Draft Risk Assessment Assumptions Document (RAAD): Addendum to the Work Plan for the Additional Evaluation of the RVAAP-05 Winklepeck Burning Grounds RVAAP/Camp Ravenna, Ravenna, Ohio

Project Order 24

Prepared for:
Ravenna Army Ammunition Plant/Camp Ravenna Joint Military Training Center
8451 State Route 5
Ravenna, Ohio 44266

US Army Corps of Engineers®
Louisville District

Prepared by:
United States Army Corps of Engineers
Louisville District
600 Martin Luther King Jr. Place
Louisville, Kentucky 40202

4 April 2013

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
04-04-2013	Work Plan Addendum	01-11-2012 - 04-04-2013

4. TITLE AND SUBTITLE
Draft Risk Assessment Assumptions Document (RAAD)
Addendum to the Work Plan for the Additional Evaluation
of the RVAAP-05 Winklepeck Burning Grounds
RVAAP/Camp Ravenna, Ravenna, Ohio

5a. CONTRACT NUMBER Project Order #24
5b. GRANT NUMBER N/A
5c. PROGRAM ELEMENT NUMBER N/A

6. AUTHOR(S)
Angela Schmidt
Derek Kinder

5d. PROJECT NUMBER N/A
5e. TASK NUMBER N/A
5f. WORK UNIT NUMBER N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
United States Army Corps of Engineers, Louisville District
600 Martin Luther King Jr. Place
Louisville, Kentucky 40202

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Ravenna Army Ammunition Plant/Camp Ravenna Joint Military Training Center
8451 State Route 5
Ravenna, Ohio 44266

10. SPONSOR/MONITOR'S ACRONYM(S)
RVAAP/CRJMTC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT
Reference Distribution Page

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
This Risk Assessment Assumption Document (RAAD) was prepared by the United States Army Corps of Engineer, Louisville District (USACE) as an Addendum to the Final Work Plan for Additional Evaluation of the RVAAP-05 Winklepeck Burning Grounds. Work described in this Addendum only addresses assumptions in the risk evaluation to be completed as part of the evaluation described in the Work Plan. The USACE is working under Project Order #24 with the National Guard Bureau and Army Environmental Command to provide environmental services for additional characterization, analysis, and evaluation of RVAAP-05 Winklepeck Burning Grounds within the Camp Ravenna Joint Military Training Center (CRJMTC), Ravenna, Ohio

15. SUBJECT TERMS
Risk Assessment Assumptions

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
N/A	N/A	N/A	N/A	45	Derek Kinder
					19b. TELEPHONE NUMBER *(Include area code)* (502)315-6393

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

DISCLAIMER STATEMENT

This document is a work prepared for the United States Government by United States Army Corps of Engineers Louisville District. In no event shall either the United States Government or United States Army Corps of Engineers Louisville District have any responsibility or liability for any consequences of any use, misuse, inability to use, or reliance on the information contained herein, nor does either warrant or otherwise represent in any way the accuracy, adequacy, efficacy, or applicability of the contents hereof.

STATEMENT OF INDEPENDENT TECHNICAL REVIEW

U.S. Army Corps of Engineers has completed the preparation of this Risk Assessment Assumptions Document (RAAD) for the Additional Evaluation of the RVAAP-05 Winklepeck Burning Grounds for RVAAP/Camp Ravenna. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps' policy.

Angela Schmidt — 4 April 2013

Study/Design Team Leader — Date

4 April 2013

Study/Design Team Member — Date

Study/Design Team Member — Date

Significant concerns and the explanation of the resolution are as follows: None

Nathaniel Peters — 4 April 2013

Independent Technical Review Team Leader — Date

PLACE HOLDER FOR:

Documentation of Ohio EPA Approval of

Final Document

(Documentation to be provided once approval is issued)

Draft Risk Assessment Assumptions Document (RAAD):

Addendum to the Work Plan for the Additional Evaluation of the RVAAP-05 Winklepeck Burning Grounds RVAAP/Camp Ravenna, Ravenna, Ohio

Project Order 24

Prepared for:
Ravenna Army Ammunition Plant/Camp Ravenna Joint Military Training Center
8451 State Route 5
Ravenna, Ohio 44266

US Army Corps of Engineers®
Louisville District

Prepared by:
United States Army Corps of Engineers
Louisville District
600 Martin Luther King Jr. Place
Louisville, Kentucky 40202

4 April 2013

DOCUMENT DISTRIBUTION

Draft Risk Assessment Assumptions Document (RAAD):
Addendum to the Work Plan for the Additional Evaluation
of the RVAAP-05 Winklepeck Burning Grounds
RVAAP/Camp Ravenna, Ravenna, Ohio

Name/Organization	Number of Printed Copies	Number of Electronic Copies
Camp Ravenna Katie Tait	1	1
ARNG Ann Wood	0	1
Ohio EPA Eileen Mohr, Brian Tucker	3	3
REIMS	0	1
RVAAP Facility Manager Mark Patterson	2	2
USACE-Louisville District	1	2

Camp Ravenna = Camp Ravenna Joint Military Training Center
ARNGD = Army National Guard Directorate
Ohio EPA - NEDO = Ohio Environmental Protection Agency-Northeast District Office
REIMS = Ravenna Environmental Information Management System
RVAAP = Ravenna Army Ammunition Plant
USACE = U.S. Army Corps of Engineers – Louisville District

Table of Contents

List of Figures

List of Tables

List of Acronyms/Abbreviations

AEC	Army Environmental Command
AOC	Area of Concern
ARNGD	Army National Guard Directorate
AUF	area use factor
bgs	below ground surface
Camp Ravenna	Camp Ravenna Joint Military Training Center
CEA	concentration exceedance area
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
COC	chemical of concern
COPC	chemical of potential concern
CSM	conceptual site model
CUG	cleanup goal
DFFO	Director’s Final Findings and Orders
DLF	dust loading factor
DQO	data quality objective
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
EU	Exposure Unit
ft	foot, feet
FWCUG	facility-wide cleanup goal
GLR	Grenade Launcher Range
HI	hazard index
LUC	Land Use Control
mg/kg	milligram per kilogram
MEC	munitions and explosives of concern
MKM	MKM Engineers, Inc.
MPMG	Multi Purpose Machinegun
NCP	National Contingency Plan
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PCB	polychlorinated biphenyl
RAAD	Risk Assessment Assumptions Document
RAFLU	Reasonably Anticipated Future Land Use
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RA	Removal Action
RAGS	Risk Assessment Guidance for Superfund
RD	Remedial Design
RI	Remedial Investigation
RSL	Regional Screening Levels
ROD	Record of Decision
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
Shaw	Shaw Environmental & Infrastructure, Inc.
SRC	site related chemical
SVOC	semi-volatile organic compound
TNT	2,4,6-trinitrotoluene
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers

UXO	Unexploded Ordinance
VOC	volatile organic compound
WBG	Winklepeck Burning Grounds

1.0 INTRODUCTION

This Risk Assessment Assumptions Document (RAAD) was prepared by the United States Army Corps of Engineers, Louisville District (USACE) as an Addendum to the Final Work Plan for Additional Evaluation of the RVAAP-05 Winklepeck Burning Grounds (USACE 2012) (hereinafter referred to as the Work Plan). Winklepeck Burning Grounds (WBG) is an area of concern (AOC) at the Ravenna Army Ammunition Plant (RVAAP)/Camp Ravenna, Ravenna, Ohio (Figure 1-1). The Work Plan was previously approved by the Ohio EPA, and the field work described in that plan was conducted in November of 2012. The evaluation of the data is ongoing. The work described in this Addendum only addresses assumptions in the risk evaluation to be completed as part of the evaluation described in the Work Plan. The Work Plan details the evaluation process to assess applicability and need for implementation of Land Use Controls (LUCs) at WBG. The USACE is executing environmental services necessary to support additional characterization, analysis, and evaluation of RVAAP-05 WBG within the RVAAP/Camp Ravenna Joint Military Training Center (Camp Ravenna), Ravenna, Ohio for the Ohio Army National Guard (OHARNG) and the Army National Guard Directorate (ARNGD). The work in this Addendum will be completed to further characterize the chemicals and their distribution in soil following the initial screening of the data from previously completed studies on WBG. These studies are described in detail in the Work Plan.

Data collected during previously completed studies on the WBG were evaluated in the Work Plan to determine which detected chemicals are site-related chemicals (SRCs) and to identify specific sample locations where SRCs were not fully delineated (i.e., bound horizontally and vertically). The chemicals detected in soil were screened for frequency of detection, background, and essential nutrients as described in the Work Plan and other RVAAP investigations (USACE 2005; SAIC 2010). Chemicals that were not screened out were identified as SRCs. In the Work Plan, each maximum concentration of each SRC was compared to the respective Facility-wide Cleanup Goal (FWCUG) at the Hazard Index (HI) of 0.1 and a Cancer Risk Level of 1.0 X 10^{-6}. If the maximum concentration of the SRC exceeded the FWCUG, then the occurrence of each sample location was evaluated to assess the nature and extent (vertically and horizontally). These SRCs were called "chemicals that require further evaluation" in the Work Plan. Because the intent of the screening was to assess nature and extent of the SRCs per sample location, these chemicals were not called Chemicals of Potential Concern (COPCs) as would normally be done for investigations at RVAAP (USACE 2006.

This RAAD describes the assumptions and other components of the Risk Assessment portion of the work described in the Work Plan on the data collected for the Additional Evaluation of the WBG. The Risk Assessment will be completed using all data concerning SRCs/COPCs from the additional sampling and analyses and the previously completed studies. The Risk Assessment methods and evaluation criteria (FWCUG) currently used on RVAAP projects as well as specific assumption are not described herein but can be found in the following documents:

- USACE. 2005. Ravenna Army Ammunition Plant Facility-Wide Human Health Risk Assessor Manual, Amendment 1, Prepared by the U.S. Army Corps of Engineers, Louisville District, November 2005.

- Science Applications International Corporation (SAIC)/USACE. 2010. Facility-wide Human Health Remediation Goals, Ravenna Army Ammunition Plant, Ravenna, Ohio, April 2010.
- USACE. 2012. Ravenna Army Ammunition Plant (RVAAP) Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals, Revised January 2012.

