21	0.5	U	U	1	0.21
1,1-Dichloroethane	ug/L	na	0.5	U	U	1	0.2	0.33	J	J	1	0.2	0.5	U	U	1	0.2	0.5	U	U	1	0.2	0.5	U	U	1	0.2	0.5	U	U	1	0.2
Acetone	ug/L	na	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5	10	U	U	20	5
Bromoform	ug/L	na	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22
Bromomethane	ug/L	na	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5
Carbon tetrachloride	ug/L	5	0.5	U	U	1	0.23	1.8			1	0.23	0.5	U	U	1	0.23	2.3			1	0.23	0.5	U	U	1	0.23	0.86	J	J	1	0.23
Chloroform	ug/L	na	0.25	U	U	0.5	0.15	0.26	J	J	0.5	0.15	0.25	U	U	0.5	0.15	0.68			0.5	0.15	0.25	U	U	0.5	0.15	0.25	U	U	0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	0.5	U	U	1	0.25	0.48	J	J	1	0.25	0.5	U	U	1	0.25	0.5	U	U	1	0.25	0.5	U	U	1	0.25	0.5	U	U	1	0.25
Dibromochloromethane	ug/L	na	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19	0.5	U	U	1	0.19
Ethylbenzene	ug/L	na	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22	0.5	U	U	1	0.22
m & p-Xylene	ug/L	na	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5	1	U	U	2	0.5
o-Xylene	ug/L	na	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24	0.5	U	U	1	0.24
Tetrachloroethene	ug/L	na	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3	0.5	U	U	1	0.3
Trichloroethene	ug/L	5	0.5	U	U	1	0.21	1.7			1	0.21	0.5	U	U	1	0.21	0.58	J	J	1	0.21	2.1			1	0.21	0.5	U	U	1	0.21
Misc.																																
Ethane	ug/L	na	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4	0.7	U	U	0.8	0.4
Ethene	ug/L	na	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5	1	U	U	1.1	0.5
Methane	ug/L	na	0.6	U	U	0.7	0.3	0.6	U	U	0.7	0.3	0.6	U	U	0.7	0.3	0.42	J	J	0.7	0.3	0.31	J	J	0.7	0.3	0.6	U	U	0.7	0.3
Chloride	mg/L	na	2.1	J	J	4	1.1	7.1			4	1.1	3.7	J	J	4	1.1	3.4	J	J	4	1.1	4.7			4	1.1	6			4	1.1
Nitrate (as N)	mg/L	na	0.17	J	J	0.4	0.08	2.1			0.4	0.08	0.15	J	J	0.4	0.08	0.54			0.4	0.08	0.7			0.4	0.08	0.48			0.4	0.08
Sulfate	mg/L	na	19			5	1.3	63			5	1.3	43			5	1.3	95			25	6.5	50	M	J	5	1.3	55			5	1.3
Total Organic Carbon	mg/L	na	1.5	U	U	3	0.5	1.5	U	U	3	0.5	0.51	J	J	3	0.5	1.5	U	U	3	0.5	1.5	U	U	3	0.5	1.5	U	U	3	0.5
MNA																																
Dissolved Fe^{2+}	mg/L	na	0.27					0.06					0.04					0.00					0.01					0.00				

Notes:
(1) Remedial Goals developed in Draft SWMU 48/49 RFI Report (CB&I, 2014a).
Exceedances denoted by bold font.
mg/L = milligrams per liter (parts per million)
µg/L = micrograms per liter (parts per billion)
RL = Reporting Limit
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 49
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Data Qualifiers

J = Estimated value.
U = Analyte concentration was not above the detection level.

Figure 5-1 SWMU 49 Carbon Tetrachloride Isopleths – October 2016

FIGURE 5-1
SWMU 49 Carbon Tetrachloride Isopleths – October 2016

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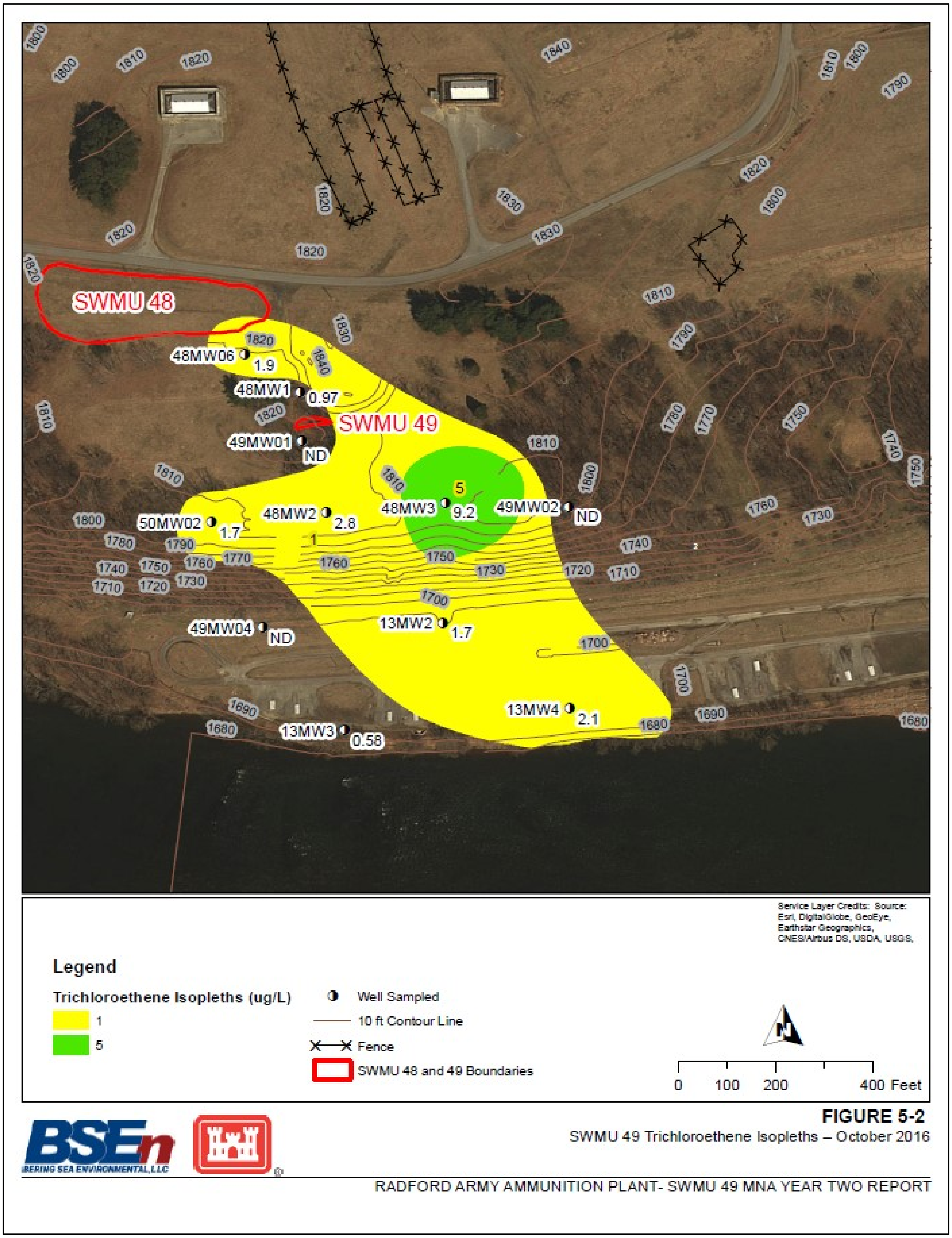
Figure 5-2 SWMU 49 Trichloroethene Isopleths – October 2016



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5.3 Sixth Quarter Groundwater Results

The sixth quarter monitoring event served as the annual event for the second year of MNA sampling. As such, all 15 monitoring wells were sampled including wells 13MW2, 13MW3, 13MW4, 13MW5, 48MW1, 48MW2, 48MW3, 48MW06, 48MW07, 49MW01, 49MW02, 49MW3, 49MW04, 49MW5, and 50MW02. A duplicate sample was collected from monitoring well 48MW07 (duplicate as 49TM1). Sample locations are provided in **Figure 4-1**. (Note: both annual and quarterly wells were sampled during this monitoring event.).

Samples were submitted for TCL VOC, dissolved gases (methane, ethane, and ethene), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-3**, while the results are presented in **Table 5-4**. The potential for biodegradation in the groundwater at SWMU 49 is discussed in Section 6.2.

TCL VOCs

Seven VOCs were detected in groundwater samples including 1,1,1-TCA, 1,1-DCA, CT, chloroform, cis-1,2-DCE, PCE, and TCE. Eight monitoring wells had one or more detected concentrations of the VOCs listed above. Monitoring wells 13MW2, 13MW5, 48MW07 (up gradient well), 49MW02, 49MW03, and 49MW05 did not have detected concentrations of VOCs.

The VOC 1,1,1-TCA was detected at monitoring wells 48MW1 and 48MW06 at estimated concentrations of 0.28 µg/L and .32 µg/L, respectively. The concentration observed at 48MW1 increased slightly from the fifth quarter concentration. An RG for 1,1,1-TCA has not been established for SWMU 49. However, the USEPA MCL for 1,1,1-TCA is 200 µg/L (USEPA, 2011).

The VOC 1,1-DCA was detected at monitoring wells 48MW1, 48MW06, and 50MW02 at concentrations ranging from an estimated value of 0.25 µg/L (50MW02) to a high of 2.4 µg/L (48MW06). The concentrations in these three wells increased slightly from the fifth quarter monitoring event. An RG for 1,1-DCA has not been established for SWMU 49. There is no USEPA MCL for 1,1-DCA (USEPA, 2011); however, the Tapwater RSL is 2.8 µg/L (USEPA, 2017).

The VOC CT was detected at six monitoring wells including 48MW2, 48MW3, 49MW01, 50MW02, 13MW3, and 49MW04. Two wells contained CT concentrations that exceeded the RG of 5 µg/L including monitoring wells 48MW2 (49 µg/L) and 48MW3 (68 µg/L); the concentrations in these two wells increased slightly from the fifth quarter monitoring event. These wells had elevated concentrations that exceeded the RG during the fifth quarterly monitoring event. The range of concentrations detected during this quarter went from a low of an estimated value of 0.58 µg/L (50MW02) to a high of 68 µg/L (48MW3) (**Figure 5-3**). Compared to the fifth quarter monitoring results, the detected concentrations of CT decreased in four wells (48MW3, 49MW01, 50MW02, and 49MW04), and increased slightly in two wells (48MW2 and 13MW3) during this quarterly event.

Chloroform was detected in five monitoring wells including 48MW2, 48MW3, 49MW01, 50MW02, and 13MW3. Concentrations ranged from an estimated value of 0.16 µg/L (50MW02) to a high of 7.7 µg/L (48MW3). Compared to the fifth quarter monitoring results, the detected concentrations of chloroform decreased in two wells (50MW02 and 13MW3), and increased slightly in three wells (48MW2, 48MW3, and 49MW01) during this quarterly event. An RG for chloroform has not been established for SWMU 49. However, the USEPA MCL for chloroform is 80 µg/L (USEPA, 2011).

The VOC cis-1,2-DCE was detected in two monitoring wells including 48MW1 and 48MW06 at an estimated concentration of 0.64 µg/L and 3.2 µg/L, respectively. This VOC was detected in 50MW02 (.48 µg/L) during the fifth quarter monitoring event, but not in this sixth quarterly monitoring event. Concentrations in 48MW1 and 48MW06 slightly increased during this quarterly event. An RG for cis-1,2-DCE has not been established for SWMU 49. However, the USEPA MCL for cis-1, 2-DCE is 70 µg/L (USEPA, 2011).

PCE was detected in monitoring well 48MW06 at an estimated concentration of 0.4 µg/L. There were no detections of PCE during the fifth quarter monitoring event. An RG for PCE has not been established for SWMU 49. However, the USEPA MCL for PCE is 5 µg/L (USEPA, 2011).

The VOC TCE was detected at seven monitoring wells including 13MW3, 13MW4, 48MW1, 48MW2, 48MW3, 48MW06 and 50MW02. Monitoring well 48MW3 contained a concentration of TCE that exceeded the RG of 5 µg/L. The range of concentrations detected during this quarter went from a low of an estimated value of 0.36 µg/L (13MW3) to a high of 9.8 µg/L (**Figure 5-4**). Concentrations in wells 50MW02, 13MW3, 48MW1, and 13MW4 decreased during this quarterly event. Concentrations in wells 48MW06, 48MW2, and 48MW3 slightly increased during this quarterly event.

Miscellaneous Analytes

Groundwater samples were also analyzed for MNA indicators (TOC, dissolved ferrous iron, dissolved gases, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed levels of TOC in the 15 monitoring wells ranged from a low of 0.0 mg/L (non-detect) (in a total of five wells) to a high of 6 mg/L (48MW07). Dissolved ferrous iron levels ranged from a low of 0.0 mg/L (non-detect) (three wells) to a high of 0.45 mg/L (50MW02). Chloride concentrations ranged from an estimated low of 1.8 mg/L (48MW07) to a high of 15 mg/L (13MW5). Detected concentrations of nitrate ranged from an estimated low of 0.16 mg/L (49MW02 and 13MW2) to an estimated high of 6.7 mg/L (48MW3). Sulfate concentrations ranged from a low of 2.4 mg/L (48MW07) to a high of 170 mg/L (49MW05). Methane, ethane, and ethene went undetected during this quarterly monitoring event. **Table 5-4** presents the MNA indicator parameters sample results.

Table 5-3 SWMU 49 Summary of Sixth Quarter Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples[1]	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs								
1,1,1-Trichloroethane	**µg/L**	**na**	**na**	2	16	0.28	0.32	48MW06
1,1-Dichloroethane	**µg/L**	**na**	**na**	3	16	0.25	2.4	48MW06
Acetone	**µg/L**	**na**	**na**	0	16	ND	ND	na
Bromoform	**µg/L**	**na**	**na**	0	16	ND	ND	na
Bromomethane	**µg/L**	**na**	**na**	0	16	ND	ND	na
Carbon tetrachloride	**µg/L**	**5**	2	6	16	0.58	68	48MW3
Chloroform	**µg/L**	**na**	**na**	5	16	0.16	7.7	48MW3
cis-1,2-Dichloroethene	**µg/L**	**na**	**na**	2	16	0.64	3.2	48MW06
Dibromochloromethane	**µg/L**	**na**	**na**	0	16	ND	ND	na
Ethylbenzene	**µg/L**	**na**	**na**	0	16	ND	ND	na
m- & p-Xylene	**µg/L**	**na**	**na**	0	16	ND	ND	na
o-Xylene	**µg/L**	**na**	**na**	0	16	ND	ND	na
Tetrachloroethene	**µg/L**	**na**	**na**	1	16	ND	0.4	48MW06
Trichloroethene	**µg/L**	**5**	1	7	16	0.36	9.8	48MW3
Misc.								
Chloride	**mg/L**	**na**	**na**	16	16	1.8	15	13MW5
Ethane	**µg/L**	**na**	**na**	0	16	ND	ND	na
Ethene	**µg/L**	**na**	**na**	0	16	ND	ND	na
Methane	**µg/L**	**na**	**na**	0	16	ND	ND	na
Nitrate (as N)	**mg/L**	**na**	**na**	16	16	0.16	6	48MW3
Sulfate	**mg/L**	**na**	**na**	16	16	2.4	170	49MW05
Total Organic Carbon	**mg/L**	**na**	**na**	12	16	ND	6	48MW07

Notes:
µg/L = micrograms per liter
mg/L = milligrams per liter
na = not applicable
ND = non-detect
RG = Remedial Goal

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Table 5-4 SWMU 49 Detected Analytes in Sixth Quarter Groundwater Samples

Sample ID			48MW07					49TM1 (Field Duplicate of 48MW07)					13MW5					49MW03					49MW05					48MW06				
Date Collected			**1/11/2017**					**1/11/2017**					**1/13/2017**					**1/12/2017**					**1/11/2017**					**1/11/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.32	J	J	1	0.21
1,1-Dichloroethane	ug/L	na	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	2.4			1	0.2
Acetone	ug/L	na	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5
Bromoform	ug/L	na	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22
Bromomethane	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
Carbon tetrachloride	ug/L	5	0.5	U		1	0.23	0.5	U		1	0.23	0.5	U		1	0.23	0.5	U		1	0.23	0.5	U		1	0.23	0.5	U		1	0.23
Chloroform	ug/L	na	0.25	UZ		0.5	0.15	0.25	UZ		0.5	0.15	0.25	UZ		0.5	0.15	0.25	UZ		0.5	0.15	0.25	UZ		0.5	0.15	0.25	UZ		0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	3.2			1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.4	J	J	1	0.3
Trichloroethene	ug/L	5	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	2.8			1	0.21
Misc																																
Ethane	ug/L	na	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5
Methane	ug/L	na	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3
Chloride	mg/L	na	1.8	J	J	4	1.1	1.9	J	J	4	1.1	15	J	J	16	4.4	5			4	1.1	10			4	1.1	12			4	1.1
Nitrate (as N)	mg/L	na	1.2			0.4	0.08	1.2			0.4	0.08	2.7	H	J	1.6	0.32	1	H	J	0.4	0.08	0.22	J	J	0.4	0.08	1.9			0.4	0.08
Sulfate	mg/L	na	2.4	J	J	5	1.3	2.4	J	J	5	1.3	160			20	5.2	4.5	J	J	5	1.3	170	M		20	5.2	110			10	2.6
Total Organic Carbon	mg/L	na	6		J	3	0.5	0.96	J	J	3	0.5	1.5	U		3	0.5	1.5	U		3	0.5	0.96	J	J	3	0.5	1	J	J	3	0.5
MNA																																
Dissolved Fe^{2+}	mg/L	na	0.00					0.00					0.04					0.42					0.16					0.29				

Table 5-4 SWMU 49 Detected Analytes in Sixth Quarter Groundwater Samples (Continued)

Sample ID			**48MW1**					**48MW2**					**48MW3**					**49MW01**					**49MW02**					**50MW02**				
Date Collected			**1/11/2017**					**1/13/2017**					**1/13/2017**					**1/12/2017**					**1/13/2017**					**1/12/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.28	J	J	1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21
1,1-Dichloroethane	ug/L	na	0.82	J	J	1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.25	J	J	1	0.2
Acetone	ug/L	na	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5
Bromoform	ug/L	na	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22
Bromomethane	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
Carbon tetrachloride	ug/L	5	0.5	U		1	0.23	**49**			1	0.23	**68**			1	0.23	2.6			1	0.23	0.5	U		1	0.23	0.58	J	J	1	0.23
Chloroform	ug/L	na	0.25	UZ		0.5	0.15	4.4	Z		0.5	0.15	7.7	Z		0.5	0.15	0.36	JZ	U	0.5	0.15	0.25	UZ		0.5	0.15	0.16	JZ	U	0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	0.64	J	J	1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3
Trichloroethene	ug/L	5	1.7			1	0.21	3.9			1	0.21	**9.8**			1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.87	J	J	1	0.21
Misc																																
Ethane	ug/L	na	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5
Methane	ug/L	na	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3
Chloride	mg/L	na	4.1			4	1.1	2.2	J	J	4	1.1	3.2	J	J	4	1.1	6.6			4	1.1	2.1	J	J	4	1.1	7.9			4	1.1
Nitrate (as N)	mg/L	na	1.4			0.4	0.08	0.82	H	J	0.4	0.08	6.7	H	J	0.4	0.08	0.43	H	J	0.4	0.08	0.16	JH	J	0.4	0.08	2.1	H	J	0.4	0.08
Sulfate	mg/L	na	53			5	1.3	5.4			5	1.3	30			5	1.3	2.6	J	J	5	1.3	20			5	1.3	67			5	1.3
Total Organic Carbon	mg/L	na	1.5	U		3	0.5	0.59	J	J	3	0.5	0.84	J	J	3	0.5	1.5	U		3	0.5	1.5	U		3	0.5	0.74	J	J	3	0.5
MNA																																
Dissolved Fe^{2+}	mg/L	na	0.00					0.40					0.14					0.33					0.18					0.45				

Table 5-4 SWMU 49 Detected Analytes in Sixth Quarter Groundwater Samples (Continued)

Sample ID			**13MW2**					**13MW3**					**13MW4**					**49MW04**				
Date Collected			**1/13/2017**					**1/13/2017**					**1/13/2017**					**1/11/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																						
1,1,1-Trichloroethane	ug/L	na	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21
1,1-Dichloroethane	ug/L	na	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2
Acetone	ug/L	na	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5
Bromoform	ug/L	na	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22	0.5	U	UJ	1	0.22
Bromomethane	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
Carbon tetrachloride	ug/L	5	0.5	U		1	0.23	2.5			1	0.23	0.5	U		1	0.23	0.66	J	J	1	0.23
Chloroform	ug/L	na	0.25	UZ		0.5	0.15	0.4	JZ	J	0.5	0.15	0.25	UZ		0.5	0.15	0.25	UZ		0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3
Trichloroethene	ug/L	5	0.5	U		1	0.21	0.36	J	J	1	0.21	2.2			1	0.21	0.5	U		1	0.21
Misc																						
Ethane	ug/L	na	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5
Methane	ug/L	na	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3
Chloride	mg/L	na	3.3	J	J	4	1.1	3.4	J	J	4	1.1	5.2			4	1.1	6.2			4	1.1
Nitrate (as N)	mg/L	na	0.16	JH	J	0.4	0.08	1	H	J	0.4	0.08	0.74	H	J	0.4	0.08	0.4			0.4	0.08
Sulfate	mg/L	na	42			5	1.3	93			5	1.3	50			5	1.3	53			5	1.3
Total Organic Carbon	mg/L	na	0.76	J	J	3	0.5	1.7	J	J	3	0.5	0.53	J	J	3	0.5	0.76	J	J	3	0.5
MNA																						
Dissolved Fe^{2+}	mg/L	na	0.02					0.05					0.07					0.04				

Notes:
(1) Remedial Goals developed in Draft SWMU 48/49 RFI Report (CB&I, 2014a).
Exceedances denoted by bold font.
mg/L = milligrams per liter (parts per million)
µg/L = micrograms per liter (parts per billion)
RL = Reporting Limit
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 49
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Data Qualifiers

H = Holding time exceeded.
J = Estimated value.
U = Analyte concentration was not above the detection level.
Z = Calibration criteria exceeded.

