Draft Final

SWMU 54 Monitored Natural Attenuation Sampling Year Four Report

Radford Army Ammunition Plant, Virginia

December 2016

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
2,4,6-TNT	2,4,6-trinitrotoluene
2ADNT	2-amino-4,6-dinitrotoluene
4ADNT	4-amino-2,6-dinitrotoluene
amsl	above mean sea level
bgs	below ground surface
BSEn	Bearing Sea Environmental, LLC
CAS	Chemical Abstracts Service
CCV	Continuing Calibration Verification
CMO	Corrective Measures Objective
CMS	Corrective Measures Study
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
COI	Chemical of Interest
COPC	Chemical of Potential Concern
DNT	Dinitrotoluene
DNX	hexahydro-1,3,5-dinitroso-5-nitro-1,3,5-triazine
DO	Dissolved Oxygen
FD	Field Duplicate
ft	feet/foot
ft/day	feet per day
ft/year	feet per year
HHRA	Human Health Risk Assessment
HI	Hazard Index
IDW	Investigative Derived Waste
IM	Interim Measure
IMWP	Interim Measures Work Plan
IS	Internal Standard
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate

LTM	Long-term Monitoring
MB	Method Blank
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
mg/L	milligrams per liter
mL/min	milliliters per minute
MNA	Monitored Natural Attenuation
MNX	hexahydro-1-nitroso-3,5- dinitro-1,2,5-triazine
MS	Matrix Spike
mS/cm	millisiemens per centimeter
MSD	Matrix Spike Duplicate
mV	millivolts
MWP	Master Work Plan
ND	Not Detected
NI	Not Identified
NG	Nitroglycerin
ng/L	nanograms per liter
NT	Not Tested
NTU	Nephelometric Turbidity Unit
ORP	Oxidation Reduction Potential
PID	Photoionization Detector
PQL	Practical Quantitation Level
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RDX	cyclotrimethylenetrinitramine
RFAAP	Radford Army Ammunition Plant
RFI	RCRA Facility Investigation
RG	Remedial Goal
RL	Reporting Limit
RPD	Relative Percent Difference
Shaw	Shaw Environmental, Inc.
SL	Screening Level

SU	Standard Unit
SVOC	Semi-volatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCDD	Tetrachlorodibenzodioxin
TCL	Target Compound List
TIC	Total Inorganic Carbon or Tentatively Identified Compound
TNT	Trinitrotoluene
TNX	hexhydro-1,3,5-trinitroso- 1,3,5-triazine
TOC	Top of the casing or Total Organic Cbargon
URS	URS Corporation
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VA	Virginia
VI	Verification Investigation

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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 Long-Term Monitoring (LTM) and Monitored Natural Attenuation (MNA) at Solid Waste Management Unit (SWMU) 54 (RAAP-014), Propellant Burning Ash Disposal Area, 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 thirteenth through sixteenth quarterly rounds conducted in 2015 through 2016. Further, this report provides a summary of the fourth year of sampling.

This work was performed under Contract No. W912QR-13-D-001, Delivery Order No. 0001 in accordance with the *Radford Army Ammunition Plant, Radford, Virginia, Final Master Work Plan (MWP)* (URS, 2003) and with Part II (D)(11-21) IM of the RFAAP Resource Conservation and Recovery Act (RCRA) Corrective Action Permit (USEPA, 2000). In order to maintain consistency with previous LTM and MNA sampling events (i.e., through year 3), the LTM and MNA activities followed the technical approach, Sampling and Analysis Plan, and quality assurance/quality control (QA/QC) procedures documented in the *Final SWMU 54 MNA Interim Measures Work Plan (IMWP)* (Shaw, 2011a).

1.1 Purpose and Scope

Soil interim measures (IMs) have been completed at SWMU 54 to mitigate the threat of a contaminant release, migration, and/or exposure to the public and the environment. The IMs included site preparation, soil excavation, waster characterization and off-site disposal, confirmation sampling, and site restoration. Detailed information concerning the IMs are presented in the *Final SWMU 54 RCRA Facility Investigation (RFI) / Corrective Measures Study (CMS) Report* (URS, 2008).

The Corrective Measures Objectives (CMOs) and Remedial Goals (RGs) were developed and presented in the *Final SWMU 54 RFI/CMS Report* (URS, 2008). The site-specific CMOs for SWMU 54 Area A are to mitigate further leaching of explosives constituents from soil-to-groundwater at levels that would potentially increase observed concentrations and adversely impact future beneficial use of groundwater; and to the extent practicable, a goal of restoring site groundwater to the most beneficial use. The site-specific CMOs for SWMU 54 Area B are to mitigate the potential hypothetical future risks that have been identified for exposure to soil under a future construction worker scenario; and to prevent leaching of contaminants of concern from soil-to-groundwater at levels that would potentially adversely impact future beneficial use of groundwater. The site-specific CMOs for Area A and B were met through the excavation and off-site disposal of contaminated soil, which was completed in 2010.

The objectives of the LTM and MNA program are to measure and track the reduction of the following compounds to levels below the RGs as defined in **Table 1-1**:

- 2,4,6-trinitrotoluene (2,4,6-TNT);
- dinitrotoluene (DNT)-mixture;
- cyclotrimethylenetrinitramine (RDX); and
- perchlorate.

Table 1-1 SWMU Groundwater Remedial Goals

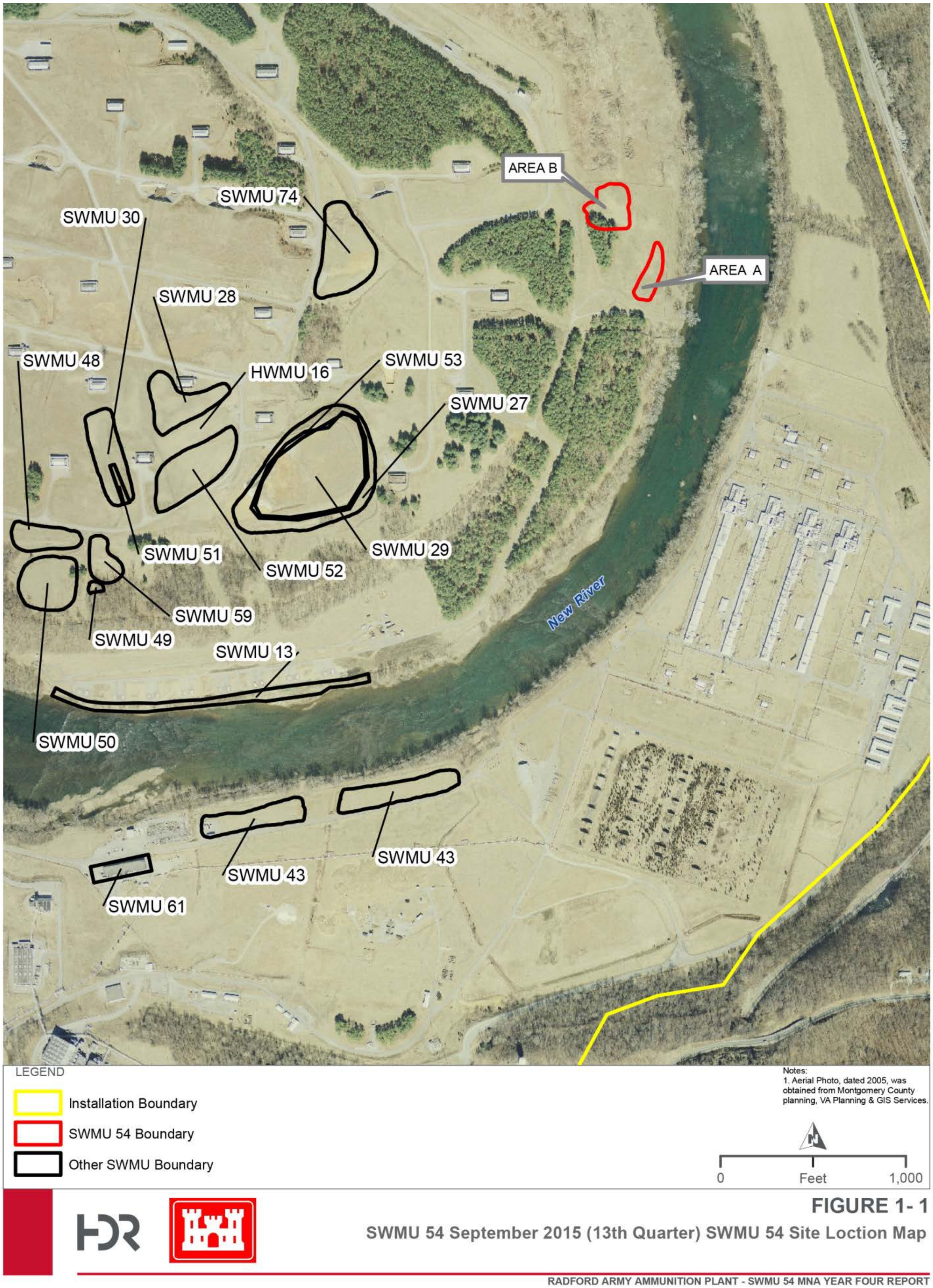
Chemical of Interest	Groundwater RG (mg/L)	Groundwater RG Source(*)
2,4,6-TNT	0.00782	RG
DNT Mixture	0.000932	RG
RDX	0.0061	RG
Perchlorate	0.0109	RG

**RGs were calculated using target risk 1E-5 for the lifetime resident and a target hazard of 1 for the adult and child resident (see URS, 2008).*

1.2 Site Description and Background

SWMU 54 is situated in the northeastern section of RFAAP within the easternmost portion of the Horseshoe Area. The SWMU consists of two the contiguous disposal areas, Area A and B. Area A is a triangular shaped parcel located in the southeast section of SWMU 54 that covers approximately 0.58-acres. Area B is a somewhat round tract located in the northwestern section that covers approximately 1.09 acres. Both areas are open fields covered with grass and bordered to the east and north by the RFAAP installation security fence. The site is currently undeveloped. SWMU 54 was reportedly used as an ash disposal area in the late 1970s that received propellant ash from the Waste Propellant Burning Grounds. The location of SWMU 54 is provided in **Figure 1-1**.

Figure 1-1 SWMU 54 September 2015 (13th Quarter) SWMU 54 Site Location Map



Notes:
1. Aerial Photo, dated 2005, was obtained from Montgomery County planning, VA Planning & GIS Services.

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2.0 Physical Characteristics

2.1 Topography

SWMU 54 is situated on a gently sloping terrace that leads to the New River to the east. Elevations range from a high of approximately 1,716 feet (ft) above mean sea level (amsl) in the western section of the SWMU to approximately 1,696 ft amsl in the eastern section. East and outside the SWMU boundary, the elevation steepens precipitously as it reaches the New River (at approximately 1,676 ft amsl). The site topography is shown in **Figure 2-1**.

2.2 Surface Water

The New River is situated approximately 150 ft east of SWMU 54, while a small stream is present on the southern boundary. Surface water runoff from the SWMU flows east and, possibly south, to the New River and the unnamed stream. SWMU 54 is located within the easternmost portion of the Horseshoe Area at RFAAP. As it currently stands, SWMU 54 is positioned within the New River 100-year floodplain.

2.3 Geology

2.3.1 Regional Geology

SWMU 54 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 Final MWP (URS, 2003).

2.3.2 Site-Specific Geology

Characterization of the SWMU 54 subsurface lithology was conducted during the advancement of soil and monitoring well borings at the site. Based on the borehole logs, two geologic cross-sections were developed and are presented in **Figure 2-1** (plan view of the cross-sectional lines), **Figure 2-2** (cross section A-A’), and **Figure 2-3** (cross section B-B’).

Soil and monitoring well borings ranged from 10 to 60 ft in depth. Depths to bedrock, which were reported to be measured directly at the monitoring well borings, ranged in elevation from approximately 1,716 ft amsl to 1,670 ft amsl. Based on the borehole logs, the determination was made that bedrock slopes to the east.

The site lithology consists of unconsolidated sediments comprised of alluvial deposits overlying a thin zone of saprolitic carbonate (i.e., weathered bedrock), which overlies the Cambrian-aged Elbrook Formation. The alluvial deposits consist primarily of silty sand overlying channel deposits of fine- to coarse-grained sand and gravel (river jack). These paleochannel deposits rest directly on the saprolite, which reportedly reaches 2.5 ft in thickness. It was also reported that some areas of the SWMU contain fill material to depths of 9 to 10 ft below ground surface (bgs).

Depth to competent bedrock at the SWMU ranges from 17 to 24 ft bgs. This competent bedrock belongs to the Elbrook Formation, which is a thickly-bedded, blue-gray dolostone interspersed with blue-gray to white limestone. Locally, the formation is described as interbedded green and maroon shale, yellowish-brown dolostone, and greenish- to grayish-brown limestone and dolostone.

A more detailed discussion of the geology and soil at RFAAP is presented in Sections 3.4 through 3.7 of the RFAAP MWP (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 range. 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 stores recharge that otherwise would be rapidly diverted to overland flow. In addition, this unit 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 locally) is one of the major karstlands in the eastern United States.

Groundwater supplies in the Valley and Ridge Province are generally of good quality when compared to surface water supplies (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.

2.4.2 Site-Specific Hydrogeology

Monitoring wells installed at SWMU 54 were screened in both the shallow (surficial aquifer) and shallow bedrock aquifers. Water levels were measured in the wells to calculate the groundwater flow direction at the SWMU. Groundwater contour maps have been prepared using water level data collected prior to each round of groundwater sampling. The maps for the fourth year of monitoring are presented in **Figures 4-2**, **4-3**, **4-4**, and **4-5**. Contour lines shown on the figures 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 east and appears to discharge to the New River along the eastern side of the site.

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Figure 2-1 SWMU 54 Topography and Cross Sections

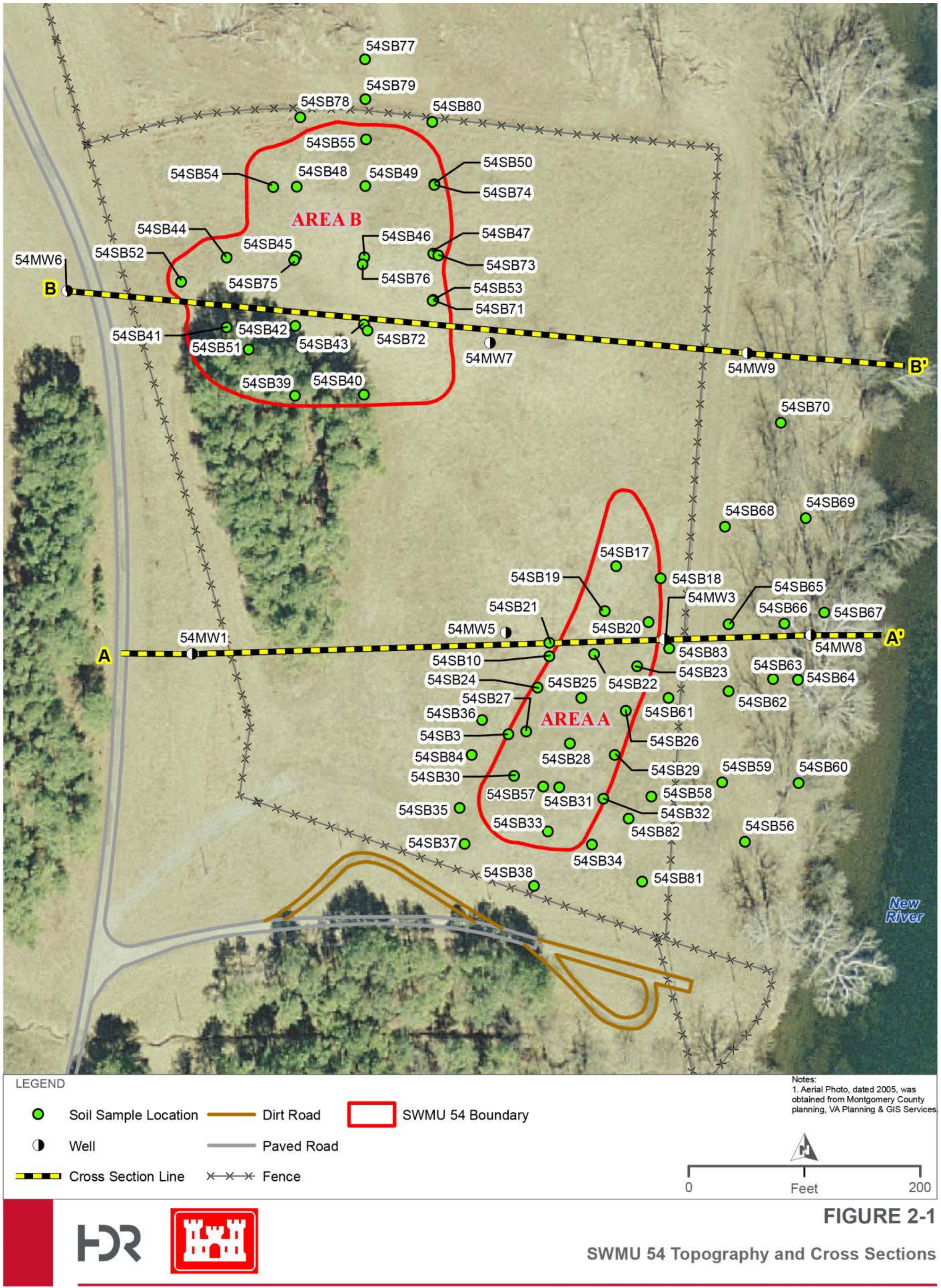

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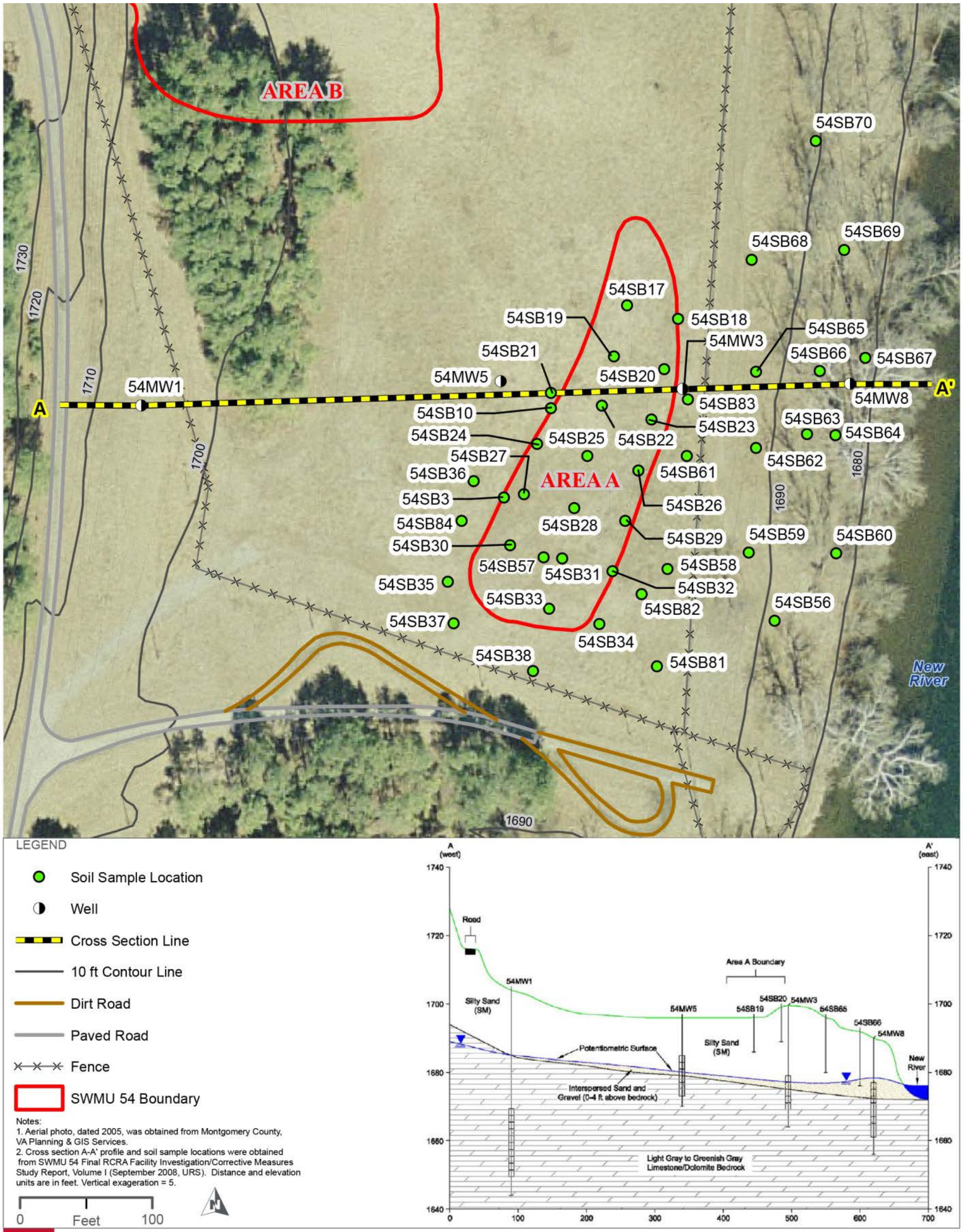
Figure 2-2 SWMU 54 Cross Section A-A'



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2. Cross section A-A' profile and soil sample locations were obtained from SWMU 54 Final RCRA Facility Investigation/Corrective Measures Study Report, Volume I (September 2008, URS). Distance and elevation units are in feet. Vertical exageration = 5.

FIGURE 2-2

SWMU 54 Cross Section A-A'

RADFORD ARMY AMMUNITION PLANT - SWMU 54 MNA YEAR FOUR REPORT

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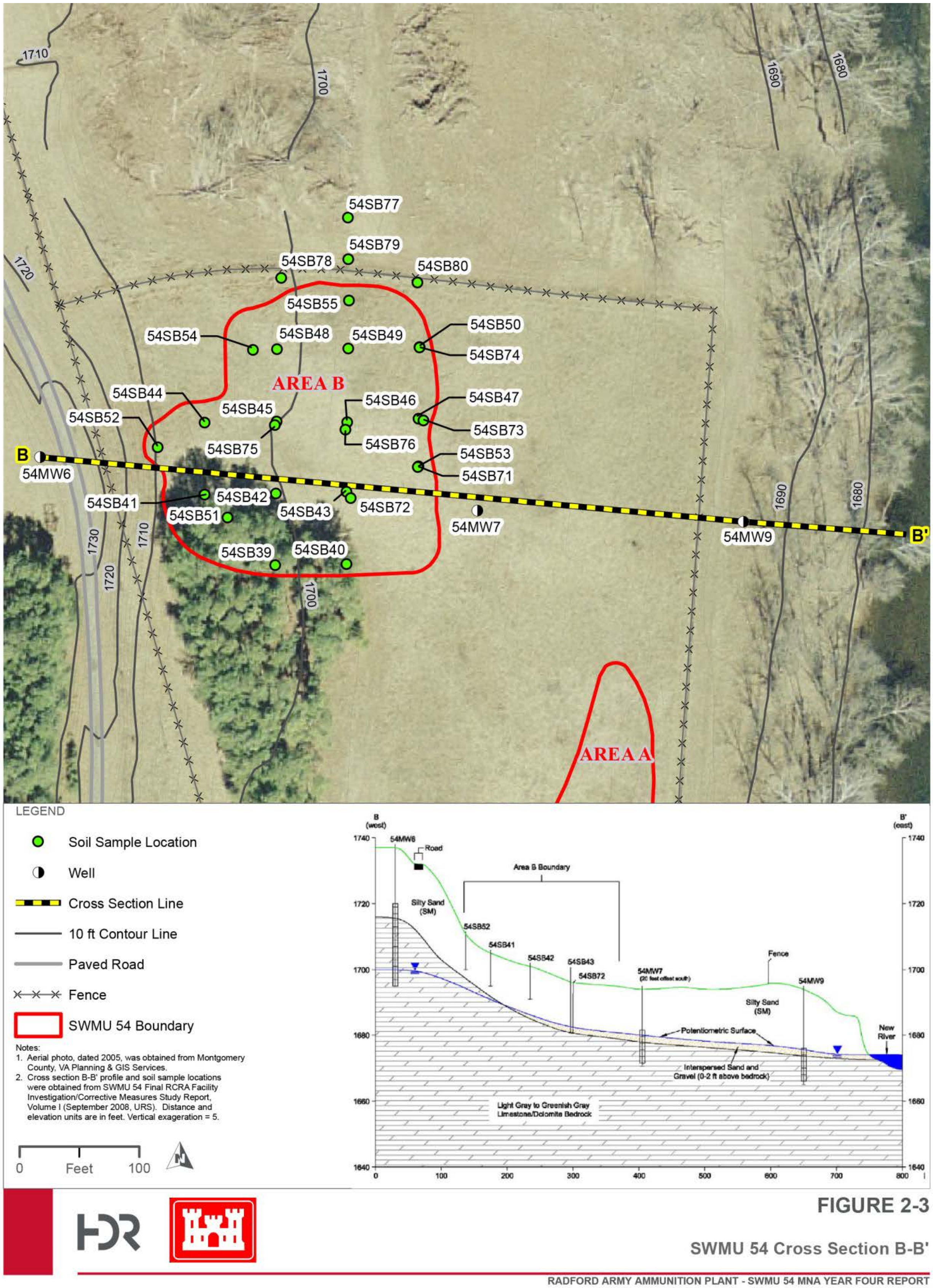
Figure 2-3 SWMU 54 Cross Section B-B’



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2. Cross section B-B' profile and soil sample locations were obtained from SWMU 54 Final RCRA Facility Investigation/Corrective Measures Study Report, Volume I (September 2008, URS). Distance and elevation units are in feet. Vertical exageration = 5.

FIGURE 2-3

SWMU 54 Cross Section B-B'

RADFORD ARMY AMMUNITION PLANT - SWMU 54 MNA YEAR FOUR REPORT

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3.0 Previous Investigations

Four previous investigations have been conducted at this site prior to completion of an interim removal measure in 1999 by Parallax, Inc. Data obtained from previous site investigations prior to the IM were used to identify site boundaries and characteristics, and identify chemicals of potential concern (COPCs). In 1992, the Environmental Photographic Interpretation Center provided aerial photographic analysis of SWMU 54, under the direction of the Environmental Protection Agency (USEPA). Also in 1992, under authority of the 1984 Hazardous and Solid Waste Amendments, Dames & Moore conducted a RCRA Verification Investigation (VI) at the site to identify the ash disposal at Area A. As a follow-up to the 1992 VI, Parsons completed an RFI in 1996, as part of a multiple site investigation to "define the extent of ash and the limits of soil contamination." In 1998, a Supplemental RFI/CMS was conducted to investigate a flat grassy area ringed by mature pine trees northwest of Area A. This area was defined as Area B within SWMU 54. The purpose of the supplemental RFI was to "characterize the nature and extent of contamination within SWMU 54." In 1999, Parallax, Inc. completed IMs at Area A and Area B of SWMU 54 consisting of excavation of selected "hot spot" areas of lead and explosives in soil.

In 2008, URS Corporation (URS) conducted an RFI/CMS investigating both Area A and Area B to confirm the effectiveness of the IM as well as evaluate and assess current conditions at the sites and provide recommendations regarding potential corrective measure requirements at the sites. Direct push soil borings with chemical sampling were used to: characterize the nature and extent of constituents in soil at SWMU 54, identify the lateral and vertical extent of any waste material present, and characterize soil lithology and depth to groundwater and bedrock. Additionally, monitoring wells were installed at the site and groundwater samples were collected and analyzed. Details of these investigations are described in Section 3.0 (Field Investigation Program) of the Final SWMU 54 RFI/CMS Report (URS, 2008). A potentiometric map, portraying the groundwater levels measured in 2007 is provided as **Figure 3-1**. Historical data listing Chemicals of Interest (COI) concentrations in the on-site groundwater, New River surface water and New River sediment pore water can be found in **Tables 3-1** through **3-6**.

The nature and extent assessment indicated that the main concern at the site is the fill material and grossly-contaminated soil directly below the material. Areas A and B were evaluated separately for the soil and groundwater nature and extent assessments given the 200-ft separation between the areas, their topographic cross-gradient position, the lack of mobility of the chemicals in soil, and observed distributions of chemicals.

The main parameters of concern in Area A soil are lead, 2,4,6-TNT, DNT, RDX, amino DNTs, nitroglycerin (NG), heptachlor epoxide, and dioxins/furans. The main parameters of concern in groundwater at Area A are explosives and perchlorate. Concentrations of COIs 2,4,6-TNT, DNT, RDX, and perchlorate in groundwater have decreased since RFI monitoring began in 2003 and 2004. The lateral extent of explosives and perchlorate in groundwater extends from Area A eastward to the New River. Sampling of the groundwater/surface water interface (sediment pore water) and surface water of the New River did not indicate detectable impacts to sediment pore water or surface water from COPCs in groundwater.