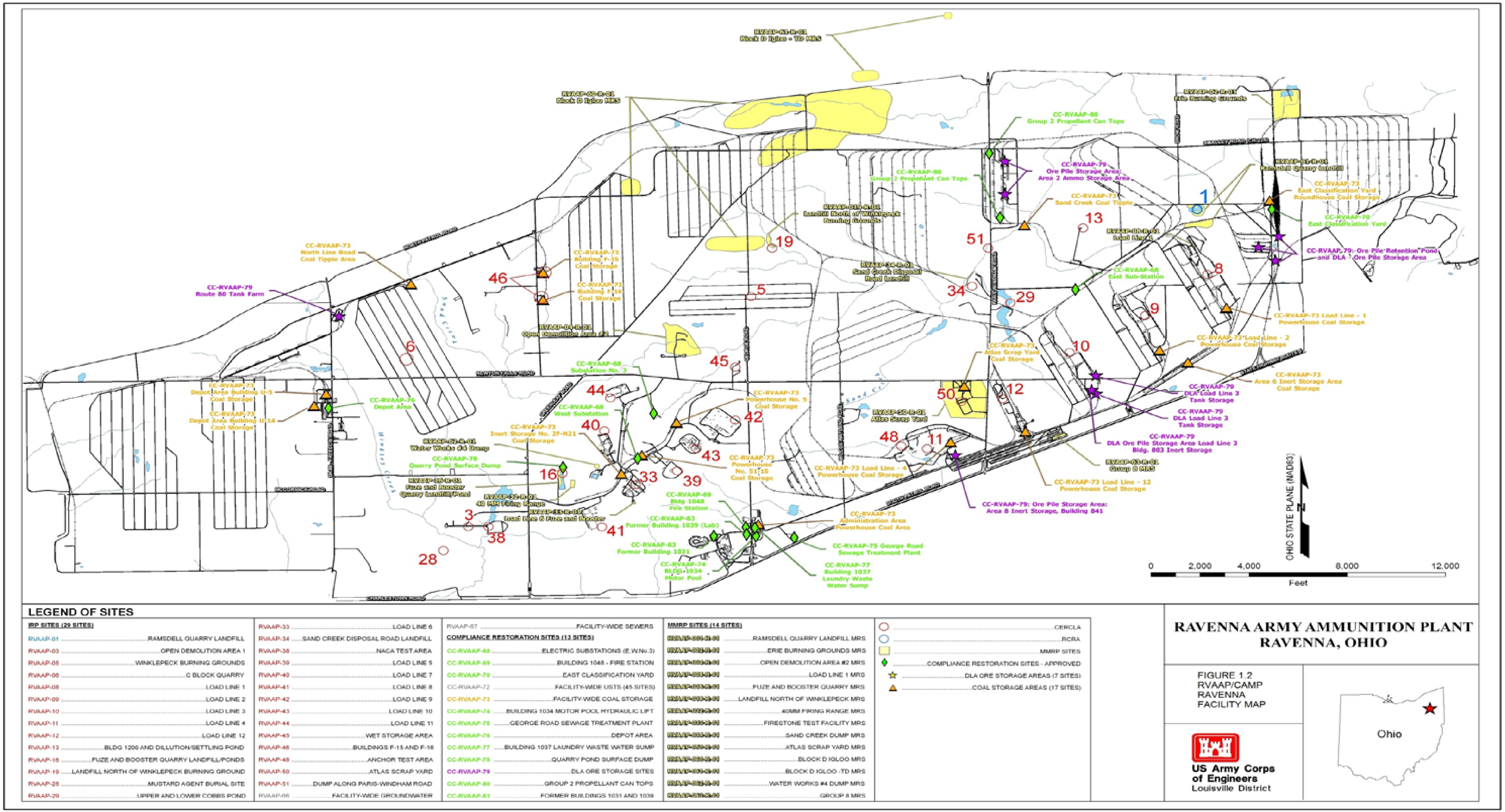


FIGURE 1-1. Map of AOCs/MRSs at RVAAP/Camp Ravenna, Ravenna, Ohio.

Planning and performance of all elements of this report and project are in accordance with the requirements of the Ohio Environmental Protection Agency (Ohio EPA) Director's Final Findings and Orders (DFFO) for the Ravenna Army Ammunition Plant (RVAAP), dated June 10, 2004 (Ohio EPA 2004). The DFFO requires conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP). In addition, this RAAD was prepared to describe the methods and risk-based decision criteria to be used in the evaluation of investigation data. This RAAD follows the general requirements suggested in the *Generic Statement of Work for Conducting Remedial Investigations and Feasibility Studies*, Ohio EPA Division of Environmental Response and Revitalization Remedial Response Program, September 1, 2006.

1.1 Purpose and Scope

A RI/FS (Remedial Investigation/Feasibility Study), Record of Decision (ROD), Remedial Design (RD), and Removal Action (RA) have been completed for the WBG AOC. These investigations and remedial actions were conducted on the basis of a limited site characterization to accelerate the timeframe in which the AOC could be developed and used as a MK19 Range. Although remedial actions were completed for WBG, the associated land use controls (LUCs)/restrictions placed on the AOC limit the use and future development of the AOC. Additional development of the AOC as a Multi-Purpose Machine Gun (MPMG) range is planned and therefore the AOC must be reassessed to fully define the nature and extent of remaining contamination (if any), re-evaluate current LUCs/restrictions, and facilitate range construction and future use and management of the AOC as a range.

The proposed Reasonably Anticipated Future Land Use (RAFLU) for this AOC is for Military Training, with development and management of the AOC as a MPMG Range. This RAAD describes risk-based methods to be used in the evaluation of the current and existing data, nature and extent of contamination, the currently implemented LUCs, and the use of the WBG as a range. This RAAD will use information and data from previously completed studies and those conducted specifically for the Work Plan (which is being conducted to ensure the full nature and extent of contamination has been defined).

The methods and processes in this RAAD will assess data to determine where potential risks to receptors may exist. To meet the RAFLU, risks will be evaluated according to the nature and extent of chemical contamination at the surface and below ground surface (bgs) with the goal of optimizing access to soils at depth. The goal is to be able to construct the new range (including disturbance to depths of 10 to 13 feet for construction activities), operate and manage the range, and perform military training at the AOC. Due to residual munitions and explosives of concern (MEC), at the AOC, any current or future activities at the AOC will require unexploded ordnance (UXO) construction support during any intrusive operations in areas that were not previously cleared of MEC. Results of this RAAD will determine if there is chemical contamination at the AOC that would require remediation to facilitate construction of and future use of the AOC as a range. The nature and extent of the site-related chemicals (SRCs) previously identified on the AOC will be reassessed at each depth sampled and further evaluated as COPCs. Analysis of the soils at specific depth intervals will allow the determination of the depth of potentially required remediation that may be needed to construct and utilize the AOC as a MPMG range.

1.2 Objectives

The scope of this RAAD is to present assumptions, methods, and supporting information that will be used to complete the risk-based analysis and risk assessment of existing data and data collected from the Work Plan. The overall Objectives of this RAAD are as follows:

- Assess investigation data and confirmation data from previous remedial activities to ultimately identify chemicals of concern (COCs) using the chemicals of potential concern (COPCs – reassessed SRCs from previously completed investigations) and the nature and extent.
- Assess risks to the National Guard Trainee, Range Maintenance Soldier, and the Dust Fire Control Worker receptors.
- Develop boundaries to illustrate a theoretical boundary around a location where a chemical's concentration is located above screening levels for each COPC. These areas are called the Concentration Exceedance Areas (CEAs).
- Calculate the Exposure Point Concentrations (EPC) for the COPCs. The EPC will be determined for the entire AOC and for each Concentration Exceedance Area (CEA) where concentrations of the COPC exceed Facility-wide Cleanup Goals (FWCUGs) for at least one applicable receptor.
- Assess EPC for each CEA using an Area Use Factor (percent of the area of a CEA to the entire area of AOC) to determine if there are risks (potential for risk exists if the EPC for the COPC exceeds the respective FWCUG).
- Evaluate risks using the FWCUGs and the percent of the CEA's contribution to the total exposure for each receptor. Chemicals are deemed COCs if their AOC EPC and/or the adjusted CEA EPC exceeds FWCUGs at cleanup levels (cancer risk 10^{-5} and HI = 1.0).
- Determine if additional remediation is required to facilitate future use of the AOC.

1.3 Background Information on Winklepeck Burning Grounds

WBG is located in the center of RVAAP/Camp Ravenna and encompasses approximately 200 acres. Historical activities at WBG included destruction of explosives in munitions, bulk explosives, propellants, and explosive-contaminated combustible material using open burning. The topography at WBG is gently undulating with a general elevation decrease from west to east. Surface water drainage during storm events generally flows from west to east to southeast across WBG. Storm water run-off ditches ultimately flow into Sand Creek. Former burn pads (a total of 70) are located on one side of each of the east/west trending gravel or dirt roads. The former burn pads range in appearance from distinct areas of soil and slag that are partially vegetated to non-descript (no visible slag and heavily vegetated). The former WBG is under the administrative control of the Army National Guard (ARNG) and is currently utilized as a MK19 range.

1.3.1 Summary of Investigations at Winklepeck Burning Grounds

WBG was the subject of a Phase I Remedial Investigation (RI) (SAIC, 1998), a Phase II RI (SAIC, 2001b), a Phase III RI (SAIC, 2005a), and a Biological Field-Truthing Effort (SAIC, 2006). The purpose of the investigations was to confirm whether or not contamination was present at the AOC, to determine the nature and extent of chemicals of potential concern, and to evaluate chemical risks and hazards to human and ecological receptors.

During the Phase I, II, and III RIs, 273 surface soil samples encompassing the 70 former burn pads were collected and analyzed for explosives, propellants, metals, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and pesticides. Not all samples were subject to all analyses. Surface soil samples were collected from either 0 to 1 or 0 to 2 ft bgs during the RIs. The Phase III RI surface soil sampling strategy was biased towards areas known or suspected to have the greatest soil contamination based on data from the Phase I and II RIs. Areas thought to be uncontaminated outside of the former burn pads were characterized using random-grid sampling.

No subsurface soil samples were collected during the Phase I RI. Ninety-five subsurface soil samples were collected during the Phase II and Phase III RIs at 14 different former burn pads. Subsurface sampling was biased towards areas that were known or suspected to have the greatest surface soil contamination. Subsurface soil samples were collected below 2 ft bgs during the RIs. The subsurface soil samples were analyzed for explosives, propellants, metals, SVOCs, VOCs, PCBs, and pesticides. Not all samples were subject to all analyses. A minimum of one 2 to 4 ft. depth sample was collected from each of the 14 targeted former burn pads for determination of the vertical extent of contamination. Based on these results, further sampling was conducted to depths up to 10 ft.