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Figure 5-3 SWMU 49 Carbon Tetrachloride Isopleths - January 2017

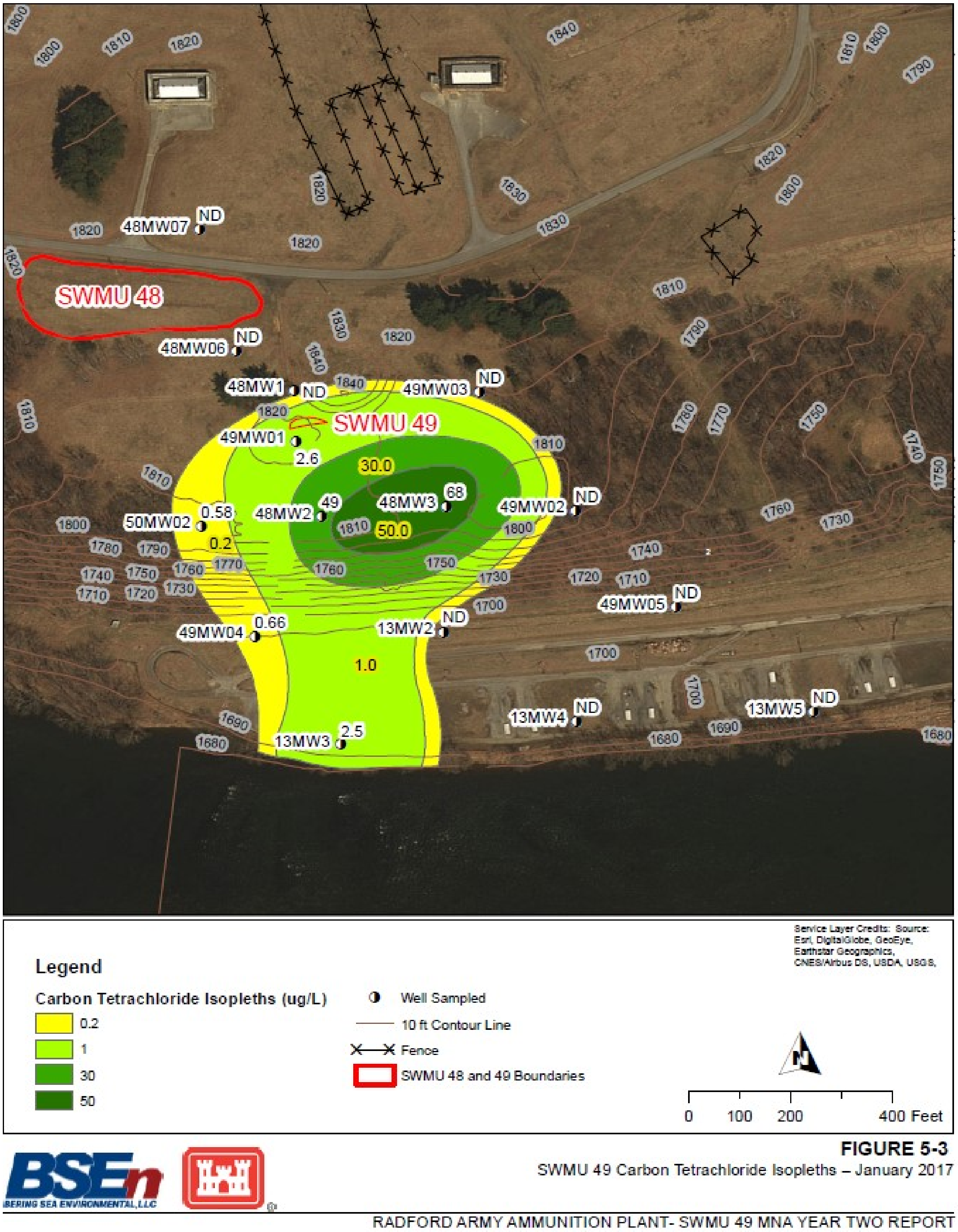

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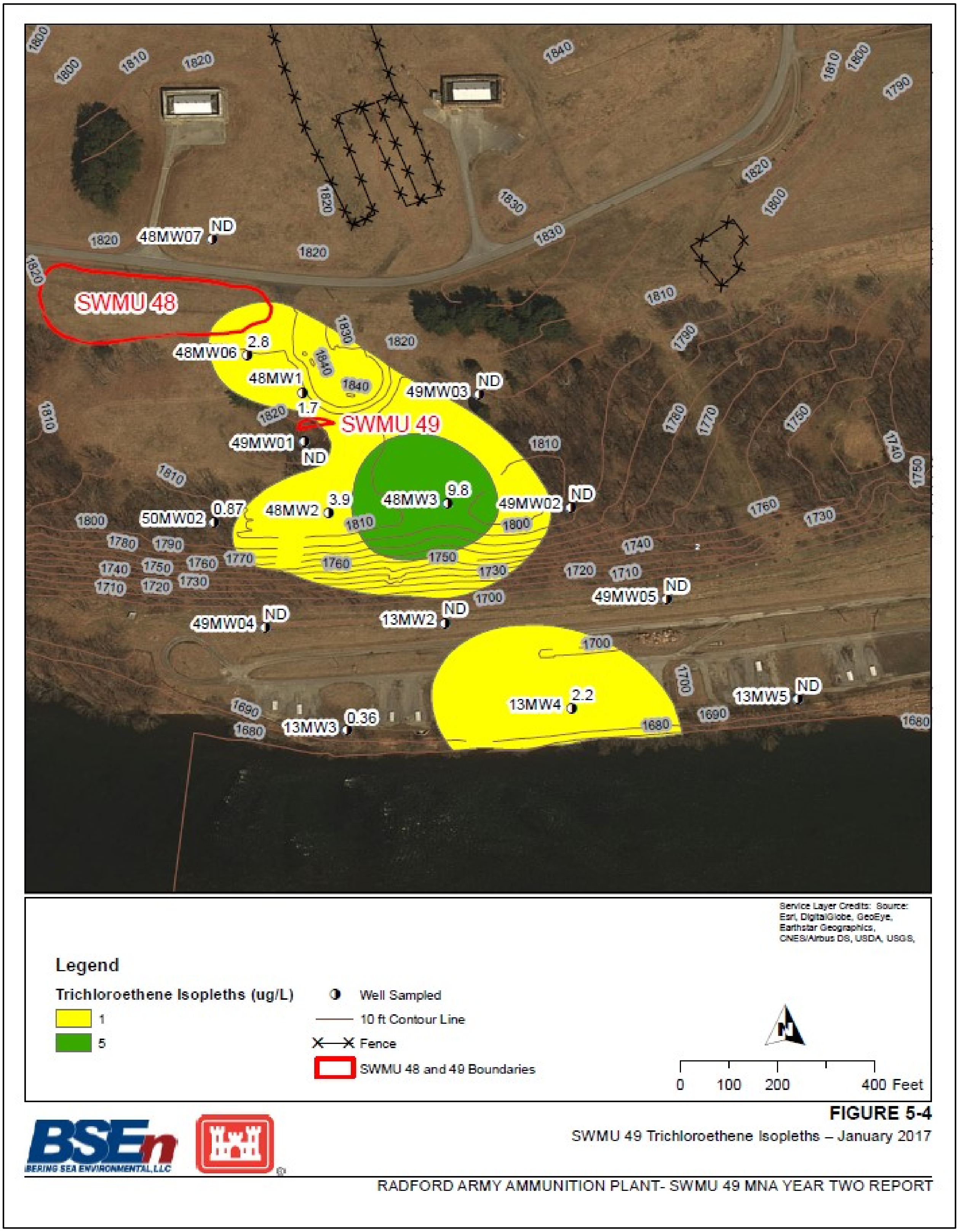
Figure 5-4 SWMU 49 Trichloroethene Isopleths - January 2017



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5.4 Seventh Quarter Groundwater Results

Eleven monitoring wells were sampled during the third quarter monitoring event including wells 13MW2, 13MW3, 13MW4, 48MW1, 48MW2, 48MW3, 48MW06, 49MW01, 49MW02, 49MW04, and 50MW02. A duplicate sample was collected from monitoring well 48MW06 (duplicate as 49TM1). Sample locations are provided in **Figure 4-1**.

Samples were submitted for TCL VOC, dissolved gases (methane, ethane, and ethene), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-5**, while the results are presented in **Table 5-6**. The potential for biodegradation in the groundwater at SWMU 49 is discussed in Section 6.2.

TCL VOCs

Seven VOCs were detected in groundwater samples including 1,1,1-TCA, 1,1-DCA, CT, chloroform, cis-1,2-DCE, PCE, and TCE. Nine monitoring wells had one or more detected concentrations of the VOCs listed above. Monitoring wells 13MW2 and 49MW02 did not have detected concentrations of VOCs.

The VOC 1,1,1-TCA was detected at monitoring wells 48MW1 and 48MW06 at concentrations ranging from an estimated low of 0.27 µg/L to an estimated high of .41 µg/L. The concentrations were generally in agreement with levels observed during the sixth quarterly monitoring event. An RG for 1,1,1-TCA has not been established for SWMU 49. However, the USEPA MCL for 1,1,1-TCA is 200 µg/L (USEPA, 2011).

The VOC 1,1-DCA was detected at monitoring wells 48MW1, 48MW06 (including its field duplicate 49TM1), and 50MW02 at concentrations ranging from an estimated low value of 0.24 µg/L (50MW02) to a high of 3 µg/L (49TM01 field duplicate of 48MW06). These wells had similar detections recorded during the sixth quarterly monitoring events. An RG for 1,1-DCA has not been established for SWMU 49. There is no USEPA MCL for 1,1-DCA (USEPA, 2011); however, the Tapwater RSL is 2.8 µg/L (USEPA, 2017).

The VOC CT was detected at six monitoring wells including 13MW3, 48MW2, 48MW3, 49MW01, 49MW04, and 50MW02. Two wells contained CT concentrations that exceeded the RG of 5 µg/L including monitoring wells 48MW2 (41µg/L) and 48MW3 (67 µg/L). These wells had elevated concentrations that exceeded the RG during the fifth and sixth quarterly monitoring events. The range of concentrations detected during this quarter went from a low estimated value of 0.78 µg/L (49MW04) to a high of 67 µg/L (48MW3) (**Figure 5-5**). Compared to the sixth quarter monitoring results, the detected concentrations of CT in monitoring wells 48MW2 and 48MW3 decreased slightly, and in monitoring wells 49MW01, 50MW02, 13MW3, and 49MW04 increased slightly.

Chloroform was detected in five monitoring wells including 13MW3, 48MW2, 48MW3, 49MW01, and 50MW02. Concentrations ranged from an estimated value of 0.17 µg/L (50MW02) to a high of 7.7 µg/L (48MW3). Compared to the seventh quarter monitoring results, the detected concentrations of chloroform were unchanged or slightly decreased during this quarterly event. An RG for chloroform has not been established for SWMU 49. However, the USEPA MCL for chloroform is 80 µg/L (USEPA, 2011).

The VOC cis-1,2-DCE was detected in three monitoring wells including 48MW1, 48MW06, and 50MW02. Concentrations ranged from an estimated low of 0.37 µg/L (50MW02) to a high of 4.5 µg/L (field duplicate sample of 48MW06). The concentrations increased slightly from last quarterly monitoring event. Additionally, cis-1,2-DCE was non-detect in 50MW02 the previous quarterly monitoring event. An RG for cis-1,2-DCE has not been established for SWMU 49. However, the USEPA MCL for cis-1, 2-DCE is 70 µg/L (USEPA, 2011).

PCE was detected in monitoring well 48MW06 (and the field duplicate sample of 48MW06) at an estimated concentration of 0.46 µg/L. Monitoring well 48MW06 also contained the only detection of PCE during the sixth quarterly monitoring event; however, the well was non-detect in the fifth quarterly monitoring event. An RG for PCE has not been established for SWMU 49. However, the USEPA MCL for PCE is 5 µg/L (USEPA, 2011).The VOC TCE was detected at seven monitoring wells including 13MW3, 13MW4, 48MW1, 48MW2, 48MW3, 48MW06 and 50MW02. Monitoring well 48MW3 (9.8 µg/L) is the only well that contained a concentration of TCE that exceeded the RG of 5 µg/L. The range of concentrations detected during this quarter went from a low estimated value of 0.58 (13MW3) to a high of 9.8 µg/L (**Figure 5-6**). In general, the concentrations and wells with detections of TCE were similar to the fifth and sixth quarterly monitoring events.

Miscellaneous Analytes

Groundwater samples were also analyzed for MNA indicators (TOC, dissolved ferrous iron, dissolved gases, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed levels of TOC in the 11 monitoring wells ranged from an estimated low of 2.7 mg/L (48MW1) to a high of 5.7 mg/L (50MW2). Dissolved ferrous iron levels ranged from a low of 0.0 mg/L (non-detect) (13MW4) to a high of 1.83 mg/L (50MW02). Chloride concentrations ranged from an estimated low of 2.1 mg/L (48MW2) to a high of 13 mg/L (48MW06). Detected concentrations of nitrate ranged from an estimated low of 0.14 mg/L (49MW02) to a high of 7.1 mg/L (48MW3). Sulfate concentrations ranged from a low of 0.0 mg/L (non-detect) (49MW01) to a high of 140 mg/L (49TM1 field duplicate of 48MW06). Methane, ethane, and ethene went largely undetected during this quarterly monitoring event, with the exception of the samples collected from 50MW02, which had a methane concentration of 3.2 µg/L, and wells 13MW03 and 48MW06 (field duplicate 49TM1), which had an estimated ethane concentration of .52, and .91 µg/L, respectively. The MNA indicator parameters are presented in **Table 5-6**.

Table 5-5 SWMU 49 Summary of Seventh Quarter Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples[1]	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs								
1,1,1-Trichloroethane	**µg/L**	**na**	**na**	3	12	0.27	0.45	49TM1 (field duplicate of 48MW06)
1,1-Dichloroethane	**µg/L**	**na**	**na**	4	12	0.24	3	49TM1 (field duplicate of 48MW06)
Acetone	**µg/L**	**na**	**na**	0	12	ND	ND	na
Bromoform	**µg/L**	**na**	**na**	0	12	ND	ND	na
Bromomethane	**µg/L**	**na**	**na**	0	12	ND	ND	na
Carbon tetrachloride	**µg/L**	**5**	2	6	12	0.78	67	48MW3
Chloroform	**µg/L**	**na**	**na**	5	12	0.17	7.7	48MW3
cis-1,2-Dichloroethene	**µg/L**	**na**	**na**	4	12	0.37	4.5	49TM1 (field duplicate of 48MW06)
Dibromochloromethane	**µg/L**	**na**	**na**	0	12	ND	ND	na
Ethylbenzene	**µg/L**	**na**	**na**	0	12	ND	ND	na
m- & p-Xylene	**µg/L**	**na**	**na**	0	12	ND	ND	na
o-Xylene	**µg/L**	**na**	**na**	0	12	ND	ND	na
Tetrachloroethene	**µg/L**	**na**	**na**	2	13	ND	0.46	48MW06 and 49TM1
Trichloroethene	**µg/L**	**5**	1	8	12	0.58	9.8	48MW3
Misc.								
Chloride	**mg/L**	**na**	**na**	12	12	2.1	13	48MW06 and 49TM1
Ethane	**µg/L**	**na**	**na**	2	12	0.52	0.91	49TM1 (field duplicate of 48MW06)
Ethene	**µg/L**	**na**	**na**	0	12	ND	ND	na
Methane	**µg/L**	**na**	**na**	1	12	ND	3.2	50MW02
Nitrate (as N)	**mg/L**	**na**	**na**	12	12	0.14	7.1	48MW3
Sulfate	**mg/L**	**na**	**na**	11	12	3.8	140	49TM1 (field duplicate of 48MW06)
Total Organic Carbon	**mg/L**	**na**	**na**	12	12	2.7	5.7	50MW02

Notes:
µg/L = micrograms per liter
mg/L = milligrams per liter
na = not applicable
ND = non-detect

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Table 5-6 SWMU 49 Detected Analytes in Seventh Quarter Groundwater Samples

Sample ID			**48MW06**					**49TM1 (Field Duplicate of 48MW6)**					**48MW1**					**48MW2**					**48MW3**					**49MW01**				
Date Collected			**4/11/2017**										**4/12/2017**					**4/13/2017**					**4/13/2017**					**4/12/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.41	J		1	0.21	0.45	J		1	0.21	0.27	J		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21
1,1-Dichloroethane	ug/L	na	2.7			1	0.2	3			1	0.2	0.89	J		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2
Acetone	ug/L	na	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5
Bromoform	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
Bromomethane	ug/L	na	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5
Carbon tetrachloride	ug/L	5	0.5	U		1	0.23	0.5	U		1	0.23	0.5	U		1	0.23	**41**			1	0.23	**67**			1	0.23	3			1	0.23
Chloroform	ug/L	na	0.25	U		0.5	0.15	0.25	U		0.5	0.15	0.25	U		0.5	0.15	3.5			0.5	0.15	7.7			0.5	0.15	0.27	J		0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	4.3			1	0.25	4.5			1	0.25	0.72	J		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.46	J		1	0.3	0.46	J		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3
Trichloroethene	ug/L	5	3			1	0.21	3			1	0.21	1.7			1	0.21	2.3			1	0.21	**9.8**			1	0.21	0.5	U		1	0.21
Misc																																
Ethane	ug/L	na	0.7	U		0.8	0.4	0.91			0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5
Methane	ug/L	na	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3
Chloride	mg/L	na	13			4	1.1	13			4	1.1	3.9	J		4	1.1	2.1	J		4	1.1	3.4	J		4	1.1	6.3			4	1.1
Nitrate (as N)	mg/L	na	2.5			0.4	0.08	2.4			0.4	0.08	1.5			0.4	0.08	0.75			0.4	0.08	7.1	M		4	0.8	0.32	J		0.4	0.08
Sulfate	mg/L	na	130			20	5.2	140			20	5.2	49			5	1.3	3.8	J		5	1.3	29			5	1.3	2.5	U		5	1.3
Total Organic Carbon	mg/L	na	4.7			3	0.5	5			3	0.5	2.7	J		3	0.5	3.8			3	0.5	4.7			3	0.5	3.3			3	0.5
MNA																																
Dissolved Fe^{2+}	mg/L	na	0.30					0.30					0.06					0.15					0.03					0.26				

Table 5-6 SWMU 49 Detected Analytes in Seventh Quarter Groundwater Samples (Continued)

Sample ID			**49MW02**					**50MW02**					**13MW2**					**13MW3**					**13MW4**					**49MW04**				
Date Collected			**4/13/2017**					**4/12/2017**					**4/12/2017**					**4/11/2017**					**4/11/2017**					**4/12/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21
1,1-Dichloroethane	ug/L	na	0.5	U		1	0.2	0.24	J		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2
Acetone	ug/L	na	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5
Bromoform	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
Bromomethane	ug/L	na	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5	1	UZ	UJ	2	0.5
Carbon tetrachloride	ug/L	5	0.5	U		1	0.23	1			1	0.23	0.5	U		1	0.23	3.5			1	0.23	0.5	U		1	0.23	0.78	J		1	0.23
Chloroform	ug/L	na	0.25	U		0.5	0.15	0.17	J		0.5	0.15	0.25	U		0.5	0.15	0.4	J		0.5	0.15	0.25	U		0.5	0.15	0.25	U		0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	0.5	U		1	0.25	0.37	J		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25	0.5	U		1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3
Trichloroethene	ug/L	5	0.5	U		1	0.21	1.3			1	0.21	0.5	U		1	0.21	0.58	J		1	0.21	0.9	J		1	0.21	0.5	U		1	0.21
Misc																																
Ethane	ug/L	na	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.52	J		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5
Methane	ug/L	na	0.6	U		0.7	0.3	3.2			0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3
Chloride	mg/L	na	2.2	J		4	1.1	8			4	1.1	3.6	JM		4	1.1	4.6			4	1.1	6.5			4	1.1	6.1			4	1.1
Nitrate (as N)	mg/L	na	0.14	J		0.4	0.08	2.2			0.4	0.08	0.2	J		0.4	0.08	1.7			0.4	0.08	0.7			0.4	0.08	0.29	J		0.4	0.08
Sulfate	mg/L	na	21			5	1.3	68			5	1.3	34	M		5	1.3	120			15	3.9	50			5	1.3	51			5	1.3
Total Organic Carbon	mg/L	na	3.8			3	0.5	5.7			3	0.5	4			3	0.5	3.9			3	0.5	3.1			3	0.5	4.2			3	0.5
MNA																																
Dissolved Fe^{2+}	mg/L	na	0.17					1.83					0.05					0.03					0.00					0.08				

Notes:
(1) Remedial Goals developed in Draft SWMU 48/49 RFI Report (CB&I, 2014a). Exceedances denoted by bold font.
mg/L = milligrams per liter (parts per million)
µg/L = micrograms per liter (parts per billion)
RL = Reporting Limit
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 49
ND = non-detect
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Data Qualifiers
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
U = Analyte concentration was not above the detection level.
Z = Calibration criteria exceeded.