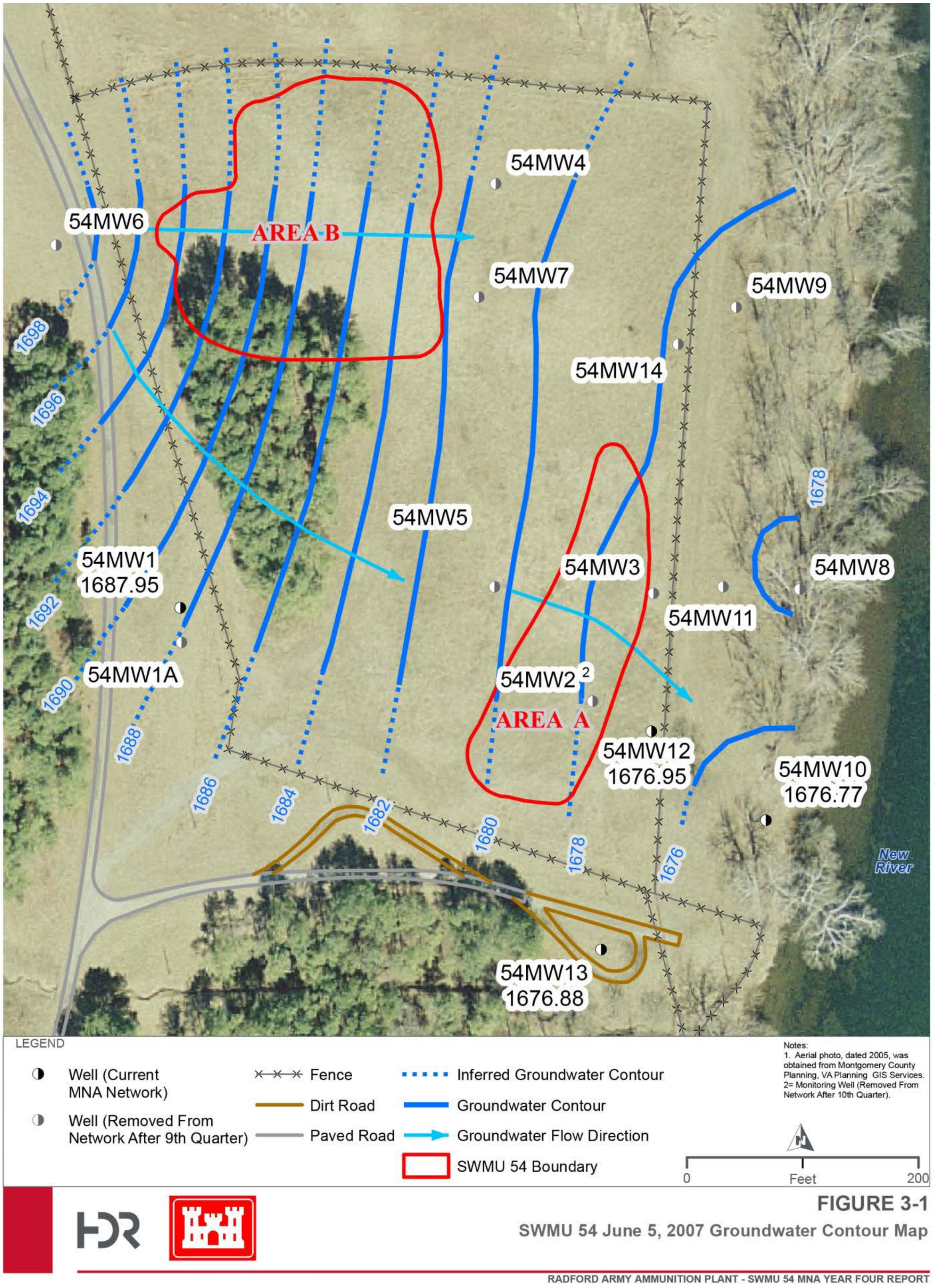
Parameters of concern in Area B soils include lead, DNT, amino DNT, NG, RDX, dieldrin, Aroclor 1254, heptachlor epoxide, and dioxins/furans. No COIs were identified for Area B Groundwater.

The Human Health Risk Assessment (HHRA) identified eight COIs at Area A (2,4,6-TNT, DNT, RDX, perchlorate, amino DNTs, NG, heptachlor epoxide, and 2,3,7,8-tetrachlorodibenzodioxin [TCDD]) and ten COIs at Area B (2,4,6-TNT, DNT, RDX, amino DNTs, NG, lead, Aroclor 1254, heptachlor epoxide, dieldrin, and 2,3,7,8-TCDD) under both an industrial and residential future-use scenario for total soil at SWMU 54. The HHRA determined that unacceptable risks to potential future residential and industrial receptors were associated with the COIs. Based on the results from the HHRA, it was concluded that based on the levels detected in the soil hot spot areas, COIs could potentially leach from soil to groundwater at levels of concern, although groundwater impacts at levels of concern have not yet been identified at Area B. Because the RFI demonstrated that COI contamination is present at concentrations associated with unacceptable human health concerns, a CMS was performed to address the propellant ash material and grossly-contaminated soil under the ash material at SWMU 54. The alternatives evaluated were as follows:

- Alternative One: No Further Action.
- Alternative Two: Excavation of Soil at Area A and Area B, Off-site Disposal, and MNA of Groundwater.
- Alternative Three: Excavation of Soil at Area A and Area B, Off-site Disposal, and Enhanced In Situ Bioremediation of Groundwater.

These three alternatives were evaluated using the selection criteria: effectiveness, implementability, and cost. The site-specific CMO for SWMU 54 is to mitigate further leaching of explosives constituents from soil to groundwater at levels that would potentially increase observed concentrations and adversely impact future beneficial use of groundwater, and to eliminate the potential threats to human health and the environment that exist within materials found in SWMU 54. Observations from the SWMU 54 soil investigations indicate that the propellant ash consisted of a black, ashy material that was very evident when encountered. Therefore, identification and removal of the propellant ash and grossly-contaminated soil was partially based on visual observations during excavation, with analytical samples collected to confirm the observations.

Figure 3-1 SWMU 54 June 5, 2007 Groundwater Contour Map



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning GIS Services.
2= Monitoring Well (Removed From Network After 10th Quarter).

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Table 3-1 2002 Area A Direct Push Groundwater Analytical Results with Remedial Goals

Sample ID Sample Date					54DPW1 12/11/2002				54DPW2 12/11/2002				54DPW3 12/11/2002				54GP77 10/13/2004				54GP78 10/11/2004				54GP78-DUP(DUP-1) 10/11/2004				54GP79 10/11/2004			
	CAS	**C/N**	**RG**	**Units**	**Result**	**LQ, VQ, r**	**DL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	<7.2	U,R,l	0.73	7.2	1.5	JB,B,z	0.33	3.3	<2.1	U,R,l	0.21	2.1	NT				NT				NT				NT			
DNT mixture*			**0.932**		ND				ND				ND				ND				ND				ND				ND			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	<7.2	U,R,l	1	7.2	<3.3	U,R,l	0.48	3.3	<2.1	U,R,l	0.31	2.1	NT				NT				NT				NT			
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	5.5		0.54	1	27.7		0.54	1	2		0.54	1	3.5		0.1	1	<1	U	0.1	1	<1	U	0.1	1	<1	U	0.1	1

Sample ID Sample Date					54GP80 10/13/2004				54GP81 10/11/2004				54GP82 10/11/2004				54GP83 10/11/2004				54GP84 10/13/2004				54GP85 10/14/2004				54GP86 10/13/2004			
	CAS	**C/N**	**RG**	**Units**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	**NT**				**NT**				**NT**				**NT**				**NT**				**NT**				**NT**			
DNT mixture*			**0.932**		**ND**				**ND**				**ND**				**ND**				**ND**				**ND**				**ND**			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	**NT**				**NT**				**NT**				**NT**				**NT**				**NT**				**NT**			
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	**<1**	**U**	**0.1**	**1**	**1**		**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**

Sample ID Sample Date					54GP87 10/14/2004				54GW56 8/18/2004				54GW57 8/17/2004				54GW58 8/24/2004				54GW59 8/18/2004				54GW59-DUP(DUP-3) 8/18/2004				54GW60 8/24/2004			
	CAS	**C/N**	**RG**	**Units**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	NT				160		0.15	1.3	1.7	,J,g	0.0749	0.65	15		0.0749	0.65	4.2	,L,f	0.0749	0.65	11	,J,g	0.0749	0.65	9.3		0.0749	0.65
DNT mixture*			**0.932**		ND				ND				ND	U			ND				ND				ND				ND			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	NT				35	,J,g	0.164	0.65	0.69		0.164	0.65	3.7		0.164	0.65	1		0.164	0.65	1.7		0.164	0.65	0.8		0.164	0.65
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	<1	U	0.1	1	13.5		0.1	1	2		0.1	1	25.8		0.1	1	4		0.1	1	3.6		0.1	1	1.7		0.1	1

Sample ID Sample Date					54GW61 8/24/2004				54GW62 8/23/2004				54GW63 8/23/2004				54GW64 8/23/2004				54GW64-DUP(DUP-9) 8/23/2004				54GW65 8/20/2004				54GW66 8/20/2004			
	CAS	**C/N**	**RG**	**Units**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	74		0.0749	0.65	9		0.0749	0.65	<0.65	U	0.0749	0.65	0.82	,J,g	0.0749	0.65	0.76	,J,g	0.0749	0.65	3		0.0749	0.65	NT			
DNT mixture*			**0.932**		ND				ND				ND				ND				ND				ND				ND			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	<0.65	U	0.164	0.65	1.6		0.164	0.65	<0.65	U	0.164	0.65	0.75	,J,g	0.164	0.65	0.73	,J,g	0.164	0.65	0.7		0.164	0.65	NT			
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	3		0.1	1	5.3		0.1	1	<1	U	0.1	1	1.1		0.1	1	0.97	B	0.1	1	1.7		0.1	1	0.94	B,J,m	0.1	1

Table 3-1 2002 Area A Direct Push Groundwater Analytical Results with Remedial Goals (Continued)

Sample ID Sample Date	CAS	C/N	RG	Units	54GW66 8/23/2004		MDL	RL	54GW67 8/20/2004		MDL	RL	54GW67 8/23/2004		MDL	RL	54GW68 8/20/2004		MDL	RL	54GW69 8/20/2004		MDL	RL	54GW69 8/23/2004		MDL	RL	54GW70 8/20/2004		MDL	RL
					Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	**<0.65**	**U**	**0.0749**	**0.65**	**NT**				**<0.65**	**U**	**0.0749**	**0.65**	**2.6**	**,J,g**	**0.0749**	**0.65**	**NT**				**1.4**		**0.0749**	**0.65**	**<0.65**	**U**	**0.0749**	**0.65**
DNT mixture*			**0.932**		**ND**				**ND**				**ND**				**ND**				**ND**				**ND**				**ND**			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	**<0.65**	**U**	**0.164**	**0.65**	**NT**				**<0.65**	**U**	**0.164**	**0.65**	**<0.65**	**U**	**0.164**	**0.65**	**NT**				**0.51**	**J**	**0.164**	**0.65**	**<0.65**	**U**	**0.164**	**0.65**
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	**NT**				**0.59**	**B,J,m**	**0.1**	**1**	**NT**				**<1**	**U**	**0.1**	**1**	**0.65**	**B,J,m**	**0.1**	**1**	**NT**				**0.76**	**B**	**0.1**	**1**

**The results of 2,4-DNT and 2,6-DNT were added together to get the DNT mixture result.*

Notes:
µg/L = micrograms per liter
MDL = Method Detection Limit
NI = Not Identified
NT = Not Tested
ND = Not Detected
RL = Reporting Limit
SVOC = Semi-volatile Organic Compound
TAL = Target Analyte List
TCL = Target Compound List
TIC = Tentatively Identified Compound
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

Data Qualifiers:
B = Not detected substantially above the level reported in laboratory or field blanks.
E = Concentration exceeded the upper level of the calibration range of the instrument for that specific analysis. For TICs, compound not present in calibration standard, calculated using total peak areas ion chromatographs and response factor of 1.
J = Analyte present. Reported value may not be accurate or precise.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
N = Sample spike recovery is outside of control limits.
P = Greater than 40% difference for detected concentrations between the two GC or HPLC columns.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
UL = Not detected, quantitation limit is probably higher.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.
o = Calibration blank contamination.
p = Preparation blank contamination.
s = Serial dilution failure.
w = Field and/or equipment blank contamination.

z = Method blank and/or storage blank contamination.

Table 3-2 2003-2004 Area A Groundwater Analytical Results with Remedial Goals

Sample ID Sample Date	CAS	C/N	RG	Units	54MW2 3/4/2003		MDL	RL	54MW3 3/4/2003		MDL	RL	54MW5 3/4/2003		MDL	RL	54MW-8 12/21/2004		MDL	RL	54MW-9 12/21/2004		MDL	RL	54MW-10 12/21/2004		MDL	RL	54MW10-DUP(DUP-1) 12/21/2004		MDL	RL
					Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives																																
2,4,6-Trinitrotoluene	118-96-7	N	7.82	µg/L	<3.6	U	0.365	3.6	38		0.365	3.6	<4.2	U	0.43	4.2	<0.65	U	0.0749	0.65	<0.65	U	0.0749	0.65	62		0.15	1.3	65		0.15	1.3
DNT mix*			0.932	µg/L	ND				ND				ND				ND				ND				ND				ND			
RDX (Hexahydro-1,3,5-trinitro-1,3,5-tria	121-82-4	C	6.1	µg/L	<3.6	U	0.526	3.6	32		0.526	3.6	<4.2	U	0.61	4.2	0.2	J,J,g	0.164	0.65	1.1	,J,g	0.164	0.65	28		0.164	0.65	29		0.164	0.65
Perchlorate																																
Perchlorate	14797-73-0	N	10.90	µg/L	12		0.54	1	59.2		0.54	1	1.6		0.54	1	0.22	B	0.1	1	0.21	B	0.1	1	9.8		0.1	1	9.1		0.1	1
Field Parameters																																
Dissolved Oxygen	--	--	--	mg/L	6.97				5.18				2.88				0.25				2.56				1.25				1.25			
Oxidation Reduction Potential	--	--	--	mV	159.5				119.0				95.1				215				234				208				208			
pH	--	--	--	SU	6.37				6.65				7.00				7.20				7.53				7.06				7.06			
Conductivity	--	--	--	mS	0.191				0.341				0.310				0.627				0.706				0.760				0.760			
Temperature	--	--	--	°C	16.24				15.97				12.91				13.6				13.2				13.8				13.8			
Turbidity	--	--	--	NTU	0.80				1.93				12.0				4.17				4.13				3.52				3.52			

**DNT mixture result is the result of the adding together of 2,4-DNT and 2,6-DNT.*

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MCL = Maximum Contaminant level
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
NT = Not Tested
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
SVOC = Semi-volatile Organic Compound
TAL = Target Analyte List
TCL = Target Compound List
TIC = Tentatively Identified Compound
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

RBC = USEPA Region III Risk-Based Concentration (RBC) values from the October 11, 2007, RBC Table and October 11, 2007, Alternate RBC Table

Data Qualifiers:
B = Not detected substantially above the level reported in laboratory or field blanks.
E = Concentration exceeded the upper level of the calibration range of the instrument for that specific analysis. For TICs, compound not present in calibration standard, calculated using total peak areas ion chromatographs and response factor of 1.
J = Analyte present. Reported value may not be accurate or precise.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
N = Sample spike recovery is outside of control limits.
P = Greater than 40% difference for detected concentrations between the two GC or HPLC columns.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
UL = Not detected, quantitation limit is probably higher.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.
o = Calibration blank contamination.
p = Preparation blank contamination.
s = Serial dilution failure.
w = Field and/or equipment blank contamination.
.
z = Method blank and/or storage blank contamination.

Table 3-3 2006-2007 Area A Quarterly Groundwater Monitoring Results with Remedial Goals

First Quarter – November/December 2006																															
Sample ID Sample Date				**54MW1 11/29/2006**				**54MW2 11/29/2006**				**54MW3 12/5/2006**				**54MW5 11/29/2006**				**54MW8 12/1/2006**				**54MW9 12/1/2006**				**54MW10 12/1/2006**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (µg/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	**<5**	**U**	**0.075**	**5**	**5.6**		**0.075**	**5**	**0.85**	**J**	**0.075**	**5**	**0.29**	**J**	**0.075**	**5**	**<5**	**U**	**0.075**	**5**	**<5**	**U**	**0.075**	**5**	**2.1**	**J**	**0.075**	**5**
Dinitrotoluene Mixture	--	C	**0.932**	**<5**				**<5**				**<5**				**<5**				**<5**				**<5**				**<5**			
RDX	121-82-4	C	**6.100**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**3.3**	**J**	**0.16**	**5**
Perchlorate (µg/L)																															
Perchlorate	14797-73-0	N	**10.90**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	11.95				10.29				11.94				10.1				8.94				8.51				8.13			
Oxidation Reduction Potential (mV)	--	--	--	153				159				171				231				32				53				36			
pH (SU)	--	--	--	7.86				7.15				7.26				7.2				7.53				7.65				7.39			
Conductivity (mS)	--	--	--	0.44				0.533				0.580				0.557				0.605				0.790				0.733			
Temperature (°C)	--	--	--	18.6				17.7				18.3				18.5				17.1				19.1				16.3			
Turbidity (NTU)	--	--	--	4.47				1.16				0.07				16.6				11.83				23.5				10.31			

Second Quarter – March 2007																															
Sample ID Sample Date				**54MW-1 3/28/2007**				**54MW-2 3/28/2007**				**54MW-3 3/28/2007**				**54MW-5 3/28/2007**				**54MW-8 3/27/2007**				**54MW-9 3/27/2007**				**54MW10 DUP AVG 3/27/2007**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (ug/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	0.25	J,J,d	0.1	5	<5	U	0.1	5	0.84	J,J,g	0.1	5	14		0.1	5	<5	U	0.1	5	6.018		0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				1.146				<5				<5				<5				<5				0.898			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	8.1		0.092	5	<5	U	0.092	5	3.87		0.092	5
Perchlorate (ug/L)																															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.036	0.2	3.6		0.036	0.2	<0.2	U	0.036	0.2	0.52		0.036	0.2	0.26		0.036	0.2	0.24		0.036	0.2	2.9		0.036	0.2
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	8.06				7.75				6.12				8.38				6.68				6.51				8			
Oxidation Reduction Potential (mV)	--	--	--	-5				44				-11				53				-17				-10				11			
pH (SU)	--	--	--	7.63				6.45				6.94				6.51				7.05				7.18				6.88			
Conductivity (mS)	--	--	--	0.199				0.183				0.311				0.167				0.267				0.960				0.334			
Temperature (°C)	--	--	--	13.44				15.8				15.22				12.73				13.92				14.43				15.95			
Turbidity (NTU)	--	--	--	1.82				0.37				2.13				1.22				13.96				7.71				3.64			

Table 3-3 2006-2007 Area A Quarterly Groundwater Monitoring Results with Remedial Goals (Continued)

Fourth Quarter – September 2007																															
Sample ID Sample Date				**54MW-1 6/5/2007**				**54MW-2 6/5/2007**				**54MW-3 6/5/2007**				**54MW-5 6/5/2007**				**54MW-8 6/5/2007**				**54MW-9 6/5/2007**				**54MW-10 6/5/2007**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (ug/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	3.9	J	0.1	5	1	J	0.1	5	0.49	J	0.1	5	<5	U	0.1	5	<5	U	0.1	5	2.4	J	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	ND				ND				ND				ND				ND				0.466				ND			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	6.3		0.092	5	<5	U	0.092	5	1.6	J	0.092	5
Perchlorate (ug/L)																															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	2		0.08	0.2	0.88		0.08	0.2	0.58		0.08	0.2	0.7		0.08	0.2	0.23		0.08	0.2	0.37		0.08	0.2
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	7.57				8.46				5.06				8.44				8.82				5.21				7.35			
Oxidation Reduction Potential (mV)	--	--	--	297				268				109				236				285				94				187			
pH (SU)	--	--	--	7.33				6.78				6.2				6.24				6.9				6.25				6.87			
Conductivity (mS)	--	--	--	0.192				0.225				0.003				0.163				0.245				0.003				0.353			
Temperature (°C)	--	--	--	13.58				13.48				15.66				21.68				13.4				15.44				14.51			
Turbidity (NTU)	--	--	--	0.48				0.29				0.36				0.67				0.06				1.67				**9.37**			

Fourth Quarter – September 2007																															
Sample ID Sample Date				**54MW-1 9/19/2007**				**54MW-2 9/19/2007**				**54MW-3 9/19/2007**				**54MW-5 9/19/2007**				**54MW-8 9/18/2007**				**54MW-9 9/18/2007**				**54MW-10 9/18/2007**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (ug/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	0.78	J	0.1	5	1.2	J	0.1	5	0.38	J,J,g	0.1	5	<5	U	0.1	5	<5	U	0.1	5	17		0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	ND				ND				ND				ND				ND				ND				0.696			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	8		0.092	5
Perchlorate (ug/L)																															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	0.57		0.08	0.2	0.31		0.08	0.2	0.34		0.08	0.2	0.37		0.08	0.2	<0.2	U	0.08	0.2	2.9		0.08	0.2
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	4.03				2.37				6.34				5.53				4.06				3.78				3.89			
Oxidation Reduction Potential (mV)	--	--	--	233				172				205				228				288				237				239			
pH (SU)	--	--	--	8.2				7.01				5.67				6.89				6.82				7.11				6.76			
Conductivity (mS)	--	--	--	0.487				0.637				0.57				0.647				0.711				0.833				0.844			
Temperature (°C)	--	--	--	19.79				15.91				15.6				17.36				14.41				18.05				17.27			
Turbidity (NTU)	--	--	--	0.79				2.19				2.02				1.62				0.43				2.19				7.19			

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MCL = Maximum Contaminant level
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
ng/L= nanograms per liter
NT = Not Tested
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
▭ *=Exceeds RG*

RBC = USEPA Region III Risk-Based Concentration (RBC) values from the October 11, 2007, RBC Table and October 11, 2007, Alternate RBC Table

Data Qualifiers:
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
c = calibration failure.
d = MS/MSD or LCS/LCSD RPD imprecision.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.

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Table 3-4 2003 Area B Groundwater Analytical Results with Remedial Goals

Sample ID **Sample Date**			**54MW4** **3/4/2003**				**54MW6** **3/3/2003**				**54MW7** **3/4/2003**				**54MW7-DUP (GW-DUP-1)** **3/4/2003**			
	RG	**Units**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives																		
2,4,6-Trinitrotoluene	**7.82**	µg/L	<5.4	U	0.55	5.4	<4.2	U	0.43	4.2	<3.6	U	0.365	3.6	<4.8	U	0.487	4.8
DNT Mixture	**0.932**	µg/L	ND				ND				ND				ND			
RDX (Hexahydro-1,3,5-trinitro-1,3,5-tria	**6.1**	µg/L	<5.4	U	0.79	5.4	<4.2	U	0.61	4.2	<3.6	U	0.526	3.6	<4.8	U	0.701	4.8
Perchlorate																		
Perchlorate[1]	**10.9**	µg/L	<1	U	0.54	1	<1	U	0.54	1	<1	U	0.54	1	<1	U	0.54	1

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

Data Qualifiers:
B = Not detected substantially above the level reported in laboratory or field blanks.
E = Concentration exceeded the upper level of the calibration range of the instrument for that specific analysis. For TICs, compound not present in calibration standard, calculated using total peak areas ion chromatographs and response factor of 1.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
J = Analyte present. Reported value may not be accurate or precise.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
N = Sample spike recovery is outside of control limits.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
UL = Not detected, quantitation limit is probably higher.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.
o = Calibration blank contamination.
p = Preparation blank contamination.
s = Serial dilution failure.
w = Field and/or equipment blank contamination.

z = Method blank and/or storage blank contamination.

Table 3-5 2006-2007 Area B Quarterly Groundwater Monitoring Results with Remedial Goals

First Quarter – November/December 2006															
Sample ID Sample Date	**CAS**	**C/N**	**Adjusted Tap Water RBC**	**54MW4 11/30/2006**		**MDL**	**RL**	**54MW6 11/29/2006**		**MDL**	**RL**	**54MW7 12/5/2006**		**MDL**	**RL**
				Result	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**		
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	9.9				11.63				10.46			
Oxidation Reduction Potential (mV)	--	--	--	-92				181				170			
pH (SU)	--	--	--	7.77				8				7.56			
Conductivity (mS)	--	--	--	1.13				0.297				0.729			
Temperature (°C)	--	--	--	15				16.6				15.9			
Turbidity (NTU)	--	--	--	2.66				4.87				5.91			

Second Quarter – March 2007															
Sample ID Sample Date	**CAS**	**C/N**	**RG**	**54MW-4 3/27/2007**		**MDL**	**RL**	**54MW-6 3/27/2007**		**MDL**	**RL**	**54MW-7 3/27/2007**		**MDL**	**RL**
				Result	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**		
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	<5	U	0.1	5	<5	U	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.036	0.2	<0.2	U	0.036	0.2	<0.2	U	0.036	0.2
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	5.97				8.8				6			
Oxidation Reduction Potential (mV)	--	--	--	-95				135				-44			
pH (SU)	--	--	--	7.16				8.21				7			
Conductivity (mS)	--	--	--	1.11				0.314				0.323			
Temperature (°C)	--	--	--	15.68				17.77				14.25			
Turbidity (NTU)	--	--	--	1.54				31.1				6.59			

Table 3-5 2006-2007 Area B Quarterly Groundwater Monitoring Results with Remedial Goals (Continued)

Third Quarter – June 2007															
Sample ID Sample Date				**54MW4 DUP AVG 6/5/2007**				**54MW-6 6/5/2007**				**54MW-7 6/5/2007**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	<5	U	0.1	5	<5	U	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	<0.2	U	0.08	0.2	<0.2	U	0.08	0.2
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	5.15				4.5				7.72			
Oxidation Reduction Potential (mV)	--	--	--	91				76				225			
pH (SU)	--	--	--	6.39				6.03				6.97			
Conductivity (mS)	--	--	--	0.003				0.003				0.302			
Temperature (°C)	--	--	--	14.54				19.28				3.03			
Turbidity (NTU)	--	--	--	0.67				9.96				0.71			

Fourth Quarter – September 2007															
Sample ID Sample Date				**54MW4 9/19/2007**				**54MW6 9/19/2007**				**54MW7 DUP AVG 9/19/2007**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	<5	U	0.1	5	<5	U	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	ND				ND				ND			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	0.1	J	0.08	0.2	<0.2	U	0.08	0.2
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	4.03				7.47				4.56			
Oxidation Reduction Potential (mV)	--	--	--	-1				236				266			
pH (SU)	--	--	--	7.91				8.13				6.97			
Conductivity (mS)	--	--	--	1.1				0.267				0.766			
Temperature (°C)	--	--	--	16.08				16.69				16.83			
Turbidity (NTU)	--	--	--	0.43				4.37				0.39			

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
ng/L = nanogram per liter

NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

Data Qualifiers:
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

See Table 6-3D (December 2006) and Table 6-3E (June 2007) for Total 2,3,7,8-TCDD TEQ Calculations

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Table 3-6 2006 New River Surface and Sediment Pore Water Sample Results with Remedial Goals

Surface Water

Sample ID Sample Date	CAS	C/N	RG	NR-SW-1 11/30/2006		MDL	RL	NR-SW-2 11/30/2006		MDL	RL	NR-SW-3 11/30/2006		MDL	RL	NR-SW-4 11/30/2006		MDL	RL	NR-SW-5 11/30/2006		MDL	RL	NR-SW-6 11/30/2006		MDL	RL
				Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives (μg/L)																											
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (μg/L)																											
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																											
Dissolved Oxygen (mg/L)	--	--	--	17.05				15.83				14.64				12.93				14.83				15.11			
Oxidation Reduction Potential (mV)	--	--	--	219				118				47				53				32				35			
pH (SU)	--	--	--	8.9				8.1				7.96				7.81				7.67				8.3			
Conductivity (mS)	--	--	--	0.116				0.113				0.118				0.174				0.117				0.155			
Temperature (°C)	--	--	--	10.1				9.9				10.1				10.3				10.2				10.4			
Turbidity (NTU)	--	--	--	71.3				13.7				17.48				9.94				7.66				6.21			

Pore Water

Sample ID Sample Date	CAS	C/N	RG	NR-PW-1 11/30/2006		MDL	RL	NR-PW-2 11/30/2006		MDL	RL	NR-PW-3 11/30/2006		MDL	RL	NR-PW-4 11/30/2006		MDL	RL	NR-PW-5 11/30/2006		MDL	RL	NR-PW-6 11/30/2006		MDL	RL
				Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives (μg/L)																											
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (μg/L)																											
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																											
Dissolved Oxygen (mg/L)	--	--	--	10.38				10.46				12.2				9.35				10.82				11.34			
Oxidation Reduction Potential (mV)	--	--	--	-109				-174				20				-182				-44				-58			
pH (SU)	--	--	--	7.33				7.21				7.47				7.57				7.44				7.2			
Conductivity (mS)	--	--	--	0.307				0.344				0.248				0.38				0.553				0.353			
Temperature (°C)	--	--	--	12.8				10.7				10.8				10.6				13.2				11.9			
Turbidity (NTU)	--	--	--	16.35				37.9				22.7				4.86				3.63				11.85			

Table 3-6 2006 New River Surface and Sediment Pore Water Sample Results with Remedial Goals (Continued)

Surface Water																							
Sample ID Sample Date				**NR-SW-7 12/1/2006**				**NR-SW-8 12/1/2006**				**NR-SW-8-DUP(DUP-4) 12/1/2006**				**NR-SW-9 12/1/2006**				**NR-SW-10 12/1/2006**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (µg/L)																							
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)																							
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																							
Dissolved Oxygen (mg/L)	--	--	--	13.13				13.27				13.27				13.76				14.69			
Oxidation Reduction Potential (mV)	--	--	--	10				41				41				51				52			
pH (SU)	--	--	--	8.11				7.8				7.8				7.62				7.83			
Conductivity (mS)	--	--	--	0.140				0.124				0.124				0.131				0.114			
Temperature (°C)	--	--	--	11.7				12.5				12.5				11.8				11			
Turbidity (NTU)	--	--	--	148				13.8				13.8				20.5				11.46			

Pore Water																							
Sample ID Sample Date				**NR-PW-6-DUP(DUP-3) 11/30/2006**				**NR-PW-7 12/1/2006**				**NR-PW-8 12/1/2006**				**NR-PW-9 12/1/2006**				**NR-PW-10 12/1/2006**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (µg/L)																							
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)																							
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																							
Dissolved Oxygen (mg/L)	--	--	--	11.34				9.25				9.74				10.55				10.18			
Oxidation Reduction Potential (mV)	--	--	--	-58				-194				-173				-173				-157			
pH (SU)	--	--	--	7.2				7.54				7.36				7.23				7.47			
Conductivity (mS)	--	--	--	0.353				0.517				0.660				0.533				0.479			
Temperature (°C)	--	--	--	11.9				13				12.9				13.2				13.1			
Turbidity (NTU)	--	--	--	11.85				3.72				5.6				15.87				1.66			

**DNT mixture results are obtained by adding together the results of 2,4-DNT and 2,6-DNT*

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MDL = Method Detection Limit
mg/L = milligram per liter
mV = millivolt
mS = milliSiemen
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

RBC = USEPA Region III Risk-Based Concentration
(RBC) values from the October 11, 2007, RBC Table
and October 11, 2007, Alternate RBC Table

BTAG = Biological Technical Assistance Group
Water - BTAG Freshwater Screening Values, 2006a

Data Qualifiers:
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.

