DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, UNITED STATES ARMY GARRISON, REDSTONE
4488 MARTIN ROAD
REDSTONE ARSENAL, ALABAMA 35898-5000

REPLY TO
ATTENTION OF

Environmental Management Division

5/3/22

Mr. Jason Wilson
Chief, Land Division
Alabama Department of Environmental Management
Post Office Box 301463
Montgomery, AL 36130-1463

SUBJECT: Submittal of Slip Pages for the Rev 1 Corrective Measures Implementation Plan for RSA-072-1-R-01(RSA-282) Former Mortar Test Site (Not in Range), U.S. Army Garrison-Redstone, Madison County, Alabama

Dear Mr. Wilson:
References:

a. Installation Restoration Program at Redstone Arsenal, Alabama (EPA ID AL7 210 020 742).

b. Redstone Arsenal's Alabama Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility/Thermal Treatment/Solid Waste Management Unit Corrective Action Permit, dated July 19, 2021

c. Alabama Department of Environmental Management (Department) letter, Revision O, Corrective Measures Implementation (CMI) Work Plan, RSA-072-R-01 (RSA-282) Former Mortar Test Site (Not in Range), Operable Unit 15, dated July 26, 2019, Redstone Arsenal (RSA) DSMOA, Redstone Arsenal (RSA) DSMOA Environmental Restoration Program, U.S. EPA I.D. No. AL 7 210 020 742.

In accordance with Redstone Arsenal's Alabama Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility/Thermal Treatment/Solid Waste Management Unit Corrective Action Permit, the Army is submitting the enclosed slip pages for the Revision 1, RSA-072-R-01 (RSA-282) Corrective Measures Implementation Plan. The purpose of the slip pages are to capture the modification of the Land Use Controls (LUCs) boundary and changes in the number of signs and sign locations at the site. The reason for the change is to better optimize the land use of the area. The CMIP changes were previously discussed with the Department and a site visit has been performed to show and discuss the changes without any major comments.

My point of contact for this matter is Mr. Jason Watson, Environmental Management Division, 256-842-1448 or e-mail Jason.n.watson3.civ@army.mil.

Sincerely,

Clint Howard

Clint Howard
Chief, Environmental Management Division

Corrective Measures Implementation Work Plan
RSA-072-R-01 (RSA-282), Former Mortar Test Site (Not in Range)
Operable Unit 15
U.S. Army Garrison-Redstone
Madison County, Alabama
EPA ID No. AL7 210 020 742

Prepared for:

Mission & Installation Contracting Command
ATTN: MICC Center – FSH
2107 17th Street
Building 4197, Suite 15
Fort Sam Houston, Texas 78234-5015

Prepared by:

Aptim Federal Services, LLC
2410 Cherahala Boulevard
Knoxville, Tennessee 37932

Contract No. W91ZLK-09-D-0006
APTIM Project Number 500982
Task Order 0020

July 2019

Corrective Measures Implementation Work Plan
RSA-072-R-01 (RSA-282), Former Mortar Test Site (Not in Range)
Operable Unit 15
U.S. Army Garrison-Redstone
Madison County, Alabama
EPA ID No. AL7 210 020 742

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Kenneth J Hurley
Kenneth Hurley
Alabama PE No. 25249

7/30/19
Date

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Executive Summary

Aptim Federal Services, LLC, on behalf of the U.S. Army Garrison–Redstone, has prepared this corrective measures implementation work plan for Redstone Arsenal, Madison County, Alabama, under the management of the U.S. Army Environmental Command. The Mission & Installation Contracting Command has contracted Aptim Federal Services, LLC under Contract Number W91ZLK-09-D-0006 to perform environmental remediation and restoration and program management services at Redstone Arsenal under the Resource Conservation and Recovery Act Corrective Action Program. This corrective measures implementation work plan has been developed to provide technical guidance for implementing soil corrective measures selected for RSA-072-R-01 (RSA-282), Former Mortar Test Site (Not in Range). RSA-072-R-01 (RSA-282) will be referred to as RSA-072-R-01 in this corrective measures implementation work plan.

This work plan incorporates applicable elements of Redstone Arsenal's Hazardous Wastes Management and Minimization Act Hazardous Wastes Storage Facility/Thermal Treatment/Solid Waste Management Unit Corrective Action Permit, Modification No. 13, and the most recent edition of the Alabama Environmental Investigation and Remediation Guidance. This work plan is submitted to fulfill, in part, the requirements listed in Section VI.E of the Permit. As specified in Section VI.E.3 of the Permit, a request for permit modification is included as part of this plan.

RSA-072-R-01 was part of the former RSA-072 mortar-tube proofing range. Due to the changes in operational range boundaries identified in the 2005 Operational Range Inventory Sustainment, RSA-072-R-01 was removed as an operational range and thus became Military Munitions Response Program eligible. Munitions and explosives of concern were found and removed prior to and during a time-critical removal action performed in 2008-2009 during construction of the Software Engineering Directorate complex (Buildings 6271 and others).

The RSA-072-R-01 Resource Conservation and Recovery Act facility investigation defined the nature and extent of contamination and evaluated potential risks to current and future receptors. The investigation and evaluations of this former range site determined with 95 percent confidence that there is less than 0.652 unexploded ordnance per acre, which is an upper bound on the munitions and explosives of concern density at the site. These results were based on the digital geophysical mapping. Intrusive investigations were performed in full coverage (northern portion of Geophysical Survey Area 2) or along transects in select areas (Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Survey Area 2) to characterize munitions and explosives of concern at RSA-072-R-01. Consideration that this site was originally part of an

active proofing range, and the statistical uncertainty regarding the presence of munitions and explosives of concern, plus the fact that munitions and explosives of concern were found at this site, and removed during a prior action, this site does not meet the requirements needed for unrestricted use as defined in Alabama Administrative Code r. 335-5. This regulation defines unrestricted use as the "designation of acceptable future use at a property or site where the remediation levels, based on either background or standard exposure factors, shall have been attained in all media to allow the property or site to be used for any purpose." Army agrees that there are residual risks that munitions and explosives of concern may still occur at this site given the historical site use, the remaining statistical uncertainty regarding the presence of munitions, and the past positive identification of munitions and explosives of concern at this site, and intends to manage these risks through corrective measures.

In addition, the RSA-072-R-01 Resource Conservation and Recovery Act facility investigation determined that the Army's historical operations at RSA-072-R-01 have not resulted in the release of hazardous substances to soil, surface water, or sediment that pose an unacceptable risk to human health or the environment or a leaching threat to groundwater. Two chemicals of concern, 2-nitrotoluene and trichloroethene, were identified in the groundwater and will be addressed with the RSA-150 groundwater unit corrective measures.

Due to the limited probability that munitions and explosives of concern are present at this site, and because of the absence of risks to human health and the environment from chemical hazards, the Army has elected to impose land-use controls for the former time-critical removal area/retention pond in the west-northwestern part of the site and site access and use restrictions for the remainder of the site as the final corrective measures. These controls/restrictions are being implemented in accordance with the Alabama Administrative Code 335-5-1-.02(3)(a)(1)(i) for Notice of Environmental Use Restriction, Redstone Arsenal's site access control regulations as incorporated into Redstone Arsenal's permit, and in accordance with Redstone Arsenal's Explosive Safety Management Program. The remaining residual risk at the site is managed by implementing these controls/restrictions to ensure the likelihood of encountering munitions and explosives of concern is negligible.

This corrective measures implementation work plan presents the specific activities necessary to ensure implementation of the corrective measures. Several corrective measures have already been implemented at RSA-072-R-01, including establishing the Army access and use restriction boundary for the site, posting warning signs, and entering dig restrictions in the Redstone Arsenal Real Property Master Plan. The Redstone Arsenal Explosive Safety Management Program requirements ensure that the site will be inspected annually for effectiveness of the access and use restrictions as required by Redstone Arsenal's Explosive Safety Management

Program. On-call unexploded ordnance construction support is available as needed at the site for the annual inspections and any future construction activities. Based on the results of the 2008-2009 time-critical removal action, the former time-critical removal action/retention pond area of the site will require additional signage and controls since chemically-configured munitions and explosives of concern items were found.

The following plans and supporting documentation are included as appendices to this corrective measures implementation work plan:

- Alabama Department of Environmental Management Concurrence Letter for RSA-072-R-01 Resource Conservation and Recovery Act Facility Investigation Report
- Request for Redstone Resource Conservation and Recovery Act Permit Modification
- Corrective Measures Implementation Schedule.

1.0 Introduction

Aptim Federal Services, LLC (APTIM), on behalf of the U.S. Army Garrison–Redstone (hereinafter referred to as the Army), has prepared this corrective measures implementation (CMI) work plan for Redstone Arsenal (RSA), Madison County, Alabama, under the management of the U.S. Army Environmental Command. The Mission & Installation Contracting Command has contracted APTIM under Contract Number W91ZLK-09-D-0006 to perform environmental remediation and restoration and program management services at RSA under the Resource Conservation and Recovery Act (RCRA) Corrective Action program in accordance with RSA's Alabama Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility/Thermal Treatment/Solid Waste Management Unit (SWMU) Corrective Action Permit, Modification No. 13, dated August 27, 2018 (hereinafter referred to as the Permit) (U.S. Environmental Protection Agency [EPA] ID # AL7 210 020 742) (Alabama Department of Environmental Management [ADEM], 2018). This CMI work plan has been developed to provide technical guidance for implementing the soil corrective measures selected for SWMU RSA-072-R-01, Former Mortar Test Site (Not in Range), in Operable Unit (OU) 15 (known as RSA-282 in the Permit). RSA-072-R-01 (RSA-282) will be referred to hereinafter as RSA-072-R-01.

This CMI work plan incorporates applicable elements of the Permit (ADEM, 2018) and the most recent edition of the Alabama Environmental Investigation and Remediation Guidance (AEIRG) (ADEM, 2017a). This CMI work plan is submitted to fulfill in part the requirements listed in Section VI.E of the Permit. As specified in Permit Section VI.E.3, the request for permit modification is included as part of this plan.

1.1 Purpose

The purpose of this CMI work plan is to describe the corrective measures selected for use at RSA-072-R-01 to address the limited statistical uncertainty regarding the presence of munitions and explosives of concern (MEC) in soil that could pose risks to human health. Although no MEC was found at the site during the RCRA facility investigation (RFI), this site was part of a former range and chemically configured MEC was found and removed from within the boundary of the current site prior to and during a time-critical removal action (TCRA) in 2008-2009. However, there remains limited uncertainty for the presence of MEC since the statistical sampling program Unexploded Ordnance (UXO) Estimator found the investigation to be 95 percent confident that there is less than 0.652 UXO per acre. These results were based on the digital geophysical mapping (DGM), and intrusive investigations that were performed in full coverage (northern portion of Geophysical Survey Area 2) or along transects in select areas

(Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Survey Area 2) to characterize MEC at RSA-072-R-01. The nature and extent of contamination was presented in the RFI report (CB&I Federal Services LLC [CB&I], 2016) for RSA-072-R-01, which received concurrence from ADEM on December 29, 2016. An Alabama Risk-Based Corrective Action (ARBCA) evaluation for human health and a screening-level ecological risk assessment (SLERA) were prepared for RSA-072-R-01 as part of the RFI. The ARBCA evaluation concluded that chemicals in soil, surface water, and sediment pose no unacceptable human health risks to commercial/industrial or hypothetical future residential receptors and no threat to groundwater due to contaminant leaching and migration to the water table. The SLERA determined that contaminants present in surface soil, sediment, or surface water are not expected to pose a potential risk for adverse impacts to terrestrial plant or soil invertebrate communities and food chain receptors are unlikely to be impacted. However, the RFI report concluded that corrective measures are needed to address risks with the potential presence of MEC at the site. Two chemicals of concern (COC), 2-nitrotoluene and trichloroethene (TCE), were identified in groundwater and will be addressed with the RSA-150 groundwater unit corrective measures.

This CMI work plan has been prepared to describe the technical approach and rationale for the activities that will be part of the selected corrective measures for RSA-072-R-01.

1.2 Site Description

RSA-072-R-01 occupies approximately 117 acres in the northwestern portion of RSA and lies above the RSA-150 groundwater unit (Figure 1-1). RSA-072-R-01 contains all of Hackberry Road and portions of Hale Road and Shelby Drive (Figure 1-2). Approximately one-half of the site area is occupied by buildings, parking lots, and other paved surfaces.

1.2.1 Site History

A brief site history is provided below, but a more comprehensive description is included in the RFI report (CB&I, 2016a). RSA-072-R-01 was part of the former RSA-072 mortar-tube proofing range and contained all or part of three potential source areas:

- RSA-072-R-01 was once a downrange portion of RSA-072, Mortar Shell Test Site, Area B, which was a mortar-tube proofing range during the early 1940s. However, use of this range was limited since the range of the 4.2-inch mortar was increased during World War II when a high explosive mortar shell was developed. Thus, mortar-tube proofing was believed to have been relocated to RSA-071 to the west (Figure 1-3). Due to the changes in operational range boundaries identified in the 2005 Operational Range Inventory Sustainment, RSA-072-R-01 was removed as an operational range and thus became Military Munitions Response Program (MMRP) eligible.

- Former Troop Training Area C slightly overlapped RSA-072-R-01 along its eastern boundary (Figure 1-4) and may have been used by the National Guard and rescue units for training exercises beginning in the early to mid-1960s.

- Former Range 1B overlapped the southern portion of RSA-072-R-01 (Figure 1-4) and was identified as a former 4.2-inch mortar impact area.

- Three former Powder Storage Magazines were located within the central portion of RSA-072-R-01 (Figure 1-4). The magazines were built in 1943, and the type(s) of powder stored in the magazines is unknown. There is no indication in the given historical records that any chemical warfare materiel was used, stored, or disposed at RSA-072 or these potential source areas.

RSA-072-R-01 has been assigned to the U.S. Department of Defense (DoD) MMRP for investigation and cleanup. OU-15 consists of sites, including RSA-072-R-01, within the MMRP.

1.2.2 Site Topography

The elevation of the site ranges from approximately 594 feet above mean sea level along the western site boundary to 642 feet above mean sea level at the northern site boundary (Figure 1-2). Generally, the land slopes from east to west at the site.

1.2.3 Climate

Climate is a primary component in the hydrologic cycle and water budget and an integral element of the hydrogeologic framework of a site. Seasonal and storm-related trends in temperature and rainfall influence surface water and groundwater flow conditions. Average annual rainfall at RSA is 52 inches, and rainfall is the principal source of groundwater recharge, either directly through infiltration and percolation through the vadose zone (unsaturated overburden) or as runoff to streams, which may also recharge groundwater. On an annual basis, 75 to 90 percent of rainfall at RSA is lost to evapotranspiration (Shaw Environmental, Inc. [Shaw], 2003). Discounting runoff to surface water, 5 to 13 inches of rainfall remain available to recharge groundwater. Rainfall contributes to groundwater recharge primarily during the winter, when deciduous trees are leafless, reducing overall transpiration. With the onset of the growing season in April, temperatures increase dramatically, and most potential recharge is lost through evaporation and transpiration.

1.2.4 Ecology

Most of the site's undeveloped land consists of open grassland. There are pockets of sparse trees along Hackberry Road and in the area bounded by Hackberry Road, Shelby Drive, and Hale Road. Small drainage ditches are located along the sides of the roads. One significant drainage feature enters the site from the north and flows southwesterly through the site on its path to Indian Creek, located approximately 1800 feet from the site's western boundary. This drainage

flows in series through a retention pond and then an evaporation pond located along the western boundary. The retention pond is north of the evaporation pond and is usually dry. The evaporation pond typically contains water and provides for an aquatic habitat. The drainage ditches, including the one which flows to Indian Creek, are not considered to be permanent aquatic habitats. Edges of the mixed pine and hardwood forested areas around portions of the site penetrate into the southwest, south, and southeast boundaries of the site. Few trees associated with these woodlands are actually inside the site boundary.

1.2.5 Geology

Discussions of regional stratigraphic and structural geology, surface and subsurface hydrology, and other physiographic and geographic topics are presented in the RSA-150/153 RFI report (APTIM, 2018) and the installation-wide work plan (IT Corporation, 2002).

Soil. The overburden at RSA-072-R-01 is approximately 37 to 49 feet thick based on refusal depth in soil borings installed using direct-push technology. The lithologic logs from soil indicate native soils consisting of low-permeability, residual red, brown, and gray clay; silty clay; and silt. The overburden or unconsolidated soil layer across most of RSA is called residuum because it formed from in situ chemical weathering of the underlying karstic limestone bedrock. This overburden layer consists mainly of clay and silty clay. It also includes varying amounts of residual chert fragments which were present within the parent limestone and have resisted chemical weathering because of their siliceous composition. The chert can be found scattered within the clay matrix as nodules or concentrated locally as near-horizontal layers within the soil.

Although there is little compositional variation within the overburden, the residuum does not transmit groundwater uniformly. Groundwater infiltration follows preferred pathways because zones of higher hydraulic conductivity developed during soil-forming processes. Preferred pathways within the overburden directly affect contaminant migration and distribution within the soil column.

Residual clay generally has low horizontal and vertical hydraulic conductivities. At a given location, a layer of chert within the clay may decrease vertical hydraulic conductivity and increase horizontal conductivity, while isolated nodules of chert may increase the vertical conductivity. Preferred groundwater flow pathways in the overburden also include macropores caused by rotting tree roots and burrowing animals.

Additionally, microfractures may be created within the clay during raveling, a process in which the clay slowly subsides as it is eroded and carried away by groundwater in bedrock fractures

and conduits. Vertical movement of the soil caused by raveling or sloughing into fractures and conduits results in the development of microfractures in the overlying material. The microfractured clay soils have higher hydraulic conductivities than undisturbed clay and also act as preferred groundwater flow pathways.

Bedrock. The depth to bedrock in borings drilled to refusal at RSA-072-R-01 ranged from 37 to 49 feet below ground surface (bgs). Lithologic data from bedrock wells installed across this portion of RSA indicate that the shallow bedrock first encountered correlates with middle to upper Tuscumbia Limestone or the Fort Payne Formation and exhibits well-developed karst features. The upper Fort Payne is characterized by intervals of impermeable chert with interbedded limestone or dolomite. Bedding in the Fort Payne formation is typically nondistinct or not preserved, replaced by abundant, variably weathered stylolites. Within the upper Fort Payne, voids ranging up to several tenths of a foot in height are seen, often isolated by impermeable chert-carbonate rock both above and below. Neither individual stylolites nor solutionally enlarged stylolites are correlable for any distance from well to well. The lower Fort Payne is similar to the upper Fort Payne, but with an increase in stylolites at the base. Lacking bedding planes, stylolites appear to be either weathered or slightly solutionally enlarged and serve as primary water-bearing features where developed. A thin greenish-gray shaley zone is often encountered in the basal Fort Payne just above the Chattanooga Shale. The Fort Payne is underlain by the Chattanooga Shale, a dark gray to black, fissile shale.

1.2.6 Hydrogeology

Surface Water. The primary surface water structure on the site is the constructed evaporation pond along the western boundary (Figure 1-2). The evaporation pond appears to be a permanent water body and does provide an aquatic habitat. North of the evaporation pond, a retention pond was constructed for capturing runoff. This retention pond is typically dry and only holds water during high-runoff events. The aforementioned drainage ditch (Section 1.2.4) is the most prominent of several drainage ditches within the site; most of the site drainage ditches are located along the roads (Figure 1-2). None of these drainage structures are considered to be aquatic habitats.

Drainage within the site is typically toward the nearest surface water bodies. The retention pond and the evaporation pond were designed to contain runoff from the airfield located north of the site and the Software Engineering Directorate complex. In general, surface water flow is toward Indian Creek. The area of the site surrounding the ponds lies in the 100-year floodplain (Figure 1-2).

Groundwater. Groundwater beneath RSA-072-R-01 occurs in the unconsolidated overburden and the upper portion of the carbonate bedrock. The overburden and upper bedrock comprise a single interconnected, unconfined water table aquifer. At depth, groundwater occurs under semiconfined conditions, flowing along discrete joints and bedding-plane partings. The water table across the site is generally flat, mimicking local topography. Depending upon the time of the year, the depth to groundwater varies across the site from 19.4 to more than 39.6 feet bgs; the site average depth to water is 28.17 feet bgs. May 2014 and October 2014 site potentiometric surface maps indicate that overburden groundwater flows north to south through the site (CB&I, 2016). Just south of the site, groundwater flows southwest toward Indian Creek and southeast toward an Indian Creek tributary. Indian Creek and its tributaries serve as groundwater discharge zones for this area.

1.3 Document Organization

This CMI work plan is organized into the following chapters:

- Chapter 1.0 presents the purpose and overview of the document and includes a brief site description, including the topography, climate, ecology, geology, and hydrogeology associated with the site.
- Chapter 2.0 presents additional background information about the site, including investigation history, the nature and extent of contamination, site risks, fate and transport, and the final conceptual site models (CSM).
- Chapter 3.0 describes the basis for the action, including the corrective measure objectives (CMO), the cleanup goals (CG) if appropriate, and a summary of the selected corrective measures.
- Chapter 4.0 describes the activities necessary for implementation of the corrective measures at the site.
- Chapter 5.0 describes the mechanism to address foreseeable challenges that may arise during execution of the corrective measures described herein.
- Chapter 6.0 provides the references that contributed to the preparation of this CMI work plan.

The following plans and supporting documentation are included as appendices to this CMI work plan:

- Appendix A: ADEM Concurrence Letter for RSA-072-R-01 RFI Report
- Appendix B: Request for Redstone RCRA Permit Modification
- Appendix C: CMI Schedule.

2.0 Investigation Results

This chapter presents additional background information for RSA-072-R-01, including the investigation history, the nature and extent of contamination, the site risks, fate and transport, and the final CSMs.

2.1 Investigation History

Environmental investigations relevant to RSA-072-R-01 are listed below.

- RSA-150, RSA-153, RSA-154, and RSA-155 potential source area investigation (Shaw, 2006)
- Historical records review (Malcolm Pirnie, Inc., 2008a)
- Site inspection report (Malcolm Pirnie, Inc., 2008b)
- Site-specific final report for the Redstone Software Engineering Directorate Phases I and II TCRA (EOD Technology, Inc. (EODT], 2010)
- RFI report for RSA-072-R-01 (CB&I, 2016)
- RFI report for RSA-150/153 groundwater units (APTIM, 2018).

A complete discussion of the previous site investigations is available in the RFI report for RSA-072-R-01 (CB&I, 2016). This document also includes information on the TCRA conducted in 2008-2009 to support construction of the Software Engineering Directorate complex. Prior to and during the TCRA, MEC was identified and removed in select areas of the site (Figure 2-1a).

During the RFI, DGM and intrusive investigations were performed in full coverage (northern portion of Geophysical Survey Area 2) or along transects in select areas (Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Survey Area 2) to characterize MEC at RSA-072-R-01 (Figure 2-1b). The statistical sampling program UXO Estimator was used to design the investigation along the transects. Inputs to the UXO Estimator program included a UXO target density of 1 per acre at a confidence level of 95 percent. After the investigation was completed, the UXO Estimator program was used to analyze the field data and confirmed that the target inputs were achieved. The UXO Estimator program calculated a 95 percent confidence that there is less than 0.652 UXO per acre, which is an upper bound on the MEC density at RSA-072-R-01.

The RFI evaluated available sample data for usability and defined an appropriate data set for characterizing munitions constituents (MC) and hazardous and toxic waste (HTW) constituents at RSA-072-R-01, which consists of analytical results from the following:

- Sixteen surface soil samples
- Thirty subsurface soil samples
- One sediment sample
- One surface water sample
- Eight overburden groundwater samples
- One bedrock groundwater sample.

The samples were analyzed for one or more of the following: volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, explosives, and perchlorate. Although not within the CSM for RSA-072-R-01, analyses for VOCs and SVOCs were included for select groundwater and/or surface water samples to evaluate possible impacts from adjacent surface and groundwater sites. Figure 2-2 shows the RSA-072-R-01 sampling locations. The RSA-072-R-01 RFI consisted of statistically based MEC characterization and environmental sampling to evaluate potential releases from on-site activities. The nature and extent of contamination in soil, surface water, sediment, and groundwater at RSA-072-R-01 have been defined.

2.2 Nature and Extent of Contamination Summary

This section provides general summary information on the nature and extent of MEC and HTW/MC contamination at RSA-072-R-01. Further discussion of the investigative results is included in the RFI report (CB&I, 2016).

2.2.1 Munitions and Explosives of Concern

After MEC (sulfur trioxide and chlorosulfonic acid solution (FS)-filled 4.2-inch mortars) was encountered at 8 feet bgs during excavation for a utility line and a sump during construction activities at the Software Engineering Directorate complex (Building 6271 and others) which encompasses most of the RSA-072-R-01 area, a TCRA was performed in 2008-2009 with UXO support from the Technical Escort Unit (EODT, 2010). MEC and munitions debris (MD) were recovered during the TCRA using "mag and dig" procedures with either a Schonstedt GA-52Cx magnetic locator or a Geonics EM61-MK2 metal detector, hand tools, and mini-excavator. During the course of surface sweeps and intrusive operations, 17 MEC items were found and identified as 4.2-inch mortar projectiles (FS smoke-filled and either fuzed or unfuzed), all determined to contain energetics. Sixteen of the 4.2-inch mortars were uncovered and removed from the retention pond area from 15 locations (two projectiles were found in one location) and one 4.2-inch mortar projectile was located east of the retention pond at the location of the current Building 6267 and removed (Figure 2-1a).

No surface or subsurface MEC (in the form of a 4.2-inch mortar projectile) was found during the 2013 intrusive investigation of Geophysical Survey Areas 1, 2, and 3, either along the full-coverage investigation of the northern portion of Geophysical Area 2 or along the 84 east-west

transects within Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Survey Area 2 (Figure 2-1b). A total of 781 anomalies were investigated. An estimated 2,134.5 pounds of non-munitions-related debris and 55.8 pounds of MD were removed. The full-coverage investigation over 2.8 acres was able to conclude that a density of less than 1 MEC per acre is present within the northern portion of Geophysical Area 2. The UXO Estimator used within the transect areas of Geophysical Survey Areas 1, 2, and 3 (50.6 total acres of investigation with 4.26 acres of actual investigation) calculated that sampling was adequate to be 95 percent confident that there is less than 0.652 UXO per acre. During the RFI environmental sampling no MC was found in site soils at sufficiently high enough concentrations to pose an explosive hazard. Based on these results, the RFI concluded that although MEC may not be present at this site, RSA-072-R-01 retains limited statistical uncertainty regarding the presence of small numbers of MEC.