Figure 5-5 SWMU 49 Carbon Tetrachloride Isopleths - April 2017

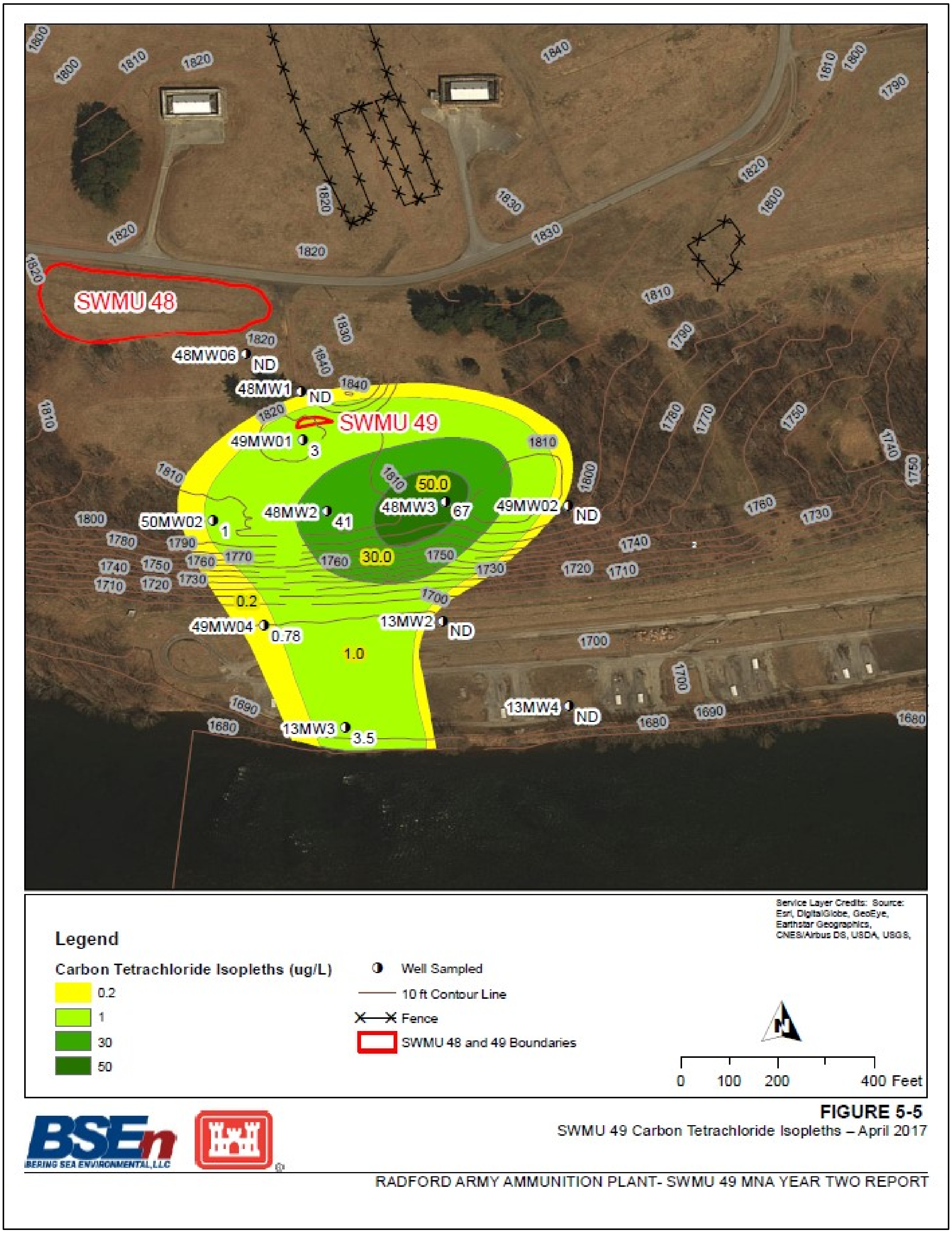

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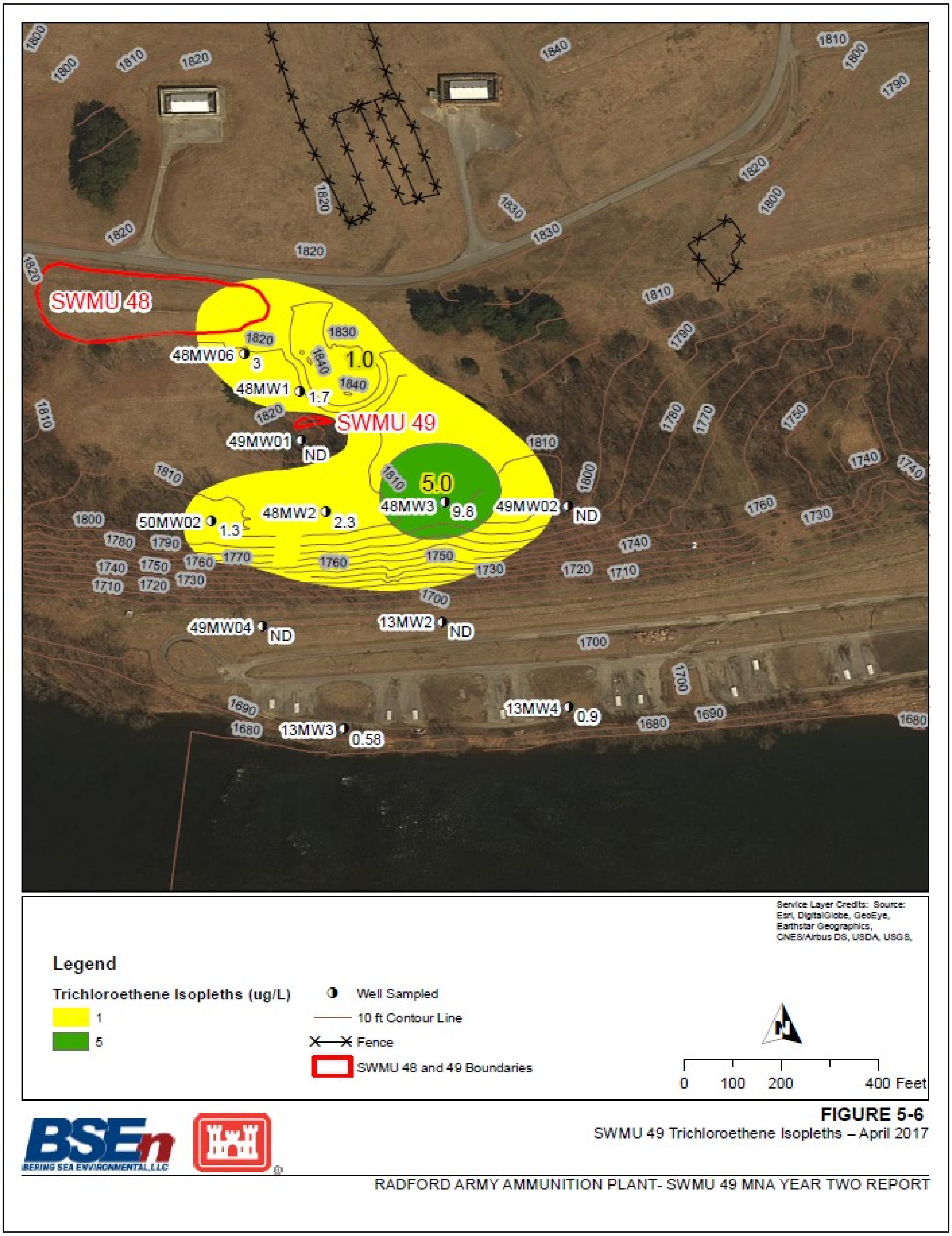
Figure 5-6 SWMU 49 Trichloroethene Isopleths - April 2017



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5.5 Eighth Quarter Groundwater Results

Eleven monitoring wells were sampled during the eighth quarter monitoring event including wells 13MW2, 13MW3, 13MW4, 48MW1, 48MW2, 48MW3, 48MW06, 49MW01, 49MW02, 49MW04, and 50MW02. Two duplicate samples were collected from monitoring wells 48MW06 (duplicate as 49TM1) and 49MW02 (duplicate as 49TM2). Sample locations are provided in **Figure 4-1**.

Samples were submitted for TCL VOC, dissolved gases (methane, ethane, and ethene), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-7**, while the results are presented in **Table 5-8**. The potential for biodegradation in the groundwater at SWMU 49 is discussed in Section 6.2.

<u>TCL VOCs</u>

Seven VOCs were detected in groundwater samples including 1,1,1-TCA, 1,1-DCA, CT, chloroform, cis-1,2-DCE, PCE, and TCE. All eleven monitoring wells had one or more detected concentrations of the VOCs listed above.

The VOC 1,1,1-TCA was detected at monitoring wells 48MW1, 48MW06, and 50MW02 ranging from an estimated low concentration of 0.22 µg/L to an estimated high concentration of 0.75 µg/L. An RG for 1,1,1-TCA has not been established for SWMU 49. However, the USEPA MCL for 1,1,1-TCA is 200 µg/L (USEPA, 2011).

As with VOC 1,1,1-TCA, the VOC 1,1-DCA was also detected at monitoring wells 48MW1, 48MW06, and 50MW02. Concentrations ranged from an estimated value of 0.38 µg/L (50MW02) to a high of 5.1 µg/L (48MW06 field duplicate 49TM1). The concentrations of 1,1-DCA in these wells increased slightly when compared to the seventh quarter monitoring event, with the exception of 48MW1, which slightly decreased. An RG for 1,1-DCA has not been established for SWMU 49. There is no USEPA MCL for 1,1-DCA (USEPA, 2011); however, the Tapwater RSL is 2.8 µg/L (USEPA, 2017).

The VOC CT was detected at six monitoring wells including 13MW3, 48MW2, 48MW3, 49MW01, 49MW04, and 50MW02. Two wells contained CT concentrations that exceeded the RG of 5 µg/L including monitoring wells 48MW2 (42 µg/L) and 48MW3 (69 µg/L [estimated]). These wells had elevated concentrations that exceeded the RG during all four quarterly monitoring events. The range of concentrations detected during this quarter went from a low estimated value of 0.55 µg/L (49MW04) to an estimated high of 69 µg/L (**Figure 5-7**). Compared to the seventh quarter monitoring results, the number of wells and detected concentrations of CT remained similar.

Chloroform was detected in four monitoring wells including 48MW2, 48MW3, 49MW01, and 13MW3. Concentrations ranged from an estimated value of 0.36 µg/L (49MW01) to a high of 8.1 µg/L (48MW3). Compared to the seventh quarter monitoring results, the detected concentrations of chloroform remained similar and 50MW02 was non-detect this quarterly sampling event. An RG for chloroform has not been established for SWMU 49. However, the USEPA MCL for chloroform is 80 µg/L (USEPA, 2011).

The VOC cis-1,2-DCE was detected in ten monitoring wells, and the only non-detect was in 48MW2. Concentrations ranged from an estimated low of 0.28 µg/L (49MW04) and to a high of 9.8 µg/L (48MW06 field duplicate 49TM1). When compared to the seventh quarterly monitoring event, the number of detections increased, along with the concentrations. An RG for cis-1,2-DCE has not been established for SWMU 49. However, the USEPA MCL for cis-1, 2-DCE is 70 µg/L (USEPA, 2011).

PCE was detected in monitoring well 48MW06 at an estimated concentration of 0.91 µg/L (48MW06 field duplicate 49TM1). The concentrations from 49MW06 were slightly increased from the seventh quarterly monitoring event. An RG for PCE has not been established for SWMU 49. However, the USEPA MCL for PCE is 5 µg/L (USEPA, 2011).

The VOC TCE was detected at nine monitoring wells, and the only non-detects were from 49MW04 and 13MW2. Monitoring wells 48MW06, 48MW2, and 48MW3 contained concentrations of TCE that exceeded the RG of 5 µg/L. The range of concentrations detected during this quarter went from a low estimated value of 0.23 µg/L (48MW02) to a high of 11 µg/L (48MW3) (**Figure 5-8**). In general, the number of wells with detections increased from the seventh quarterly monitoring event, as did the TCE concentrations, with the exception of 48MW1 which was unchanged.

Miscellaneous Analytes

Groundwater samples were analyzed for MNA indicators (TOC, dissolved ferrous iron, dissolved gases, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed levels of TOC in the 11 monitoring wells ranged from an estimated low of 0.00 mg/L (non-detect) as 50MW02 to an estimated high of 5.3 mg/L (48MW06 field duplicate 49TM1). Dissolved ferrous iron levels ranged from a low of 0.06 mg/L to a high of 2.31 mg/L (48MW2). Chloride concentrations ranged from an estimated low of 2 mg/L (49MW02) to a high of 14 mg/L (48MW06). Detected concentrations of nitrate ranged from an estimated low of 0.14 mg/L (49MW02) to a high of 6.7 mg/L (48MW3). Sulfate concentrations ranged from an estimated low of 0.0 mg/L (non-detect) at 49MW01, to a high of 200 mg/L (48MW06). Methane, ethane, and ethene went largely undetected during this quarterly monitoring event, with the exception of the samples collected from 50MW02, 48MW06, 48MW02, and 13MW2. Sample 50MW02 had an estimated ethane concentration of 0.68 µg/L. Sample 48MW06 had an estimated methane concentration of 0.42 µg/L. Sample 48MW2 had an estimated methane concentration of 0.48 µg/L, and an estimated ethane concentration of 0.73 µg/L. Sample 13MW2 had an ethane concentration of 1.4 µg/L. The MNA indicator parameter sample results are provided in **Table 5-8**.

Table 5-7 SWMU 49 Summary of Eighth Quarter Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples[1]	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs								
1,1,1-Trichloroethane	**µg/L**	**na**	**na**	4	13	0.22	0.75	49TM1 (field duplicate of 48MW06)
1,1-Dichloroethane	**µg/L**	**na**	**na**	4	13	0.38	5.1	49TM1 (field duplicate of 48MW06)
Acetone	**µg/L**	**na**	**na**	0	13	ND	ND	na
Bromoform	**µg/L**	**na**	**na**	0	13	ND	ND	na
Bromomethane	**µg/L**	**na**	**na**	0	13	ND	ND	na
Carbon tetrachloride	**µg/L**	**5**	2	6	13	0.55	69	48MW3
Chloroform	**µg/L**	**na**	**na**	4	13	0.36	8.1	48MW3
cis-1,2-Dichloroethene	**µg/L**	**na**	**na**	12	13	0.28	9.8	49TM1 (field duplicate of 48MW06)
Dibromochloromethane	**µg/L**	**na**	**na**	0	13	ND	ND	na
Ethylbenzene	**µg/L**	**na**	**na**	0	13	ND	ND	na
m- & p-Xylene	**µg/L**	**na**	**na**	0	13	ND	ND	na
o-Xylene	**µg/L**	**na**	**na**	0	13	ND	ND	na
Tetrachloroethene	**µg/L**	**na**	**na**	2	13	0.87	0.91	49TM1 (field duplicate of 48MW06)
Trichloroethene	**µg/L**	**5**	4	11	13	0.23	11	48MW3
Misc.								
Chloride	**mg/L**	**na**	**na**	13	13	2	14	48MW06 and 49TM1
Ethane	**µg/L**	**na**	**na**	3	13	0.68	1.4	13MW2
Ethene	**µg/L**	**na**	**na**	0	13	ND	ND	na
Methane	**µg/L**	**na**	**na**	3	13	0.42	0.48	48MW2
Nitrate (as N)	**mg/L**	**na**	**na**	13	13	0.14	6.7	48MW3
Sulfate	**mg/L**	**na**	**na**	12	13	ND	200	48MW06
Total Organic Carbon	**mg/L**	**na**	**na**	12	13	ND	5.3	49TM1 (field duplicate of 48MW06)

Notes:
µg/L = micrograms per liter
mg/L = milligrams per liter
na = not applicable
ND = non-detect
RG = Remedial Goal

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Table 5-8 SWMU 49 Detected Analytes in Eighth Quarter Groundwater Samples

Sample ID			**48MW06**					**49TM1 (Field Duplicate of 48MW06)**					**48MW1**					**48MW2**					**48MW3**					**49MW01**				
Date Collected			**7/12/2017**					**7/12/2017**					**7/12/2017**					**7/13/2017**					**7/13/2017**					**7/12/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.71	J		1	0.21	0.75	J		1	0.21	0.22	J		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21
1,1-Dichloroethane	ug/L	na	5			1	0.2	5.1			1	0.2	0.72	J		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2
Acetone	ug/L	na	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5
Bromoform	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
Bromomethane	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
Carbon tetrachloride	ug/L	5	0.5	U		1	0.23	0.5	U		1	0.23	0.5	U		1	0.23	**47**			1	0.23	**69**	M	J	1	0.23	3.5			1	0.23
Chloroform	ug/L	na	0.25	U		0.5	0.15	0.25	U		0.5	0.15	0.25	U		0.5	0.15	4.2			0.5	0.15	8.1			0.5	0.15	0.36	J		0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	9.7			1	0.25	9.8			1	0.25	1.8			1	0.25	0.49	J		1	0.25	0.58	J		1	0.25	1.2			1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.87	J		1	0.3	0.91	J		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3
Trichloroethene	ug/L	5	**6.1**			1	0.21	**6.1**			1	0.21	1.7			1	0.21	**5.2**			1	0.21	**11**			1	0.21	0.37	J		1	0.21
Misc																																
Ethane	ug/L	na	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.73	J		0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5
Methane	ug/L	na	0.42	J		0.7	0.3	0.42	J		0.7	0.3	0.6	U		0.7	0.3	0.48	J		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3
Chloride	mg/L	na	14	M		4	1.1	14			4	1.1	3.4	J		4	1.1	2.6	J		4	1.1	3.2	J		4	1.1	6.1			4	1.1
Nitrate (as N)	mg/L	na	4.1			0.4	0.08	4.2			0.4	0.08	1.3			0.4	0.08	0.82			0.4	0.08	6.7			0.4	0.08	0.31	J		0.4	0.08
Sulfate	mg/L	na	200	M		25	6.5	160			25	6.5	45			5	1.3	8			5	1.3	29			5	1.3	2.5	U		5	1.3
Total Organic Carbon	mg/L	na	5			3	0.5	5.3			3	0.5	1.9	J		3	0.5	1.9	J		3	0.5	0.52	J		3	0.5	2.4	J		3	0.5
MNA																																
Dissolved Fe^{2+}	mg/L	na	0.23					0.23					0.13					2.31					0.11					0.21				