Nineteen dry sediment samples were collected during the Phase I, II, and III RIs from drainage ditches at WBG. Dry sediment samples were collected from 0 to 0.5 ft bgs during the RIs. Dry sediment samples were analyzed for explosives, propellants, metals, SVOCs, VOCs, PCBs, and pesticides. Not all samples were subject to all analyses.

1.3.2 Summary of Removal Actions at Winklepeck Burning Grounds

Based on the results of the historical environmental investigations (1996 to 2003) and a 2004 MEC density survey, and in preparation for the future land use of the AOC as a Mark 19 Range, a MEC removal action was performed between March and August 2005 (MKM Engineers, Inc. [MKM], 2005a, 2005b, 2005c). The MEC removal action completed in August 2005 included the removal of soil contaminated with MEC and chemical contaminants and soil containing transite, an asbestos-containing material (ACM). Soil containing transite was disposed of off-site as asbestos-containing material (MKM, 2008a). The areas of MEC removal are shaded in Figure 1-4 of the DQO Report (Shaw, 2011) and are included in Appendix A of the Work Plan. The 2005 action included the following activities:

- Excavation, MEC removal, and backfill re-use in 10 ft by 10 ft areas centered on previous soil sampling stations WBG-243, located west of Pad 66, and WBGss-070, located west of Pad 67 to a depth of 1 ft bgs.
- Excavation in 10 ft by 10 ft area centered on previous soil sampling station WBG-217 located south of Pad 61 to a depth of 4 ft bgs. Backfill of the excavation and removal of the soil berm associated with Pad 61 were halted pending further environmental investigation.
- Excavation and MEC removal in 13.5 ft by 13.5 ft area surrounding previous soil sampling stations WBGss-401 and WBGss-071, both located at Pad 67, to a depth of 1 ft bgs. Excavated soil was staged on site and the excavation was not backfilled pending further environmental investigation.
- Excavation, MEC removal, and backfill re-use at Pads 7, 18, 26, 35, 48, and 70 to a depth of 1 ft bgs where a proposed target array overlapped the pad.

- Excavation, MEC removal, and backfill re-use at Pads 37, 38, 45, 58, 60, 61, 66, and 67 to a depth of 1 ft bgs.
- Removal of soil berms associated with Pad 58 to a depth of 1 ft below original ground surface level and with Pad 60 to ground level and off-site disposal of material.
- Excavation of test pits in the area of Pads 61 and 61A, which were backfilled with their respective excavated soil.
- Surface clearance of MEC in MEC clearance support areas, Firing Point Area, select former burn pads, and target arrays as identified in the Phase I MEC density survey (MKM, 2005a).

Approximately 180 acres of WBG was transferred to the Army National Guard (ARNG) for construction of a MK19 Range following the removal of MEC from designated areas and remediation of contaminated soil and dry sediment from the target array construction areas and firing points. Construction of three of the four planned firing Lanes (Lanes 2, 3, and 4) of the MK 19 Grenade Machinegun Range was completed in 2006.

At the conclusion of 2005 MEC removal actions, confirmation sampling indicated that additional soil contamination remained on-site. Portions of the soil at Pads 61/61A and 67 were contaminated with hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) or SVOCs at concentrations greater than levels that were considered safe for range construction workers and range maintenance personnel. In addition, transite was observed at Pad 70. These areas were all located in the planned Firing Lane 1 of the MK19 Range and were not transferred to the ARNG in 2005 for construction of the range.

Additional soil removal began in August 2008 in accordance with the Final Record of Decision (ROD) for Soil and Dry Sediment at the RVAAP-05 Winklepeck Burning Grounds at the Ravenna Army Ammunition Plant, Ravenna, Ohio (hereinafter referred to as ROD) (SAIC, 2008). The objective for remediation presented in the 2008 ROD was to prevent exposure of the National Guard Range Maintenance Soldier to contaminants in soil at concentrations greater than risk-based cleanup levels extending to a maximum depth of 4 ft below ground surface (SAIC, 2008). Chemicals of concern (COCs) and WBG cleanup goals (CUGs) for this removal action were defined in the *Final Remedial Action Work Plan, Winklepeck Burning Grounds, Ravenna Army Ammunition Plant, Ravenna, Ohio, Amendment 1* (MKM, 2008b). The scope of work included soil removal in the areas of Pads 61/61A, 67, and 70. At the completion of work, concentrations of COCs were less than WBG CUGs in confirmatory soil and dry sediment samples (MKM, 2009). The specific activities included the following:

- Excavation and grading of an area including Pads 61 and 61A to achieve design grades for Firing Lane 1 to varied depths of up to approximately 6.5 ft bgs.
- Excavation and grading of soil berms associated with Pad 61 and the area of previous soil sampling station WBG-217 located south of Pad 61 to a depth of 4.5 ft bgs.
- Excavation of limited area overlapping Pad 61A to a depth of 1 ft below design grade, backfilled with clean soil to design grade.
- Excavation and backfill of limited area overlapping Pad 67 to a depth of 2 ft bgs.
- Excavation and grading of soil stockpile overlapping Pad 70 to ground level.

Following the removal action, the area of the final firing Lane (Lane 1) of the MK 19 Grenade Machinegun Range was transferred.

1.3.3 Data Quality Objective Report

The *Final Data Quality Objectives Report for RVAAP-05 Winklepeck Burning Grounds* (Shaw, 2011) completed a review of previous reports and data to determine if there were areas at the WBG AOC that needed additional investigation in relation to the proposed future use of the site as a Multi Purpose Machinegun (MPMG) Range and a Grenade Launcher Range (GLR). When the DQO Report was completed, the evaluation to determine data gaps was similar to the approach that had been previously used for the MK 19 Range, which was to concentrate only on specific areas associated with the range being constructed, such as the target arrays. Additionally, the range design provided for the DQO report was a general Army template design as the actual design for the MPMG range at Camp Ravenna had not been developed. Therefore, the data gaps presented in the Shaw DQO report concentrated specifically on these areas.

Since the completion of the DQO report, it has been determined that the GLR will no longer be located at this site, and that future range use requires access to soils at depth over the entire site. Therefore, the data must be re-evaluated from an entire AOC perspective instead of small areas associated with a specific range design and nature and extent of contamination across the entire site must be determined.

The DQO report did however provide a great deal of useable information for this current project including: (1) an evaluation of where removal actions took place and subsequent removal of any data points that are no longer applicable at the site, (2) calculation of Exposure Point Concentrations (EPCs) over the entire site for the various media and receptors based on all current applicable investigation data, and (3) screening of the data to determine COPCs, which are referred to as "chemicals that require further evaluation" in the Work Plan.

2.0 CONCEPTUAL SITE MODEL

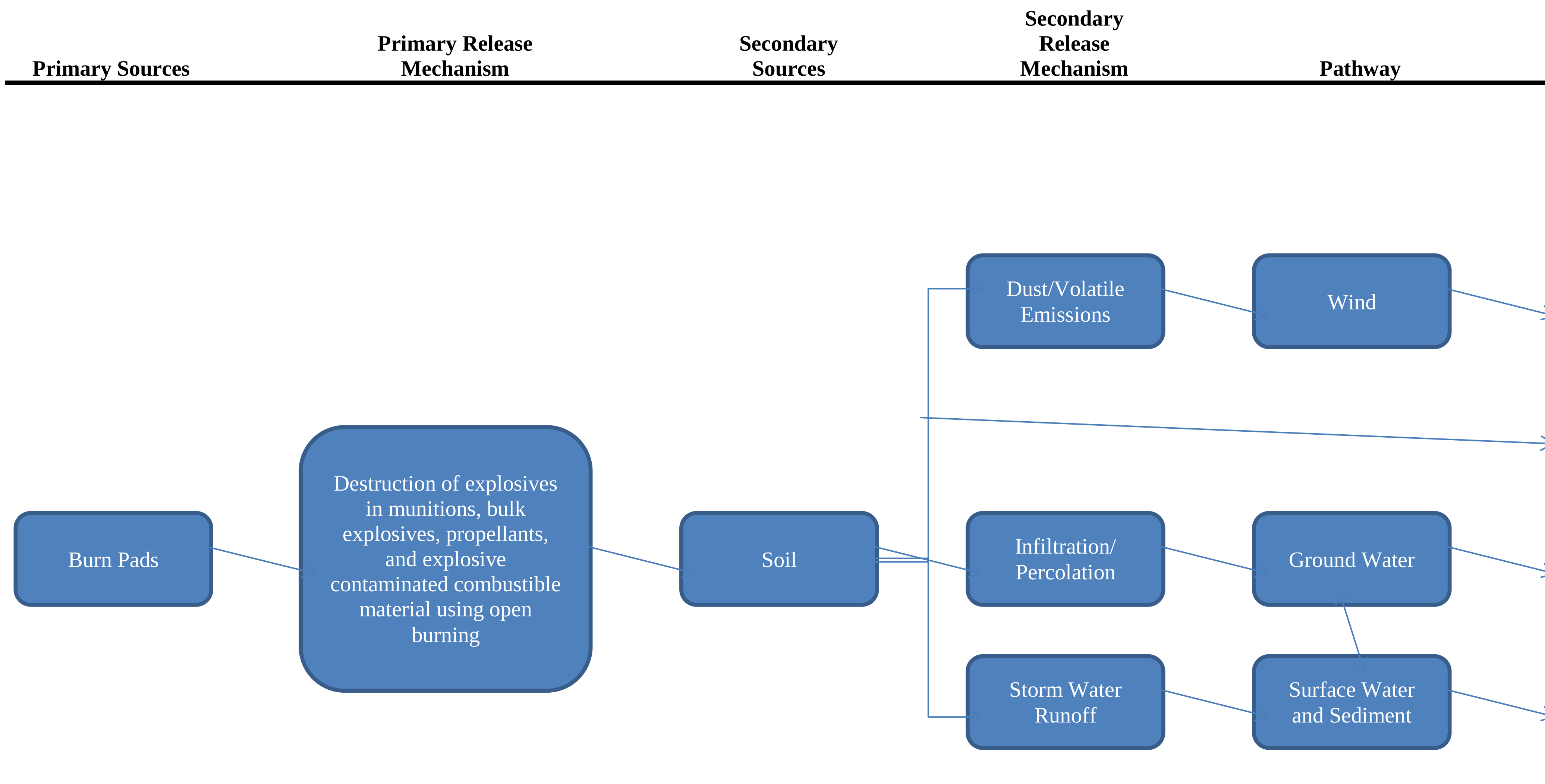
A Conceptual Site Model (CSM) is the basic component of a Risk Assessment. When developing a CSM, the Risk Assessor must consider all potential exposure scenarios and receptors relative to the future use and distribution of the chemicals of concern. It reflects an understanding of the known or expected site conditions and serves as the basis for making decisions about sample locations, frequencies, and required analytes. A good CSM is inclusive of available information, incorporating the hydrogeologic features and other characteristics of the site that combine to define the problem to be addressed (e.g., known disposal locations, primary contaminants and their properties, contaminant transport pathways, and potential human exposure scenarios, etc.).