Alternative Two, which entails excavation and off-site disposal as the primary remediation process, was found to achieve the CMO. Therefore, Alternative Two was selected as the final alternative for SWMU 54 because it is implementable and provides a greater level of protection to human health and the environment not provided by other alternatives. In addition, Alternative Two is the sole alternative that facilitates RGs without potential adverse effects to groundwater (i.e., degradation of secondary water quality parameters) from remedial implementation activities, which would occur with implementation of Alternative Three.

The CMOs and RGs were developed in the Final SWMU 54 RFI/CMS Report (URS, 2008). The following is a summary of the findings from that process.

The site-specific CMO for SWMU 54 Area A is to mitigate further leaching of explosives constituents from soil-to-groundwater at levels that would potentially increase observed concentrations and adversely impact future beneficial use of groundwater; and to the extent practicable, a goal of restoring site groundwater to the most beneficial use. The soil CMOs for Area A have been met, and the purpose of this report is to implement the groundwater IMs to meet the CMOs for groundwater.

The site-specific CMO for SWMU 54 Area B is to mitigate the potential hypothetical future risks that have been identified for exposure to soil under a future construction worker scenario; and to prevent leaching of contaminants of concern from soil-to-groundwater at levels that would potentially adversely impact future beneficial use of groundwater. The site-specific CMOs have been met through the soil excavation and off-site disposal completed in 2010.

RGs for SWMU 54 groundwater, shown in **Table 1-1** of this report, were used at SWMU 54 to confirm that all COIs were removed from soil to levels that are safe for human health and the environment. Results from the soil remedial action at SWMU 54 can be found in the approved Final Interim Measures Completion Report for SWMU 54 (Shaw, 2011b). The groundwater RGs will be used to compare results from groundwater monitoring wells to assess the progress of the MNA process.

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4.0 Field Activities

The following sections provide a discussion of field activities conducted by BSEn in the fourth year of monitoring at SWMU 54.

The fourth year of groundwater monitoring consisted of four sampling events conducted in September 2015 (thirteenth quarter), January 2016 (fourteenth quarter), April 2016 (fifteenth quarter), and July 2016 (sixteenth quarter). Multiple wells were removed from the monitoring network after the ninth and tenth quarters and were not sampled during this fourth year. As such, monitoring wells that were included in the fourth year monitoring events included 54MW1, 54MW10, 54MW12, and 54MW13, which monitor Area A at SWMU 54. Field activities were conducted in accordance with the *Final SWMU 54 MNA IMWP* (Shaw, 2011a). Copies of the groundwater sample forms are presented in **Appendix A**.

4.1 Thirteenth Quarter Groundwater Sampling (September 2015)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 during the thirteenth quarter event. The thirteenth quarter of groundwater sampling was conducted 29 – 30 September 2015 during a period of heavy rain and flooding of the New River. 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 fourth year quarterly event from the four monitoring wells at SWMU 54 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 29 September 2015. **Figure 4-2** presents a groundwater elevation contour map developed from the elevation data collected during this quarterly monitoring event.

Table 4-1 Thirteenth Quarter Groundwater Elevations at SWMU 54

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Reading (ppm)
54MW1	34.8 - 54.8	20	62	19.83	1707.78	1687.95	0.0
54MW10	12 - 27	15	35	11.33	1691.10	1679.77	0.1
54MW12	20 – 30	10	30	25.47	1702.42	1676.95	0.0
54MW13	12 – 25	10	25.33	22.02	1698.90	1676.88	0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm = parts per million
TOC = top of casing

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 8.2 ft, resulting in a calculated hydraulic gradient of 0.015 ft/ft. Using an average K value for Area A of 4.86 feet per day (ft/day) and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.37 ft/day [135.1 feet per year (ft/year)]. It should be noted that heavy rains were experienced during the September 2015 monitoring event that caused high water elevations at 54MW10, which is located adjacent to the New River. As such, the hydraulic gradient and calculated groundwater flow velocity were slightly lower than previous yearly monitoring events.

Area B, although not monitored during the fourth year, is expected to have a similar groundwater flow velocity as Area A, as reported in the Third Year MNA Report (CB&I, 2014).

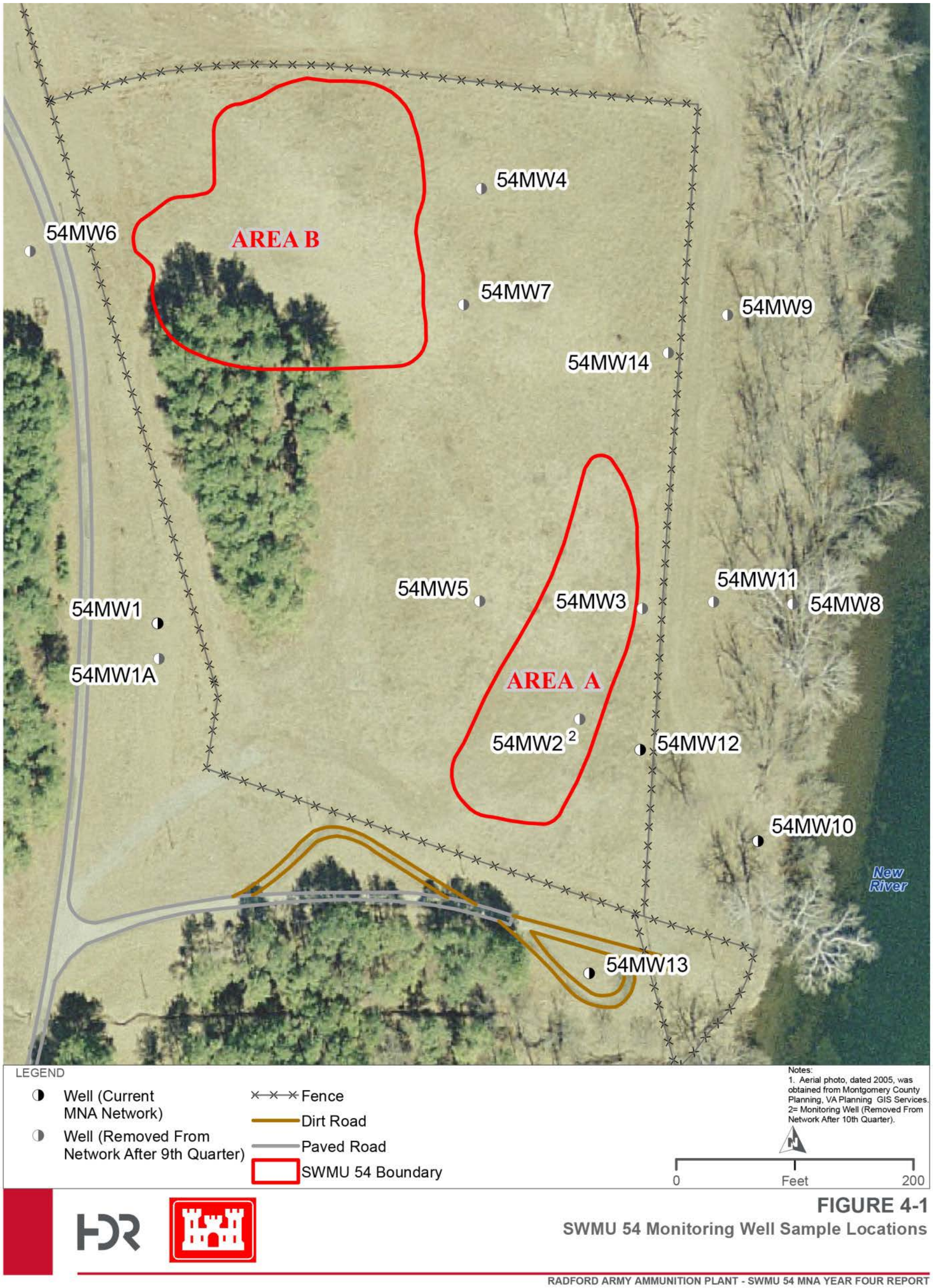
4.1.2 Groundwater Sampling

Groundwater samples were collected from the four monitoring wells on 30 September 2015 and analyzed for the analytical suites covering explosives, perchlorate, and RDX and it’s breakdown by-products hexahydro-1,3,5-dinitroso-5-nitro-1,3,5-triazine (DNX), hexahydro-1-nitroso-3,5-dinitro-1,2,5-triazine (MNX), and hexhydro-1,3,5-trinitroso-1,3,5-triazine (TNX). The breakdown by-products of RDX are considered MNA indicator parameters. In addition, the following MNA parameters were collected: Total Organic Carbon (TOC), Total Inorganic Carbon (TIC), dissolved ferrous iron, dissolved manganese, chlorate, chloride, chlorite, 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. **Table 4-2** presents the suite of analytes collected for analysis during the thirteenth quarterly monitoring event.

Table 4-2 Year 4 Quarterly Monitoring Analytical Suite

Well/Sample ID	Frequency	Explosives	Perchlorate	RDX MNA Parameters	MNA Indicator Parameters	Water Quality Parameters
54MW1	Quarterly	X	X	X	X	X
54MW10	Quarterly	X	X	X	X	X
54MW12	Quarterly	X	X	X	X	X
54MW13	Quarterly	X	X	X	X	X

Figure 4-1 SWMU 54 Monitoring Well Sample Locations



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning GIS Services.
2= Monitoring Well (Removed From Network After 10th Quarter).

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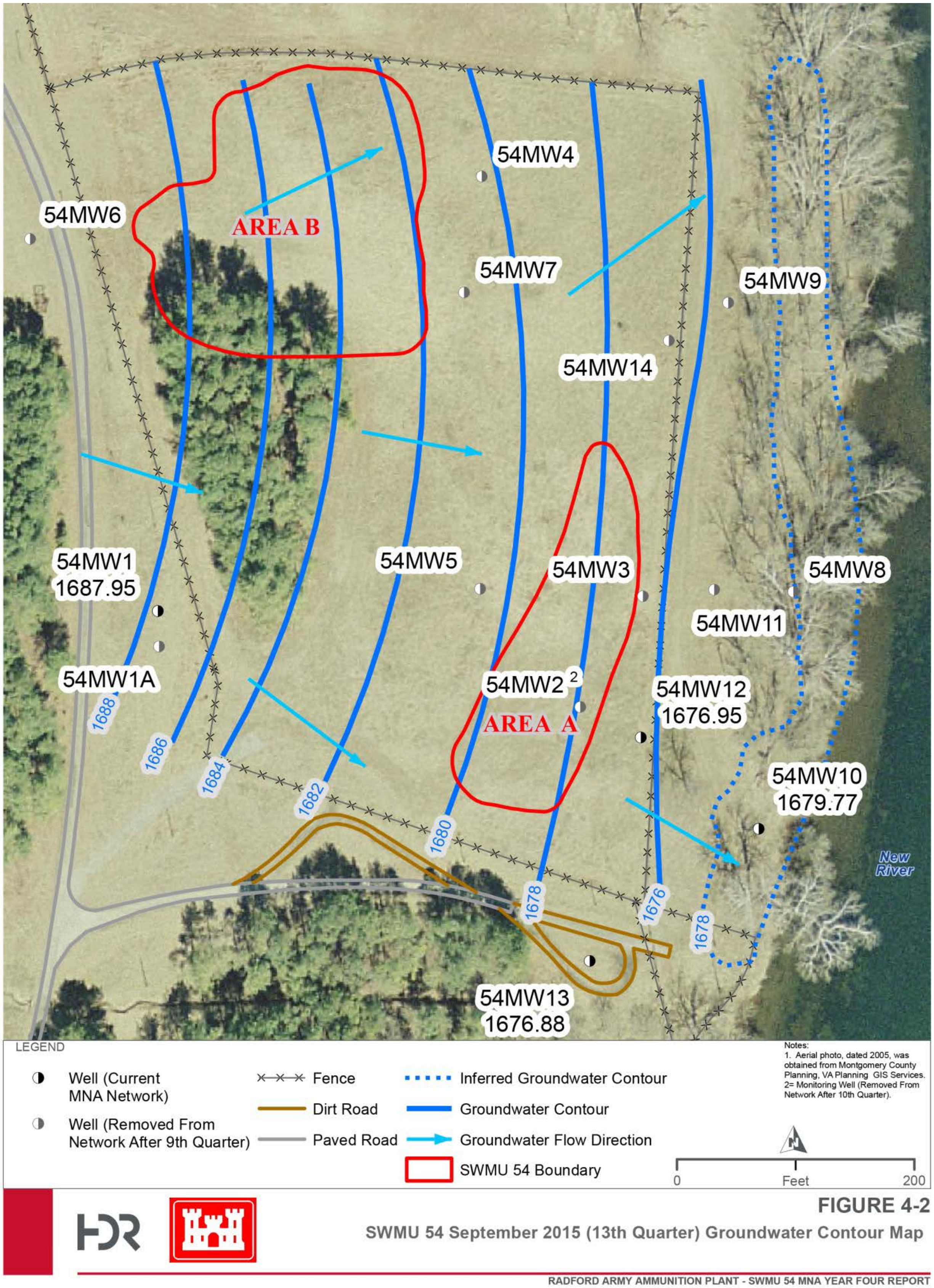
Figure 4-2 SWMU 54 September 2015 (13th Quarter) Groundwater Contour Map



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning GIS Services.
2= Monitoring Well (Removed From Network After 10th Quarter).

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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 sandpack. While measuring total depth at 54MW13, a discrepancy was noted from previous records and noted; specifically, the total depth had been reported as 22 ft when, in fact, the depth is 25.33 ft.
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 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 conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were measured in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.
5. **Table 4-3** presents a summary of the final (stabilized) water quality readings for each well from the thirteenth quarter.

With the exception of monitoring well 54MW1 (i.e., DO < 1 ppm), the DO data collected during the thirteenth quarterly monitoring event indicate aerobic groundwater conditions. The DO levels ranged from a low of 0.75 milligrams per liter (mg/L) at monitoring well 54MW1 to a high of 8.2 mg/L at monitoring well 54MW10. ORP measurements ranged from a low of 71 millivolts (mV) in monitoring well 54MW10 to a high of 264 mV at monitoring well 54MW12. Measurements of pH ranged from a low of 5.4 standard units at monitoring well 54MW12 to a high of 6.8 at monitoring well 54MW10. The pH levels generally reflect the influence of the heavy precipitation that occurred during the thirteenth quarterly monitoring event where the lower measurements are consistent with the normal range of rainfall and stream water (e.g., 54MW10). Measurements of specific conductance ranged from a low of 0.471 microsiemens per centimeter (μS/cm) at monitoring well 54MW1 to a high of 329 μS/cm at monitoring well 54MW10.

Table 4-3 Thirteenth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)
54MW1	6.7	0.471	0.65	0.75	180	14.14
54MW10[1]	6.8	329	30.7	8.2	71	15.8
54MW12	5.4	0.557	2.66	6.0	264	14.8
54MW13	6.69	0.529	1.00	6.53	198	14.83

Notes:
[1] Well 54MW10 is located adjacent to the New River
µS/cm - microsiemens per centimeter
NTU - nephelometric turbidity unit
mg/L - milligrams per liter
mV - millivolts
°C – degrees Celsius

Prior to sampling, the flow cell was disconnected and the groundwater flow rate was maintained at 200 mL/min 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

QC samples including duplicate and temperature blanks were collected during the thirteenth monitoring event.

One duplicate sample was collected during the thirteenth monitoring event (rate of 10 percent) at 54MW10 (duplicate as SWMU54TM) and analyzed for the full suite of compounds as the parent sample. Further, one matrix spike/matrix spike duplicate (MS/MSD) [at a rate of 5 percent]) was collected at monitoring well 54MW12 (54MW12 MS/MSD) and analyzed for the full suite of compounds as the parent sample.

One IDW purge water sample (ADW02) was collected and analyzed for pH, chemical oxygen demand (COD), and total metals for disposal of IDW purge water per the RFAAP SWMU 54 MNA IMWP. Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B**.

4.2 Fourteenth Quarter Groundwater Sampling (January 2016)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 between 11 - 12 January 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**.

4.2.1 Groundwater Elevation Measurements

Table 4-4 provides the measured depth to water levels (from TOC) and groundwater elevations collected on 11 January 2016 during the fourteenth quarter monitoring event. **Figure 4-3**

presents a groundwater elevation contour map developed from the elevation data collected during the quarter.

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 13.12 ft, resulting in a calculated hydraulic gradient of 0.024 ft/ft. Using an average K value for Area A of 4.86 ft/day and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.59 ft/day (216.1 ft/year).

Table 4-4 Fourteenth Quarter Groundwater Elevations at SWMU 54

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Readings (ppm)
54MW1	34.8 - 54.8	20	62	17.50	1707.78	1690.28	PID = 0.0
54MW10	12 - 27	15	35	13.94	1691.10	1677.16	PID = 0.0
54MW12	20 - 30	10	30	22.83	1702.42	1679.59	PID = 0.0
54MW13	12 - 25	10	25.33	19.38	1698.90	1679.52	PID = 0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm = parts per million
TOC = top of casing

4.2.2 Groundwater Sampling

Groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 on 11 – 12 January 2016. The fourteenth quarter monitoring samples were tested for the same analytes as the thirteenth quarter, which are presented in **Table 4-2**.

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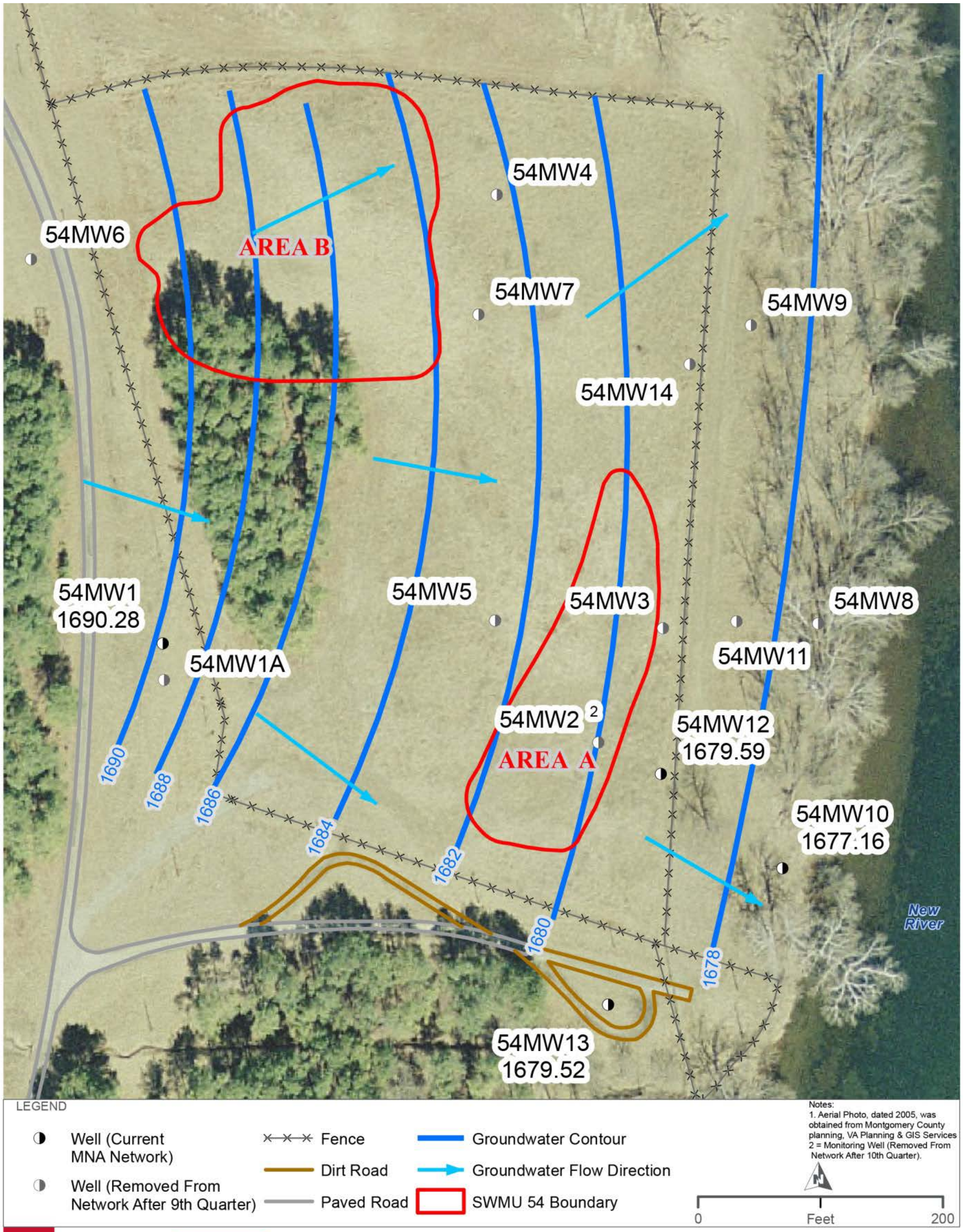
Figure 4-3 SWMU 54 January 2016 (14th Quarter) Groundwater Contour Map



Notes:
1. Aerial Photo, dated 2005, was obtained from Montgomery County planning, VA Planning & GIS Services
2 = Monitoring Well (Removed From Network After 10th Quarter).

FIGURE 4-3

SWMU 54 January 2016 (14th Quarter) Groundwater Contour Map

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Groundwater samples were collected applying the same method and approach used during the thirteenth 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 556 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 conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were tested in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.
5. **Table 4-5** presents a summary of the final (stabilized) water quality readings for each well from the thirteenth quarter.

Based on the DO data collected during the fourteenth quarterly monitoring event, groundwater within Area A exhibit aerobic conditions. The DO levels ranged from a low of 6.7 mg/L at monitoring well 54MW10 to a high of 9.89 mg/L at monitoring well 54MW1. ORP measurements ranged from a low of 73.2 mV at monitoring well 54MW13 to a high of 92.4 mV at monitoring well 54MW12. Measurements of pH ranged from a low of 6.16 standard units at monitoring well 54MW10 to a high of 7.6 at monitoring well 54MW1. The pH levels were generally more neutral than observed during the thirteenth quarterly monitoring event, which was conducted during a period of heavy precipitation. Measurements of specific conductance ranged from a low of 0.54 μS/cm in monitoring well 54MW10 to a high of 589.5 μS/cm observed at monitoring well 54MW12.

Table 4-5 Fourteenth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)
54MW1	7.6	2.8	0.78	9.89	76.2	9.6
54MW10	6.16	0.54	0.88	6.7	89.3	12.7
54MW12	6.79	589.5	5.8	8.6	92.4	12.4
54MW13	6.01	324.0	7.99	8.74	73.2	11.6

Notes:
µS/cm = microsiemens per centimeter
NTU = nephelometric turbidity unit
mg/L =- milligrams per liter
mV = millivolts
°C = degrees Celsius

Copies of the COC forms are provided in **Appendix B** along with the raw analytical data packages.

4.2.3 Quality Control Samples

QC samples including duplicate and temperature blanks were collected during the fourteenth monitoring event.

One duplicate sample was collected at 54MW10 (duplicate as 54TM10) and analyzed for the full suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 54MW12 (54MW12 MS/MSD) and analyzed for the full suite of compounds as the parent sample.

One IDW purge water sample (54ADW01) 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**.

4.3 Fifteenth Quarter Groundwater Sampling (April 2016)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 on 11 – 14 April 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**.

4.3.1 Groundwater Elevation Measurements

Table 4-6 provides the measured depth to water levels (from TOC) and groundwater elevations collected on 11 April 2016 during the quarterly monitoring event. **Figure 4-4** presents a groundwater elevation contour map developed from the elevation data collected during the quarter.

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 14.89 ft, resulting in a calculated hydraulic gradient of 0.028 ft/ft. Using an average K value for Area A of 4.86 ft/day and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.67 ft/day (245.3 ft/year).

Table 4-6 Fifteenth Quarter Groundwater Elevations at SWMU 54

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Readings (ppm)
54MW1	34.8 - 54.8	20	62	17.42	1707.78	1690.36	PID = 0.0
54MW10	12 - 27	15	35	15.63	1691.10	1675.47	PID = 0.0
54MW12	20 - 30	10	30	23.73	1702.42	1678.69	PID = 0.0
54MW13	12 - 25	10	25.33	20.29	1698.90	1678.61	PID = 0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm=– parts per million
TOC = top of casing

4.3.2 Groundwater Sampling

Groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 on 14 April 2016. The fifteenth quarter monitoring samples were tested for the same analytes as the previous two quarters, which are presented in **Table 4-2**.

Groundwater samples were collected applying the same method and approach used during the previous two quarterly monitoring events: 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 556 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 conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were tested in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.

5. **Table 4-7** presents a summary of the final (stabilized) water quality readings for each well from the thirteenth quarter.

With the exception of 54MW10 (anaerobic), DO data collected during the fifteenth quarterly monitoring event indicated aerobic groundwater conditions. The DO levels ranged from a low of 0.61 mg/L at monitoring well 54MW10 to a high of 6.86 mg/L at monitoring well 54MW13. ORP measurements ranged from a low of 51.0 mV at monitoring well 54MW1 to a high of 93.4 mV at monitoring well 54MW12. Measurements of pH ranged from a low of 6.44 standard units at monitoring well 54MW12 to a high of 7.61 at monitoring well 54MW1. The pH levels were generally in agreement with measurements observed during the fourteenth quarterly monitoring event. Measurements of specific conductance ranged from a low of 353 µS/cm in monitoring well 54MW12 to a high of 602 µS/cm observed at monitoring well 54MW10. These values were significantly higher than those observed in previous fourth year quarterly monitoring events.

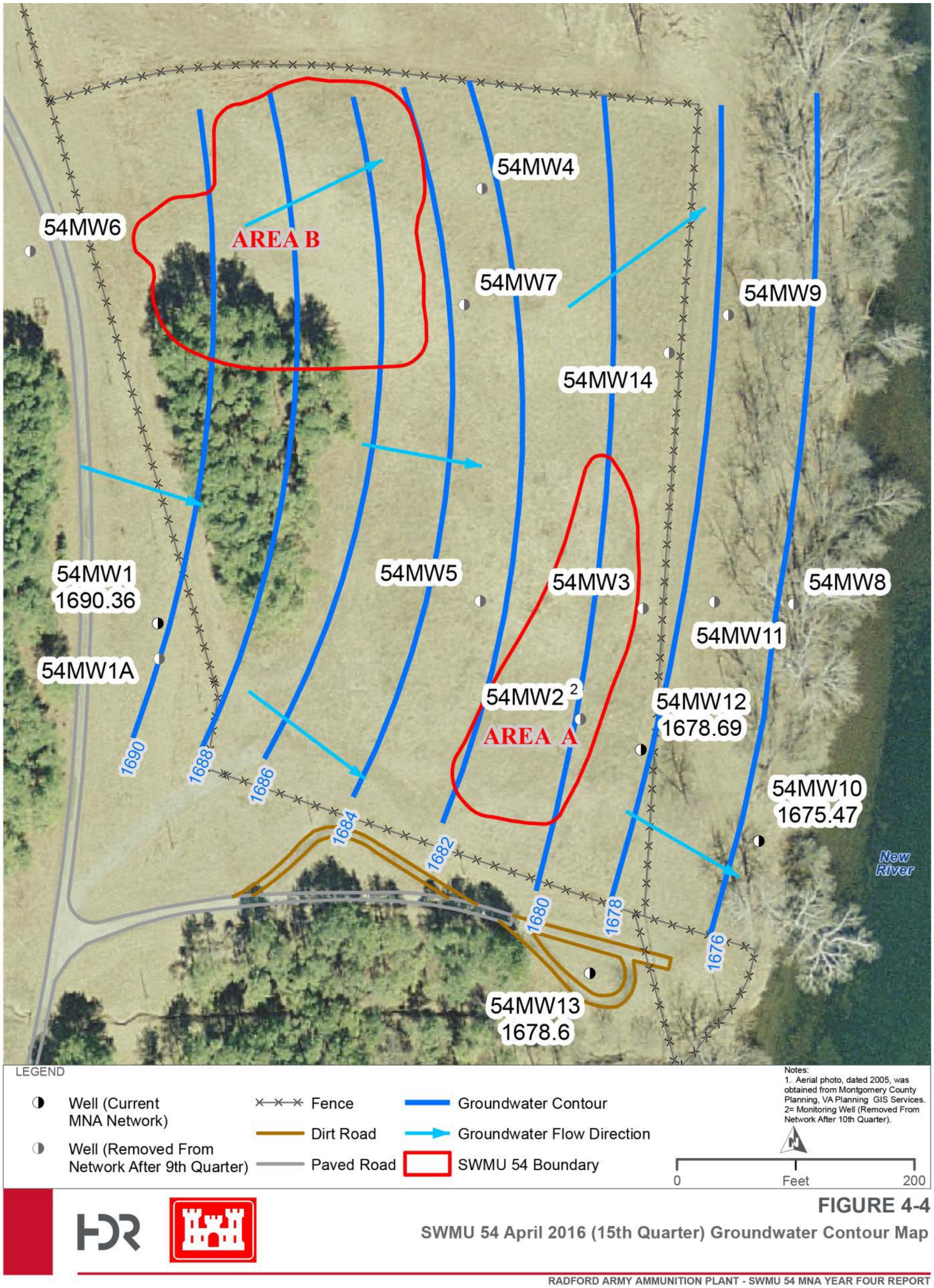
Table 4-7 Fifteenth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)
54MW1	7.61	440	0.30	4.0	51	12.01
54MW10	6.71	602	3.74	0.61	73.5	13.4
54MW12	6.44	353	5.7	5.8	93.4	14.32
54MW13	6.77	229	1.16	6.86	76.8	13.52

Notes:
µS/cm=- microsiemens per centimeter
NTU = nephelometric turbidity unit
mg/L = milligrams per liter
mV = millivolts
°C = degrees Celsius

Copies of the COC forms are provided in **Appendix B** along with the raw analytical data packages.

Figure 4-4 SWMU 54 April 2016 (15th Quarter) Groundwater Contour Map



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning GIS Services.
2= Monitoring Well (Removed From Network After 10th Quarter).

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4.3.3 Quality Control Samples

QC samples, including rinse, duplicate and temperature blanks were collected during the fifteenth monitoring event.

One duplicate sample was collected at 54MW1 (duplicate as 54TM1) and analyzed for the full suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 54MW12 (54MW12 MS/MSD) and analyzed for the full suite of compounds as the parent sample.