Table 5-8 SWMU 49 Detected Analytes in Eighth Quarter Groundwater Samples (Continued)

Sample ID			**49MW02**					**49TM2 (Field Duplicate of 49MW02)**					**50MW02**					**13MW2**					**13MW3**					**13MW4**				
Date Collected			**7/12/2017**					**7/12/2017**					**7/13/2017**					**7/12/2017**					**7/13/2017**					**7/12/2017**				
Analyte	**Units**	**Remedial Goals [(1)]**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs																																
1,1,1-Trichloroethane	ug/L	na	0.5	U		1	0.21	0.5	U		1	0.21	0.26	J		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21	0.5	U		1	0.21
1,1-Dichloroethane	ug/L	na	0.5	U		1	0.2	0.5	U		1	0.2	0.38	J		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2	0.5	U		1	0.2
Acetone	ug/L	na	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5	10	U		20	5
Bromoform	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
Bromomethane	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
Carbon tetrachloride	ug/L	5	0.5	U		1	0.23	0.5	U		1	0.23	0.95	J		1	0.23	0.5	U		1	0.23	4.3			1	0.23	0.5	U		1	0.23
Chloroform	ug/L	na	0.25	U		0.5	0.15	0.25	U		0.5	0.15	0.25	U		0.5	0.15	0.25	U		0.5	0.15	0.45	J		0.5	0.15	0.25	U		0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	0.82	J		1	0.25	0.88	J		1	0.25	1.3			1	0.25	0.35	J		1	0.25	0.67	J		1	0.25	0.42	J		1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3	0.5	U		1	0.3
Trichloroethene	ug/L	5	0.23	J		1	0.21	0.25	J		1	0.21	2.2			1	0.21	0.5	U		1	0.21	1			1	0.21	2.3			1	0.21
Misc																																
Ethane	ug/L	na	0.7	U		0.8	0.4	0.7	U		0.8	0.4	0.68	J		0.8	0.4	1.4			0.8	0.4	0.7	U		0.8	0.4	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5	1	U		1.1	0.5
Methane	ug/L	na	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3	0.6	U		0.7	0.3
Chloride	mg/L	na	2	J		4	1.1	2.1	J		4	1.1	8.7			4	1.1	4.2			4	1.1	4.4			4	1.1	4.8			4	1.1
Nitrate (as N)	mg/L	na	0.14	J		0.4	0.08	0.14	J		0.4	0.08	2.3			0.4	0.08	0.24	J		0.4	0.08	0.87			0.4	0.08	0.62			0.4	0.08
Sulfate	mg/L	na	18			5	1.3	18			5	1.3	82			25	6.5	43			5	1.3	100			25	6.5	29			5	1.3
Total Organic Carbon	mg/L	na	3.2			3	0.5	4			3	0.5	1.5	U		3	0.5	3.2			3	0.5	0.54	J		3	0.5	2.1	J		3	0.5
MNA																																
Dissolved Fe^{2+}			0.16					0.16					0.19					0.15					0.12					0.06				

Table 5-8 SWMU 49 Detected Analytes in Eighth Quarter Groundwater Samples (Continued)

Sample ID			**49MW04**				
Date Collected			**7/13/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
VOCs							
1,1,1-Trichloroethane	ug/L	na	0.5	U		1	0.21
1,1-Dichloroethane	ug/L	na	0.5	U		1	0.2
Acetone	ug/L	na	10	U		20	5
Bromoform	ug/L	na	0.5	U		1	0.22
Bromomethane	ug/L	na	1	U		2	0.5
Carbon tetrachloride	ug/L	5	0.55	J		1	0.23
Chloroform	ug/L	na	0.25	U		0.5	0.15
cis-1,2-Dichloroethene	ug/L	na	0.28	J		1	0.25
Dibromochloromethane	ug/L	na	0.5	U		1	0.19
Ethylbenzene	ug/L	na	0.5	U		1	0.22
m & p-Xylene	ug/L	na	1	U		2	0.5
o-Xylene	ug/L	na	0.5	U		1	0.24
Tetrachloroethene	ug/L	na	0.5	U		1	0.3
Trichloroethene	ug/L	5	0.5	U		1	0.21
Misc							
Ethane	ug/L	na	0.7	U		0.8	0.4
Ethene	ug/L	na	1	U		1.1	0.5
Methane	ug/L	na	0.6	U		0.7	0.3
Chloride	mg/L	na	6			4	1.1
Nitrate (as N)	mg/L	na	0.25	J		0.4	0.08
Sulfate	mg/L	na	51			5	1.3
Total Organic Carbon	mg/L	na	0.7	J		3	0.5
MNA							
Dissolved Fe^{2+}			0.10				

Notes:
(1) Remedial Goals developed in Draft SWMU 48/49 RFI Report (CB&I, 2014a). Exceedances denoted by bold font.
mg/L = milligrams per liter (parts per million)
µg/L = micrograms per liter (parts per billion)
RL = Reporting Limit
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 49
ND = non-detect
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Data Qualifiers
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
U = Analyte concentration was not above the detection level.

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Figure 5-7 SWMU 49 Carbon Tetrachloride Isopleths - July 2017

FIGURE 5-7
SWMU 49 Carbon Tetrachloride Isopleths – July 2017

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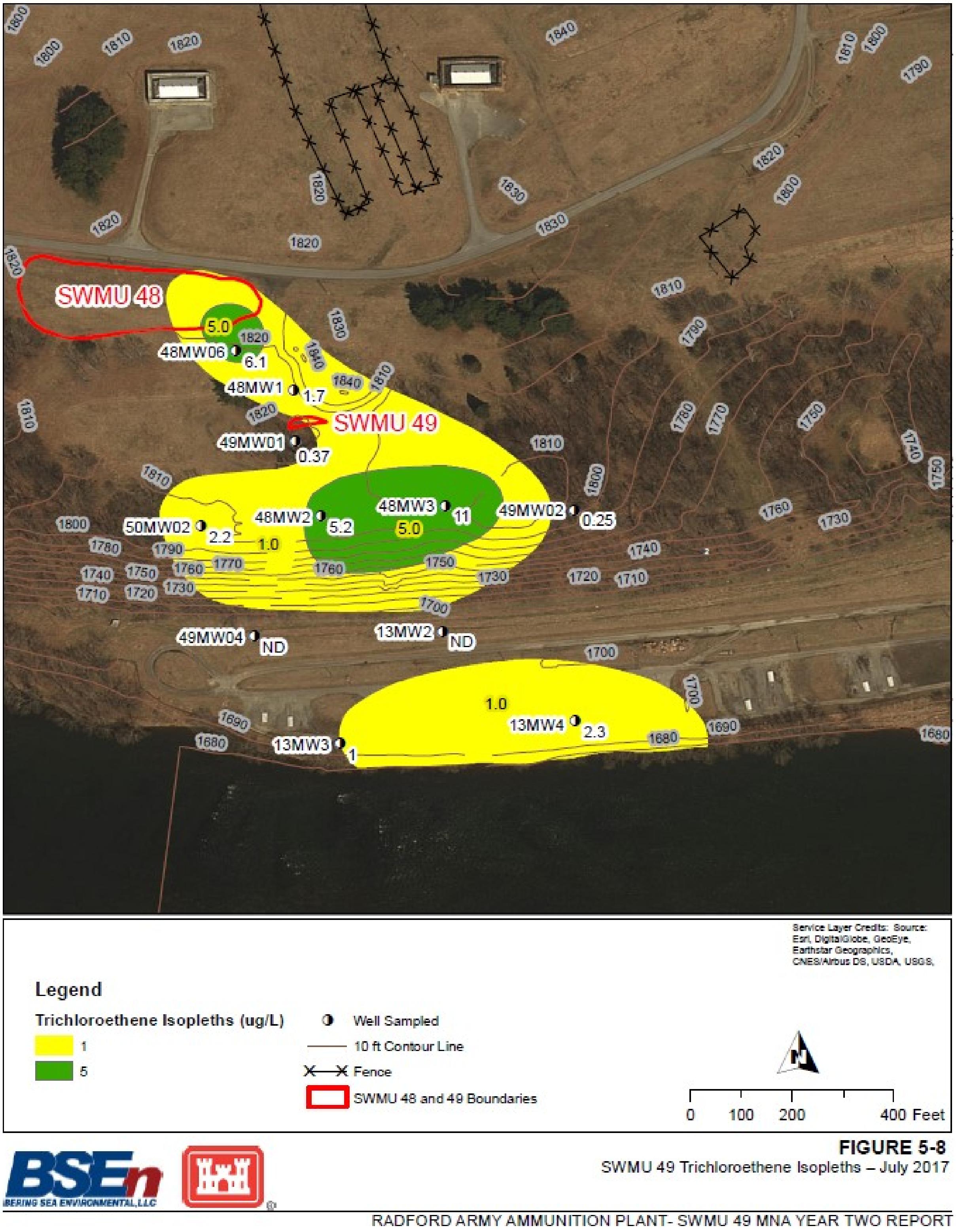
Figure 5-8 SWMU 49 Trichloroethene Isopleths - July 2017



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5.6 Year Two Sample Results

This section discusses the results from the second year of MNA sampling. Samples collected were analyzed for the full suite of analytical parameters described in **Table 4-2** (TCL VOC, dissolved gases [methane, ethane, and ethene], and MNA indicator parameter).

5.6.1 Groundwater

Carbon Tetrachloride

The VOC CT was detected in six wells during all four quarterly monitoring events. The wells included 13MW3, 48MW2, 48MW3, 49MW01, 49MW04, and 50MW02. The highest concentrations were consistently detected at monitoring wells 48MW2 and 48MW3, with the highest levels observed at 48MW3. Concentrations detected in these two wells exceeded the RG` of 5 µg/L in each quarter. In general, the concentrations detected at 48MW2 and 48MW3 were variable from quarter to quarter with no clear increasing or decreasing trend. The remaining wells with observed detections were well below the RG and, in general, had concentrations that were fairly steady throughout the second year of MNA sampling. **Figures 5-9** through **5-12** depict the concentrations at these sampling locations throughout the second year of quarterly sampling. **Figure 5-13** provides a time series plot of CT concentrations dating back to samples collected in 1996.

Trichloroethene The VOC TCE was detected in eight monitoring wells during the fifth quarterly monitoring event, seven wells during the sixth and seventh quarters, and in ten wells during the eighth quarter. Monitoring wells 13MW3, 13MW4, 48MW1, 48MW2, 48MW3, 48MW06, 50MW02 had detected concentrations of TCE during all four sample events, while wells 49MW02 and 49MW01 had observed concentrations during the eighth monitoring event. The highest concentrations were consistently detected at monitoring wells 48MW3, 48MW2, and 48MW06, with the highest levels observed at 48MW3. Concentrations detected in 48MW3 exceeded the RG of 5 µg/L in each quarter, while 48MW06 and 48MW2 had detected concentrations in the eighth quarter that exceeded the RG. In general, the concentrations detected at 48MW06 and 48MW3 increased slightly throughout the second year of MNA sampling. The remaining wells with observed detections were well below the RG and, in general, had concentrations that were fairly consistent throughout the second year of MNA sampling, although nearly all wells saw in increase in concentrations in the eighth quarter. **Figures 5-9** through **5-12** depict the concentrations at these sampling locations throughout the second year of quarterly sampling. **Figure 5-14** provides a time series plot of TCE concentrations dating back to samples collected in 1996.

Lab Analysis, Data Validation, and Reporting

The second year of MNA sampling for SWMU 49 was collected quarterly in October 2016, January 2017, April 2017 and July 2017. Groundwater samples were collected in accordance with the Quality Assurance Project Plan (QAPP), revised August 2015. Documentation pertaining to CoC and sample condition was filed in field and laboratory records.

Table 5-9 Summary of Sample and Analyses

Sampling Event ID	Data Packages	Matrix	VOCs	Methane Ethane Ethene	Chloride Nitrate Sulfate	TOC
October 2016	122845 122887 122907 122926	GW	X	X	X	X
January 2017	124700 124730 124775 124799 124825	GW	X	X	X	X
April 2017	126485 126533 126555 126611	GW	X	X	X	X
July 2017	128820 128867 128923 128935	GW	X	X	X	X

TOC – total organic carbon
VOCs – volatile organic compounds

Analytical methods are provided in **Table 5-10**.

Table 5-10 Analytical Methods

Analysis	Analytes	Method
VOCs	Numerous	USEPA SW-846 Method 8260C
Dissolved Gases	Methane Ethane Ethene	USEPA SW-846 Method 8015/RSK-175
Anions	Chloride Nitrate Sulfate	USEPA SW-846 Method 9056A
TOC	TOC	USEPA SW-846 Method 9060A

The samples were placed into coolers with ice at the time of collection. The CoC forms were completed as the samples were packaged into coolers for transport. Trip blanks, temperature blanks, and ice were added as required. All coolers were shipped to the main laboratory, CT Laboratories in Baraboo, Wisconsin.

The trip blanks were packed in the coolers with the VOC and methane/ethane/ethene samples.

The analytic data was reviewed for consistency with the test methods as noted in **Table 5-10** and the Project QAPP (Radford Army Ammunitions Plant, Virginia – LTM) to ensure that the data set met project data quality objectives and was usable for the purposes of the project. Validation was performed following the National Functional Guidelines for Inorganic Superfund Data Review (USEPA, August 2014); National Functional Guidelines for Superfund Organic Methods Data

Review (August 2014); and professional judgment. Any anomalies to the requirements for precision, accuracy, representativeness, completeness, comparability, and sensitivity are discussed below and the data were flagged where appropriate.

Application of Data Flags

General data quality flagging conventions in **Table 5-11** were used to indicate quality control anomalies. Data was flagged, where appropriate, in accordance with the National Functional Guidelines and the project QAPP. A data quality summary is provided below.

Table 5-11 Data Qualifiers

Qualifier	Description
R	Rejected: The result is rejected due to deficiencies in the analytical system or the inability to meet QC criteria.
M	Matrix effect: The concentration is estimated due to a matrix effect.
J	Estimated: The analyte was positively identified, but the quantitation is an estimate due to discrepancies in meeting certain analyte-specific QC criteria.
J+	Estimated: The analyte was positively identified, but the quantitation is an estimate, possibly biased high, due to discrepancies in meeting certain analyte-specific QC criteria.
J-	Estimated: The analyte was positively identified, but the quantitation is an estimate, possibly biased low, due to discrepancies in meeting certain analyte-specific QC criteria.
B	Blank. The analyte was detected in an associated blank.
U	Undetected: The analyte was analyzed for but not detected.
UJ	The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific QC criteria.

Preservation, Temperature, and Hold Time

All sample preservation requirements were met. Most sample analyses were within holding time, with this exception:

- Nitrate analysis on three samples from the October 2016 sampling event was not performed within 48 hours of collection and sample results were qualified as estimated (J).

- Nitrate analysis on the January 2017 samples was not performed within 48 hours of collection and sample results were qualified as estimated (J).

5.6.2 Precision

Precision was measured from the relative percent difference (RPD) between the parent sample/field duplicate (FD), laboratory duplicates, laboratory control sample (LCS), and the matrix spike and matrix spike duplicate (MS/MSD) pairs.

Field Duplicates

Field duplicates were collected at a frequency of 10% of field samples. Most RPDs were within control limits. **Table 5-12** lists FD exceedances.

Table 5-12 Field Duplicate Precision Exceedances

Sample	Analyte	Flag	RPD
(Oct 2016) 48MW3	Chloromethane	J	>20%
(Jan 2017) 48MW07	TOC	J	>20%
(April 2017) 48MW06	1,1-Dichloroethene	UJ	>20%

Notes:
J = estimated
UJ = non-detected estimated

Laboratory duplicate analysis was performed at a frequency of 10% of laboratory samples, for inorganic analyses. All RPDs were within control limits. **Table 5-13** lists laboratory duplicate exceedances.

Table 5-13 Laboratory Duplicate Precision Exceedances

Sample/Method	Analyte	Flag	RPD
None			

<u>Matrix Spike/Matrix Spike Duplicate RPD</u>

MS/MSD analyses were run at a frequency of 5% of field samples. All results were within control limits. **Table 5-14** lists matrix spike/matrix spike duplicate RPD exceedances.

Table 5-14 MS/MSD RPD Exceedances

Sample/Method	Analyte	Flag	RPD
None			

5.6.3 Accuracy

Accuracy was measured from laboratory QC sample percent recoveries including LCS, MS, MSD, and surrogates. Accuracy was also evaluated by determining whether any deviations to method or laboratory requirements for internal standard (IS), initial calibration verification (ICV), and continuing calibration verification (CCV) recoveries were noted in the case narrative(s).

<u>Laboratory Control Sample/Matrix Spike/Matrix Spike Duplicate Recovery</u>

One LCS was analyzed for each batch of 20 samples or fewer.

All LCS recoveries were within control limits. **Table 5-15** lists laboratory control sample exceedances.

Table 5-15 LCS Recovery Exceedances

Sample/Method	Analyte	Flag	RPD
None			

MS/MSD analysis was performed at a frequency of 5% of field samples.

Most recoveries were within control limits. **Table 5-16** presents MS/MSD recoveries outside control limits. The data for the parent sample was flagged as indicated on the table. If no flag was indicated, the data were not flagged. Data was not flagged in cases where the parent sample concentration was greater than four times the spike concentration.

Parent samples only were qualified.

Table 5-16 MS/MSD Recovery Exceedances

Sample ID	Analyte	Recovery	Parent Flag
(October 2016)	No exceedances		
(January 2017)	No exceedances		
(April 2017) 48MW3	1,4-Dioxane	Low	UJ
(July 2017) 48MW3	Carbon tetrachloride	Low	J

Notes:
J = estimated
UJ = non-detected estimated

Surrogates

All surrogate recoveries were within control limits. **Table 5-17** presents surrogates that exceeded acceptance criteria.

Table 5-16 Surrogate Recovery Exceedances

Method	Sample ID	Surrogate	Recovery	Qualifiers
None				

Internal Standards

There were no internal standards outside control limits.

Calibration Verification

Some calibration results were outside control limits. **Table 5-18** summarizes calibration exceedances.

Table 5-18 Calibration Exceedances

Sampling Event	Analysis	Analytes	Result	Samples	Qualifiers
October 2016	No exceedances				
Jan 2017	VOCs	Bromoform	CCV high	13MW2 13MW3 13MW4 13MW5 48MW01 48MW02 48MW03 48MW06 48MW07 49MW01 49MW02 49MW03 49MW04 49MW05 50MW02	UJ
April 2017	VOCs	Bromomethane	CCV high	13MW2 13MW3 13MW4 48MW01 48MW02 48MW03 48MW06 49MW01 49MW02 49MW04 50MW02	UJ
July 2017	No exceedances				

Notes:
UJ = non-detected estimated

5.6.4 Representativeness

The data deliverables were consistent with the site conditions of the work plan. Samples were collected from locations specified in the approved work plan.

5.6.5 Comparability

Comparability was acceptable. Standard analytical methods were used. Standard preparatory and analytical methods were applied to the samples across sampling events. In all cases, the DLs and LODs attained were below the specified LOQs. All target compounds detected below the LOQs flagged (J) by the laboratory, should be considered estimated.

5.6.6 Completeness

Completeness was measured as the number of usable results versus the total number of results. The data set was 100% complete with no omissions or rejections with respect to analysis. The information fulfilled the data quality objectives of this investigation.

5.6.7 Sensitivity

Sensitivity was measured by evaluating whether the Practical Quantitation Limit (PQL) was less than the regulatory criteria. All nominal PQLs were below the regulatory criteria.

Additionally, sensitivity was evaluated by determining whether method blank, trip blank, and rinsate blank results were less than the PQL. Some analytes were detected in some blanks, leading to qualification of sample results.

Blanks (Calibration [Instrument], Method, Trip and Rinsate)

Calibration blanks were analyzed throughout analytical runs.

One method blank was analyzed with every batch of twenty samples or fewer for each matrix.

One trip blank was included with each cooler for samples to be analyzed for VOCs and dissolved gases (methane, ethane and ethene).

One rinsate blank was analyzed for each sample date.

Table 5-19 presents samples flagged for blank results. Sample results greater than two times the blank concentration were not qualified. Data quality and usability were not affected.