The CSM presented and refined in the Final Data Quality Objectives Report for RVAAP-05 Winklepeck Burning Grounds (Shaw, 2011) is applicable as follows and further refined in Figure 2-1:

Soil: The exact source of some inorganics in soil at WBG are unknown (i.e., natural or anthropogenic). Contaminated soils within and adjacent to the former burning pads are potential secondary sources of contamination to sediment, surface water, and groundwater. Contaminants may be released from soil and migrate in storm water runoff, either in dissolved phase or adsorbed to particulates and/or colloids. Contaminants may also leach from soils throughout the vadose zone to groundwater and, subsequently, migrate along flowpaths until discharging to surface streams near the AOC. The former burn pads are expected to be the primary source of contamination, specifically at the surface where the burning occurred. If contamination was not found at the surface of a former burn pad, it is not expected to be found below or adjacent to that burn pad.

Sediment: Sediment within ditches and tributaries represents a receptor medium for contaminants eroded or leached from soils in source areas and transported by storm water runoff. In addition, sediment may function as a transport mechanism considering that contaminants adsorbed to particulates may be mobilized by surface water flow. Operational data suggest that the ditches in the vicinity of former burn areas represent likely locations where contaminants may have accumulated through erosion and redeposition.

Surface Water: Surface water conveyances within WBG are intermittent. Modeling of potential surface water transport conducted in the Phase II RI using the Environmental Protection Agency (EPA) Storm Water Management Model indicated that potential contaminant migration off of the AOC is not expected to be a future problem. Biased sampling of sediment in the ditch flowing north out of WBG indicates that the drainage is not an exit point for contaminants. This biased sampling was conducted in and downstream of Lane 1. The highest levels of contamination have been found at Lane 1, therefore, the selected sediment sample locations were expected to have the greatest probability of being contaminated.



Receptors

Exposure Route	Human	Biota	
	National Guard Receptors	Terrestrial	Aquatic
Ingestion			
Inhalation	x	x	
Dermal Contact			
Ingestion	x	x	
Dermal Contact	x	x	
Ingestion	x		
Inhalation	x		
Dermal Contact	x		
Ingestion	x	x	x
Inhalation			
Dermal Contact	x	x	x

FIGURE 2-1. Refined Conceptual Site Model to be used in the Risk Assessment for the Additional Evaluation of the Winklepeck Burning Grounds.

3.0 EXPOSURE INFORMATION AND COMPONENTS

3.1 Receptors

A receptor is the population or individual entity which is exposed to the stressor. In general, the receptors that are to be included in the risk assessment are identified early in the planning process. This identification involves defining the current and anticipated future use of the site, and identifying the current and future activities of receptors on or near the site. Most risk assessments include a residential receptor and another receptor related to occupational land use such as: recreational worker or an industrial worker. The Reasonably Anticipated Future Land Use (RAFLU) of WBG is Military Training. The WBG is currently used as an operational range (since 2006). The Ohio Army National Guard (OHARNG) plans to continue to use WBG area for training, therefore the residential receptor will not be evaluated in the Risk Assessment since it will continue to be classified as an Operational Range

This RAAD contains methods and other pertinent information to be used in the evaluation of data as described in the Work Plan to determine if additional remediation is required to both facilitate use of the AOC as a MPMG Range and reduce or minimize LUCs to allow more flexibility for training. The most applicable receptor(s) for the risk assessment are: National Guard Trainee, Range Maintenance Soldier, and Dust Fire Control Worker.

3.2 Exposure Point Concentrations

An exposure point concentration (EPC) is an estimate of the true arithmetic mean concentration of a chemical in a medium at an exposure point. The arithmetic mean generally represents the most appropriate statistic for characterizing exposure at an exposure point. Use of the EPC is based on the assumption that the receptor has random exposure across an Exposure Unit (EU).

A true arithmetic mean concentration cannot be calculated with certainty from a limited number of measurements, so USEPA recommends the 95th percentile upper confidence limit (UCL) of the arithmetic mean at each exposure point be used when calculating exposure and risk at that location (see Supplemental Guidance to RAGS: Calculating the Concentration Term (PDF) (Publication 9285.7-081, May 1992) (8 pp, 67K)). If the 95% UCL exceeds the highest detected concentration, the highest detected value is used instead (see RAGS I Part A).

The equation used to compute the 95% UCL of a data set depends on the distribution (normal, lognormal, other) of the values. In the past, it was common practice to test each environmental data set for normality and, if it did not pass, to assume that the data set was lognormal. While this is mathematically convenient, the approach is inherently limited because no environmental data set can ever truly be lognormal and this approach can substantially overestimate the true UCL. To address this problem, USEPA has software (ProUCL) that computes the UCL for a given data set by a variety of alternative statistical approaches (including several approaches that do not require the assumption of normality or lognormality) and then recommends specific UCL values as being the most appropriate for that particular data set. ProUCL is used for computing exposure point concentrations in most risk assessments.

3.3 Exposure Scenarios

An exposure scenario includes facts, data, assumptions, inferences, and sometimes professional judgment about the exposure setting, stressor characteristics, and activities of a receptor that can lead to exposure for that receptor. The risk assessment completed using assumptions/processes in this RAAD will include two basic exposure scenarios for the National Guard receptors; one for the National Guard Trainee and one for the Range Maintenance Soldier/Dust Fire Control Worker combined (Figure 3-1).

Exposure scenarios consist of the process by which exposure occurs considering: (1) potentially exposed populations; (2) potential pathways of exposure and exposure conditions; (3) chemical intakes/potential doses where the receptor contacts the chemicals. Exposure may occur by a receptor via ingestion, inhalation, or dermal absorption routes. As described in EPA's Guidelines for Exposure Assessment (U.S. EPA 1992a), exposure is dependent upon the intensity, frequency, and duration of contact.

The exposure scenario and assumptions for the proposed risk assessment are presented in Figure 3-1. The exposure factors used to estimate exposure can be found in the Facility-wide Human Health Risk Assessors Manual (USACE 2006).

3.4 Exposure Media to Be Evaluated

The exposure media to be addressed in the Risk Assessment is soil. Wet sediments are not present at the AOC. Groundwater is being evaluated under a separate AOC on a facility-wide basis. The surface soil for the National Guard Trainee, the Range Maintenance Soldier, and the Dust Fire Control Worker is 0 feet to 4 feet below ground surface (bgs). The subsurface is 4 feet to 7 feet for the National Guard Trainee. There is no subsurface exposure for the Range Maintenance Soldier or the Dust Fire Control Worker. The WBG is being re-evaluated to assess the nature and extent of chemicals in soil at an interval of 0 to 4 feet bgs and 4 feet to the deepest occurrence of a detected chemical, where practical. The EPC will be calculated for the 0 to 4 feet interval and 4 feet to the deepest interval where chemicals were detected. This approach will also be used to determine if the LUCs need to be modified or if future activities such as site re-grading will pose a potential risk.

3.5 Exposure Units and Area Use Factors

The Exposure Unit (EU) for the three National Guard receptors is the entire AOC. The Risk Assessment will be based on the assumption that there is an equal chance for the receptor to use any place within the AOC. Most of the Risk Assessments that have been completed on RVAAP use this AOC-EU approach.

The OHARNG requires maximum flexibility to use WBG at any location within the AOC without restrictions (other than with a potential requirement for UXO Construction Support); therefore, the Risk Assessment will assess each of the CEAs as a subcomponent of the entire AOC. The AOC EPC will be used to assess the EPCs of chemicals within each CEA that exceed their FWCUGs (for the most sensitive National Guard FWCUG for each chemical). For the surface soil exposure scenario and exposure depth interval of 0 to 4 feet, the surface area will be calculated for each CEA. The surface area of the AOC is assumed to be the surface area of the EU. The ratio (area use factor - AUF) of the surface area of each CEA to the surface area of the AOC will be determined by dividing the surface area of each CEA by the surface area of the AOC. The AUF ratio for each CEA represents the percent of contribution of the CEA as part of the AOC EU when addressing exposure of a receptor across an entire EU. The EPC of the CEA will then be multiplied by the AUF to determine the estimated portion that the EPC of the CEA is for the receptor's exposure over the EU.

RECEPTORS: National Guard Trainee, Range Maintenance Soldier, and the Dust Fire Control Worker use WBG for Military Training.

↓

POTENTIAL RELEASE MECHANISM: Burn Pads - Residual contamination in soils. Release of soil dust with organic substances and/ metals into the air via wind. Leaching of contaminants from soil to groundwater. Release of contaminated soil particles to storm water runoff (sediment) & surface water.

↓

CONTACT POINT: National Guard Trainee, Range Maintenance Soldier, and the Dust Fire Control Worker may contact the surface soil while performing training or working on WBG. The National Guard Trainee may contact subsurface soil. It is highly unlikely any of the three National Guard receptors will contact groundwater while working on WBG. Previously completed studies collected sediment samples however, there is no surface water or sediment present on WBG now so there is not a contact point for any of the three receptors.

↓

EXPOSURE ROUTES: Ingestion of soil/dust; inhalation of soil/dust; dermal absorption of soil.

↓

DOSE and EXPOSURE POINT CONCENTRATION: Estimate exposure point concentrations (EPC) for the entire AOC and each CEA (considering an Area Use Factor) for each COC within the WBG. Use the FWCUGs as the safe dose based on Receptor-specific exposure information for each COC.

↓

RISK: If EPCs exceed FWCUG, determine Area that needs to be addressed if risks are great enough or to ensure enough data is collected to evaluate the current LUCs.

FIGURE 3-1. Diagram of Exposure Scenario for the three National Guard Receptors at WBG.