2.2.2 Hazardous and Toxic Waste/Munitions Constituents

Metals. All metals detected above their screening criteria in surface soil, subsurface soil, and groundwater were determined to be present at naturally occurring concentrations. No metals were detected in surface water and sediment at concentrations above their background screening values (BSV).

VOCs. VOCs are not a part of the CSM at RSA-072-R-01. However, surface water and groundwater samples were analyzed for VOCs to evaluate possible impacts from off-site sources. No VOCs were present at concentrations in surface water above the preliminary screening values (PSV). TCE was present at a concentration above its PSV in one overburden monitoring well sample downgradient of the site; no VOCs were detected above the PSVs in monitoring wells within the site boundary. Although the RSA-150 groundwater unit does not contain mappable plumes, TCE is a chemical considered to be ubiquitous within RSA-150 (APTIM, 2018).

SVOCs. SVOCs are not in the CSM at RSA-072-R-01. However, SVOCs were analyzed for in one historical groundwater sample from 2011, and none were present at concentrations above their PSVs.

Explosives. Explosives were not detected in any of the surface soil, subsurface soil, sediment, or surface water samples. 2-Nitrotoluene was the only explosive detected in overburden groundwater samples at concentrations above its PSV. 2-Nitrotoluene was not detected in the bedrock groundwater sample. Nitrobenzene and RDX were detected in the bedrock groundwater sample, but at concentrations below their respective PSVs.

Perchlorate. Perchlorate was not detected in any of the surface soil, subsurface soil, sediment, surface water, or overburden groundwater samples.

A summary of the nature and extent of contamination in soil, surface water, and sediment is presented on Figure 2-3. This figure demonstrates that all constituents were below their PSVs or determined to be naturally occurring for metals.

2.3 Site Risk Summary

Risks from exposure to MEC were identified based on the data quality objectives for the MEC investigation. In addition, an ARBCA human health risk evaluation, which includes a vapor intrusion evaluation, and a SLERA were performed for RSA-072-R-01 (CB&I, 2016). The site risks are summarized in Sections 2.3.1 through 2.3.4. The fate and transport evaluation is summarized in Section 2.3.5.

2.3.1 Munitions and Explosives of Concern Evaluation

No MEC was discovered during the RSA-072-R-01 RFI but chemically configured MEC had been previously found and removed prior to and during a TCRA in 2008-2009. As discussed in Section 2.2.1, the UXO Estimator statistical program was used to design the transect and single-point subsurface anomalies investigation. After the analog investigation, UXO Estimator confirmed that the target inputs were achieved, calculating with 95 percent confidence that there are less than 1.0 UXO per acre. Considering the actual area investigated, sampling was adequate to be 95 percent confident that there is less than 0.652 UXO per acre, which is an upper statistical limit. Based on this representative evaluation, it was concluded that RSA-072-R-01 retains limited statistical uncertainty regarding the presence of small numbers of MEC and thus may pose unacceptable risks to current and future human receptors at the site.

2.3.2 Current and Potential Future Land Use

RSA-072-R-01 is located in an area zoned as Industrial in the RSA Real Property Master Plan (U.S. Army Garrison-Redstone, 2013). Planned future use is also Industrial. RSA-072-R-01 is located in the area designated as RSA (NW), and the primary mission is administrative and research and development. Approximately 95 percent of this RSA (NW) area is utilized by test ranges or contains wetlands, floodplains, and environmental cleanup sites. Mitigation efforts are required for most areas within this parcel of land prior to development. This RSA (NW) area encompasses approximately 20 buildings/structures including the Software Engineering Directorate complex within the footprint of RSA-072-R-01. Where practical, the Army has restricted entry into the RCRA SWMUs by fencing them and/or placing warning signs at key entry points in accordance with the site access control (SAC) program (U.S. Army Garrison-Redstone, 2012). The area surrounding RSA-072-R-01 is not fenced but lies within the secure

RSA boundary. The Army has posted warning signs at key access locations within the site boundary. Site redevelopment (e.g., construction of parking lots, buildings, or other structures) is possible in the future, but residential use or daycare facilities are not anticipated for RSA-072-R-01 in the future.

2.3.3 Human Health ARBCA Evaluation

Plausible receptors evaluated under current and future site use of RSA-072-R-01 consisted of a commercial worker and a construction worker (commercial/industrial scenario). A residential receptor was also included as a potential hypothetical future receptor. It is not anticipated that RSA-072-R-01 will be developed such that it would be used residentially. Although Army risk regulations, policy, and guidance are to only evaluate those receptors that are actually at a site or could reasonably be anticipated to occur, the risk assessment conducted for RSA-072-R-01 in the RFI report (CB&I, 2016) included a residential use scenario only to comply with the AEIRG (ADEM, 2017a) and ARBCA guidance (ADEM, 2017b). RSA is legally mandated to comply with the Permit (ADEM, 2018). In the Permit, ADEM requires that these guidance documents including approved risk assessment work plans (IT Corporation, 2002; Shaw, 2010a) be adhered to during environmental investigations and evaluations. At RSA, the residential scenario is included in the risk assessment in order to determine if a site is eligible for unrestricted use as defined in Alabama Administrative Code (AAC) r. 335-5-1-.03(r) or support the use of land-use controls (LUC) as a component of the selected remedy. Therefore, risks to a residential site user receptor were assessed in the Risk Management (RM)-2 cumulative risk assessment.

A recreationist was not evaluated for exposure to surface water because no COCs were identified in surface water. Exposure to sediment is not evaluated for human health because sediment perennially covered with surface water is generally considered insignificant. The commercial worker, construction worker, and hypothetical residential receptors were evaluated for exposure to soil and groundwater hypothetically developed as a potable source. There is no current potable use of groundwater at RSA-072-R-01. An installation-wide groundwater interim record of decision (IROD) (Shaw, 2007) was instituted to prevent potable use and provide management control over nonpotable uses of all groundwater beneath RSA. The RSA SAC program (U.S. Army Garrison-Redstone, 2012) was designed to be used at sites that have not had final remedy selection made. The IROD is interim in nature and is not a final remedy. In order to design the final remedy, which may include LUCs, the potable use must be considered.

The ARBCA guidance (ADEM, 2017b) considers an individual excess lifetime cancer risk (IELCR) of 1E-05 to be the target cumulative risk. The target noncancer threshold is a hazard index (HI) of 1.0. Estimated cumulative risks/hazards at or below these target levels do not require additional action.

No chemicals were identified as COCs in surface soil, subsurface soil, total soil, surface water, and sediment during the preliminary screening level evaluation in accordance with ARBCA guidance. 2-Nitrotoluene and TCE were identified as COCs in groundwater because their maximum detected concentrations exceed their PSVs. Arsenic, chromium, lead, and bis(2-ethylhexyl)phthalate were retained as COCs in groundwater even though their maximum contaminant levels did not exceed their PSVs; ARBCA guidance (ADEM, 2017b) requires that any chemicals detected in groundwater that have maximum contaminant levels, whether they fail their PSV comparisons, be designated as COCs and included in the RM-2 cumulative risk assessment. All COCs from the preliminary screening level evaluation were further evaluated in the RM-2 cumulative risk assessment.

The cumulative IELCR and HI estimates for RSA-072-R-01 are summarized in Table 2-1. Since no COCs were identified in soil, no cancer risks or noncancer hazards were estimated. The cumulative IELCR for exposure to groundwater hypothetically developed as a potable source exceeded the ADEM target level of 1E-05 for the commercial worker and hypothetical resident receptor but not for the construction worker. The cumulative HI for exposure to groundwater exceeded the threshold level of 1.0 for all receptors.

Table 2-2 summarizes COCs requiring action in soil and significant contributors to unacceptable risk in groundwater. No COCs requiring action were identified in soil. 2-Nitrotoluene and TCE are COCs requiring action in groundwater for the commercial worker and hypothetical resident, while only TCE is a COC requiring action for the construction worker. Concentrations of TCE also exceeded its maximum contaminant level.

A screening-level vapor intrusion evaluation was conducted to determine whether there has been a release of VOCs to groundwater at RSA-072-R-01 that may volatilize and migrate upward to pose an unacceptable risk to occupants of current or future commercial/industrial buildings or a hypothetical residential building. No VOCs were analyzed in soil because VOCs are not part of the CSM; thus, it was not necessary to evaluate VOCs in soil for vapor intrusion. The vapor intrusion evaluation concluded that VOC concentrations in groundwater are unlikely to pose unacceptable health threats to occupants of existing buildings or buildings erected on site in the future (including residential buildings).

2.3.4 Screening-Level Ecological Risk Assessment

The SLERA for RSA-072-R-01 (CB&I, 2016) was conducted in accordance with the guidelines set forth in the ARBCA guidance manual (ADEM, 2008; 2017b), the RSA installation-wide work plan (IT Corporation, 2002), and the final SLERA supplements to the installation-wide work plan (Shaw, 2010a). A SLERA was performed in order to determine if the site is eligible

for no further action in accordance with ADEM requirements. Note that the SLERA relies on ecological screening values (ESV) rather than the human-health based PSVs.

The surface soil, sediment, and surface water data for RSA-072-R-01 were compared to their respective BSVs and ESVs. Constituents with concentrations above their BSVs (if applicable) and ESVs (or with no ESVs) were identified as preliminary chemicals of potential ecological concern (COPEC). A COPEC refinement process determined whether site-related constituents at RSA-072-R-01 have the potential to pose hazards to ecological receptors. The results and conclusions are described in the following paragraphs.

Surface Soil. The screening-level hazard evaluation for surface soil at RSA-072-R-01 identified aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, manganese, mercury, potassium, selenium, vanadium, and zinc as preliminary COPECs that required further evaluation (Table 2-3). All of the other constituents detected in surface soil at RSA-072-01 were detected at concentrations less than their respective ESVs and/or BSVs and considered to pose negligible ecological hazards.

The COPEC refinement process concluded that no further evaluation was warranted for aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, manganese, mercury, potassium, selenium, vanadium, and zinc in surface soil at RSA-072-R-01. Concentrations of aluminum, arsenic, barium, calcium, chromium, copper, iron, manganese, mercury, potassium, selenium, and zinc in surface soil at RSA-072-R-01 are likely naturally occurring; calcium and potassium are essential nutrients that do not require further evaluation when concentrations are determined to be naturally occurring; and cobalt and vanadium are not in the CSM. The results of the screening evaluation and COPEC refinement process indicated that further evaluation of chemicals in surface soil is not warranted.

Sediment. The results of the screening-level hazard evaluation for sediment at RSA-072-R-01 showed that all of the constituents detected in sediment at RSA-072-R-01 were detected at concentrations less than their respective ESVs and/or BSVs; therefore, no preliminary COPECs were identified that required further evaluation (Table 2-4).

Surface Water. The results of the screening-level hazard evaluation for surface water at RSA 072-R-01 showed that all of the constituents detected in surface water at RSA-072-R-01 were detected at concentrations less than their respective ESVs and/or BSVs; therefore, no preliminary COPECs that required further evaluation were identified (Table 2-5).

In summary, the results of the SLERA indicate that COPECs in surface soil, sediment, and surface water at RSA-072-R-01 are unlikely to pose hazards to ecological receptor communities

and/or populations, and further evaluation of ecological hazards at RSA-072-R-01 is not warranted.

2.3.5 Contaminant Fate and Transport Summary

This section summarizes the fate of contaminants in the environment and their potential transport mechanisms at RSA-072-R-01 (CB&I, 2016). The primary potential contaminant migration pathway is the dissolution of site-related chemicals from soil to form leachate and the subsequent transport to the water table resulting from the downward percolation of infiltrating rainfall. Overland transport of soil contaminants by wind or water is unlikely at RSA-072-R-01 because the site is relatively level, mostly wetland, and fairly well vegetated.

The RFI (CB&I, 2016) included an evaluation of the potential for migration of contaminants from soil to groundwater. This evaluation consisted of the comparison of site soil concentrations to RSA-specific dilution-attenuation factor (DAF)4 soil screening levels (SSL). Site-related chemicals with concentrations above these SSLs were evaluated further considering a variety of factors including considering the presence or absence of the constituent in groundwater, the magnitude of the exceedance in soil, the frequency of exceedances in soil, the vertical distribution of exceedances, borehole average compared to soil screening levels, and leachability study data. All metals detected in soil were determined to be naturally occurring and therefore did not require an evaluation for potential leaching to groundwater. No VOCs, SVOCs, perchlorate, or explosives were detected at concentrations above their RSA-specific DAF4 SSLs. Thus, no contaminant detected in soil at RSA-072-R-01 is considered to be a current or future source of contamination to groundwater from the soil-to-groundwater migration pathway.

2.4 Site Hazards

The site hazards with MEC at RSA-072-R-01 are presented in Sections 2.4.1 and 2.4.2.

2.4.1 Munitions and Explosives of Concern Hazard Assessment

A MEC hazard assessment is used to evaluate the potential explosive hazard associated with conventional MEC present at a site under a variety of site conditions, including various cleanup scenarios and land-use assumptions (EPA, 2008). However, none of the items recovered during the RFI intrusive investigation at RSA-072-R-01 were classified as MEC. Therefore, a MEC hazard assessment score was not required.

2.4.2 Munitions Response Site Prioritization Protocol Summary

The Munitions Response Site Prioritization Protocol (MRSPP) is a methodology developed by the DoD to assess the relative risks and assign a relative priority to Munitions Response Sites (MRS) (DoD, 2007). The MRSPP uses three modules to evaluate hazards associated with a site:

Explosive Hazard Evaluation (EHE) Module, Chemical Warfare Materiel Hazard Evaluation (CHE) Module, and Health Hazard Evaluation (HHE) Module. The overall MRSPP priority is determined by converting the individual module rating scores to priorities. As summarized from the tables included the RSA-072-R-01 RFI report (CB&I, 2016), the results of applying this protocol to RSA-072-R-01 are as follows:

- ***EHE Module: E***. "A" is the highest rating (highest priority) and "G" is the lowest rating (lowest priority). RSA-072-R-01 originally scored a "B" for the EHE module as a result of the SI process (Malcolm Pirnie, Inc., 2008b). However, a TCRA was completed at the site in 2008-2009 that identified and removed MEC that included 4.2-inch mortar projectiles. During the RFI, no MEC was encountered but MD was removed. Based on the completion of the TCRA and the results and conclusions of the RFI, the EHE module rating was updated to "E."

- ***CHE Module: No Known or Suspected Chemical Warfare Materiel Hazard (alternate rating).*** There is no history of chemical warfare materiel use or disposal at RSA-072-R-01.

- ***HHE Module: G***. "A" is the highest rating (highest priority) and "G" is the lowest rating (lowest priority). Based on the RFI sampling conducted, which detected metals in soil at naturally occurring conditions and explosives-related compounds below their HHE module comparison values in groundwater, the HHE module rating was assigned a rating of "G."

- ***MRS Priority: 6***. "1" is the highest rating (highest priority) and "8" is the lowest rating (lowest priority). The MRS priority is determined by converting the individual module rating scores to priorities. RSA-072-R-01 was assigned a priority of 6.

2.5 Final Conceptual Site Model

A CSM was developed for RSA-072-R-01 based on historical operations; site information; and soil, sediment, surface water, and groundwater data. Figure 2-4 presents a visual representation of the site, including potential contaminant sources, migration pathways, investigated media, chemicals warranting action in site media, and potential receptors. Figures 2-5 and 2-6 present the CSMs for MEC and MC, respectively, and illustrate the source (site and MEC location), interactions (activity and access), and potential receptors.

The final CSMs for MEC, MC, and HTW for RSA-072-R-01 include the following main components:

- MEC and MC may be present at RSA-072-R-01 based on past uses of RSA-072 as a mortar test range with slight overlap of a troop training area and the presence of powder storage magazines. MEC was confirmed at RSA-072-R-01 and removed prior to and during a TCRA in 2008-2009. Given the mortar test range, there is the possibility that exploded and unexploded mortar projectiles remain in this area

following the TCRA, where unexploded projectiles could have penetrated into the subsurface. No historical documentation has been found indicating use of a projectile filled with a chemical warfare materiel at RSA-072. Figure 2-5 shows that MEC presents a potentially complete pathway for current and future receptors at the site.

- Troop Training Area C slightly overlaps RSA-072-R-01 along its eastern boundary south of Hale Road. Details regarding the nature of the training activities conducted within this area have not been found (Shaw, 2006). If any munitions-related training items were used, they could have been dropped on the ground as either expended or unexpended. Over time and through the deposition of organic matter or development of the land, these items would have become buried.

- Given the powder storage magazines, handling of powder (type unknown) could have resulted in surface spills. However, these magazines were investigated and are not a current source for MC.

- A direct exposure pathway to surface water and sediment was not included in the CSM since the existing evaporation pond does not appear in aerial photographs until after 1984; this pond would not have been directly impacted by mortar projectiles. Given their distances from the evaporation pond, the troop training area and powder storage magazines would not have directly impacted the pond.

- Potential munitions-related contaminants were as follows:

  – 4.2-inch mortars: explosives (HMX, RDX, and TNT), metals (lead, copper, and zinc), and perchlorate.

  – Smokeless powder: explosives (e.g., nitroglycerin and dinitrotoluene).

  – Flares: metals, explosives, and perchlorate.

  – Blank small-arms ammunition: metals (aluminum, antimony, iron, copper, lead, and zinc).

  Figure 2-6 shows the pathways for MC are complete but do not pose unacceptable risk.

- The most viable contaminant transport pathway is leaching of contaminants from soil to groundwater. An evaluation of contaminant transport revealed that no contaminants in RSA-072-R-01 soil pose a potential leaching threat to groundwater.

- Current human receptors are limited to commercial and construction workers. Future potential receptors include all current receptors, plus recreational users and hypothetical child and adult residents under a land reuse scenario. No COCs for HTW/MC were identified in soils, surface water, or sediment (Figures 2-4 and 2-6) but the potential presence of low-probability MEC that could present risks to receptors remains at the site (Figure 2-5).

3.0 Decision Summary

As discussed in Section 2.2.1, the UXO Estimator statistical program was used to design the transect and single-point subsurface anomalies investigation. After the analog investigation, UXO Estimator confirmed that the target inputs were achieved, calculating with 95 percent confidence that there are less than 1.0 UXO per acre, which is the upper bound on the MEC target density at RSA-072-R-01. Considering the actual area investigated, sampling was adequate to be 95 percent confident that there is less than 0.652 UXO per acre, which is within the target density. These results were based on the DGM, and intrusive investigations that were performed in full coverage (northern portion of Geophysical Survey Area 2) or along transects in select areas (Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Survey Area 2) to characterize MEC at RSA-072-R-01. Consideration that this site was originally part of an active proofing range, and the statistical uncertainty regarding the presence of munitions and explosives of concern, plus the fact that chemically configured munitions and explosives of concern were found at this site, and removed during a prior action, it was concluded that RSA-072-R-01 retains a limited probability regarding the presence of small numbers of MEC and thus may pose unacceptable risks to current and future human receptors at the site.

The RSA-072-R-01 RFI report also concluded that the Army's historical operations at this site have not resulted in the release of hazardous chemicals that pose an unacceptable risk to human health or the environment or a leaching threat to groundwater. Therefore, no corrective measures are needed for chemicals present in soil, surface water, and sediment at RSA-072-R-01. However, because of the site's limited statistical uncertainty regarding the presence of small amounts of MEC and potential unacceptable risks to receptors at the site, corrective measures are required to ensure the likelihood of current and future human receptors encountering MEC is negligible.

Based on these RFI findings, this chapter identifies the CMOs and notes that numerical CGs are not applicable at RSA-072-R-01 since CGs are used in evaluating alternatives (or those parts of alternatives) that rely on reduction of chemical concentrations to achieve the CMOs. For MEC, CMOs are defined differently than for chemicals, as there are no established risk-based "values" to use for MEC.

3.1 Basis for the Action

The RFI did not identify any MEC on the ground surface or in the subsurface at RSA-072-R-01. However, because of the site's historical use as a mortar-tube proofing range, the presence of MEC identified and removed prior to and during the 2008-2009 TCRA, and the fact that a full

site investigation for MEC was not performed, this site retains limited statistical uncertainty regarding the presence of small amounts of MEC and thus the potential for the presence of MEC that could pose risks to receptors remains. The RFI report (CB&I, 2016) concluded that corrective measures are required to prevent MEC exposure to current and future human receptors at RSA-072-R-01. Two COCs (TCE and 2-nitrotoluene) were identified in groundwater but will be addressed separately by the RSA-150 groundwater unit corrective measures.

3.2 Corrective Measure Objective

The CMO for RSA-072-R-01 is as follows:

- Prevent direct human contact with MEC, thereby reducing hazards associated with a "low" probability MEC site consistent with current and future land use.

The Army intends to achieve this CMO for RSA-072-R-01 through implementation of LUCs around the former TCRA area/retention pond in accordance with a notice of environmental use restriction (NEUR) regulated by AAC r. 335-5-1-.02(3) and site access and use restrictions for the remainder of the site in accordance with RSA SAC regulations (U.S. Army Garrison-Redstone, 2012) and the RSA Explosive Safety Management Program (ESMP) (U.S. Army Garrison-Redstone, 2018).

3.2.1 Cleanup Goals for the Corrective Measures

Corrective measures and CGs are developed based on consideration of applicable laws and regulations as well as consideration of concentrations that will achieve an acceptable risk/hazard. As previously indicated, the CMO is related to reducing the hazards associated with potential MEC, where numerical CG values are not applicable. However, the CMO can be achieved by actions that will ensure the likelihood of encountering MEC is negligible.

3.2.2 Need for Corrective Measures

Because of the site history as a former range and the fact that chemically configured MEC was found and removed during a prior action at this site, plus the limited statistical uncertainty regarding the presence of MEC, this site does not meet the requirements needed for unrestricted use as defined in AAC r. 335-5. Unrestricted use is defined as the "designation of acceptable future use at a property or site where the remediation levels, based on either background or standard exposure factors, shall have been attained in all media to allow the property or site to be used for any purpose." The Army intends to manage this uncertainty through implementation of corrective measures in order to protect human health. The selected corrective measures for RSA-072-R-01 include LUCs and site access and use restrictions which will ensure that all intrusive site activities are managed so that the likelihood of encountering MEC is negligible.

3.2.3 Applicable Regulations

Corrective measures must consider applicable federal and state laws and regulations as well as consideration of concentrations that will achieve an acceptable risk/hazard. Potential regulations were reviewed for applicability to the RSA-072-R-01 corrective measures and are summarized in Table 3-1. The following regulation is relevant to the selection of LUCs and site access and use restrictions as the corrective measures for RSA-072-R-01:

- Alabama Uniform Environmental Covenants Program, Chapter 335-5.

This regulation establishes the requirements for an environmental covenant for a site if the site is not being remediated to unrestricted use. AAC r. 335-5-1-.02(3)(a) states "In lieu of an environmental covenant, a Notice of Environmental Use Restriction for properties or sites owned by the federal government shall be prepared and submitted to ADEM for approval that gives notice of the current and future use of the federal property."

3.2.4 Scope of the Corrective Measures

The overall strategy for cleanup at RSA has been presented to the regulatory agencies in two cleanup strategy documents, the *Installation-Wide Groundwater Cleanup Strategy* (Shaw, 2009) and the *Installation-Wide Strategy for Cleanup of Impacted Wetlands* (Shaw, 2010b). The scope of the corrective measures for RSA-072-R-01 is consistent with these strategies. The selected corrective measures will ensure the likelihood of encountering MEC at this site is negligible. Without corrective measures, exposure to MEC poses a potential risk to current and future receptors. Corrective measures for groundwater will be conducted by the RSA-150 groundwater unit and are not as part of this scope.

3.3 Corrective Measures Evaluation and Selection

The following information summarizes the analysis of technologies and alternatives and selection of the corrective measures for this site in the corrective measures study report (CB&I, 2017).

3.3.1 Summary of the Corrective Measure Alternatives Evaluation

The site conditions at RSA-072-R-01 met the requirements under EPA guidance for a streamlined or focused corrective measures study (EPA, 1994). Five technologies were screened against the criteria of performance, reliability, safety, implementability, and cost.

The following three technologies considered in the initial screening were not retained for further development and evaluation (CB&I, 2017):

- ***Surface MEC Removal.*** No surface or subsurface MEC was found within the current boundary of RSA-072-R-01 during the RFI, resulting in a statistically determined UXO density of less the 0.652 per acre with 95 percent confidence within the transect investigation areas. Thus, the likelihood of MEC being found on the surface is very low. Since LUCs and/or site access and use restrictions would still be needed to address the potential for buried MEC with this technology, surface MEC removal was not retained.

- ***Focused MEC Removal.*** Since MEC was not found at the site during the RFI, a focused MEC removal was not retained.

- ***Full MEC Removal.*** Before a full search and removal of MEC could be performed on the surface and subsurface at RSA-072-R-01, vegetation and tree clearing would be required in parts of the site for proper operation of MEC detection equipment, provide the required ground visibility, and allow for the full search and removal of MEC. The soil/sediment would require sifting, a very time-consuming process. There would be adverse impacts to the environment (e.g., aquatic habitat within the evaporation pond) as a result of this technology, and also potential issues with managing the floodplain area of the site. This technology would be extremely expensive to implement (millions of dollars) and would be destructive to the environment, and there is a low probability of finding MEC. Although this technology would be effective, it was deemed too costly and not a good use of the government's money. Thus, this technology was not retained as a feasible alternative for RSA-072-R-01.

No action, LUCs, and site access and use restrictions were retained as feasible technologies and packaged into the following corrective measure alternatives for RSA-072-R-01:

- ***Alternative 1: No Action.*** Under the no-action alternative, no corrective measures would be taken to address the potential MEC hazards at RSA-072-R-01. Because this alternative may not be protective of human health and the environment, it is not considered a candidate for implementation but presents a baseline for evaluating other retained alternatives.