Table 5-19 Blank Flags

Sample Event	Type of Blank	Method	Analyte	Samples Qualified	Flag
Oct 2016	Method	VOCs	Chloromethane	13MW2 13MW3 13MW4 48MW1 48MW2 48MW3 49MW01 49MW02 49MW04	J
Jan 2017	Rinsate	VOCs	Chloroform	49MW01 50MW02	U
Apr 2017	No exceedances				
Jul 2017	No exceedances				

Notes:
U = non-detected
J = estimated

Reporting Limits

Nominal reporting limits, before adjustments for dilutions, were below the regulatory criteria noted in the project QAPP.

Summary

In summary, all data was considered usable with the qualifications discussed above. No data were rejected and the completeness goals for the project were met. The data was considered of good quality for the project goals.

This Data Quality Assessment was prepared by: Katia Kiarashpoor, LDC, Inc.

Figure 5-9 SWMU 49 Fifth Quarter CT and TCE Concentrations

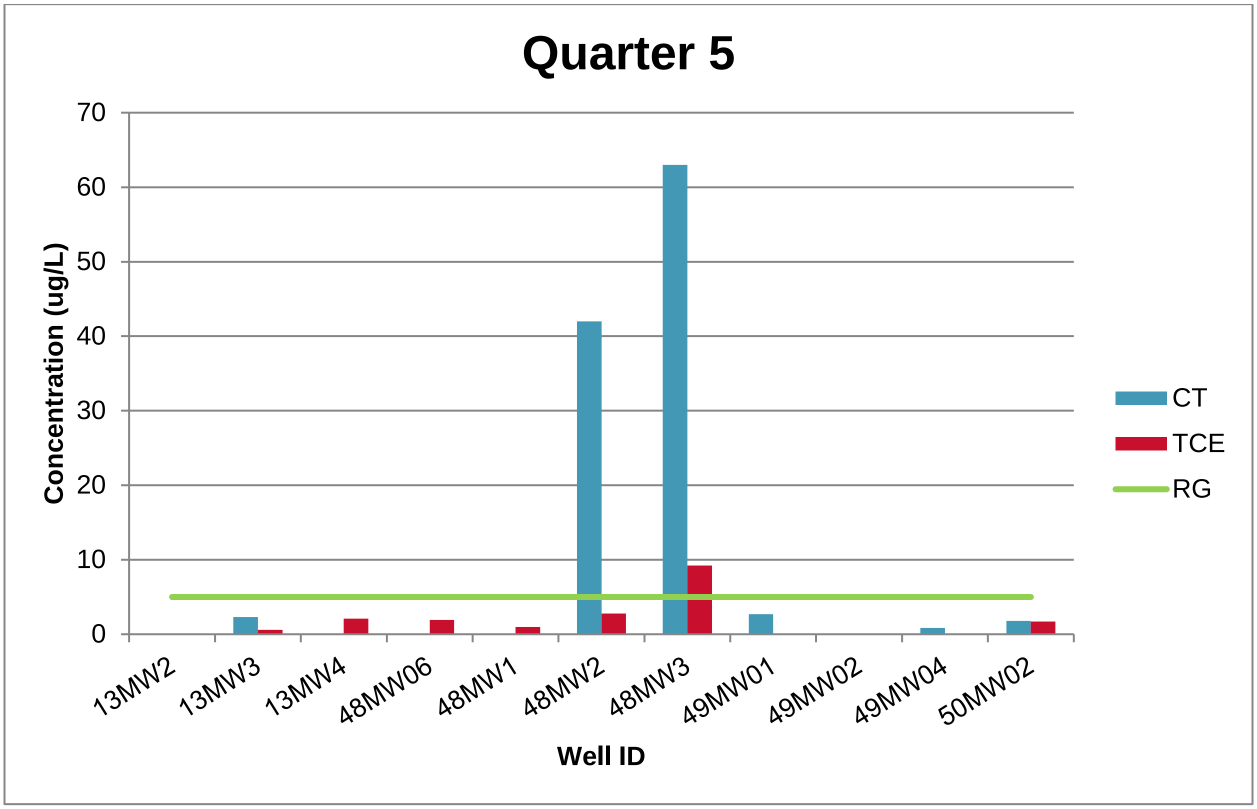


Figure 5-10 SWMU 49 Sixth Quarter CT and TCE Concentrations

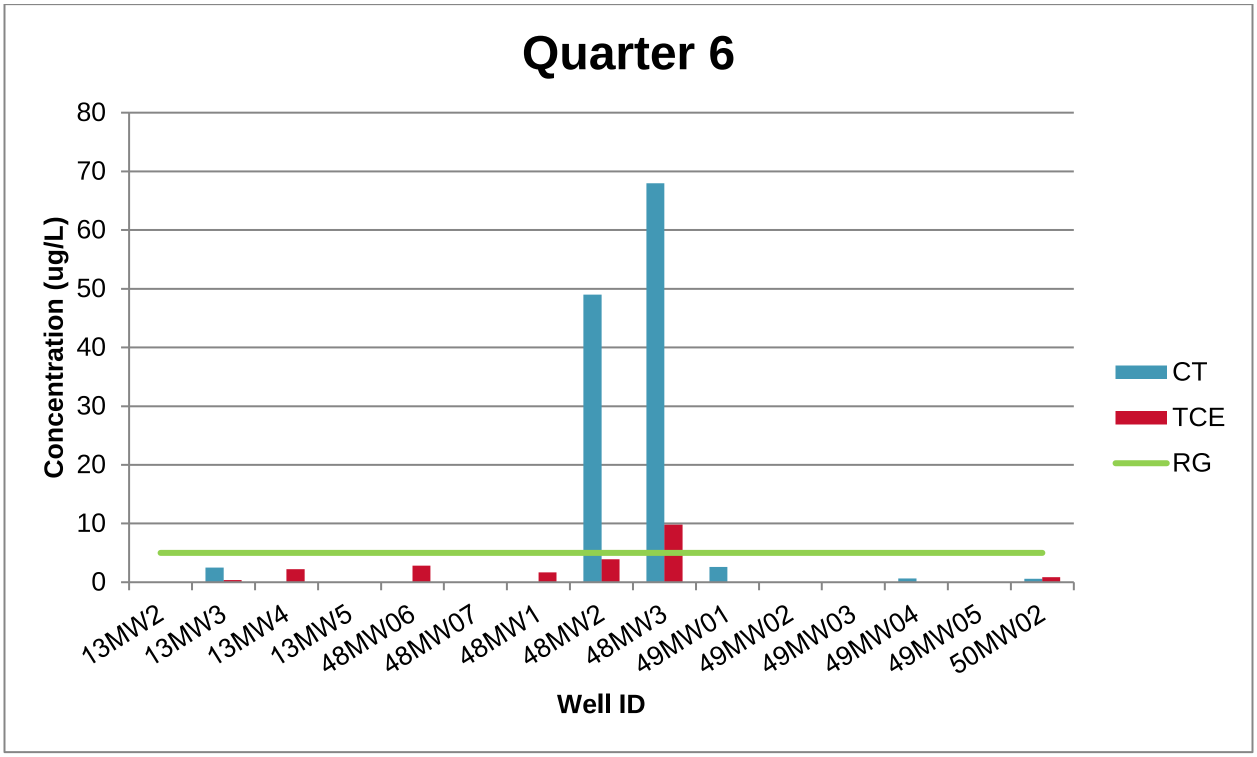


Figure 5-11 SWMU 49 Seventh Quarter CT and TCE Concentrations

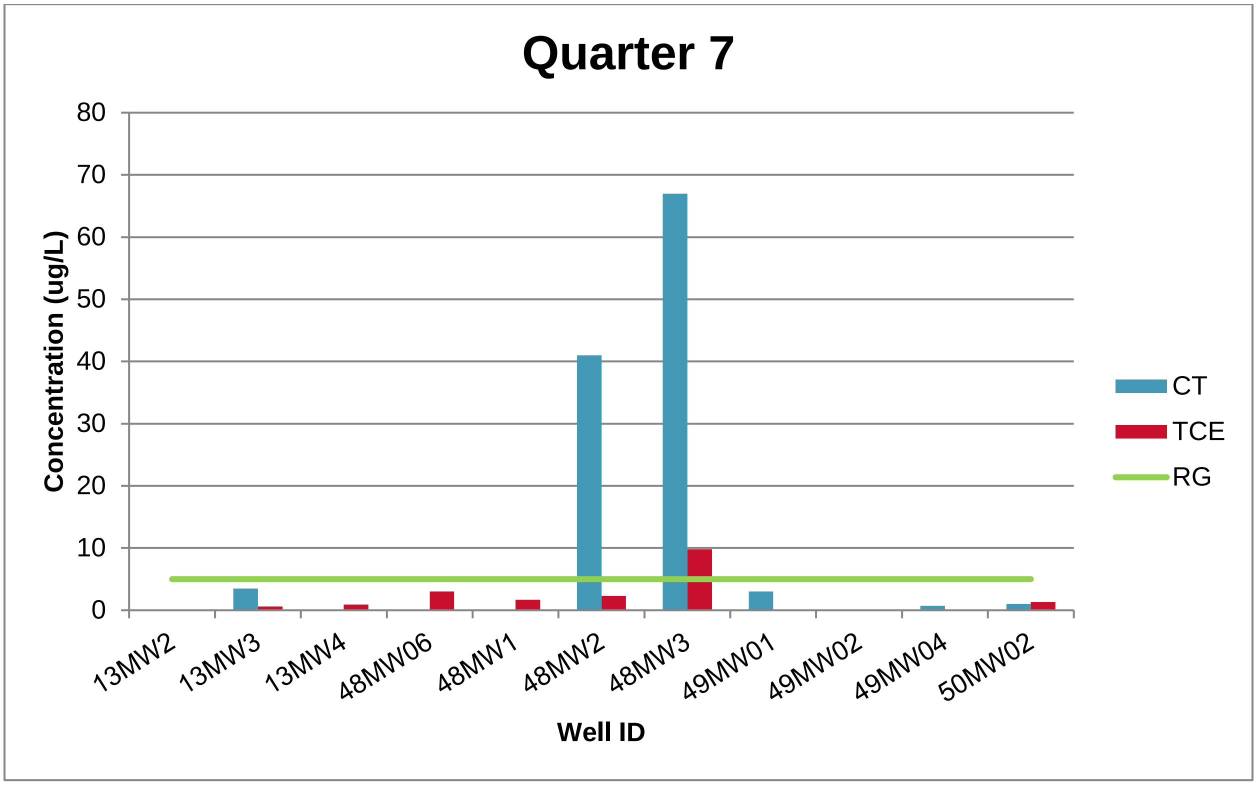


Figure 5-12 SWMU 49 Eighth Quarter CT and TCE Concentrations

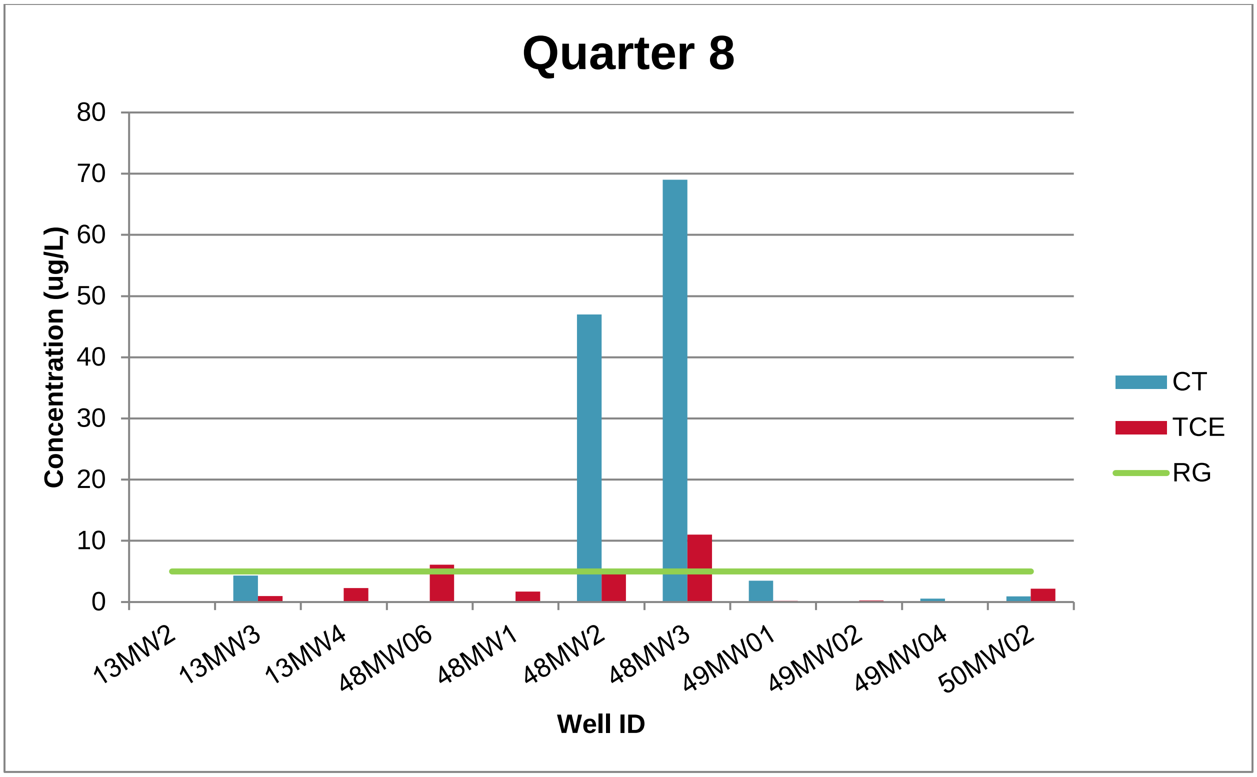
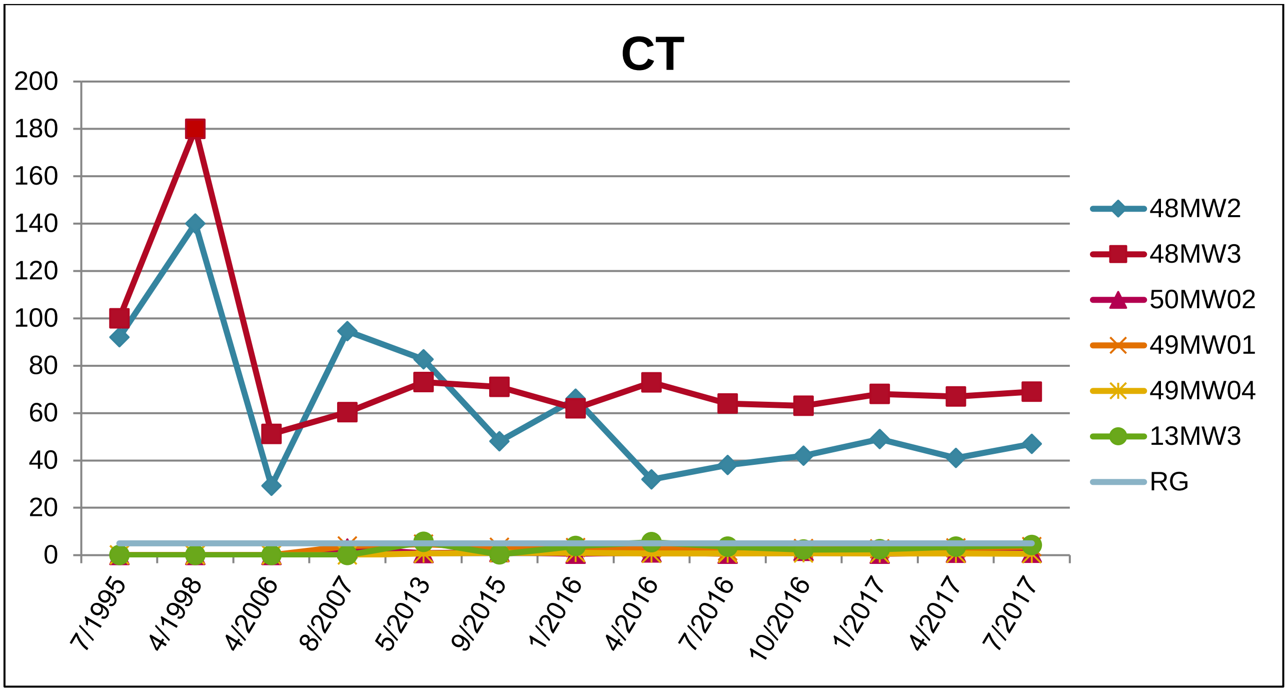
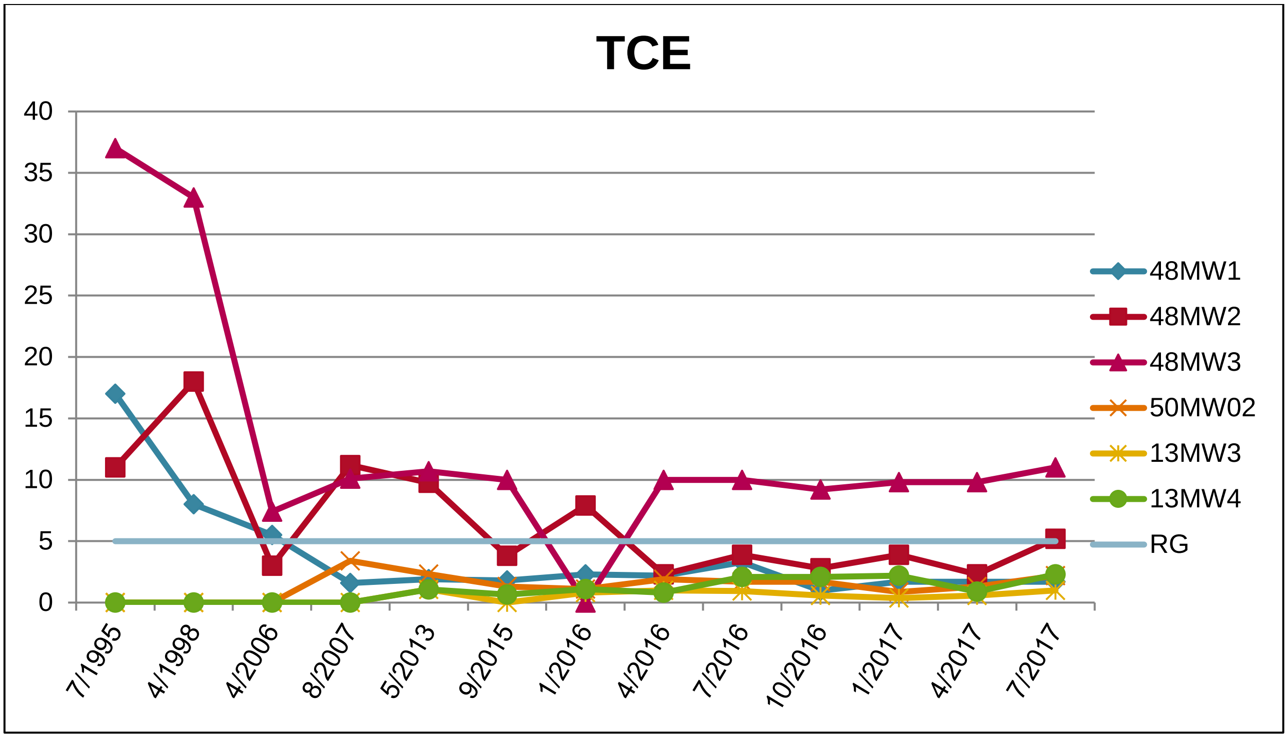


Figure 5-13 SWMU 49 CT Concentration Trends



Note: x-axis time intervals do not reflect actual period of time between events.

Figure 5-14 SWMU 49 TCE Concentration Trends



Note: x-axis time intervals do not reflect actual period of time between events.

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6.0 MNA Evaluation of SWMU 49

Eleven monitoring wells were sampled in the SWMU 49 study area for four quarters, while four wells were sampled on an annual basis during the second year of MNA monitoring. Sample results were evaluated to determine whether MNA is continuing to occur at the site. This section presents and summarizes the results for the second year MNA sampling. Consistent with the TCL VOC results from the sampling event in May 2013 and the baseline sampling conducted in January 2015, the highest concentrations of CT were observed in wells 48MW2 and 48MW3, where the center of the plume is located. One trend that continued to change from previous results was the TCE concentrations detected at 48MW2, where historically high concentrations had been detected. With the exception of the eighth quarter results, TCE concentrations in well 48MW2 were below the RG, and only slightly above the RG in the eighth quarter. Further, well 48MW06 contained the second highest TCE concentrations during the eighth quarter of MNA sampling, which is located up gradient from 48MW2 and 48MW3.