3.6 Exposure Assumptions

Table 3-1 presents the exposure assumptions for the three National Guard receptors. The chemical–specific parameters are provided in Table 3-2.

TABLE 3-1. Exposure Factors for National Guard Receptors used in the FWCUGs.

Parameter	Units	National Guard		
		Dust/Fire Control Worker	Trainee	Range Maintenance Soldier
Surface Soil				
Incidental ingestion				
Soil ingestion rate	kg/day	0.0001[a]	0.0001[a]	0.0001[a]
Exposure time	hours/day	4[b]	24[b]	6
Exposure frequency	days/year	15[b]	39[b]	85
Exposure duration	years	25[b]	25[b]	25
Body weight	kg	70[a]	70[a]	70[a]
Carcinogen averaging time	days	25,550[a]	25,550[a]	25,550[a]
Noncarcinogen averaging time	days	9125[a]	9125[a]	9125[a]
Fraction ingested	unitless	1[b]	1[b]	1
Conversion factor	days/hour	0.042	0.042	0.042
Dermal contact				
Skin area	m^2/event	0.33[d]	0.33[d]	0.33[d]
Adherence factor	mg/cm^2	0.3[c]	0.3[c]	0.3[c]
Absorption fraction	unitless	chem. spec.[p]	chem. spec.[p]	chem. spec.[p]
Exposure frequency	events/year	15[b]	39[b]	85
Exposure duration	years	25[b]	25[b]	25
Body weight	kg	70[a]	70[a]	70[a]
Carcinogen averaging time	days	25,550[a]	25,550[a]	25,550[a]
Noncarcinogen averaging time	days	9125[a]	9125[a]	9125[a]
Conversion factor	(kg-cm^2)/(mg-m^2)	0.01	0.01	0.01
Inhalation of VOCs and dust				
Inhalation rate	m^3/day	44.4[t]	44.4[t]	19.5
Exposure time	hours/day	4[b]	24[b]	6
Exposure frequency	days/year	15[b]	39[b]	85
Precipitation modifying factor	unitless	NA	NA	NA
Exposure duration	years	25[b]	25[b]	25
Body weight	kg	70[a]	70[a]	70[a]
Carcinogen averaging time	days	25,550[a]	25,550[a]	25,550[a]
Noncarcinogen averaging time	days	9125[a]	9125[a]	9125[a]
Particulate emission factor	m^3/kg	9.24E+08	1.67E+06	9.24E+08
Conversion factor	days/hour	0.042	0.042	0.042

Parameter	Units	National Guard		
		Dust/Fire Control Worker	Trainee	Range Maintenance Soldier
Surface Soil				
Soil ingestion rate	kg/day	NA	0.0001[a]	NA
Exposure time	hours/day	NA	24[b]	NA
Exposure frequency	days/year	NA	39[b]	NA
Exposure duration	years	NA	25[b]	NA
Body weight	kg	NA	70[a]	NA
Carcinogen averaging time	days	NA	25,550[a]	NA
Non-carcinogen averaging time	days	NA	9125[a]	NA
Fraction ingested	unitless	NA	1[b]	NA
Conversion factor	days/hour	NA	0.042	NA
Dermal contact				
Skin area	m^2/event	NA	0.33[d]	NA
Adherence factor	mg/cm^2	NA	0.3[c]	NA
Absorption fraction	unitless	NA	chem. spec.[p]	NA
Exposure frequency	events/year	NA	39[b]	NA
Exposure duration	years	NA	25[b]	NA
Body weight	kg	NA	70[a]	NA
Carcinogen averaging time	days	NA	25,550[a]	NA
Non-carcinogen averaging time	days	NA	9125[a]	NA
Conversion factor	(kg-cm^2)/(mg-m^2)	NA	0.01	NA
Inhalation of VOCs and dust				
Inhalation rate	m^3/day	NA	44.4[t]	NA
Exposure time	hours/day	NA	24[b]	NA
Exposure frequency	days/year	NA	39[b]	NA
Exposure duration	years	NA	25[b]	NA
Body weight	kg	NA	70[a]	NA
Carcinogen averaging time	days	NA	25,550[a]	NA
Non-carcinogen averaging time	days	NA	9125[a]	NA
Particulate emission factor	m^3/kg	NA	1.67E+06	NA
Conversion factor	days/hour	NA	0.042	NA

NA = not applicable for this scenario. [a] RAGS, Part B (EPA 1991a).

[b] Site-specific (value assumed for site or value obtained from site personnel). National Guard Trainee assumed to be on –site 24 hrs/d for 24 d/yr for inactive duty training and 24 hrs/d for 15 d/yr for annual training. National Guard Fire/Dust Suppression receptor is assumed to spend 4 hours/day for 5 days/year for fire suppression and 4 hours/day for 10 days/year) for dust suppression. Both National Guard Receptors are assumed to remain at RVAAP and at the AOC of interest for 25 year enlistment.

[c] Maintenance Worker = Adult Groundskeeper (95th percentile); Hunter/Trapper = Residential Default; National Guard Trainee = Construction Worker (95th percentile) (RAGS, Vol. 1 Part E, Supplemental Guidance for Dermal Risk Assessment, Interim) EPA/540/R/99/005.

[d] Maintenance Worker, National Guard Trainee, and National Guard Dust/Fire Control = Industrial Default; Hunter/Fisher and Resident Farmer = Adult Residential Default. Exposure Factors Handbook (EPA 1997a).

TABLE 3-2. Chemical-specific Exposure Parameters for Ravenna Facility Wide COPCs

COPC	Dermal Absorption Factor[a] (unitless)	Permeability Constant[b] (cm/hr)	Volatilization Factor[c] (m^3/kg)
Inorganics			
Aluminum	1.0E-03	1.0E-03	--
Antimony	1.0E-03	1.0E-03	--
Arsenic	3.0E-02	1.0E-03	--
Barium	1.0E-03	1.0E-03	--
Cadmium	1.0E-03	1.0E-03	--
Chromium	1.0E-03	2.0E-03	--
Chromium, hexavalent	1.0E-03	2.0E-03	--
Cobalt	1.0E-03	4.0E-04	--
Copper	1.0E-03	1.0E-03	--
Iron	1.0E-03	1.0E-03	--
Manganese	1.0E-03	1.0E-03	--
Mercury	1.0E-03	1.0E-03	--
Nickel	1.0E-03	2.0E-04	--
Nitrate	1.0E-03	1.0E-03	--
Silver	1.0E-03	6.0E-04	--
Thallium	1.0E-02	1.0E-03	--
Vanadium	1.0E-03	1.0E-03	--
Zinc	1.0E-03	6.0E-04	--
Organics			
1,1,2,2-Tetrachloroethane	--	6.9E-03	--
1,2-Dichloroethane	--	4.2E-03	--
1,2-Dichloroethene	--	7.7E-03	--
1,3,5-Trinitrobenzene	1.9E-02	--	--
1,3-Dinitrobenzene	1.0E-02	2.1E-03	--
1,4-Dichlorobenzene	--	4.2E-02	--
2,4,6-Trinitrotoluene	3.2E-02	1.1E-03	--
2,4-Dimethylphenol	--	1.1E-02	--
2,4-Dinitrotoluene	1.0E-01	3.1E-03	--
2,6-Dinitrotoluene	9.9E-02	2.1E-03	--
2-Amino-4,6-dinitrotoluene	6.0E-03	2.4E-03	--
2-Methylnaphthalene	1.0E-02	--	9.0E+04
2-Nitrotoluene	1.0E-02	1.2E-02	1.9E+05
4,4'-DDD	--	1.8E-01	--
4,4'-DDE	1.0E-02	1.6E-01	--
4,4'-DDT	--	2.7E-01	--
4-Amino-2,6-dinitrotoluene	6.0E-03	2.4E-03	--
4-Chloro-3-methylphenol	1.0E-02	--	--
4-Methylphenol	--	7.7E-03	--
4-Nitrobenzenamine	--	2.7E-03	--

COPC	Dermal Absorption Factor[a] (unitless)	Permeability Constant[b] (cm/hr)	Volatilization Factor[c] (m^3/kg)
Organics			
4-Nitrophenol	1.0E-02	--	--
4-Nitrotoluene	1.0E-02	1.3E-02	--
Aldrin	1.0E-02	1.4E-03	--
Benz(a)anthracene	1.3E-01	4.7E-01	--
Benzene	--	1.5E-02	--
Benzo(a)pyrene	1.3E-01	7.0E-01	--
Benzo(b)fluoranthene	1.3E-01	7.0E-01	--
Benzo(k)fluoranthene	1.3E-01	1.2E+00	--
Bis(2-chloroethoxy)methane	1.0E-02	--	--
Bis(2-ethylhexyl)phthalate	--	2.5E-02	--
Carbazole	1.0E-02	--	--
Carbon tetrachloride	--	1.6E-02	--
Chloroform	--	6.8E-03	--
Chrysene	1.3E-01	4.7E-01	--
Dibenz(a,h)anthracene	1.3E-01	1.5E+00	--
Dibenzofuran	1.0E-02	--	--
Dieldrin	1.0E-02	1.2E-02	--
Endrin	1.0E-02	--	--
Endrin aldehyde	--	--	--
Fluoranthene	1.3E-01	--	--
Fluorene	1.3E-01	--	4.6E+05
HMX	6.0E-03	1.1E-04	--
Heptachlor	1.0E-02	8.6E-03	--
Heptachlor epoxide	1.0E-02	2.8E-02	--
Indeno(1,2,3-cd)pyrene	1.3E-01	1.0E+00	--
Lindane	--	1.1E-02	--
Methylene chloride	--	3.5E-03	--
N-Nitroso-di-n-propylamine	1.0E-02	--	--
Naphthalene	1.3E-01	--	6.9E+04
Nitrobenzene	--	7.0E-03	--
Nitroglycerin	1.0E-02	1.1E-03	--
PCB-1016	1.4E-01	--	--
PCB-1242	--	9.2E-01	--
PCB-1248	1.4E-01	--	--
PCB-1254	1.4E-01	1.3E+00	--
PCB-1260	1.4E-01	5.5E+00	--
Pentachlorophenol	2.5E-01	3.9E-01	--
Pyrene	1.3E-01	3.2E-01	--
RDX	1.5E-02	3.5E-04	--
Tetrachloroethene	--	3.3E-02	--
Toxaphene	--	1.2E-02	--
Trichloroethene	--	1.2E-02	--

COPC	Dermal Absorption Factor[a] (unitless)	Permeability Constant[b] (cm/hr)	Volatilization Factor[c] (m^3/kg)
Organics			
alpha-BHC	--	2.8E-02	--
alpha-Chlordane	--	--	--
beta-BHC	1.0E-02	2.8E-02	--
cis-1,2-Dichloroethene	--	1.5E-02	--
gamma-Chlordane	--	--	--

[a] Chemical-specific absorption factor values from RAIS. When chemical-specific values are not available the following default values are used for soil and sediment only: SVOCs = 0.1, VOCs = 0.01, inorganics = 0.001 per USEPA

[b] From Risk Assessment Information System (RAIS) *http://risk.lsd.ornl.gov/tox/tox_values.shtml* for groundwater and surface water.

