**RVAAP's Facility Wide
HUMAN HEALTH RISK
ASSESSOR MANUAL**

Amendment 1
01 Dec 2005

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LIST OF ACRONYMS

ADD	Average Daily Dose
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area Use Factor
bgs	Below Ground Surface
BCF	Biological Concentration Factor
BRA	Baseline Risk Assessment
BTF	Bio-transfer Factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980.
COPC	Chemical of Potential Concern
CRREL	Cold Regions Research and Engineering Laboratory (USACE)
DNT	Dinitrotoluene
DQO	Data Quality Objective
ECAO	ATSDR Environmental Criteria and Assessment Office
ECSM	Environmental Conceptual Site Model
EE/CA	Engineering Evaluations/Cost Analysis
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESA	Endangered Species Act
EU	Exposure Unit
FSAP	Facility-Wide Sampling and Analysis Plan
FSHP	Facility-Wide Safety and Health Plan
GOCO	Government-Owned, Contractor-Operated
HQ	Hazard Quotient
HHRA	Human Health Risk Assessment
IRP	Installation Restoration Program
LOAEL	Lowest Observed Adverse Effect Level
NOAEL	No Observed Adverse Effect Level
ODOW	Ohio Department of Wildlife
OEPA	Ohio Environmental Protection Agency
ONG	Ohio National Guard
OSC	Operations Support Command
PC	Permeability Coefficient
PPRTVs	EPA's Provisional Peer Reviewed Toxicity Values
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS

RDX	Cyclotrimenthylenetrinitramine
RGOs	Remedial Goal Objectives
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RRSE	Relative Risk Site Evaluation
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
STSC	Superfund Health Risk Technical Support Center
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
T&E	Threatened and Endangered
TNT	2, 4, 6-Trinitrotoluene
TRV	Toxicity Reference Value
TUF	Temporal Use Factor
UCL_{95}	Upper 95% Confidence Limit
USACE	U.S. Army Corps of Engineers
USAEHA	U.S. Army Environmental Hygiene Agency
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WBG	Winklepeck Burning Ground

FORWARD

Note to Contractors or Others Performing Risk Assessment at RVAAP:

Please ensure that you have agreement with Ohio EPA respective to risk characterization white papers prior to commencing any risk assessments at RVAAP. The white paper required by this manual is to ensure that what is proposed is acceptable to the Agency. If a contractor proceeds without prior contact and/or written approval to proceed, the contractor is proceeding at their own risk and may be required to revise/re-do work already conducted.

1.0 INTRODUCTION

The Ravenna Army Ammunition Plant (RVAAP) has command organization from US Army Materiel Command; Engineering, Housing, Environmental and Installation Logistics, Environmental Quality Division. Additionally the Base Realignment and Closure Office (BRACO) which Army Environmental Center used for technical support has authority over RVAAP's environmental restoration program. Said command utilizes an Installation Action Plan (IAP) to cover remedial investigations and clean up needed for closure of RVAAP. The purpose of the IAP is to outline the total multi-year restoration program for an installation. The IAP defines Installation Restoration Program (IRP) requirements and proposes a comprehensive approach and associated costs to conduct future investigations and remedial actions at each Area of Concern (AOC) at the installation and other areas of concern.

The IAP for the RVAAP coordinates planning information between IRP manager, major army commands (MACOMs), installations, executing agencies, regulatory agencies (Ohio EPA), and the public. The IAP is used to track requirements, schedules, and tentative budgets for RVAAP IRP.

Inherent to the IRP is the use of risk assessments as a decision making tool within the CERCLA and RCRA corrective action process. The RCRA and CERCLA ("Superfund") programs use different terminology, but follow parallel procedures in responding to releases.

"A baseline Risk Assessment is conducted in the Remedial Investigation (RI) (CERCLA) or RCRA Facility Investigation (RFI) under RCRA. Section 105 of CERCLA/SARA charges the On-Scene Coordinator (OSC) or Remedial Project manager (RPM) with the responsibilities of identifying potential impacts on public health, welfare, and the environment, and setting priorities for this protection which is delegated to the Department of Defense (DOD) under Section 115 and Executive Order 12580 for DOD facilities.

RCRA Section 3019 requires the facility owner/operator to submit an exposure information report, which provides exposure and health assessment information for certain storage and land disposal waste management units. In the RFI, as required by permit conditions or enforcement actions under RCRA Sections 3008(h), 7003, and/or 3013, health and environmental assessment (HEA) or BRA is used to determine quantitatively if the site or any of its units has exceeded established health criteria. As indicated in the RFI guidance (EPA 1989), a site-specific risk assessment will be performed prior to the Corrective Measures Study (CMS) to assess potential risk to humans and to determine if no response action is appropriate. Under CERCLA Section 120, risk assessment is one of the primary documents identified for submission to EPA for comment and review in the Federal facility Agreement." [USACE EM 200-1-4, 30 June 1995].

Therefore the overall objective of this manual is to provide risk assessors and risk managers with:

- Insight to chemical contaminants at the facility,
- Information for conceptualization of risk characterization needs for comparable AOCs, risk management options associated with the decision for interim removals,
- Sampling strategies that have proven effective in deriving media source term concentrations; and,
- Documenting options associated with hazardous, toxic, and radioactive waste investigations, studies and designs consistent with the principles of good science in defining the quality of risk assessments.

Likewise this manual will guide in the preparation of technical memoranda that serve as the blue print for risk characterization. The technical memorandum is a short document prepared prior to initiating a risk assessment at the RVAAP to delineate which land use scenarios will be evaluated and to discuss any extra or special conditions not already covered herein. A risk assessment is a tool that is used within the investigation phases of the CERCLA process to determine if exposure to contamination by receptors, such as humans, is within acceptable levels or if a cleanup or remedy is necessary to protect human health from adverse effects.

The purpose of preparing the technical memorandum is to outline the process that allows the U. S. Army Corps of Engineers, U.S. Army, Ohio Army National Guard, Ohio EPA, and other regulatory agencies and stakeholders to reach a scientific management decision for the AOC(s). Additionally, the technical memorandum will serve as a scoping document to ensure that all risk assessment requirements, such as source term concentration, receptor(s), and exposure factors with respective algorithms are defined. This approach also has been proposed to ensure that all parties involved, agree on the approach and methodology prior to undertaking a risk assessment.

The manual presents methodologies for conducting human health risk assessments. The methodologies have been developed to ensure that the objectives of the risk assessment will be met. The specific objectives of the risk assessment are:

- Estimate potential human health risks and impacts associated with the RVAAP if no remedial action occurs.

- Identify areas that pose no unacceptable risks to human health and thus require no further action from the human health standpoint.

- Develop a list of constituents of concern (COCs) for each site that contribute unacceptable risks to human health.

- Provide baseline risks for the no action alternative in the Feasibility Study (FS) that will be used to evaluate risk reduction for each proposed alternative, if risk is determined to be unacceptable.

- Develop risk based concentrations for the identified COCs to provide the basis of site specific cleanup goals for use in decision making during the FS in order to focus future remedy selection for COCs that are the significant contributors to human health risks.

1.1 AREAS OF CONCERN

Previous investigations have been conducted that identified former areas of activity at the RVAAP that could potentially be contaminated due to past activities. The first stage of the CERCLA investigation process is to conduct a preliminary assessment (PA). This is a general review of all historical information and existing site data to determine the likelihood of contamination. The PA for RVAAP identified past military activity to include:

- Melt/pour load lines
- Fuze & booster burn pits
- Burning grounds
- Demolition areas
- Quarry landfill
- Sewage treatment plants
- Landfills
- Maintenance areas & waste oil tanks
- Buildings where PCB or pesticide storage occurred
- Buildings with sumps
- Fuze and booster lines
- Scrap areas,
- Ranges (e.g., pistol and 40 mm Ranges)
- Burn pits and burn grounds; and
- Various dump areas that occurred along roads and creeks.

Areas where former activity resulted in contamination are called AOCs. The aforementioned types of areas are considered AOCs at RVAAP. All identified AOCs require additional investigation, such as a site investigation (SI) or remedial investigation (RI) per the CERCLA process, to determine if contaminant concentrations are at acceptable levels.

Within each AOC there may be an exposure unit (EU). An exposure unit may be defined as the extent of contamination for which exposure to a receptor is possible. A pathway and exposure route must be present at the exposure unit in order for the site to be considered a complete exposure pathway. Within an AOC different exposure units may

be present, such as a hot spot. A hot spot is considered a localized area of contaminant anomaly, i.e. different from the contaminants found as a result of the specific historical operation of the AOC.

PROJECT PLANNING

Patches of earth represented as areas of contaminant anomaly, for example, lead shavings, or an uncovered drum do not represent the trend of contamination within the AOC and/or EU. In these circumstances where the contamination is specific to the anomalous finding, i.e. different from the trend of contamination within the AOC, removal would be considered as an interim action. Coordination with the Ohio EPA would be necessary. In these instances where remedial action occurs without conducting a risk assessment, the facility wide background levels for metals (naturally occurring inorganic constituents) and US EPA Region 9 PRGs would serve as remedial goal objectives. These interim actions would be completed upon discovery and the results of the actions will be considered and incorporated with the final remedy decision-making and remedy.

In order to reduce repetitive risk assessments within RVAAP an evaluation will be made of AOCs that had comparable site activity e.g. load lines, burning grounds, and the like. AOCs that can be aggregated based on comparable activity will have one risk characterization performed based on what is believed to be the worst contaminated AOC in the aggregate. The other AOCs within the same aggregate will have the same Remedial Goal Objectives as those developed for the worst-case AOC provided that two conditions exist: (1) nature of the contamination remains the same among all AOCs in the aggregate; and, (2) the exposure point concentrations of constituents of potential concern are equal to or less than respective concentrations within worst-case AOC.

However, certain AOC aggregates may not fit the aforementioned provisional conditions. For example, if an AOC is not consistent with the area being used as the model for the risk assessment (e.g., different COPCs, different land uses are considered, concentrations of contaminants may be different etc.) then an AOC specific risk assessment would be warranted. This approach reduces iterative risk characterizations among comparable AOCs.

2.0 DESCRIPTION AND BACKGROUND OF RAVENNA ARMY AMMUNITION PLANT

RVAAP is located in northeastern Ohio within Portage and Trumbull counties, approximately 4.8 km (3 miles) east-northeast of the city of Ravenna and approximately 1.6 km (1 mile) northwest of the town of Newton Falls. The installation consists of 8668.3 ha (21,419 acres) contained in a 17.7-km (11-mile)-long, 5.6-km (3.5-mile)-wide tract bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System

Railroad on the south; State Route 534 on the east; Garrettsville and Berry Roads on the west; and the CONRAIL Railroad on the north. The land use surrounding the installation is primarily farmland with sparse private residences. The installation is surrounded by several local communities: Windham, which borders on the installation to the north; Garrettsville, located 9.6 km (6 miles) to the northwest; Newton Falls, 1.6 km (1 mile) to the east; Charleston, bordering the southwest; and Wayland, 4.8 km (3 miles) to the southeast.

RVAAP was established on August 26, 1940 for the primary purpose of loading medium- and major-caliber artillery ammunition; bombs, mines; fuze and boosters; primers and percussion elements; and for the storage of finished ammunition components. Originally, the installation was divided into two separate units; one was designated as Portage Ordnance Depot with the primary mission of the depot's storage activity, and the other was designated as the Ravenna Ordnance Plant with the primary mission of the ammunition-loading activities.

Over the years, RVAAP handled and stored strategic and critical materials for various government agencies and received, stored, maintained, transported, and demilitarized military ammunition and explosive items. RVAAP maintained the capabilities to load, assemble, and pack military ammunition; however, these operations are inactive. As part of the RVAAP mission, the inactive facilities were maintained in a standby status by keeping equipment in a condition to permit resumption of production within the prescribed time limitations.