Based on the second year MNA results, the CT and TCE plumes changed only slightly from quarter to quarter (seasonally) (See **Figures 5-1** through **5-8**). In general, the CT and TCE plumes were centered on monitoring wells 48MW3/48MW2 and 48MW06/48MW3, respectively. These trends continued throughout the year, with the exception of TCE. During the sixth, seventh, eighth quarterly events, the plume decreased in size when TCE went undetected at monitoring well 13MW2. During the eighth quarter, TCE concentrations increased slightly in monitoring wells 48MW06 and 48MW2. In all quarterly events during the second year of MNA monitoring, isolated detections of CT were detected down gradient at well 13MW3, which is next to the New River. Similarly, TCE was detected down gradient at monitoring wells 13MW3 and 13MW4.

6.1 First Line of Evidence: Occurrence of Contaminants

The first line of evidence consists of evaluating contaminant and daughter product concentrations in monitoring wells over time. The VOC CT reduces to form chloroform, while TCE will be reduced to form cis-1,2-DCE, among other by products. Both CT and TCE attenuate more favorably under anaerobic conditions. Fifteen monitoring wells were included in the MNA monitoring at SWMU 49, which targeted areas with CT and TCE contamination. Historical trends and the results of the second year MNA quarterly groundwater sampling are discussed below, and the data is provided in **Table 6-1**.

Table 6-1 SWMU 49 Carbon Tetrachloride and TCE Quarterly Concentrations

Parameter	Remediation Goal (RG)	October 2016 (Q5)	January 2017 (Q6)	April 2017 (Q7)	July 2017 (Q8)
13MW2					
Carbon tetrachloride	**5**	ND	ND	ND	ND
Trichloroethene	**5**	1.7	ND	ND	ND
13MW3					
Carbon tetrachloride	**5**	2.3	2.5	3.5	4.3
Trichloroethene	**5**	0.58	0.36	0.58	1
13MW4					
Carbon tetrachloride	**5**	ND	ND	ND	ND
Trichloroethene	**5**	2.1	2.2	0.9	2.3
13MW5					
Carbon tetrachloride	**5**	A	ND	A	A
Trichloroethene	**5**	A	ND	A	A
48MW06					
Carbon tetrachloride	**5**	ND	ND	ND	ND
Trichloroethene	**5**	1.9	2.8	3	6.1
48MW07					
Carbon tetrachloride	**5**	A	ND	A	A
Trichloroethene	**5**	A	ND	A	A
48MW1					
Carbon tetrachloride	**5**	ND	ND	ND	ND
Trichloroethene	**5**	0.97	1.7	1.7	1.7
48MW2					
Carbon tetrachloride	**5**	42	49	41	37
Trichloroethene	**5**	2.8	3.9	2.3	5.2
48MW3					
Carbon tetrachloride	**5**	63	68	67	69
Trichloroethene	**5**	9.2	9.8	9.8	11
49MW01					
Carbon tetrachloride	**5**	2.7	2.6	3	3.5
Trichloroethene	**5**	ND	ND	ND	0.37
49MW02					
Carbon tetrachloride	**5**	ND	ND	ND	ND
Trichloroethene	**5**	ND	ND	ND	0.25
49MW03					
Carbon tetrachloride	**5**	A	ND	A	A
Trichloroethene	**5**	A	ND	A	A
49MW04					
Carbon tetrachloride	**5**	0.86	0.66	0.78	0.55
Trichloroethene	**5**	ND	ND	ND	ND
49MW05					
Carbon tetrachloride	**5**	A	ND	A	A
Trichloroethene	**5**	A	ND	A	A
50MW02					
Carbon tetrachloride	**5**	1.8	0.58	1.0	0.95
Trichloroethene	**5**	1.7	0.87	1.3	2.2

ND = non detect
A = Sampled Annually

Carbon Tetrachloride

There is good correlation of chloroform to CT concentrations for all four quarterly monitoring periods. Based on the data, wells with detected concentrations of CT also contained measurable levels of chloroform, with the exception of 49MW04; chloroform went undetected in this monitoring well for all quarterly monitoring events. Chloroform also went undetected in 50MW02 in the eighth quarter monitoring event. In nearly every case chloroform was detected along with CT, chloroform levels either increased or decreased in correlation to CT concentrations. Based on available data, the presence of chloroform suggests the degradation of CT is occurring at SWMU 49. **Figures 6-1** through **6-8** provide correlation data from the second year of MNA sampling.

Trichloroethene

The correlation of cis-1,2-DCE to TCE does not appear to be as strong as the case for CT to chloroform. There is evidence that some correlation exists, however, in wells that contained the highest observed concentrations of TCE, cis-1,2-DCE went undetected or was detected at extremely low levels. In some cases, cis-1,2-DCE concentrations exceeded those of TCE. There is strong correlation, however, in the eighth quarter in that all wells with detected concentrations of TCE also included detected concentrations of cis-1,2-DCE. Based on the available data, a strong correlation of TCE degradation to cis-1,2-DCE cannot be determined. **Figures 6-1** through **6-8** provide correlation data from the second year of MNA sampling.

Figure 6-1 SWMU 49 Fifth Quarter Carbon Tetrachloride to Chloroform Correlation

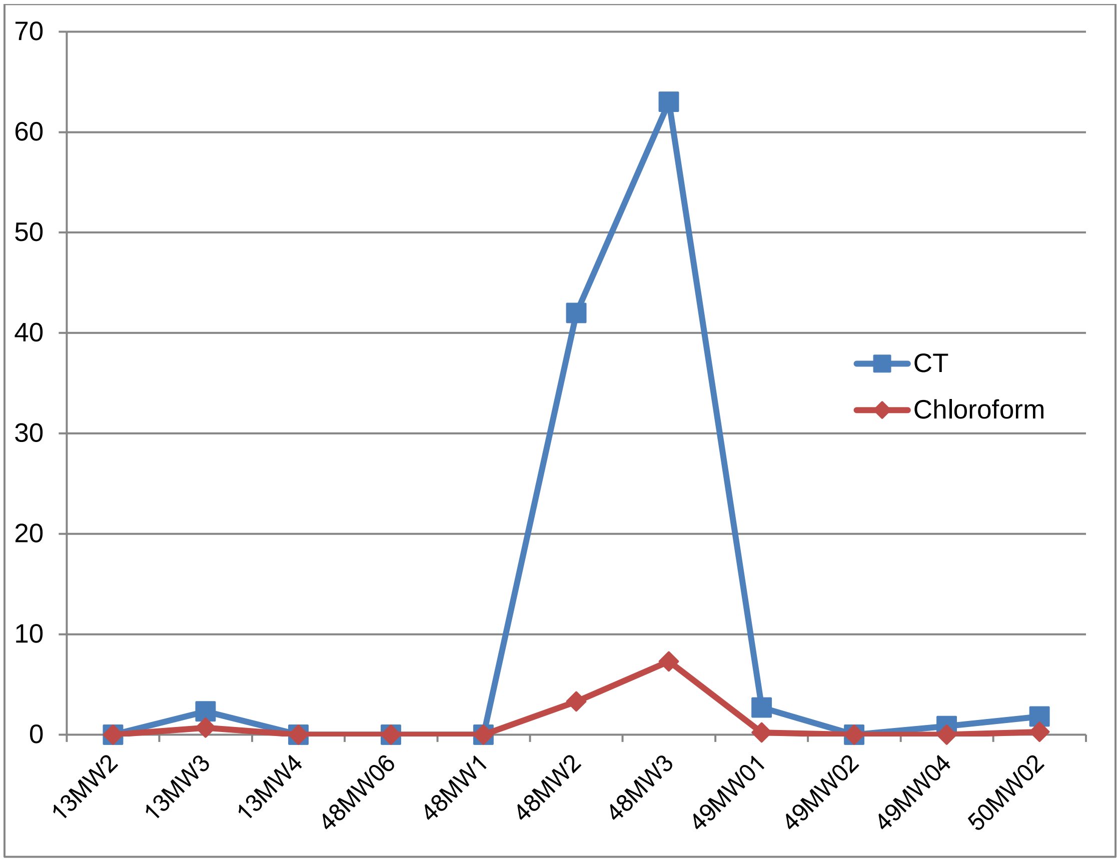


Figure 6-2 SWMU 49 Fifth Quarter TCE to cis-1,2-DCE Correlation

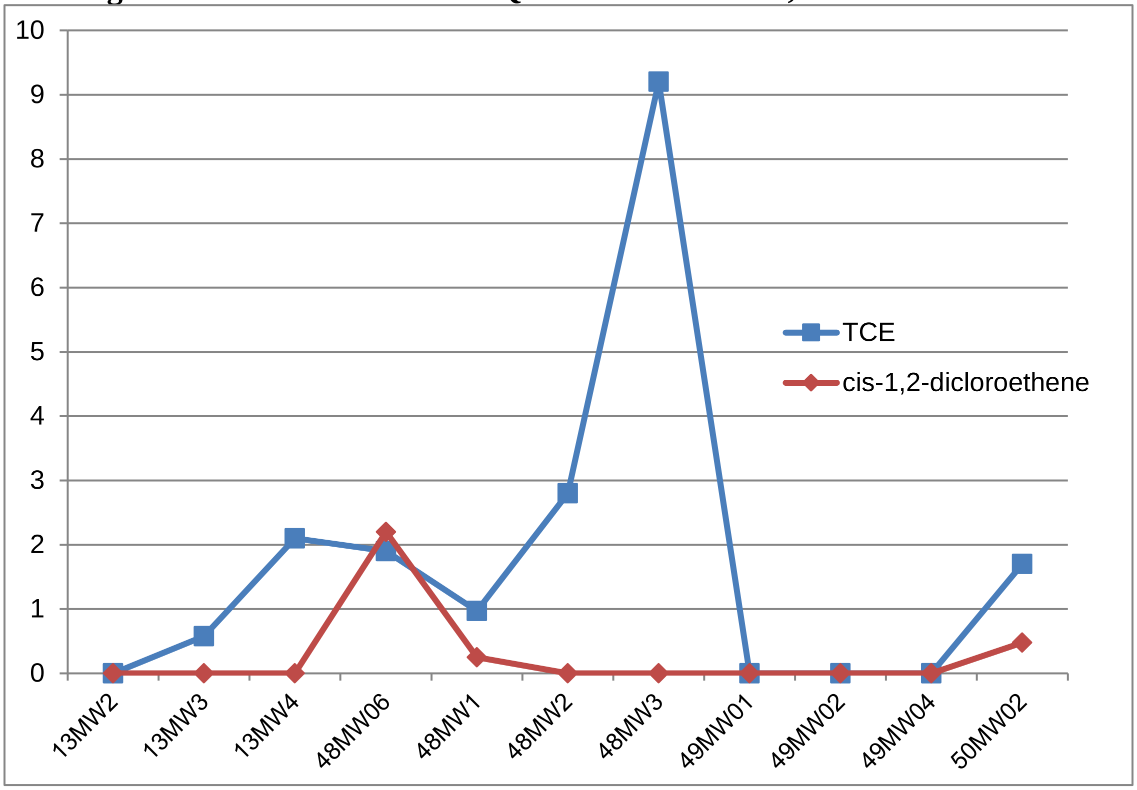


Figure 6-3 SWMU 49 Sixth Quarter Carbon Tetrachloride to Chloroform Correlation

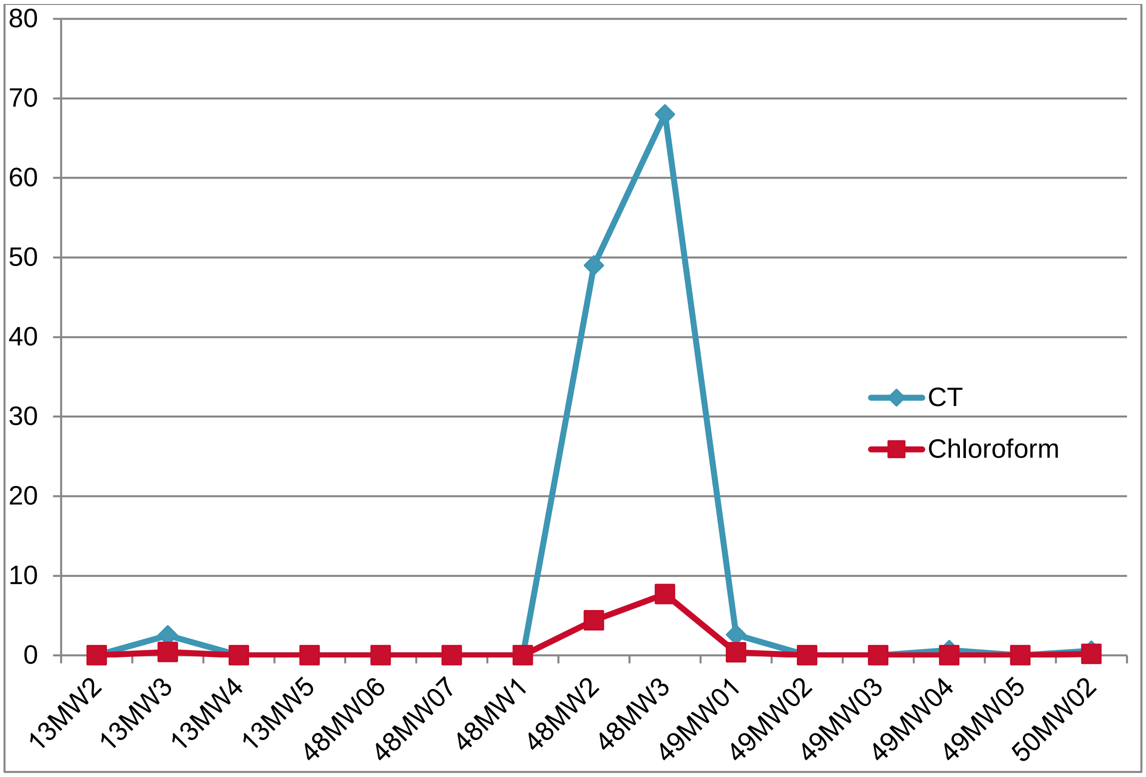


Figure 6-4 SWMU 49 Sixth Quarter TCE to cis-1,2-DCE Correlation

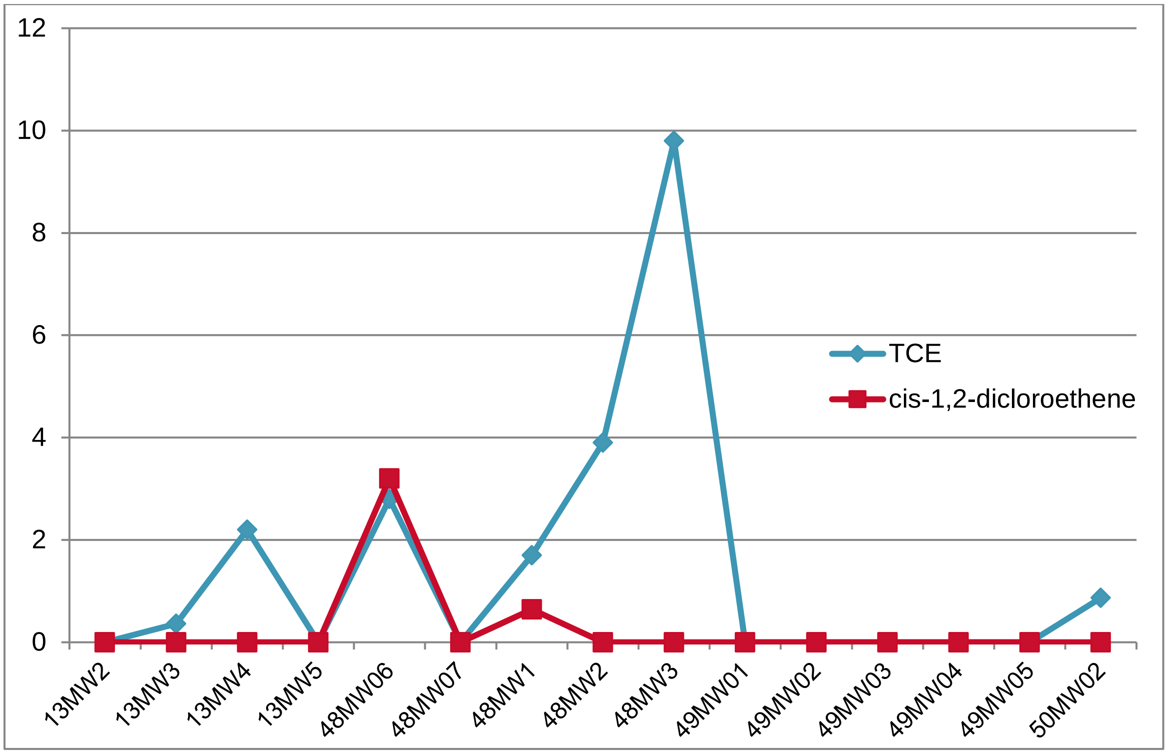


Figure 6-5 SWMU 49 Seventh Quarter Carbon Tetrachloride to Chloroform Correlation