[c] Volatilization factors (VFs) calculated using the 1996 EPA Soil Screening Guidance Methods for soil

COPC = Chemical of potential concern.

RAGS = Risk Assessment Guidance for Superfund.

SVOC = Semivolatile organic compound.

VOC = Volatile organic compound.

-- = No value available or chemical is not a COPC for the appropriate media requiring the exposure parameter in a calculation.

4.0 SCREENING VALUES AND PROCESSES

The screening values that will be used in the Risk Assessment are RVAAP-specific background values and RVAAP/receptor-specific FWCUGs. The FWCUGs were developed for a set of chemicals that were identified as COPCs in previously completed studies. The current practice for risk assessments completed at RVAAP is the use the FWCUGs as the primary screening number for human health. When no FWCUG is available for a chemical, the USEPA Regional Screening Level (RSL) is used or a FWCUG can be calculated for the chemical and the receptors being evaluated in the risk assessment.

4.1 Background Values

Ravenna-specific background values were determined for soil for two depth intervals (0 to 1 feet and 1 to 13 feet) for inorganic chemicals. These background values can be found in Phase II Remedial Investigation Report for the Winklepeck Burning Ground at RVAAP, OH (SAIC April 2001).

4.2 Facility-wide Cleanup Goals

The Screening values to be used in the Risk Assessment are the site specific clean up goals calculated for RVAAP. The site-specific cleanup goals are presented in the Final *Facility-Wide Human Health Remediation Goals at the RVAAP* (SAIC, 2010) and are referred to as FWCUG Report. The USACE also issued a Position Paper to Contractors regarding the use and application of FWCUGs as part of the path forward in the risk assessment process and appropriate risk levels for:

- Determining presence/absence of contamination,
- Assessing data gaps,
- Evaluating nature and extent of contamination, and
- Identifying cleanup requirements.

The Army has worked closely with the Ohio EPA to develop an acceptable approach for the completion of human health risk assessments. Following the initial successes of the human health risk assessment program, there was mutual agreement to streamline the process. Streamlining the Human Health Risk Assessment process resulted in the establishment of FWCUGs. The original intent of developing the FWCUGs was to eliminate the need for baseline risk assessments. Since the development of the FWCUGs, they also have been recognized as appropriate tools to be used in screening-level assessments.

The FWCUGs were developed to reduce the level of effort and to limit the amount of time required to make informed risk management decisions regarding sampling locations, delineations of contamination, data gaps, and remediation of contaminants without needing to complete a baseline risk assessment. The selection of chemicals requiring a FWCUG was based upon the screening process outlined in the *Ravenna Army Ammunition Plant Facility-Wide Human Health Risk Assessor Manual, Amendment 1* (USACE 2005), herein referred to as the Risk Manual.

While the FWCUGs can be found in the FWCUG Report, the equations needed to calculate them are not readily available in the FWCUG Report. The following sections provide the basic intake and risk equations that were used to calculate the FWCUGs.

4.2.1 Equations and Calculations of the Facility-wide Cleanup Goals

The FWCUGs were developed using basic risk assessment equations. Although the risk equations were designed to estimate a dose/intake for a particular receptor based on a measured concentration in the media, these equations are rearranged where the toxicity value (from USEPA's Integrated Risk Assessment System – IRIS) is substituted for the media intake (dose) term and then the equation is solved for a concentration that represents a safe concentration for a particular media. The estimated concentration for each type of exposure pathway for each receptor is then summed and used to calculate the FWCUG for chemical/receptor non-carcinogenic Hazard Quotient values of 1.0 and 0.1; and carcinogenic risks at 1.0 X 10^{-5} and 1.0 x 10^{-6} risk levels.

4.2.2 General Intake Equations

The applicable basic equations used to quantify intakes of chemicals by exposure pathways identified for National Guard receptors from environmental media (air, soil, and groundwater) are presented below. These equations are rearranged to solve for C, the safe concentration of the chemical that can occur in a particular media. The exposure pathway intake value Intake is set from the chemical specific toxicity value (safe dose). Only the equations relative to the National Guard receptors are discussed in this RAAD.

4.2.2.1 Incidental Inhalation of Chemicals in Soil

Inhalation of soils or dry sediments was calculated using the following equation:

$$Chemical\ Intake\ (mg/kg-day) = \frac{C_s \times IR_a \times EF \times ED \times (VF^{-1} + PEF^{-1}) \times ET \times CF}{BW \times AT}$$

where

C_s	=	chemical concentration in soils or sediments (mg/kg),
IR_a	=	inhalation rate (m^3/day),
EF	=	exposure frequency (days/year),
ED	=	exposure duration (years),
VF	=	volatilization factor (chemical-specific m^3/kg),
PEF	=	particulate emission factor m^3/kg),
ET	=	exposure time adjustment (hr/day),
CF	=	conversion factor for ET (day/hr),
BW	=	body weight (kg),
AT	=	averaging time (days) for carcinogens or non-carcinogens.

The general PEF value for receptors except the National Guard is the default value for Cleveland Ohio assuming a 0.5-acre source area (9.24 X 10^8 m^3/kg). The exposure units can range in size from approximately one-quarter acre (Water Tower) to more than 10 acres (Perimeter Area); however, the contamination tends to be limited to small areas around the buildings. Therefore, a 0.5-acre contaminated source area is considered appropriate. A smaller PEF value (1.67×10^6) was used for the National Guard scenario because the activities of this receptor are assumed to generate more dust. This PEF value was calculated from a dust loading factor (DLF) of 600 $\mu g/m^3$ (DOE 1993) as:

$$PEF = 1/(DLF \times \text{Conversion Factor}) = 1/(600\ \mu g/m^3 \times 1 \times 10^{-9}\ kg/\mu g) = 1.67 \times 10^6\ m^3/kg$$

4.2.2.2 Incidental Ingestion of Chemicals in Soil

The following equation is used to estimate Incidental ingestion of soils:

$$Chemical\ \ Intake\ \ (mg/kg\ \text{-}\ day) = \frac{C_S \times IR_S \times EF \times ED \times FI \times ET \times CF}{BW \times AT}$$

where

C_s	=	chemical concentration in soils or sediments (mg/kg),
IR_s	=	ingestion rate (kg/day),
EF	=	exposure frequency (days/year),
ED	=	exposure duration (years),
FI	=	fraction ingested (value of 1, unitless),
ET	=	exposure time adjustment (hr/day),
CF	=	conversion factor for ET (day/hr),
BW	=	body weight (kg),
AT	=	averaging time (days) for carcinogens or non-carcinogens.

4.2.2.3 Dermal Contact with Chemicals in Soil

The following approach must conform to USEPA Risk Assessment Guidance for Superfund (RAGS), Part E. Unlike the methods for estimating inhaled or ingested intake of a chemical, which quantify the chemical concentration at the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), dermal intake is estimated as the amount of chemical that crosses the skin and is systematically absorbed. For this reason, dermal toxicity values are also based on an absorbed intake. The absorbed intake of the chemical is estimated from the following equation:

$$DAD = (DA_{event})(CF)(SA)(EF)(ED)/(BW)(AT)$$

where:

DAD = average dermal absorbed intake of COPC (mg/kg-day)
DA_{event} = intake absorbed per unit body surface area per day (mg/cm^2-event day)
CF = 1 event per day
SA = surface area of the skin available for contact with soil (cm^2)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

DA_{event} is calculated differently for dermal uptake from soil or sediment and from water. Dermal uptake of constituents from soil or sediment assumes that absorption is a function of the fraction of a dermal applied constituent that is absorbed.

The DA_{event} is calculated from the following equation:

$$DA_{event} = (C_s)(FI_s)(CF)(AF)(ABS)$$

where:

DA_{event} = COPC absorbed per unit body surface area per day (mg/cm^2-event day)
C_s = concentration of COPC in soil (mg/kg)
FI_s = fraction of exposure attributed to site soil or sediment (unitless)
CF = conversion factor (10E-6 kg/mg)
AF = soil-to-skin adherence factor (mg/cm^2-event)
ABS = absorption fraction (unitless, chemical-specific value)

Absorption fraction (ABS) values have not been determined for all chemicals. The USEPA has recommended reasonable default values of 0.001 for inorganic chemicals and 0.01 for organic chemicals, to reflect the matrix effect (i.e., binding to organic matter in soil).

4.2.3 Risk Equations and the FWCUG Equation

There are two basic risk equations; one for non-carcinogens (HQ) and the second for carcinogenic compounds (Risk). These two equations are presented below. The FWCUG is estimated using these equations for each chemical and receptor-specific intake values by setting the non-carcinogenic and carcinogenic risk levels and then rearranging the equations.

The intake equations associated with the daily intake calculated by using a chemical–specific toxicity value and the equations presented in Section 4.1.2.1 of the RAAD. Once the Intake calculation is performed as stated in Section 4.1.2.1, where the equation was rearranged and solved for the concentration of the chemical per media, then the intake value for each exposure pathway for a chemical is substituted into the appropriate risk equation.

The risk equation is rearranged to obtain a chemical concentration (FWCUG) in a media for a receptor.