RVAAP was a Government-Owned, Contractor-Operated (GOCO) U.S. Army Operations Support Command (OSC) facility. The Atlas Powder Company was the original GOCO manager of the Ravenna Ordnance Depot and operated the plant from 1940-1945; the government operated the Portage Ordnance Depot. The last production for World War II was in August 1945. The government assumed operations of both areas from 1945 to 1951 when Ravenna Arsenal Inc. (RAI), a subsidiary of the Firestone Tire and Rubber Co., Akron, Ohio, was contracted to operate the entire facility. In 1982, Physics International Co., a subsidiary of Rockcor Inc., purchased RAI from Firestone. Olin Corporation purchased Rockcor Inc. in June 1985.

In 1992, the status of RVAAP changed from inactive-maintained to modified caretaker. The only activities still being carried out from the wartime era are the storage of bulk explosives and propellants and the infrequent demolition of unexploded ordnance (UXO) found at the installation. The Army is also overseeing the reclamation of railroad track, telephone line, and steel for reuse or recycling. The Army has completed the demolition of excess buildings at Load Lines 1 and 12, and is currently conducting demolition activities at Load Line 2, which includes the removal of friable asbestos. RVAAP's operations and mission-related activities are directed by the Operations Support Command (OSC). Environmental restoration activities at RVAAP are conducted under the auspices of the IRP. As of January 2003, oversight and funding responsibilities for the IRP were transferred from the OSC to the U.S. Army Environmental Center (AEC).

In addition to Army mission-related and IRP activities, a large portion of RVAAP is currently used by the Ohio Army National Guard (OHARNG) for training missions.

In May 1999, OHARNG assumed administrative control over all but 1,481 acres at RVAAP. These 1,481 acres encompass the AOCs and munitions storage areas and remain under control of the U.S. Army BRACO. A 2001 Memorandum of Agreement (MOA) concerning conditions for transfer of acreage was signed between OHARNG and Department of Army. In March of 2002 Army and OHARNG ratifying the agreement for transfer of remaining property signed Amendment 1 to this MOA.

A brief overview of the history of RVAAP is provided in a chronological order to provide a summary of the site's history.

Date	Description of Activity/Facility Status
1940	10,117.5 ha (25,000 acres) purchased by the United States Government. Began construction of the plant.
Sept 1940	Operated by Atlas Powder Company
Dec 1941 to Jan 1942	Facility completed and began operations. Primary mission was depot storage and ammunition loading. Divide installation into two separate units: Portage Ordnance Depot – depot storage of munitions and components; and Ravenna Ordnance Plant – loading ammunition
Aug 1943	Designated as the Ravenna Ordnance Center
Nov 1945	Designated as Ravenna Arsenal
1945	Turned over to Ordnance Department
1945-1949	Silas Mason Co. operated the ammonium nitrate line for the production of ammonium nitrate fertilizer.
1950	Plant placed on standby status. Operations limited to renovation, demilitarization, and normal maintenance of equipment and stored ammunition and components.
Apr 1951	RAI contracted to run the facility. Subsidiary of Firestone Tire and Rubber Co.
Jul 1954	Plum Brook Ordnance Works of Sandusky, Ohio, and the Keystone Ordnance Works of Meadville, Pennsylvania, were made satellites of Ravenna.
Aug 1957	All at-plant production ended.
Oct 1957	The installation was placed on standby status.
Mar 1958	Plum Brook Ordnance Works ceased to be under the jurisdiction of Ravenna.
Jul 1959	Keystone Ordnance Works was transferred to General Services Administration.
Oct 1960	Began rehabilitation work to replace facilities in the ammonium nitrate line for the processing and explosive melt-out of bombs.

Date	Description of Activity/Facility Status *(continued)*
Jan 1961	Operations began for the processing and explosive melt-out of bombs. Operation of this type was first in the ammunition industry.
Jul 1961	Plant again deactivated.
Nov 1961	Installation was divided into Ravenna Ordnance Plant and the industrial section. Entire facility was designated as the RVAAP.
May 1968	RVAAP reactivated in support of the Southeast Asian Conflict for loading, assembly, and packing munitions on three load lines and two component lines.
1971	Operations ceased at Load Lines 1, 2, 3, and 4.
Jun 1973 to Mar 1974	Deactivated major load lines and component line to demilitarization of the M7IA1 90 MM projectile.
Oct 1982	Physics International Company (a subsidiary of Rockcor Inc.) purchased Ravenna Arsenal Inc. from Firestone.
Jun 1985	Rockcor Inc. was purchased by Olin Corporation.
1992	The RVAAP mission was discontinued, placing the installation on the 'Inactive Maintained' status.
Mar 1993	Transfer of RVAAP from 'Inactive Maintained' to 'Inactive Modified-Caretaker' status.
Sept 1993	RVAAP was placed in 'Modified-caretaker' Status.
Sept 1993	A report of Excess determined the load lines and associated real estate as excess to the U.S. Army. The excess area includes approximately 2006.0 ha (4957 acres) and 362 buildings in Load Lines 1 through 12 (excluding 7 and 11), Area 4, and Area 8.
Oct 1993	Mason & Hanger-Silas Mason Co., Inc. took over as the installation's contractor modified caretaker.
Oct 1997	R+R International became the installation's contractor modified caretaker.
1998	Salvage and demolition operations commenced at RVAAP. Removal of the railroad ties and rails, copper wire, and excess metal for salvage was completed. Demolition of Load Lines 1, 2, and 12 commenced with removal of transite (friable asbestos and concrete) siding and roofing. Transite has been removed from the

Date	Description of Activity/Facility Status *(continued)*
	warehouses, melt pour buildings, and bulk storage buildings of LL2.
May 1999	Administrative control of 16, 164 of RVAAP was transferred to the Ohio Army National Guard for use in training and related activities. These parcels of land are outside any known areas of concern.
Feb 2000	Tol-Test, Inc. replaced R+R International as contractor-modified caretaker.
Dec 2001	MOA between Army and OHARNG developed for land transfer.
March 2002	Amendment 1 to MOA ratifying agreement for transfer of remaining property to OHARNG.
Jan 27, 2003	Flash Wet Storage Igloos
Feb 10, 2003	Thermal Decomposition of Wet Storage Igloos
May 5, 2003	Thermal Decomposition of Load Line 6
May 8, 2003	Thermal Decomposition of Load Line 9

Although currently inactive, RVAAP has historically handled hazardous wastes and operated several waste management units in support of their operations. Materials of potentially hazardous nature were stored, treated, deposited in landfills, or burned at the site.

The industrial operations at RVAAP consisted of 12 load lines. Load Lines 1 through 4 were used to melt and load trinitrotoluene (TNT) and Composition B into munitions. The operations on the Load Lines 1 through 4 produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floor and the walls would be hosed down with water and steam cleaned. The liquid, containing TNT and Composition B constituents, would be collected in holding tanks, filtered, and pumped to one of the four settling ponds. Load Lines 5 through 11 were used to manufacture, fuzes, primers, and boosters while Load Line 12 housed the ammonium nitrate plant. Potential contaminants in Lines 5 through 11 included, but are not limited to, lead azide, lead styphnate, and black powder, TNT, Composition B and Pentaerythrioltetranitrate (PETN). Load Line 12 was operated to produce ammonium nitrate for explosives and fertilizers.

Landfills at RVAAP were used to bury waste from industrial operations and sanitary sources. In addition, burial sites may also be located on-site based on historical information. Potential contaminants from these areas include, but are not limited to,

primary and secondary explosives, explosive wastes, mustard agent, metals, and compounds such as sodium chloride and calcium chloride that have specific requirements under RCRA-Closure.

Settling and retention ponds at the site collected wastewater from munitions wash-down operations at various facilities. Potential contaminants associated with the settling and retention ponds include, but are not limited to, explosive compounds, aluminum chloride, metals, and heavy metals.

RVAAP had several areas associated with the burning, demolition, and testing of various munitions. These burning grounds and demolition areas consisted of large areas of land or abandoned quarries for these activities. Potential contaminants at these sites include, but are not limited to, explosives [cyclonite [hexahydro-1,3,5-trinitro-1,3,5-triazine](RDX), Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), Composition B, TNT, black powder] white phosphorous, antimony sulfide, lead azide, propellant, waste oils, heavy metals, sludge from load lines, various laboratory chemicals, and sanitary waste.

RVAAP has various industrial operations that have been identified as potential sources of contaminants. These operations include sewage treatment, wastewater treatment, vehicle maintenance, storage tanks, waste storage areas, equipment storage areas, furnaces, and evaporation units. Contaminants associated with these operations include, but are not limited to, explosives, lead azide, lead styphnate, metals, heavy metals, polychlorinated biphenyls (PCBs), waste oil, and petroleum.

2.1 ENVIRONMENTAL SETTING
Maps such as the zone of influence for groundwater wells, surface water drainage areas, storm sewer drains, etc., are found in the AOC-specific documents.

CLIMATIC CONDITIONS
The general climate of the RVAAP area is continental and is characterized by moderately warm and humid summers, reasonably cold and cloudy winters, and wide variations in precipitation from year to year. The following climatological data were obtained from the National Weather Service Office (NWS 1995) at the Youngstown-Warren Regional Airport located in Trumbull County and are based on a 30-year average.

Total annual rainfall in the RVAAP area is approximately 93.25 cm (37.3 inches), with the highest monthly average occurring in July [10.2 cm (4.07 inches)] and the lowest monthly average occurring in February [5.0 cm (2.03 inches)]. Average annual snowfall totals approximately 140.5 cm (56.2 inches) with the highest monthly average occurring in January [32.2 cm (12.9 inches)]. It should be noted that due to the influence of lake-effect snowfall events associated with Lake Erie [located approximately 56.3 km (35 miles) to the northwest of RVAAP], snowfall totals vary widely throughout northeastern Ohio.

The average annual daily temperature in the RVAAP area is 48.3 ºF, with an average daily high temperature of 57.7 ºF and an average daily low temperature of 38.7 ºF. The record high temperature of 100 ºF occurred in July 1988, and the record low temperature of -22 ºF occurred in January 1994. The prevailing wind direction at RVAAP is from the southwest, with the highest average wind speed occurring in January [18.7 km (11.6 miles) per hour] and the lowest average wind speed occurring in August [11.9 km (7.4 miles) per hour].

Thunderstorms occur on approximately 35 days per year and are most abundant from April through August. The RVAAP area is susceptible to tornadoes; minor structural damage to several buildings on facility property occurred as the result of a tornado in 1985.

GEOLOGIC SETTING

UNCONSOLIDATED DEPOSITS

Two glacial advances during the Wisconsin Age of the Pleistocene Epoch resulted in the deposition of glacial till over the entire RVAAP installation. The first glacial advance deposited the Lavery Till over the facility. The Lavery Till consists mostly of clay and silt with a few cobbles and sporadic boulders. The second glacial advance deposited the Hiram Till over the eastern two-thirds of the facility only. The Hiram Till consists of 12% sand, 41% silt, and 47% illite and chlorite clay minerals, and ranges in depth from 1.5 to 4.6 m (5 to 15 feet) below ground surface (bgs). The Hiram Till overlies thin beds of sandy outwash material in the far northeastern corner of the facility. Field observations

indicate that overall till thickness is less than 0.6 m (2 feet) in some areas of the RVAAP facility. The reduced till thickness may be due to natural erosion or construction grading operations and is not necessarily the result of deposition.

A suspect buried glacial valley, oriented in a southwest–northeast direction, is located in the central portion of the facility. This valley is filled with glacial out-wash consisting of poorly sorted clay, till, gravel, and silty sand. Depths of unconsolidated sediments in the valley range from 30.5 to 61 m (100 to 200 feet) BGS.