- ***Alternative 2: LUCs and Site Access and Use Restrictions.*** This alternative involves implementation of LUCs and site access and use restrictions on land use at RSA-072-R-01 due to potential hazards with MEC including signage, on-call UXO construction support for intrusive activities, restricting future land use in the RSA Real Property Master Plan, and annual inspections.

Because of the potential for exposure to MEC at the site, which may pose unacceptable risks to current and future human receptors, the no-action alternative did not meet the CMO to reduce the hazards to low probability MEC at the site. Implementation of Alternative 2 would prevent

receptor exposure to MEC and limit impacts to the environment. Therefore, Alternative 2 was selected as the preferred corrective measure for RSA-072-R-01.

3.3.2 Selected Corrective Measures

The Army selected Alternative 2 as the corrective measure that most appropriately addresses the limited statistical uncertainty regarding the presence of MEC that remains at RSA-072-R-01. LUCs and site access and use restrictions allow the Army to manage this uncertainty in order to protect human health and minimize impacts to environmentally sensitive areas. The site access and use restrictions will ensure that all intrusive activities that may be conducted at the site are safely managed. The major components of this alternative include the following:

- Posting of warning signs (U.S. Army Garrison-Redstone, 2012)
- Availability of on-call UXO construction support (U.S. Army Garrison-Redstone, 2018)
- Outlining restrictions for this site in the RSA Real Property Master Plan (U.S. Army Garrison-Redstone, 2013)
- Complying with AAC r. 335-5-1-.02(3)(a) for a NEUR.

Army site access and use restrictions were chosen over the other alternative because they provide the best balance of trade-offs with respect to the evaluation criteria. Because restrictions for site access and use are needed for this site, it is not eligible for no further action at this time.

3.4 Request for Permit Modification

The RFI report for RSA-072-R-01 (CB&I, 2016) was approved by ADEM on December 29, 2016. A copy of the ADEM concurrence letter for the RFI report is included in Appendix A. The request for permit modification (Appendix B) accompanies this CMI work plan for RSA-072-R-01 and presents the supporting information, including all procedures necessary to implement and monitor the corrective measures for this site in accordance with AAC r.335-14-8-.04(2). The inclusion of this request for permit modification meets requirements specified in Section VI.E.3 of the Permit.

4.0 Corrective Measures Implementation

This chapter provides an overview of the corrective measures activities for RSA-072-R-01. The general schedule for implementation of corrective measures at RSA-072-R-01 is provided in Appendix C. Communication and coordination during the CMI will follow the installation-wide quality assurance program plan (Shaw, 2013 and as updated) for the Army and ADEM, and RSA's community involvement plan (CB&I, 2015 and as updated) for the Army and the public.

The corrective measures to be implemented at the former TCRA area/retention pond consist of LUCs. Site access and use restrictions will be implemented at the remainder of the site. These areas are shown on Figure 4-1.

4.1 LUCs at Former TCRA Area/Retention Pond

4.1.1 Preliminary Activities

Preliminary activities include procurement and subcontracting, mobilization, requirements for base access, digging permits, utility marking, surveying, and obtaining on-call UXO construction support. All field personnel will follow this work plan.

4.1.1.1 Procurement and Subcontracting

The following subcontracted services may be required for the completion of the project:

- On-call UXO construction support
- Utility locating
- Surveying.

Support materials will be procured through equipment vendors and shipped directly to the site. Support materials and equipment includes radios, pin flags, signs, and posts. Copiers and fax machine at the contractor's office will also be used to support the work at RSA-072-R-01.

4.1.1.2 Mobilization

Upon notice to proceed, the contractor will begin mobilization, including the deployment of personnel, equipment, subcontractors, and materials necessary to commence CMI activities at RSA 072-R-01. After field mobilization, contractor personnel will attend a preconstruction meeting and safety orientation to review the tasks and the sequencing of work to ensure safe

work activities and a clear line of communication is established. All necessary site-specific safety training will be conducted at this time.

4.1.1.3 Access to Redstone Arsenal

RSA is a secure facility; badging for civilians will be conducted in accordance with all applicable requirements as are current upon the future contract award to implement corrective measures at the three sites.

Military and government personnel will present current military (active, retired, or family) or federal government identification cards and do not require a host RSA organization. Further information may be obtained by contacting the RSA Visitor's Center located at Gate 9 at (256) 876-1122.

Registered personnel may access RSA-072-R-01 using Gate 1 at Martin Road or Gate 9 at Rideout Road. Directions from Gate 1 at Martin Road to the RSA-072-R-01 site are west along Martin Road and south on Patton Road. Gate 9 is open seven days a week and 24 hours per day. Directions from the Gate 9 at Rideout Road to the RSA-072-R-01 site are south along Rideout Road and west on Hale Road. Gate 1 is open five days a week (Monday through Friday) from 0530 to 2100. Gate hours and conditions are subject to change; therefore, operational hours should be verified.

4.1.1.4 Digging Permit and Utility Marking

In advance of any new sign post installation, a job order request that describes the proposed activities will be submitted. This information will be provided to RSA through a system that affords various RSA entities the opportunity to review the proposed activities and verify that impacts to RSA resources (e.g., natural, cultural, etc.) are properly managed.

Also prior to any new sign post installation, a digging permit will be requested from the RSA Directorate of Public Works. As part of this permit, RSA will locate and mark underground utilities in the vicinity of the proposed intrusive working area. The procedure requires notification by telephone ([256] 876-9881) within 14 days of intrusive activities and requesting a work order for a digging permit.

The digging permit must be renewed every 30 days, if required. To avoid temporary shutdown, a request for permit extension will be made at least 1½ weeks prior to expiration for the extension to be granted.

4.1.1.5 Surveying of LUC Area

A licensed land surveyor in the state of Alabama will be subcontracted to delineate the LUC boundary at RSA-072-R-01. The perimeter of the area will be marked with highly visible wooden stakes, tape, or pin flags for the survey. The proposed LUC boundary with Geographic Information System (GIS) coordinates for the former TCRA area/retention pond is shown on Figure 4-1. A figure with coordinates from the survey plat for the final LUC boundary will be included in the CMI report for this action.

4.1.1.6 On-Call UXO Construction Support

The probability of encountering UXO has been determined to be low at this site, and on-call UXO construction support has been determined to provide the appropriate level of protection for conducting the sign installation, routine LUC inspections, and other intrusive construction activities as required by the Army. Prior to the start of work, explosive ordnance disposal or UXO-qualified personnel will be contacted to ensure their availability, advised of the project tasks, and placed on call to assist if suspected UXO is encountered during the construction activity (DoD, 2008).

4.1.2 Posting of Signage

Signs will be posted around the perimeter of the former TCRA area/retention pond where MEC was found noting that digging is prohibited without on-call UXO construction support and the approval of the Chief, Installation Restoration Branch, within the Environmental Management Division. Figure 4-2 shows the proposed sign details. Minor text adjustments may be made to the signs based on input from RSA's safety office or other reviews or as needed to conform to the physical layout of the sign. The final verbiage used will be included in the CMI report for this site. The signs and lettering must be visible from a distance of 25 feet. The proposed area for LUCs where signs will be placed around the LUC area perimeter is shown on Figure 4-3. Twenty-one signs are planned for placement around the LUC area boundary on an approximate 100-foot spacing consistent with signage spacing at other RSA sites closed with LUCs.

4.1.3 Inspections

The signs will be inspected annually or as specified in Appendix D of the SAC program (Army, 2012). The inspections will ensure that the signs are present and that undocumented activities are not occurring on the site inconsistent with the LUCs.

4.1.4 Daily Reports

Daily reports which include daily construction logs will be prepared during the conduct of the CMI activities at RSA-072-R-01, and RSA will be provided a weekly submittal of daily construction logs throughout the duration of the activity in accordance with the quality assurance

program plan (Shaw, 2013 or as updated). Variances, inspection forms, survey data, photographs of corrective measures, and dig permits will be included in the project reporting (Section 4.1.7).

4.1.5 Demobilization

Personnel, equipment, and subcontractors will be demobilized from the project site after completion of the LUC corrective measures activities.

4.1.6 Implementation of LUCs

LUCs will be implemented in accordance with AAC r. 335-5 (ADEM, 2013) to ensure that any soil disturbance conducted at RSA-072-R-01 remains protective of human health. The LUC boundary area is shown on Figure 4-1. Signs will be placed around the perimeter of the LUC area stating that soil disturbance is prohibited without Army approval and availability of on-call UXO construction support; a contact phone number will be provided for Army review and approval of requested tasks. Proposed specifications for the signs are presented on Figure 4-2 with any revisions to be managed as per Section 4.1.2. The following institutional controls will be implemented at the former TCRA area/retention pond where MEC was found in this portion of RSA-072-R-01:

- Implementation of an NEUR in accordance with AAC r. 335-5-1-.02(3) that will restrict land use at RSA-072-R-01 (ADEM, 2013) and require inspection, maintenance, and repair of signage as well as on-call UXO support for intrusive site activities. The finalized NEUR will be included in the CMI report for this site.
- Incorporation of the NEUR into the RSA Real Property Master Plan as required by AAC r. 335-5-1-.02(3)(a)(1)(iv) (ADEM, 2013).
- Recording of the NEUR in the land records for the property, as required by AAC r. 335-5-.02(3)(a)(1)(iv).

The requirements of the NEUR are discussed in Sections 4.1.6.1 and 4.1.6.2.

4.1.6.1 Survey Plat

In accordance with the Permit (ADEM, 2018 and as updated), where land cannot be released for unrestricted use, RSA will submit a survey plat indicating the locations and dimensions of the land area included in the LUC boundary at RSA-072-R-01 in accordance with Section VIII.B.5 of the Permit. The survey plat shall be submitted to the Madison County Probate Judge's Office and to ADEM as part of the NEUR in the CMI report. This survey plat must be prepared and certified by a professional land surveyor registered in the state of Alabama and contain a prominently displayed note stating RSA's obligations to limit property to the specified restricted uses. The survey plat shall be maintained as described in the Permit until RSA can demonstrate to ADEM that the levels of hazardous constituents in all contaminated media are within limits

appropriate for unrestricted land uses. A preliminary plan showing the areas to which LUCs will be applied is shown on Figure 4-1, with draft survey coordinates from the GIS database (latitude and longitude) of the corners of the LUC boundary.

4.1.6.2 Notice of Environmental Use Restriction

An NEUR is required when an approved CMI allows a cleanup that will not result in remediation of the property or portions of the property to unrestricted use. The purpose of an NEUR is to ensure that risks to human health and/or the environment are properly managed by imposing activity and use restrictions on the applicable portions of the property and making these restrictions a legal obligation until the NEUR is removed. The Army has determined that there is a low probability of encountering MEC as documented on the UXO probability map included in the SAC regulation (Army, 2012) within the boundary of the former TCRA/retention pond area where MEC was found and throughout the site. The following restrictions will be imposed and enforced:

- The signs will be inspected annually (or as specified in Appendix D of the SAC program [Army, 2012])
- The site must remain for industrial use only.

A completed NEUR will be provided in the CMI report for this site. ADEM will be notified within 10 days after uses inconsistent with the NEUR are identified. Additionally, notice regarding any observed changes in use, identified proposed changes in use, applications for building permits, or proposals for site work inconsistent with the NEUR will be provided to ADEM as part of the annual monitoring report.

Once the NEUR is approved, ADEM will execute and return the original document to RSA to be filed in the Madison County Probate Judge's Office within 30 days of receipt and no later than the submission of the survey plat. Certification that the NEUR was recorded with the Madison County Probate Judge's Office will be submitted to ADEM. This certification will include a copy of the NEUR and the document in which the notation was placed. RSA will maintain the NEUR until such time in the future that conditions can be demonstrated to ADEM's acceptance that the land can be released for unrestricted use.

If the property is transferred to an owner that is not the federal government, an environmental covenant will be executed and filed at that time in accordance with AAC r. 335-5-1-.02(3)(a)(1)(i) (ADEM, 2013).

4.1.7 Corrective Measures Implementation Reporting

A CMI report will be prepared following installation of signage at the site and the survey of the LUC boundary. This report will include the completed NEUR with the required legal description of the property.

4.1.8 Ongoing Obligations and Responsibilities

4.1.8.1 Inspections and Repairs

Inspections will be conducted and documented on an annual basis as follows:

- Inspection of the signage around the LUC boundary to determine whether signs are still present and legible.
- Repairs/replacements to the warning signs shall be completed on an as-needed basis to maintain access control and shall be initiated within 10 days of identifying the need for such repairs.
- Ensure that site use remains for industrial use only.

ADEM will be notified within 10 days after uses inconsistent with the NEUR are identified.

4.1.8.2 Monitoring

An annual inspection report will be submitted to ADEM. This report will document the inspections and identify the status of the NEUR and how any deficiencies or inconsistent uses have been addressed. The annual evaluation will address whether the use restrictions and controls referenced previously were communicated in the deed(s), the owners and state and local agencies were notified of the use restrictions and controls affecting the property, and use of the property has conformed with such restrictions and controls. The report will include a copy of the inspection forms, any violations noted, and recommendations for any changes to the NEUR. Annual monitoring of signage will be conducted for visibility, maintenance, and repairs, as necessary, to ensure their long term effectiveness and protection.

4.1.8.3 Notices

Notice shall be provided to ADEM in the annual monitoring report regarding any observed changes in use, any identified proposed changes in use, applications for building permits, or proposals for any site work inconsistent with the NEUR. RSA shall notify ADEM at least 90 days in advance of the proposed closing on any sale or other conveyance of any interest in any or all of the Property, in accordance with ADEM Memorandum #304 as cited in RSA's Permit. If the property is transferred to an owner that is not the federal government, an environmental

covenant will be executed and filed at that time in accordance with AAC r. 335-5-1-.02(3)(a)(1)(i) (ADEM, 2013).

4.2 Site Access and Use Restrictions at Remainder of the Site

For the site areas outside of the 2008-2009 TCRA area/retention pond where MEC removal was conducted, the Army will implement site access and use restrictions in accordance with the RSA Real Property Master Plan (Army, 2013) and the RSA ESMP (Army, 2018).

4.2.1 Warning Signs

The Army has posted four warning signs at key access locations within the remainder of the site where receptors would likely access the site. Figure 4-3 shows the locations of the warning signs currently in place through the Army's SAC program. The warning signs ensure that potential human receptors contact the Chief, Installation Restoration Branch for approval of any actions that may require soil disturbance; the contact number is provided on each sign. These signs are inspected annually and maintained in accordance with the SAC Program 200-7 (Army, 2012).

4.2.2 Site Access and Use Restriction Boundary

The site access and use restriction boundary for the remainder of the site is shown on Figure 4-1. The site access and use restriction boundary coincides with the site boundary of the areas outside of the area designated as former TCRA area/retention pond where MEC was found. This site access and use restriction boundary is captured and maintained in the RSA Real Property Master Plan (Army, 2013) and the RSA ESMP (Army, 2018). The GIS coordinates for the site access and use restriction boundary are presented on Figure 4-1.

4.2.3 On-Call UXO Construction Support

The probability of encountering UXO has been determined to be low within the remainder of the site, and on-call UXO construction support has been determined to provide the appropriate level of protection during the conduct of the routine site access and use inspections and any construction activity that may be necessary. Army personnel who would access this site for the site access and use restriction inspections and potential construction activities are trained in accordance with the ESMP (Army, 2018) and on call explosive ordnance disposal personnel are available 24/7 through the U.S. Army Aviation and Missile Command Safety Office if suspected UXO is encountered.

4.2.4 Master Plan Restrictions

The Army has specified site access and use restrictions for the remainder of the site in the RSA Real Property Master Plan to ensure compliance with this CMIP (Army, 2013). This site is located in a designated area of RSA where future industrial development can occur but

restrictions or mitigation efforts may be required. These restrictions include a requirement for use of anomaly avoidance and on-call UXO construction support for any development or construction activities within the site access and use restriction boundary. The restrictions in the RSA Real Property Master Plan will be maintained until the Army can demonstrate that the uncertainty with the potential for MEC at the site no longer remains and the land use would be suitable for unrestricted use and exposure. It is understood that a permit modification would be needed to remove the site access and use restrictions from this site.

4.2.5 Site Access and Use Restriction Inspections

The Army will conduct site access and use restriction inspections annually for the remainder of the site to ensure compliance with AAC r. 335-5-1-.02(3)(a). These inspections will ensure 1) the land use remains appropriately restricted to commercial/industrial, 2) the signs remain present and legible, 3) intrusive activities within the site are conducted with appropriate approvals and safety controls (e.g., anomaly avoidance and on-call UXO construction support), and 4) undocumented activities inconsistent with the site access and use restrictions are not occurring at the site. Sign repair or replacement will be made on an as-needed basis. The Army will document the annual inspections in accordance with the SAC program (Army, 2012) and the ESMP (Army, 2018). These inspection records will be made available to ADEM upon request. The Army will notify ADEM within 10 days if the inspections identify any site uses inconsistent with the restrictions imposed on the site.

4.2.6 Environmental Use Restriction

An NEUR is required when an approved CMI allows a cleanup that will not result in remediation of the property or portions of the property to unrestricted use (Table 3-1). The purpose of an NEUR is to ensure that risks to human health and/or the environment are properly managed by imposing activity and use restrictions on the applicable portions of the property and including these restrictions into the RSA Real Property Master Plan. In the case of RSA-072-R-01, the Army has determined that there is a low probability of encountering MEC as documented on the UXO probability map included in the SAC regulations (Army, 2012). The Army will comply with the AAC r. 335-5-1-.02(3)(a) for the NEUR for RSA-072-R-01.

4.2.7 Property Transfer

RSA will notify ADEM at least 90 days in advance of the proposed closing on any sale or other conveyance of any interest in any or all of the Property. If the property is transferred to an owner that is not the federal government, an environmental covenant will be executed and filed at that time in accordance with AAC r. 335-5-1-.02(3)(a)(1)(i) (ADEM, 2013).

5.0 Contingencies

Available information including historical records and recent environmental sampling data was reviewed with respect to MEC, chemical warfare materiel, or chemical agent potential at RSA-072-R-01. The review indicated that the probability of encountering UXO is low. Based on this evaluation, it was determined that chemical agent monitoring or on-site UXO construction support will not be required for the conduct of the corrective measures at RSA-072-R-01. However, in the event any suspicious item is encountered, all work shall stop. The on-call UXO construction support will be contacted. The notification procedures specified in the RSA ESMP (Army, 2018), and requirements specified in EM 385-1-97 (DoD, 2008) will be followed. Any suspect MEC encountered during the inspections will be marked for avoidance, documented, and managed in accordance with the ESMP (Army, 2018).

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ATTACHMENT 1

LIST OF ACRONYMS AND ABBREVIATIONS

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter
µg/m^3	micrograms per cubic meter
ºC	degrees Celsius
ºF	degrees Fahrenheit
%D	percent difference
%R	percent recovery
1,1,2-TCA	1,1,2-trichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-Dichloroethene
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4,5-TP	2,4,5-trichlorophenoxypropionic acid
2,4-D	2,4-dichlorophenoxyacetic acid
2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
AAC	Alabama Administrative Code
AAFES	Army and Air Force Exchange Service
AAP	Army Ammunition Plant
AB	ambient blank
ABLM	adult blood lead model
ABP	agent breakdown products
ABS	dermal absorption factor
ACAD	AutoCadd
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos-containing material
ACSIM	Assistant Chief of Staff for Installation Management
ADAF	age-determined adjustment factor
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
AEC	U.S. Army Environmental Command
AEDA	ammunition, explosives, and other dangerous articles
AEDB	Army Environmental Database
AEIRG	Alabama Environmental Investigation and Remediation Guidance
AEL	airborne exposure limit
AET	apparent effects threshold
AF	soil-to-skin adherence factor
AFFF	Aqueous Fire Fighting Foam
AGS	Alabama Geographic Society
AHA	ammunition holding area
AHWMMA	Alabama Hazardous Wastes Management and Minimization Act
AIPH	Army Institute of U.S. Public Health
AL	Alabama
ALDOT	Alabama Department of Transportation
ALNHP	Alabama Natural Heritage Program
amb.	amber
AMRDEC	Aviation and Missile Research, Development, and Engineering Center
amsl	above mean sea level (1988 North American Vertical Datum, NAVD 88)
ANOVA	Analysis of Variance
AOC	area of concern
AOI	area of investigation
AP	armor piercing
APEC	areas of potential ecological concern
APHC	U.S. Army Public Health Center
APT	armor-piercing tracer
APTIM	Aptim Federal Services, LLC
AR	Army Regulation
AR/COC	analysis request/chain of custody
ARAR	applicable or relevant and appropriate requirement
ARBCA	Alabama Risk-Based Corrective Action
AREE	area requiring environmental evaluation
ARFO	ammunition returned from overseas
Army	U.S. Army
AS	air sparging
ASCII	American Standard Code for Information Interchange
ASP	Ammunition Supply Point
ASR	archives search report
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
ASV	alternative screening value
ASWCC	Alabama Soil and Water Conservation Committee
AT	averaging time
ATF	Bureau of Alcohol, Tobacco, Firearms and Explosives
atm-m^3/mol	atmosphere cubic meters per mole
ATS	alternative treatment standard

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
ATSDR	Agency for Toxic Substances and Disease Registry
ATTN	attention
ATV	all-terrain vehicle
AUF	area use factor
AWARE	Associated Water and Air Resources Engineers, Inc.
AWBC	alternative water balance cover
AWQC	ambient water quality criteria
AWQS	ambient water quality standard
B	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)
BAF	bioaccumulation factor
$BAF_{soil\text{-}to\text{-}invert}$	soil-to-invertebrate bioaccumulation factor
BaOH	barium hydroxide
BAP	benzo(a)pyrene
BCF	bioconcentration factor
BCT	BRAC Cleanup Team
BDCM	bromodichloromethane
BEHP	bis(2-ethylhexyl)phthalate
BEM	Buried Explosion Module
BERA	baseline ecological risk assessment
BFB	bromofluorobenzene
BFE	base flood elevation
BFM	bonded fiber matrix
BG	Bacillus globigii
bgs	below ground surface
Bhate	Bhate Environmental Associates, Inc.
BHC	hexachlorocyclohexane
BHHRA	baseline human health risk assessment
BIM	basic information map
BIP	blow(n)-in-place
bkg	background
bls	below land surface
BMP	best management practice
BOD	biological oxygen demand
Bp	soil-to-plant biotransfer factors
BR	bedrock
BR-D	deep bedrock
BRAC	Base Realignment and Closure
BSAF	biota-to-sediment accumulation factors
BSC	background screening criterion
BSCRN	bottom of screen
BSV	background screening value
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethyl benzene, and xylenes
BTOC	below top of casing
BTV	background threshold value
BW	body weight
BZ	breathing zone
C	ceiling limit value
C&D	Construction & Demolition
Ca	carcinogen
CA	chemical agent; corrective action
CAA	Clean Air Act
CAB	chemical warfare agent breakdown products
CACM	Chemical Agent Contaminated Media
$CaCO_3$	calcium carbonate
CAIS	chemical agent identification set
CalEPA	California Environmental Protection Agency
CAMU	corrective action management unit
CAP	corrective action plan; Contractor Acquired Property
CAR	corrective action request
CARA	Chemical, Biological, Radiological, Nuclear, and High-Yield Explosives (CBRNE) Analytical and Remediation Activity
CAS	Chemical Abstracts Service
CASNO	Chemical Abstract Service identification number
CASRN	Chemical Abstracts Service Registry Number
CB	chlorobenzene
CB&I	CB&I Federal Services LLC
CBFM	collodial borescope flowmeter
CBMPP	construction best management practices plan
CBR	chemical, biological, and radiological
CBRN	chemical, biological, radiological, nuclear
CBRNE	Chemical, Biological, Radiological, Nuclear, and High-Yield Explosives
CBZ	chlorobenzene
CCAL	continuing calibration
CCB	continuing calibration blank
CCC	criterion continuous concentration
CCDC	Combat Capabilities Development Command
CCl_4	carbon tetrachloride

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
CCV	continuing calibration verification
CD	compact disk; Consent Decree
CDE	Chemical Defense Equipment
CDI	chronic daily intake
CDTF	Chemical Defense Training Facility
CEHNC	U.S. Army Engineering and Support Center, Huntsville
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CESAS	Corps of Engineers South Atlantic Savannah
CF	conversion factor
CFC	chlorofluorocarbon
CFDP	Center for Domestic Preparedness
CFR	Code of Federal Regulations
cfs	cubic feet per second
C_{fw}	contaminant concentration in fish from surface water
CG	phosgene (carbonyl chloride); cleanup goal
CGI	combustible gas indicator
ch	inorganic clays of high plasticity
CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
CIH	Certified Industrial Hygienist
cis-1,2-DCE	cis-1,2-Dichloroethene
CK	cyanogen chloride
Cl	chloride, chlorinated
CLIN	contract line item number
ClO_4^-	perchlorate
CLP	Contract Laboratory Program
CLPILM	EPA CLP's prefix designation for the inorganic metals analysis statement of work
CLP M	EPA CLP's prefix designation for the mercury analysis statement of work
CM	corrective measure
cm	centimeter
cm/hour	centimeters per hour
cm^2	cubic centimeter
cm^2/second	square centimeters per second
cm^3/g	cubic centimeters per gram
CMA	U.S. Army Chemical Materials Activity; corrective measure alternative
CMC	criterion maximum concentration
CMD	corrective measures design
CMI	corrective measures implementation
CMICR	corrective measures implementation completion report
CMIP	corrective measures implementation work plan
CMO	corrective measure objective
CMS	corrective measures study
CMT	Continuous Multichannel Tubing
CN	chloroacetophenone
CNB	chloroacetophenone, benzene, and carbon tetrachloride
CNS	chloroacetophenone, chloropicrin, and chloroform
CO	carbon monoxide
CO_2	carbon dioxide
Co-60	cobalt-60
CoA	Code of Alabama
COAC	chemical of analytical concern
COC	when discussing chemicals, COC means chemical of concern; when discussing field paperwork, COC means chain of custody
COE	Corps of Engineers
COI	constituent of interest
Con	skin or eye contact
COPAC	chemical of potential analytical concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
COR	Contracting Officer's Representative
CP	communication plan; Competent Person
CPFF	cost plus fixed fee
CPOM	coarse particulate organic matter
CPSS	chemicals present in site samples
CPVC	chlorinated polyvinyl chloride
C_{pw}	chemical of potential ecological concern concentration in pore water
CQA	construction quality assurance
CQAP	construction quality assurance plan
CRA	Conestoga-Rovers and Associates
CRDL	contract-required detection limit
CRL	certified reporting limit
CRP	community relations plan; compliance-related program
CRQL	contract-required quantitation limit
CRSA	Central Redstone Arsenal
CRZ	contamination reduction zone
CS	ortho-chlorobenzylidene-malononitrile
CSA	confirmation sampling activities
CSDWP	Comprehensive Site-Specific Demolition Work Plan