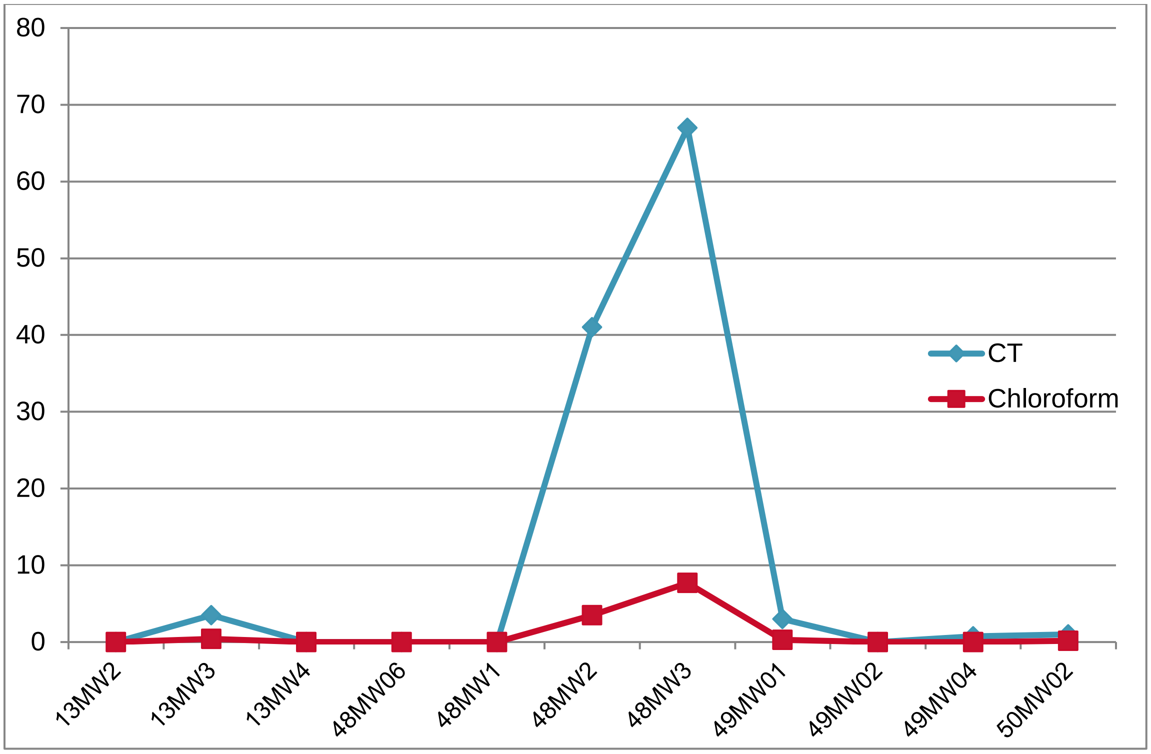


Figure 6-6 SWMU 49 Seventh Quarter TCE to cis-1,2-DCE Correlation

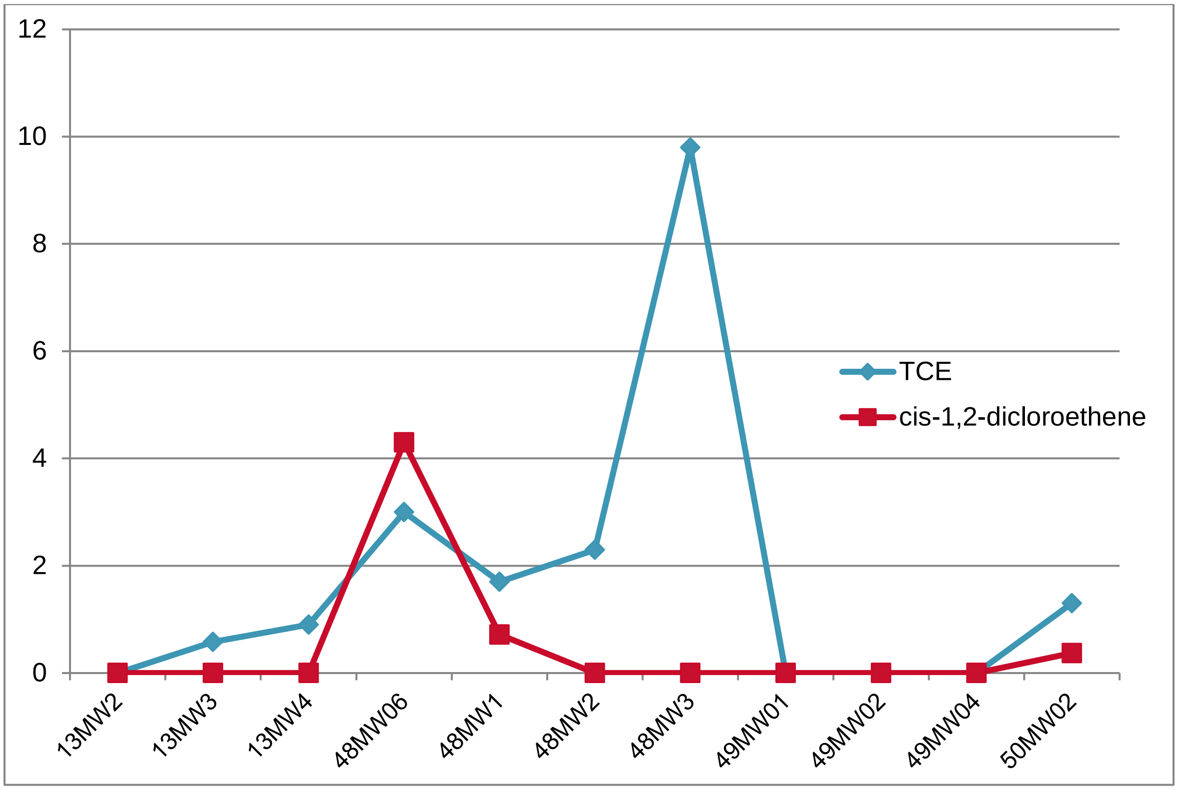


Figure 6-7 SWMU 49 Eighth Quarter Carbon Tetrachloride to Chloroform Correlation

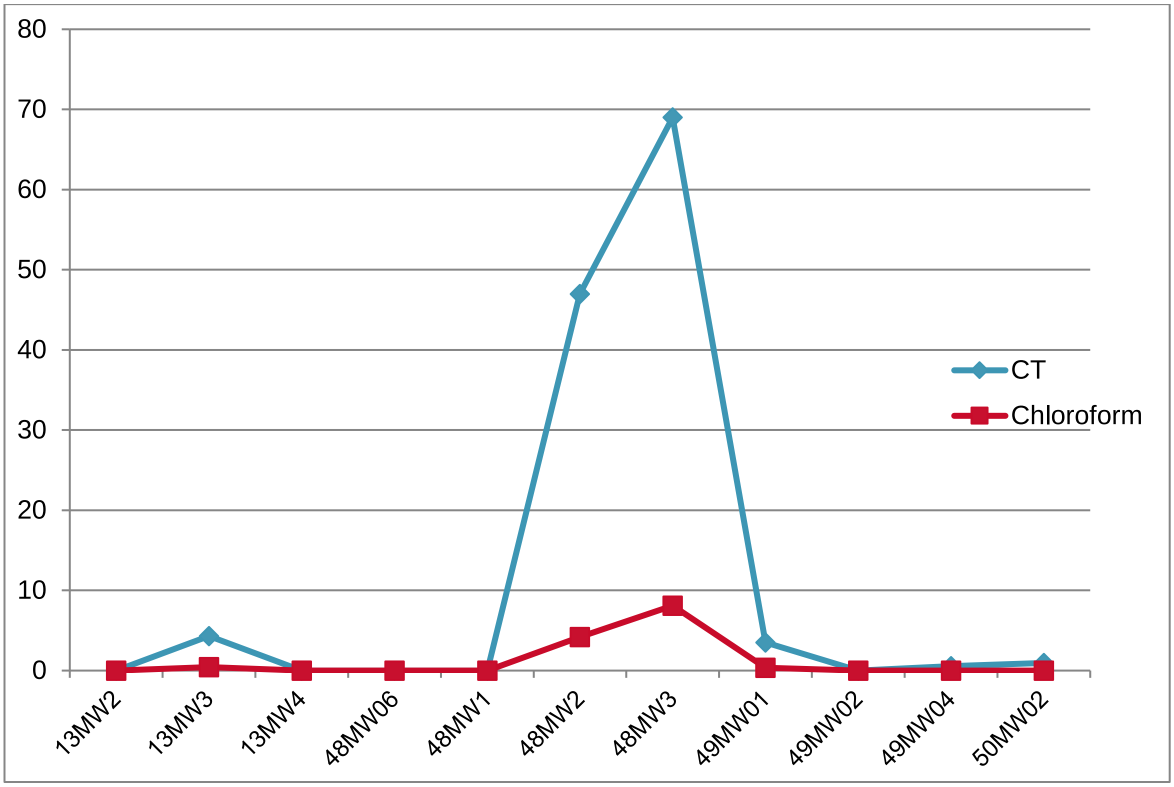
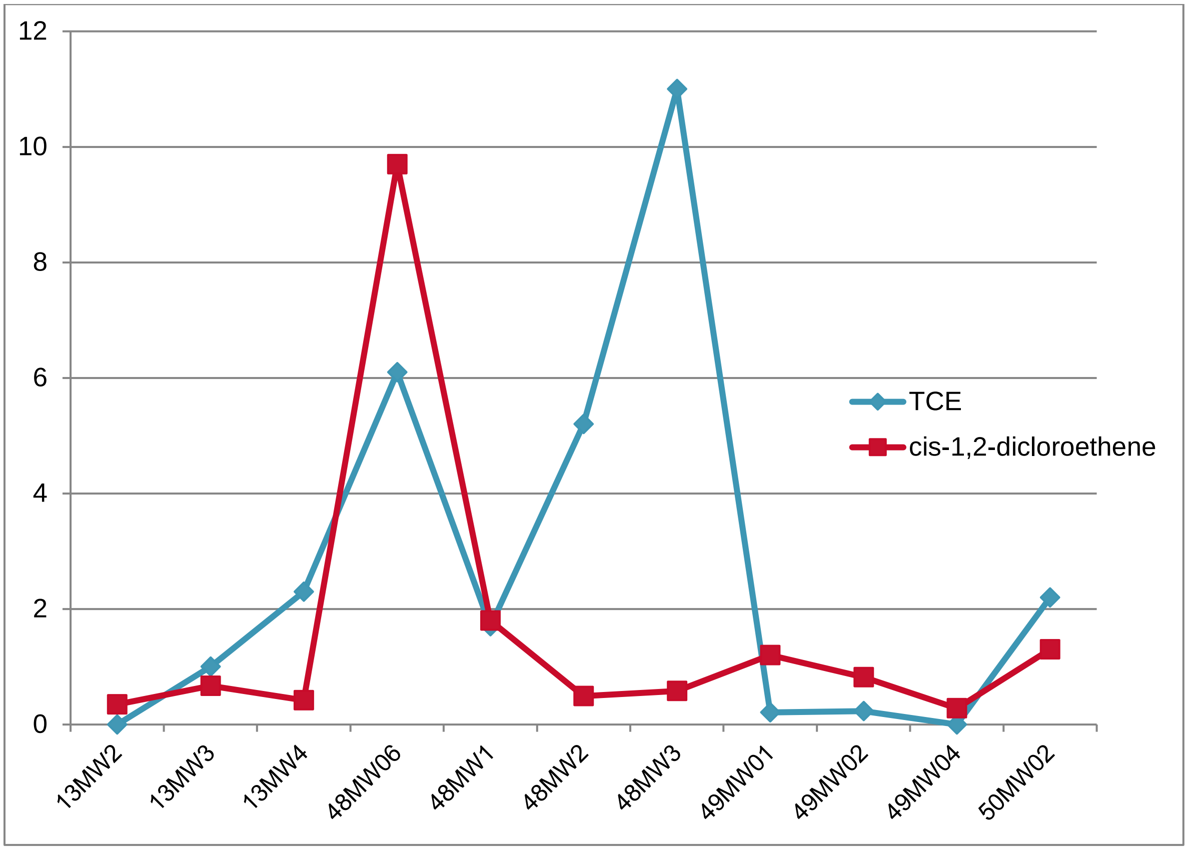


Figure 6-8 SWMU 49 Eighth Quarter TCE to cis-1,2-DCE Correlation



6.2 Second Line of Evidence: Geochemical Conditions

Geochemical data is available for all four quarterly groundwater monitoring events at SWMU 49. Field parameters (DO, ORP, pH, temperature, and specific conductivity) were collected for all four quarters as part of the low-flow sampling procedures. Laboratory analysis for nitrate, sulfate, and TOC were conducted for all four quarterly groundwater monitoring events at SWMU 49. These geochemical data are discussed regarding the potential for biodegradation in the groundwater at SWMU 49.

The degradation of CT primarily occurs under anaerobic conditions, either through denitrification, iron reduction, sulfate reduction or methanogenesis. The degradation of TCE can occur under anaerobic reductive chlorination and aerobic oxidizing conditions. Historical trends and the results of the second year MNA quarterly groundwater sampling are discussed below and the data is provided in **Table 6-2.**

Dissolved Oxygen (DO). The preferred terminal electron acceptor during aerobic microbial respiration is oxygen, and DO is measured to determine whether the groundwater is under aerobic or anaerobic conditions. Average DO values less than 1 mg/L, are tolerable of anaerobic microbial activities. Further, DO values higher than 8 mg/L were considered biased high given their relative magnitude to oxygen solubility at field temperatures and are not included in this analysis.

DO levels during the second four quarterly monitoring events (October 2016 to July 2017) ranged from 0.01 to 8.27 mg/L indicating both anaerobic and aerobic conditions were present at the site. Wells where CT degradation products were observed (13MW3, 48MW2, 48MW3, 49MW01, and 50MW02), DO levels (between 2.29 and 7.36 mg/L) indicate aerobic conditions (**Table 6-2**). CT degradation is more favorable under anaerobic conditions. Wells where TCE degradation products were observed (48MW06, 48MW1, 48MW2, 48MW3, 49MW01, 49MW02, 50MW02, 13MW2, 13MW3, and 13MW4), DO levels ranged between 0.01 and 7.36 mg/L indicating a flux between anaerobic and aerobic conditions remains in place. However, aerobic conditions were most prevalent.

Oxidation-Reduction Potential (ORP). ORP values indicate the groundwater's reductive potential and are used to confirm the DO measurements in groundwater. ORP values less than +50 mV typically correspond to mildly reducing, anaerobic conditions, while ORP values less than -200 mV correspond to highly reducing, anaerobic conditions.

ORP levels recorded during the second year of MNA sampling ranged from 9.41 to 192.7 mV indicating both anaerobic and aerobic conditions were present at the site. However, aerobic conditions appeared to be more prevalent (**Table 6-2**). Further, the ORP values and DO readings did not show a clear corresponding trend for samples taken at the same well and same sampling event.

pH. The pH for optimum microbial activity ranges from 5 to 9 SU. Microbial activity may decrease at lower pH values. The second year of pH data ranged between 6.68 and 14.2 SUs, within this optimal pH range (**Table 6-2**). In general, the pH environment at SWMU 49 is suitable for microbial activity.

Nitrate. Following oxygen, microorganisms preferentially use nitrate (NO3-) as a terminal electron acceptor. Elevated nitrate concentrations may indicate nitrate-reducing conditions which promote the degradation of CT forming breakdown by-products.

Nitrate levels during the second year of MNA sampling were generally low (overall <1 mg/L) with concentrations ranging from 0.14 to 7.1 mg/L.

Ferrous Iron. Ferric iron is reduced to soluble ferrous iron in the groundwater where iron-reducing bacteria have been active. An increase in ferrous iron concentrations is indicative of iron-reducing conditions. Biological reduction of CT is favored in nitrate-reducing conditions and therefore, elevated levels of ferrous iron are an indicator of favorable groundwater conditions.

Ferrous iron concentrations for all wells during the second year of MNA monitoring ranged between 0.0 mg/L (non-detect) and 2.31 mg/L indicating that iron-reducing conditions are improving slightly from the first year of MNA monitoring where concentrations ranged from 0.0 (non-detect) and 1.06 mg/L.

Sulfate. Sulfate concentrations were measured in the groundwater during each of the second year MNA sampling events and were found to range between 0.0 mg/L (non-detect) and 200 mg/L. Sulfate levels at monitoring wells where CT and chloroform were detected (13MW3, 48MW2, 48MW3, 49MW01, and 50MW02) generally had concentrations ranging between 0.00 (non-detect) mg/L and 120 mg/L.

Total Organic Carbon (TOC). TOC concentrations greater than 20 mg/L are considered adequate to support microbial activity. For the second year of MNA monitoring, TOC levels ranged from 0.00 mg/L (non-detect) and 6 mg/L, suggesting an unfavorable environment. However, TOC levels recorded during quarters seven and eight increased nearer to the 5 mg/L range (**Table 6-2**).

Figure 6-9 provides a time series plot of CT and chloroform concentrations relative to specific conductivity readings for 48MW2 and 48MW3 for monitoring years 1 and 2. **Figure 6-10** provides a time series plot of TCE and cis-1,2-DCE concentrations relative to specific conductivity readings for 48MW2 and 48MW3 for monitoring years 1 and 2. Specific conductivity is the indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, and Fe, all degradation by-products. **Figures 6-11 and 6-12** provide time series plots of MNA indicators sulfate, nitrate, chloride, TOC, ethene, and methane in source wells 48MW2 and 48MW3 for monitoring years 1 and 2. **Figure 6-13** provides a time series plot of water quality parameters DO, Fe, and ORP in 48MW2 and 48MW3 for monitoring years 1 and 2. Data suggest that TCE and CT contaminants are biodegrading and more dissolved inorganic ions (such as chlorides, nitrates, and sulfates, and Fe) are creating the electrical current witnessed in the specific conductivity readings. Organic compounds do not carry current and therefore have almost no conductivity (USACE, 1999).

Monitoring well **48MW3** appears to carry more of the dissolved solids due to the higher conductivity readings. Biodegradation consumes sulfate and nitrate and produces alkalinity. The sulfate and nitrate concentrations at 48MW3 fluctuate slightly, though no obvious declining trend. However, chloride is the ion that is formed during dechlorination that takes place in an anaerobic reduction zone; chloride concentrations are increasing slightly. Anaerobic conditions prevail at 48MW3 with steady DO readings below 1 mg/L.

Monitoring well **48MW2** fluctuates between anaerobic and aerobic conditions. Sulfate is a waste product created when sulfate-reducing bacteria generate usable energy under anaerobic conditions; data show that the sulfate concentrations are on the decline, though their concentrations increase when conditions are generally more aerobic. Chloride concentrations are also impacted by more aerobic conditions, but are on a declining trend. Nitrate concentrations are in a steady state. Methane concentrations increased in September 2015 and July 2017; suggesting biodegradation via sequential dechlorination of TCE to non-chlorinated products under anaerobic conditions.

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Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 49

Well ID	13MW2	13MW3	13MW4	13MW5	48MW06	48MW07	48MW1	48MW2	48MW3	49MW01	49MW02	49MW03	49MW04	49MW05	50MW02
SWMU 49 Fifth Quarter (October 2016) Water Quality Parameters															
pH	9.3	7.99	9.32	---	11.7	---	13.42	9.74	10.14	10.39	13.02	---	8.6	---	9.25
Specific Conductivity (mS/cm)	742	584	472	---	559	---	427	504	740	479	550	---	646	---	711
Turbidity (NTU)	1.79	1.52	1.43	---	55.10	---	2.02	42	1.46	97.2	10.6	---	---	---	15.9
Dissolved Oxygen (mg/L)	4.6	2.29	3.36	---	2.10	---	4.3	6.12	3.75	5.98	2.21	---	1.67	---	3.57
ORP (mV)	99.5	9.41	74.6	---	171.1	---	186.3	192.7	174.6	191.3	138.1	---	165.3	---	144.4
Temperature (°C)	15.04	16.84	16.0	---	13.18	---	13.21	14.38	13.62	15.23	13.02	---	15.3	---	12.80
Dissolved Ferrous Iron (mg/L)	0.04	0.00	0.01	---	0.90	---	0.00	0.21	0.00	0.92	0.27	---	0.00	---	0.06
Nitrate (mg/L)	0.15	0.54	0.7	---	1.3	---	0.72	0.72	6.6	0.4	0.17	---	0.48	---	2.1
Sulfate (mg/L)	43	95	50	---	76	---	37	3.8	28	ND	19	---	55	---	63
TOC (mg/L)	0.51	ND	ND	---	0.78	---	ND	ND	ND	ND	ND	---	ND	---	ND
SWMU 49 Sixth Quarter (January 2017) Water Quality Parameters															
pH	7.04	6.89	6.68	7.08	7.30	7.84	7.72	7.37	7.17	7.58	7.32	7.58	7.34	7.16	6.77
Specific Conductivity (mS/cm)	761	599.6	539.2	835	722	203.4	521.5	555.2	810	502.6	619.2	378.4	660	878	818
Turbidity (NTU)	1.41	3.45	1.56	0.67	43.1	1.30	2.91	35.8	0.40	38	4.31	57.4	3.01	35.4	78.5
Dissolved Oxygen (mg/L)	4.34	3.45	3.75	4.57	2.51	8.27	2.82	7.36	4.70	5.79	1.37	7.70	1.51	2.52	5.29
ORP (mV)	71.6	103.1	88.5	74.8	90.1	76.1	81.7	103.9	81.0	66.4	66.4	81.1	75.9	63.8	134.0
Temperature (°C)	14.3	14.1	14.9	11.4	12.3	12.1	11.8	10.0	9.8	12.6	9.6	11.6	13.3	13.8	11.8
Dissolved Ferrous Iron (mg/L)	0.02	0.05	0.07	0.04	0.29	0.00	0.00	0.40	0.14	0.33	0.18	0.42	0.04	0.16	0.45
Nitrate (mg/L)	0.16	1	0.74	2.7	1.9	1.2	1.4	0.82	6.7	0.43	0.16	1	0.4	0.22	2.1
Sulfate (mg/L)	42	93	50	160	110	2.4	53	5.4	30	2.6	20	4.5	53	170	67
TOC (mg/L)	0.76	1.7	0.53	ND	1	6	ND	0.59	0.84	ND	ND	ND	0.76	0.96	0.74
SWMU 49 Seventh Quarter (April 2017) Water Quality Parameters															
pH	7.05	6.94	6.84	---	7.15	---	7.65	7.42	7.20	7.63	7.37	---	7.31	---	7.02
Specific Conductivity (mS/cm)	680	567	445	---	730	---	475	482	700	441	526	---	610	---	680
Turbidity (NTU)	1.76	1.14	0.52	---	39.1	---	1.47	17.1	0.57	18.7	3.84	---	1.35	---	34.2
Dissolved Oxygen (mg/L)	5.63	3.94	5.36	---	2.12	---	2.72	6.56	3.57	5.16	1.37	---	0.94	---	3.09
ORP (mV)	150.1	109.2	105.7	---	124.6	---	116.7	115.0	97.4	131.3	107.4	---	135.3	---	138.1
Temperature (°C)	15.1	14.4	14.1	---	14.1	---	12.8	13.3	12.5	13.0	12.7	---	14.9	---	13.0
Dissolved Ferrous Iron (mg/L)	0.05	0.03	0.00	---	0.30	---	0.06	0.15	0.03	0.26	0.17	---	0.08	---	1.83
Nitrate (mg/L)	0.2	1.7	0.7	---	2.5	---	1.5	0.75	7.1	0.32	0.14	---	0.29	---	2.2
Sulfate (mg/L)	34	120	50	---	130	---	49	3.8	29	ND	21	---	51	---	68
TOC (mg/L)	4	3.9	3.1	---	4.7	---	2.7	3.8	4.7	3.3	3.8	---	4.2	---	5.7
SWMU 49 Eighth Quarter (July 2017) Water Quality Parameters															
pH	7.14	7.10	6.92	---	7.08	---	7.72	7.54	7.27	14.2	7.38	---	7.39	---	7.14
Specific Conductivity (mS/cm)	751	615	445.4	---	0.90	---	499.0	532.7	760	487.2	584.0	---	664	---	702
Turbidity (NTU)	3.13	0.52	0.75	---	21.2	---	9.11	675	0.40	18.7	3.93	---	2.35	---	6.53
Dissolved Oxygen (mg/L)	6.04	4.53	3.02	---	0.01	---	3.70	6.37	3.12	4.30	0.67	---	4.29	---	2.64
ORP (mV)	93.0	98.3	91.1	---	26.8	---	94.1	115.0	115.7	121.5	102.7	---	114.3	---	108.0
Temperature (°C)	15.3	18.9	14.8	---	14.5	---	14.2	14.1	13.8	14.2	14.6	---	14.3	---	14.2
Dissolved Ferrous Iron (mg/L)	0.15	0.12	0.06	---	0.23	---	0.13	2.31	0.11	0.21	0.16	---	0.10	---	0.19
Nitrate (mg/L)	0.24	0.87	0.62	---	4.1	---	1.3	0.82	6.7	0.31	0.14	---	0.25	---	2.3
Sulfate (mg/L)	43	100	29	---	200	---	45	8	29	ND	18	---	51	---	82
TOC (mg/L)	3.2	0.54	2.1	---	5	---	1.9	1.9	0.52	2.4	3.2	---	0.7	---	ND