One equipment rinse blank (041416R1) was collected during the fourteenth quarterly monitoring event by pouring de-ionized water over a decontaminated bladder pump and into clean laboratory supplied bottles. The rinse blank was collected and analyzed for the same suite of compounds as the monitoring well samples. Finally, one IDW purge water sample (54ADW01) 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**.

4.4 Sixteenth Quarter Groundwater Sampling (July 2016)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 between 11 - 14 July 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**.

4.4.1 Groundwater Elevation Measurements

Table 4-8 provides the measured depth to water levels (from TOC) and groundwater elevations collected on 11 July 2016 during the quarterly monitoring event. **Figure 4-5** presents a groundwater elevation contour map developed from the elevation data collected during the quarter.

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 14.13 ft, resulting in a calculated hydraulic gradient of 0.026 ft/ft. Using an average K value for Area A of 4.86 ft/day and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.64 ft/day (232.8 ft/year).

Table 4-8 Sixteenth Quarter Groundwater Elevations at SWMU 54

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Readings (ppm)
54MW1	34.8 - 54.8	20	62	18.93	1707.78	1688.85	PID = 0.0
54MW10	12 - 27	15	35	16.38	1691.10	1674.72	PID = 0.0
54MW12	20 - 30	10	30	25.26	1702.42	1677.16	PID = 0.0
54MW13	12 - 25	10	25.33	21.81	1698.90	1677.09	PID = 0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm= parts per million
TOC = top of casing

4.4.2 Groundwater Sampling

Groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 on 11 - 14 April 2016. The sixteenth quarter monitoring samples were tested for the same analytes as the previous three quarters, which are presented in **Table 4-2**.

Groundwater samples were collected applying the same method and approach used during the previous quarterly monitoring events: 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 556 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 conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were tested in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.

5. **Table 4-9** presents a summary of the final (stabilized) water quality readings for each well from the thirteenth quarter.

With the exception of 54MW10 (anaerobic), DO data collected during the sixteenth quarterly monitoring event indicated aerobic groundwater conditions. The DO levels ranged from a low of 0.37 mg/L at monitoring well 54MW10 to a high of 4.6 mg/L at monitoring well 54MW10. ORP measurements ranged from a low of -10.1 mV at monitoring well 54MW1 to a high of 109 mV at monitoring well 54MW10. Measurements of pH ranged from a low of 6.32 standard units at monitoring well 54MW12 to a high of 7.39 at monitoring well 54MW10. The pH levels were generally in agreement with measurements observed during the previous two quarterly monitoring events. Measurements of specific conductance ranged from a low of 473 µS/cm in monitoring well 54MW13 to a high of 775 µS/cm observed at monitoring well 54MW10. These values were generally in agreement with values observed in the previous quarterly monitoring event.

Table 4-9 Sixteenth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)
54MW1	6.82	619	4.62	3.14	-10.1	16.56
54MW10	7.39	775	5.36	0.37	109	13.79
54MW12	6.32	499	6.50	4.60	8.2	14.33
54MW13	7.27	473	0.72	2.09	12	15.2

Notes:
µS/cm = microsiemens per centimeter
NTU = nephelometric turbidity unit
mg/L = milligrams per liter
mV = millivolts
°C = degrees Celsius

Copies of the COC forms are provided in **Appendix B** along with the raw analytical data packages.

4.4.3 Quality Control Samples

QC samples, including rinse, duplicate and temperature blanks were collected during the sixteenth quarterly monitoring event. One duplicate sample was collected at 54MW10 (duplicate as 54TM10) and analyzed for the full suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 54MW12 (54MW12 MS/MSD) and analyzed for the full suite of compounds as the parent sample. One equipment rinse blank (071116R1) was collected during the sixteenth quarterly monitoring event by pouring de-ionized water over a decontaminated bladder pump and into clean laboratory supplied bottles. The rinse blank was collected and analyzed for the same suite of compounds as the parent samples. Finally, one IDW purge water sample (54ADW01) 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**.

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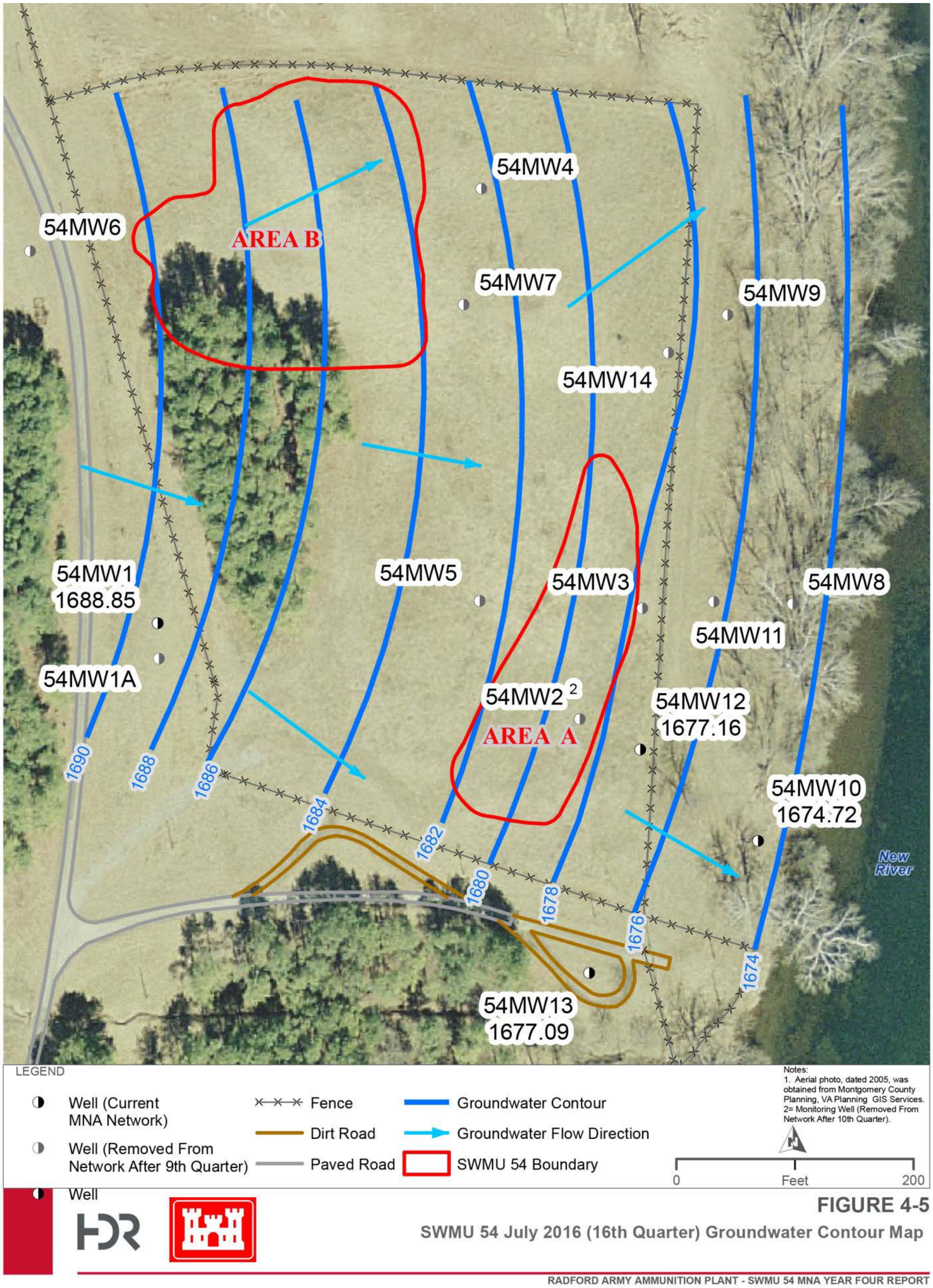
Figure 4-5 SWMU 54 July 2016 (16th Quarter) Groundwater Contour Map



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5.0 Chemical Analytical Results

5.1 Selection of Comparison Criteria

The analytical data collected during this investigation were compared to RGs selected in the Final SWMU 54 RFI/CMS Report (URS, 2008). Screening levels (SLs) are calculated values that are derived from theoretical risk scenarios. Compounds are grouped as carcinogens or noncarcinogens, and carcinogen SL values are calculated to represent an increase of 10^{-6} in cancer risk. Noncarcinogen SLs are calculated to a Hazard Index (HI) of 1. In order to account for potential cumulative effects of exposure to noncarcinogenic compounds, values for noncarcinogens have been recalculated to an HI of 0.1. **Tables 5-1** through **5-10** present the analytical results and summaries of the thirteenth through sixteenth 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 Thirteenth Quarter Groundwater Results (September 2015)

Four (4) groundwater monitoring wells were sampled during this quarterly monitoring event including wells 54MW1, 54MW10, 54MW12, and 54MW13, while a duplicate sample was collected from monitoring well 54MW10. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-1**, while the results are presented in **Table 5-2**. Sample locations are provided in **Figure 4-1**.

<u>Explosives</u>

Four explosives were detected in groundwater samples including 2,4,6-TNT, 2-amino-4,6-dinitrotoluene (2ADNT), 4-amino-2,6-dinitrotoluene (4ADNT), and RDX. All four explosives were detected in monitoring wells 54MW10, 54MW12, and 54MW13. No explosives were detected in monitoring well 54MW1.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at a concentration of 6.6 micrograms per liter (µg/L); at monitoring well 54MW12 at a concentration of 11.0 µg/L; and at monitoring well 54MW13 at a concentration of 5.4 µg/L. The concentration of 2,4,6-TNT detected at monitoring well 54MW12 exceeded the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW10 at a concentration of 3.2 µg/L; at monitoring well 54MW12 at a concentration of 4.2 µg/L; and at monitoring well 54MW13 at a concentration of 1.2 µg/L. An RG has not been established for 2ADNT.

The explosive 4ADNT was detected at monitoring wells 54MW10 and 54MW12 at a concentration of 2.5 µg/L, while monitoring well 54MW12 had an observed concentration of 0.8 µg/L.

RDX was detected at monitoring well 54MW10 at a concentration of 2.1 µg/L; at monitoring well 54MW12 at a concentration of 3.9 µg/L; and at monitoring well 54MW13 at a concentration of 2.6 µg/L. All three detections were well below the RG of 6.1 µg/L. No RDX breakdown by-products (DNX, MNX, and TNX) were detected at any of the monitoring wells during this quarterly monitoring event.

The monitoring wells with detected concentrations of explosives were typically the same wells with observed hits recorded during previous sampling rounds, albeit at lower concentrations. The monitoring well location (54MW12) where 2,4,6-TNT exceeded the RG is provided in **Figure 5-1**.

Perchlorate

Perchlorate was detected in two groundwater samples collected from monitoring wells 54MW12 and 54MW13 during this quarterly monitoring event. Concentrations of perchlorate at 54MW12 equaled 0.737 µg/L, while 54MW13 had an observed concentration of 0.27 µg/L. Both detections were well below the RG of 10.9 µg/L.

Miscellaneous Analytes

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

Observed levels of TOC in the four monitoring wells ranged from a low of 4.1 mg/L (54MW1) to a high of 13.0 mg/L (54MW13), while the levels of TIC ranged from a low of 30.0 mg/L (54MW10) to a high of 62.0 mg/L (54MW12). Dissolved ferrous iron levels ranged from a low of 0.0 mg/L (non detect) (54MW 1) to a high of 0.11 mg/L (54MW10, 54MW13). Manganese concentrations ranged from a low of 0.066 mg/L (54MW12) to a high of 0.087 mg/L (54MW1). Chloride concentrations ranged from a low of 2.8 mg/L (54MW1) to a high of 6.2 mg/L (54MW10). Detected concentrations of nitrate ranged from a low of 0.14 mg/L (54MW1) to a high of 0.92 mg/L (54MW12). Sulfate concentrations ranged from a low of 23.0 mg/L (54MW10) to a high of 26.0 mg/L (54MW13). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-2** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-1 SWMU 54 Summary of Thirteenth Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples$^{(1)}$	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives								
1,3-Dinitrobenzene	**µg/L**	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	1	4	5	5.4	11	54MW12
DNT Mixture*	**µg/L**	**0.932**	0	0	5	ND	ND	na
2,4-Dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**µg/L**	**na**	na	4	5	1.2	4.2	54MW12
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2-Nitrotoluene	**µg/L**	**na**	na	4	5	0.8	2.5	54MW10, SWMU54TM, 54MW12
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	na	4	5	1.9	3.9	54MW12
RDX	**µg/L**	**6.1**	0	0	5	ND	ND	na
DNX	**µg/L**	**na**	na	0	5	ND	ND	na
MNX	**µg/L**	**na**	na	0	5	ND	ND	na
TNX	**µg/L**	**na**	na	0	5	ND	ND	na
Misc.								
Perchlorate	**µg/L**	**10.9**	0	2	5	0.27	0.737	54MW12
Chlorate	**µg/L**	**na**	na	0	5	ND	ND	na
Chlorite	**µg/L**	**na**	na	0	5	ND	ND	na
Chloride	**mg/L**	**na**	na	5	5	2.8	6.2	54MW10
Nitrate (as N)	**mg/L**	**na**	na	5	5	0.14	0.92	54MW12
Sulfate	**mg/L**	**na**	na	5	5	23	26	54MW13
Total Inorganic Carbon	**mg/L**	**na**	na	5	5	30	62	54MW12
Total Organic Carbon	**mg/L**	**na**	na	5	5	4.1	13	54MW13

Notes:
[1] One sample was a duplicate
na = not applicable
ND = non detect

Table 5-2 SWMU 54 Detected Analytes in Thirteenth Quarter Groundwater Samples

Sample ID			**54MW1**					**54MW10**					**SWMU54TM (Field Duplicate 54MW10)**				
Date Collected			**9/30/2015**					**9/30/2015**					**9/30/2015**				
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**
Explosives																	
1,3-Dinitrobenzene	**µg/L**	**na**	0.3	U	U	0.5	0.1	0.3	U	UJ	0.5	0.1	0.32	U	U	0.54	0.11
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	0.3	U	U	1	0.11	6.6		J	1	0.11	5.4			1.1	0.12
DNT Mixture*	**µg/L**	**0.932**	0.6	U	U	1.5	0.27	0.6	U	UJ	1.5	0.27	0.64	U	U	1.64	0.29
2,4-Dinitrotoluene	**µg/L**	**na**	0.3	U	U	1	0.15	0.3	U	UJ	1	0.15	0.32	U	U	1.1	0.16
2,6-Dinitrotoluene	**µg/L**	**na**	0.3	U	U	0.5	0.12	0.3	U	UJ	0.5	0.12	0.32	U	U	0.54	0.13
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	0.3	U	U	0.5	0.12	3.2		J	0.5	0.12	2.9			0.54	0.13
2-Nitrotoluene	**µg/L**	**na**	0.4	U	U	2	0.2	0.4	U	UJ	2	0.2	0.43	U	U	2.2	0.22
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	0.3	U	U	0.5	0.14	2.5		J	0.5	0.14	2.5			0.54	0.15
RDX	**µg/L**	**6.1**	0.3	U	U	0.5	0.09	2.1	P	J	0.5	0.09	1.9			0.54	0.097
DNX	**µg/L**	**na**	0.2	U	U	0.4	0.09	0.2	U	U	0.4	0.09	0.22	U	U	0.43	0.097
MNX	**µg/L**	**na**	0.1	U	U	0.2	0.03	0.1	U	U	0.2	0.03	0.11	U	U	0.22	0.032
TNX	**µg/L**	**na**	0.2	U	U	0.4	0.1	0.2	U	U	0.4	0.1	0.22	U	U	0.43	0.11
Misc.																	
Perchlorate	**µg/L**	**10.9**	0.2	U	U		0.1	0.2	U	U		0.1	0.2	U	U		0.1
Chlorate	**µg/L**	**na**	ND					ND					ND				
Chlorite	**µg/L**	**na**	ND					ND					ND				
Chloride	**mg/L**	**na**	2.8	J	J	4	1.1	6.2			4	1.1	6.1			4	1.1
Nitrate (as N)	**mg/L**	**na**	0.14	J	J	0.4	0.08	0.25	J	J	0.4	0.08	0.26	J	J	0.4	0.08
Sulfate	**mg/L**	**na**	25			5	1.3	23			5	1.3	24			5	1.3
Total Inorganic Carbon	**mg/L**	**na**	53			3	0.5	30			3	0.5	31			3	0.5
Total Organic Carbon	**mg/L**	**na**	4.1			3	0.5	8.1			3	0.5	6.9			3	0.5
MNA																	
Dissolved Fe^{2+}	**mg/L**	**na**	0					0.11					0.11				
Dissolved Mn	**mg/L**	**na**	0.087					0.081					0.081				

Table 5-2 SWMU 54 Detected Analytes in Thirteenth Quarter Groundwater Samples (Continued)

Sample ID			54MW12					54MW13				
Date Collected			**9/30/2015**					**9/30/2015**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives												
1,3-Dinitrobenzene	µg/L	na	0.3	UM,Y	UJ	0.5	0.1	0.3	U	UJ	0.5	0.1
2,4,6-Trinitrotoluene	µg/L	7.82	11			1	0.11	5.4		J	1	0.11
DNT Mixture*	µg/L	0.932	0.6	UM,Y	UJ	1.5	0.27	0.6	U	UJ	1.5	0.27
2,4-Dinitrotoluene	µg/L	na	0.3	UM,Y	UJ	1	0.15	0.3	U	UJ	1	0.15
2,6-Dinitrotoluene	µg/L	na	0.3	UM,Y	UJ	0.5	0.12	0.3	U	UJ	0.5	0.12
2-Amino-4,6-dinitrotoluene	µg/L	na	4.2	M	J	0.5	0.12	1.2		J	0.5	0.12
2-Nitrotoluene	µg/L	na	0.4	UM,Y	UJ	2	0.2	0.4	U	UJ	2	0.2
4-Amino-2,6-dinitrotoluene	µg/L	na	2.5	M,Y	J	0.5	0.14	0.8		J	0.5	0.14
RDX	µg/L	6.1	3.9	P		0.5	0.09	2.6	P	J	0.5	0.09
DNX	µg/L	na	0.2	U	U	0.4	0.09	0.2	U	U	0.4	0.09
MNX	µg/L	na	0.1	U	U	0.2	0.03	0.1	U	U	0.2	0.03
TNX	µg/L	na	0.2	U	U	0.4	0.1	0.2	U	U	0.4	0.1
Misc.												
Perchlorate	µg/L	10.9	0.737		J		0.1	0.27	J	J		0.1
Chlorate	µg/L	na	ND					ND				
Chlorite	µg/L	na	ND					ND				
Chloride	mg/L	na	5.1			4	1.1	4.8			4	1.1
Nitrate (as N)	mg/L	na	0.92			0.4	0.08	0.5			0.4	0.08
Sulfate	mg/L	na	24	M		5	1.3	26			5	1.3
Total Inorganic Carbon	mg/L	na	62		J	3	0.5	55			3	0.5
Total Organic Carbon	mg/L	na	8.3	Y	J	3	0.5	13			3	0.5
MNA												
Dissolved Fe^{2+}	mg/L	na	0.07					0.11				
Dissolved Mn	mg/L	na	0.066					0.081				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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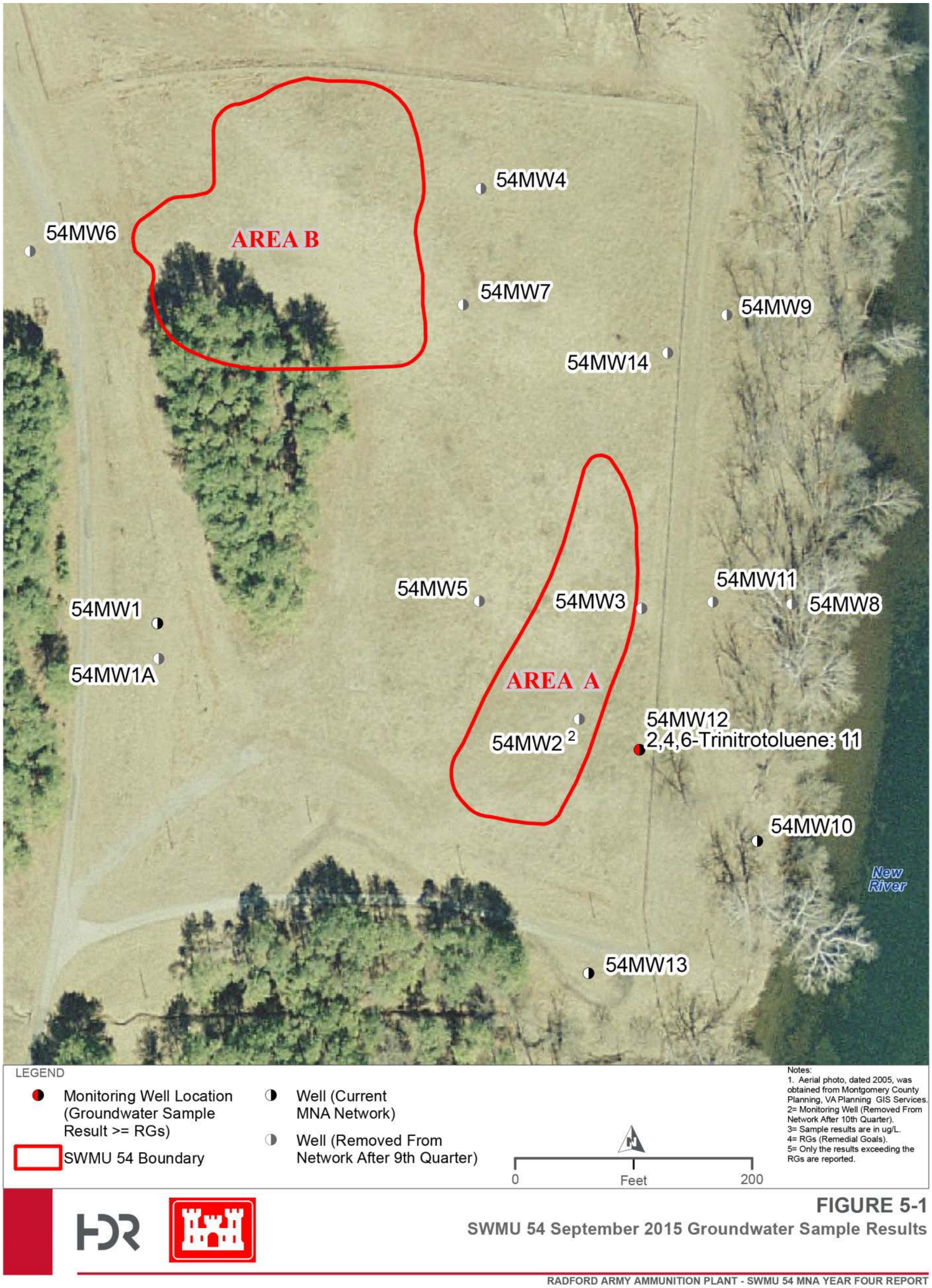
Figure 5-1 SWMU 54 September 2015 Groundwater Sample Results



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning GIS Services.
2= Monitoring Well (Removed From Network After 10th Quarter).
3= Sample results are in ug/L.
4= RGs (Remedial Goals).
5= Only the results exceeding the RGs are reported.

FIGURE 5-1
SWMU 54 September 2015 Groundwater Sample Results

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5.3 Fourteenth Quarter Groundwater Results (January 2016)

Four (4) groundwater monitoring wells were sampled during the fourteenth quarterly monitoring event, including wells 54MW1, 54MW10, 54MW12, and 54MW13. A duplicate sample was collected from monitoring well 54MW10. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-3**, while the analytical results are presented in **Table 5-4**. Sample locations are provided in **Figure 4-1**.

Explosives

Five explosives were detected in groundwater samples including 2,4,6-TNT, 2ADNT, 4ADNT, RDX, and the RDX breakdown by-product DNX. The explosive 4ADNT was only detected at monitoring well 54MW10, while DNX was only detected at monitoring well 54MW12. All five explosives were qualified as estimated values. No explosives were detected in monitoring well 54MW1.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at an estimated concentration of 4.1 µg/L; at monitoring well 54MW12 at an estimated concentration of 110.0 µg/L; and at monitoring well 54MW13 at an estimated concentration of 1.4 µg/L. The concentration of 2,4,6-TNT detected at monitoring well 54MW12 exceeded the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW10 at an estimated concentration of 1.2 µg/L; at monitoring well 54MW12 at an estimated concentration of 13.0 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.44 µg/L. An RG has not been established for 2ADNT.

The explosive 4ADNT was detected solely at monitoring well 54MW10 at an estimated concentration of 0.78 µg/L.

RDX was detected at monitoring well 54MW10 at an estimated concentration of 3.1 µg/L; at monitoring well 54MW12 at an estimated concentration of 30.0 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.54 µg/L. The concentration of RDX detected at monitoring well 54MW12 exceeded the RG of 6.1 µg/L.

The RDX breakdown by-product DNX was detected solely at monitoring well 54MW12 at an estimated concentration of 0.72 µg/L. An RG has not been established for DNX.

The monitoring wells with detected concentrations of explosives were typically the same wells with hits recorded during previous sampling rounds, albeit at lower concentrations. The monitoring well location (54MW12) where RDX and 2,4,6-TNT exceeded the RG is provided in **Figure 5-2**.

Perchlorate

Perchlorate was detected at estimated concentrations in three groundwater samples collected from monitoring wells 54MW10, 54MW12, and 54MW13 during this quarterly monitoring event. Perchlorate was detected at monitoring well 54MW10 at an estimated concentration of 0.326 µg/L; at monitoring well 54MW12 at an estimated concentration of 8.85 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.216 µg/L. All three detections were below the RG of 10.9 µg/L.

Miscellaneous Analytes

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

Observed levels of TOC in the four monitoring wells ranged from a low of 0.97 mg/L (54MW10) to a high of 1.8 mg/L (54MW12), while the levels of TIC ranged from a low of 46.0 mg/L (54MW13) to a high of 91.0 mg/L (54MW12). Dissolved ferrous iron levels ranged from a low of 0.0 mg/L (non detect) (54MW1 and 54MW10) to a high of 0.1 mg/L (54MW12). Manganese concentrations ranged from a low of 0.03 mg/L (54MW12) to a high of 0.063 mg/L (54MW1 and 54MW13). Chloride concentrations ranged from a low of 2.5 mg/L (54MW13) to a high of 6.0 mg/L (54MW12). Detected concentrations of nitrate ranged from a low of 0.15 mg/L (54MW1) to a high of 2.5 mg/L (54MW12). Sulfate concentrations ranged from a low of 20.0 mg/L (54MW13) to a high of 76.0 mg/L (54MW10). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-4** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-3 SWMU 54 Summary of Fourteenth Quarter Groundwater Samples

	RG	# of RG Exceedances	# of Detections	# of Samples[1]	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (µg/L)							
1,3-Dinitrobenzene	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**7.82**	1	4	5	1.4	110.0	54MW12
DNT Mixture	**0.932**	0	0	5	0.6	0.6	54MW10
2,4-Dinitrotoluene	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**na**	na	0	5	ND	ND	na
2-Amino-4,6-dinitrotoluene	**na**	na	4	5	0.44	13.0	54MW12
2-Nitrotoluene	**na**	na	0	5	ND	ND	na
4-Amino-2,6-dinitrotoluene	**na**	na	4	5	0.76	0.78	54MW10
RDX	**6.1**	1	4	5	0.54	30.0	54MW12
DNX	**na**	na	1	5	0.72	0.72	54MW12
MNX	**na**	na	0	5	ND	ND	na
TNX	**na**	na	0	5	ND	ND	na
Misc. (µg/L)							
Perchlorate	**10.9**	0	4	5	0.216	8.85	54MW12
Chlorate	**na**	na	0	5	ND	ND	na
Chlorite	**na**	na	0	5	ND	ND	na
Chloride	**na**	na	5	5	2.5	6.0	54MW12
Nitrate (as N)	**na**	na	4	5	0.45	2.5	54MW12
Sulfate	**na**	na	5	5	20.0	76.0	54MW10
Total Inorganic Carbon	**na**	na	5	5	46.0	91.0	54MW12
Total Organic Carbon	**na**	na	5	5	0.97	1.8	54MW12

Notes:
[1] One sample was a duplicate
na = not applicable
ND = non detect

Table 5-4 SWMU 54 Detected Analytes in Fourteenth Quarter Groundwater Samples

Sample ID			54MW1					54MW10					SWMU54TM (Field Duplicate 54MW10)				
Date Collected			**1/12/2016**					**1/11/2016**					**1/11/2016**				
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**
Explosives																	
1,3-Dinitrobenzene	μg/L	na	0.30	U	UJ	0.50	0.10	0.30	U	UJ	0.50	0.10	0.30	U	UJ	0.50	0.10
2,4,6-Trinitrotoluene	μg/L	**7.82**	0.30	U	UJ	1.0	0.11	4.1		J	1.0	0.11	4.3		J	1.0	0.11
DNT Mixture	μg/L	**0.932**	0.60	U	UJ	1.50	0.27	0.60	U	UJ	1.50	0.27	0.60	U	UJ	1.50	0.27
2,4-Dinitrotoluene	μg/L	na	0.30	U	UJ	1.0	0.15	0.30	U	UJ	1.0	0.15	0.30	U	UJ	1.0	0.15
2,6-Dinitrotoluene	μg/L	na	0.30	U	UJ	0.50	0.12	0.30	U	UJ	0.50	0.12	0.30	U	UJ	0.50	0.12
2-Amino-4,6-dinitrotoluene	μg/L	na	0.30	U	UJ	0.50	0.12	1.2		J	0.50	0.12	1.3		J	0.50	0.12
2-Nitrotoluene	μg/L	na	0.40	U	UJ	2.0	0.20	0.40	U	UJ	2.0	0.20	0.40	U	UJ	2.0	0.20
4-Amino-2,6-dinitrotoluene	μg/L	na	0.30	U	UJ	0.50	0.14	0.78		J	0.50	0.14	0.76		J	0.50	0.14
RDX	μg/L	**6.1**	0.30	U	UJ	0.50	0.090	3.1	P	J	0.50	0.090	3.2	P	J	0.50	0.090
DNX	μg/L	na	0.20	U	UJ	0.40	0.090	0.20	U	UJ	0.40	0.090	0.20	U	UJ	0.40	0.090
MNX	μg/L	na	0.10	U	UJ	0.20	0.030	0.10	U	UJ	0.20	0.030	0.10	U	UJ	0.20	0.030
TNX	μg/L	na	0.20	U	UJ	0.40	0.10	0.20	U	UJ	0.40	0.10	0.20	U	UJ	0.40	0.10
Misc.																	
Perchlorate	μg/L	**10.9**	0.200	U	U	0.40	0.10	0.326	J	J	0.40	0.10	0.284	J	J	0.400	0.100
Chlorate	μg/L	na	0.360	U	U	10.0	0.36	0.360	U	U	10.0	0.36	0.360	U	U	10.0	0.360
Chlorite	μg/L	na	0.720	U	U	10.0	0.72	0.720	U	U	10.0	0.72	0.720	U	U	10.0	0.720
Chloride	mg/L	na	2.6	J	J	4.0	1.1	4.6		J	4.0	1.1	4.6	M		4.0	1.1
Nitrate (as N)	mg/L	na	0.15	U	U	0.40	0.08	0.45			0.40	0.08	0.46			0.40	0.080
Sulfate	mg/L	na	26			5.0	1.3	76			25	6.5	73			25	6.5
Total Inorganic Carbon	mg/L	na	61		J	3.0	0.50	77			3.0	0.50	81			3.0	0.50
Total Organic Carbon	mg/L	na	1.5	U	U	3.0	0.50	0.97	J	J	3.0	0.50	1.1	J	J	3.0	0.50
MNA																	
Dissolved Fe^{2}+	mg/L	na	0					0.0					0.0				
Dissolved Mn	mg/L	na	0.063					0.054					0.054				