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
C_{sed}	chemical of potential ecological concern concentration in sediment from groundwater
CSEM	conceptual site exposure model
CSM	conceptual site model
CSP	chemical site plan
CSP	corrugated steel pipe
CSS	chemical safety submission
CT	carbon tetrachloride
CTC	cost to completion
ctr.	container
CVAA	2-chlorovinylarsenous acid
C_w	contaminant concentration in water
CWA	when discussing chemicals, CWA means chemical warfare agent; when discussing laws, CWA means Clean Water Act
CWM	If used in the text of a document this acronym means chemical warfare materiel; if used in an analytical table which summarizes container requirements, this acronym means clear, widemouth container
CWS	Chemical Warfare Service
CX	dichloroformoxime
D	duplicate; duplicate contamination; when used as a validation qualifier, D means dilution
D2PC	Personal Computer Program for Chemical Hazard Prediction
DAD	average dermally absorbed dose
DAVS	detector-aided visual survey
D&I	detection and identification
DA	Department of the Army
DA PAM	Department of the Army Pamphlet
DAAMS	Depot Area Air Monitoring System
DA_{event}	dermal dose absorbed per event
DAF	dilution-attenuation factor
DAF4	dilution-attenuation factor 4
DANC	decontamination agent, non-corrosive
DAP	diammonium phosphate
DASAF	Department of the Army Safety Office
DAVS	detector-aided visual survey
DBA	dibenz(a,h)anthracene
DBCP	1,2-dibromo-3-chloropropane
DC	District of Columbia
DCA	dichloroethane
DCB	decachlorobiphenyl
DCE	dichloroethene
DCMA	Defense Contract Management Agency
DCQAP	data collection quality assurance plan
DD	Decision Document
DD	Department of Defense (form only)
DDD	dichlorodiphenyldichloroethane (this is an industry standard acronym for this chemical)
DDE	dichlorodiphenyldichloroethene (this is an industry standard acronym for this chemical)
DDESB	Department of Defense Explosives Safety Board
DDT	dichlorodiphenyltrichloroethane
DEH	Directorate of Engineering and Housing
DEHP	bis(2-ethylhexyl)phthalate
DEMIL	Demilitarization Areas
DEP	depositional soil
DERP	Defense Environmental Restoration Program
DES	Directorate of Environment and Safety
DF	dilution factor
DFTPP	decafluorotriphenylphosphine
DFOW	Definable Feature of Work
DGM	digital geophysical mapping
DHC	*Dehalococcoides* sp.
DI	deionized
DID	data item description
DIMP	di-isopropylmethylphosphonate
DL	detection limit
DM	adamsite
DMBA	dimethylbenz(a)anthracene
DMM	discarded military munitions
DMMP	dimethylmethylphosphonate
DNAPL	dense nonaqueous-phase liquid
DNB	dinitrobenzene
DNBZ	dinitrobenzene
DNOC	4,6-dinitro-2-methylphenol
DNT	dinitrotoluene
DO	dissolved oxygen
DoD	U.S. Department of Defense
DODI	Department of Defense Instruction
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
DP	direct-push
DPDO	Defense Property Disposal Office
DPT	direct-push technology

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
DQCR	Daily Quality Control Report
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
DS	deep (subsurface) soil
DS2	Decontamination Solution Number 2
DSERTS	Defense Site Environmental Restoration Tracking System
DSMOA	Defense and State Memorandum of Agreement
DSN	Defense Switched Network
DSR	demolition and site restoration
DTSC	Department of Toxic Substances Control
DU	decision unit
DUA	data usability assessment
DVD	digital versatile disc or digital video disc
DWEL	drinking water equivalent level
e.g.	for example
E3	Electromagnetic Environmental Effects
EB	equipment blank
EBS	environmental baseline study
EC_{20}	effects concentration for 20 percent of a test population
EC_{50}	effects concentration for 50 percent of a test population
ECBC	Edgewood Chemical and Biological Center
Eco-RGRG	ecological risk-based remedial goal
Eco-SSL	ecological soil screening level
ECM	earth covered magazine
ED	exposure duration
EDD	electronic data deliverable
EDQL	ecological data quality level
EDTA	ethylenediaminetetracetic acid
EE/CA	engineering evaluation and cost analysis
EF	exposure frequency
EFR	enhanced fluid recovery
Eh	oxidation-reduction potential
ELAP	Environmental Laboratory Accreditation Program
Elev.	elevation
EM(1)	electromagnetic
EM(2)	Engineer Manual
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
EMI	electromagnetic induction
Empirical	Empirical Laboratories, LLC
EMSI/EL	Environmental Management Services, Inc./Environmental Laboratories
EMT	emergency medical technician
EOC	Emergency Operation Center
EOD	explosive ordnance disposal
EODT	explosive ordnance disposal team; EOD Technology, Inc.
EP	exit pathway
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPDS	Emergency Personnel Decontamination Station
EPIC	Environmental Photographic Interpretation Center
EPP	Environmental Protection Plan
EPRI	Electrical Power Research Institute
EPT	Ephemeroptera, Plecoptera, Trichoptera
EQ	EQ Environmental Quality Company
EQL	estimated quantitation limit
ER	equipment rinsate; USACE Engineer Regulation
ERA	ecological risk assessment
ERH	electrical resistive heating
ERIS	Environmental Restoration Information System
ER-L	effects range-low
ER-M	effects range-medium
ERMA	Environmental Remediation Services Multiple Award
ESA	ecologically sensitive area
ESB	Equilibrium Partitioning Sediment Benchmark
ESE	Environmental Science and Engineering, Inc.
ESL	ecological screening level
ESP	explosives site plan
ESMP	Endangered Species Management Plan; Explosives Safety Management Program
ESS	explosives safety submission
ESTCP	Environmental Security Technology Certification Program
ESV	ecological screening value
ET	exposure time
ET_{sw}	exposure time - surface water
EU	exposure unit
EUR	Environmental Use Restriction
EV	event frequency

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
E-W	east to west
Excel	Excel Geophysical Services
Exp.	Explosives
ExplorTech	ExplorTech, LLC
EXTOXNET	Extension Toxicology Network
Ey	Etowah silty clay loam
EZ	exclusion zone
FA	focus area
FA	fraction absorbed
FAC	facultative wetland
FACU	facultative upland
FACW	facultative wetland
FADL	Field Activity Daily Log
FAR	Federal Acquisition Regulations
FAV	final acute value
FB	field blank
FBI	Family Biotic Index
FCSV	food chain screening value
FCV	final chronic value
FD	field duplicate
FDA	U.S. Food and Drug Administration
Fe^{+2}	ferrous iron
Fe^{+3}	ferric iron
FEC	fluid electrical conductivity
FedEx	Federal Express, Inc.
FEMA	Federal Emergency Management Agency
FFA	Federal Facilities Agreement
FFCA	Federal Facilities Compliance Act
FFE	field flame expedient
FFP	firm fixed price
FFS	focused feasibility study
FI	fraction of exposure; filtered
FID	flame ionization detector
FIFRA	Federal Insecticide, Fungicide, & Rodenticide Act
FLUTe	Flexible Liner Underground Technologies, Ltd. Co.
FM-ARNGTC	Fort McClellan Army National Guard Training Center
FMDC	Fort McClellan Development Commission
FML	flexible membrane liner
f_{oc}	fraction organic carbon
FOIA	Freedom Of Information Act
FOMRA	Former Ordnance Motor Repair Area
FOST	Finding of Suitability to Transfer
Foster Wheeler	Foster Wheeler Environmental Corporation
FR	Federal Register
Frtn	fraction
FS	feasibility study
FSH	Fort Sam Houston
FSP	field sampling plan
FS smoke	sulfur trioxide and chlorosulfonic acid
ft	foot, feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
ft^2	square feet
ft^2/day	square feet per day
FTA	Fire Training Area
FUP	fixed unit price
FWV	fieldwork variance
FY	fiscal year
g	gram
G&M	Geraghty and Miller, Inc.
g/cm^3	grams per cubic centimeter
g/m^2	grams per square meter
g/m^3	gram per cubic meter
G-856	Geometrics, Inc. G-856 magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GA	tabun
GAC	granular activated carbon
GAF	General Aniline and Film; gastrointestinal absorption factor
gal	gallon
gal/min	gallons per minute
GB	sarin (isopropyl methylphosphonofluoridate)
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
GCL	geosynthetic clay liner
GCMR	Geophysical Classification for Munitions Response

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
GCWD	Gulf Chemical Warfare Depot
GCWS	Gulf Chemical Warfare Service
GEAE	Generic Ecological Assessment Endpoint
GEDIT	gaseous electron donor injection technology
GFAA	graphite furnace atomic absorption
GIP	geophysical investigation plan
GIS	geographic information system
GNSS	Global Navigation Satellite System
GPCR	gas phase chemical reduction
gpm	gallons per minute
GPR	ground-penetrating radar
GPS	global positioning system
GRA	general response action
GRIM	Groundwater Responsibility Information Matrix
GRO	gasoline range organics
GS	ground scar
GSA	when discusing the federal government requirements, GSA means General Services Administration; when discussing geology, GSA means Geologic Survey of Alabama
GSE	Great Southern Engineering
GSR	green and sustainable remediation
GST	ground stain
GSV	geophysical systems verification
GUC	groundwater use control
GW	groundwater
GWDT	Groundwater Design Team
GWMZ	groundwater monitoring well, multizone
GWTR	groundwater monitoring well
H&S	health and safety
H_2O_2	hydrogen peroxide
H_2S	hydrogen sulfide
HA	hand auger; hazard assessment
HAL	Health Advisory level
HAMUST56	Huntsville Arsenal Mustard Plant 2, Lines 5 & 6
Harmon	Harmon Engineering Associates, Inc.
HAZMATCAD™	Hazardous Material Chemical Agent Detector
HAZWOPER	Hazardous Waste Operations and Emergency Response
HBESL	health-based environmental screening level
HC	mixture of hexachloroethane, aluminum powder, and zinc oxide (smoke producer)
HCE	hexchloroethane
HCl	hydrochloric acid
HD	distilled mustard (bis-[dichloroethyl]sulfide); hazard division
HDPE	high-density polyethylene
HE	high explosive
HEAST	Health Effects Assessment Summary Tables
HEAT	High Explosive Anti-Tank
Herb.	herbicides
HFD	hazardous fragment distance
HHAWQS	human health Alabama water quality standard
HHRA	human health risk assessment
HHRE	human health risk evaluation
HI	hazard index
HI_{COC}	total hazard index for a given relevant COC, for a given receptor added across all exposure routes for given source medium
Hi_{cum}	cumulative hazard index summed across chemicals and source media
HI_{TO}	total hazard index for a given target organ for a given receptor
Hm	hot measurement
HMW	high molecular weight
HMX	cyclotetramethylenetetranitramine; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocane
HN	hydrogen mustard
HNC	hydrogen cyanide
HNO_3	nitric acid
HP	hydropunch
HPLC	high-performance liquid chromatography
HQ	hazard quotient
HQ_{COCi}	hazard quotient for the target organ of interest estimated for the ith COC
$'HQ_i$	hazard index for a given chemical summed across exposure routes and source media
$'HQ_{Ri}$	hazard quotient for the given chemical for exposure route i
HQ_{screen}	screening-level hazard quotient
hr	hour
HRR	Historical Records Review
HS	mustard
HSA	hollow-stem auger
HSB	Huntsville Spring Branch
HSDB	Hazardous Substances Data Bank
HSF	historic site feature
HSMR	Huntsville Spring Branch at Martin Road
HT	British Mustard

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
HTPB	hydroxy-terminated polybutadiene
HTRW	hazardous, toxic, and radioactive waste
HTW	hazardous and toxic waste
HUB	Historically Underutilized Business
HWCL	hazardous waste control limit
HWSU	hazardous waste storage unit
HY	hydrostratigraphic unit
HYPN	hydropunch
Hz	hertz
I	out of control, data rejected due to low recovery
I-565	Interstate 565
IAP	Installation Action Plan
IATA	International Air Transport Authority
I-AVSS	instrument-aided visual surface sweep
ICAL	initial calibration
ICAM	improved chemical agent monitor
ICB	initial calibration blank
ICP	inductively coupled plasma
ICS	interference check sample
ICV	initial calibration verification
ID	identification; inside diameter
IDL	instrument detection limit
IDLH	immediately dangerous to life or health
IDM	investigative-derived media
IDQTF	Intergovernmental Data Quality Task Force
IDS	intrusion detection system
IDW	investigation-derived waste; investigative-derived waste
i.e.	that is (in other words)
IELCR	individual excess lifetime cancer risk
$IELCR_{coc}$	total individual excess lifetime cancer risk for a given relevant chemical of concern, for a given receptor added across all exposure routes for a given source medium
$'IELCR_{Cum}$	cumulative cancer risk for a given receptor summed across chemicals and source media
$'IELCR_{Ri}$	cancer risk for the given chemical in a given source medium for exposure route i
$'IELCR_{T}$	total cancer risk for the given chemical in a given source medium summed across exposure routes
$IELCR_{(Ti)}$	total cancer risk for chemical i in a given source medium summed across exposure routes
IEOC	Installation Emergency Operations Center
IEUBK	Integrated Exposure Uptake Biokinetic
IF	ingestion factor; inhalation factor
IHF	interim holding facility
IIP	intrusive investigation plan
ILCR	incremental lifetime cancer risk
ILM	EPA CLP's prefix designation for the inorganic metals analysis statement of work for EPA contract laboratory program
IM	interim measure; isobutyl methacrylate
IMO	interim measure objective
IMU	inertial measurement unit
IM-AE	isobutyl methacrylate polymer AE
IMPA	isopropylmethyl phosphonic acid
in.	inch
Inc.	Incorporated
Ing	ingestion
Inh	inhalation
INT	interface
IOU	integrator operable unit
IP	ionization potential
IPS	International Pipe Standard
IR	ingestion rate
IRAO	interim remedial action objective
IRDMIS	Installation Restoration Data Management Information System
IR_{f}	fish ingestion rate
$'IR_{sw}$	ingestion rate
IRFNA	inhibited red fuming nitric acid
IRIS	Integrated Risk Information System
IROD	interim record of decision
IRP	Installation Restoration Program
IRSL	industrial regional screening level
IS	incremental sampling
ISAB	in situ anaerobic bioremediation
ISBN	International Standard Book Number
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
ISEB	in situ enhanced bioremediation
ISL	initial screening level
ISO	industry standard object
ISTD	in situ thermal destruction
ISTT	in situ thermal treatment
IT	IT Corporation

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
ITEMS	IT Environmental Management System™
ITRC	Interstate Technology and Regulatory Council
IV	intervention value
IVS	instrument verification strip
IW	installation-wide
IWGW	installation-wide groundwater
IWWP	installation-wide work plan
J	estimated concentration
J&E	Johnson and Ettinger
JD	jurisdictional determination
JOR	job order request
K	conductivity
KAPSDIDS	Kinetically Adjustable Pore Spaace Dilation Injection Delivery System
K_d	soil-water distribution coefficient
Kd_{bs}	bed sediment-sediment pore water partition coefficient
KeV	kilo electron volt
kg	kilogram
kg/m^3	kilograms per cubic meter
$KMnO_4$	potassium permanganate
KO	Contracting Officer
K_p	permeability coefficient
K_{oc}	organic carbon partioning coefficient
K_{ow}	octanol-water partition coefficient
kVA	kilovolt-ampere
L	if used as part of the units of measure, the acronym stands for "liter", if used as a chemical name, this acronym stands for lewisite
L/cm^3	liters per cubic centimeter
L/day	liters per day
L/kg/day	liters per kilogram per day
LANL	Los Alamos National Laboratory
lb	pound
LBP	lead-based paint
lbs/year	pounds per year
LC	liquid chromatography
LC_{50}	lethal concentration for 50 percent population tested
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LD_{50}	lethal dose for 50 percent population tested
LDD	lost, damage, or destruction
LEL	lower explosive limit
LF	Leaching Factor
LGAC	liquid-phase granular activated carbon
LiDAR	Light Detection and Ranging
LL	low level
LLC	limited liability company
LNAPL	light nonaqueous-phase liquid
LOAEL	lowest-observed-adverse-effects level
LOD	limit of detection
LOEC	lowest-observable-effect-concentration
LOQ	limit of quantitation
LSA	limited site assessment
LSV	leachate screening value
LTO	long-term operation
LTM	long-term management
LTV	leachate threshold value
LUC	land-use control
LUCAP	land-use control assurance plan
LUCER	land-use control effectiveness report
LUCIP	land-use control implementation plan
m	meter
m/year	meters per year
m/yr	meters per year
m/second	meters per second
m^3/hour	cubic meters per hour
m^3/kg	cubic meters per kilogram
MACOM	Major Command
MADEP	Massachusetts Department of Environmental Protection
MADL	minimum analytical detection limit
MAG	monitoring acceptance goal
MARB	Munitions Assessment Review Board
max	maximum
MB	method blank
MC	munitions constituents
MCDZ	McDonald Creek discharge zone
MCE	Maximum Credible Event
MCL	maximum contaminant level
MCLG	maximum contaminant level goal

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
MCPA	4-chloro-2-methylphenoxyacetic acid
MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid
MCS	media cleanup standard
MD	munitions debris; Mahalanobis Distance
MDAS	Material Documented as Safe
MDC	maximum detected concentration
MDCC	maximum detected constituent concentration
MDEH	Material Documented as an Explosive Hazard
MDL	method detection limit
MEC	munitions and explosives of concern
MEE	methane, ethane, and ethene
MEP	Multiple Extraction Procedure
MeV	mega electron volt
Mfp	Mississippian Fort Payne
mg	milligrams
mg/cm^2	milligrams per square centimeter
mg/cm^2/day	milligrams per square centimeter per day
mg/cm^2/event	milligrams per square centimeter per event
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg-day	milligram per kilogram day
mg/kgbw/day	milligrams per kilogram of body weight per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mgal	million gallons
MGFD	munition with the greatest fragmentation distance
mh	highly plastic, inorganic silts, micaceous or diatomaceous fine, sandy or silt soils
MHz	megahertz
MI	multi-incremental
MICC	Mission & Installation Contracting Command
MiHPT	Membrane Interface Hydraulic Profile Tooling
min	minimum
MIMS	Munitions Information Management System
MINICAMS	miniature continuous air monitoring system
MIS	Management Information System
mL	milliliter
mm	millimeter
MMAS	Mobile Munitions Assessment Systems
MMBtu/hr	million Btu per hour
MMCS	Missile and Munitions Command School
MM-CX	Military Munitions Center of Expertise
MMRP	Military Munitions Response Program
Mn^{+4}	manganese
MNA	monitored natural attenuation
MnO_4-	permanganate ion
MNR	monitored natural recovery
MOA	Memorandum of Agreement
MOCA	4,4-methylene-bis(2-chloroaniline)
MOGAS	motor vehicle gasoline
MOUT	Military Operations in Urban Terrain
MP	Military Police
MPA	methyl phosphonic acid
MPC	maximum permissible concentration; measurement performance criteria
MPM	most probable munition
MPPEH	Material Potentially Presenting an Explosive Hazard
MPR	4.2-Inch Mortar Proofing Range
MQL	method quantitation limit
MQO	measurement quality objective
MR	molasses residue; munitions response
MRA	munitions response area
MRC	multiple round container
MRL	method reporting limit
MRL	minimal risk level
MRR	Materials Receiving Report
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
MS	matrix spike
mS/cm	millisiemens per centimeter
mS/m	millisiemens per meter
MS/MSD	matrix spike/matrix spike duplicate
MSD	when discussing laboratory QC, MSD means matrix spike duplicate; when discussing explosives, MSD means minimum separation distance
MSFC	George C. Marshall Space Flight Center
msl	mean sea level
Mt	Mississippian Tuscumbia Limestone
MTBE	methyl tertiary butyl ether
M&TE	measurement and test equipment

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
mV	millivolts
MW	monitoring well
Na	sodium
N/A	not applicable
NA	not applicable
NAD	North American Datum
NAD83	North American Datum of 1983
$NaMnO_4$	sodium permanganate
NAPL	nonaqueous-phase liquid
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NAVD 88	North American Vertical Datum, 1988 adjustment
NAVD88	North American Vertical Datum of 1988
NB	nitrobenzene
NBA	Northern Burial Area
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NDA	Northern Disposal Area
NDMA	n-nitrosodimethylamine
NDPA	n-nitroso-di-n-propylamine
NE	northeast
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Protection Act
NEW	net explosive weight
NFA	no further action
NFG	National Functional Guidelines
NFPA	National Fire Protection Agency
NG	National Guard
ng/L	nanograms per liter
NGB	National Guard Bureau
NGP	National Guardsperson
NGVD	National Geodetic Vertical Datum
Ni	nickel
NIC	notice of intended change
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NJDEP	New Jersey Department of Protection
NLM	National Library of Medicine
NLT	no later than
NMEA	National Marine Electronics Association
No.	number
NO_3^-	nitrate
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects level
NOEC	no-observable-effect concentration
NONEL	non-electric
NP	nitropropyl
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPW	net present worth
NR	not requested
NRC	National Research Council
NRCC	National Research Council of Canada
NRHP	National Register of Historic Places
NRL	Naval Research Laboratory
NRT	near real time
ns	nanosecond
NS	not surveyed
N-S	north to south
NSA	New South Associates, Inc.
NT	nitrotoluene
nT	nanotesla
nT/m	nanoteslas per meter
NTCRA	Non-Time Critical Removal Action
NTIS	National Technical Information Service
NTU	nephelometric turbidity unit
nv	not validated
NY DOH	New York State Department of Health
O&G	oil and grease
O&M	operation and maintenance
O_2	oxygen
O_3	ozone
OB/OD	open burn/open detonation
OBL	obligate

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
OCDD	octachlorodibenzo-p-dioxin
OD	outside diameter; other (nonmunitions) debris
OE	ordnance and explosives
OEC	Ordnance Explosives Center
OEHHA	Office of Environmental Health Hazard Assessment (of the California Environmental Protection Agency)
OESS	Ordnance and Explosives Safety Specialist
OGMS	Ordnance Guided Missile School
oh	organic clays of medium to high plasticity
OH·	hydroxyl radical
ol	organic silts and organic silty clays of low plasticity
OMEMS	Ordnance Munitions and Electronic Maintenance School
OP	organophosphorus; organochlorine pesticide
ORA	Operational Range Assessment
ORAP	Operational Range Assessment Program
Ord	Ordovician
ORP	oxidation-reduction potential
OSA	Open Storage Area
OSD	overage/shortage/damage
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
OVA	organic vapor analyzer
OVB	overburden
OVB-S	shallow overburden
OVM	organic vapor monitoring
OVM-PID/FID	organic vapor meter-photoionization detector/flame ionization detector
OWS	oil/water separator
oz	ounce
P&T	pump and treat
PA	preliminary assessment
PA3	Plant Area 3, Incendiaries Manufacturing
PAED	Public Access Exclusion Distance
PAH	polynuclear aromatic hydrocarbon
PAL	preliminary action level
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
Parsons	Parsons Engineering Science, Inc.
Pb	lead
PBAA	polybutadiene acrylic acid
PBAN	polybutadiene/acrylic acid/acrylonitrile
PBC	performance-based contract
PBMS	performance-based measurement system
PC	permeability coefficient
PCA	tetrachloroethane
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PCE	tetrachloroethene
PCHL	2,3,4,5-6-pentachlorocyclohexanol
PCMIA	Personal Computer Memory Card International Association
PCP	pentachlorophenol
PCR	polymerase chain reaction
PCWM	Potential Chemical Warfare Materiel
PDA	Personal Digital Assistant
PDB	polyethylene diffusive bag sampler
PDF	Portable Document Format
PDS	Personnel Decontamination System
PDT	Project Delivery Team
PEC	probable effect concentration
PEF	particulate emission factor
PEL	permissible exposure limit
PELA	P.E. LaMoreaux and Associates, Inc.
PERA	preliminary ecological risk assessment
PERC	perchloroethene
PES	potential explosive site
Pest.	pesticides
PETN	pentaerythritol tetranitrate
PFAS	polyfluoroalkyl substance
PFO	palustrine forested wetland
PFOA	perfluorooctanoic acid
PFOS	perfluorooctyl sulfonate
PFT	portable flamethrower
PG	professional geologist
pg/g	picograms per gram
PgM	program manager
pH	measure of acidity/alkalinity; hydrogen ion activity (negative of the logarithm, base 10)
PHC	principal hazardous constituent
PID	photoionization detector