Notes:
ºC = degrees Celsius
mg/L = milligrams per liter
mS/cm = millisiemens per centimeter
mV = millivolt
NTU = nephelometric turbidity unit
Aerobic/Anaerobic Indicators:
DO = anaerobic <1mg/L> aerobic
ORP = highly reducing, anaerobic conditions < -200 mV ≤ mildly reducing anaerobic+50mV ≥ aerobic

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Figure 6-9 CT and Chloroform Concentration Trends Relative to Specific Conductivity 48MW2 and 48MW3

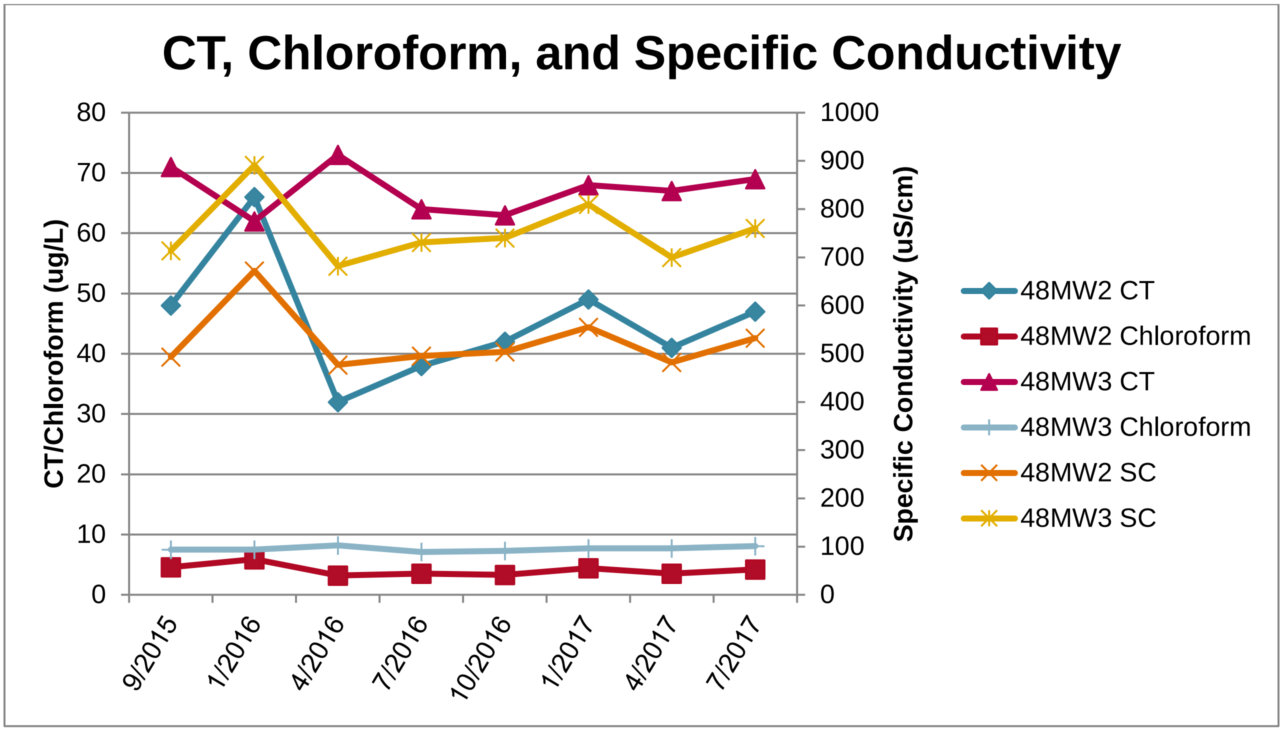


Figure 6-10 TCE and cis-1,2-DCE Concentration Trends Relative to Specific Conductivity 48MW2 and 48MW3

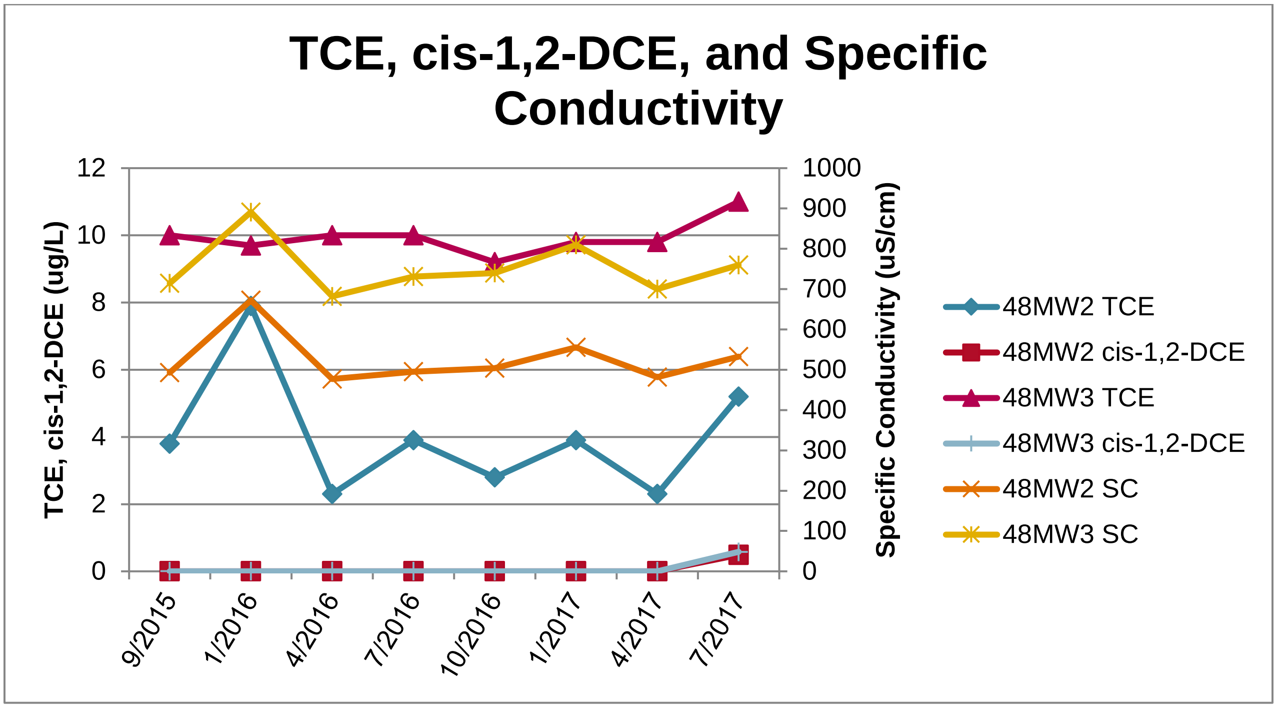


Figure 6-11 48MW2 MNA Indicators Years 1 and 2

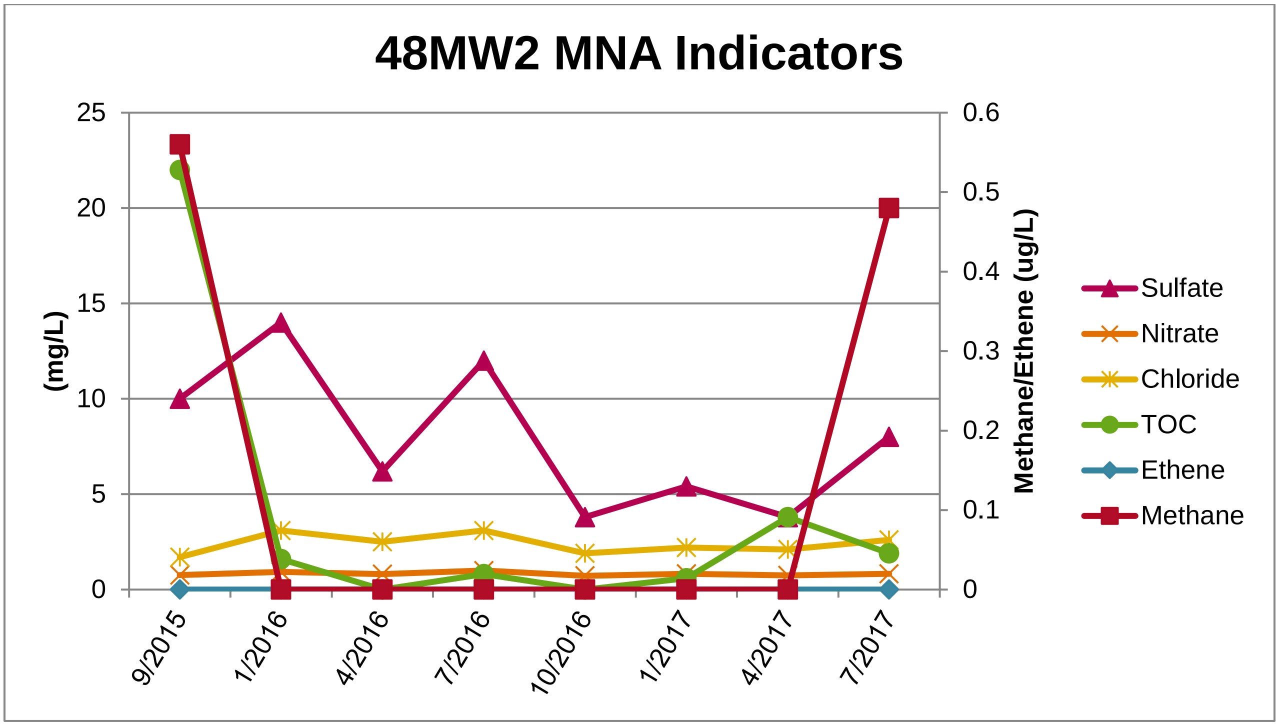


Figure 6-12 48MW3 MNA Indicators Years 1 and 2

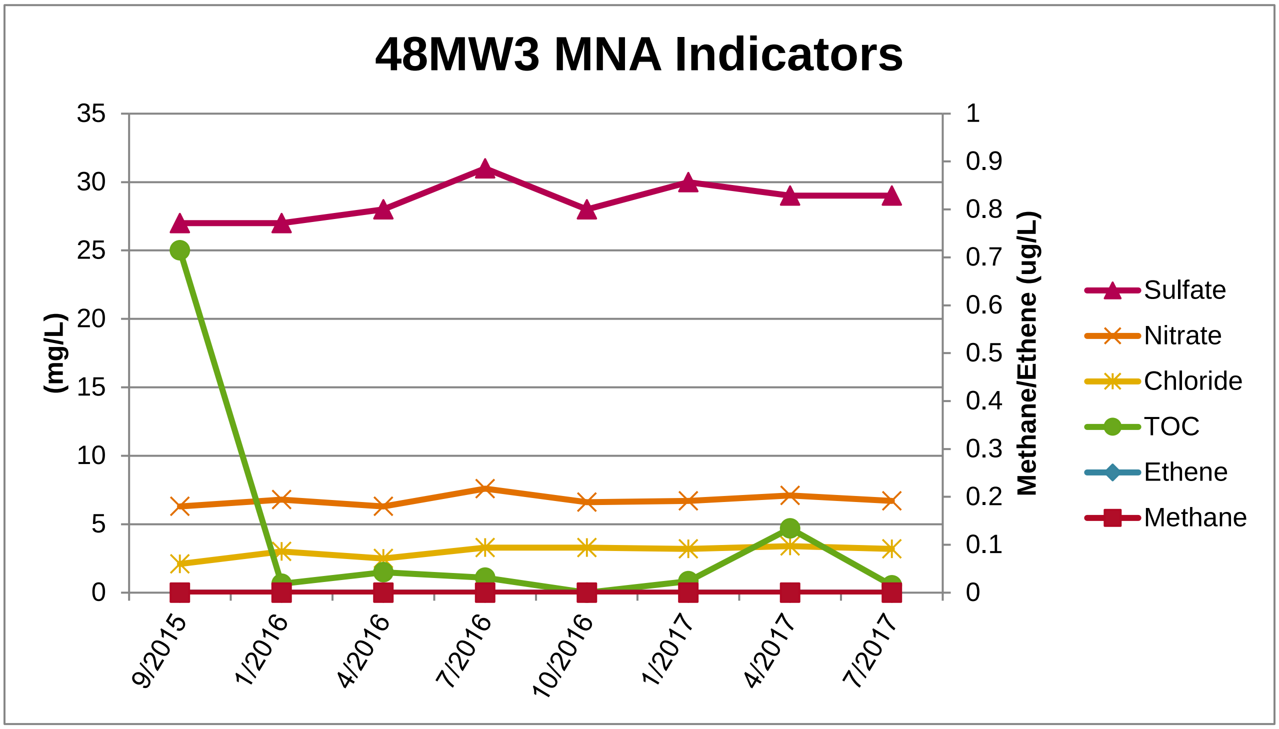
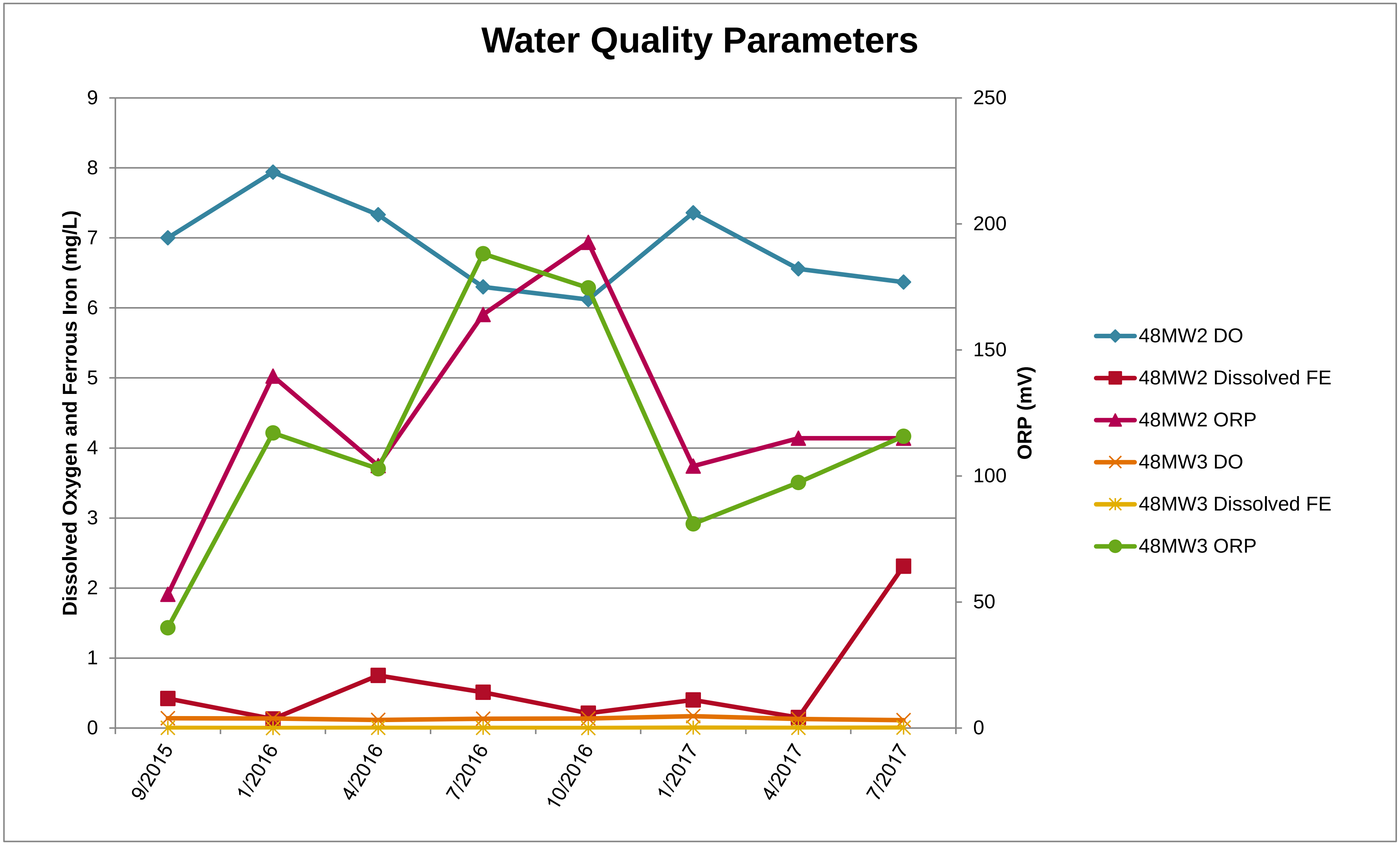


Figure 6-13 Water Quality Parameters 48MW2 and 48MW3 Years 1 and 2



7.0 Summary and Conclusions

Eleven (11) groundwater monitoring wells were sampled on a quarterly basis during the second year of MNA monitoring at SWMU 49, while four more were sampled on an annual basis. The four quarters of sample data suggest that CT and TCE concentrations are fairly stable at SWMU 49. The CT contaminant plume remains centered around monitoring wells 48MW2 and 48MW3, although detections were observed at 13MW3 during all four quarters, one of which exceeded the RG. Further, TCE was detected in all four quarters at monitoring wells 13MW3 and 13MW4, which are located down gradient and adjacent to the New River. TCE was also detected in all four quarters at monitoring wells 48MW06, 48MW1 (located adjacent to 48MW06), and 50MW02 well below the RG. Based on the presence of chloroform in wells where CT was observed, it appears that the VOC is degrading. Chloroform was not detected in any wells where CT went undetected. The data suggest that MNA processes may be decreasing mass; as such, the CT plume does not appear to be expanding. The data suggest that the correlation of cis-1,2-DCE to TCE is not as prevalent as an indicator of degradation. However, TCE levels remained consistent at all wells with observed concentrations suggesting that the plume is not expanding.

In summary, the following conclusions and recommendations were made regarding the potential for MNA in contaminated groundwater at SWMU 49:

- Presence of chloroform suggest that degradation is occurring, which may be aiding in removing CT mass in the groundwater.
- The breakdown product, cis-1,2-DCE is present at the site, although no substantive correlation exists with TCE. However, TCE concentrations remain stable across the site.
- Geochemical parameters also indicate that groundwater conditions are generally aerobic (DO and ORP levels) and that pH and TOC levels are adequate to promote microbial degradation. However, overall ferrous iron, nitrate, and sulfate concentrations do not appear to favor conditions to support degradation. Overall, conditions are trending toward a favorable environment for microbial degradation.
- Based on the MNA results presented in the SWMU 49 MNA Sampling Baseline Report (CB&I, 2015), other MNA processes including sorption, dilution, dispersion, and chemical stabilization are occurring in groundwater at the SWMU 49 study area. Conditions appear favorable that these processes will not significantly change or diminish and will continue to contribute to attenuation of the contaminants at SWMU 49.
- The monitoring well network appears adequate to monitor MNA at SWMU 49.

It is our recommendation that groundwater monitoring continues on a quarterly basis at the fifteen monitoring well locations. For the third year LTM annual report, an evaluation of MNA as an adequate remedy including timeframe for meeting RGs should be included. This MNA evaluation should include a degradation rate and comparison to a “reasonable” timeframe. Furthermore, the third year report should include a discussion of the need for an alternative remedy dependent on the timeframe to achieve the RGs. Due to the limited data base, it is also recommended that the analytical suite of TCL VOCs, dissolved gases, and MNA indicator parameters continue to be tested.

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8.0 References

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Appendix A
Field Sampling Logs
(Electronic Only)

Appendix B-1
Data Validation Reports
(Electronic Only)

Appendix B-2
Laboratory Analytical Reports
(Electronic Only)