BEDROCK

The bedrock geology of RVAAP consists of Carboniferous Age sedimentary rocks that lie stratigraphically beneath the glacial deposits of the Lavery and Hiram tills. The oldest bedrock within the facility is the Cuyahoga Formation of the Mississippian Age. Three members comprise this formation: (1) the Orangeville Shale, (2) the Sharpsville Sandstone, and (3) the Meadville Shale. The Cuyahoga outcrops in the far northeastern corner of the facility and generally consists of blue-gray silty shale with interbedded sandstone. The regional dip of the Cuyahoga strata is between 1.5 to 3.0 m (5 to 10 feet) per mile to the south.

The remainder of the facility is underlain by bedrock associated with the Pottsville Formation of Pennsylvanian Age. The Pottsville Formation, which lies unconformably on an erosional surface of the Cuyahoga Formation, is divided into four members: (1) the Sharon, (2) the Connoquenessing Sandstone, (3) the Mercer, and (4) the Homewood Sandstone. The Sharon Member consists of two individual units: the Sharon Conglomerate and the Sharon Shale. The Sharon Conglomerate is a second cycle sedimentary rock, and the pebbles are comprised of quartzite. The Sharon Conglomerate also has locally occurring thin shale lenses in the upper portion of the unit. Due to the differences in lithology between the Sharon Conglomerate and the underlying shales of the Cuyahoga Formation, the contact between the Pottsville and Cuyahoga Formations usually is quite distinct. The Sharon Shale overlies the Sharon Conglomerate and consists of sandy, gray-black, fissile shale with some plant fragments and thin flagstone beds. Sharon sandstones are exposed on the ground surface at Load Line 1 and the former Ramsdell Quarry.

The Connoquenessing Sandstone member of the Pottsville Formation unconformably overlies the Sharon Member and is a medium- to coarse-grained, gray-white sandstone with more feldspar and clay than the Sharon Conglomerate. Thin interbeds and partings of sandy shale also are common in the Connoquenessing. The Mercer member of Pottsville Formation overlies the Connoquenessing and consists of silty to carbonaceous shale with abundant thin, discontinuous sandstone lenses in the upper portion. Regionally, the Mercer also has been noted to contain interbeds of coal. The Homewood Member of the Pottsville Formation unconformably overlies the Mercer member and consists of coarse-grained cross bedded sandstones that contain discontinuous shale lenses.

The Connoquenessing, Mercer, and Homewood members are present only in the western half of the RVAAP facility. The Sharon Conglomerate unit is the upper bedrock surface in most of the eastern half. The regional dip of the Pottsville Formation strata is between 1.5 and 3.5 m (5 and 10 feet) per 1.6 km (1.0 mile) to the south.

HYDROLOGIC SETTING

UNCONSOLIDATED SEDIMENTS

The largest groundwater supplies within Portage County come from areas that underlie Franklin, Brimfield, and Suffield townships and Streetsboro, Shalersville, and Mantua townships, respectively. The unconsolidated units that consist of sand and gravel are favorably situated to receive recharge from surface streams and surface infiltration. These same areas are used as a source of drinking water for a good percentage of residents in the vicinity of RVAAP.

The water-bearing characteristics for the sand and gravel aquifers in the vicinity of the RVAAP installation are poorly documented. Wells that penetrate these aquifers can yield up to 6080 liters per minute (LPM) [1600 gallons per minute (GPM)]. However, yields from wells penetrating silty or clay till materials are significantly lower. In general, the Kent and Hiram tills are too thin and impermeable to produce useful quantities of water.

BEDROCK

The most important bedrock sources of groundwater in the vicinity of the RVAAP facility are the sandstone/conglomerate members of the Pottsville Formation. These aquifers, together with two other deeper Mississippian/Devonian sandstone aquifers, represent the most important bedrock sources of groundwater in Northeastern Ohio.

The Sharon Conglomerate is the primary source of groundwater at RVAAP and maintains the most significant well yields of the Pottsville Formation members with hydraulic conductivity values of 19 to 7600 liters per day per meter (LPD/m) [5 to 2,000 gallons per day per foot (GPD/ft)]. Past studies of the Sharon Conglomerate indicate that the highest yields are associated with the true conglomerate phase (coarse-grained sandstone with abundant quartzite pebbles) and with joints and fractures in the bedrock; however, there is no facility-specific information available regarding variations in aquifer properties due to these factors. Where present, the overlying Sharon Shale acts as a relatively impermeable confining layer for the Sharon Conglomerate. Several flowing artesian production wells have been noted at the facility.

The Connoquenessing Sandstone and the Homewood Sandstone are the remaining aquifers of the Pottsville Formation and exhibit hydraulic conductivities of 19 to 1140 LPD/m (5 to 300 GPD/ft) and 19 to 760 LPD/m (5 to 200 GPD/ft), respectively. Well yields in the Connoquenessing and Homewood sandstones, although lower than the Sharon Conglomerate, are high enough to provide significant quantities of water. Several

wells at the RVAAP facility have penetrated both the Sharon Conglomerate and the Connoquenessing Sandstone and reportedly produced water from both units.

In general, hydraulic conductivities in the shales of the Sharon and Mercer members of the Pottsville Formation are low and result in insignificant groundwater yields. The primary porosity of the shales is likely secondary, owing to joints and fractures in the bedrock; however, there is no facility-specific information available regarding the occurrence of joints and fractures in these units.

GROUNDWATER UTILIZATION

All groundwater utilized at the RVAAP facility during past operations was obtained from on-site production wells, with the large majority of wells screened in the Sharon Conglomerate. Production wells scattered throughout the facility provided necessary sanitary and process water for RVAAP operations. All remaining process production wells were permanently abandoned in 1992. Currently, only two groundwater production wells remain in operation. These wells, located in the central portion of the facility, provide sanitary water to the remaining site personnel. Additionally, a production well, not in operation, is located at the former site of Building T-5301. This well will be activated per IRP needs, to include but not limited to, decon, water for bioremediation, and the like.

Residential groundwater use in the surrounding area is similar to that for RVAAP, with the Sharon Conglomerate acting as the major producing aquifer in the area. The Connoquenessing Sandstone and the Homewood Sandstone also provide limited groundwater resources, primarily near the western half of the RVAAP facility.

The *Ground Water Pollution Potential of Portage County* published by the Ohio Department of Natural Resources (1991) provides additional insight into the groundwater characteristics of the RVAAP area. This map indicates the relative vulnerability of groundwater in a specific area to contamination from surface sources. Intended primarily as a groundwater resource management and planning tool, the Ground Water Pollution Potential Map presents index values based on several hydrogeologic criteria including depth to water, hydraulic conductivity, topography, and others. Resulting index values range from a low pollution potential (zero) to a high pollution potential (200+).

Based on this mapping system, the majority of the RVAAP facility has a moderate pollution potential that ranges between 100 and 159, depending on location. In addition, three general hydrogeologic settings are defined for RVAAP and include: (1) glacial till overlying bedded sedimentary rock, (2) glacial till overlying sandstone, (3) and alluvium overlying bedded sedimentary rock. In general, the highest pollution potential values at RVAAP occur in the areas where alluvium overlies bedded sedimentary rock (index range of 140 to 159); however, these areas occur primarily in the northeast portion of the facility. The majority of RVAAP has pollution potential indices that range between 100 and 139.

SURFACE WATER

The entire RVAAP facility is situated within the Ohio River Basin, with the West Branch of the Mahoning River representing the major surface stream in the area. The West Branch flows adjacent to the west end of the facility, generally in a north to south direction, before flowing into the M.J. Kirwan Reservoir, which is located to the south of State Route 5. The West Branch flows out of the reservoir along the southern facility boundary before joining the Mahoning River east of RVAAP.

The western and northern portions of the RVAAP facility display low hills and a dendritic surface drainage pattern. The eastern and southern portions are characterized by an undulating to moderately level surface, with less dissection of the surface drainage. The facility is marked with marshy areas and flowing and intermittent streams whose headwaters are located in the facility's hills. Three primary watercourses drain RVAAP: (1) the South Fork of Eagle Creek, (2) Sand Creek, and (3) Hinkley Creek. All of these water courses have many associated tributaries.

Sand Creek, with a drainage area of 36 km^2 (13.9 miles^2), flows generally in a northeast direction to its confluence with the South Fork of Eagle Creek. In turn, the South Fork of Eagle Creek then continues in a northerly direction for 4.3 km (2.7 miles) to its confluence with Eagle Creek. The drainage area of the South Fork of Eagle Creek is 67.8 km^2 (26.2 miles^2), including the area drained by Sand Creek. Hinkley Creek originates just southeast of the intersection between State Routes 88 and 303 to the north of the facility. Hinkley Creek, flows in a southerly direction through the installation to its confluence with the West Branch of the Mahoning River south of the facility. Hinkley Creek has a drainage area of 28.5 km^2 (11.0 miles^2).

Approximately 50 ponds are scattered throughout the installation. Many were built within natural drainage-ways to function as settling ponds or basins for process effluent and runoff. Others are natural in origin, resulting from glacial action or beaver activity. All water bodies at RVAAP could support aquatic vegetation and biota. None of the ponds within the installation is used as a water supply source.

Storm water runoff is controlled primarily by natural drainage except in facility operations areas where an extensive storm sewer network helps to direct runoff to drainage ditches and settling ponds. In addition, the storm sewer system was one of the primary drainage mechanisms for process effluent during the period that production facilities were in operation.

SURFACE WATER UTILIZATION

Past and present surface water utilization at RVAAP generally was limited to use by wildlife and recreational users. Although some surface water may have been used intermittently for various facility operations, the vast majority of process water was provided by on-site groundwater production wells. There is no available documentation that indicates any past irrigation or other agricultural use of surface water sources on

facility property. It is likely that some agricultural use of surface water was conducted in this area before facility construction due to the presence of homesteads and farms, with the assumption that surface water uses may have included livestock water sources at that time. On-site recreational surface water use was limited to managed fishing programs conducted in the past.

Some recreational use of surface water does occur on a limited basis, primarily for fishing. According to Tim Morgan, Forester for OHARNG: "Catch and release occurs at all the AOC ponds not because the fish tissue tested positive for elevated metals or because we historically did catch and release, but because the IRP is in progress and we don't want to cause any controversy." Additionally, according to Mr. Morgan, "the goal when the IRP is done is to have unrestricted fishing and taking of fish from all the ponds." Likewise conversations with the OHARNG have indicated that training will include the use of surface water for fire and/or dust suppression.

Further, not all AOC ponds will be suitable for current or end-use fishing. The Erie Burning Grounds (EBG) is an interesting case. There really is not much of a fishery in the wetland because it's so shallow. According to Mr. Morgan, "EBG will never be a good fishing pond. It is however a very good waterfowl habitat and waterfowl hunting area." Thus Mr. Morgan will control EBG for waterfowl hunting rather than fishing - simply because of the habitat characteristics - shallow with lots of aquatic vegetation. The Ramsdell Quarry is also not a fishery because of the fluctuating water level. It's a seasonal wetland and wildlife habitat area.

The major surface water drainages at RVAAP all exit facility property and eventually flow into the Mahoning River to the east. Surface water from Sand Creek, which flows to the northeast across the facility, joins the South Fork of Eagle Creek, which flows to the east inside the northern property boundary. The South Fork of Eagle Creek continues to the east until it eventually discharges to the Mahoning River. Hinkley Creek, which enters facility property from the north and flows to the south across the western portion of RVAAP, eventually discharges to the West Branch of the Mahoning River (and the West Branch Reservoir) south of State Route 5. It is doubtful that the Hinkley Creek is used for any agricultural purposes, although the Creek may be used for dust suppression and fire control (See Table below, OHARNG, personal communication between Col Tadsen and Dr. Brancato 07 Mar 2003).