Table 5-4 SWMU 54 Detected Analytes in Fourteenth Quarter Groundwater Samples (Continued)

Sample ID			**54MW12**					**54MW13**				
Date Collected			**1/12/2016**					**1/12/2016**				
Analyte	**Units**	**Remedial Goals $^{(1)}$**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives												
1,3-Dinitrobenzene	**µg/L**	**na**	0.30	U	UJ	0.50	0.10	0.30	U	UJ	0.50	0.10
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	110	M	J	10	1.1	1.4		J	1.0	0.11
DNT Mixture	**µg/L**	**0.932**	0.60	U	UJ	1.50	0.27	0.60	U	UJ	1.50	0.27
2,4-Dinitrotoluene	**µg/L**	**na**	0.30	U	UJ	1.0	0.15	0.30	U	UJ	1.0	0.15
2,6-Dinitrotoluene	**µg/L**	**na**	0.30	U	UJ	0.50	0.12	0.30	U	UJ	0.50	0.12
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	13		J	0.50	0.12	0.44	J	J	0.50	0.12
2-Nitrotoluene	**µg/L**	**na**	0.40	U	UJ	2.0	0.20	0.40	U	UJ	2.0	0.20
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	0.30	UM	UJ	0.50	0.14	0.30	U	UJ	0.50	0.14
RDX	**µg/L**	**6.1**	30	M,P	J	5.0	0.90	0.54		J	0.50	0.090
DNX	**µg/L**	**na**	0.72	P,M	J	0.40	0.090	0.20	U	UJ	0.40	0.090
MNX	**µg/L**	**na**	0.10	UY	UJ	0.20	0.030	0.10	U	UJ	0.20	0.030
TNX	**µg/L**	**na**	0.20	UP,M	UJ	0.40	0.10	0.20	U	UJ	0.40	0.10
Misc.												
Perchlorate	**µg/L**	**10.9**	8.85		J	0.400	0.100	0.216	J	J	0.400	0.100
Chlorate	**µg/L**	**na**	0.360	U	U	10.0	0.360	0.360	U	U	10.0	0.360
Chlorite	**µg/L**	**na**	0.720	U	U	10.0	0.720	0.720	U	U	10.0	0.720
Chloride	**mg/L**	**na**	6.0			4.0	1.1	2.5	J	J	4.0	1.1
Nitrate (as N)	**mg/L**	**na**	2.5		B	0.40	0.080	0.46			0.40	0.080
Sulfate	**mg/L**	**na**	45			5.0	1.3	20			5.0	1.3
Total Inorganic Carbon	**mg/L**	**na**	91	M	J	3.0	0.50	46		J	3.0	0.50
Total Organic Carbon	**mg/L**	**na**	1.8	JY	J	3.0	0.50	1.8	J	J	3.0	0.50
MNA												
Dissolved Fe^{2+}	**mg/L**	**na**	0.10					0.05				
Dissolved Mn	**mg/L**	**na**	0.030					0.063				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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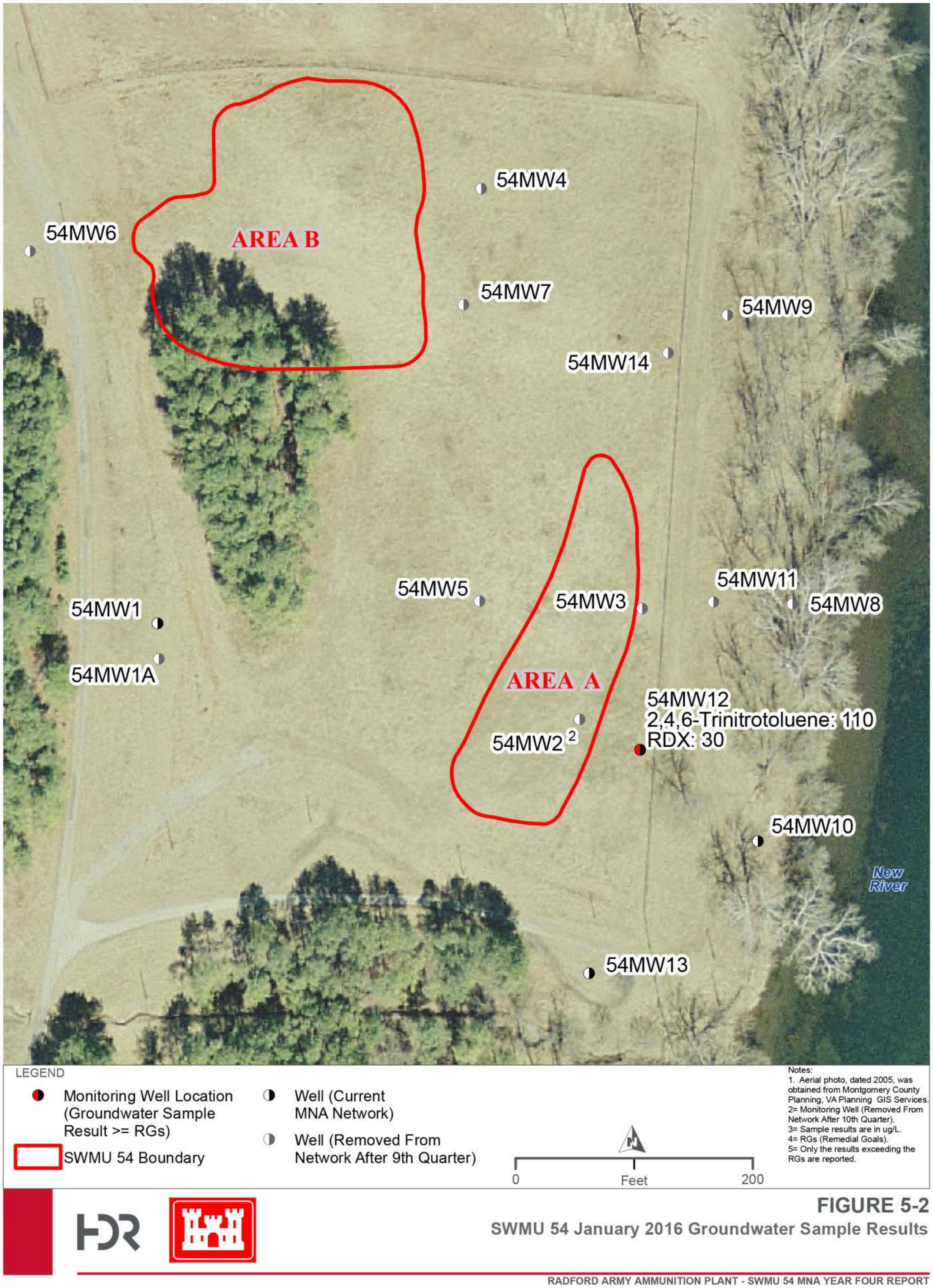
Figure 5-2 SWMU 54 January 2016 Groundwater Sample Results



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5.4 Fifteenth Quarter Groundwater Results (April 2016)

Four (4) groundwater monitoring wells were sampled during the fifteenth quarterly monitoring event, including wells 54MW1, 54MW10, 54MW12, and 54MW13. A duplicate sample was collected from monitoring well 54MW1. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-5**, while the analytical results are presented in **Table 5-6**. Sample locations are provided in **Figure 4-1**.

Explosives

Four explosives were detected in groundwater samples including 2,4,6-TNT, 2ADNT, 4ADNT, and RDX. All four explosives were detected in monitoring wells 54MW10, 54MW12, and 54MW13. No explosives were detected in monitoring well 54MW1. All four explosives were qualified as estimated values.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at an estimated concentration of 2.7 µg/L; at monitoring well 54MW12 at an estimated concentration of 11.0 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.79 µg/L. The concentration of 2,4,6-TNT detected at monitoring well 54MW12 exceeded the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW10 at an estimated concentration of 0.42 µg/L; at monitoring well 54MW12 at an estimated concentration of 4.3 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.25 µg/L. An RG has not been established for 2ADNT.

The explosive 4ADNT was detected at monitoring well 54MW10 at an estimated concentration of 0.49 µg/L; at monitoring well 54MW12 at an estimated concentration of 2.7 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.23 µg/L. An RG has not been established for 4ADNT

RDX was detected at monitoring well 54MW10 at an estimated concentration of 1.8 µg/L; at monitoring well 54MW12 at an estimated concentration of 2.5 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.17 µg/L. The monitoring wells did not contain concentrations of RDX that exceeded the RG of 6.1 µg/L.

The monitoring wells with detected concentrations of explosives were typically the same wells with hits recorded during previous sampling rounds, albeit at lower concentrations. The monitoring well location (54MW12) where 2,4,6-TNT exceeded the RG is provided in **Figure 5-3**.

Perchlorate

Perchlorate was detected at estimated concentrations in three groundwater samples collected from monitoring wells 54MW10, 54MW12, and 54MW13. Perchlorate was detected at monitoring well 54MW10 at an estimated concentration of 0.086 µg/L; at monitoring well 54MW12 at an estimated concentration of 1.2 µg/L; and at monitoring well 54MW13 at an estimated concentration of 0.18 µg/L. All three detections were below the RG of 10.9 µg/L.

Miscellaneous Analytes

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

Observed TOC concentrations in the four monitoring wells ranged from a low of 0.68 mg/L (54MW13) to a high of 8.9 mg/L (54MW10), while the levels of TIC ranged from a low of 27.0 mg/L (54MW13) to a high of 56.0 mg/L (54MW10). Dissolved ferrous iron levels ranged from a low of 0.02 mg/L (54MW1 and 54MW13) to a high of 0.04 mg/L (54MW12). Manganese concentrations ranged from a low of 0.02 mg/L (54MW12) to a high of 0.057 mg/L (54MW10). Chloride concentrations ranged from a low of 1.1 mg/L (54MW10) to a high of 4.3 mg/L (54MW12). Detected concentrations of nitrate ranged from a low of 0.14 mg/L (54MW1) to a high of 1.3 mg/L (54MW12). Sulfate concentrations ranged from a low of 19.0 mg/L (54MW13) to a high of 83.0 mg/L (54MW10). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-6** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-5 SWMU 54 Summary of Fifteenth Quarter Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples [(1)]	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives								
1,3-Dinitrobenzene	**µg/L**	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	1	3	5	.79	11	54MW12
DNT Mixture*	**µg/L**	**0.932**	0	0	5	ND	ND	na
2,4-Dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	na	3	5	.25	4.3	54MW12
2-Nitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	na	3	5	.23	2.7	54MW12
RDX	**µg/L**	**6.1**	0	3	5	.17	2.5	54MW12
DNX	**µg/L**	**na**	na	0	5	ND	ND	na
MNX	**µg/L**	**na**	na	0	5	ND	ND	na
TNX	**µg/L**	**na**	na	0	5	ND	ND	na
Misc.								
Perchlorate	**µg/L**	**10.9**	0	3	5	.082	1.2	54MW12
Chlorate	**µg/L**	**na**	na	0	5	ND	ND	na
Chlorite	**µg/L**	**na**	na	0	5	ND	ND	na
Chloride	**mg/L**	**na**	na	5	5	1.6	4.4	54MW10
Nitrate (as N)	**mg/L**	**na**	na	5	5	.14	1.3	54MW12
Sulfate	**mg/L**	**na**	na	5	5	26	83	54MW10
Total Inorganic Carbon	**mg/L**	**na**	na	5	5	27	56	54MW10
Total Organic Carbon	**mg/L**	**na**	na	5	5	.68	8.9	54MW10

Notes:
[1] One sample was a duplicate
na = not applicable
ND = non detect

Table 5-6 SWMU 54 Detected Analytes in Fifteenth Quarter Groundwater Samples

Sample ID			54MW1					54TM1 (Field Duplicate 54MW1)					54MW10				
Date Collected			4/14/2016					4/14/2016					4/14/2016				
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
Explosives																	
1,3-Dinitrobenzene	µg/L	na	0.32	U	UJ	0.53	0.11	0.32	U	UJ	0.53	0.11	0.32	U	UJ	0.53	0.11
2,4,6-Trinitrotoluene	µg/L	7.82	0.32	U	UJ	1.1	0.12	0.32	U	UJ	1.1	0.12	2.7		J	1.1	0.12
DNT Mixture	µg/L	0.932	0.64	U	UJ	1.63	0.29	0.64	U	UJ	1.63	0.29	0.64	U	UJ	1.63	0.29
2,4-Dinitrotoluene	µg/L	na	0.32	U	UJ	1.1	0.16	0.32	U	UJ	1.1	0.16	0.32	U	UJ	1.1	0.16
2,6-Dinitrotoluene	µg/L	na	0.32	U	UJ	0.53	0.13	0.32	U	UJ	0.53	0.13	0.32	U	UJ	0.53	0.13
2-Amino-4,6-dinitrotoluene	µg/L	na	0.32	U	UJ	0.53	0.13	0.32	U	UJ	0.53	0.13	0.42	J	J	0.53	0.13
2-Nitrotoluene	µg/L	na	0.43	U	UJ	2.1	0.21	0.42	U	UJ	2.1	0.21	0.42	U	UJ	2.1	0.21
4-Amino-2,6-dinitrotoluene	µg/L	na	0.32	U	UJ	0.53	0.15	0.32	U	UJ	0.53	0.15	0.49	J	J	0.53	0.15
RDX	µg/L	6.1	0.32	U	UJ	0.53	0.096	0.32	U	UJ	0.53	0.095	1.8		J	0.53	0.095
DNX	µg/L	na	0.10	U	UJ	0.21	0.083	0.10	U	UJ	0.20	0.080	0.10	U	UJ	0.20	0.081
MNX	µg/L	na	0.10	U	UJ	0.21	0.083	0.10	U	UJ	0.20	0.080	0.10	U	UJ	0.20	0.081
TNX	µg/L	na	0.10	U	UJ	0.21	0.083	0.10	U	UJ	0.20	0.080	0.10	U	UJ	0.20	0.081
Misc.																	
Perchlorate	µg/L	10.9	0.10	U	U	0.20	0.050	0.10	U	U	0.20	0.050	0.082	J	J	0.20	0.050
Chlorate	µg/L	na	10	U	U	10		10	U	U	10		10	U	U	10	
Chlorite	µg/L	na	10	U	U	10		10	U	U	10		10	U	U	10	
Chloride	mg/L	na	2.4	J	J	4.0	1.1	2.3	J	J	4.0	1.1	4.4			4.0	1.1
Nitrate (as N)	mg/L	na	0.14	J	J	0.40	0.080	0.14	J	J	0.40	0.080	0.18	J	J	0.40	0.080
Sulfate	mg/L	na	29			5.0	1.3	26			5.0	1.3	83			5.0	1.3
Total Inorganic Carbon	mg/L	na	51			3.0	0.50	51			3.0	0.50	56			3.0	0.50
Total Organic Carbon	mg/L	na	4.2			3.0	0.50	4.0			3.0	0.50	8.9			3.0	0.50
MNA																	
Dissolved Fe^{2+}	mg/L	na	0.02					0.02					0.03				
Dissolved Mn	mg/L	na	0.021					0.021					0.057				

Table 5-6 SWMU 54 Detected Analytes in Fifteenth Quarter Groundwater Samples (Continued)

Sample ID			54MW12					54MW13				
Date Collected			4/14/2016					4/14/2016				
Analyte	Units	Remedial Goals (1)	Result	Lab Q	Val Q	RL	MDL	Result	Lab Q	Val Q	RL	MDL
Explosives												
1,3-Dinitrobenzene	µg/L	na	0.31	U	UJ	0.52	0.10	0.30	U	UJ	0.51	0.10
2,4,6-Trinitrotoluene	µg/L	7.82	11		J	1.0	0.11	0.79	J	J	1.0	0.11
DNT Mixture	µg/L	0.932	0.62	U	UJ	1.52	0.27	0.60	U	UJ	1.51	0.27
2,4-Dinitrotoluene	µg/L	na	0.31	U	UJ	1.0	0.15	0.30	U	UJ	1.0	0.15
2,6-Dinitrotoluene	µg/L	na	0.31	U	UJ	0.52	0.12	0.30	U	UJ	0.51	0.12
2-Amino-4,6-dinitrotoluene	µg/L	na	4.3		J	0.52	0.12	0.25	J	J	0.51	0.12
2-Nitrotoluene	µg/L	na	0.41	U	UJ	2.1	0.21	0.40	U	UJ	2.0	0.20
4-Amino-2,6-dinitrotoluene	µg/L	na	2.7		J	0.52	0.14	0.23	J	J	0.51	0.14
RDX	µg/L	6.1	2.5		J	0.52	0.093	0.17	J	J	0.51	0.091
DNX	µg/L	na	0.10	U	UJ	0.20	0.080	0.10	U	UJ	0.20	0.080
MNX	µg/L	na	0.10	U	UJ	0.20	0.080	0.10	U	UJ	0.20	0.080
TNX	µg/L	na	0.10	U	UJ	0.20	0.080	0.10	U	UJ	0.20	0.080
Misc.												
Perchlorate	µg/L	10.9	1.2		J	0.20	0.050	0.18	J	J	0.20	0.050
Chlorate	µg/L	na	10	U	U	10		10	U	U	10	
Chlorite	µg/L	na	10	U	UJ	10		10	U	U	10	
Chloride	mg/L	na	4.3			4.0	1.1	1.6	J	J	4.0	1.1
Nitrate (as N)	mg/L	na	1.3			0.40	0.080	0.43			0.40	0.080
Sulfate	mg/L	na	27	M	J	5.0	1.3	19			5.0	1.3
Total Inorganic Carbon	mg/L	na	39			3.0	0.50	27			3.0	0.50
Total Organic Carbon	mg/L	na	6.8			3.0	0.50	0.68	J	J	3.0	0.50
MNA												
Dissolved Fe^{2+}	mg/L	na	0.04					0.02				
Dissolved Mn	mg/L	na	0.020					0.025				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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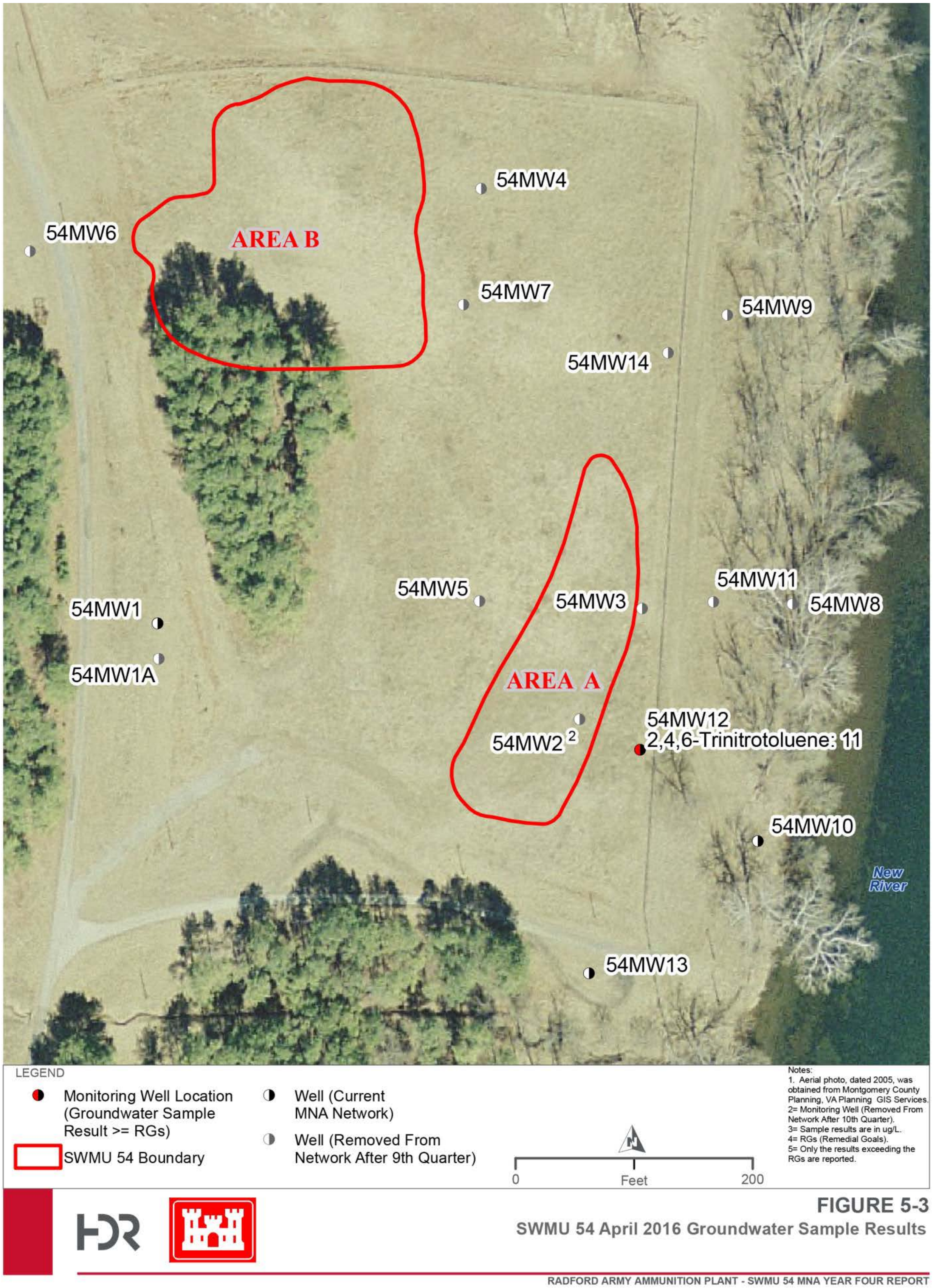
Figure 5-3 SWMU 54 April 2016 Groundwater Sample Results



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning GIS Services.
2= Monitoring Well (Removed From Network After 10th Quarter).
3= Sample results are in ug/L.
4= RGs (Remedial Goals).
5= Only the results exceeding the RGs are reported.

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5.5 Sixteenth Quarter Groundwater Results (July 2016)

Four (4) groundwater monitoring wells were sampled during the sixteenth quarterly monitoring event, including wells 54MW1, 54MW10, 54MW12, and 54MW13. A duplicate sample was collected from monitoring well 54MW10. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-7**, while the analytical results are presented in **Table 5-8**. Sample locations are provided in **Figure 4-1**.

Explosives

Four explosives were detected in groundwater samples including 2,4,6-TNT, 2ADNT, 4ADNT, and RDX. All four explosives were detected in monitoring wells 54MW10, 54MW12, and 54MW13. No explosives were detected in monitoring well 54MW1. With the exception of 2,4,6-TNT and RDX, the explosives were qualified as estimated values.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at a concentration of 24.2 µg/L; at monitoring well 54MW12 at a concentration of 7.4 µg/L; and at monitoring well 54MW13 at a concentration of 13.9 µg/L. The concentration of 2,4,6-TNT detected at monitoring wells 54MW10 and 54MW13 exceeded the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW10 at an estimated concentration of 1.9 µg/L; at monitoring well 54MW12 at an estimated concentration of 5.6 µg/L; and at monitoring well 54MW13 at an estimated concentration of 1.7 µg/L. An RG has not been established for 2ADNT.

The explosive 4ADNT was detected at monitoring well 54MW10 at a concentration of 2.0 µg/L; at monitoring well 54MW12 at a concentration of 2.8 µg/L; and at monitoring well 54MW13 at a concentration of 1.2 µg/L. An RG has not been established for 4ADNT

RDX was detected at monitoring well 54MW10 at a concentration of 6.6 µg/L; at monitoring well 54MW12 at a concentration of 0.37 µg/L; and at monitoring well 54MW13 at a concentration of 0.86 µg/L. The concentration of RDX detected at monitoring well 54MW10 exceeded the RG of 6.1 µg/L.

The monitoring wells with detected concentrations of explosives were typically the same wells with hits recorded during previous sampling rounds. The monitoring well locations where 2,4,6-TNT (54MW10 and 54MW13) and RDX (54MW10) exceeded the RGs are provided in **Figure 5-4**.

Perchlorate

Perchlorate was detected in three groundwater samples collected from monitoring wells 54MW10, 54MW12, and 54MW13. Perchlorate was detected at monitoring well 54MW10 at a concentration of 0.84 µg/L; at monitoring well 54MW12 at a concentration of 0.56 µg/L; and at monitoring well 54MW13 a concentration of 0.33 µg/L. All three detections were below the RG of 10.9 µg/L.

Miscellaneous Analytes

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

Observed TOC concentrations in the four monitoring wells ranged from a low of 0.58 mg/L (54MW10) to a high of 1.2 mg/L (54MW12), while the levels of TIC ranged from a low of 59.0 mg/L (54MW1) to a high of 87.0 mg/L (54MW10). Dissolved ferrous iron levels ranged from a low of 0.0 mg/L (non-detect) (54MW13) to a high of 0.14 mg/L (54MW1). Manganese concentrations ranged from a low of 0.031 mg/L (54MW13) to a high of 0.062 mg/L (54MW1). Chloride concentrations ranged from a low of 2.8 mg/L (54MW1) to a high of 6.4 mg/L (54MW12). Detected concentrations of nitrate ranged from a low of 0.15 mg/L (54MW1) to a high of 0.81 mg/L (54MW12). Sulfate concentrations ranged from a low of 25.0 mg/L (54MW12) to a high of 93.0 mg/L (54MW10). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-8** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-7 SWMU 54 Summary of Sixteenth Quarter Groundwater Samples

	RG	# of RG Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (µg/L)							
1,3-Dinitrobenzene	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**7.82**	3	4	5	7.4	30.3	54MW10
DNT Mixture*	**0.932**	na	0	5	ND	ND	na
2,4-Dinitrotoluene	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**0.932**	0	0	5	ND	ND	na
2-Amino-4,6-dinitrotoluene	**na**	na	4	5	1.7	5.6	54MW12
2-Nitrotoluene	**na**	na	0	5	ND	ND	na
4-Amino-2,6-dinitrotoluene	**na**	na	4	5	1.2	2.8	54MW12
RDX	**6.1**	2	4	5	.37	7.5	54MW10
DNX	**na**	na	0	5	ND	ND	na
MNX	**na**	na	0	5	ND	ND	na
TNX	**na**	na	0	5	ND	ND	na
Misc.							
Perchlorate	**10.9**	0	4	5	.33	.89	54MW10
Chlorate	**na**	na	0	5	ND	ND	na
Chlorite	**na**	na	0	5	ND	ND	na
Chloride	**na**	na	5	5	2.8	6.4	54MW12
Nitrate (as N)	**na**	na	4	5	.47	.81	54MW12
Sulfate	**na**	na	5	5	25	93	54MW10
Total Inorganic Carbon	**na**	na	5	5	59	87	54MW10
Total Organic Carbon	**na**	na	5	5	.58	1.2	54MW12

Notes:
na = not applicable
ND = non detect

Table 5-8 SWMU 54 Detected Analytes in Sixteenth Quarter Groundwater Samples

Sample ID			54MW1					54MW10					54TM10 (Field Duplicate 54MW10)				
Date Collected			**7/11/2016**					**7/11/2016**					**7/11/2016**				
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**
Explosives																	
1,3-Dinitrobenzene	µg/L	na	**0.1**	U	U	0.2	0.082	0.1	U	U	0.2	0.08	0.11	U	U	0.21	0.085
2,4,6-Trinitrotoluene	µg/L	7.82	**0.10**	U	U	0.20	0.082	24.2			0.40	0.16	30.3			0.43	0.17
DNT Mixture	µg/L	0.932	**0.2**	U	U	0.4	0.164	0.2	U	U	0.4	0.16	0.22	U	U	0.42	0.17
2,4-Dinitrotoluene	µg/L	na	**0.10**	U	U	0.20	0.082	0.10	U	U	0.20	0.08	0.11	U	U	0.21	0.085
2,6-Dinitrotoluene	µg/L	na	**0.10**	U	U	0.20	0.082	0.10	U	U	0.20	0.08	0.11	U	U	0.21	0.085
2-Amino-4,6-dinitrotoluene	µg/L	na	**0.10**	U	U	0.20	0.082	1.9		J+	0.20	0.080	2.3		J+	0.21	0.085
2-Nitrotoluene	µg/L	na	**0.10**	U	U	0.20	0.082	0.10	U	U	0.20	0.080	0.11	U	U	0.21	0.085
4-Amino-2,6-dinitrotoluene	µg/L	na	**0.10**	U	U	0.20	0.082	2.0			0.20	0.080	2.1			0.21	0.085
RDX	µg/L	6.1	**0.10**	U	U	0.20	0.082	6.6			0.20	0.080	7.5			0.21	0.085
DNX	µg/L	na	**0.1**	U	U	0.20	0.082	0.10	U	U	0.20	0.080	0.11	U	U	0.21	0.085
MNX	µg/L	na	**0.1**	U	U	0.20	0.082	0.10	U	U	0.20	0.080	0.11	U	U	0.21	0.085
TNX	µg/L	na	**0.1**	U	U	0.20	0.082	0.10	U	U	0.20	0.080	0.11	U	U	0.21	0.085
Misc.																	
Perchlorate	µg/L	10.9	**0.10**	U	U	0.20	0.050	0.84			0.20	0.050	0.89			0.20	0.050
Chlorate	µg/L	na	**10**	U	U	10	1.9	10	U	U	10	1.9	10	U	U	10	1.9
Chlorite	µg/L	na	**10**	U	U	10	5.7	10	U	U	10	5.7	10	U	U	10	5.7
Chloride	mg/L	na	**2.8**	J	J	4.0	1.1	4.9			4.0	1.1	5.0			4.0	1.1
Nitrate (as N)	mg/L	na	**0.15**	U	U	0.40	0.080	0.47			0.40	0.080	0.51			0.40	0.080
Sulfate	mg/L	na	**29**			5.0	1.3	93			25	6.5	87			25	6.5
Total Inorganic Carbon	mg/L	na	**59**			3.0	0.50	87			3.0	0.50	87			3.0	0.50
Total Organic Carbon	mg/L	na	**0.92**	J	J	3.0	0.50	0.58	J	J	3.0	0.50	0.77	J	J	3.0	0.50
MNA																	
Dissolved Fe^{2+}	mg/L	na	**0.14**					0.02					0.02				
Dissolved Mn	mg/L	na	**0.062**					0.048					0.048				