The FWCUGs are calculated for the HQ level of 0.1 and 1.0 non-carcinogenic risks using the following equation:

$$HQ = \frac{DI_n}{RfD} \quad **DIn = \frac{C \times IR \times EF \times ED}{AT \times BW}$$

where

HQ = hazard quotient (unitless)
DI_n** = daily intake for non-carcinogens (mg/kg-day)
RfD = chemical-specific oral reference dose (mg/kg-day)

Non-carcinogenic HQ Equation rearranged where HQ = 1.0 and C is determined for each pathway using the intake equations:

$$1.0 = \frac{\frac{C \times IR \times EF \times ED}{AT \times BW}}{RfD(ingestion) or\ RfC\ (inhalation), or\ DAD(dermal\ absorption)}$$

The equation is rearranged to solve for the C for each exposure pathway to get the concentration for the respective media considering how much of a chemical can be in the soil that is safe for a receptor. This approach addresses a concentration of a chemical in soil and how much it could be inhaled or dermally absorbed from the soil for a certain receptor. These C terms are based on a set non-carcinogenic HQ level.

$$FWCUGnoncancer = \frac{1}{\frac{1}{IngestConcentration} + \frac{1}{InhalationConcentraiton} + \frac{1}{DermalConcentration}}$$

where

FWCUG = C, a concentration term for a chemical in the media, and C must be estimated for a receptor's appropriate exposure pathway:

The FWCUGs are calculated for the Risk levels of 1.0 X 10^{-6} and 1.0 X 10^{-5} carcinogenic risks using the following equation.

$$Risk = DI_c \cdot SF \qquad **DI_c = \frac{C \times IR \times EF \times ED}{AT \times BW}$$

where

Risk	=	risk (unitless)
DI_{c**}	=	daily intake for carcinogens (mg/kg-day)
SF	=	chemical-specific carcinogenic oral slope factor $(mg/kg\text{-}day)^{-1}$

The Carcinogenic Risk Equation rearranged where Risk is set at 1.0 X 10-6 and C is determined for each pathway using the intake equations as indicated in the following equation for each chemical and exposure pathway:

$$1.0\ X\ 10^{-6} = \frac{\frac{C \times IR \times EF \times ED}{AT \times BW}}{SF\ (ingestion, inhalation, or\ dermal)}$$

where

Risk	=	risk (unitless)
DI_c	=	daily intake for carcinogens (mg/kg-day)
SF	=	chemical-specific carcinogenic slope factor $(mg/kg\text{-}day)^{-1}$

The equation is rearranged to solve for the C for each exposure pathway to get the concentration for the respective media considering how much of a chemical can be in the soil that is safe for a receptor. This approach addresses a concentration of a chemical is soil and how much it could be inhaled or dermally absorbed from the soil for a certain receptor. These C terms are based on a pre-set Risk level.

$$FWCUGcancer = \frac{1}{\frac{1}{IngestConcentration} + \frac{1}{InhalationConcentraiton} + \frac{1}{DermalConcentration}}$$

4.3 Overview of the Risk Assessment Process

The Risk Assessment will use data gathered pursuant to the Work Plan together with information and sample results from previous studies described in the Work Plan to evaluate WBG. The evaluation will follow the LUC Assessment Process (as referenced below in Section 4.2) to determine if the current LUCs for WBG can be reduced or minimized. Initially, sample results from previous studies were reviewed to assess the nature and extent of detected chemicals.

A data gap analysis was completed on the previously collected data for WBG and is described in Section 1.3.3 (Data Quality Objectives Report – DQO Report) of this RAAD. The data was screened against background values, essential nutrients, and frequency of detections per the Facility-wide Human Health Risk Assessor's Manual for the determination of site-related chemicals (SRCs). The maximum concentrations of the SRC chemicals were compared to the FWCUGs at the following risk levels to determine the COPCs or those chemicals that required further evaluation:

- Hazard Index of 0.1 and the non-carcinogenic risk level and
- Carcinogenic Risk Level of 1.0×10^{-6}.

The data gap analysis essentially identified chemicals that were SRCs and using the maximum detected analytical result, assessed SRCs that were COPCs. In the report, a data gap was identified when there were areas on WBG where COPCs needed more characterization to fully define the nature and extent.

As described in the Work Plan, the next step was to evaluate each of the data points where there were exceedances of the FWCUGs. The evaluation was completed at each location of each exceedance of the FWCUG. Each location was evaluated to determine whether or not it had been vertically or horizontally bound. Areas that were not fully bound were re-sampled, pursuant to the Work Plan in November 2012, to determine the nature and extent. These COPCs were deemed "chemicals that require further evaluation" in the Work Plan.

In the Risk Assessment, chemicals identified as requiring further evaluation are considered COPCs at each data point (sample location) that exceeds its FWCUG. When the additional data from the sampling as described in the Work Plan is evaluated for each COPC, an EPC across the AOC as well as an EPC for each CEA will be calculated. The AOC EPC for each chemical will be determined to assist in the evaluation of the EPC for each CEA. All COPCs will be assessed to determine if they are a chemical of concern (COC). The data (AOC and CEA EPCs) will be compared to the FWCUGs at the following risk levels to determine COCs:

- Hazard Index of 1.0 and the non-carcinogenic risk level and
- Carcinogenic Risk Level of 1.0 X 10^{-5}.

At each data point (sample location) that a COPC was identified, the sample location (point) was evaluated to ensure that it has been bound both vertically and horizontally. Sample locations that had not been fully bound or where there appeared to be a data gap were identified to be sampled as part of the Additional Evaluation of WBG.

The Risk Assessment for the Additional Evaluation of WBG will be completed on the sample results from the additional sampling and other previously collected data for each COPC identified. The Hazard Index of 1.0 and the non-carcinogenic risk level and Carcinogenic Risk Level of 1.0 X 10^{-5} will be used to identify COCs. The EPC will be calculated for the entire AOC for each COPC with a concentration that exceeds the respective FWCUG for at least one applicable receptor that may potentially use the site.

The next step in the Risk Assessment is to evaluate each COPC at each sample location where there is a concentration that exceeds the FWCUG within a specific location (CEA). The EPC will be calculated for each CEA using an Area Use Factor (percent of the CEA to the entire AOC). The EPC will be used to determine if there are risks (potential for risk exists if the EPC for either the AOC or CEA exceeds the respective FWCUG). This process incorporates the LUC Evaluation Assessment for a localized area rather than over the entire AOC. In addition, exceedance boundaries will be developed to illustrate a theoretical boundary where the chemical contamination is located above screening levels for each COPC. This approach is being used to identify areas within the AOC that may need to be remediated to alleviate risks and achieve the RAFLU.

4.4 Land Use Control Assessment

The Risk Assessment will incorporate the process to assess risks in the Ohio EPA approved-document entitled: *Evaluation of Land Use Controls at Ravenna Army Ammunition Plant* (USACE, 2011). This evaluation process presents the Land Use Control (LUC) Assessment Process which standardizes an approach to evaluate LUCs at RVAAP. The premise of the additional evaluation of the WBG as described in the Work Plan will utilize the first few steps of the process including historical research and recent, current, and future site activities, summary of contamination, calculation of exposure point concentrations, and evaluation of results. Ultimately, the LUC Assessment process will be used in the Risk Assessment to determine the CEAs that may need to be remediated to allow for construction and management of the AOC as a range.

4.5 Historical Research and Recent, Current, and Future Site Activities

Section 1.2 presents background information for WBG including previous investigations and removal actions. The land was transferred to the OHARNG for development and use as a small arms range, specifically a MK 19 Grenade Machinegun Range, which is the current use of the site.

The proposed Reasonably Anticipated Future Land Use (RAFLU) for this AOC is Military Training, with development and management of the AOC as a range. The goal is to be able to construct the new range (including disturbance to depths of 10 to 13 feet for construction activities), operate and manage the range, and perform military training at the AOC. Due to residual MEC at the AOC, any current or future activities at the AOC will require UXO construction support during any intrusive operations in areas that were not previously cleared of MEC.

Currently, land use controls/restrictions are in place at the WBG AOC. These are included in the *Final Remedial Action Work Plan* (MKM, 2008) as follows:

"Land use shall be limited to use of the WBG AOC as a small arms range (including the existing Mark 19 Grenade Machinegun Range), and activities on the WBG AOC shall be limited to the following activities: target practice; maintenance of targetry and associated lifting mechanisms; range maintenance (including but not limited to such activities as removal of target practice rounds from the ground surface within the impact area, clearing of target practice rounds from the surface of the range area, road and culvert repair, routine ditch maintenance, and vegetation management [mowing, brush and weed cutting, controlled burning, and herbicide application]); and compatible natural resources management activities (including but not limited to such activities as flora and fauna surveys, timber management to include timber stand improvement and forest products harvesting, soil stabilization and erosion control, invasive/non-native species control, nuisance wildlife control, drainage maintenance, wetland delineations, grassland management, and scientific research). Duration of exposure shall be based upon the established National Guard Range Maintenance Soldier exposure scenario cited at 85 days per year at 6 hours per day for a maximum of 25 years (*RVAAP Facility-Wide Human Health Risk Assessor Manual with Amendment 1* – USACE 2005). All activities must be in compliance with range safety regulations, established digging restrictions, and established exposure limits. In accordance with current Department of the Army Regulations, the small arms range will be marked with signage, facing outward, to warn personnel that the area is a live fire range. All other uses of the WBG AOC are prohibited and the Army will cause appropriate notice to be posted."

This document further defines disturbance restrictions as follows:

"All digging or excavation on the WBG AOC outside of the UXO/MEC-cleared areas, within the Mark 19 Grenade Machinegun Range, as delineated within this RD Figure 2, is prohibited, subject to the following exceptions:

a. Routine maintenance of the roads, ditches and culverts.

b. Ground surface repairs by authorized range personnel in support of authorized range activities.

c. Digging along target array areas by authorized range personnel, to a depth of 1 foot bgs."

The OHARNG is able to use the WBG AOC as a Mark 19 Machine Gun Range with these land use restrictions. However, these use restrictions will not allow the OHARNG to use the site for their RAFLU. The digging restrictions do not allow military personnel to access soils (dig) from 0 to 4' bgs over the entire AOC. Currently, only the authorized personnel (Range Maintenance Soldier) can dig outside the areas previously cleared of MEC with the required UXO Construction Support.

The purpose of the Work Plan is to describe activities to define the full nature and extent of chemical contamination and to determine if residual contamination remains on the AOC at levels that require additional remediation for construction, use and management of the AOC as an MPMG range. Defining the nature and extent of MEC is not required as UXO Construction Support will continue to be required during intrusive operations in areas that were not previously cleared of MEC.