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
PIEZ	piezometer
PINS	portable isotopic neutron microscopy
PK	packer
PLS	Professional Land Surveyor
PLS	Professional (licensed) Land Surveyor
PM	project manager
PMC	Program Management Contract
PNMSCM	Product Manager for Non-Stockpile Chemical Materiel
PMP	Project Management Plan
PMTP	Program Management Team Plan
POC	point of contact
POL	petroleum, oils, and lubricants
POTW	publicly owned treatment works
POW	prisoner of war; palustrine open water
Powell	John Powell Chemical Company
PP	Proposed Plan
ppb	parts per billion
ppbv	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
PPMP	Print Plant Motor Pool
PPRTV	provisional peer-reviewed toxicity values
ppt	parts per trillion
ppT	parts per thousand
PQL	practical quantitation limit
PR	potential risk
PRA	preliminary risk assessment
PRE	preliminary risk evaluation
PRG	preliminary remediation goal
PRO	petroleum range organics
PS	chloropicrin
PSA	potential source area
PSL	preliminary screening level
PSS	palustrine scrub shrub
PSSC	potential site-specific chemical
PSV	preliminary screening value
pt	peat or other highly organic silts
PT1	an incendiary mixture in munitions
PTFE	Polytetrafluoroethylene (Teflon)
PTMP	program team management plan
PTSM	principal threat source material
PVC	polyvinyl chloride
PWS	performance work statement
PZ	piezometer
QA	quality assurance
QA/QC	quality assurance/quality control
QAM	quality assurance manual
QAO	quality assurance officer
QAPP	quality assurance project plan
QASAS	Quality Assurance Specialist Ammunition Surveillance
QASP	Quality Assurance Surveillance Plan
QC	quality control
QCP	quality control plan
QCSM	Quality Control Site Manager
QCSR	quality control summary report
Q-D	quantity-distance
QL	quantitation limit
QP	Qualified Person
Q-Q	quantile-quantile
QSAR	quantitative structure-activity relationship
QSM	quality systems manual
QST	QST Environmental, Inc.
qty	quantity
Qual	qualifier
QuickSilver	QuickSilver Analytics, Inc.
R	when used as a validation qualifier, R means rejected; when used as a lab qualifier, R means resample; when used in text, R means retardation factor
R&A	relevant and appropriate
R^2	coefficient of determination
RA	remedial action
RA(O)	remedial action (operations)
RAO	remedial action objective
RAP	recommended action plan
RAR	remedial action report
RARE	Redstone Arsenal Rocket Engine
RAWP	remedial action work plan
Raytheon	Raytheon Company

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
RBA	relative bioavailability
RBC	risk-based concentration
RBP	Rapid Bioassessment Protocol
RBRG	risk-based remedial goal
RBSC	risk-based screening concentration
$RBSC_I$	risk-based screening concentration for industrial soil
$RBSC_R$	risk-based screening concentration for residential soil
$RBSC_T$	risk-based screening concentration for tap water
RBTL	risk-based target level
$RBTL_{coc}$	risk-based target level for a given relevant COC, receptor, and source medium
RC	representative concentration; response complete
RC_{coc}	representative concentration of the relevant COC in the given medium
RCA	root cause analysis
RCMD	Recovered Chemical Materiel Directorate
RCRA	Resource Conservation and Recovery Act
RCRA CA	Resource Conservation and Recovery Act Corrective Action
RCWM	Recovered Chemical Warfare Materiel
RD	remedial design
RDECOM	U.S. Army Research, Development, and Engineering Command
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine; cyclotrimethylenetrinitramine; 1,3,5-trinitro-1,3,5-triazine (cyclonite); Royal Demolition Explosive
REAT	Regional Environmental Acquisition Tools
REG	regular field sample
REL	recommended exposure limit; reference exposure level
RER	Record of Environmental Review
Rev	Revision
RF	response factor
RFA	request for analysis
RfC	reference concentration
RfD	reference dose
RFI	RCRA facility investigation
RFQ	request for quotation
RG	remedial goal
RGO	remedial goal option
RI	remedial investigation
RIP	remedy in place
RL	reporting limit
RM	risk management
RM-1	Risk Management-1
RM-2	Risk Management 2
RME	reasonable maximum exposure
RMP	risk management plan
Ro	Robertsville silt loam
ROD	Record of Decision
ROF	report of findings
ROI	radius of influence
ROP	Redstone Ordnance Plant
ROPS	roll over protection system
RPD	relative percent difference
RR	range residue
RRF	relative response factor
RRSE	Relative Risk Site Evaluation
RRSL	residential regional screening level
RS	prefix for groundwater monitoring well at Redstone Arsenal
RSA	Redstone Arsenal
RSD	relative standard deviation
RSL	Regional Screening Level
RSP	Redstone Arsenal spring
RTAP	Real-Time Analytical Platform
RTC	Redstone Test Center
RTECS	Registry of Toxic Effects of Chemical Substances
RTK	real-time kinematic
RTO	regenerative thermal oxidizer
RTOP	Request for Task Order Proposal
RTS	robotic total station
RTTC	Redstone Technical Test Center
Rust	Rust Environment and Infrastructure, Inc.
s/n	signal-to-noise ratio
SA	exposed skin surface area; source area
SAA	satellite accumulation area
SAC	site access control
SACIMS	Site Access Control Information Management System
SACP	Site Access Control Plan
SAD	South Atlantic Division
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAP	sampling and analysis plan
SAR	structure-activity relationship

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SC	specific conductance
SCG	storage compatibility group
SCBA	self-contained breathing apparatus
Sch.	schedule
SCM	site conceptual model
SD	sediment
SDG	sample delivery group
SDS	safety data sheet
SDSW	sediment/surface water
SDWA	Safe Drinking Water Act
SDZ	surface danger zone
SED	Software Engineering Directorate
SEE	steam enhanced extraction
SF	cancer slope factor
SFSP	site-specific field sampling plan
SGF	standard grade fuels
Shaw	Shaw Environmental, Inc.
SHP	safety and health plan
SI	site inspection
Sil	Silurian
SIM	Selective Ion Monitoring
SIR	secondary investigation report
SL	standing liquid
SLERA	screening-level ecological risk assessment
SM	sulfur monochloride
SMDP	Scientific Management Decision Point
SMF	smoke munitions filling
SMF 3	Smoke Munitions Filling Plant 3
SMP	site management plan
SNR	signal-to-noise ratio
SO_4	sulfate
SOD	soil oxidant demand
SOP	standard operating procedure
SOPP	standard operating project procedure
SP	submersible pump
SPA	single point anomaly
SPCC	system performance calibration compound
SPCS	State Plane Coordinate System
SPLP	synthetic precipitation leaching procedure
SPM	sample planning module
SPRG	spring
SQG	sediment quality guideline
SQRT	screening quick reference tables
SRA	streamlined human health risk assessment; saturated response area
SRB	sulfate-reducing bacteria
SRI	supplemental remedial investigation
SRM	standard reference material
SS	surface soil
SSC	site-specific chemical
SSHO	site safety and health officer
SSHP	site-specific safety and health plan
SSL	soil screening level
SSSL	site-specific screening level
SSTL	site-specific target level
SSPA	site-specific probability assessment
STB	supertropical bleach
STC	source-term concentration
STD	standard deviation
Std. units	standard units
STEL	short-term exposure limit
STP	sewage treatment plant
STL	Severn-Trent Laboratories
STT	sludge thickener tank
SU	sampling unit when used in a grid for incremental sampling; when used as a unit for pH, this acronym stands for standard unit
SUXOS	senior UXO supervisor
SV	screening value
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SW-846	U.S. EPA's *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*
SW	surface water
SWCC	State of Alabama Soil and Water Conservation Committee
SWMU	solid waste management unit
SWTR	surface water
SZ	support zone
TA	test area

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
TAL	target analyte list
TAT	turn around time
TB	trip blank
TBC	to be considered
TBD	to be determined
TCA	trichloroethane
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofurans
TCE	trichloroethene
TCH	thermal conductive heating
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TCMX	tetrachloro-m-xylene
TCRA	time critical removal action
TDGCL	thiodiglycol
TDGCLA	thiodiglycol chloroacetic acid
TDS	total dissolved solids
TEA	triethylaluminum
TEC	threshold effect concentration
TeCA	1,1,2,2-tetrachloroethane
TEMP	temperature
TEMTADS	Time-Domain Electromagnetic Multisensor Tower Array Detection System
TEQ	toxic equivalency quotient
TERC	Total Environmental Restoration Contract
Tetryl	trinitrophenylmethylnitramine
TEU	Technical Escort Unit
THI	target hazard index
Thiokol	Thiokol Corporation
TIC	tentatively identified compound
TIR	thermal infrared survey
TLV	threshold limit value
TM	Technical Manual
TMP	temperature measuring point
TMPW	temporary groundwater monitoring well
TN	Tennessee
TNB	trinitrobenzene
TNT	trinitrotoluene
TO	task order
TOC	use top of casing when defining the well depth; use total organic carbon when defining a general chemistry parameter
TOI	target of interest
TOW	tube-launched, optically-tracked, wire-guided missile
TP	Technical Paper
TPH	total petroleum hydrocarbon
TPI	three-phase inspection
TPP	Technical Project Planning
TR	target cancer risk
TRADOC	U.S. Army Training and Doctrine Command
TRPH	total recoverable petroleum hydrocarbons
TRS	TRS Group Inc.
TRV	toxicity reference value
TSA	temporary storage area
TSCA	Toxic Substances Control Act
TSCRN	top of screen
TSDF	treatment, storage, and disposal facility
TSLC	target soil leachate concentration
TSS	total suspended solids
TTAP	treatment system tap (port)
TTZ	target treatment zone
Tu	Tupelo silt loam
TVA	Tennessee Valley Authority
TWA	time-weighted average
TXDOT	Texas Department of Transportation
TX-3	small rocket motor used for ballistics testing
U	not detected above reporting limit
U.S.	United States (of America)
UB	potential blank contamination
UCL	upper confidence limit
UCR	upper certified range
UDMH	unsymmetrical dimethyl hydrazine
UF	uncertainty factor
UFP	Uniform Federal Policy
UIC	underground injection control
UJ	not detected, estimated due to data validation anomaly
UNEP	United Nations Environment Program
UPL	upper prediction limit; upland
UR	not detected; rejected due to data validation anomaly
URF	unit risk factor

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
USACE	U.S. Army Corps of Engineers
USACMLS	U.S. Army Chemical School
USAEC	U.S. Army Environmental Command
USAEHA	U.S. Army Environmental Hygiene Agency
USAESCH	U.S. Army Engineering Support Center, Huntsville
USAMPS	U.S. Army Military Police School
USAPHC	U.S. Army Public Health Command
USATCES	U.S. Army Technical Center for Explosive Safety
USATEU	U.S. Army Technical Escort Unit
USATHAMA	U.S. Army Toxic and Hazardous Material Agency
USC	United States Code
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTL	upper tolerance limit
UTM	Universal Transverse Mercatir
UTS	universal treatment standard
UTV	utility terrain vehicle
UXO	unexploded ordnance
UXOSP	unexploded ordnance sweep personnel
UXOQCS	UXO Quality Control Supervisor
UXOSO	UXO safety officer
V	vanadium
VC	vinyl chloride
VGIC	liquid-phase granular activated carbon
VI	vapor intrusion
VISL	vapor intrusion screening level
VOA	volatile organic analyte
VOC	volatile organic compound
VOH	volatile organic hydrocarbon
VP	soil vapor point
VQ	validation qualifier
vs	versus
VSI	visual site inspection
VSL	vapor screening level
VSP	Visual Sample Plan
VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)
WAC	Women's Army Corps
WDTA	Waste Disposal Trench Area
WNWR	Wheeler National Wildlife Refuge
WOE	weight of evidence
WP	white phosphorus
WPL	worker population limit
WQC	water quality criteria
WRS	Wilcoxon rank sum
WS	watershed
WSA	Watershed Screening Assessment
WTP	water treatment plant
WWI	World War I
WWII	World War II
WWTP	wastewater treatment plant
X	Data collected in a manner that is now considered to be inconsistent with good scientific practice. These data are considered unusable. However, since these data exist in the database, additional definitive samples may be needed to verify the presence or absence of any positively detected result.
XRF	x-ray fluorescence
yd^3	cubic yards
ZVI	zero-valent iron

TABLES

Table 2-1

Summary of Receptor Cancer Risk and Noncancer Hazard for Chemicals of Concern
Reasonable Maximum Exposure
RSA-072-R-01 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

CANCER RISK

Receptors	Total Soil IELCR	Groundwater IELCR	CUMULATIVE RISK SOIL	CUMULATIVE RISK SOIL AND GROUNDWATER
Industrial Receptors:				
Commercial Worker	NA	7.4E-05	NA	7.4E-05
Construction Worker	NA	3.3E-06	NA	3.3E-06
Hypothetical Residential Receptors:				
Child Resident [a]	NA	6.7E-05	NA	6.7E-05
Adult Resident [a]	NA	1.1E-04	NA	1.1E-04
Lifetime Resident [a]	NA	1.8E-04	NA	1.8E-04

NONCANCER HAZARD

Receptors	Total Soil HI	Groundwater HI	CUMULATIVE HI SOIL	CUMULATIVE HI SOIL AND GROUNDWATER
Industrial Receptors:				
Commercial Worker	NA	1.4	NA	1.4
Construction Worker	NA	1.6	NA	1.6
Hypothetical Residential Receptors:				
Child Resident [a]	NA	5.6	NA	5.6

[a] Risk associated with the hypothetical residential receptor; child and adult resident risk are summed to estimate the cancer risk for the lifetime resident. Noncancer hazard estimates are based on the hypothetical child resident only.

HI - Hazard index.

IELCR - Individual excess lifetime cancer risk.

NA - Not applicable.

Table 2-2

Conclusions of the ARBCA RM-2 Evaluation
RSA-072-R-01 Corrective measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Receptors	Exposure to Soil [a]	COCs Requiring Action in Soil [b,c]	Exposure to Soil and Groundwater [a]	Significant Contributors From Exposure to Groundwater [d]
Commercial Worker	√	(None)	X	2-Nitrotoluene Trichloroethene
Construction Worker	√	(None)	X	Trichloroethene
Hypothetical Resident	√	(None)	X	2-Nitrotoluene Trichloroethene

Notes:

√ Cumulative cancer risk and noncancer hazard were found to be acceptable.

X Cumulative cancer risk and/or noncancer hazard were found to be unacceptable.

[a] Risk conclusions exclude inorganics found to be naturally occurring.

[b] Conclusions regarding risk and identification of COCs requiring action in soil exclude consideration of contribution of risk from exposure to groundwater.

[c] Includes only those COCs requiring action for receptors whose cumulative total risk is greater than 1×10^{-5}.

[d] Chemicals with maximum detected concentrations below their maximum contaminant levels are not included as significant contributors from exposure to groundwater.

ARBCA - Alabama Risk-Based Corrective Action.
COC - Chemical of concern.
RM-2 - Risk Management-2.

Table 2-3

Summary of Screening-Level Ecological Risk Assessment Results - Surface Soil
RSA-072-R-01 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Detected Chemical	Preliminary COPEC?	Refined COPEC?	Community-Level Assessment Results		Food Chain Assessment	Final COEC?
			RSA Plant Communities	RSA Invertebrate Communities	RSA Populations	
Inorganics :						
Aluminum	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Antimony	No		NO FURTHER ACTION REQUIRED			
Arsenic	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Barium	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Beryllium	No		NO FURTHER ACTION REQUIRED			
Cadmium	No		NO FURTHER ACTION REQUIRED			
Calcium	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Chromium	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Cobalt	Yes	No (2)	NO FURTHER ACTION REQUIRED			
Copper	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Iron	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Lead	No		NO FURTHER ACTION REQUIRED			
Magnesium	No		NO FURTHER ACTION REQUIRED			
Manganese	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Mercury	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Nickel	No		NO FURTHER ACTION REQUIRED			
Potassium	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Selenium	Yes	No (1)	NO FURTHER ACTION REQUIRED			
Thallium	No		NO FURTHER ACTION REQUIRED			
Vanadium	Yes	No (2)	NO FURTHER ACTION REQUIRED			
Zinc	Yes	No (1)	NO FURTHER ACTION REQUIRED			

Notes :

COEC - Chemical of ecological concern.

COPEC - Chemical of potential ecological concern.

Rationale for exclusion as a refined COPEC or final COEC:

1 - Naturally occurring or background related based on site-to-background comparisons.

2 - No further evaluation is warranted based on constituent is not in the conceptual site model.

Table 2-4

Summary of Screening-Level Ecological Risk Assessment Results - Sediment
RSA-072-R-01 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Detected Chemical	Preliminary COPEC?	Refined COPEC?	Community-Level Assessment Results	Food Chain Assessment Results	Final COEC?
			RSA Benthic Invertebrate Communities	RSA Populations	
Inorganics :					
Aluminum	No	NO FURTHER ACTION REQUIRED			
Antimony	No	NO FURTHER ACTION REQUIRED			
Arsenic	No	NO FURTHER ACTION REQUIRED			
Barium	No	NO FURTHER ACTION REQUIRED			
Beryllium	No	NO FURTHER ACTION REQUIRED			
Cadmium	No	NO FURTHER ACTION REQUIRED			
Calcium	No	NO FURTHER ACTION REQUIRED			
Chromium	No	NO FURTHER ACTION REQUIRED			
Cobalt	No	NO FURTHER ACTION REQUIRED			
Copper	No	NO FURTHER ACTION REQUIRED			
Iron	No	NO FURTHER ACTION REQUIRED			
Lead	No	NO FURTHER ACTION REQUIRED			
Magnesium	No	NO FURTHER ACTION REQUIRED			
Manganese	No	NO FURTHER ACTION REQUIRED			
Mercury	No	NO FURTHER ACTION REQUIRED			
Nickel	No	NO FURTHER ACTION REQUIRED			
Potassium	No	NO FURTHER ACTION REQUIRED			
Selenium	No	NO FURTHER ACTION REQUIRED			
Thallium	No	NO FURTHER ACTION REQUIRED			
Vanadium	No	NO FURTHER ACTION REQUIRED			
Zinc	No	NO FURTHER ACTION REQUIRED			

Notes :
COEC - Chemical of ecological concern.
COPEC - Chemical of potential ecological concern.

Table 2-5

Summary of Screening-Level Ecological Risk Assessment Results - Surface Water
RSA-072-R-01 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Detected Chemical	Preliminary COPEC?	Refined COPEC?	Community-Level Assessment Results	Food Chain Assessment Results	Final COEC?
			RSA Water Column Communities	RSA Populations	
Inorganics :					
Aluminum	No	NO FURTHER ACTION REQUIRED			
Barium	No	NO FURTHER ACTION REQUIRED			
Calcium	No	NO FURTHER ACTION REQUIRED			
Iron	No	NO FURTHER ACTION REQUIRED			
Magnesium	No	NO FURTHER ACTION REQUIRED			
Manganse	No	NO FURTHER ACTION REQUIRED			
Potassium	No	NO FURTHER ACTION REQUIRED			
Sodium	No	NO FURTHER ACTION REQUIRED			
Volatile Organic Compounds:					
Acetone	No	NO FURTHER ACTION REQUIRED			

Notes :
COEC - Chemical of ecological concern.
COPEC - Chemical of potential ecological concern.

Table 3-1

Potential Federal and State Regulations Applicable to Corrective Measures
RSA-072-R-01 CMI Work Plan
Redstone Arsenal, Madison County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicability	Comments
Federal			
Safe Drinking Water Act – 40 CFR 149	Sole-source drinking water aquifer designation.	Not applicable	The site is not located over a sole-source aquifer.
Safe Drinking Water Act, 42 USC Section 300 – National Primary Drinking Water Standards - 40 CFR Part 141	Applicable to the use of public water systems. Establishes maximum contaminant level, monitoring requirements, and treatment techniques.	Not applicable	Federal drinking water standards are used by ADEM to establish cleanup standards. However, groundwater is not part of the RSA-072-R-01 corrective measures.
Safe Drinking Water Act, 42 USC Section 300 – Maximum Contaminant Level Goals, 40 CFR 141 Subpart F	Establishes drinking water quality goals set at levels of no known or anticipated adverse health effects.	Not applicable	Federal drinking water goals are used by ADEM to establish cleanup standards. However, groundwater is not part of the RSA-072-R-01 corrective measures.
Floodplain Management – 44 CFR Part 9, Executive Order 11988	Federal agencies proposing actions to be located in a floodplain must first evaluate the potential adverse effects those actions might have on the natural and beneficial values served by the floodplain.	Not applicable	Although part of the site is located within the 100-year floodplain, no actions are planned that will potentially affect its natural and beneficial values.
Floodplain Management – Resource Conservation and Recovery Act (RCRA); RCRA Location Standards, 42 USC Section 6901, 40 CFR 264.18(b)	Requires treatment, storage, or disposal facilities to be designated, constructed, operated, and maintained to avoid washout on a 100-year floodplain.	Not applicable	Although part of the site is located within the 100-year floodplain, no treatment, storage, or disposal is planned at the site.
Protection of Wetlands – 44 CFR Part 9, Executive Order 11990	Federal agencies are directed to avoid construction located in wetlands unless the agency head finds: (1) no practical alternative to such construction, and (2) the proposed action includes all practical measures to minimize harm to wetlands which might result from such use.	Not applicable	No wetlands are located at the site.
Protection of Wetlands – 40 CFR 230	Sets forth guidelines for fill material in wetlands.	Not applicable	No wetlands are located at the site.
Wetlands Permitting - Clean Water Act, Section 404	Identifies permitting requirements for excavation activities in wetlands.	Not applicable	No wetlands are located at the site.

Table 3-1

Potential Federal and State Regulations Applicable to Corrective Measures
RSA-072-R-01 CMI Work Plan
Redstone Arsenal, Madison County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicability	Comments
Endangered Species Act 16 USC 1531 50 CFR 200 & 402	Requires federal agencies to ensure that actions are not likely to threaten the continued existence of endangered/threatened species or adversely modify or destroy the critical habitats of such species.	Not applicable	Actions are not anticipated that will modify or destroy critical habitats.
Fish and Wildlife Coordination Act - 16 USC 661-666 33 CFR 320-330	Sets forth procedures for consultation between regulatory agencies to consider wildlife conservation. Requires any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service.	Not applicable	Discharge to surface water is not a component of the expected remedy.
Wild and Scenic Rivers Act, 16 USC 1274, 40 CFR 6.302(e)	Restricts activities within areas affecting national wild, scenic, or recreational rivers.	Not applicable	No such areas present.
Presence of archaeological resources, 43 CFR 7.4(a), 43 CFR 7.5(b)(1), 43 CFR 10.4(c), 43 CFR 10.4(d)	Restricts excavating, removing, damaging, or otherwise altering or defacing such resources unless by permit or exception. Protects any such archaeological resources, if discovered. Restricts activities in the area of discovery and requires a reasonable effort be made to protect the objects discovered. Requires consultation with the Indian tribe likely to be affiliated with the objects to determine further disposition per 43 CFR 10.5(b).	Not applicable	No actions are planned at the site that would impact any archeological resources, if present.
National Archaeological and Historical Preservation Act (16 USC Section 469-470); 36 CFR Parts 65, 79	Requires action be taken to recover and preserve artifacts.	Not applicable	No actions are planned at the site that would impact any archeological resources, if present.
Department of the Army, Environmental Protection and Enhancement; Historic Preservation, 32 CFR 643.28	Requires preservation, restoration, or rehabilitation of all sites, structures, and objects of historical, architectural, archeological, or cultural significance located on Army-controlled property.	Not applicable	No actions are planned at the site that would impact any archeological resources, if present.

Table 3-1

Potential Federal and State Regulations Applicable to Corrective Measures
RSA-072-R-01 CMI Work Plan
Redstone Arsenal, Madison County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicability	Comments
Native American Graves Protection and Repatriation Act, 25 USC 3001-3013 and 43 CFR 10	Requires protection of Native American graves discovered during excavation activities.	Not applicable	Actions are not anticipated that would impact Native American burial sites or cultural items if they are present at the site.
American Indian Religious Freedom Act, 42 USC 1996	Requires activities in the area of discovery to be stopped and affected work to be suspended until a compliance strategy is approved.	Not applicable	Actions are not anticipated that would impact historic resources if they are present at the site.
Standards Applicable to Generators of Hazardous Waste, 40 CFR Part 262	Establishes standards for generators of hazardous waste under RCRA. Specifies requirements for hazardous waste packaging, labeling, manifesting, record keeping, and accumulation time.	Not applicable	Hazardous waste is not expected to be generated as part of the site remedy.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264.13(a)(1)	Must obtain a detailed chemical and physical analysis on a representative sample of the waste(s).	Not applicable	Hazardous waste is not expected to be generated as part of the site remedy.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264.170-179	Management of hazardous waste in containers.	Not applicable	Hazardous waste is not expected to be generated as part of the site remedy.
Land Disposal Restrictions, 40 CFR 268	Identifies hazardous wastes that are restricted from land disposal.	Not applicable	Hazardous waste is not expected to be generated as part of the site remedy.
Discharge to Offsite Surface Water, 40 CFR 122.26, 122.41, and 122.48	Requires that the selected remedial action must establish a standard of control to maintain surface water quality protection from stormwater runoff.	Not applicable	Discharge to surface water is not anticipated as part of the site remedy.
Superfund Amendments and Reauthorization Act, 42 USC Section 9601 et. Seq	Requires the discharge to comply with federal water quality criteria.	Not applicable	Discharge to surface water is not anticipated as part of the site remedy.