Table 5-8 SWMU 54 Detected Analytes in Sixteenth Quarter Groundwater Samples (Continued)

Sample ID			**54MW12**					**54MW13**				
Date Collected			**7/11/2016**					**9/30/2015**				
Analyte	**Units**	**Remedial Goals [(1)]**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives												
1,3-Dinitrobenzene	**µg/L**	na	0.1	U	U	0.2	0.08	0.10	U	U	0.20	0.080
2,4,6-Trinitrotoluene	**µg/L**	7.82	7.4			0.20	0.080	13.9		J-	0.20	0.080
DNT Mixture	**µg/L**	0.932	0.2	U	U	0.4	0.16	0.2	U	U	0.4	0.16
2,4-Dinitrotoluene	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.080
2,6-Dinitrotoluene	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.080
2-Amino-4,6-dinitrotoluene	**µg/L**	na	5.6		J+	0.20	0.080	1.7		J+	0.20	0.080
2-Nitrotoluene	**µg/L**	na	0.10	U	U	0.20	0.080	0.10	U	U	0.20	0.080
4-Amino-2,6-dinitrotoluene	**µg/L**	na	2.8			0.20	0.080	1.2			0.20	0.080
RDX	**µg/L**	6.1	0.37			0.20	0.080	0.86			0.20	0.080
DNX	**µg/L**	na	0.10	U	U	0.20	0.080	0.10	U	U	0.20	0.080
MNX	**µg/L**	na	0.10	U	U	0.20	0.080	0.10	U	U	0.20	0.080
TNX	**µg/L**	na	0.10	U	U	0.20	0.080	0.10	U	U	0.20	0.080
Misc.												
Perchlorate	**µg/L**	10.9	0.56			0.20	0.050	0.33			0.20	0.050
Chlorate	**µg/L**	na	10	U	U	10	1.9	10	U	UJ	10	1.9
Chlorite	**µg/L**	na	10	U	U	10	5.7	10	U	UJ	10	5.7
Chloride	**mg/L**	na	6.4		J-	4.0	1.1	5.7	M	J-	4.0	1.1
Nitrate (as N)	**mg/L**	na	0.81			0.40	0.080	0.60			0.40	0.080
Sulfate	**mg/L**	na	25			5.0	1.3	36	M		5.0	1.3
Total Inorganic Carbon	**mg/L**	na	60	Y		3.0	0.50	72			3.0	0.50
Total Organic Carbon	**mg/L**	na	1.2	J	J	3.0	0.50	0.78	J	J	3.0	0.50
MNA												
Dissolved Fe^{2+}	**mg/L**	na	0.02					0.00				
Dissolved Mn	**mg/L**	na	0.033					0.031				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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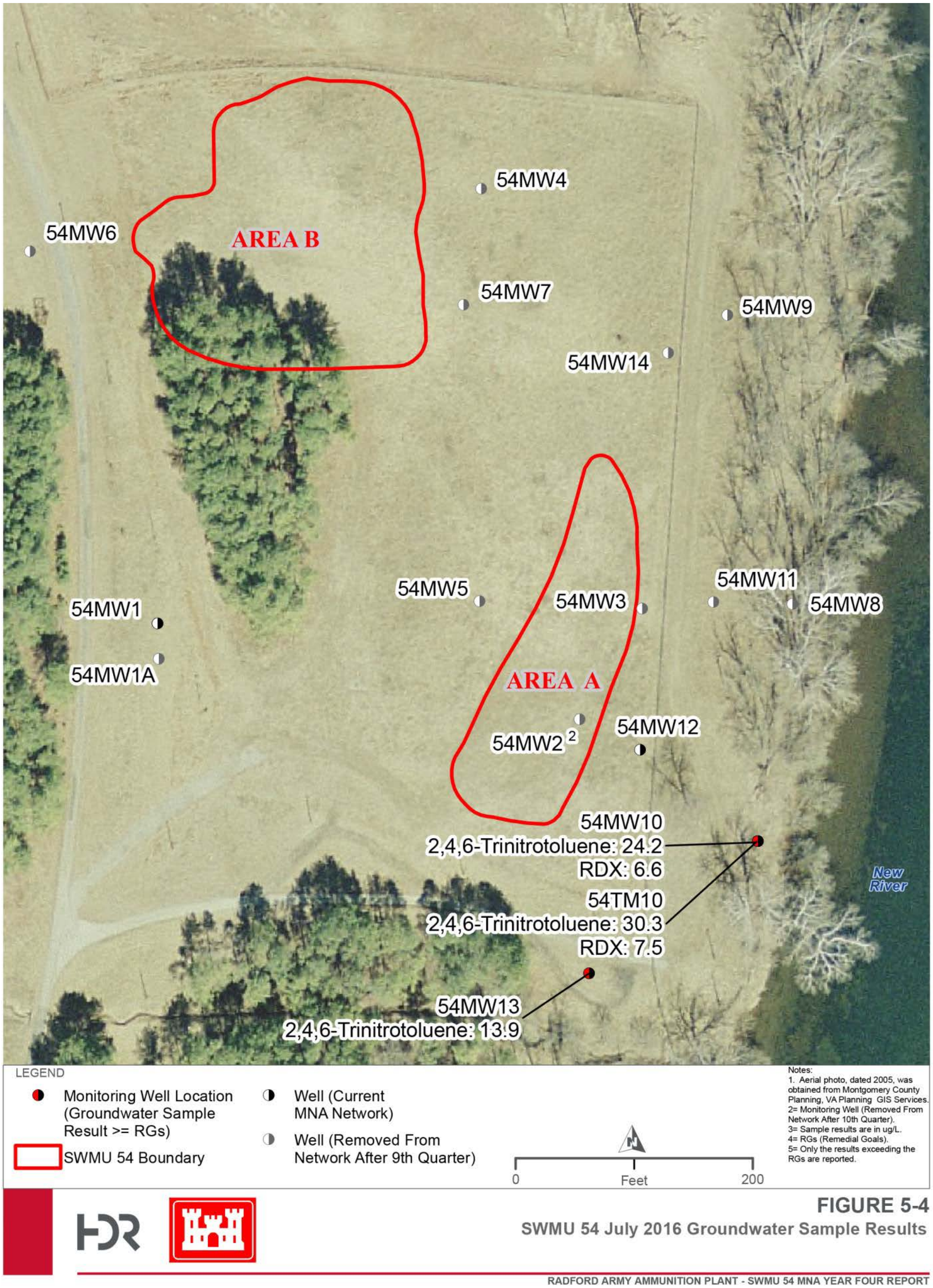
Figure 5-4 SWMU 54 July 2016 Groundwater Sample Results



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning GIS Services.
2= Monitoring Well (Removed From Network After 10th Quarter).
3= Sample results are in ug/L.
4= RGs (Remedial Goals).
5= Only the results exceeding the RGs are reported.

FIGURE 5-4
SWMU 54 July 2016 Groundwater Sample Results

RADFORD ARMY AMMUNITION PLANT - SWMU 54 MNA YEAR FOUR REPORT

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5.6 Year One Through Year Four Sample Results

Samples collected during the first two years were analyzed for explosives, perchlorate, and MNA indicators. The Year 2 MNA Report (CB&I, 2013) recommended elimination of the wells with no COI exceedances for the first two years, based on criteria established in the MNA work plan. The ninth quarter of sampling occurred prior to regulatory approval of the MNA report, and the original parameters were included in that sampling event. After approval of the Year 2 report, the sample plan was modified to include RDX MNA indicators in the analytical suite and reduce the sampling program from 14 monitoring wells to three wells with COI exceedances (54MW10, 12, and 13), and an upgradient well (54MW1) to monitor background conditions.

Multiple wells were removed from the monitoring network after the ninth and tenth quarters and were not sampled during the third and fourth year. Monitoring wells that were included in these yearly events included 54MW1, 54MW10, 54MW12, and 54MW13, which monitor Area A at SWMU 54. This section discusses the results from the first four years (sixteen quarters) of MNA sampling at these wells. The fourth year sampling included the analyses of explosives, perchlorate, RDX, RDX breakdown by-products (DNX, MNX and TNX), MNA indicator parameter, and water quality parameters.

5.6.1 Groundwater

Explosives

Samples from the four monitoring wells within SWMU 54 were analyzed for explosives for sixteen quarters of sampling. During the year three sampling round (quarters 10 thru 12), thirteen explosives were detected in the samples including DNX, MNX, and TNX. This number was reduced to five compounds during the fourth year of sampling. The explosives included 2,4,6-TNT, 2ADNT, 4ADNT, RDX, and the RDX breakdown by-product DNX.

With the exception of the up gradient monitoring well 54MW1, the explosives 2,4,6-TNT, and RDX were detected at concentrations above the RGs in all three monitoring wells. The explosive 2,4,6-TNT was detected during all four quarters (13 – 16) of sampling above the RG, while RDX was detected above the RG during the fourteenth and sixteenth quarters. **Figures 5-5** through **5-8** depict time line series plots of concentrations at these sampling locations throughout the sixteen quarters of sampling.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 above the RG during the tenth, eleventh, twelfth, and again during the sixteenth quarterly monitoring events (See **Figure 5-6**). Monitoring well 54MW12 has had detectable concentrations of 2,4,6-TNT above the RG during all sampling events, with the exception of quarters six, seven, and sixteen. Quarters eight and fourteen recorded the highest concentrations of 2,4,6-TNT at 108 µg/L and 110 µg/L, respectively (See **Figure 5-7**). 2,4,6-TNT concentrations at 54MW13 have typically been below the RG with the exception of the fifth, tenth, and sixteenth quarters of sampling where it exceeded the RG. The detected concentration in the sixteenth quarter was the highest value recorded to date at this monitoring well (**Figure 5-8**).

Concentrations of RDX exceeded the RG in monitoring well 54MW10 during the fifth, tenth, twelfth, and again during the sixteenth quarter. Monitoring well 54MW12 had detectable concentrations of RDX above the RG during seven of the first twelve quarters of sampling, but only one detection above the RG during year four (fourteenth quarter) of sampling. It would appear that elevated concentrations of RDX at 54MW12 are cyclic with periods of lower concentrations in between. Historically, monitoring well 54MW13 has not had a detection of RDX above the RG through the first twelve quarters of sampling; this trend continued during the year four monitoring event. Further, when compared to historic concentrations, the year four RDX levels appeared to decrease.

DNX was detected once during the year four monitoring event. Monitoring well had an estimated concentration of 0.72 µg/L, which was fairly consistent with previous detections. The only other detections of DNX at 54MW12 occurred during the tenth and twelfth quarters, when the break down by-product was also detected at monitoring wells 54MW10 and 54MW13. The concentrations of these compounds were low (less than 1 µg/L), but generally mirrored the RDX concentrations in the wells. Detection of the RDX daughter products in these wells with elevated RDX concentrations suggests degradation and natural attenuation of RDX is a viable, ongoing remedial process at the site.

Many of the intermediate and end-products of RDX degradation are relatively short-lived in the environment, and accumulation of these would not be expected. Studies on the fate and transport of explosives in the environment state that the nitroso intermediates of RDX (DNX, MNX, and TNX) have rarely been observed in the field at the few sites where analyses have been conducted for them (Brannon and Pennington, 2002). Many of these intermediates are observed only transiently due to their susceptibility to rapid mineralization, typically persisting only on the scale of several hours to several days. Significant observations of the final end-products are also not expected. Hydrazines, dimethylhydrazines, and methanol are not likely to accumulate in the environment, particularly at the low concentrations they would be produced as end-products, because these compounds very rapidly biodegrade. Therefore, the observation of intermediate and end-products of RDX biodegradation (DNX, MNX, and TNX), even at low concentrations, would be considered strong presumptive evidence of active and ongoing degradation processes.

The 2,4,6-TNT degradation intermediaries 2ADNT and 4ADNT have been detected with regularity at monitoring wells 54MW10, 54MW12, and 54MW13; the exception being the fourteenth quarter when 4ADNT went undetected in monitoring wells 54MW12 and 54MW13.

Analysis of the historic and recent data for monitoring wells 54MW10, 54MW12, and 54MW13 shows a correlation in 2,4,6-TNT concentration spikes with increasing concentrations of both 2ADNT and 4ADNT, indicating a limited transformation process from 2,4,6-TNT (**Figures 5-10** through **5-12**, respectively). 2,4,6-TNT degradation leading to amino-DNTs is likely occurring at localized zones within the soil matrix where the conditions are more favorable.

Perchlorate

Site-wide perchlorate levels have typically been steady and below the RG with the exception of the concentrations detected at 54MW12 during the fourth and eighth quarters. These spikes were reported as correlating with peaks in 2,4,6-TNT concentration. During the year four monitoring event, monitoring well 54MW12 continued to exhibit the highest concentrations, with the exception of the sixteenth quarter when the greatest values were detected at monitoring well 54MW10.

A summary of these results are provided in Table 6-1.

5.7 Lab Analysis, Data Validation, and Usability

The RFAAP, VA LTM Year 4 sampling effort was collected, quarterly, in September 2015, January 2016, April 2016 and July 2016. 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 pH	Explosives	Metals	TOC TIC COD	Chlorate Chlorite Perchlorates
September-October 2015	114433 114422 114475	GW	X	X	X	X	X	X	X
January 2016	116426 116448 116472 116508 116524	GW	X	X	X	X	X	X	X
April 2016	118236 118280 118319	GW	X	X	X	X	X	X	X
July 2016	120379 120408 120462 120518	GW	X	X	X	X	X	X	X

Notes:
COD = chemical oxygen demand
TIC = total inorganic carbon
TOC = total organic carbon
VOCs = volatile organic compounds

Analytical methods were as shown 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
pH	pH	USEPA SW-846 Method 9040
Explosives	Numerous	USEPA SW-846 Method 8330B
Metals	Numerous	USEPA SW-846 Method 6010C USEPA SW-846 Method 7470A (Mercury)
TOC / TIC	TIC TOC	USEPA SW-846 Method 9060A
COD	COD	USEPA SW-846 Method 410.4
Chlorate / Chlorite	Chlorate Chlorite	USEPA SW-846 Method 300.1
Perchlorates	Perchlorates	USEPA SW-846 Method 6850

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; this lab then repacked samples as necessary and shipped to the subcontractor labs (SGS Accutest in Orlando, Florida; Microbac Laboratories in Marietta, Ohio; Summit Environmental Technologies in Cuyahoga Falls, Ohio; and Eurofins/Eaton Analytical in South Bend, Indiana).

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

The analytic data was reviewed for consistency with the test methods as noted in Table 2 and the Project QAPP (RFAAP, VA – 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, 2014a); National Functional Guidelines for Superfund Organic Methods Data Review (USEPA, 2014b); 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 these exceptions:

- Nitrate analysis on the September 2015 samples was not performed within 48 hours of collection and sample results were qualified as non-detect estimated (UJ) or estimated (J).
- Two samples were analyzed for pH in the July 2016 event. The holding time for pH analysis is considered a field test parameter and should be analyzed immediately. Any analysis performed at a laboratory is considered outside of method criteria; therefore, analysis will be considered estimated (J).

5.7.1 Precision

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

Field Duplicates

FDs 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
(Sept 2015)	No exceedances		
(Jan 2016)	No exceedances		
(April 2016) 48MW06	TOC	J	>20%
(July 2016) 48MW6	1,1,1-Trichlorethane	J	>20%
(July 2016) 48MW6	cis-1,2-Dichloroethene	J	>20%
(July 2016) 50MW02	1,4-Dioxane	J	>20%
(July 2016) 50MW02	Methane	J	>20%

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

Table 5-13 Laboratory Duplicate Precision Exceedances

Sample/Method	Analyte	Flag	RPD
(Sept 2015) ADW01	Chromium	J	High
(Sept 2015) 54MW12	TIC/TOC	J	High
(Jan 2016) 54ADW01	Iron	J	High
(Jan 2016) 54MW12	TIC/TOC	J	High
(Jan 2016) 48MW02	TIC/TOC	J	High
(April 2016) 49ADW01	Manganese	J	High
(April 2016) 48MW3	TIC/TOC	J	High
(July 2016)	No exceedances		

Laboratory Control Sample and Duplicate, and Matrix Spike and Duplicate RPD

One LCS/LCSD was analyzed for each batch of 20 samples or fewer for some methods. There were no LCS/LCSD RPD exceedances.

MS/MSD analyses were run at a frequency of 5% of field samples. Most results were within control limits. There were three MS/MSD RPD exceedances.

Table 5-14 presents LCS/LCSD and MS/MSD recoveries outside control limits.

Table 5-14 LCS/LCSD and MS/MSD RPD Exceedances

Sample ID	Method	Analyte	RPD	Flag	Samples Affected
(Sept 2015) 54MW12	Explosives	Most analytes	>20%	Detections: J	54MW12 (Sept 2015)
(Jan 2016) 48MW2	VOCs	1,1,2,2-Tetrachloroethane EDB 1,4-Dioxane MEK 2-Hexanone MIBK Acetone Bromodichloromethane Bromomethane Methyl acetate trans-1,3-Dichloropropene	>20%	Detections: J	48MW2 (Jan 2016)
(Jan 2016) 54ADW01	Metals	Manganese	>20%	J	54ADW01 (Jan 2016)
(April 2016)	No exceedances				
(July 2016)	No exceedances				

5.7.2 Accuracy

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

Laboratory Control Sample and Duplicate and Matrix Spike and Duplicate Recovery

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

Most recoveries were within control limits. **Table 5-15** lists the LCS/LCSD recovery exceedances.

Table 5-15 LCS/LCSD Recovery Exceedances

Method	Analyte	Flag	Qualified Samples
(July 2016) Explosives	2-animo-4,6-Dintrotoluene	J+	Same extraction batch

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
(Sept 2015) 54MW12	Most explosives	Low	J / UJ
(Sept 2015) 54MW12	Perchlorate	Low	J
(Sept 2015) ADW01	Chromium	High	J
(Sept 2015) 13MW3	Sulfate	Low	J
(Sept 2015) 48MW2	TOC	Low	J
(Jan 2016) 48MW2	Bromomethane Trichlorofluoromethane Ethylbenzene	High	UJ UJ UJ
(Jan 2016) 54MW12	Perchlorate	High / Low	J
(Jan 2016) 54ADW01	Aluminum Cadmium Chromium Cobalt Iron Lead Manganese Nickel Silver Thallium Vanadium Zinc	High	J / UJ
(Jan 2016) 54MW10	Chloride	112%	J
(April 2016) 54MW12	Explosives	High	J
(April 2016) 49ADW01	Perchlorate	Low	J
(April 2016) 49ADW01	Antimony Arsenic Barium Copper Selenium	High	J / UJ
(April 2016) 48MW3	Chloride	High	J
(April 2016) 49MW01	Chloride Nitrate		J
(April 2016) 54MW12	Sulfate	Low	J / UJ
(April 2016) 54MW12	Chlorite	Low	UJ
(July 2016) 48MW2	1,4-Dioxane	High	J

Table 5-16 MS/MSD Recovery Exceedances (Continued)

Sample ID	Analyte	Recovery	Parent Flag
(July 2016) 48MW6	1,4-Dioxane Bromoform Chloromethane cis-1,2-Dichloroethene Trichloroethene	High	J
(July 2016) 49ADW01	Mercury	Low	J
(July 2016) 48MW1	Chloride	High	J
(July 2016) 54MW12	m-Nitrotoluene	Low	UJ
(July 2016) 54MW12	Perchlorate	Low	J
(July 2016) 54ADW01	Arsenic	High	None
(July 2016) 54MW12	Chloride	Low	J-
(July 2016) 54MW12	Chlorite Chlorate	Low	UJ

Notes:
ID = identification
LCL = lower control limit
UCL = upper control limit

Surrogates

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

Table 5-17 Surrogate Recovery Exceedances

Method	Sample ID	Surrogate	Recovery	Qualifiers
Explosives	54MW10 (Sept 2015)	1, 2-Dinitrobenzene	Low	UJ/J
Explosives	54MW13 (Sept 2015)	1, 2-Dinitrobenzene	Low	UJ/J
Explosives	54MW12 (Jan 2016)	1, 2-Dinitrobenzene	Low	UJ/J
Explosives	All samples (April 2016)	1, 2-Dinitrobenzene	Low/high	UJ/J

Notes:
ID = Identification Number
LCL = Lower Control Limit
UCL = Upper Control Limit

Internal Standards

There were no internal standards outside control limits.

Continuing 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
Sept 2015	VOCs	Methyl acetate Bromomethane	CCV low	Analytical batch	UJ
Jan 2016	VOCs	Bromomethane	2nd Source low	Analytical batch	UJ
	VOCs	Bromomethane Dichlorofluoromethane Dichlorodifluoromethane	CCV low	Analytical batch	UJ
	Metals	Various	CCV high / low	Analytical batch	J / UJ
	TOC/TIC	TIC TOC	CCV high / low	Analytical batch	J / UJ

5.7.3 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.

5.7.4 Comparability

Comparability was acceptable. Standard analytical methods were used. Standard preparatory and analytical methods were applied to the samples across sampling events.

5.7.5 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.

5.7.6 Sensitivity

Sensitivity was measured by evaluating whether the practical quantitation level (PQL) was less than the regulatory criteria. All nominal PQLs were below the regulatory criteria.

Additionally, sensitivity was evaluated by determining whether method blank and trip 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 Equipment [Rinse])

Calibration blanks were analyzed throughout analytical runs.

One method blank (MB) 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).

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
Sept 2015	ICB	Dissolved gases	Methane	Instrument batch	B
	Trip	VOCs	Acetone	Same collection date	B
	Rinsate	Anions	Nitrate	49MW02	B
Jan 2016	ICB	Dissolved gases	Methane	Instrument batch	B
	Method	Metals	Silver	Prep batch	B
	Method	Metals	Selenium	Prep batch	B
	Rinsate	Anions	Nitrate	13MW3 54MW12 48MW3 49TM01 50MW01	B
	Rinsate	Anions	Chloride	13MW2 48MW06 49MW01 49MW03 49MW05 50MW02 54MW12	B
April 2016	ICB/CCB	Metals	Antimony Beryllium Copper Potassium Selenium Silver	Instrument batch	B
	Method	Metals	Calcium Copper Selenium	Prep batch	B
July 2016	Trip	VOCs	1,4-Dioxane	Same collection date	B
	Rinsate	VOCs	Chloromethane Styrene Toluene	Same collection date	B
	Rinsate	TIC/TOC	TIC TOC	Same collection date	B

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: Lynn K. Lutz, HDR Inc.