Table 1.   OHARNG Proposed Surface Water Use[1]

AOC	AOC Title	Proposed Use of Surface Water	Exposure Type[2]	Exposure Duration
RVAAP-01	Ramsdell Quarry Landfill	None	N/A	N/A
RVAAP-02	Erie Burning Grounds	Waterfowl Hunting	Water and Sediments - Hip boots, Chest Waders, Hands, Setting decoys, Retrieving Game, Hunting Dog	6:00 a.m. to 12:00 noon, 2 times per year. On ice to check and clean wood duck boxes 1 time per year 1 hour.
		Trapping	Water and Sediments - Hip boots, Chest Waders, Rubber Gloves, Hands	2 hours to scout and set traps. Check traps every day thereafter @ 1/2 hour per check and a max of 6 checks per year.
		Fishing	Water and Sediments - Hip boots, Chest Waders, Hands	Up to 4 hours x 5 days per yr = 20 hours.
		Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-05	Winklepeck Burning Grounds (Mack's Pond)	Trapping	Water and Sediments - Hip boots, Chest Waders, Rubber Gloves, Hands	2 hours to scout and set traps. Check traps every day thereafter @ 1/2 hour per check and a max of 6 checks per year.
		Fishing	Water and Sediments - Hip boots, Chest Waders, Hands	Up to 4 hours x 5 days per yr = 20 hours.
		Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
RVAAP-8	Load Line 1 (Criggy's Pond)	Waterfowl Hunting	Water and Sediments - Hip boots, Chest Waders, Hands, Setting decoys, Retrieving Game, Hunting Dog	6:00 a.m. to 12:00 noon, 2 times per year. On ice to check and clean wood duck boxes 1 time per year 1 hour.
		Trapping	Water and Sediments - Hip boots, Chest Waders, Rubber Gloves, Hands	2 hours to scout and set traps. Check traps every day thereafter @ 1/2 hour per check and a max of 6 checks per year.

AOC	AOC Title	Proposed Use of Surface Water	Exposure Type[2]	Exposure Duration
		Fishing	Water and Sediments - Hip boots, Chest Waders, Hands	Up to 4 hours x 5 days per yr = 20 hours.
		Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-9	Load Line 2 (Kelly's Pond)	Waterfowl Hunting	Water and Sediments - Hip boots, Chest Waders, Hands, Setting decoys, Retrieving Game, Hunting Dog	6:00 a.m. to 12:00 noon, 2 times per year. On ice to check and clean wood duck boxes 1 time per year 1 hour.
		Trapping	Water and Sediments - Hip boots, Chest Waders, Rubber Gloves, Hands	2 hours to scout and set traps. Check traps every day thereafter @ 1/2 hour per check and a max of 6 checks per year.
		Fishing	Water and Sediments - Hip boots, Chest Waders, Hands	Up to 4 hours x 5 days per yr = 20 hours.
		Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-11	Load Line 4 (Pond)	Waterfowl Hunting	Water and Sediments - Hip boots, Chest Waders, Hands, Setting decoys, Retrieving Game, Hunting Dog	6:00 a.m. to 12:00 noon, 2 times per year. On ice to check and clean wood duck boxes 1 time per year 1 hour.
		Trapping	Water and Sediments - Hip boots, Chest Waders, Rubber Gloves, Hands	2 hours to scout and set traps. Check traps every day thereafter @ 1/2 hour per check and a max of 6 checks per year.
		Fishing	Water and Sediments - Hip boots, Chest Waders, Hands	Up to 4 hours x 5 days per yr = 20 hours.
		Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.

AOC	AOC Title	Proposed Use of Surface Water	Exposure Type[2]	Exposure Duration
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-12	Load Line 12 Dilution/Settling Pond	None	N/A	N/A
RVAAP-13	Building 1200 Dilution/Settling Pond	None	N/A	N/A
RVAAP-16	Fuze and Booster Quarry Landfill/Pond	Waterfowl Hunting	Water and Sediments - Hip boots, Chest Waders, Hands, Setting decoys, Retrieving Game, Hunting Dog	6:00 a.m. to 12:00 noon, 2 times per year. On ice to check and clean wood duck boxes 1 time per year 1 hour.
		Trapping	Water and Sediments - Hip boots, Chest Waders, Rubber Gloves, Hands	2 hours to scout and set traps. Check traps every day thereafter @ 1/2 hour per check and a max of 6 checks per year.
		Fishing	Water and Sediments - Hip boots, Chest Waders, Hands	Up to 4 hours x 5 days per yr = 20 hours.
		Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-29	Upper and Lower Cobbs Pond	Waterfowl Hunting	Water and Sediments - Hip boots, Chest Waders, Hands, Setting decoys, Retrieving Game, Hunting Dog	6:00 a.m. to 12:00 noon, 2 times per year. On ice to check and clean wood duck boxes 1 time per year 1 hour.
		Trapping	Water and Sediments - Hip boots, Chest Waders, Rubber Gloves, Hands	2 hours to scout and set traps. Check traps every day thereafter @ 1/2 hour per check and a max of 6 checks per year.
		Fishing	Water and Sediments - Hip boots, Chest Waders, Hands	Up to 8 hours x 10 days per yr = 80 hours.
		Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-31	Ore Pile Retention Pond	Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.

AOC	AOC Title	Proposed Use of Surface Water	Exposure Type[2]	Exposure Duration
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-33	Load Line 6	Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.
RVAAP-38	NACA Test Area	Fire Suppression	Water and Sediments - Hand, Rubber Boots	Sporadically, 0 to 8 hours per year. Mostly 0 hrs.
		Dust Control	Water and Sediments - Hand, Rubber Boots	Sporadically as needed. Mostly 0 hours per year, up to 40 hours.

[1]Written Communication between OHARNG, Tim Morgan (Forester) and USACE, Dr. David J. Brancato, March 2003

[2]Refer to Table 5, to obtain details of exposure factors for receptor contact to this media.

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AIR QUALITY FOR SURROUNDING AREA

The RVAAP facility is located in a rural area and has air quality that generally can be described as good. Based on a southwesterly prevailing wind direction, Windham is the nearest significant downwind urban area. Currently, there are no significant airborne emissions from RVAAP due to its inactive status. In addition, there is no operating air monitoring program in place at the facility at this time. There are no significant documented air pollution sources in close proximity to facility property that would affect air quality at RVAAP.

SITE USE

Directed activities within the facility may be conducted after authorized personnel have been properly briefed on potential hazards. At the present time, RVAAP is an inactive facility maintained by a contracted caretaker, TolTest, Inc. Site workers infrequently visit the AOCs for maintenance purposes, e.g., mowing. The OHARNG also occupies RVAAP and plans to conduct training exercises within RVAAP as indicated by the Table 1 below. The future use of the AOCs within RVAAP has not been formally documented, and at this time, are speculated to become part of the training center for the OHARNG and under OSWER 9355.7-04 remains the reasonable use scenario pertinent to risk characterizations for the site.

Table 2.   OHARNG Proposed Land Use

AOC Title	Proposed land Use	Concerns/Issues
Ramsdell Quarry Landfill	Restricted Access[1]	Closed Landfill/UXO/Wetland
Erie Burning Grounds	Restricted Access	Wetland/UXO
Open Demolition Area #1	Dismounted Training - No Digging[2]	UXO
Open Demolition Area #2	Restricted Access – Authorized Personnel Only	UXO
Winklepeck Burning Grounds	Mark 19 Range[3]	UXO/Active Live Fire Range/Digging IAW Army regs only
C Block Quarry	Restricted Access – Authorized Personnel Only	UXO/Active Munitions Range
Bldg 1601 Haz Waste Storage	Mark 19 Range	Demolish/remove infrastructure
Load Line 1	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 2	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 3	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 4	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 12 Dilution/Settling Pond	Mounted Training – No Digging	Soil Contamination
Bldg 1200 Dilution/Settling Pond	Dismounted Training – Digging (7')[4]	Soil Contamination
Load Line 6 Evaporation Unit	Mounted Training – No Digging[5]	Demolish/remove infrastructure/ not IRP eligible
Load Line 6 Treatment Plant	Mounted Training – No Digging	Demolish/remove infrastructure/ not IRP eligible
Fuze and Booster Quarry Landfill/Pond	Mounted Training – No Digging	Pond/UXO
AOC Title	Proposed land Use	Concerns/Issues
Deactivation Furnace	Mark 19 Range	Pending Findings and Orders
Load Line 12 Pink Wastewater Treatment Plant	Mounted Training – No Digging	Remove Infrastructure
Landfill North of Winklepeck BG	Dismounted Training – No Digging	Closed Solid waste landfill/UXO

AOC Title	Proposed land Use	Concerns/Issues
Sand Creek Sewage Treatment Plant	Dismounted Training – No Digging	Demolish/remove infrastructure/not IRP eligible
Depot Sewage Treatment Plant	Dismounted Training – Digging (7')	Demolish/remove infrastructure/not IRP eligible
George Road Sewage Treatment Plant	Dismounted Training – No Digging	Demolish/remove infrastructure/not IRP eligible
Unit Training Equipment Site UST	Dismounted Training – No Digging	None
Waste Oil Tank	Dismounted Training – No Digging	None
Bldg 1034 Motor Pool AST	Dismounted Training – No Digging	None
Fuze Booster Area Settling Tanks	Mounted Training – No Digging	None
Bldg 854, PCB Storage	Dismounted Training – No Digging	None
Mustard Agent Burial Site	Restricted Access – Authorized Personnel Only	Alleged Buried Mustard Agent
Upper and Lower Cobbs Pond	Dismounted Training – No Digging	Pond/UXO
Load Line 7 Pink Wastewater Treatment Plant	Mounted Training – No Digging	None
Ore Pile Retention Pond	Mounted Training – No Digging	Contamination not addressed/not IRP eligible
40 mm Firing Range	Mounted Training – No Digging	UXO
Load Line 6	Mounted Training – No Digging	Demolish/remove infrastructure
Sand Creek Disposal Road Landfill	Dismounted Training – No Digging	Closed solid waste landfill/UXO
Bldg 1037 Laundry wastewater Sump	Dismounted Training – No Digging	None
Pistol Range	Dismounted Training – No Digging	Active live fire range
Pesticide Bldg S-4452	Dismounted Training – No Digging	None
NACA Test Area	Dismounted Training – No Digging	None
Load Line 5	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 7	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 8	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 9	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 10	Mounted Training – No Digging	Demolish/remove infrastructure
Load Line 11	Mounted Training – No Digging	Demolish/remove infrastructure
Wet Storage Area	Mounted Training – No Digging	Demolish/remove infrastructure
Bldgs F-15 & F-16	Dismounted Training – Digging (7')	Demolish/remove infrastructure
Bldg T-5301	Dismounted Training – No Digging	Active Well On-site
Anchor Test Area	Mounted Training – No Digging	UXO
Central Burn Pits	Dismounted Training – No Digging	None
Atlas Scrap Yard	Mounted Training – No Digging	UXO
Dump Along Paris-Windham Road	Dismounted Training – Digging (7')	None

[1]Restricted Access-Authorized Personnel Only: This area is closed to all normal training and administrative activities. May contain hazardous contamination, unexploded ordnance (UXO), other hazards to human health and safety, protected cultural or historical sites, and/or protected environmentally sensitive areas. Surveying, sampling and other essential security, safety, natural resources management, and other directed activities may be conducted here only after authorized personnel have been properly briefed on potential hazards/sensitive areas. Individuals unfamiliar with the hazards/restrictions will be escorted by authorized personnel at all times while in the restricted area.

[2]Dismounted Training – No Digging: Direct contact is permitted w/soil and/or water 24 hrs/day, 24 days/year on inactive duty training and/or 24 hrs/day, 15 days/yr during annual training w/ no ill effect to the soldier. All digging is prohibited in this area. Digging and occupying fighting positions, tank defilade positions, tank ditches and battle positions that extend below ground surface is prohibited. Exposures are expected to occur down to 4 feet bgs due to track disturbances of soils. Tracked and wheeled operations are permitted only as directed in section 16, AGO Pam 210-1.

[3]Mark 19 Range: This area is the fenced surface danger zone in support of Mark 19 grenade machine gun range, a dud-producing live fire range. This area is closed to all normal training and range administrative/support activities, with the exception of the Mark 19 and M203 grenade launcher firing exercises. Digging operations related to training activities are prohibited. Digging operations associated with authorized range support activities and conducted by authorized personnel are permitted. Individuals unfamiliar with the hazards/restrictions will be escorted by authorized personnel at all times while in the restricted area.