5.0 CHEMICALS OF POTENTIAL CONCERN IN SOIL

5.1 Summary of Contamination/Calculation of Exposure Point Concentrations

For the Risk Assessment, the summary of contamination and calculation of EPCs for each COPC will be evaluated for the entire AOC and each CEA. Extensive investigation data for chemical contamination has been collected during past and current investigations and will be utilized. All applicable investigation data will be used to calculate EPCs for each COPC. These COPCs will be evaluated to determine if the extent of contamination has been defined horizontally and vertically at the site. The RAFLU for this site is Military Training; therefore National Guard receptors will be evaluated. Applicable National Guard receptors who are expected to use the site are the Range Maintenance Soldier, the Trainee, and the Dust/Fire Control Worker. Since the AOC will be used as an active range and due to residual MEC, the residential receptors (Resident Farmer Adult and Resident Farmer Child) will not be evaluated in the Risk Assessment. Site specific clean up goals have been calculated for RVAAP and are presented in the Final *Facility-Wide Human Health Remediation Goals at the RVAAP* (SAIC, 2010) and are hereafter referred to as FWCUGs.

5.2 COPCs from the Confirmation Data

Please refer to the Work Plan for the COPCs identified in the areas where remedial actions have been completed and confirmation data was available. Confirmation data was also considered for the process used to determine COPCs as well as select locations to sample to delineate distribution of the COPCs.

5.2.1 Surface Soil COPCs

The appropriate National Guard receptors for the proposed RAFLU are the National Guard Trainee, the Range Maintenance Soldier, and the Dust/Fire Control Worker. Surface soil for the National Guard receptors is considered 0 to 4 feet below ground surface (bgs) and is referred to as deep surface soil. The applicable investigation data points that were completely within or partially within the 0 to 4 ft bgs stratum were used to calculate EPCs for each COPC.

Table B-1 in appendix B of the Work Plan presents the screening steps and the chemicals identified as COPCs in deep surface soil for the applicable National Guard Receptors. A summary of the results of this table are shown in Table 5-1.

5.2.2 Subsurface Soil COPCs

Subsurface soil for the National Guard Trainee is from 4 to 7 feet bgs. The Dust/Fire Control Worker and Range Maintenance Soldier do not have subsurface soil FWCUGs since their exposure parameters assumed they will not access soils deeper than 4 feet bgs. However, because the Dust/Fire Control Worker and or the Range Maintenance Soldier may have more stringent FWCUGs for a particular chemical compared to the National Guard Trainee, all three receptor's FWCUGs were evaluated to determine COPCs in the subsurface soils in this RAAD.

The Work Plan describes studies that will evaluate subsurface soil for all applicable National Guard receptors and will not be limited from 4 to 7 feet bgs. These studies (using the LUC Evaluation Process) will evaluate from 4 feet bgs to the deepest sample locations. Data below seven feet will help to determine if future activities such as site re-grading will pose a potential risk.

TABLE 5-1. COPCs in Deep Surface Soil (0 to 4 feet) for at least one of the National Guard Receptors using FWCUGs for cancer Risk Range 1.0 X 10^{-6} and HQ = 0.1.

Deep Surface Soil (0 to 4')	**Requires Further Evaluation of Data Gaps for the Indicated National Guard Receptor**			**Value**		
Chemicals that require further evaluation of data gaps for at least 1 NG Receptor	Dust/Fire	RMS	Trainee	Maximum Detect (mg/kg)	Most Stringent Receptor or RSL	Most Stringent FWCUG (10^-6 or HI=.1) or RSL (mg/kg)
Explosives and Propellants						
2,4,6-TNT	x	x	x	3800	Trainee	249
3-Nitrotoluene	x	x	x	21	RSL	0.61
RDX	x	x	x	9500	Trainee	145
Inorganics						
Barium			x	10400	Trainee	351
Cadmium		x	x	877	Trainee	10.9
Cr VI			x	10.1	Trainee	1.64
SVOCs						
2,4-Dinitrotoluene		x	x	19	RMS	9.82
Benzo(a)pyrene	x	x	x	2.3	RMS	0.262

NG: National Guard
Dust/Fire: Dust/Fire Control Worker
RMS: Range Maintenance Soldier
FWCUG: Facility Wide Clean Up Goal
RSL: Region 9 Regional Screening Level

These additional studies are being done to optimize access to a maximum depth as well as address the issue of any changes in grade due to future construction at the WBG AOC. The COPCs identified in the initial screening of the SRCs from previously completed studies at WBG are presented in Table 5-2 below.

The DQO Report used all applicable investigation data points that were completely within or partially within the 4 to 7' bgs stratum for any detected chemical. While this covered the majority of samples deeper than 4' bgs, there were some data points from 8 to 10'' that were not included. These data points were added to the data set for all subsurface data below 4' bgs. Appendix B of the Work Plan presents the Pro UCL output for calculating AOC wide UCLs for inorganics in subsurface soil. Table B-2 in Appendix B presents the screening steps and the chemicals identified as COPCs in subsurface soil for the applicable National Guard receptors.

TABLE 5-2. COPCs in Subsurface Soil (4 to 7 feet) for at least one of the National Guard Receptors using FWCUGs for cancer Risk Range 1.0 X 10-6 and HQ = 0.1.

Subsurface Soil (4'- deepest)	Requires Further Evaluation of Data Gaps for which National Guard Receptor			Value		
Chemicals that require further evaluation of data gaps for at least 1 NG Receptor	Dust/Fire	RMS	Trainee	Maximum Detect (mg/kg)	Most Stringent Receptor or RSL	Most Stringent FWCUG (10^-6 or HI=.1) or RSL (mg/kg)
Explosives and Propellants						
2,4,6-TNT	x	x	x	5200	Trainee	248.76
RDX		x	x	260	Trainee	145
Inorganics						
Cadmium			x	69.1	Trainee	10.93
Cr VI			x	2.8	Trainee	1.64

NG: National Guard
Dust/Fire: Dust/Fire Control Worker
RMS: Range Maintenance Soldier
EPC: Exposure Point Concentration
FWCUG: Facility Wide Clean Up Goal

6.0 SUMMARY

The information and methods discussed in this RAAD will be used to complete the evaluation of risks for the WBG. A modified risk assessment process will be completed on the new and existing data for the WBG to determine risks to National Guard receptors, provide flexibility in future use, and to develop, use and manage the AOC as a future range.

The overall strategy that will be used for this re-evaluation is as follows:

- Determine risks to the National Guard Trainee, Range Maintenance Soldier, and the Dust Fire Control Worker receptors.
- Assess investigation data and confirmation data from previous remedial activities to identify COPCs and their nature and extent. COPCs will be identified at specific sample locations where chemical concentrations exceeded those of their FWCUGs for at least one of the applicable receptors.
- Evaluate additional sampling and analysis results for chemicals that required further evaluation to ensure risk level exceedances are horizontally and vertically bound by non-exceedances.
- Develop exceedance boundaries to illustrate a theoretical boundary where the chemical contamination is located above screening levels for each COPC.
- Calculate the Exposure Point Concentrations (EPC) for the COCs. The EPC will be determined for the entire AOC and for each Concentration Exceedance Area (CEA) where concentrations of the COC exceed Facility-wide Cleanup Goals (FWCUGs) for all receptors that may potentially use the site.
- Assess area/volume of the entire AOC for the Area Use Calculation. Determine the Area Use Factor (AUF – ratio of CEA surface area to that of the AOC) for each CEA by using the following equation:

$$AUF = \text{Surface Area CEA} \div \text{Surface Area of the AOC}$$

- Estimate the EPC within the CEA. Adjust the EPC within the each CEA by the appropriate AUF for that CEA to obtain the CEA Adjusted EPC.
- Compare the $EPC_{adjusted}$ to the FWCUGs at the appropriate risk levels for all receptors.
- Identify any COCs (chemicals within a CEA where the EPC adjusted exceeds the FWCUGs at the 1.0 X -5 or HQ = 1.0 risk levels).
- Prepare Report and risk assessment/evaluation for the COPC and COC evaluation. Include recommendations for remediation and the appropriate next step in the determination of the WBG for other uses as well as a review of the existing LUCs is relation to the newly identified COCs within each CEA and over the entire AOC.

7.0 REFERENCES

MKM Engineers, Inc. (MKM). 2005a. Final Phase I MEC Density Survey After Action Report at RVAAP-05 Winklepeck Burning Grounds, March.

MKM. 2005b. Final Work Plan for Phase II MEC Clearance and Munitions Response at RVAAP-05 Winklepeck Burning Grounds, March.

MKM. 2005c. Final Phase II MEC Clearance and Munitions Response at Winklepeck Burning Grounds, December 16.

MKM. 2008a. Final Field Sampling and Analysis Plan MEC Clearance and Munitions Response Amendment 1 for RVAAP-05 Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, October.

MKM. 2008b. Final Remedial Action Work Plan, Winklepeck Burning Grounds, Ravenna Army Ammunition Plant, Ravenna, Ohio, Amendment 1, September.

MKM. 2009. Final Remedial Action Completion Report for RVAAP-05 Winklepeck Burning Grounds Pads 61/671A, 67, and 70, November 19.

Ohio EPA. 2004. Ohio Environmental Protection Agency (Ohio EPA) Director's Final Findings and Orders (DFFO) for the Ravenna Army Ammunition Plant (RVAAP), June.

Science Applications International Corporation (SAIC). 1998, Final Phase I Remedial Investigation Report for High Priority Areas of Concern at the Ravenna Army Ammunition Plant, Ravenna, Ohio. February.

SAIC. 2001b. Final Phase II Remedial Investigation Report for the Winklepeck Burning Grounds at RVAAP, Ravenna, Ohio, April.

SAIC. 2005a. Final Phase III Remedial Investigation Report for the Winklepeck Burning Grounds at the Ravenna Army Ammunition Plant, Ravenna, Ohio, March.

SAIC. 2006. Revised Final Report On The Biological Field-Truthing Effort At Winklepeck Burning Grounds At Ravenna Army Ammunition Plant, Ravenna, Ohio, August.

SAIC. 2008. Final Record of Decision for Soil and Dry Sediment at the RVAAP-05 Winklepeck Burning Grounds at the Ravenna Army Ammunition Plant, Ravenna, Ohio. August.

SAIC. 2010. Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio, March 23.

Shaw. 2011. Final Data Quality Objectives Report for RVAAP-05 Winklepeck Burning Grounds, June.

United States Army Corps of Engineers (USACE). 2005, Ravenna Army Ammunition Plant Facility-Wide Human Health Risk Assessor Manual, Amendment 1.

USACE. 2009. Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals, June.

USACE. 2011. Final Guidance Document for the Evaluation of Land Use Controls at Ravenna Army Ammunition Plant

USACE. 2012. Final Work Plan for Additional Evaluation of the RVAAP-05 Winklepeck Burning Grounds, October 29.