Figure 5-5 SWMU 54: 54MW1 Explosives Concentrations Q1 through Q16

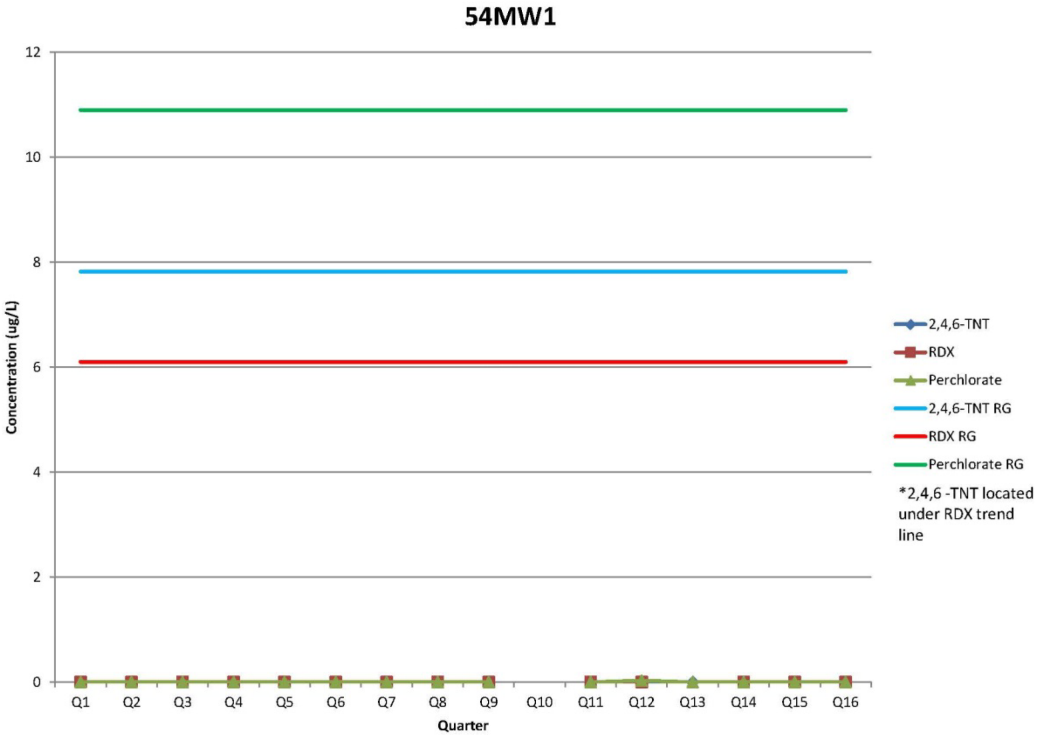


Figure 5-6 SWMU 54: 54MW10 Explosives Concentrations Q1 through Q16

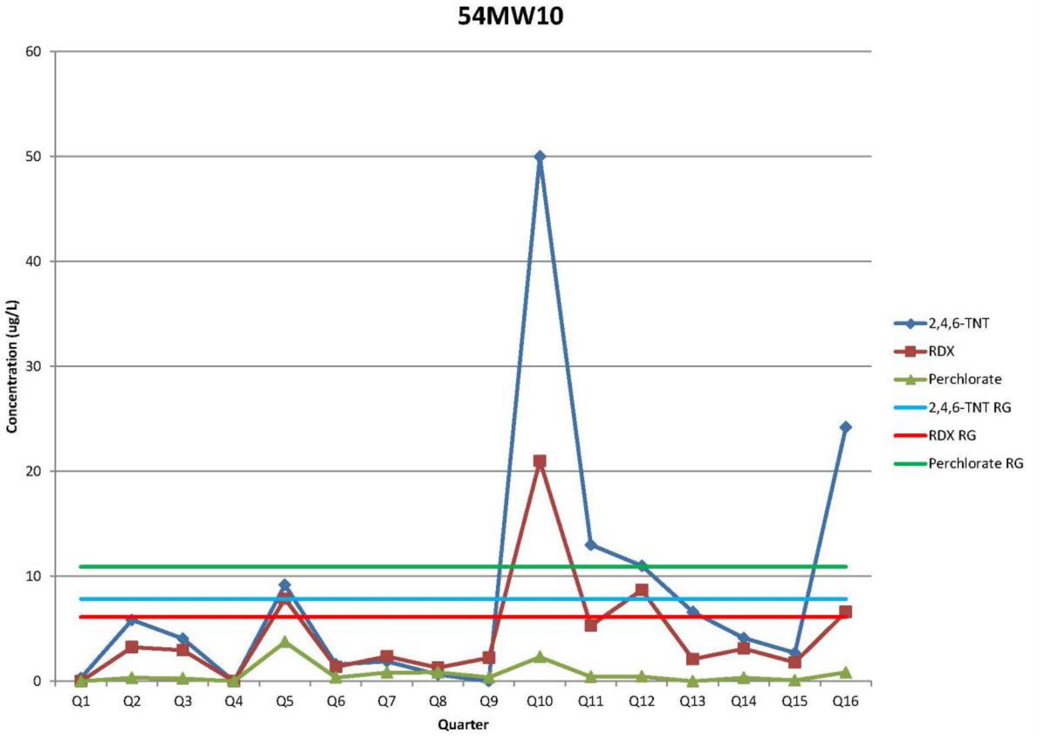


Figure 5-7 SWMU54: 54MW12 Explosives Concentrations Q1 through Q16

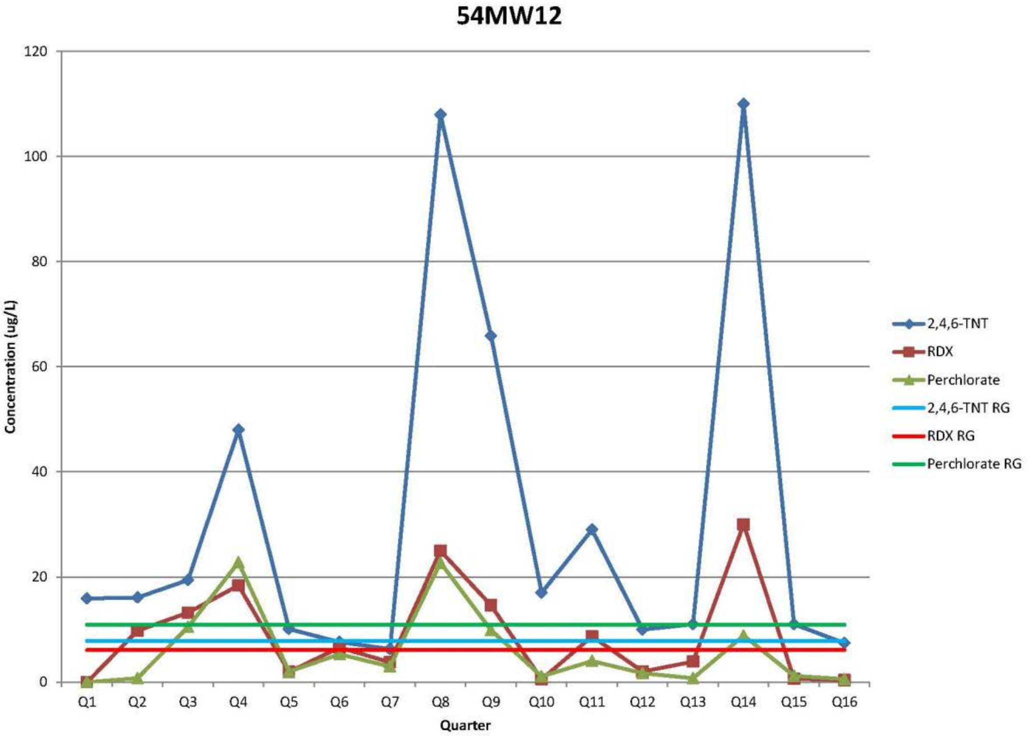


Figure 5-8 SWMU 54: 54MW13. Explosives Concentrations Q1 through Q16

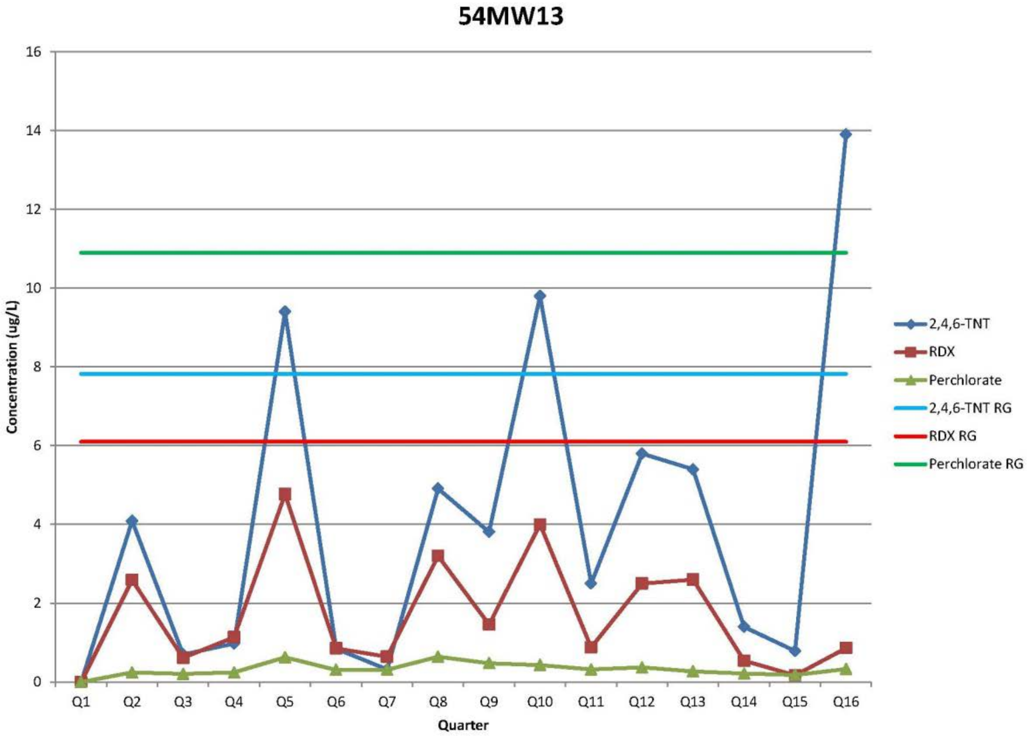


Figure 5-9 SWMU 54: 54MW1 2,4,6-TNT to Amino-DNT Correlation

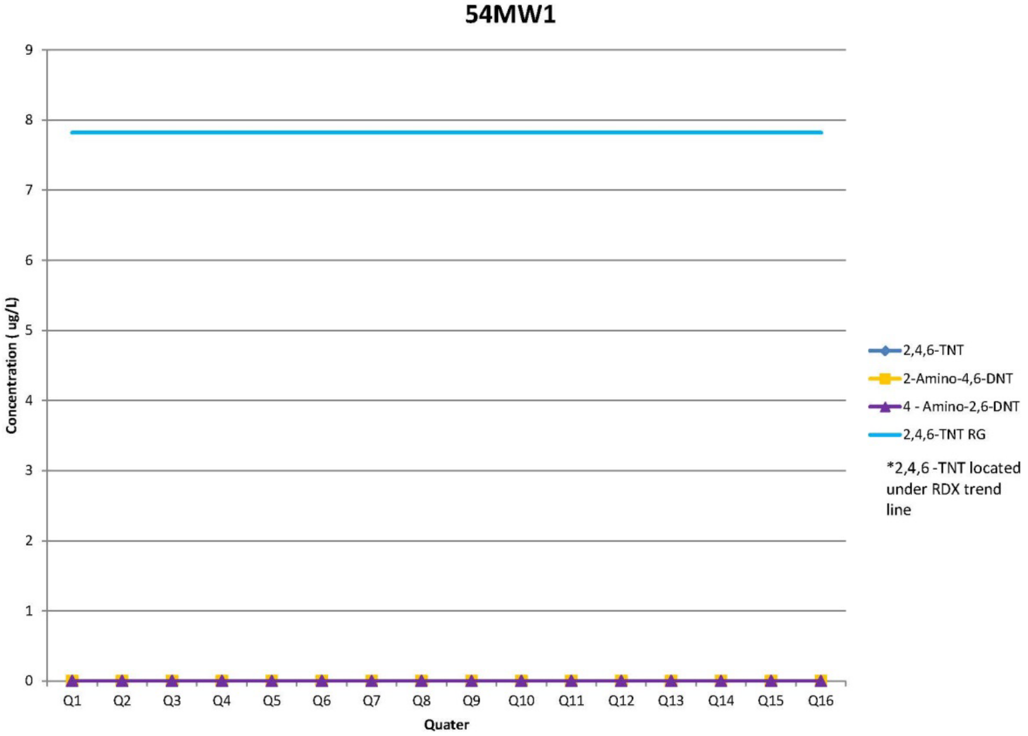


Figure 5-10 SWMU 54: 54MW10 2,4,6-TNT to Amino-DNT Correlation

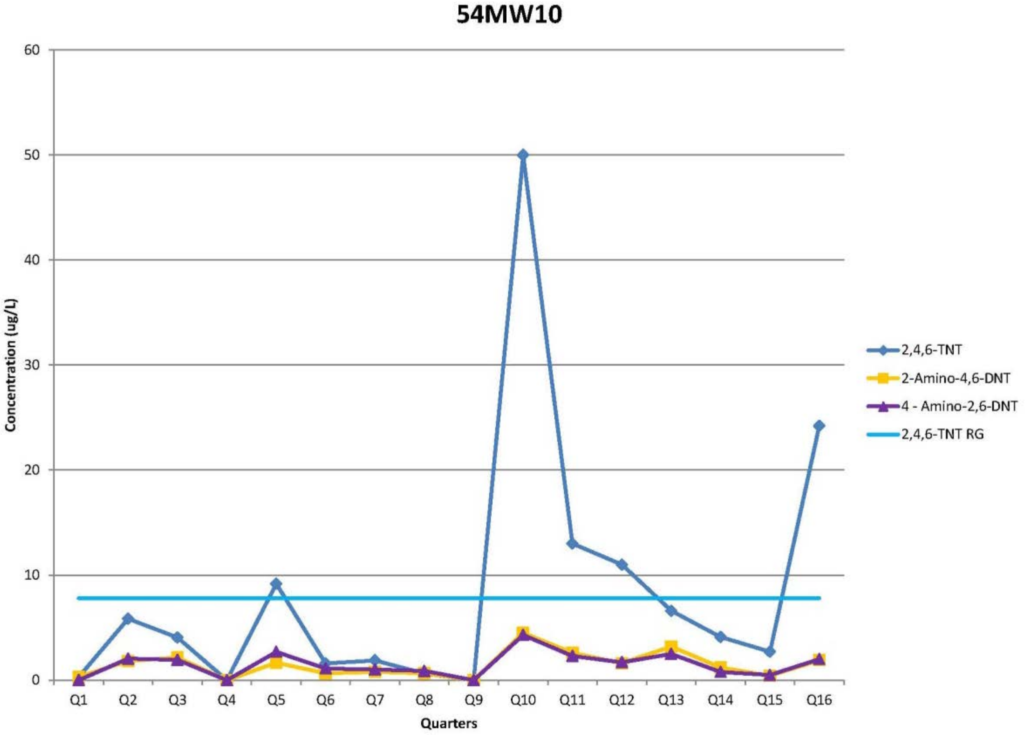


Figure 5-11 SWMU 54: 54MW12 2,4,6-TNT to Amino-DNT Correlation

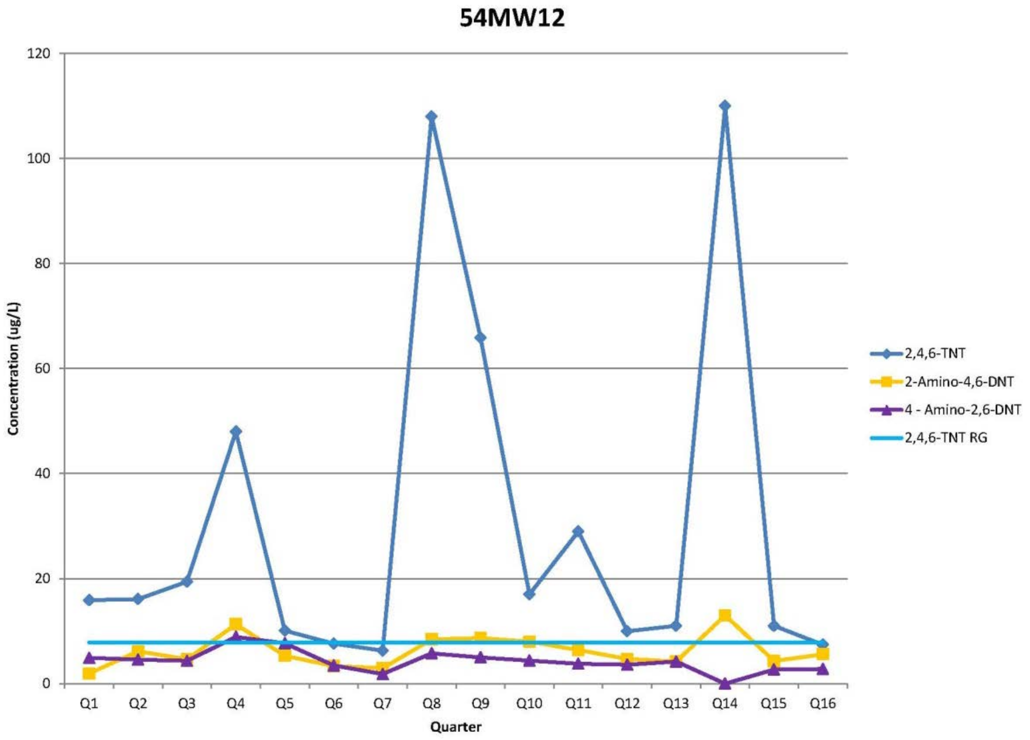
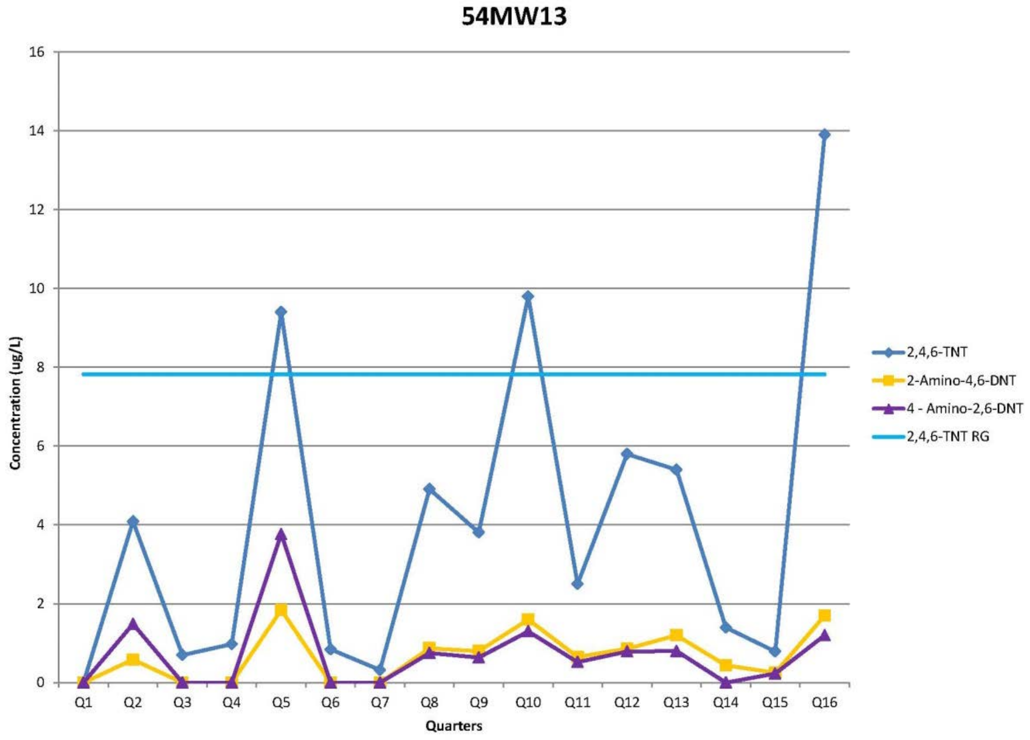


Figure 5-12 SWMU 54: 54MW13 2,4,6-TNT to Amino-DNT Correlation



6.0 MNA Evaluation of SWMU 54

MNA is a remedial approach in which physical, chemical, and biological processes occur under favorable conditions, without human interferences to reduce the mass, toxicity, volume, concentration, and mobility of contaminants in soil and groundwater. The physical, chemical, and biological processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization (USEPA, 1998). Analytical results from multiple groundwater sampling events at SWMU 54 were evaluated for qualitative indications of natural attenuation processes that may reduce the levels of nitroaromatics (specifically 2,4,6-TNT and RDX) and perchlorate (ClO4). The following sections present the results as they pertain to the lines of evidence used to demonstrate the potential for MNA.

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. SWMU 54 contains 14 wells (54MW1, 54MW2, 54MW3, 54MW4, 54MW5, 54MW6, 54MW7, 54MW8, 54MW9, 54MW10, 54MW11, 54MW12, 54MW13, and 54MW14), which targeted areas of potential nitroaromatic and perchlorate contamination. The target wells were reduced after the ninth and tenth quarters to 54MW1 (background), 54MW10, 54MW12, and 54MW13. Historical trends and the results of quarterly groundwater sampling are discussed below, and the data is provided in **Table 6-1**.

2,4,6-TNT. Elevated concentrations of 2,4,6-TNT above the RG of 7.82 µg/L were observed in wells 54MW10, 54MW12, and 54MW13 during the year four monitoring period. Five detections at these wells exceeded the RG, including one at 54MW10 (quarter 16), three at 54MW12 (quarters 13, 14, and 15), and one at 54MW13 (quarter 16).

2,4,6-TNT concentrations have fluctuated in these three wells during the sixteen quarterly monitoring events. At monitoring well 54MW10, the 2,4,6-TNT concentration went from undetected in quarter nine to the highest concentration recorded (50 µg/L in quarter 10) in this well during the four years of monitoring. The following five quarters of sampling (quarters 11 – 15) saw concentrations decline dramatically until a spike was observed during the sixteenth quarter. The concentration spike of 24.2 µg/L at 54MW10 exceeded the RG. Monitoring well 54MW12 also experienced the highest detected concentration of 2,4,6-TNT during the year four monitoring period when a concentration of 110 µg/L was detected during the fourteenth quarter. Otherwise, the concentrations detected in 54MW12 in the remaining quarters were similar to historic levels. Similarly, monitoring well 54MW13 experienced the highest detected concentration of 2,4,6-TNT during the year four monitoring period when a concentration of 13.9 µg/L was detected during the sixteenth quarter. Again, the concentrations detected in 54MW13 in the remaining quarters were similar to historic levels.

DNT Mixture. Previous reports noted that DNT was detected in the fourth, tenth, eleventh and twelfth quarters of sampling at monitoring wells 54MW10, 54MW12 and 54MW13, yet combined the concentrations of 2,4- DNT and 2,6-DNT did not exceed the RG of 0.932 µg/L. During year four, the combined concentrations of 2,4-DNT and 2,6-DNT did not exceed the method detection limit in any of the four wells sampled.

RDX. Elevated concentrations of RDX above the RG of 6.1 µg/L were observed in monitoring wells 54MW10 and 54MW12 during the year four monitoring period. RDX concentrations have fluctuated in these two wells during the sixteen quarterly sampling events. At monitoring well 54MW10, a sharp increase in RDX concentrations was observed from 2.23 µg/L in the ninth quarter to 21 µg/L in the tenth quarter. The tenth quarter observed concentration was the highest level reported in this well during the sixteen quarters of sampling. Concentrations decreased during the next six quarters of sampling (quarters 11 – 16), albeit the RG was exceeded during the twelfth and sixteenth quarters. Monitoring well 54MW12 had seven reported concentrations of RDX above the RG of 6.1 µg/L in the first twelve quarters of sampling. During the year four monitoring period, concentrations decreased dramatically to levels below the RG, with the exception of the fourteenth quarter which saw a spike to 30 µg/L. The detected concentration is the highest level observed at this well during all sixteen rounds of sampling. Regardless, the following two quarters revealed low concentrations of 0.62 µg/L (quarter fifteen) and 0.37 µg/L (quarter sixteen).

One RDX breakdown by-product (DNX) was detected once at monitoring well 54MW12 during the year four monitoring period. The detection (0.72 µg/L) was similar to historic concentrations observed at this well. Historically, RDX breakdown by-products (DNX, MNX, TNX) have been observed in monitoring wells 54MW10, 54MW12 and 54MW13. These detections were observed in quarters ten through twelve. The highest total concentrations were observed in monitoring well 54MW10 during the tenth quarter when a spike in the RDX occurred. Thereafter, the RDX by-products concentrations steadily decreased. Similar correlations with RDX concentrations were observed in monitoring well 54MW12 and 54MW13. The highest concentrations of DNX, MNX and TNX were identified in 54MW12 and 54MW13 during the eleventh and tenth quarters, respectively, which coincides with the highest RDX concentrations recorded in these wells during that time period.

Amino DNT. As 2,4,6-TNT is biologically degraded, the two daughter products 2ADNT and 4ADNT are formed. The by-product 2ADNT was detected in monitoring wells 54MW10, 54MW12, and 54MW13 during all four quarters (quarters 13 – 16) during the year four monitoring period. This is generally in agreement with the earlier quarterly monitoring results. The by-product 4ADNT was detected in all three monitoring wells with the exception of 54MW12 and 54MW13 during the fourteenth quarter. There is good correlation of 2ADNT and 4ADNT concentrations with 2,4,6-TNT levels; that is, as 2,4,6-TNT concentrations increase or decrease, a corresponding increase or decrease of 2ADNT and 4ADNT is observed. The presence of 2ADNT and 4ADNT along with the decreasing concentrations of 2,4,6-TNT continue to suggest biological degradation of 2,4,6-TNT is occurring at these locations.

Perchlorate. Perchlorate levels at monitoring wells 54MW10 and 54MW13 continued to remain well below the RG of 10.9 µg/L during year four of monitoring and consistent with levels observed through the first three years of monitoring. Monitoring well 54MW12 continued to have the highest observed concentrations of perchlorate at SWMU 54 during year four of monitoring, but at levels below the RG. Concentrations continued to decrease during the year four monitoring; this trend first was observed after the ninth quarterly sample event. However, one exception was observed during the fourteenth quarter when the concentration spiked to 8.85 µg/L. The fifteenth and sixteenth quarters saw a return to lower concentrations and a decreasing trend in perchlorate concentrations. Historically, monitoring well 54MW12 has had two detected concentrations above the RG: the first in the fourth quarter sample event and again in the eighth quarter.

Chloride, chlorate, and chlorite are daughter products of perchlorate degradation. At SWMU 54, chloride is present within the groundwater system, including monitoring well 54MW1 (background). Based on the chloride background levels through year three of monitoring, a determination that any measureable change due to perchlorate reduction could not be established. However, while chloride was detected at monitoring well 54MW1 during all of the year four monitoring events, the concentrations detected at wells 54MW10, 54MW12, and 54MW13 during the same period were all slightly higher. Samples collected for chlorate and chlorite from all wells during the year four monitoring period did not detect measurable concentrations above the MDL. This may suggest that chlorate and chlorite have been exhausted in the system and only residual levels of chloride are being produced as perchlorate levels diminish.

The time series plots (**Figures 5-7** and **5-8**) show a large degree of variability in 2,4,6-TNT concentrations in wells 54MW12 and 54MW13. As such, Mann-Kendall tests were run for both monitoring wells. The results indicated no trend in 54MW12, while 2,4,6-TNT concentrations were probably increasing in monitoring well 54MW13. While the 2,4,6-TNT concentrations have shown variability over time, the first line of evidence indicates that the presence of daughter products, 2ADNT and 4ADNT, suggest that natural attenuation via biological degradation of 2,4,6-TNT is occurring at SWMU 54. In addition, the identification of RDX daughter product, DNX, in the monitoring well 54MW12 with RDX detections indicate active degradation of RDX. Overall decreasing trends in RDX and perchlorate and the identification of intermediate by-products suggest natural attenuation of RDX and perchlorate is occurring.

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Table 6-1 Analytical Results for Groundwater Performance Monitoring at SWMU 54

Parameter	Remediation Goal (RG)	July 2011 (Q1)	October 2011 (Q2)	January 2012 (Q3)	April 2012 (Q4)	August 2012 (Q5)	November 2012 (Q6)	February 2013 (Q7)	May 2013 (Q8)	August 2013 (Q9)	November 2013 (Q10)	February 2014 (Q11)	May 2014 (Q12)	September 2015 (Q13)	January 2016 (Q14)	April 2016 (Q15)	July 2016 (Q16)
54MW1																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND
Perchlorate	**10.9**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND
54MW2																	
2,4,6-TNT	**7.82**	2.1	0.9	2.08	2.66	ND	ND	ND	0.749	0.974	0.46	--	--	--	--	--	--
RDX	**6.1**	0.572	ND	ND	0.384	ND	ND	ND	ND	ND	0.075	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--
Perchlorate	**10.9**	3.07	0.547	1.91	4.02	ND	0.842	1.41	1.82	1	0.26	--	--	--	--	--	--
54MW3																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
Perchlorate	**10.9**	0.53	0.18	ND	ND	0.405	0.303	0.309	0.59	0.446	--	--	--	--	--	--	--
54MW4																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	--	--	--	--
Perchlorate	**10.9**	ND	ND	ND	ND	ND	0.141	ND	ND	ND	-	-	-	--	--	--	--
54MW5																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
Perchlorate	**10.9**	0.311	0.393	0.313	0.301	0.42	0.28	0.255	0.309	0.389	--	--	--	--	--	--	--
54MW6																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	Dry	ND	ND	Dry	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	Dry	ND	ND	Dry	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	Dry	ND	ND	Dry	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	0.127	0.159	ND	0.175	Dry	0.16	0.171	Dry	--	--	--	--	--	--	--
54MW7																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
Perchlorate	**10.9**	0.321	ND	ND	0.365	ND	0.103	0.162	0.103	0.37	--	--	--	--	--	--	--
54MW8																	
2,4,6-TNT	**7.82**	0.928	0.433	ND	0.301	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
RDX	**6.1**	0.761	0.567	0.493	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	0.408	0.355	0.388	0.392	0.286	0.484	0.118	0.334	--	--	--	--	--	--	--
54MW9																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	0.229	0.262	0.217	ND	ND	1.07	0.923	0.327	--	--	--	--	--	--	--
54MW10																	
2,4,6-TNT	**7.82**	0.305	5.84	4.05	ND	**9.17**	1.59	1.88	0.637	ND	**50**	**13**	**11**	6.6	4.1	2.7	**24.2**
RDX	**6.1**	ND	3.24	2.95	ND	**7.84**	1.35	2.36	1.29	2.23	**21**	5.3	**8.7**	2.1	3.1	1.8	**6.6**
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	0.068	0.13	ND	ND	ND	ND
Perchlorate	**10.9**	ND	0.325	0.258	ND	3.74	0.344	0.832	0.835	0.365	2.3	0.42	0.44	ND	0.326	0.082	.84

Table 6-1 Analytical Results for Groundwater Performance Monitoring at SWMU 54 (Continued)

Parameter	Remediation Goal (RG)	July 2011 (Q1)	October 2011 (Q2)	January 2012 (Q3)	April 2012 (Q4)	August 2012 (Q5)	November 2012 (Q6)	February 2013 (Q7)	May 2013 (Q8)	August 2013 (Q9)	November 2013 (Q10)	February 2014 (Q11)	May 2014 (Q12)	September 2015 (Q13)	January 2016 (Q14)	April 2016 (Q15)	July 2016 (Q16)
54MW11																	
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	ND	0.239	ND	ND	ND	0.263	0.43	0.132	--	--	--	--	--	--	--
54MW12																	
2,4,6-TNT	**7.82**	**15.9**	**16.1**	**19.4**	**48**	**10.1**	7.62	6.29	**108**	**65.9**	**17**	**29**	**10**	**11**	**110**	**11**	7.4
RDX	**6.1**	ND	**9.77**	**13.2**	**18.4**	1.95	**6.59**	3.79	**25**	**14.6**	0.54	**8.7**	2	3.9	**30**	0.62	.37
DNT Mixture	**0.932**	ND	ND	ND	0.381	ND	ND	ND	ND	ND	0.2	0.31	0.93	ND	ND	ND	ND
Perchlorate	**10.9**	ND	0.726	10.5	**22.8**	2	5.31	2.98	**22.7**	9.88	1.1	4	1.7	0.737	8.85	1.2	.56
54MW13																	
2,4,6-TNT	**7.82**	ND	4.09	0.699	0.979	**9.4**	0.843	0.318	4.91	3.81	**9.8**	2.5	5.8	5.4	1.4	0.79	**13.9**
RDX	**6.1**	ND	2.59	0.614	1.14	4.77	0.855	0.642	3.2	1.46	4	0.88	2.5	2.6	0.54	0.17	.86
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.11	ND	0.099	ND	ND	ND	ND
Perchlorate	**10.9**	ND	0.244	0.206	0.243	0.627	0.308	0.313	0.64	0.477	0.43	0.32	0.37	0.270	0.216	0.18	.33
54MW14																	
2,4,6-TNT	**7.82**	0.928	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--
RDX	**6.1**	0.761	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--
Perchlorate	**10.9**	ND	ND	0.215	0.181	0.214	0.24	ND	ND	0.195	0.456	--	--	--	--	--	--

6.2 Second Line of Evidence: Geochemical Conditions

Respiratory substrates are used preferentially during microbial metabolism based on the amount of energy that can be derived from each of them. Respiratory substrates are used in the following order:

$$O_2 > NO_3^- > Fe^{+3} > ClO_4 > SO_4^{-2} > CO_2$$

Geochemical data is available for all sixteen quarterly groundwater monitoring events at SWMU 54. Field parameters (DO, ORP, pH, temperature, and conductivity) have been collected since 2011 as part of the low-flow sampling procedures. Laboratory analysis for nitrate, sulfate, and TOC were conducted for all sixteen quarterly groundwater monitoring events at SWMU 54. These geochemical data are discussed regarding the potential for biodegradation in the groundwater at SWMU 54.

The microbial degradation of nitro-aromatic compounds primarily occurs under nitrate-reducing conditions, whereas perchlorate requires sulfate reducing groundwater conditions.

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 supportive 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 first twelve quarterly monitoring events (early 2011 to May 2014) ranged from 0.0 to 7.81 mg/L indicating both anaerobic and aerobic conditions were present at the site. During the year four monitoring period DO values ranged from 0.37 mg/L to 6.86 mg/L. Wells where biological degradation products were observed (54MW10, 54MW12, and 54MW13), DO levels (between 0.37 and 6.86 mg/L) indicate a flux between anaerobic and aerobic conditions, although aerobic conditions appear to be favored (**Table 6-2**). TNT has been known to be reduced under a variety of conditions (aerobic and anaerobic); however, further reduction of TNT breakdown products, including 2ADNT and 4ADNT, and reduction of RDX and perchlorate is more favorable under anaerobic conditions (Spain, 1995).

The sharp increase in explosive concentrations at 54MW10 and 54MW12 during the fourteenth quarter took place under aerobic conditions at these wells. Under aerobic conditions, biodegradation is not as effective in the reduction of explosives and perchlorates. As a result of the subsurface biochemistry, the decreased biological activity may have led to an increase in the explosives and perchlorate concentrations during this period. This trend was also noticed during the ninth and tenth quarterly monitoring events.

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. As mentioned previously, TNT reduction can occur in aerobic systems, but the reduction of TNT breakdown products, RDX, and perchlorate are favored under anaerobic conditions (generally observed when ORP values are between -100 mV and 0 mV).

ORP levels during the first twelve quarterly sampling events (early 2011 to May 2014) ranged from -33 to 297 mV indicating both anaerobic and aerobic conditions were present at the site. However, it was reported that aerobic conditions appeared to be more prevalent (**Table 6-2**). Further, the year three ORP values and DO readings did not show a clear corresponding trend for samples taken at the same well and same sampling event. At monitoring wells with elevated concentrations of TNT and RDX (54MW10, 54MW12 and 54MW13), it was suggested that ORP readings were in agreement with DO levels, indicating aerobic conditions.

The year four ORP readings ranged from -10.1 mV to 264 mV indicating that both anaerobic and aerobic conditions were present at SWMU 54. However, there was only one reading (at 54MW1 in quarter 16) indicating reducing conditions; as such, it would appear that aerobic conditions are more prevalent at the SWMU. The year four ORP trends are generally in agreement with year three.

pH. The pH for optimum microbial activity ranges from 5 to 9 standard units. Microbial activity may decrease at lower pH values. The first three years of pH data are within this optimal pH range (**Table 6-2**) and continued during year four. In general, the pH environment at SWMU 54 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 nitroaromatics (including 2,4,6-TNT) forming breakdown by-products. However, it should be noted that elevated nitrate levels (>1 mg/L) will inhibit perchlorate reduction (IRTC, 2008).