Table 3-1

Potential Federal and State Regulations Applicable to Corrective Measures
RSA-072-R-01 CMI Work Plan
Redstone Arsenal, Madison County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicability	Comments
Clean Water Act, 33 USC Sections 1351-1376 – Best Available Treatment Technology, 40 CFR 122	Requires use of best available technology economically achievable to control discharge of toxic pollutants to a POTW.	Not applicable	There is no POTW. Sewer at RSA is private.
Clean Water Act, 33 USC Sections 1351-1376 – National Pollutant Discharge Elimination System Permit Regulations, 40 CFR 122 Subpart C	Requires use of best available technology economically achievable for toxic pollutants discharged to surface waters. Mandates that the discharge must comply with the EPA-approved Water Quality Management Plan.	Not applicable	No discharge to surface water is planned for this site.
Discharge to a POTW, 33 USC Section 1317, 40 CFR 403	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge to POTWs.	Not applicable	There is no POTW. Sewer at RSA is private.
Tennessee Valley Authority Act of 1933 [48 Stat. 58-59, 16 USC sec. 831], 18 CFR 1304	Identifies permit requirements for approval of construction in the Tennessee River system and regulation of structures and other alterations.	Not applicable	No construction is planned that will affect the Tennessee River system.
Clean Air Act, codified under 40 CFR Part 60, Part 61, or Part 63. Prerequisite for this action: 40 CFR 264,1030(e)	Process vents associated with air or stream stripping operations that manage hazardous wastes with organic concentrations of at least 10 parts per million weight.	Not applicable	No treatment is anticipated for the site.
State			
Alabama Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, ADEM 335-14-5, Hazardous Waste Program	Establishes location standards for facilities located in 100-year floodplains. Forbids placement of any non-containerized or bulk liquid hazardous waste within any salt dome/salt bed, underground mine or cave.	Not applicable	Although the site is located within the 100-year floodplain, no action is planned that would impact the floodplain area.
Alabama Identification and Listing of Hazardous Waste, ADEM 335-14-3	Establishes standards for generators of hazardous waste including, identification, accumulation, transport, and reporting.	Not applicable	Hazardous waste is not expected to be generated as part of the site remedy.
Alabama Drinking Water Standards ADEM 335-7-2	Applicable to the use of public water systems. Establishes maximum contaminant level, monitoring requirements, and treatment techniques.	Not applicable	Groundwater is not part of the site remedy.
Alabama Water Quality Criteria, ADEM 335-6-10, Water Quality Program	Requires any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service. Establishes antidegradation policy based on water use classifications and potentially impacted wildlife, fish, and aquatic life.	Not applicable	Discharge to surface water is not included as a component of the remedy for this site.

Table 3-1

Potential Federal and State Regulations Applicable to Corrective Measures
RSA-072-R-01 CMI Work Plan
Redstone Arsenal, Madison County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicability	Comments
UST Requirements – ADEM 335-6-15	Technical standards, corrective action requirements and financial responsibility for owners and operators of USTs.	Not applicable	USTs were not present at the site.
Wetlands Protection - ADEM 335-8-2.02/2.03	Defines requirements for dredging or filling and mitigation of impacts to wetlands.	Not applicable	No wetlands are located at the site.
Alabama Non-Game Species Regulation, AAC 220-2.92	Identifies state-protected species.	Not applicable	Applicable if state-protected species are encountered. However, proposed activities are unlikely to adversely impact any non-game species that may be present.
Phase I Organic Air Emission Standards: AAC 335-14-5-.27 and 335-15-5-.28	For TSDFs. Emission standards for process vents and emission standards for leaks from specific equipment containing hazardous waste with a total organic concentration of at least 10 percent by weight.	Not applicable	No TSDFs are planned as part of the expected remedy.
Phase II Organic Air Emission Standards: AAC 335-14-5-.29	For TSDFs. Emission standards tanks, surface impoundments, containers and miscellaneous units that contact hazardous waste containing an average organic concentration greater than 500 parts per million weight.	Not applicable	No regulated units will be developed as part of the expected remedy.
Alabama Solid Waste Act, Code of Alabama, Title 22, Chapter 27	Establishes sitewide program to provide for the safe management of nonhazardous wastes.	Not applicable	Nonhazardous waste will not be generated during corrective measure activities.
Alabama Solid Waste Management Regulations, ADEM 335-13-1 through 335-13-8	Establishes minimum criteria for the processing, recycling, transportation, and disposal of solid wastes and the design, location, and operation of solid waste disposal facilities.	Not applicable	Nonhazardous waste will not be generated, transported, or disposed as part of corrective measure activities.
Alabama Stormwater Discharge Regulations, ADEM 335-6-12	Establishes requirements for a stormwater discharge permit for construction activities that disturb greater than 1 acre of land.	Not applicable	The remedy will not create disturbance of greater than 1 acre of land.
Alabama Water Quality Criteria and Use Classifications Regulations, ADEM 335-6-10	Establishes water quality criteria and uses for lakes and rivers based on toxicity to aquatic organisms and human health and water use classifications and antidegradation policy.	Not applicable	No discharge to surface water is planned as part of the remedy for this site.

Table 3-1

Potential Federal and State Regulations Applicable to Corrective Measures
RSA-072-R-01 CMI Work Plan
Redstone Arsenal, Madison County, Alabama

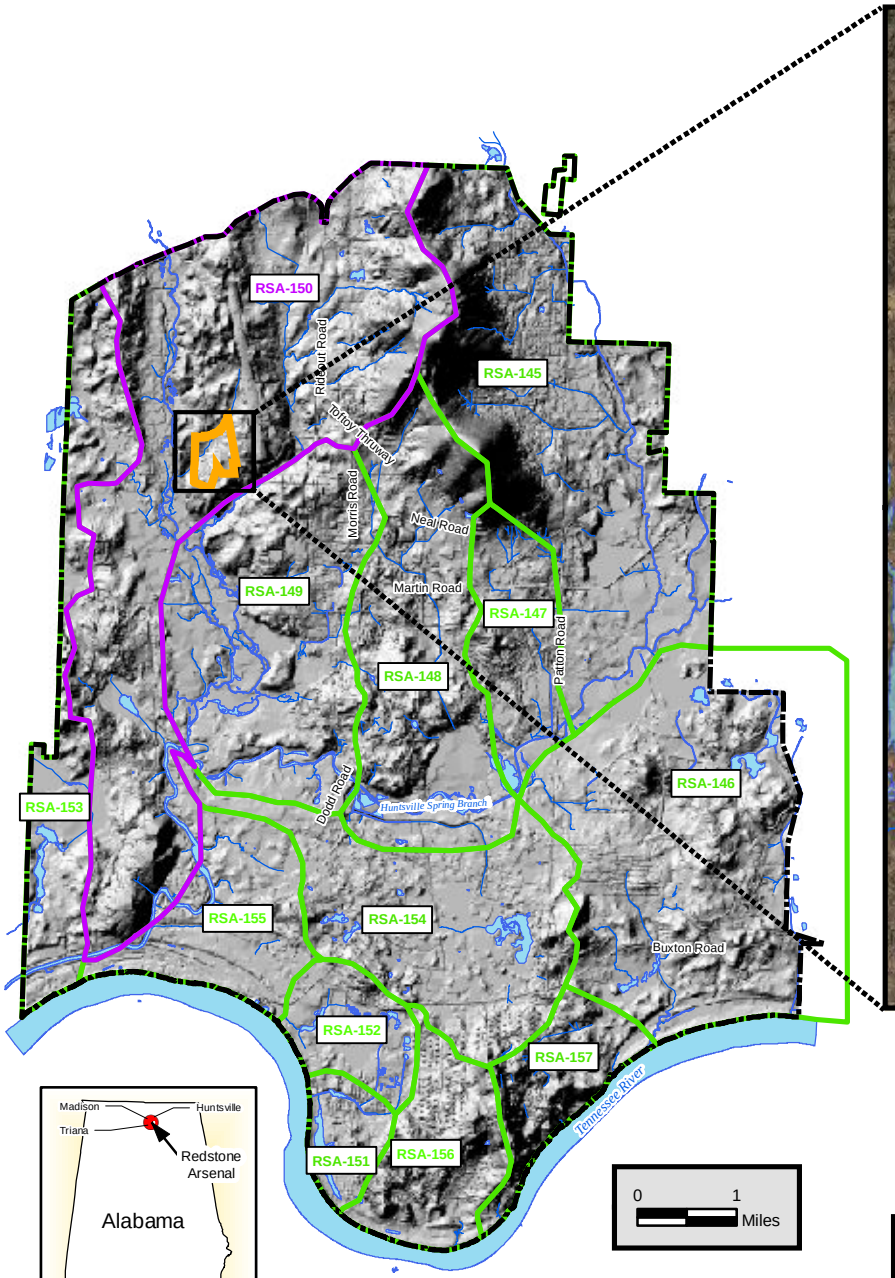
Standard, Requirement, or Criterion	Requirement	Applicability	Comments
Indirect Discharge Permits and Pretreatment Rules, ADEM 335-6-5	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge to POTWs and defines the requirements for State Indirect Discharge permits for discharge to POTWs.	Not applicable	There is no POTW. Sewer at RSA is private.
Alabama Wellhead Protection Program, ADEM 335-7-12	Establishes requirements for the closure or abandonment of groundwater monitoring or extraction wells.	Not applicable	No monitoring wells are planned to be abandoned/closed as part of the corrective measures.
Alabama Uniform Environmental Covenants Program, ADEM 335-5	**Establishes the requirements for environmental use restrictions on federal facility property.**	**Applicable**	**Environmental use restrictions are part of the corrective measures at the site.**

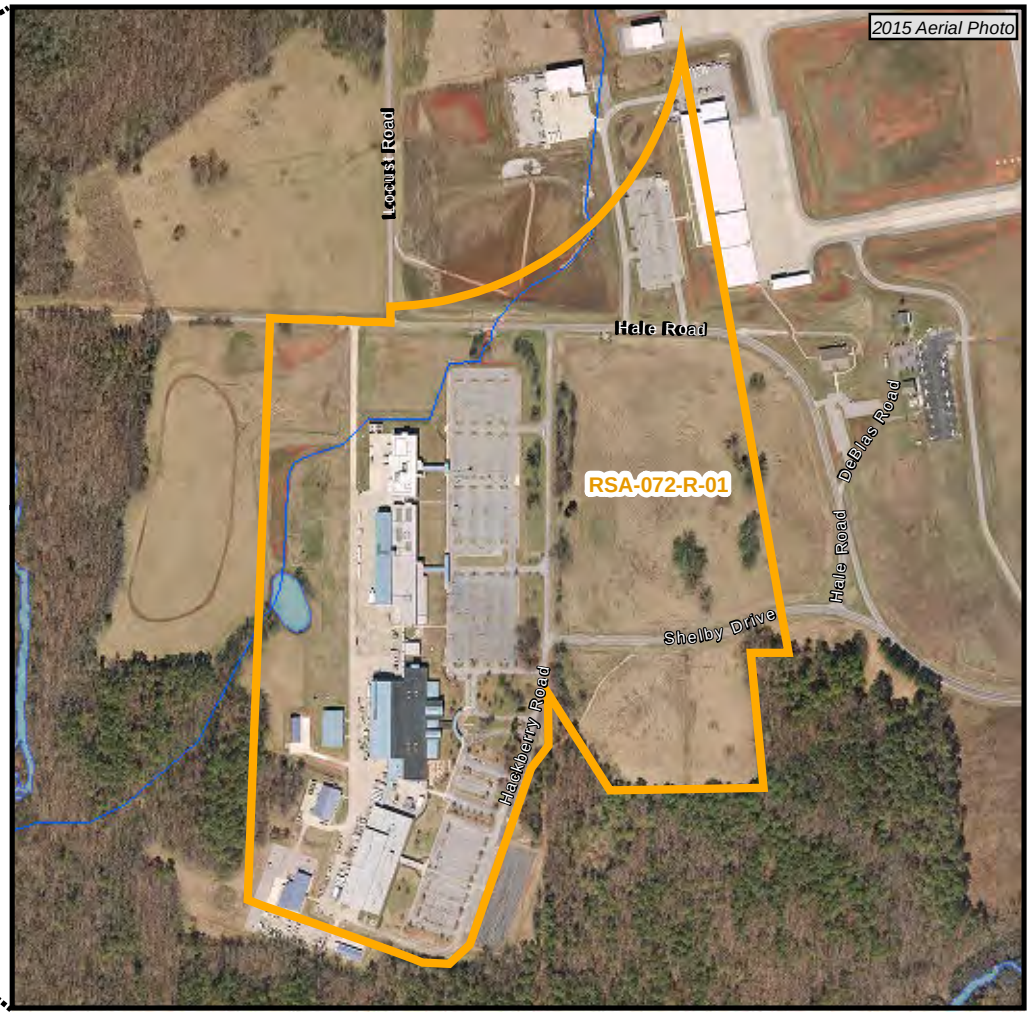
Notes:

This list is a comprehensive list of potential federal and state regulations potentially applicable to corrective measures performed at RSA. Only those specifically applicable to the selected corrective measures for RSA-072-R-01 are listed in bold.

ADEM - Alabama Department of Environmental Management.
CFR – Code of Federal Regulations.
LUC - Land-use control.
POTW - Publicly owned treatment works.
RCRA – Resource Conservation and Recovery Act.
RSA - Redstone Arsenal.
TSDF - Treatment, storage, and/or disposal facility.
USC – United States Code.
UST – Underground storage tank.

FIGURES





Legend

- RSA-072-R-01 Site Boundary
- RSA-150 Groundwater Unit Boundary
- Groundwater Unit Boundaries
- RSA Installation Boundary
- Water Bodies
- Surface Drainage Features (Some Ephemeral)

Figure 1-1

RSA-072-R-01
Site Location Map

Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

1 inch = 800 feet

0 400 800 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

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2015 Aerial Photo

RSA-120
RSA-253
RSA-278
RSA-313
RSA-071
RSA-284
RSA-319
RSA-035
RSA-042
RSA-034
MSFC-033A
RSA-036
RSA-072-R-01
RSA-072
RSA-121
RSA-285
MSFC-D
MSFC-055
MSFC-027
MSFC-065
RSA-183
MSFC-034
MSFC-053
MSFC-077
MSFC-002
RSA-073
RSA-312
RSA-074
RSA-009
RSA-254
RSA-254
RSA-050

Overlook Road
Rideout Road
Goss Road
Bennet Street
Homestead Road
Locust Road
Indian Creek
Anderson Road
Airfield Road
Rideout Road
Toftoy Thruway
Hale Road
Shelby Drive
Hackberry Road
Marshall Drive
Neal Road
Neal Road
Pioneer Street
Pogo Road
Apollo Road
Digney Road
Mercury Road
Tiros Street
Gemini Road
Titan Street
Morris Road
Avenue
Martin Road
Beacon Street
Centaur Street
Fowler Road

Legend

- RSA-072-R-01 Site Boundary
- Nearby Environmental Site
- No Further Action Site (NFA)
- RSA Boundary
- Water Bodies
- Wetland Area
- Surface Drainage Features (Some Ephemeral)

Figure 1-3

RSA-072-R-01
Surrounding Sites

Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

1 inch = 1,800 feet

N

0 900 1,800 3,600 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

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2015 Aerial Photo

RSA-072

RSA-072-R-01

Overlook Road
Rideout Road
Goss Road
Locust Road
Homestead Road
Toftoy Thruway
Airfield Road
Rideout Road
Anderson Road
Hale Road
Shelby Drive
Hackberry Road
Marshall Drive
Neal Road
Neal Road
Pioneer Street
Pogo Road
Digney Road
Apollo Road
Mercury Road
Tiros Street
Titan Street
Martin Road
Centerline Road

Legend

- Surface Drainage Features (Some Ephemeral)
- Water Bodies
- Wetland Area
- Former Troop Training Area C
- Former Powder Storage Magazines
- Former Range 1B
- RSA-072-R-01 Site Boundary
- RSA-072 Site Boundary
- RSA Boundary

Figure 1-4

RSA-072-R-01
Potential Source Areas

Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

1 inch = 1,500 feet

N

0 750 1,500 3,000 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

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2015 Aerial Photo

Locust Road

Rotary Wing Facility
No MEC or MD

Area A
1 MEC Item (1.5 feet bgs)
4 MD Items

Hale Road

Retention Pond
16 MEC Items (1-4 feet bgs)
No MD

RSA-072-R-01

Shelby Drive

Hackberry Road

Sewer Line Installation
and Parking Lot Extension
No MEC or MD

Legend
bgs - Below ground surface
MD - Munitions Debris
MEC - Munitions and Explosives of Concern
TCRA - Time-Critical Removal Action

- Projectile Location (4.2-inch Mortars)
- Sewer Line
- Surface Drainage Features (Some Ephemeral)
- Water Bodies
- TCRA Area Cleared (Investigated and any MEC/MD Removed)
- RSA-072-R-01 Site Boundary

Figure 2-1a

RSA-072-R-01
2008-2009 Time-Critical Removal Action Areas

Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

1 inch = 300 feet

N

0 150 300 600 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

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2015 Aerial Photo

Locust Road

Hale Road

Hackberry Road

Shelby Drive

Geophysical Survey Area 3, Transect

Geophysical Survey Area 1, Transect

Evaporation Pond not Surveyed

Geophysical Survey Area 2, Full Coverage

Geophysical Survey Area 2, Transect

374
467
169
105
261
359
226
262
1794
2199
224
301
223
319
2148
306
1731
292
320
321
312
326
325
234
327

06267
06264
06266
06263
06274
06271
06273
6265A
06265
06260
06272
06259

Legend

RFI - Resource Conservation and Recovery Act Facility Investigation

2013 Intrusive Investigation Findings

Munition Debris:

- Cartridge Case, 40-mm
- Projectile, 4.2-in, mortar, cement filled
- Projectile, 4.2-in, mortar, sand filled
- Projectile, 40-mm, parachute, illumination, M583 series
- Signal, illumination
- Unidentifiable Fragment

Small Arms Ammunitions

- Small Arms Ammunitions

2008-2009 Time-Critical Removal Action, Select Findings

- Projectile (fired)
- RFI Geophysical Full-Coverage Survey Area
- RFI Geophysical Transect Survey Area
- RSA-072-R-01 Site Boundary

Figure 2-1b

RSA-072-R-01
2013 Intrusive Investigation Findings
Munitions-Related Items

Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

1 inch = 250 feet

0 125 250 500 Feet

NAD 1983 State Plane Alabama East Feet

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2015 Aerial Photo

RSA-072-R-01

Z-RS1128
072-SB01
072-IS01
072-IS03
072-SB03
072-SB06
072-SB011
072-RS1629
072-IS04
072-SO001
072-SB08
072-RS1628
072-SD002
072-SW002
072-SD004
072-SD005
072-SB010
072-SB09
072-RS2817
072-SB07A
072-RS1627
072-SB07
U72-RS1347

Hale Road
Locust Road
Airfield Road
South Access Road
DeBlois Road
Shelby Drive
Hackberry Road

Legend

- Overburden Well
- Bedrock Well
- Surface Soil Sample Location
- Soil Sample Location
- Sediment Sample Location
- Surface Water Sample Location
- No groundwater samples could be collected due to insufficient yield
- Fence
- Surface Drainage Features (Some Ephemeral)
- Water Bodies
- Wetland Area
- Incremental Sample Units Area
- RSA-072-R-01 Site Boundary

Figure 2-2

RSA-072-R-01
Sample Location Map

Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

1 inch = 420 feet

N

0 210 420 840 Feet

NAD 1983 State Plane Alabama East Feet

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Legend

Color Indication:
Red -- Exceeds Residential Soil PSV (See Note 1 for Metals)
Green -- Below Residential Soil PSV (See Note 2 for Metals)
PSV -- Preliminary Screening Value
BSV -- Background Screening Value

Note 1: Metals concentrations that exceed both the BSVs and PSVs, and were determined to be anomalous by site-to-background comparison, are posted as red.
Note 2: Metals results below BSV or PSV, or determined to be naturally occuring by site-to-background comparison, are posted in green.

- Overburden Well
- Surface Soil Sample Location
- Soil Sample Location
- Sediment Sample Location
- Surface Water Sample Location
- Surface Drainage Features (Some Ephemeral)
- Water Bodies
- RSA-072-R-01 Site Boundary

Hale Road
DeBlas Road
Shelby Drive
Hackberry Road
Locust Road

072-SB01
072-SB06
072-SB03
072-SB011
072-RS1629
072-SB08
072-RS1628
072-SD002
072-SW002
072-SD004
072-SD005
072-SB010
072-SB09
072-SB07
072-SB07A
072-SO001

RSA-072-R-01 Surface Soil, Sediment, and Surface Water

2015 Aerial Photo

RSA-072-R-01 Subsurface Soil

Figure 2-3
RSA-072-R-01
Summary of Nature and Extent of Contamination in Soils, Sediment, and Surface Water

Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

1 inch = 500 feet
0 250 500 Feet
NAD 1983 State Plane Alabama East Feet

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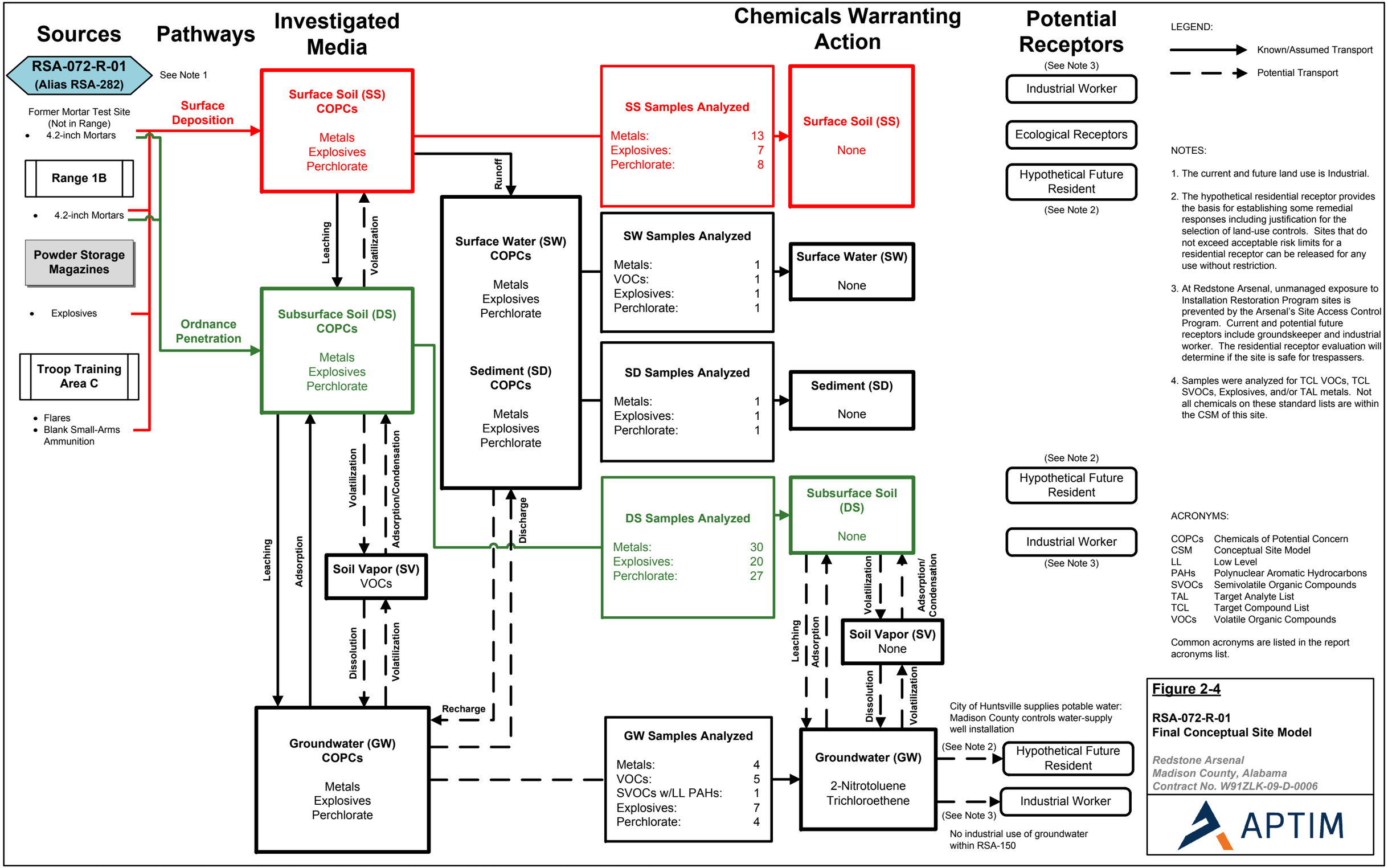

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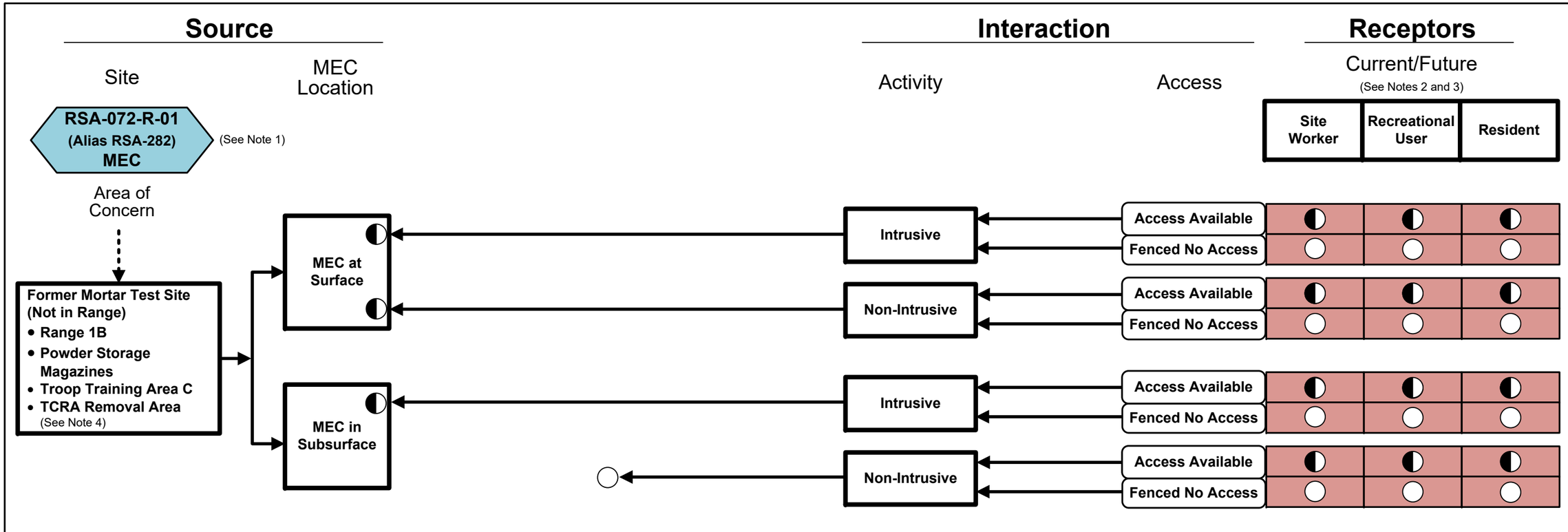
S. Bentley



NOTES:
1. The current and future land use is Industrial.
2. The hypothetical residential receptor provides the basis for establishing some remedial responses. Sites that do not exceed acceptable risk limits for a residential receptor can be released for any use without site access and use restrictions.
3. At Redstone Arsenal, unmanaged exposure to Installation Restoration Program sites is prevented by the Arsenal's Site Access Control Program. Current and potential future receptors include site worker (groundskeeper and construction worker). The residential receptor evaluation will determine if the site is safe for trespassers. Potential future only receptors include recreational users and hypothetical residential receptors.
4. MEC was not found during the RSA-072-R-01 RCRA facility investigation, but a total of 17 MEC items were found prior to and during a TCRA in 2008-2009. This site was part of a former range and full coverage geophysical mapping and intrusive investigations have only been conducted across select areas of the site. Thus, MEC is potentially present in site areas outside of where the TCRA removals occurred (Figure 2-1a and Section 2.2.1).