[4]Dismounted Training – Digging (7'): Direct contact is permitted w/ soil and water from the surface to 7' below ground surface 24 hrs/day, 24 days/year on inactive duty training and/or 24 hours/day, 15 days/year during annual training w/ no ill effect to the soldier. Digging and occupying fighting positions to 7' below ground surface is permitted (IAW STP 21-1-SMCT, Oct 94, pp 245-255). Tracked and wheeled operations are permitted only as directed in section 16, AGO Pam 210-1.

[5]Mounted Training – No Digging: Direct contact is permitted w/ soil and/or water up to 24 hrs/day, 24 days/year on inactive duty training and/or 24 hrs/day, 15 days/yr during annual training w/ no ill effect to the soldier. All digging is prohibited in this area. Digging and occupying fighting positions, tank defilade positions, tank ditches and battle positions that extend below ground surface

are prohibited. Tracked and wheeled operations are permitted only as directed in section 16, AGO Pam 210-1. Maneuver damage of up to 4' below ground surface.

It should be noted that if risk assessment and remedy selection is based on specific assumptions regarding land use (e.g., training, no digging), then the area would not be considered "unrestricted use." These cases would require specific land use controls be implemented and maintained until such time as the property is reevaluated. In addition, these areas where use is restricted would require a land use control plan that would outline how the restrictions would be managed.

Areas adjacent to the RVAAP have remained the same for over 50 years. The land use immediately surrounding the facility is primarily rural. Approximately 55 percent of Portage County is either woodland or farmland (Portage County Soil and Water Conservation District Resources Inventory 1985: U.S. Census Bureau 1992). To the south of the facility is the Michael J. Kirwan Reservoir, which is used for recreational purposes. Further, as confirmed with Ohio EPA Division of Drinking and Ground waters personnel the reservoir is not used as a public water supply source. The reservoir is south of the site, across State Route 5. The reservoir is fed by the West Branch of the Mahoning River, which flows south along the western edge of the installation. Hinkley Creek flows south across the western portion of the facility and eventually flows into the West Branch of the Mahoning River. The major surface drainages at RVAAP, i.e., Sand Creek and South Fork Eagle Creek, exit the facility property and eventually flow east to the Mahoning River.

Residential groundwater use occurs outside the facility, which most of the residential wells tapping into either the Sharon Conglomerate or the surficial unconsolidated aquifer. Groundwater from on-site production wells was used during operations at the facility (USACE 1996); however, all but two production wells have been abandoned at the facility. These wells, located in the central portion of the facility, provide sanitary water to the facility. The Sharon Conglomerate is the major producing aquifer at the facility.

Currently surface water is primarily used by only wildlife. However, projected use of surface water includes dust suppression, fire control, fishing (catch/release), trapping, and waterfowl hunting. Contact with surface water will be greatest with the trapper, who is assumed to spend one hour in water setting the traps, half an hour checking the traps for up to three days (total exposure to surface water will be 2.5 hours).

The OHARNG will become the owner of the property with the following federal, state and community missions: The Federal Mission is to maintain combat ready units and soldiers available to mobilize in support of national military strategy. The state mission is to provide organized, trained, and equipped units to protect life and property, and to preserve peace, order, and public safety, as well as to act in the event of a disaster or to promote the health and safety, and welfare of the citizens of Ohio, when so ordered by the Governor of the State of Ohio. The Community mission is to participate in local, state, and national programs designed to add value to America and to enhance the quality of life for all of its citizens.

Potential future uses include:
- Continued storage of bulk explosives short term (<5 years);
- Continued use of certain areas for training purposes by the OHARNG;
- Expanded training and occupancy by the OHARNG to encompass the entire facility (long term) >5 years; and
- Recreational use, e.g., hunting, fishing, and hiking.

2.2 SUMMARY OF EXISTING SITE DATA

During the last 30 years multiple environmental-related investigations were conducted at RVAAP. A brief summary of these investigations is provided below.

Date	Description of Investigation
1978	U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted an Installation Assessment of RVAAP and concluded that no migration of contamination to groundwater had occurred at the installation (USATHAMA 1978).
1982	Reassessment by USATHAMA also concluded that no migration of contamination to groundwater had occurred (USATHAMA 1982).
1988	The U.S. Army Environmental Hygiene Agency (USAEHA) conducted a groundwater contamination survey and an evaluation of Solid Waste Management Units (SWMUs). Twenty-nine potentially contaminated SWMUs were identified. Further investigation was recommended for 15 of the 29 SWMUs to determine if contaminants had migrated from these units.
1989	The U.S. Environmental Protection Agency (EPA) contracted Jacobs Engineering to perform a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) – Preliminary Review and Visual Site Inspection (USEPA 1989). The report identified 31 SWMUs, 13 of which were recommended for no further action (NFA). These 31 SWMUs are listed as sites in the Restoration Management Information System (RMIS).
1992	USAEHA conducted a hydrogeologic study of the Open Burning/Open Detonation (OB/OD) areas as part of a response to a Notice of Deficiency issued by Ohio EPA regarding the installation's RCRA Part B permit application. Minor amounts of contamination were reported at these areas.
1994	USAEHA performed a Preliminary Assessment Screening (PAS) of the Boundary Load Line areas at RVAAP and provided a Statement of Findings to support a Record of Environmental Considerations along with recommendations for additional activities at these sites.

Date	Description of Investigation
1996	The U.S. Army Corps of Engineers (USACE) performed a facility-wide preliminary assessment covering all known environmental sites at RVAAP.
1996	USACE developed a Facility-wide Sampling and Analysis Plan (FSAP) and Facility-wide Safety and Health Plan (FSHP) for conducting investigations at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) AOCs at RVAAP.
1996	USACE conducted Phase I Remedial Investigations of 11 areas of concern. These AOCs were Load Lines 1–4, Load Line 12, Winklepeck Burning Grounds (WBG), Landfill North of Winklepeck Burning Grounds, Building 1200, Demolition Area #2, Upper and Lower Cobbs Ponds, and Load Line 12 Pink Wastewater Treatment Plant.
1996	USACHPPM performed Relative Risk Site Evaluations at several known or suspected former areas of concerns: Erie Burning Grounds, Demo Area 1, C Block Quarry DP, LL 6 Treatment Plant, Quarry Landfill/Pond, LL 12 Pink Waste Water Treatment, Unit Training Equipment Site UST, Waste Oil Tank, Bldg 1034 Motor Pool AST, Fuze/Booster Area Settling Tanks, Mustard Agent Burial Site, LL 7 Pink Waste Water Treatment, 40 & 60 MM Firing Range, Firestone Test Facility, Sand Creek Disposal Landfill, Bldg 1037, Pistol Range, Pesticide Bldg, NACA Test Area.
1997	USACE conducted a field investigation to support RCRA and other clean closures at the following SWMUs: Building 1601, Open Burning Area (Pad #37 at Winklepeck Burning Grounds), Open Detonation Area (in Demolition Area #2), Deactivation Furnace Area (Pad #45 at WBG), and the Pesticides Building S-4452.
1998	USACE conducted a Phase II Remedial Investigation at Winklepeck Burning Grounds, including Baseline Human Health and Ecological Risk Assessments (BHHRA).
1998	USACE performed a groundwater investigation at Ramsdell Quarry Landfill.
1998	USACHPPM performed Relative Risk Site Evaluations at several known or suspected former waste disposal sites. LL-5/Fuze Line 1; LL-7/Booster Line 1; LL-8/Booster Line 2; LL-9/Detonator Line; LL-10/Percussion Element; LL-11/Artillery Primer; Wet Storage Area; Building F-12/Building F-16; Building T-5301; Anchor Test Area; Central Burn Pits; Atlas Scrap Yard; Dump along Paris-Windham Road.
1999	USACE performed Phase I Remedial Investigations at Erie Burning Grounds, NACA Test Area, and Demolition Area #1. They also completed the installation of monitoring wells for the Phase II RI at Load Line 1.

Date	Description of Investigation
2000	U.S. Army OSC performed a Phase I Remedial Investigation at Load Line 11.
2000	U.S. Army OSC performed an Unexploded Ordnance (UXO) Removal and Site Restoration at Demolition Area #2.
2000	USACE performed Phase II Remedial Investigations at Load Line 12 and Load Line 1.
2000	USACE performed a biological assessment at Winklepeck Burning Grounds to support a feasibility study.
2001	U.S. Army OSC performed a Phase I Remedial Investigation at Central Burn Pits and a Phase II RI at Cobbs Pond.

The nature of contaminants remains the same as described under Section 1.1, above. Contaminants associated with Load Lines 1-4 include explosives, metals, VOCs, SVOCs and propellants. Contaminants in Load Lines 5 through 11 included metals and explosives. Load Line 12 contaminants are primarily explosives and metals. Potential contaminants associated with the settling and retention ponds include, but are not limited to, explosive compounds, aluminum chloride, metals, and heavy metals. Contaminants for burning grounds and demolition areas include, but are not limited to, primary/secondary explosives, metals, white phosphorous, and SVOCs. Contaminants associated with sewage treatment, wastewater treatment, vehicle maintenance, storage tanks, waste storage areas, equipment storage areas, furnaces, and evaporation units include, but are not limited to, metals, polychlorinated biphenyls (PCBs), waste oil, and petroleum.

3.0 DATA COLLECTION AND EVALUATION

Site specific sampling and analysis plans specific to the needs of the facility wide human health risk assessment manual can be appended to the Facility-Wide Sampling and Analysis Plan (USACE 2001). Samples will be collected from the following media: soils, sediment, surface water, groundwater, air, and building materials where appropriate depending on specifics of AOCs under investigation. Samples will be analyzed for various potential constituents of concern depending on the investigative area (i.e. AOC) and media.

Objectives for sampling are 1) determine if releases of explosive and other compounds have occurred; 2) determine the complete, to the extent practicable, nature, and extent, of any potential contaminants; and, 3) provide data of sufficient quality to support risk assessment and remedy selection. Consequently, sampling methodology should be selected based on operational histories and similarities in design of comparable AOCs. Exact sampling locations should be finalized in the work plans and confirmed by field

observations (e.g., staining, effluent pipes, drainage, etc.) to ensure the most representative locations are sampled. Each evaluation and sampling event will require a manual to be reviewed and approved by Ohio EPA.

The over arching need is to define correct sampling strategy necessary to characterize contamination. Proper characterization of an AOC will address chemical heterogeneity. Pivotal to characterization of the AOC is assuring the proper method detection limits (MDLs) are established prior to analysis. Likewise, the human health and ecological risk assessors are to coordinate their data needs to establish the appropriate MDLs. For additional information risk assessors may refer to the RVAAP Facility Wide Ecological Risk Work Plan, 21 April 2003.

Media sampling and analysis will be described in a sampling plan that is reviewed and approved by Ohio EPA prior to the event occurring. The sampling plan is designed with knowledge of primary and secondary release of source contamination as well as with an understanding of physical and chemical characteristics of media that are important for evaluating fate and transport. Design of sample collection will be evaluated whether there is a reliable prediction of the chemical quantity in the exposure area of a specific media. Therefore soil samples collected must be able to support quantities of the chemical that impact other media, such as groundwater, surface water, sediment, and air. Likewise groundwater samples need to be collected using an approach that adequately defines the contaminant plume provided one exists. Additionally, surface water and sediment sample design should have sufficient samples to characterize exposure pathways as well as at discharge points to the water body to determine if contaminant contribution from the AOC.

3.1 MULTI-INCREMENTAL SAMPLE COLLECTION STRATEGY

Sampling strategy is the methodology for development of the source term concentration of a contaminant that the risk assessor uses to determine the risk characterization of the contaminant to a specified receptor. The source term concentration may be represented by the average (mean) or the 95% UCL.