Nitrate levels during the twelve sampling events were generally low (overall < 1 mg/L) with concentrations ranging from non-detect to 4.8 mg/L, suggesting that perchlorate reduction is not inhibited (**Table 6-2**). This trend was continued during the year four monitoring period where 14 of 16 nitrate concentrations were well below 1 mg/L and nitrate levels ranged from non-detect to 2.5 mg/L.

Monitoring well 54MW12, where the highest and more persistent perchlorate concentrations have been identified, consistently had nitrate levels greater than 1 mg/L during the first twelve quarters of monitoring and again during the year four monitoring period. It was reported that this may indicate perchlorate degradation may be limited at this well. In contrast, the reduction of 2,4,6-TNT concentrations and corresponding levels of 2ADNT and 4ADNT present suggest the biodegradation of TNT. The trends for both perchlorate and 2,4,6-TNT continued into the year four monitoring period.

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 TNT is favored in nitrate-reducing conditions and therefore, elevated levels of ferrous iron are an indicator of favorable groundwater conditions for TNT degradation. However, the degradation of TNT breakdown products, 2ADNT and 4ADNT, RDX, and perchlorate are favored in iron-reducing conditions. Ferrous iron concentrations for all wells during the four years of monitoring have been less than 0.2 mg/L (non- detect) or equal to 0.2 mg/L indicating that iron-reducing conditions are not present at this time, or that the iron has been reduced previously.

Sulfate. Biological degradation of TNT breakdown products, 2ADNT and 4ADNT, RDX, and perchlorate actively occurs under sulfate-reducing conditions. Sulfate levels greater than 20 µg/L may cause competitive exclusion (USEPA, 2008). Sulfate concentrations were measured in the groundwater during each of the first twelve quarterly monitoring events and were found to generally be greater than 20 mg/L (ranging from 15.0 to 403 mg/L), indicating that biological degradation of 2ADNT and 4ADNT may be inhibited at SWMU 54 (**Table 6-2**). During the fourth year of monitoring, sulfate concentrations were slightly lower (ranging from 19 to 93 mg/L), but again suggest inhibition of biological degradation of the 2,4,6-TNT by-products 2ADNT and 4ADNT.

Total Organic Carbon (TOC). Organic carbon is a required source of reduced carbon and energy needed to sustain microbial degradation of nitroaromatics and perchlorate. TOC concentrations greater than 20 mg/L are considered adequate to support microbial activity. For the majority of the first three years of monitoring, TOC levels were found to be considerably lower than what is consider adequate to support microbial activity. TOC levels during this time frame ranged from less than 0.50 (non-detect) to 7.47 mg/L (**Table 6-2**). However, measured TOC concentrations during the twelfth quarter exceeded 20 mg/L in monitoring wells 54MW1 (51.0 mg/L) and 54MW10 (63.0 mg/L). The year four TOC results, however, again indicated low levels considered inadequate to support microbial activity. The range of TOC during the year four monitoring period ranged from 0.3 mg/L to 8.9 mg/L.

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 First Quarter (July 2011) Water Quality Parameters														
pH	7.7	6.36	6.86	7.19	6.36	7.33	6.6	6.98	6.29	7.13	7.14	6.67	6.75	7.23
Conductivity (mS/cm)	0.357	0.526	0.491	0.949	0.371	0.449	0.419	0.544	0.535	1.68	0.651	0.568	0.676	0.582
Turbidity (NTU)	5.6	0	1.5	1.9	3	0.2	0	4.6	6	89.8	62.6	100	94	16.9
Dissolved Oxygen (mg/L)	4.86	2.35	4.71	0	4.87	0.68	3.91	3.53	1.23	0.51	0	3.52	0.9	1.06
ORP (mV)	130	178	121	-18	178	110	170	134	198	67	96	152	29	73
Temperature (°C)	14.12	17.07	19.82	15.52	19.88	19.32	18.87	17.86	14.3	25.19	14.94	18.38	20.09	23.76
Dissolved Manganese	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	0.2	<0.05	0.05	<0.05	0.65	<0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	25.2	1.09	0.967	0	0.613	0	0.119	0.639	0.233	0	0	2.79	0.439	0.242
Sulfate (mg/L)	27.1	39.8	23.6	329	15.1	27.4	61.5	40	62.2	167	93.6	38.1	38.8	33.6
TOC (mg/L)	3.9	3.51	7.26	2.51	6.14	1.95	3.17	6.05	5.1	1.61	5.97	2.64	2.55	6.73
SWMU 54 Second Quarter (October 2011) Water Quality Parameters														
pH	7.49	7.02	7.05	7.27	6.78	7.49	7.3	7.09	7.2	6.83	7.31	6.7	7.05	7.16
Conductivity (mS/cm)	0.432	0.56	0.674	0.912	0.502	0.305	0.734	0.541	0.562	0.677	0.654	0.523	0.831	0.568
Turbidity (NTU)	164	167	160	81.1	231	107	155	104	79.9	236	685	69	--	157
Dissolved Oxygen (mg/L)	0	0	0	2.44	2.68	3.8	0.1	0.05	0.06	0	0	1.72	0.37	0
ORP (mV)	102	117	107	-15	143	122	66	151	146	82	-13	144	126	73
Temperature (°C)	18.04	14.77	14.16	14.32	15.48	13.18	18.01	14.94	14.75	14.75	13.73	14.81	14.63	14.93
Dissolved Manganese (mg/L)	<0.05	<0.05	0.1	0.05	0.1	0.05	0.4	0.05	0.2	0.15	0.3	<0.05	0.35	0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0	0.394	0.357	0	0.568	0.167	0	0.514	0.184	0.388	0	2	0.21	0.202
Sulfate (mg/L)	27.1	27	44.4	210	17.4	7.06	216	39.9	46.9	96.7	119	31.8	90.2	34.1
TOC (mg/L)	3.9	3.2	3.22	1.38	1.88	2.68	1.31	7.47	6.78	6.98	3.22	4.71	3.31	4.64
SWMU 54 Third Quarter (January 2011) Water Quality Parameters														
pH	7.59	7.48	7.4	7.36	7.15	7.53	7.43	7.08	7.4	7.46	7.59	6.09	7.45	7.48
Conductivity (mS/cm)	0.498	0.662	0.762	1.11	0.628	0.305	0.905	0.492	0.674	0.707	0.763	0.595	0.687	0.651
Turbidity (NTU)	8.9	15.3	19.2	55.6	32.1	72.4	26.8	66.7	36.8	1.1	6.8	---	226	0
Dissolved Oxygen (mg/L)	0	0	0	0	7.81	12.01	0	16.65	8.48	6.06	5.09	4.02	7.63	1.66
ORP (mV)	100	33	24	5	121	191	3	104	111	118	101	186	25	61
Temperature (°C)	13.2	13.91	13.26	13.04	13.58	11.93	12.73	9.72	9.65	11.16	11.4	12.86	11.53	12.91
Dissolved Manganese (mg/L)	<0.05	<0.05	0.1	0.05	0.1	0.05	0.4	0.05	0.2	0.15	0.3	<0.05	0.35	0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0	0.609	0	0	0.578	0.158	0	0.401	0.174	0.572	0.158	1.94	0.237	0.241
Sulfate (mg/L)	26.3	28.2	73.7	480	20.3	4.55	249	41.5	62.5	72.7	93	37.6	53.9	32.2
TOC (mg/L)	2.1	1.8	2.39	1.16	1.42	1.94	2.38	1.66	2.78	1.66	6.71	5.09	6.63	1.68

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	**54MW1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
SWMU 54 Fourth Quarter (April 2012) Water Quality Parameters														
pH	5.42	5.19	5.38	5.33	4.99	5.76	5.57	5.38	5.46	5.48	5.59	5.05	5.32	5.5
Conductivity (mS/cm)	0.958	1.12	1.46	0.001	0.891	0.73	1.58	1.21	1.26	1.73	1.4	1.35	0.981	1.2
Turbidity (NTU)	2.5	4.4	2.4	125	70.1	318	38	3.4	65.3	30.8	94.7	37	312	36
Dissolved Oxygen (mg/L)	7.36	7.18	2.24	23.45	10.47	6.49	2.01	7.43	11.29	2.83	5.8	9.44	7.1	5.55
ORP (mV)	-30	236	225	180	168	132	162	134	145	61	36	267	116	149
Temperature (°C)	13.37	12.44	12.02	11.56	20.98	19.09	12.57	14.69	14.21	15.5	14.11	12.67	15.52	12.69
Dissolved Manganese (mg/L)	<0.05	<0.05	0.1	0.5	<0.05	0.05	0.4	0.05	0.2	0.1	0.3	<0.05	0.35	<0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0	1.33	0	0	0.677	0.129	0.231	0.483	0.139	0	0	2.65	0.294	0.386
Sulfate (mg/L)	34.9	34.9	80	432	14	14.9	69.4	40.1	56	221	104	37.9	35.4	29.3
TOC (mg/L)	1.8	1.57	1.18	1.82	2.33	5.46	0.99	2.36	3.01	2.4	2.68	2.34	3.51	1.09
SWMU 54 Fifth Quarter (August 2012) Water Quality Parameters														
pH	7.08	6.94	6.71	7.05	6.71	7.47	7.03	6.87	6.84	6.71	7.06	6.61	6.97	7.05
Conductivity (mS/cm)	0.395	0.722	0.644	0.968	0.58	0.363	0.817	0.599	0.752	0.693	0.715	0.665	0.697	0.625
Turbidity (NTU)	4.1	43	19	14	23	0	7.4	19	5.2	0.8	10.8	48	95	9.2
Dissolved Oxygen (mg/L)	5.34	0	0	0.23	3.96	4.84	0	2.78	0.56	0.4	0	0.33	1.75	0
ORP (mV)	212	65	209	-33	200	134	128	125	-10	47	-22	226	135	-13
Temperature (°C)	13.89	13.49	12.93	15.06	13.44	16.52	13.66	13.7	14.09	13.93	13.64	13.71	16.12	14.08
Dissolved Manganese (mg/L)	<0.05	<0.05	0.05	0.05	<0.05	0.05	0.05	0.05	0.2	0.05	0.05	<0.05	0.3	<0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0.600	0.190	0.613	3.00	0.728	0.120	3.00	0.581	1.80	0.594	1.80	1.06	0.681	0.214
Sulfate (mg/L)	26.1	95.5	23.8	378	18.0	15.7	186	41.8	87.2	102	97.6	27.0	38.2	31.8
TOC (mg/L)	0.721	2.00	2.00	1.10	2.00	1.00	1.02	2.00	2.00	1.37	2.00	2.00	1.05	2.04
SWMU 54 Sixth Quarter (November 2012) Water Quality Parameters														
pH	7.63	7.21	6.97	7.03	6.99	Dry	7.31	7.23	7.23	7.29	7.28	7.6	5.72	7.3
Conductivity (mS/cm)	0.443	0.62	0.561	1.01	0.612	Dry	0.826	0.628	0.784	0.779	0.698	0.635	0.918	0.6
Turbidity (NTU)	2.9	11.4	0.2	17	5.5	Dry	46	3.9	27.7	4.7	2.5	2.4	35	43
Dissolved Oxygen (mg/L)	1.44	0.86	4.09	1	1.01	Dry	0.56	2.71	1.14	0.38	1.1	0.26	0.95	0.45
ORP (mV)	148	141	145	72	167	Dry	59	101	-28	43	117	135	209	100
Temperature (°C)	10.03	13.43	12.22	11.27	11.21	Dry	10.83	11.98	11.35	13.61	12.95	13.99	12.26	10.61
Dissolved Manganese (mg/L)	0.05	0.05	0.05	0.05	0.05	Dry	0.05	0.05	0.2	0.05	0.05	0.1	0.3	0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	Dry	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0.600	0.327	0.656	3.00	0.944	Dry	1.80	0.403	1.80	0.381	0.600	2.86	0.369	0.600
Sulfate (mg/L)	31.3	35.4	22.9	403	21.5	Dry	179	60.3	199	151	99.1	49.8	76.7	39.0
TOC (mg/L)	1.96	2.68	3.29	2.93	4.31	Dry	3.72	4.90	6.73	5.55	5.88	3.41	2.00	2.12

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Seventh Quarter (February 2013) Water Quality Parameters														
pH	7.85	6.89	6.76	7.52	6.56	7.08	7.4	7.03	7.04	6.69	7.09	6.36	6.96	7.45
Conductivity (mS/cm)	0.465	0.682	0.504	1.01	0.417	0.293	0.474	0.498	0.487	0.542	0.687	0.464	0.37	0.619
Turbidity (NTU)	0	20	9	16	0	44.3	16	9.2	10.9	13.2	2	14.2	6.8	1.2
Dissolved Oxygen (mg/L)	0.71	1.43	6.97	0.53	9.19	9.28	2.83	5.36	8.28	2.97	0.58	1.27	8.39	0.47
ORP (mV)	-5	156	171	-56	168	72	12	168	194	125	169	168	158	56
Temperature (°C)	12.17	8.28	11.98	12.09	11.18	13.15	11.48	9.89	9.74	11.22	10.14	10.31	7.98	12.26
Dissolved Manganese (mg/L)	0.05	<0.05	0.1	0.05	<0.05	0.05	0.1	0.05	0.2	0.1	0.25	<0.05	0.2	<0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0.600	0.315	0.423	3.00	0.636	0.209	0.205	0.336	0.510	0.477	0.346	1.95	0.501	0.600
Sulfate (mg/L)	27.1	36.8	25.3	340	15.5	4.29	34.2	44.6	117	70.1	120	35.8	23.1	41.1
TOC (mg/L)	1.19	0.916	1.07	1.35	1.00	1.50	0.791	1.00	2.09	1.14	1.88	1.21	0.683	1.46
SWMU 54 Eighth Quarter (May 2013) Water Quality Parameters														
pH	7.38	6.52	7.06	7.51	6.83	7.33	7.41	7.47	7.95	6.94	7.59	6.78	6.97	7.31
Conductivity (mS/cm)	0.398	0.315	0.499	1.021	0.4	0.494	0.674	0.596	0.521	0.537	0.592	0.665	0.44	0.608
Turbidity (NTU)	1.2	0.2	1.4	6.2	8.9	7.1	0.5	1.6	5.2	1.4	0.3	3.8	0.2	6.4
Dissolved Oxygen (mg/L)	4.13	2.74	3.55	1.05	3.28	1.29	3.24	0.4	7.58	2.43	1.17	2.54	1.4	4.13
ORP (mV)	122	254.3	273.6	257.1	283.1	128.4	282.7	255.1	244.2	287.8	255.8	292.4	284	296.5
Temperature (°C)	13.43	12.22	13.31	11.73	12.2	13.48	12.74	13.32	11.12	12.89	12.42	13.28	12.84	13.42
Dissolved Manganese (mg/L)	<0.05	0.05	0.05	0.05	<0.05	<0.05	0.05	0.05	0.1	0.05	0.05	<0.05	0.15	0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0.368	0.988	0.911	3.00	1.60	0.600	1.10	0.600	0.637	0.740	0.647	4.03	1.05	0.543
Sulfate (mg/L)	26.1	24.1	29.0	329	15.7	14.0	137	41.1	96.7	48.8	89.4	47.6	29.2	37.0
TOC (mg/L)	0.949	1.68	1.36	0.619	1.06	2.41	0.793	1.00	1.38	1.00	0.635	1.36	0.817	0.583
SWMU 54 Ninth Quarter (August 2013) Water Quality Parameters														
pH	7.82	6.91	6.75	6.96	6.28	Dry	6.71	6.95	7.12	6.48	7.04	6.36	6.57	6.84
Conductivity (mS/cm)	0.452	0.592	0.617	0.937	0.333	Dry	0.478	0.559	0.419	0.496	0.637	0.491	0.351	0.554
Turbidity (NTU)	3	0	0	0	0	Dry	7.2	0	6.1	0	0	7.0	0	0
Dissolved Oxygen (mg/L)	0.136	0.8	1.69	0.39	6.28	Dry	2.4	0.67	2.36	0.86	4.65	2.85	6.57	0.52
ORP (mV)	223.2	84	96	-18	129	Dry	86	42	-13	35	68	91	146	50
Temperature (°C)	14.51	15.25	15.08	13.22	15.49	Dry	13.05	13.4	13.25	14.51	13.46	15.7	13.89	13.21
Dissolved Manganese (mg/L)	0.05	NM	<0.05	0.05	0.05	Dry	<0.05	<0.05	0.05	<0.05	0.05	0.05	0.15	0.05
Dissolved Ferrous Iron (mg/L)	<0.2	NM	<0.2	<0.2	<0.2	Dry	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	<0.600	0.326	0.521	<0.600	0.849	Dry	<0.600	0.273	0.194	0.206	0.12	4.8	0.591	0.29
Sulfate (mg/L)	26.7	30.8	26.1	322	15.0	Dry	27.3	38.0	39.2	44.3	91.8	39.6	23.3	28.2
TOC (mg/L)	3.32	1.5	1.11	2.7	0.91	Dry	0.822	2.30	4.17	4.28	3.11	3.27	2.35	3.64

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Tenth Quarter (November 2013) Water Quality Parameters														
pH	--	7.45	--	--	--	--	--	--	--	6.89	--	NM	7.29	--
Conductivity (mS/cm)	--	0.635	--	--	--	--	--	--	--	0.615	--	0.469	0.643	--
Turbidity (NTU)	--	0	--	--	--	--	--	--	--	0	--	4.6	0.4	--
Dissolved Oxygen (mg/L)	--	2.7	--	--	--	--	--	--	--	2.45	--	1.17	1.32	--
ORP (mV)	--	51	--	--	--	--	--	--	--	18	--	108	25	--
Temperature (°C)	--	14.09	--	--	--	--	--	--	--	15.25	--	14.96	15.96	--
Dissolved Manganese (mg/L)	--	<0.05	--	--	--	--	--	--	--	<0.05	--	0.05	0.05	--
Dissolved Ferrous Iron (mg/L)	--	<0.2	--	--	--	--	--	--	--	<0.2	--	<0.2	<0.2	--
Nitrate (mg/L)	--	0.25	--	--	--	--	--	--	--	0.670	--	1.1	0.45	--
Sulfate (mg/L)	--	29.0	--	--	--	--	--	--	--	57.0	--	26.0	39.0	--
TOC (mg/L)	--	2.5	--	--	--	--	--	--	--	0.68	--	0.5	<0.50	--
SWMU 54 Eleventh Quarter (February 2014) Water Quality Parameters														
pH	8.1	--	--	--	--	--	--	--	--	6.89	--	7.21	7.21	--
Conductivity (mS/cm)	0.41	--	--	--	--	--	--	--	--	0.587	--	0.643	0.481	--
Turbidity (NTU)	0	--	--	--	--	--	--	--	--	0	--	3.8	14	--
Dissolved Oxygen (mg/L)	1.32	--	--	--	--	--	--	--	--	1.43	--	0.7	2.09	--
ORP (mV)	127	--	--	--	--	--	--	--	--	153	--	150	142	--
Temperature (°C)	12.34	--	--	--	--	--	--	--	--	13.2	--	14.11	12.04	--
Dissolved Manganese (mg/L)	<0.05	--	--	--	--	--	--	--	--	<0.05	--	<0.05	0.05	--
Dissolved Ferrous Iron (mg/L)	<0.2	--	--	--	--	--	--	--	--	0.2	--	0.2	<0.2	--
Nitrate (mg/L)	<0.025	--	--	--	--	--	--	--	--	0.470	--	3.1	0.44	--
Sulfate (mg/L)	30.00	--	--	--	--	--	--	--	--	89.0	--	36.0	31.0	--
TOC (mg/L)	1.00	--	--	--	--	--	--	--	--	0.53	--	1.00	<0.50	--
SWMU 54 Twelfth Quarter (May 2014) Water Quality Parameters														
pH	7.79	--	--	--	--	--	--	--	--	6.93	--	NM	NM	--
Conductivity (mS/cm)	0.469	--	--	--	--	--	--	--	--	0.582	--	0.453	0.47	--
Turbidity (NTU)	3	--	--	--	--	--	--	--	--	3.8	--	10	9	--
Dissolved Oxygen (mg/L)	1.65	--	--	--	--	--	--	--	--	1.56	--	2.25	1.14	--
ORP (mV)	222.3	--	--	--	--	--	--	--	--	127.4	--	272.1	71.3	--
Temperature (°C)	16.61	--	--	--	--	--	--	--	--	12.81	--	14.61	16.57	--
Dissolved Manganese (mg/L)	0.05	--	--	--	--	--	--	--	--	0.1	--	0.1	0.05	--
Dissolved Ferrous Iron (mg/L)	0.2	--	--	--	--	--	--	--	--	<0.2	--	0.2	0.2	--
Nitrate (mg/L)	0.031	--	--	--	--	--	--	--	--	0.330	--	1.6	0.41	--
Sulfate (mg/L)	29.0	--	--	--	--	--	--	--	--	58.0	--	31.0	27.0	--
TOC (mg/L)	51.0	--	--	--	--	--	--	--	--	62.0	--	<0.50	<0.50	--

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Thirteenth Quarter (September 2015) Water Quality Parameters														
pH	6.7	--	--	--	--	--	--	--	--	6.8	--	5.4	6.69	--
Conductivity (mS/cm)	0.471	--	--	--	--	--	--	--	--	329	--	0.557	0.529	--
Turbidity (NTU)	0.65	--	--	--	--	--	--	--	--	30.7	--	2.66	1.00	--
Dissolved Oxygen (mg/L)	0.75	--	--	--	--	--	--	--	--	8.2	--	6.0	6.53	--
ORP (mV)	180	--	--	--	--	--	--	--	--	71	--	264	198.0	--
Temperature (°C)	14.14	--	--	--	--	--	--	--	--	15.8	--	14.8	14.83	--
Dissolved Manganese (mg/L)	0.087	--	--	--	--	--	--	--	--	0.081	--	0.066	0.081	--
Dissolved Ferrous Iron (mg/L)	0	--	--	--	--	--	--	--	--	0.11	--	0.07	0.11	--
Nitrate (mg/L)	0.14	--	--	--	--	--	--	--	--	0.25	--	0.92	0.5	--
Sulfate (mg/L)	25	--	--	--	--	--	--	--	--	23	--	24	26	--
TOC (mg/L)	4.1	--	--	--	--	--	--	--	--	8.1	--	8.3	13	--
SWMU 54 Fourteenth Quarter (February 2014) Water Quality Parameters														
pH	7.60	--	--	--	--	--	--	--	--	6.16	--	6.79	7.01	--
Conductivity (mS/cm)	2.8	--	--	--	--	--	--	--	--	0.54	--	589.5	324.0	--
Turbidity (NTU)	0.78	--	--	--	--	--	--	--	--	0.88	--	5.8	7.99	--
Dissolved Oxygen (mg/L)	9.89	--	--	--	--	--	--	--	--	6.70	--	8.6	8.74	--
ORP (mV)	76.2	--	--	--	--	--	--	--	--	89.3	--	92.4	73.2	--
Temperature (°C)	9.6	--	--	--	--	--	--	--	--	12.7	--	12.4	11.6	--
Dissolved Manganese (mg/L)	0.063	--	--	--	--	--	--	--	--	0.054	--	0.030	0.063	--
Dissolved Ferrous Iron (mg/L)	0	--	--	--	--	--	--	--	--	0.0	--	0.10	0.05	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.45	--	2.5	0.46	--
Sulfate (mg/L)	26	--	--	--	--	--	--	--	--	76	--	45	20	--
TOC (mg/L)	1.5	--	--	--	--	--	--	--	--	0.97	--	1.8	1.8	--
SWMU 54 Fifteenth Quarter (May 2014) Water Quality Parameters														
pH	7.61	--	--	--	--	--	--	--	--	6.71	--	6.44	6.77	--
Conductivity (mS/cm)	440	--	--	--	--	--	--	--	--	602	--	353	229	--
Turbidity (NTU)	0.3	--	--	--	--	--	--	--	--	3.74	--	5.7	1.16	--
Dissolved Oxygen (mg/L)	4	--	--	--	--	--	--	--	--	0.61	--	5.8	6.86	--
ORP (mV)	51	--	--	--	--	--	--	--	--	73.5	--	93.4	76.8	--
Temperature (°C)	12.01	--	--	--	--	--	--	--	--	13.4	--	14.32	13.52	--
Dissolved Manganese (mg/L)	0.021	--	--	--	--	--	--	--	--	0.057	--	0.020	0.025	--
Dissolved Ferrous Iron (mg/L)	0.02	--	--	--	--	--	--	--	--	0.03	--	0.04	0.02	--
Nitrate (mg/L)	0.14	--	--	--	--	--	--	--	--	0.18	--	1.3	0.43	--
Sulfate (mg/L)	29	--	--	--	--	--	--	--	--	83	--	27	19	--
TOC (mg/L)	4.2	--	--	--	--	--	--	--	--	8.9	--	6.8	0.68	--

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Sixteenth Quarter (November 2013) Water Quality Parameters														
pH	6.82	--	--	--	--	--	--	--	--	7.39	--	6.32	7.27	--
Conductivity (mS/cm)	619	--	--	--	--	--	--	--	--	775	--	499	473.0	--
Turbidity (NTU)	4.62	--	--	--	--	--	--	--	--	5.36	--	6.50	0.72	--
Dissolved Oxygen (mg/L)	3.14	--	--	--	--	--	--	--	--	0.37	--	4.60	2.09	--
ORP (mV)	-10.1	--	--	--	--	--	--	--	--	109	--	8.2	12.0	--
Temperature (°C)	16.56	--	--	--	--	--	--	--	--	13.79	--	14.33	15.2	--
Dissolved Manganese (mg/L)	0.062	--	--	--	--	--	--	--	--	0.048	--	0.033	0.031	--
Dissolved Ferrous Iron (mg/L)	0.14	--	--	--	--	--	--	--	--	0.02	--	0.02	0.00	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.47	--	0.81	0.60	--
Sulfate (mg/L)	29	--	--	--	--	--	--	--	--	93	--	25	36	--
TOC (mg/L)	0.92	--	--	--	--	--	--	--	--	0.58	--	1.2	0.78	--

Notes:
-- = Wells eliminated from monitoring program
°C = degrees Celsius
mg/L =- milligrams per liter
mS/cm = milliseimens per centimeter
NM = not measured
NTU = Nephelometric Turbidity Unit mV - millivolts

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7.0 Summary and Conclusions

This report covers 4 years of groundwater monitoring. Fourteen (14) groundwater monitoring wells were sampled on a quarterly basis for over 2 years (nine quarters) at SWMU 54. After the ninth and tenth quarters, the monitoring program was reduced to the three wells which have had COI concentrations above RGs (54MW10, 54MW12, and 54MW13) and an upgradient well (54MW1). Samples collected during the first twelve quarters were analyzed for explosives, perchlorate, and MNA indicators. For Quarters 10 through 16, samples were also analyzed for RDX breakdown products. Sample results were compared to RGs and evaluated to determine whether MNA is occurring at the SWMU. This report presents and summarizes the analytical results of the first four years (sixteen quarters) of monitoring.

Based on contaminant concentrations and biological indicator parameters measured in groundwater at SWMU 54, MNA processes are reducing the concentrations of 2,4,6-TNT and RDX. These processes include biodegradation and to a lesser extent sorption, dilution, dispersion, and chemical stabilization. The data also suggest that the MNA processes are preventing downgradient plume expansion and decreasing nitroaromatic and perchlorate mass.

In summary, the following conclusions and recommendations were made regarding the potential for MNA in contaminated groundwater at SWMU 54:

- Presence of 2,4,6-TNT daughter products 2ADNT and 4ADNT is further evidence that biological degradation has occurred, which may be aiding in removing mass in the groundwater.
- Identification of RDX breakdown products DNX, MNX, and TNX indicate active degradation of RDX, although breakdown products were less prevalent during the year four monitoring period.
- All perchlorate concentrations in the third and fourth years of monitoring were below the RG and showed a steady decline in concentrations during the two year period.

Observed levels of DO (0.37 mg/L to 6.86 mg/L) and ORP (-10.1 mV to 264 mV) during year four indicated both aerobic and anaerobic conditions exist at SWMU 54. However, aerobic conditions were determined to be more prevalent. While TNT has been known to be reduced under a variety of conditions (aerobic and anaerobic), further reduction of 2ADNT, 4ADNT, and reduction of RDX and perchlorate is more favorable under anaerobic conditions (Spain, 1995).

The source removal efforts at SWMU 54 appear to have been effective in significantly lowering the site-wide COCs in groundwater. This is evident by the fact that eleven of the fourteen monitoring well locations (54MW1 through 54MW9, 54MW11, and 54MW14) had observed concentrations below site selected RGs for eight consecutive quarters for 2,4,6-TNT, DNT mixture, RDX, and perchlorate. As recommended in the *Final SWMU 54 MNA IMWP* (Shaw, 2011a), these wells were removed from the MNA sampling program after the ninth and tenth quarters.

Historic pore water samples PW-1, PW-3, PW-5, PW-8, and PW-9 had no detections of explosives or perchlorate in 2 years of sampling. As recommended in the *Final SWMU 54 MNA IMWP* (Shaw, 2011a), the pore water sample locations were removed from the MNA sampling program after Quarter 9 (August 2013).

Explosives concentrations through sixteen quarters of groundwater monitoring indicate that limited biodegradation at well locations 54MW10, 54MW12, and 54MW13 (SWMU 54 Area A wells) is occurring. Based on the localized distribution of elevated constituents and the generally declining concentrations site-wide, an active groundwater remedy at SWMU54 does not appear necessary at this time. However, the fourteenth quarter of sample collection included the most elevated concentrations of explosive COIs reported at monitoring well 54MW12, warranting continued monitoring. The sharp increase in explosive concentrations at 54MW12 during the fourteenth quarter occurred under aerobic conditions. Biodegradation is not as effective under aerobic conditions to reduce explosives and perchlorates concentrations. As a result of the subsurface biochemistry, the decreased biological activity may have led to an increase in the explosives and perchlorate concentrations during this period.

The direction and speed of groundwater flow is consistent with previous reporting periods and the current network of groundwater monitoring wells are adecuate for future groundwater monitoring events. It is our recommendation that groundwater monitoring continues on a quarterly basis at well locations 54MW10, 54MW12, and 54MW13. In addition to monitoring wells 54MW10, 54MW12, and 54MW13, monitoring well 54MW1 will continue to be monitored as an upgradient well, despite meeting the criteria for being removed from the network.

8.0 References

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