ACRONYMS:

MEC	Munitions and Explosives of Concern
RCRA	Resource Conservation Recovery Act
TCRA	Time-Critical Removal Action

● **Complete Pathway**

○ **Incomplete Pathway**

◐ **Potentially Complete Pathway**

Figure 2-5

RSA-072-R-01
Final Conceptual Site Model for MEC
Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

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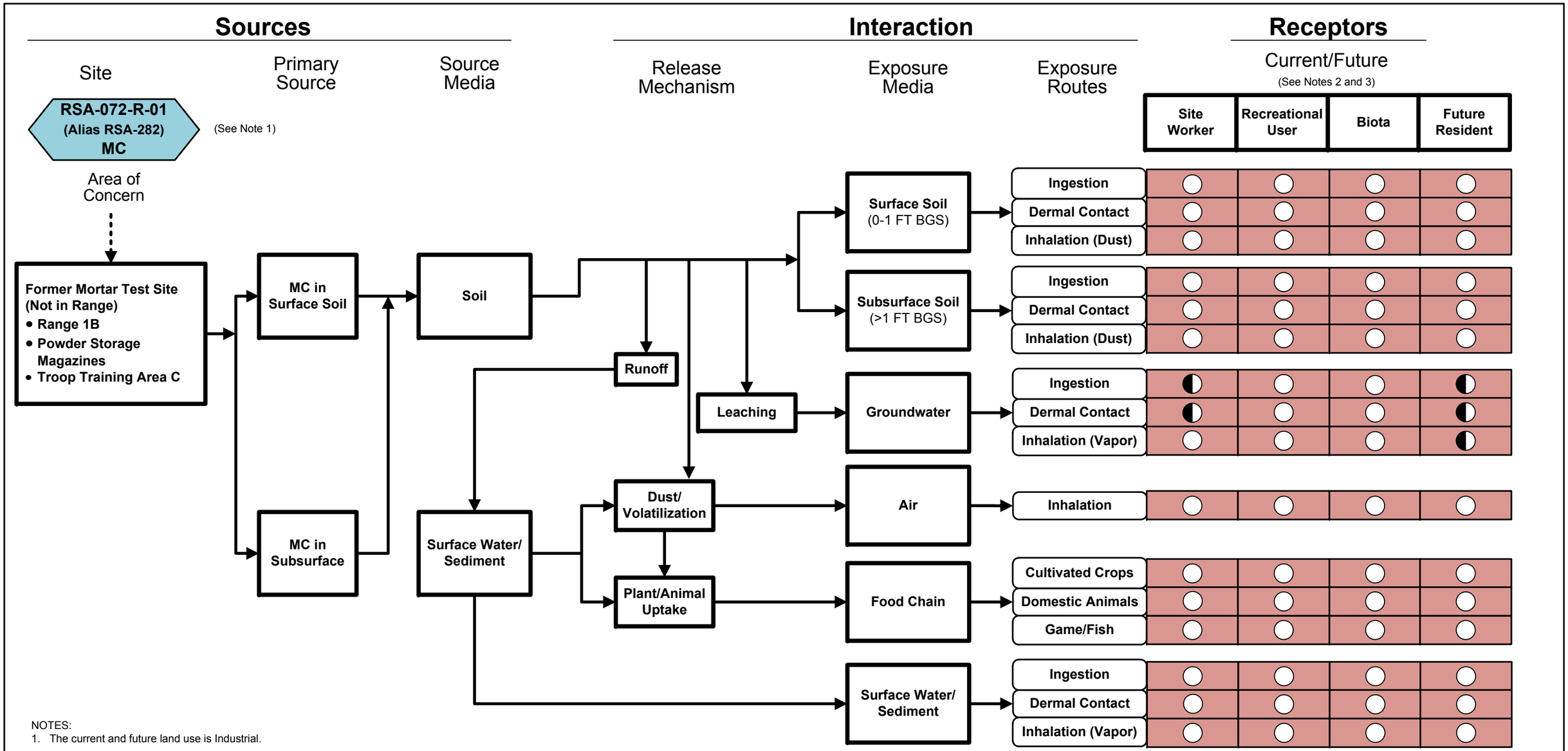
S. Bentley

(R-6/20/2019)



NOTES:

1. The current and future land use is Industrial.
2. The hypothetical residential receptor provides the basis for establishing some remedial responses including justification for the selection of land-use controls. Sites that do not exceed acceptable risk limits for a residential receptor can be released for any use without restriction.
3. At Redstone Arsenal, unmanaged exposure to Installation Restoration Program sites is prevented by the Arsenal's Site Access Control Program. Current and potential future receptors include site worker (groundskeeper and construction worker). The residential receptor evaluation will determine if the site is safe for trespassers. Potential future only receptors include recreational users and hypothetical residential receptors.
4. Pathways for exposure to MC are incomplete in all media except for groundwater because MC was found to pose no risks to human health or the environment at RSA-072-R-01.

ACRONYMS:

FT BGS Feet Below Ground Surface
MC Munitions Constituents

● Complete Pathway

○ Incomplete Pathway or Pathway Poses No Unacceptable Risks

◐ Potentially Complete Pathway

Figure 2-6

RSA-072-R-01
Final Conceptual Site Model for MC
Redstone Arsenal
Madison County, Alabama
Contract No. W91ZLK-09-D-0006

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S. Bentley

Site Access and Use Restriction Coordinates		
Point Number	Latitude	Longitude
1	34° 40' 9.482" N	86° 41' 37.950" W
2	34° 40' 9.359" N	86° 41' 31.950" W
3	34° 40' 10.018" N	86° 41' 31.965" W
4	34° 40' 10.424" N	86° 41' 28.534" W
5	34° 40' 11.951" N	86° 41' 24.306" W
6	34° 40' 14.620" N	86° 41' 20.692" W
7	34° 40' 17.932" N	86° 41' 18.380" W
8	34° 40' 20.282" N	86° 41' 17.595" W
9	34° 39' 55.885" N	86° 41' 11.941" W
10	34° 39' 55.868" N	86° 41' 13.834" W
11	34° 39' 50.303" N	86° 41' 13.143" W
12	34° 39' 50.154" N	86° 41' 20.804" W
13	34° 39' 54.145" N	86° 41' 23.931" W
14	34° 39' 51.973" N	86° 41' 23.895" W
15	34° 39' 51.034" N	86° 41' 24.742" W
16	34° 39' 43.739" N	86° 41' 27.738" W
17	34° 39' 42.951" N	86° 41' 28.725" W
18	34° 39' 42.994" N	86° 41' 30.083" W
19	34° 39' 45.499" N	86° 41' 38.828" W
20	34° 39' 59.028" N	86° 41' 38.321" W
21	34° 40' 5.216" N	86° 41' 38.106" W

Land-Use Control Coordinates		
Point Number	Latitude	Longitude
1	34° 39' 58.288" N	86° 41' 34.241" W
2	34° 39' 58.312" N	86° 41' 35.004" W
3	34° 39' 58.198" N	86° 41' 35.595" W
4	34° 39' 59.371" N	86° 41' 36.574" W
5	34° 39' 59.409" N	86° 41' 37.977" W
6	34° 39' 59.436" N	86° 41' 38.055" W
7	34° 40' 1.541" N	86° 41' 38.442" W
8	34° 40' 3.656" N	86° 41' 38.827" W
9	34° 40' 4.693" N	86° 41' 38.493" W
10	34° 40' 5.507" N	86° 41' 37.770" W
11	34° 40' 5.489" N	86° 41' 36.262" W
12	34° 40' 5.476" N	86° 41' 34.748" W
13	34° 40' 4.788" N	86° 41' 34.259" W
14	34° 40' 3.323" N	86° 41' 34.176" W
15	34° 40' 1.195" N	86° 41' 34.175" W
16	34° 39' 59.324" N	86° 41' 34.144" W

Figure 4-1
RSA-072-R-01
Land-Use Control and Site Access and Use Restriction Boundaries
Redstone Arsenal
Madison County, Alabama
Contract No. W9124J-18-D-0004

Environmental Chemical Corporation

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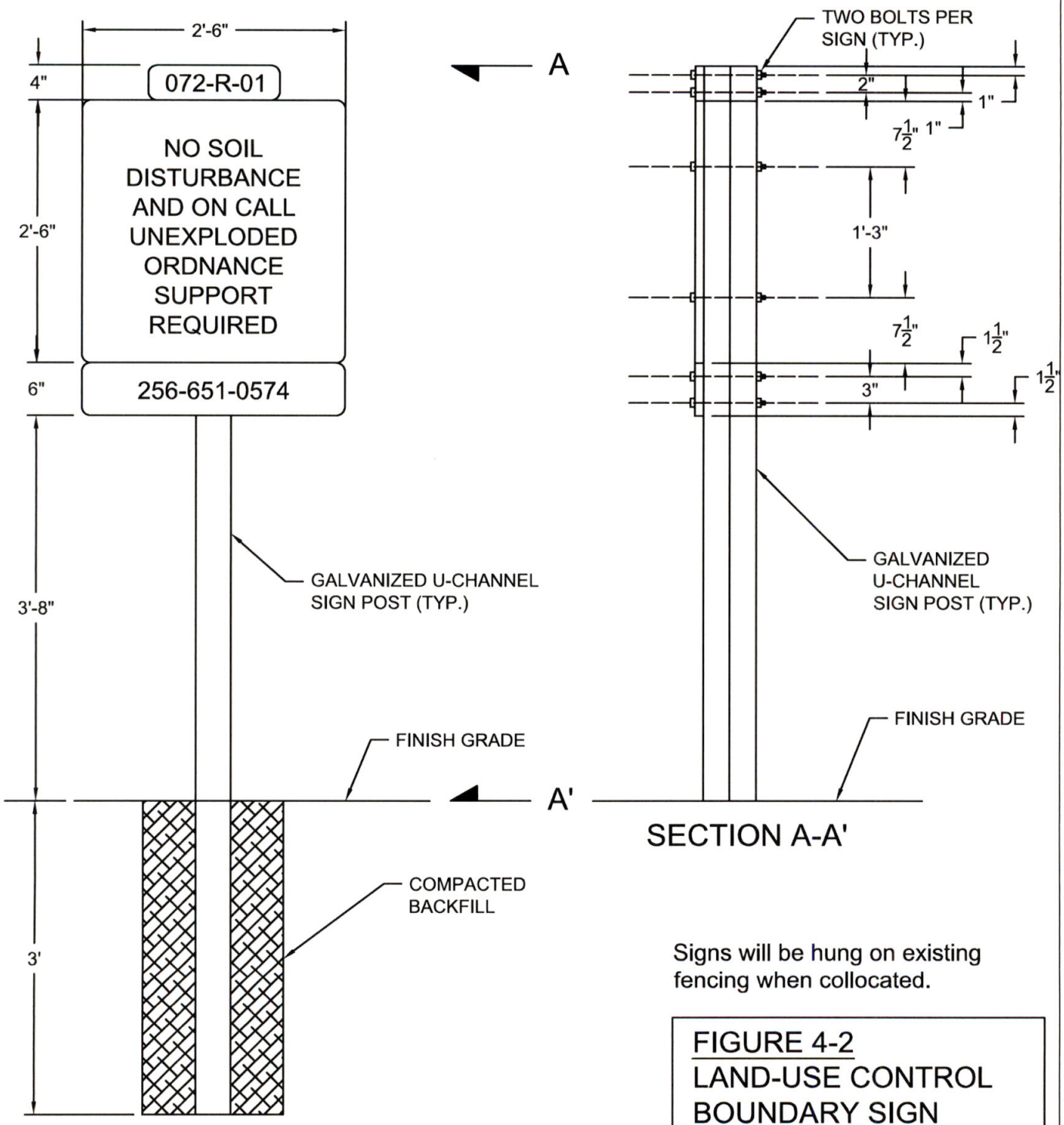

FIGURE 4-2
LAND-USE CONTROL BOUNDARY SIGN
RSA-072-R-01

Redstone Arsenal
Madison County, Alabama
Contract No. W9124J-18-D-004

Environmental Chemical Corporation

Figure 4-3
RSA-072-R-01
Locations of New and Existing Signs
Redstone Arsenal
Madison County, Alabama
Contract No. W9124J-18-D-0004

APPENDIX A

ADEM CONCURRENCE LETTER FOR RSA-072-R-01 RFI REPORT

LANCE R. LEFLEUR
DIRECTOR

ROBERT J. BENTLEY
GOVERNOR

Alabama Department of Environmental Management
adem.alabama.gov

1400 Coliseum Blvd. 36110-2400 ■ Post Office Box 301463
Montgomery, Alabama 36130-1463
(334) 271-7700 ■ FAX (334) 271-7950

December 29, 2016 91 7199 9991 7034 1847 2369

CERTIFIED MAIL #

Mr. Terry Hazle
Director
Directorate of Environmental Management
DEPARTMENT OF THE ARMY
Installation Restoration Division
(AMSAM-RA-DEM-IR)
US Army Aviation and Missile Command
Bldg. 4488
Redstone Arsenal, AL 35898

RE: **ADEM Review and Concurrence:** *Revision 1, Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for RSA-072-R-01, Former Mortar Test Site (Not in Range), Operable Unit 15,* dated November 2, 2016
Redstone Arsenal (RSA) DSMOA Environmental Restoration Program
U.S. EPA I.D. No. AL 7 210 020 742

Dear Mr. Hazle:

The Alabama Department of Environmental Management (ADEM or the Department) has reviewed the Army's *Revision 1, Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for RSA-072-R-01, Former Mortar Test Site (Not in Range), Operable Unit 15,* dated November 2, 2016. Based on this review, the Department has determined that all comments on the Revision 0 version of this document have been adequately resolved and concurs with the Revision 1 RFI Report for RSA-072-R-01. The Department understands that the surface media may be impacted by munitions and explosives of concern (MEC) but have not been impacted by munitions constituents (MC) at RSA-072-R-01. Groundwater has been determined to contain two contaminants of concern (COCs) (i.e., 2-nitrotoluene and trichloroethene (TCE)) above preliminary screening values which appear over a large area of the RSA-150 groundwater unit and does not appear to have originated from RSA-072-R-01. Therefore, the Army will address 2-nitrotoluene and TCE as part of the RSA-150 groundwater unit.

In the RSA-072-R-01 RFI Report, the Army recommends an action for surface media at RSA-072-R-01 (which is identified as RSA-282 in Table VI.2 of the Permit) for the potential of MEC. It is possible that UXO is present at a density of up to 1 per acre in some areas of RSA-072-R-01. The Army has determined that although COCs do not exist in surface media at the site,

Birmingham Branch
110 Vulcan Road
Birmingham, AL 35209-4702
(205) 942-6168
(205) 941-1603 (FAX)

Decatur Branch
2715 Sandlin Road, S.W.
Decatur, AL 35603-1333
(256) 353-1713
(256) 340-9359 (FAX)

Mobile Branch
2204 Perimeter Road
Mobile, AL 36615-1131
(251) 450-3400
(251) 479-2593 (FAX)

Mobile-Coastal
3664 Dauphin Street, Suite B
Mobile, AL 36608
(251) 304-1176
(251) 304-1189 (FAX)

corrective measures are needed to ensure that the potential presence to MEC does not pose an unacceptable risk to possible receptors.

Since the findings of this RFI Report indicate action is needed in surface media for potential MEC, a Corrective Measures Implementation (CMI) Plan to address this action is required. The action for groundwater will be addressed as part of the RSA-150 groundwater unit. In accordance with Permit Condition VI.E.2, the CMI Plan must be completed within 120 calendar days following notification from the Department that a CMI Plan is required. Therefore, the Army should submit a CMI Plan which addresses the potential for MEC in surface media within 120 calendar days of receipt of this letter. The Department will move RSA-072-R-01 (also known as RSA-282) from Table VI.2 to Table VI.6 (Sites requiring a corrective measures implementation work plan) in the facility's Alabama Hazardous Wastes Management and Minimization Act (AHWMMA) permit as part of the next permit modification.

If you have any questions on this matter, please contact Philip Stroud of the Facilities Engineering Section at 334-270-5684 or via e-mail at pns@adem.state.al.us.

Sincerely,

Stephen A. Cobb, Chief
Governmental Hazardous Waste Branch
Land Division

SAC/jw/pns

cc: Michelle P. Thornton, US EPA Region IV (via email)
Robert Morris, US EPA Region IV (via email)
J. Jason Wilson/ADEM
Ashley T. Mastin/ADEM
Brian Roberson, NASA MSFC
Terry de la Paz, Redstone Arsenal
Salee Downey, AMTEC (via email)
Bob Barnwell/ADEM (via email)
Kelly Hartley/ADEM (via email)

APPENDIX B

REQUEST FOR REDSTONE RCRA PERMIT MODIFICATION

REQUEST FOR PERMIT MODIFICATION
RSA-072-R-01 (RSA-282), FORMER MORTAR TEST SITE (NOT IN RANGE), OPERABLE UNIT 15
U.S. ARMY GARRISON – REDSTONE
MADISON COUNTY, ALABAMA
JULY 2019

1.0 Introduction

As specified in Section VI.E.3 of the U.S. Army Garrison–Redstone (hereinafter referred to as the Army) Alabama Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility, Thermal Treatment, Solid Waste Management Unit Corrective Action Permit, Modification No. 13 (hereafter referred to as the Permit) (dated August 27, 2018) (Alabama Department of Environmental Management [ADEM], 2018), a request for permit modification is to be submitted along with a corrective measures implementation (CMI) work plan. The Army has been directed to include this request for permit modification in an appendix to the CMI work plan. Therefore, this request for modification to the Permit has been prepared for Solid Waste Management Unit (SWMU) RSA-072-R-01, Former Mortar Test Site (Not in Range) (also known as RSA-282) at Redstone Arsenal (RSA) in Madison County, Alabama. The Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) report for RSA-072-R-01 (CB&I Federal Services LLC [CB&I], 2016) received concurrence from ADEM on December 29, 2016. The Army has prepared the CMI work plan and is ready to implement corrective measures for soil at RSA-072-R-01.

As part of the RFI report, the Army requested that ADEM move this site from Table VI.2 to Table VI.6 in the Permit and list it as requiring corrective measures for soil. ADEM subsequently moved RSA-072-R-01 to Table VI.6 in Permit Modification No. 10 (ADEM, 2017a). As specified in Section VI.E.3 of the Permit, this modification will serve to incorporate the proposed remedy, including all procedures necessary to implement and monitor the final corrective measures for this site, into the Permit in accordance with Alabama Administrative Code (AAC) r. 335-14-8-.04(2).

2.0 Facility and Site Description

RSA is located in the southwestern portion of Madison County, which is in the northern portion of Alabama (Figure 1-1 in the CMI work plan). RSA is a U.S. Army facility that encompasses approximately 38,300 acres of land, all of which are either owned or controlled by the Army.

Development within RSA has largely centered on the historical production (and later disposal) of conventional and chemical munitions and, more recently, development and testing of missiles and rockets. These processes have produced chemical wastes since operations began in the early 1940s.

A brief site description of RSA-072-R-01 is provided below, but a more comprehensive description is included in the RFI report (CB&I, 2016). RSA-072-R-01 is a 117-acre surface site located in the northwestern portion of RSA, above the RSA-150 groundwater unit (Figure 1-1 in the CMI work plan). RSA-072-R-01 contains all of Hackberry Road and portions of Hale Road and Shelby Drive (Figure 1-2 in the CMI work plan). Approximately one-half of the site area is occupied by buildings, parking lots, and other paved surfaces. RSA-072-R-01 was part of the former RSA-072 mortar-tube proofing range and contained all or part of three potential source areas as follows:

- RSA-072-R-01 was once a downrange portion of RSA-072, Mortar Shell Test Site, Area B, which was a mortar-tube proofing range during the early 1940s. However, use of this range was limited since the range of the 4.2-inch mortar was increased during World War II when a high explosive mortar shell was developed. Thus, mortar-tube proofing was believed to have been relocated to RSA-071 to the west (Figure 1-3 in the CMI work plan). Due to the changes in operational range boundaries identified in the 2005 Operational Range Inventory Sustainment, RSA-072-R-01 was removed as an operational range and thus became Military Munitions Response Program (MMRP) eligible.

- Former Troop Training Area C slightly overlapped RSA-072-R-01 along its eastern boundary (Figure 1-4 in the CMI work plan) and may have been used by the National Guard and rescue units for training exercises beginning in the early to mid-1960s.

- Former Range 1B overlapped the southern portion of RSA-072-R-01 (Figure 1-4 in the CMI work plan) and was identified as a former 4.2-inch mortar impact area.

- Three former Powder Storage Magazines were located within the central portion of RSA-072-R-01 (Figure 1-4 in the CMI work plan). The magazines were built in 1943, and the type(s) of powder stored in the magazines is unknown. There is no indication in the given historical records that any chemical warfare materiel was used, stored, or disposed at RSA-072 or these potential source areas.

RSA-072-R-01 has been assigned to the U.S. Department of Defense (DoD) MMRP for investigation and cleanup.

3.0 Investigative History

Environmental investigations relevant to RSA-072-R-01 are listed below.

- RSA-150, RSA-153, RSA-154, and RSA-155 potential source area investigation (Shaw Environmental, Inc. [Shaw], 2006)
- Historical records review (Malcolm Pirnie, Inc., 2008a)
- Site inspection report (Malcolm Pirnie, Inc., 2008b)
- Site-specific final report for the Redstone Software Engineering Directorate Phases I and II time-critical removal action (TCRA) (EOD Technology, Inc., 2010)
- RFI report for RSA-072-R-01 (CB&I, 2016)
- RFI report for RSA-150/153 groundwater units (Aptim Federal Services, LLC [APTIM], 2018a).

A TCRA was completed at the site in 2008-2009 that identified and removed munitions and explosives of concern (MEC) that included 4.2-inch mortar projectiles (Figure 2-1a in the CMI work plan). During the subsequent RFI, digital geophysical mapping and intrusive investigations were performed in full coverage (northern portion of Geophysical Survey Area 2) or along transects in select areas (Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Survey Area 2) to characterize MEC at RSA-072-R-01 (Figure 2-1b in the CMI work plan). The statistical sampling program Unexploded Ordnance (UXO) Estimator was used to design the investigation along the transects. Inputs to the UXO Estimator program included a UXO target density of 1 per acre at a confidence level of 95 percent. After the investigation was completed, the UXO Estimator program was used to analyze the field data and confirmed that the target inputs were achieved. The UXO Estimator program calculated a 95 percent confidence that there are less than 0.652 UXO per acre, which is an upper bound on the UXO density at RSA-072-R-01.

The RSA-072-R-01 total usable data set to characterize munitions constituents (MC) and hazardous and toxic waste (HTW) constituents included results from 16 surface soil samples, 30 subsurface soil samples, 1 sediment sample, 1 surface water sample, 8 overburden groundwater samples, and one bedrock groundwater sample (Figure 2-2 in the CMI work plan). Samples were analyzed for one or more of the following: volatile organic compounds (VOC), semivolatile organic compounds (SVOC) (overburden groundwater only), metals, explosives, and perchlorate. Although not within the conceptual site model (CSM) for RSA-072-R-01, analyses for VOCs and SVOCs were included for select groundwater and/or surface water

samples to evaluate possible impacts from adjacent surface and groundwater sites. The RSA-072-R-01 RFI consisted of statistically based MEC characterization and environmental sampling to evaluate potential releases from on-site activities. The nature and extent of contamination in soil, surface water, sediment, and groundwater at RSA-072-R-01 have been defined.

4.0 Scope of the Corrective Measures for RSA-072-R-01

The overall strategy for cleanup at RSA has been presented to the regulatory agencies in two cleanup strategy documents, the *Installation-Wide Groundwater Cleanup Strategy* (Shaw, 2009a) and the *Installation-Wide Strategy for Cleanup of Impacted Wetlands* (Shaw, 2010a). The scope of the corrective measures for RSA-072-R-01 is consistent with these strategies. The selected corrective measures will reduce the hazards associated with exposure to low-probability MEC that may be present at the site. Without corrective measures, the exposure to MEC poses a potential risk to current and future receptors. The corrective measures for chemicals of concern (COC) in groundwater beneath RSA-072-R-01 will be the responsibility of groundwater unit RSA-150.

5.0 Site Characteristics

This chapter provides general information on the site characteristics of RSA-072-R-01 and identifies the components of its CSMs for the site. Further discussion of the site characteristics is included in the RFI report (CB&I, 2016).

Approximately 50 percent of the site area is occupied by buildings, parking lots, and other paved surfaces while the remainder of the site is open grassland with some trees (Figure 1-2 in the CMI work plan). The elevation of the site ranges from approximately 594 feet above mean sea level along the western site boundary to 642 feet above mean sea level at the northern site boundary. Generally, the land slopes from east to west at the site. A surface drainage feature runs southwest from the northern part of the site, channeling surface water into a retention pond on the western site boundary and then to an evaporation pond that drains off site to the west. Numerous on-site sinkholes may provide a connection between surface water and groundwater. The western area of the site surrounding the evaporation pond lies within the 100-year floodplain associated with Indian Creek. Indian Creek and its bordering wetlands are located approximately 1,000 feet west of the site. The average depth to groundwater is 28.17 feet below ground surface. The overburden thickness, as determined from installation of monitoring wells, ranges from approximately 37 to 49 feet below ground surface.