Sampling theory is used to derive of the average and the 95%UCL. Multi-incremental sampling is used when there is certainty in representing the true average concentration of a contaminant at the EA or AOC. However, when uncertainty exists in estimating the true average concentration of an EA or AOC, then the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used.

Sampling as part of the Remedial Investigation (RI) Study must account for contaminant heterogeneity. Theories to address heterogeneous nature of contaminants in soil, sediment, and surface water at RVAAP may include use of discrete or multi-incremental sampling to define average concentration of contaminants. These sampling strategies are discussed in, but not limited to:

Soil Sampling Handling and Testing, AGF-206-95. Ohio State University Extension. Department of Horticulture and Crop Science. 2021 Coffey Road, Columbus, Ohio

43210-1044.
- Pitard, Francis F. Pierre Gy's Sampling Theory and Sampling Practice, 2nd ed.; CRC Press, 1993.
- Gilbert, R.O., Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, New York, 1987.

It is anticipated that soil is contaminated with explosives and possibly metals from process activities. The aforementioned sample strategies are applicable to any area within former RVAAP. Please note that the final sampling strategy to address the DQOs will be discussed between the contractor and Ohio EPA.

3.2 DISCRETE SAMPLE COLLECTION STRATEGY

If sampling is performed such that the exposure is represented by the true mean, then it becomes the concentration term in the assessment. If the concentration term has uncertainty associated with estimating the mean because of detects and non-detects within the sampled area, then the concentration term may be represented by the 95%UCL or the maximum detect of the respective constituent, whichever is lower.

It is the responsibility of the data users in cooperation with the Ohio EPA to determine the best approach based on funding to define extent. To determine the UCL_{95} on the mean the following guidance is used: Supplemental Guidance to RAGS: Calculating the Concentration Term (EPA 1992b). The Shapiro-Wilk test is used to determine distribution, normal or lognormal, of the concentrations.

When concentrations are normally distributed use:

$$UCL_{95}(normal) = \bar{x}_n + \frac{(t)(s_x)}{\sqrt{n}}$$

where:

x_n	=	mean of the untransformed data,
t	=	student-t statistic
s_x	=	standard deviation of the untransformed data,
n	=	number of sample results available

For lognormally distributed concentrations, the UCL_{95} on the mean is calculated using the following equation:

$$UCL_{95}(lognormal) = e^{(x + 0.5s^2 + sH/\sqrt{n-1})}$$

Where:

e	=	constant (base of the natural log, equal to 2.718
x	=	mean of the transformed data
s	=	standard deviation of the transformed data
H	=	H-statistic (e.g. from the Table published in Gilbert, 1987)
n	=	number of samples

Calculation of the UCL_{95} of sample populations that are neither normal nor lognormal will require consultation with the Ohio EPA.

3.3 DATA VALIDATION

Analytical data for environmental media will be compiled and evaluated to identify potential contaminants and estimate exposure-point concentrations for each contaminant in each media (EPA, 1989a). For further information please refer to the Facility-Wide Sampling and Analysis Plan for Environmental Investigations at RVAAP (USACE, March 2001)

3.3.1 COMPREHENSIVE DATA PACKAGE

Contains sufficient information to completely reconstruct the analyses that were performed (all Batch QC results, instrument QC results, method detection limit studies and raw data). This data package is required for third party data validation using EPA National Functional Guidelines. For further information please refer to USACE (U.S. Army Corps of Engineers). April 2001b. *Louisville Chemistry Guidance.* Samir A. Mansy, Ph.D., Engineering Division, Environmental Branch

There are four levels of data assessment. For definitive data the following are required:
- Data Verification: Basic assessment of data to evaluate the completeness (everything is present), correctness, consistency and compliance of data package to a standard or contract.
- Data Review: Review to produce a Chemical Quality Assurance Report (Comparing QC lab data to QA lab data). The purpose is to document any possible effects on the data that result from QC failures. It does not determine data usability or assign qualifiers.
- Data Evaluation: Review to produce a Chemical Data Quality Assurance Report. This determines if the data meets the project specific DQOs and contract requirements (i.e., to determine data usability).
- Data Validation: Review to assign data qualifiers (flags) using the Functional Guidelines and procedures detailed in the QAPP. This process will alert the data user of deficiencies in the data generally because of QC failures. [Third Party: A pre-determined per cent of the analytical data is reviewed in every data package for each sample delivery group. If quality control criteria are not met and/or problems are identified with the review of the data package components, qualifiers are assigned to the affected field samples.]

3.4 DATA TABULATION

The following information is tabulated for each chemical:
- Frequency of detection;
- Range of detected values;
- Range of detected limits;
- Sampling Strategy Statistic

- Mean concentration if appropriate sampling technique is used;
- 95% UCL on the mean of the concentration (statistic based on discrete sampling, the lesser between the maximum detected value or the statistically calculated value) (refer to Section 3.1.5.2, above);
- Appropriate risk-based screening concentration (refer to Section 3. 5.2, below);
- Background concentrations, if appropriate (inclusive of mean, and the lesser between the maximum detect and the 95% UCL on the mean);
  - RVAAP Background Concentrations, USACE. Phase II Remedial Investigation Report for The Winklepeck Burning Ground at RVAAP, OH. April 2001;
  - Selection of the COPC (refer to Sections 3.4.1and 3.5.2, below).

3.4.1 DATA STATISTICS

Characterizing contamination in environmental media may be based on the mean or the 95% UCL on the mean and is reported for each medium of interest (EPA, 1992a). The data set for each chemical for which the maximum detected concentration exceeds the EPA Region 9 PRG risk-based screening concentration will be tested for normality, because different equations are used to compute the 95% UCL for normal and log-normal distributions. Data will be tested (W-Test) to determine normality or log-normality, after which the proper calculations will be made to derive the 95% upper confidence limit (UCL) for specific TCLs/TALs.

Evaluating Frequency of Detection: Applicable for sample strategies where discreet sample collection is the choice protocol. Chemicals that are detected infrequently, except explosives and propellants, may be artifacts in the data due to sampling, analytical, or other problems and therefore may not be related to site activities or disposal practices (EPA 1989a). These chemicals should not be included in the risk assessment. If the chemical is not a common lab contaminant (acetone, 2-butanone, methylethyl ketone, methylene chloride, phthalate esters), and the sample concentration is greater than or equal to 5X its respective blank concentration, and it is expected as being site-related then it is retained as a COPC.

Sample aggregations, except for explosives and propellants, with at least 20 samples and a frequency of detection of less than 5%, a weight-of evidence approach is used to determine if the chemical is AOC/EU related. The magnitudes and clustering of the detections and the potential source of the chemical should be evaluated. If detected results are not clustered, and the chemical is not found in other media at the study area, and the concentrations are not substantially elevated relative to the detection limit, and the chemical was not used in the area being investigated, then the chemical should be considered spurious and be eliminated from further consideration.

Thus, chemicals that are detected only at low concentrations in less than 5 percent of the samples from a given medium are dropped from further consideration, unless their presence is expected based on historical information about the site, or is likely to identify the existence of a 'hot spot.'

3.5 DATA EVALUATION

Essential Nutrients

Chemicals that are considered essential nutrients (calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) are an integral part of the human food supply and are often added to foods as supplements. U.S. EPA recommends that these chemicals not be evaluated as COPCs as long as they are (1) present at low concentrations (i.e., only slightly elevated above naturally occurring levels) and (2) toxic at very high doses (i.e., much higher than those that could be associated with contact at the site). Recommended daily allowance (RDA) and recommended daily intake (RDI) values are available for seven of these metals. Based on these RDA/RDI values, a receptor ingesting 100 mg of soil per day would receive less than the RDA/RDI of calcium, magnesium, phosphorous, potassium, and sodium, even if the soil consisted of the pure mineral (i.e., soil concentrations > 1,000,000 mg/kg). Receptors ingesting 100 mg of soil per day would require soil concentrations of 1,500 mg/kg of iodine and 100,000 to 180,000 mg/kg of iron to meet their RDA/RDI for these metals.

3.5.1 CONCENTRATION-TOXICITY SCREENING

A risk-based screening step is performed early in the chemicals-for-risk-assessment-selection-process, as an option identified by EPA (1989), to focus the assessment on the chemicals that may contribute significantly to the overall risk.

Chemicals of Potential Concern Screening Assumptions
- Total chromium is evaluated conservatively by screening against one-tenth of the EPA Region 9 PRGs for hexavalent chromium, unless sample methodology chemically speciates Cr+3 from Cr+6.
- Alpha-chlordane and gamma-chlordane are evaluated by screening against one-tenth of the EPA Region 9 PRG for chlordane.
- Sampling and assessment of chemicals that may not be considered as under CERCLA should be determined by the Army, Ohio EPA and contractor. The analysis of these constituents may fall under other environmental regulations such as FIFRA. Pesticides and herbicides in particular, fall into this category as they would be CERCLA if it was a spill or unintentional release but covered under FIFRA if the chemical was applied under intended use.

3.5.2 SCREENING AGAINST EPA REGION 9 PRGS.

Specifically for soil, sediment, groundwater and surface water it is recommended that Region 9 PRGs be used with an adjustment (1/10th the values based on non-cancer effects). Further, the MCL is also used when evaluating groundwater contamination. Residual contaminant concentrations in the respective media that are below the aforementioned media criteria will be eliminated in the human health risk assessment.

SCREENING

Concentrations of constituents (i.e. the maximum value), in soil ,sediment, surface water and groundwater will be compared to health based screening levels contained in USEPA Region 9 Preliminary Remediation Goals (PRG) Tables. Screening values listed for residential receptors will be used. The most updated values listed on the Internet at http://www.epa.gov/region09/waste/sfund/prg/index.htm will be accessed. In addition, the Region 9 PRGs for compounds with non-cancer disease endpoint are to be reduced by an order of magnitude (adjusted by 1/10th based on non-cancer endpoint). All organic constituents that exceed the screening benchmarks will be retained as COPCs.

Inorganics whose site-specific concentrations exceed the benchmark values will be retained for further comparison to the soil background concentrations in the report USACE, Phase II Remedial Investigation Report for the Winklepeck Burning Ground at RVAAP, OH, April 2001. If exceedances above background occur, then the respective metals are retained as COPCs. All COPCs will be included in the Base-line Risk Assessment (BRA)

Additionally, in some cases the absence of real-time analytical data groundwater concentrations may be estimated using mathematical models because exposure to groundwater could potentially be a complete pathway. Modeling will be conducted by the following method presented in USEPA (1996) and assuming a default Dilution Attenuation Factor (DAF) of 20. However, the default DAF of 20 should be evaluated and adjusted as necessary per section 2.5.6 Default Dilution-Attenuation Factor, USEPA 1996. Modeled concentrations of constituents in groundwater will be compared to health based screening levels contained in USEPA Region 9 PRG Tables for tap water. In addition, the Region 9 PRGs for compounds with non-cancer disease endpoint are to be reduced by an order of magnitude (adjusted by 1/10th based on non-cancer endpoint). The most updated values listed on the Internet at http://www.epa.gov/region09/waste/sfund/prg/index.htm will be accessed. Constituents in groundwater that fail this screening will move forward as COPCs and be included in the BRA.

If a situation arises where groundwater contaminant concentrations exceed the respective Region 9 PRG tap water value but are below a Maximum Contaminant Level (MCL), a risk management decision may be appropriate for "No Further Action".

4.0 EXPOSURE ASSESSMENT

4.1 CONCEPTUAL SITE MODEL

The conceptual site model provides the basis for identifying and evaluating the potential risks to human health in the HHRA. The conceptual site model includes the receptors appropriate to all plausible scenarios, and the potential exposure pathways. Graphically presenting all possible pathways by which a potential receptor may be exposed, including all sources, release and transport pathways, and exposure routes, facilitates consistent and comprehensive evaluation of risk to human health, and helps to ensure that potential pathways are not overlooked. The elements necessary to construct a complete exposure pathway and develop the conceptual site model include:
- Source (i.e., contaminated environmental) media
- Contaminant release mechanisms
- Contaminant transport pathways
- Receptors
- Exposure pathways

Table 3.   **Preliminary Conceptual Site Model:**

	VARIABLES	**HYPOTHESIS**
Sources	Contaminants, Concentrations Time, Locations	Source exists, Source can be contained, Source can be removed and disposed, Source can be treated
Pathways	Media, Rates of Migration, Time Loss and Gain Functions	Pathway Exists Pathway Can Be Interrupted, Pathway Can Be Eliminated
Receptors	Types, Sensitivities, Time Concentrations, Numbers	Receptor Is Not Impacted By Migration of Contaminants, Receptor Can Be Relocated, Institutional Controls Can Be Applied, Receptor Can Be Protected

Source: US EPA 1987a

POTENTIAL CONTAMINANT RELEASE MECHANISMS AND TRANSPORT PATHWAYS INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING:

- Release of soil dust with organic substances and metals into the air.
- Leaching of contaminants from soil to groundwater.
- Release of contaminated soil particulates to storm water runoff (sediment) & surface water.
- Discharge of groundwater to surface (possible).

END-USE POTENTIAL RECEPTORS

Table 4. Exposure Pathways for Receptors at AOC/EU, RVAAP

Revised Receptors and Exposure Pathways for RVAAP AOCs

Exposure Pathways		Exposure Media			Soil	
		Groundwater	Surface Water	Sediment	Shallow[a]	Deep[b]
National Guard - Trainee						
Ingestion						
	Incidental	--	X	X	X	X
	Drinking water	X	--	--	--	--
Dermal		X	X	X	X	X
Inhalation						
	Vapor	X[c]	X[c]	X[c]	X[c]	X[c]
	Dust	--	--	X	X	X
Ingestion of food		--	--	--	--	--
Resident						
Ingestion						
	Incidental	--	X	X	X	X
	Drinking water	X	X	--	--	--
Dermal		X	X	X	X	X
Inhalation						
	Vapor	X	X[c]	X[c]	X[c]	X[c]
	Dust	--	--	X	X	X
Ingestion of food		X	--	--	X	--
National Guard - Fire/Dust Suppression Worker						
Ingestion						
	Incidental	--	X	X	X	--
	Drinking water	--	--	--	--	--
Dermal		--	X	X	X	--
Inhalation						
	Vapor	--	X[c]	X[c]	X[c]	--
	Dust	--	--	X	X	--
Ingestion of food		--	--	--	--	--
Recreators - Hunter/Trapper/Fisher						
Ingestion						
	Incidental	--	X	X	X	--
	Drinking water	--	--	--	--	--

Exposure Pathways		Groundwater	Surface Water	Sediment	Shallow[a]	Deep[b]
				Soil		
Dermal		--	X	X	X	--
Inhalation						
	Vapor	--	X[c]	X[c]	X[c]	--
	Dust	--	--	X	X	--
Ingestion of waterfowl and fish		--	X[d]	X[d]	--	--
Trespasser (Adult/Juvenile)						
Ingestion						
	Incidental	--	X	X	X	--
	Drinking water	--	--	--	--	--
Dermal		--	X	X	X	--
Inhalation						
	Vapor	--	X[c]	X[c]	X[c]	X[c]
	Dust	--	--	X	X	X
Ingestion of food		--	--	--	--	--
Security and Maintenance Personnel						
Ingestion						
	Incidental	--	X	X	X	--
	Drinking water	--	--	--	--	--
Dermal		--	X	X	X	--
Inhalation						
	Vapor	--	X[c]	X[c]	X[c]	--
	Dust	--	--	X	X	--
Ingestion of food		--	--	--	--	--

[a]Shallow soil will be 0-1 for all receptors except the National Guard Trainee. Surface to the Guard Trainee will be 0 to 4 feet bgs due to nature of ground training activities that result in tank depression down to 4 feet bgs. Please note that sometimes site data will be available from the 0-2 ft depth. Ohio EPA should be consulted on the suitability of using site data from this interval to represent surface soil exposure.

[b]Deep Soil for the Guard Trainee will be 4-7 feet bgs because dismounted digging will be no greater than 7 feet for the trainee, whereas the resident may be 1-13 feet bgs unless rock is encountered at a depth less than 13 ft.

[c] No VOCs in media (to date), but will be evaluated as appropriate.

[d]Hunter/trapper will ingest water fowl that feed on surface water, aquatic plants, sediment,

and sediment dwelling invertebrates, and fish exposed to surface water.

Table 5. Exposure Factors for Receptors at RVAAP (per "Current" & "END-USE")

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Surface Soil							
Incidental ingestion							
Soil ingestion rate (Adult)	kg/day	0.0001[a]	0.0001[a]	0.0001[a]	0.0001/[a]	0.0001[a]	0.0001[a]
Soil ingestion rate (Child)	kg/day	NA	NA	NA	NA	0.0002[a]	0.0002[a]
Exposure time	hours/day	1[b]	4[b]	24[b]	6/4[b]	2[b]/2[b]	24[a]
Exposure frequency (adult/juvenile)	days/year	250[a]	15[b]	39[b]	2/5[b]	75[a]/50[a]	350[a]
Exposure duration (Adult)	years	25[a]	25[b]	25[b]	30[a]	30[a]	30[a]
Exposure duration (Child)	years	NA	NA	NA	NA	10[a]	6[a]
Body weight (Adult)	kg	70[a]	70[a]	70[a]	70[a]	70[a]	70[a]
Body weight (Child)	kg	NA	NA	NA	NA	45[a]	15[a]
Carcinogen averaging time	days	25550[a]	25550[a]	25550[a]	25550[a]	25550[a]	25550[a]
Noncarcinogen averaging time (Adult)	days	9125[a]	9125[a]	9125[a]	10950[a]	10950[a]	10950[a]
Noncarcinogen averaging time (Child)	days	NA	NA	NA	NA	3650[a]	2190[a]
Fraction ingested	unitless	1[b]	1[b]	1[b]	1[b]	1[b]	1[a]
Conversion factor	days/hour	0.042	0.042	0.042	0.042	0.042	0.042
Dermal contact							
Skin area	m^2/event	0.33[d]	0.33[d]	0.33[d]	0.57[d]	0.57[d]/0.815[d]	0.57[d] /0.22 [t]
Adherence factor	mg/cm^2	0.7[c]	0.3[c]	0.3[c]	0.3[c]	0.4[c] /0.2[t]	0.4[c] /0.2[t] /
Absorption fraction	Unitless	NA	Chem. Spec[p]	Chem. Spec[p]	Chem. Spec[p]	Chem. Spec[p]	Chem. Spec[p]
Exposure frequency (adult/juvenile)	events/year	250[a]	15[b]	39[b]	2/5[b]	75[a]/50[a]	350[a]
Exposure duration	years	25[a]	25[b]	25[b]	30[a]	30[a]/10[a]	30[a] /6[a]
Body weight	kg	70[a]	70[a]	70[a]	70[a]	70[a]/45[a]	70[a] /15[a]

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Carcinogen averaging time	days	25550^a	25550^a	25550^a	25550^a	25550^a	25550^a
Noncarcinogen averaging time	days	9125^a	9125^a	9125^a	10950^a	$10950^a/3650^a$	10950^a 2190^a
Conversion factor	$(kg\text{-}cm^2)/(mg\text{-}m^2)$	0.01	0.01	0.01	0.01	0.01	0.01
Inhalation of VOCs and dust							
Inhalation rate	m^3/day	20^a	44.4^t	44.4^t	20^a	20^a	20^a /10^q
Exposure time	hours/day	1^b	4^b	24^b	$6/4^b$	2^b	$24/24^a$
Exposure frequency	days/year	250^a	15^b	39^b	$2/5^b$	$75^a/50^a$	350^a
Exposure duration	years	25^a	25^b	25^b	30^a	$30^a/10^a$	30^a /6^a
Body weight	kg	70^a	70^a	70^a	70^a	$70^a/45^a$	70^a /15^a
Carcinogen averaging time	days	25550^a	25550^a	25550^a	25550^a	25550^a	25550^a
Noncarcinogen averaging time	days	9125^a	9125^a	9125^a	10950^a	$10950^a/3650^a$	10950^a /2190^a
Conversion factor	days/hour	0.042	0.042	0.042	0.042	0.042	0.042
Subsurface Soil							
Incidental ingestion							
Soil ingestion rate (Adult)	kg/day	NA	NA	0.0001^a	NA	NA	0.0001^a
Soil ingestion rate (Child)	kg/day	NA	NA	NA	NA	NA	0.0002^a
Exposure time	hours/day	NA	NA	24^b	NA	NA	24
Exposure frequency	days/year	NA	NA	39^b	NA	NA	350^a
Exposure duration (Adult)	years	NA	NA	25^b	NA	NA	30^a
Exposure duration (Child)	years	NA	NA	NA	NA	NA	6^a
Body weight (Adult)	kg	NA	NA	70^a	NA	NA	70^a
Body weight (Child)	kg	NA	NA	NA	NA	NA	15^a
Carcinogen averaging time	days	NA	NA	25550^a	NA	NA	25550^a
Noncarcinogen averaging time (Adult)	days	NA	NA	9125^a	NA	NA	10950^a
Noncarcinogen averaging time (Child)	days	NA	NA	NA	NA	NA	2190^a

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Fraction ingested	unitless	NA	NA	1^b	NA	NA	1^a
Conversion factor	days/hour	NA	NA	0.042	NA	NA	0.042
Dermal contact							
Skin area	m^2/event	NA	NA	0.33^d	NA	NA	0.57^d /0.22^t
Adherence factor	mg/cm^2	NA	NA	0.3^c	NA	NA	0.4^c /0.2^t
Absorption fraction	unitless	NA	NA	chem. Spec^p		NA	chem. Spec^p
Exposure frequency	events/year	NA	NA	39^b	NA	NA	350^a
Exposure duration	years	NA	NA	25^b	NA	NA	30^a /6^a
Body weight	kg	NA	NA	70^a	NA	NA	70^a /15^a
Carcinogen averaging time	days	NA	NA	25550^a	NA	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	9125^a	NA	NA	10950^a /2190^a
Conversion factor	(kg-cm^2)/(mg-m^2)	NA	NA	0.01	NA	NA	0.01
Inhalation of VOCs and dust							
Inhalation rate	m^3/day	NA	NA	44.4^t	NA	NA	20^a /10^q
Exposure time	hours/day	NA	NA	24^b	NA	NA	24^a
Exposure frequency	days/year	NA	NA	39^b	NA	NA	350^a
Exposure duration	years	NA	NA	25^b	NA	NA	30^a/6^a
Body weight	kg	NA	NA	70^a	NA	NA	70^a /15^a
Carcinogen averaging time	days	NA	NA	25550^a	NA	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	9125^a	NA	NA	10950^a /2190^a
Conversion factor	days/hour	NA	NA	0.042	NA	NA	0.042
Sediment							
Incidental ingestion							
Soil ingestion rate (Adult)	kg/day	NA	0.0001^a	0.0001^a	0.0001^a	0.0001^a	0.0001^a
Soil ingestion rate (Child or juvenile)	kg/day	NA	NA	NA	NA	0.0002^a	0.0002^a
Exposure time	hours/day	NA	4^b	24^b	$6/4^b$	2^b	24^a
Exposure frequency (adult/juvenile)	days/year	NA	15^b	39^b	$2/5^b$	$75^a/50^a$	350^a