Conceptual Site Model. The RSA-072-R-01 CSMs used for the investigation of MEC, MC, and HTW include the following main components:

- MEC and MC may be present at RSA-072-R-01 based on past uses of RSA-072 as a mortar test range with slight overlap of a troop training area and the presence of powder storage magazines. Chemically configured MEC was confirmed at RSA-072-R-01 and removed prior to and during a TCRA in 2008-2009. Given the mortar test range, there is the possibility that exploded and unexploded mortar projectiles remain in this area following the TCRA, where unexploded projectiles could have penetrated into the subsurface. No historical documentation has been found indicating use of a projectile filled with a chemical warfare materiel at RSA-072. Figure 2-5 in the CMI work plan shows that MEC presents a potentially complete pathway for current and future receptors at the site.

- Troop Training Area C slightly overlaps RSA-072-R-01 along its eastern boundary south of Hale Road. Details regarding the nature of the training activities conducted within this area have not been found (Shaw, 2006). If any munitions-related training items were used, they could have been dropped on the ground as either expended or unexpended. Over time and through the deposition of organic matter or development of the land, these items would have become buried.

- Given the powder storage magazines, handling of powder (type unknown) could have resulted in surface spills. Therefore, these magazines were investigated and are not a current source for MC.

- A direct exposure pathway to surface water and sediment was not included in the CSM since the existing evaporation pond does not appear in aerial photographs until after 1984; this pond would not have been directly impacted by mortar projectiles. Given their distances from the evaporation pond, the troop training area and powder storage magazines would not have directly impacted the pond.

- Potential munitions-related contaminants were as follows:

  - 4.2-inch mortars: explosives (HMX, RDX, and TNT), metals (lead, copper, and zinc), and perchlorate.

  - Smokeless powder: explosives (e.g., nitroglycerin and dinitrotoluene).

  - Flares: metals, explosives, and perchlorate.

  - Blank small-arms ammunition: metals (aluminum, antimony, iron, copper, lead, and zinc).

  Figure 2-6 in the CMI work plan shows the pathways for MC are complete but do not pose unacceptable risk.

- The most viable contaminant transport pathway is leaching of contaminants from soil to groundwater. An evaluation of contaminant transport revealed that no contaminants in RSA-072-R-01 soil pose a potential leaching threat to groundwater.

- Current human receptors are limited to commercial and construction workers. Future potential receptors include all current receptors, plus recreational users and hypothetical child and adult residents under a land reuse scenario. No COCs for HTW/MC were identified in soils, surface water, or sediment (Figures 2-4 and 2-6 in the CMI work plan) but the potential presence of low-probability MEC that could present risks to receptors remains at the site (Figure 2-5 in the CMI work plan).

6.0 Investigative Results

This chapter provides general summary information on the nature and extent of MEC and HTW/MC contamination at RSA-072-R-01. Further discussion of the investigative results is included in the RFI report (CB&I, 2016).

6.1 Munitions and Explosives of Concern

MEC (4.2-inch mortar projectiles) was found and removed during a TCRA in 2008-2009 during construction of the Software Engineering Directorate complex (Buildings 6271 and others) (Figure 2-1a in the CMI work plan). No surface or subsurface MEC was found during the 2013 intrusive investigation of Geophysical Survey Areas 1, 2, and 3, either along the full-coverage investigation of the northern portion of Geophysical Area 2 or along the 84 east-west transects within Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Survey Area 2 (Figure 2-1b in the CMI work plan). A total of 781 anomalies were investigated. An estimated 2,134.5 pounds of non-munitions-related debris and 55.8 pounds of munitions debris were removed. The full-coverage investigation over 2.8 acres was able to conclude that a density of less than 1 MEC per acre is present within the northern portion of Geophysical Area 2. The UXO Estimator within the transect areas of Geophysical Survey Areas 1 and 3 and southern portion of Geophysical Area 2 (50.6 total acres of investigation with 4.26 acres of actual investigation) that sampling was adequate to be 95 percent confident that there is less than 0.652 UXO per acre. During the RFI environmental sampling no MC was found in site soils at high enough concentrations to pose an explosive hazard.

6.2 Hazardous and Toxic Waste/Munitions Constituents

Although groundwater results are summarized here, the scope of the CMI is soil, surface water, and sediment. Further discussion of the investigative results and the groundwater contaminant maps is included in the RFI report (CB&I, 2016).

Metals. All metals detected above their screening criteria in surface soil, subsurface soil, and groundwater were determined to be present at naturally occurring concentrations. No metals were detected in surface water and sediment at concentrations above their background screening values (BSV).

VOCs. VOCs are not a part of the CSM for RSA-072-R-01. However, surface water and groundwater samples were analyzed for VOCs to evaluate possible impacts from off-site sources. No VOCs were present in surface water at concentrations above the preliminary screening values (PSV). Trichloroethene (TCE) was present at a concentration above its PSV in one overburden monitoring well sample downgradient of the site; no VOCs were detected above the PSVs in monitoring wells within the site boundary. Although the RSA-150 groundwater unit does not contain mappable plumes, TCE is a chemical considered to be ubiquitous within RSA-150 (APTIM, 2018a).

SVOCs. SVOCs are not in the CSM for RSA-072-R-01. However, SVOCs were analyzed in one historical groundwater sample from 2011; no SVOCs were present at concentrations above their PSVs.

Explosives. Explosives were not detected in any of the surface soil, subsurface soil, sediment, or surface water samples. 2-Nitrotoluene was the only explosive detected in overburden groundwater samples at concentrations above its PSV. 2-Nitrotoluene was not detected in the bedrock groundwater sample. Nitrobenzene and RDX were detected in the bedrock groundwater sample, but at concentrations below their respective PSVs.

Perchlorate. Perchlorate was not detected in any of the surface soil, subsurface soil, sediment, surface water, or overburden groundwater samples.

7.0 Land and Resource Use

Current and Future Land Use. RSA-072-R-01 is located in an area zoned as Industrial in the RSA Real Property Master Plan (U.S. Army Garrison-Redstone, 2013). Planned future use is also Industrial. RSA-072-R-01 is located in the area designated as RSA (NW) and the primary mission is administrative and research and development. Approximately 95 percent of this RSA (NW) area is utilized by test ranges or contains wetlands, flood plains, and environmental cleanup sites. Mitigation efforts are required for most areas within this parcel of land prior to development. This RSA (NW) area encompasses approximately 20 buildings/structures including the Software Engineering Directorate complex within the footprint of RSA-072-R-01. Where practical, the Army has restricted entry into the RCRA SWMUs by fencing them and/or

placing warning signs at key entry points in accordance with the site access control (SAC) program (U.S. Army Garrison-Redstone, 2012). The area surrounding RSA-072-R-01 is not fenced but lies within the secure RSA boundary. The Army has posted warning signs at key access locations within the site boundary. Site redevelopment (e.g., construction of parking lots, buildings, or other structures) is possible in the future, but residential use or daycare facilities are not anticipated for RSA-072-R-01 in the future.

Current Groundwater Use. Groundwater under RSA-072-R-01 is not currently used for human consumption or any nonpotable purposes. RSA's installation-wide groundwater interim record of decision (IROD) (Shaw, 2007) and land-use control (LUC) remedial design (Shaw, 2009b) as implemented by the Army SAC program (U.S. Army Garrison-Redstone, 2012) prevent the current use of groundwater for potable purposes and ensure that any nonpotable uses of groundwater are reviewed and evaluated by the Army prior to being allowed.

Future Groundwater Use. Future use of groundwater under RSA-072-R-01 is possible. However, under the provisions of the installation-wide groundwater IROD (Shaw, 2007) and the Army SAC program (U.S. Army Garrison-Redstone, 2012), future groundwater resources beneath RSA-072-R-01 and elsewhere on RSA may not be developed for potable purposes, and groundwater withdrawals for nonpotable uses must be managed until remedies are selected in the final decision documents for the various groundwater units within RSA, including the RSA-150 groundwater unit. In the meantime, as part of the Permit, ADEM has required that the Army perform annual monitoring of wells located within the RSA perimeter (ADEM, 2018). This annual monitoring will allow both the Army and ADEM to assess the rate of long-term groundwater recovery and ensure protection for residents living outside of the boundary of RSA (APTIM, 2018b).

8.0 Site Risks

A MEC evaluation is presented in Section 8.1. An Alabama Risk-Based Corrective Action (ARBCA) human health risk evaluation and a screening-level ecological risk assessment (SLERA) are summarized in Sections 8.2 and 8.3. The fate and transport evaluation is summarized in Section 8.4. Further details are presented in the RFI report (CB&I, 2016).

8.1 Munitions and Explosives of Concern Evaluation

No MEC was discovered during the RSA-072-R-01 RFI but chemically configured MEC had been previously found and removed prior to and during a TCRA in 2008-2009. As discussed in Section 6.1, the UXO Estimator statistical program was used to design the transect and single-

point subsurface anomalies investigation. After the analog investigation, UXO Estimator confirmed that the target inputs were achieved, calculating with 95 percent confidence that there are less than 1.0 UXO per acre. Considering the actual area investigated, sampling was adequate to be 95 percent confident that there is less than 0.652 UXO per acre, which is an upper statistical limit. Based on this representative evaluation, it was concluded that RSA-072-R-01 retains limited statistical uncertainty regarding the presence of small numbers of MEC and thus may pose unacceptable risks to current and future human receptors at the site.

8.2 Human Health Risk

Receptors evaluated under current and future site use of RSA-072-R-01 consisted of a commercial worker and a construction worker. A residential receptor was also included as a potential hypothetical future receptor. It is not anticipated that RSA-072-R-01 will be developed such that it would be used residentially. Although Army risk regulations, policy, and guidance are to only evaluate those receptors that are actually at a site or could reasonably be anticipated to occur, the risk assessment conducted for RSA-072-R-01 in the RFI report (CB&I, 2016) included a residential use scenario only to comply with the Alabama Environmental Investigation and Remediation Guidance (ADEM, 2017b) and ARBCA guidance (ADEM, 2017c). RSA is legally mandated to comply with the Permit (ADEM, 2018). In the Permit, ADEM requires that these guidance documents including approved risk assessment work plans (IT Corporation, 2002; Shaw, 2010b) be adhered to during environmental investigations and evaluations. At RSA, the residential scenario is included in the risk assessment in order to determine if a site is eligible for unrestricted use as defined in AAC r. 335-5-1-.03(r) or support the use of LUCs as a component of the selected remedy. Therefore, risks to a residential site user receptor were assessed in this Risk Management (RM)-2 cumulative risk assessment.

The recreationist was not evaluated for exposure to surface water because no COCs were identified in surface water. Exposure to sediment is not evaluated for human health because sediment perennially covered with surface water is generally considered insignificant. The commercial worker, construction worker, and hypothetical residential receptors were evaluated for exposure to soil and groundwater hypothetically developed as a potable source. There is no current potable use of groundwater at RSA-072-R-01. An installation-wide groundwater IROD (Shaw, 2007) was instituted to prevent potable use and provide management control over nonpotable uses of all groundwater beneath RSA. RSA's SAC program (U.S. Army Garrison-Redstone, 2012) was designed to be used at sites that have not had final remedy selection made. The IROD is interim in nature and is not a final remedy. In order to design the final remedy, which may include LUCs, the potable use must be considered.

The ARBCA guidance (ADEM, 2017c) considers an individual excess lifetime cancer risk (IELCR) of 1E-05 to be the target cumulative risk. The target noncancer threshold is a hazard index (HI) of 1.0. Estimated cumulative risks/hazards at or below these target levels do not require additional action.

No chemicals were identified as COCs in surface soil, subsurface soil, total soil, surface water, and sediment. 2-Nitrotoluene and TCE were identified as COCs in groundwater because their maximum detected concentrations exceed their PSVs. Arsenic, chromium, lead, and bis(2-ethylhexyl)phthalate were retained as COCs in groundwater even though their maximum contaminant levels did not exceed their PSVs; ARBCA guidance (ADEM, 2017c) requires that any chemicals detected in groundwater that have maximum contaminant levels, whether they fail their PSV comparisons, be designated as COCs and included in the RM-2 cumulative risk assessment. All COCs from the preliminary screening level evaluation were further evaluated in the RM-2 cumulative risk assessment.

No COCs were identified in soil; therefore, no cancer risks or noncancer hazards were estimated (Table 2-1 in the CMI work plan). The cumulative IELCR for exposure to groundwater hypothetically developed as a potable source exceeded the ADEM target level of 1E-05 for the commercial worker and hypothetical resident receptor but not for the construction worker. The cumulative HI for exposure to groundwater exceeded the threshold level of 1.0 for all receptors.

2-Nitrotoluene and TCE are COCs requiring action in groundwater for the commercial worker and hypothetical resident, while only TCE is a COC requiring action for the construction worker (Table 2-2 in the CMI work plan). Concentrations of TCE also exceeded its maximum contaminant level.

A screening-level vapor intrusion evaluation was conducted to determine whether there has been a release of VOCs to groundwater at RSA-072-R-01 that may volatilize and migrate upward to pose an unacceptable risk to occupants of current or future commercial/industrial buildings or a hypothetical residential building. No VOCs were analyzed in soil because VOCs are not part of the CSM; thus, it was not necessary to evaluate VOCs in soil for vapor intrusion. The vapor intrusion evaluation concluded that VOC concentrations in groundwater are unlikely to pose unacceptable health threats to occupants of existing buildings or buildings erected on site in the future (including residential buildings).

8.3 Ecological Risk

The SLERA for RSA-072-R-01 (CB&I, 2016) was conducted in accordance with the guidelines set forth in the ARBCA guidance manual (ADEM, 2017c), the RSA installation-wide work plan

(IT Corporation, 2002), and the final SLERA supplements to the installation-wide work plan (Shaw, 2010b). A SLERA was performed in order to determine if the site is eligible for no further action in accordance with ADEM requirements. Note that the SLERA relies on ecological screening values (ESV) rather than on the human-health based PSVs.

The surface soil, sediment, and surface water data for RSA-072-R-01 were compared to their respective BSVs and ESVs. Constituents with concentrations above their BSVs (if applicable) and ESVs (or with no ESVs) were identified as preliminary chemicals of potential ecological concern (COPEC). A COPEC refinement process determined whether site-related constituents at RSA-072-R-01 have the potential to pose hazards to ecological receptors. The results and conclusions are described in the following paragraphs.

Surface Soil. The screening-level hazard evaluation for surface soil at RSA-072-R-01 identified aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, manganese, mercury, potassium, selenium, vanadium, and zinc as preliminary COPECs that required further assessment. All of the other constituents detected in surface soil at RSA-072-01 were detected at concentrations less than their respective ESVs and/or BSVs and considered to pose negligible ecological hazards.

The COPEC refinement process concluded that no further evaluation was warranted for aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, manganese, mercury, potassium, selenium, vanadium, and zinc in surface soil at RSA-072-R-01. Concentrations of aluminum, arsenic, barium, calcium, chromium, copper, iron, manganese, mercury, potassium, selenium, and zinc in surface soil at RSA-072-R-01 are likely naturally occurring; calcium and potassium are essential nutrients that do not require further evaluation when concentrations are determined to be naturally occurring; and cobalt and vanadium are not in the CSM. The results of the screening evaluation and COPEC refinement process indicated that further evaluation of chemicals in surface soil is not warranted.

Sediment. The results of the screening-level hazard evaluation for sediment at RSA-072-R-01 showed that all of the constituents detected in sediment at RSA-072-R-01 were detected at concentrations less than their respective ESVs and/or BSVs; therefore, no preliminary COPECs that required further evaluation were identified.

Surface Water. The results of the screening-level hazard evaluation for surface water at RSA 072-R-01 showed that all of the constituents detected in surface water at RSA-072-R-01 were detected at concentrations less than their respective ESVs and/or BSVs; therefore, no preliminary COPECs that required further evaluation were identified.

In summary, the results of the SLERA indicate that COPECs in surface soil, sediment, and surface water at RSA-072-R-01 are unlikely to pose hazards to ecological receptor communities and/or populations, and further evaluation of ecological hazards at RSA-072-R-01 is not warranted.

8.4 Contaminant Fate and Transport

The major potential contaminant migration pathway is the dissolution of site-related chemicals from soil to form leachate and the subsequent transport to the water table resulting from the downward percolation of infiltrating rainfall. Overland transport of soil contaminants by wind or water is unlikely at RSA-072-R-01 because the site is relatively level, mostly wetland, and fairly well vegetated.

All metals detected in soil were naturally occurring and did not require an evaluation for potential leaching to groundwater. No VOCs, SVOCs, perchlorate, or explosives were detected at concentrations above their respective RSA-specific dilution-attenuation factor 4 soil screening levels. Thus, no contaminant detected in soil at RSA-072-R-01 is considered to be a current or future source of contamination to groundwater from the soil-to-groundwater migration pathway (CB&I, 2016).

8.5 Site Hazards

The site hazards associated with MEC at RSA-072-R-01 are presented in Sections 8.5.1 and 8.5.2.

8.5.1 Munitions and Explosives of Concern Hazard Assessment

A MEC hazard assessment is used to evaluate the potential explosive hazard associated with conventional MEC present at a site under a variety of site conditions, including various cleanup scenarios and land-use assumptions. However, none of the items recovered during the RFI intrusive investigation at RSA-072-R-01 were classified as MEC. Therefore, a MEC hazard assessment score was not required.

8.5.2 Munitions Response Site Prioritization Protocol Summary

The Munitions Response Site Prioritization Protocol (MRSPP) is a methodology developed by the DoD to assess the relative risks and assign a relative priority to Munitions Response Sites (MRS) (DoD, 2007). The MRSPP uses three modules to evaluate hazards associated with a site: Explosive Hazard Evaluation (EHE) Module, Chemical Warfare Materiel Hazard Evaluation (CHE) Module, and Health Hazard Evaluation (HHE) Module. The overall MRSPP priority is determined by converting the individual module rating scores to priorities. As summarized from

the tables included in the RSA-072-R-01 RFI report (CB&I, 2016), the results of applying this protocol to RSA-072-R-01 are as follows:

- EHE Module: E. "A" is the highest rating (highest priority) and "G" is the lowest rating (lowest priority). RSA-072-R-01 originally scored a "B" for the EHE module as a result of the SI process (Malcolm Pirnie, Inc., 2008b). However, a TCRA was completed at the site in 2008-2009 that identified and removed MEC that included 4.2-inch mortar projectiles. During the RFI, no MEC was encountered but munitions debris was removed. Based on the completion of the TCRA and the results and conclusions of the RFI, the EHE module rating was updated to "E."

- CHE Module: No Known or Suspected Chemical Warfare Materiel Hazard (alternate rating). There is no history of chemical warfare materiel use or disposal at RSA-072-R-01.

- HHE Module: G. "A" is the highest rating (highest priority) and "G" is the lowest rating (lowest priority). Based on the RFI sampling conducted, which detected metals in soil at naturally occurring conditions and explosives-related compounds below their HHE module comparison values in groundwater, the HHE module rating was assigned a rating of "G."

- MRS Priority: 6. "1" is the highest rating (highest priority) and "8" is the lowest rating (lowest priority). The MRS priority is determined by converting the individual module rating scores to priorities. RSA-072-R-01 was assigned a priority of 6.

9.0 Objectives of the Corrective Measures and Cleanup Goals

The RFI conducted at RSA-072-R-01 (CB&I, 2016) defined the nature and extent of contamination and concluded that further action is not required for soils, surface water, or sediment at the site. However, this site was used for munitions-related activities, chemically configured MEC had been previously discovered and removed, and a full site investigation for MEC was not performed. Thus, the site retains limited statistical uncertainties regarding the presence of MEC. The Army intends to manage this uncertainty through implementation of corrective measures in order to protect human health. The selected corrective measure for RSA-072-R-01 are LUCs around the former TCRA area/retention pond in accordance with a notice of environmental use restriction regulated by AAC r. 335-5-1-.02(3) and site access and use restrictions for the remainder of the site in accordance with RSA SAC regulations (U.S. Army Garrison-Redstone, 2012) and the RSA Explosive Safety Management Program (U.S. Army Garrison-Redstone, 2018). These restrictions will ensure that all surface and intrusive subsurface activities are managed.

The corrective measure objective (CMO) for RSA-072-R-01 is as follows:

- Prevent direct human contact with MEC, thereby reducing hazards associated with a "low" probability MEC site consistent with current and future land use.

Cleanup goals are relevant to alternatives that reduce concentrations of chemical contaminants, such as soil excavation or treatment. For RSA-072-R-01, the development of numerical cleanup goals is not relevant to achieving the CMO for MEC. Since the CMO is related to reducing the hazards associated with potential MEC, the selected alternative would ensure the likelihood of encountering MEC is negligible.

10.0 Description and Comparison of Alternatives

The site conditions at RSA-072-R-01 meet the requirements under EPA guidance for a streamlined or focused corrective measures study (EPA, 1994). The technologies were screened against the criteria of performance, reliability, safety, implementability, and cost.

The following three technologies considered in the initial screening were not retained for further development and evaluation in the corrective measures study report (CB&I, 2017):

- ***Surface MEC Removal.*** No surface or subsurface MEC was found within the current boundary of RSA-072-R-01 during the RFI, resulting in a statistically determined UXO density of 0.652 UXO per acre with 95 percent confidence within the transect investigation areas. Thus, the likelihood of MEC being found on the surface is very low. Since LUCs and/or site access and use restrictions would still be needed to address the potential for buried MEC with this technology, surface MEC removal was not retained.

- ***Focused MEC Removal***. Since MEC was not found at the site during the RFI, a focused MEC removal was not retained.

- ***Full MEC Removal***. Before a full search and removal of MEC could be performed on the surface and subsurface at RSA-072-R-01, vegetation and tree clearing would be required in parts of the site for proper operation of MEC detection equipment, provide the required ground visibility, and allow for the full search and removal of MEC. The soil/sediment would require sifting, a very time-consuming process. There would be adverse impacts to the environment (e.g., aquatic habitat within the evaporation pond) as a result of this alternative, and also potential issues with managing the floodplain area of the site. This technology would be extremely expensive to implement (millions of dollars) and would be destructive to the environment, and there is a low probability of finding MEC. Although this technology would be effective, it was deemed too costly and not a good use of the government's money. Thus, this technology was not retained as a feasible alternative for RSA-072-R-01.

No action, LUCs, and site access and use restrictions were retained as feasible technologies and were packaged into the following corrective measure alternatives for RSA-072-R-01:

- ***Alternative 1: No Action.*** Under the no-action alternative, no corrective measures would be taken to address the potential MEC hazards at RSA-072-R-01. Because this alternative may not be protective of human health and the environment, it is not considered a candidate for implementation but presents a baseline for evaluating other retained alternatives.
- ***Alternative 2: LUCs and Site Access and Use Restrictions.*** This alternative involves implementation of LUCs and site access and use restrictions on land use at RSA-072-R-01 due to potential hazards with MEC including signage, on-call UXO construction support for intrusive activities, restricting future land use in the RSA Real Property Master Plan, and annual inspections.

Because of the potential for exposure to MEC at the site, which may pose unacceptable risks to current and future human receptors, the no-action alternative does not meet the CMO to reduce the hazards to low probability MEC at the site. Implementation of Alternative 2 would prevent receptor exposure to MEC and limit impacts to the environment. Therefore, Alternative 2 was selected as the preferred corrective measure alternative for RSA-072-R-01.

11.0 Selected Corrective Measure

The major components of the selected corrective measures in Alternative 2 include the following:

- Post signage at the site restricting soil disturbance without on-call UXO construction support (DoD, 2008) and Army approval (U.S. Army Garrison-Redstone, 2012)
- On-call UXO construction support (U.S. Army Garrison-Redstone, 2018)
- Establish LUC (former TCRA/retention pond area) and site access and use restriction (remainder of site) boundaries
- Outline restrictions for this site in the RSA Real Property Master Plan
- Comply with AAC r. 335-1-.02(3)(a) for a notice of environmental use restriction
- Conduct annual routine LUC and site access and use restriction inspections.

Alternative 2 meets the four general standards for corrective measures applicable to RSA-072-R-01 (overall protection of human health and the environment, attainment of media cleanup standards, control of the sources of the release, and compliance with standards for management of wastes). As discussed in Chapter 10, the selected corrective measures in Alternative 2 were chosen over the

other corrective measures in the corrective measures study report (CB&I, 2017) because they provide the best balance of trade-offs among the other corrective measure alternatives with respect to the evaluation criteria. Figures 4-1, 4-2, and 4-3 in the CMI work plan present the LUC and site access and use restriction boundaries, proposed sign details for the LUC boundary, and new/existing warning sign locations, respectively.

12.0 Public Involvement

Public participation requirements specified under AAC r. 335-14-8-.08(6) will be met during the permit modification process for the RSA-072-R-01 corrective measures. In addition, the Army will inform the public of the proposed RSA-072-R-01 corrective measures in a newspaper announcement in local newspapers.

13.0 Conclusions

This request for permit modification presents the supporting information needed to allow ADEM to modify the Permit, in accordance with AAC r. 335-14-8-.04(2), with respect to cleanup status at RSA-072-R-01.

14.0 References

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APPENDIX C

CORRECTIVE MEASURES IMPLEMENTATION SCHEDULE

ID	Task Mode	Task Name	Duration	Start	Finish	3rd Qua Qtr 3	4th Qua Qtr 4	1st Quar Qtr 1	2nd Qua Qtr 2	3rd Qua Qtr 3	4th Qua Qtr 4	1st Quar Qtr 1
1		Final Determination Letter accepting Corrective Measure in CMIP	1 day	Mon 10/28/19	Mon 10/28/19							
2		Annual Routine Inspection for Land-Use Control Effectiveness (Initial)	2 days	Mon 10/26/20	Tue 10/27/20							

Project: Proposed RSA-072-R-01 Corrective Measures Implementation Schedule
Date: Thu 1/31/19

Task		Inactive Summary	
Split		Manual Task	
Milestone		Duration-only	
Summary		Manual Summary Rollup	
Project Summary		Manual Summary	
External Tasks		Start-only	
External Milestone		Finish-only	
Inactive Task		Deadline	
Inactive Milestone		Progress	

* Start Date Dependent on Permit Modification following Concurrence on Corrective Measures Implementation Work Plan