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Exposure duration (Adult)	years	NA	25^b	25^b	30^a	30^a	30^a
Exposure duration (Child)	years	NA	NA	NA	NA	10^a	6^a
Body weight (Adult)	kg	NA	70^a	70^a	70^a	70^a	70^a
Body weight (Child)	kg	NA	NA	NA	NA	45^a	15^a
Carcinogen averaging time	days	NA	25550^a	25550^a	25550^a	25550^a	25550^a
Noncarcinogen averaging time (Adult)	days	NA	9125^a	9125^a	10950^a	10950^a	10950^a
Noncarcinogen averaging time (Child)	days	NA	NA	NA	NA	3650^a	2190^a
Fraction ingested	unitless	NA	1^b	1^b	1^b	1^b	1^a
Conversion factor	days/hour	NA	0.042	0.042	0.042	0.042	0.042
Dermal contact							
Skin area	m^2/event	NA	0.33^d	0.33^d	0.52^d	0.57^d/ 0.815^d	0.57^d /0.22^t
Adherence factor (adult/juvenile)	mg/cm^2	NA	0.3^c	0.3^c	0.3^c	*$0.4^c/0.2^t$*	*$0.4^c/0.2^t$*
Absorption fraction	unitless	NA	NA	chem. Spec^p	chem. Spec^p	chem. Spec^p	chem. Spec^p
Exposure frequency	events/year	NA	15^b	39^b	$2/5^b$	$75^a/50^a$	350^a
Exposure duration	years	NA	25^b	25^b	30^a	$30^a/10^a$	30^a /6^a
Body weight	kg	NA	70^a	70^a	70^a	$70/45^a$	70^a /15^a
Carcinogen averaging time	days	NA	25550^a	25550^a	25550^a	25550^a	25550^a
Noncarcinogen averaging time	days	NA	9125^a	9125^a	10950^a	$10950^a/3650^a$	10950^a /2190^a
Conversion factor	(kg-cm^2)/(mg-m^2)	NA	0.01	0.01	0.01	0.01	0.01
Inhalation of VOCs and dust							
Inhalation rate	m^3/day	NA	44.4^t	44.4^t	20^a	20^a	$20^a/10^a$
Exposure time	hours/day	NA	4^b	24^b	$6/4^b$	2^b	24^a
Exposure frequency	days/year	NA	15^b	39^b	$2/5^b$	$75^a/50^a$	350^a
Exposure duration	years	NA	25^b	25^b	30^a	30^a /10^a	30^a /6^a
Body weight	kg	NA	70^a	70^a	70^a	$70^a/45^a$	70^a /15^a
Carcinogen averaging time	days	NA	25550^a	25550^a	25550^a	25550^a	25550^a
Noncarcinogen averaging time	days	NA	9125^a	9125^a	10950^a	10950^a /3650^a	10950^a /2190^a

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Conversion factor	days/hour	NA	0.042	0.042	0.042	0.042	0.042
Surface Water Incidental ingestion while swimming/wading/showering							
Drinking water ingestion rate	L/hr	NA	NA	NA	NA	NA	0.05
Incidental water ingestion rate	L/day	NA	0.1[b]	0.1[b]	0.1[b]	0.05[b] 0.05[b] L/hr for 2hr/day = 0.1 L/day	0.1[b]
Exposure frequency	days/year	NA	15[b]	39[b]	2/5[b]	75[a]/50[a]	350[a]
Exposure duration	years	NA	25[b]	25[b]	30[a]	30[a] /10[a]	30[a] /6[a]
Body weight	kg	NA	70[b]	70[a]	70[a]	70[a]/45[a]	70[a] /15[a]
Carcinogen averaging time	days	NA	25550[a]	25550[a]	25550[a]	25550[a]	25550[a]
Noncarcinogen averaging time	days	NA	9125[a]	9125[a]	10950[a]	10950[a] /3650	10950[a] /2190[a]
Dermal contact while swimming/wading/showering							
Skin area	m²	NA	0.33[d]	0.33[d]	0.52[d]	0.57[d] / 0.815[d]	0.57[d] /0.22[t]
Exposure time	hours/day	NA	4[b]	24[b]	6/4[b]	2[b]	0.25[c]
Exposure frequency	days/year	NA	15[b]	39[b]	2/5[b]	75[a]/50[a]	350[a]
Exposure duration	years	NA	25[b]	25[b]	30[a]	30[a] /10[a]	30[a] /6[a]
Body weight	kg	NA	70[a]	70[a]	70[a]	70[a]/45[a]	70[a] /15[a]
Carcinogen averaging time	days	NA	25550[a]	25550[a]	25550[a]	25550[a]	25550[a]
Noncarcinogen averaging time	days	NA	9125[a]	9125[a]	10950[a]	10950[a] /3650[a]	10950[a] /2190[a]
Conversion factor	(m/cm)(L/m³)	NA	10	10	10	10	10
Inhalation of VOCs							
Inhalation rate	m³/day	NA	44.4[t]	44.4[t]	20[a]	20[a]	20[a]
Exposure time	hours/day	NA	4[b]	24[b]	6/4[b]	2[b]	NA
Exposure frequency	days/year	NA	15[b]	39[b]	2/5[b]	75[a]/50[a]	350[a]
Exposure duration	years	NA	25[b]	25[b]	30[a]	30[a] /10[a]	30[a] /6[a]
Body weight	kg	NA	70[a]	70[a]	70[a]	70[a]/45[a]	70[a] /15[a]
Carcinogen averaging time	days	NA	25550[a]	25550[a]	25550[a]	25550[a]	25550[a]
Noncarcinogen averaging time	days	NA	9125[a]	9125[a]	10950[a]	10950[a]/3650[a]	10950[a] /2190[a]

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Conversion factor	days/hour	NA	0.042	0.042	0.042	0.042	NA
Volatilization factor (No volatiles found to date)	Multiply by 1000 L/m^3	NA	Site spec	Site spec	Site spec	Site spec	0.0005^a
Groundwater Drinking Water Ingestion							
Drinking water ingestion rate	L/day	NA	NA	2^a	NA	NA	2^a /1.5^t
Exposure frequency	days/year	NA	NA	39^b	NA	NA	350^a
Exposure duration	years	NA	NA	25^b	NA	NA	30^a /6^a
Body weight	kg	NA	NA	70^a	NA	NA	70^a /15^a
Carcinogen averaging time	days	NA	NA	25550^a	NA	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	9125^a	NA	NA	10950^a /2190^a
Dermal contact while showering							
Skin area	m^2	NA	NA	1.94^g	NA	NA	1.94^g /0.866^s
Exposure time	hours/day	NA	NA	0.25^a	NA	NA	0.25^a
Exposure frequency	days/year	NA	NA	39^b	NA	NA	350^a
Exposure duration	years	NA	NA	25^b	NA	NA	30^a /6^a
Body weight	kg	NA	NA	70^a	NA	NA	70^a /15^a
Carcinogen averaging time	days	NA	NA	25550^a	NA	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	9125^a	NA	NA	10950^a /2190^a
Conversion factor	(m/cm)(L/m^3)	NA	NA	10	NA	NA	10
Inhalation of VOCs during household water use							
Inhalation rate	m^3/day	NA	NA	20^a	NA	NA	20^a /10^q
Exposure frequency	days/year	NA	NA	39^b	NA	NA	350^a
Exposure duration	years	NA	NA	25^b	NA	NA	30^a /6^a
Body weight	kg	NA	NA	70^a	NA	NA	70^a /15^a
Carcinogen averaging time	days	NA	NA	25550^a	NA	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	9125^a	NA	NA	10950^a /2190^a
Volatilization factor	L/m^3	NA	NA	0.5^a	NA	NA	0.5^a
Foodstuffs							
Ingestion of venison							

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Conversion factor	unitless	NA	NA	NA	NA	NA	1.25
Browse ingestion rate	kg dry weight/day	NA	NA	NA	NA	NA	0.87^b
Fraction browse ingested from site *site-specific: home-range of deer/size of area or*	unitless	NA	NA	NA	NA	NA	Site spec^u
Fat ratio (venison to beef)	unitless	NA	NA	NA	NA	NA	0.20
Venison ingestion rate	kg/day	NA	NA	NA	NA	NA	0.03^b
Fraction ingested	unitless	NA	NA	NA	NA	NA	1^b
Exposure frequency	days/year	NA	NA	NA	NA	NA	365^b
Exposure duration	years	NA	NA	NA	NA	NA	30ª /6^a
Body weight	kg	NA	NA	NA	NA	NA	70ª /15^a
Carcinogen averaging time	days	NA	NA	NA	NA	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	NA	NA	NA	10950^a /2190^a
Ingestion of beef							
Resuspension multiplier	unitless	NA	NA	NA	NA	NA	0.25^i
Quantity of pasture ingested	kg dry weight/day	NA	NA	NA	NA	NA	7.2^j
Fraction of year cow is on-site *site-specific: area of graze/size of area or*	unitless	NA	NA	NA	NA	NA	Site spec
Fraction of cow's food from on-site	unitless	NA	NA	NA	NA	NA	0.9^b
Quantity of soil ingested by cow	kg/day	NA	NA	NA	NA	NA	1^k
Beef ingestion rate	kg/day	NA	NA	NA	NA	NA	0.044^l
Fraction ingested	unitless	NA	NA	NA	NA	NA	1^b
Exposure frequency	days/year	NA	NA	NA	NA	NA	365^b
Exposure duration	years	NA	NA	NA	NA	NA	30ª /6^a
Body weight	kg	NA	NA	NA	NA	NA	70ª /15^a
Carcinogen averaging time	days	NA	NA	NA	NA	NA	25550^a

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Noncarcinogen averaging time	days	NA	NA	NA	NA	NA	10950^a /2190^a
Ingestion of milk products							
Resuspension multiplier	unitless	NA	NA	NA	NA	NA	0.25^i
Quantity of pasture ingested	kg dry weight/day	NA	NA	NA	NA	NA	16.1^j
Fraction of year cow is on-site	unitless	NA	NA	NA	NA	NA	1^b
Fraction of cow's food from on-site	unitless	NA	NA	NA	NA	NA	0.6^b
Quantity of soil ingested by cow	kg/day	NA	NA	NA	NA	NA	1^k
Milk ingestion rate (Adult)	kg/day	NA	NA	NA	NA	NA	0.305^l
Milk ingestion rate (Child)	kg/day	NA	NA	NA	NA	NA	0.509^m
Fraction ingested	unitless	NA	NA	NA	NA	NA	1^b
Exposure frequency	days/year	NA	NA	NA	NA	NA	365^b
Exposure duration (Adult)	years	NA	NA	NA	NA	NA	30^a
Exposure duration (Child)	years	NA	NA	NA	NA	NA	6^a
Body weight (Adult)	kg	NA	NA	NA	NA	NA	70^a
Body weight (Child)	kg	NA	NA	NA	NA	NA	15^a
Carcinogen averaging time	days	NA	NA	NA	NA	NA	25550^a
Noncarcinogen averaging time (Adult)	days	NA	NA	NA	NA	NA	10950^a
Noncarcinogen averaging time (Child)	days	NA	NA	NA	NA	NA	2190^a
Ingestion of vegetables							
Resuspension multiplier	unitless	NA	NA	NA	NA	NA	0.26^n
Vegetable ingestion rate	kg/day	NA	NA	NA	NA	NA	0.2^l
Fraction ingested	unitless	NA	NA	NA	NA	NA	0.4^l
Exposure frequency	days/year	NA	NA	NA	NA	NA	365^a
Exposure duration	years	NA	NA	NA	NA	NA	30^a /6^a
Body weight	kg	NA	NA	NA	NA	NA	15^a /70^a
Carcinogen averaging time	days	NA	NA	NA	NA	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	NA	NA	NA	10950^a /2190^a
Ingestion of fish/waterfowl							

Parameter	Units	Security Guard/ Maintenance Worker	National Guard Dust/Fire Control	National Guard Trainee	Hunter/ Fisher Recreator	Trespasser Adult/ Juvenile	Resident Farmer (adult/child)
Fish ingestion rate	kg/day	NA	NA	NA	0.0132^b/ 0.0154^o	NA	0.054^o
Fraction ingested	unitless	NA	NA	NA	1^b	NA	1^a
Exposure frequency	days/year	NA	NA	NA	365^b	NA	365^b
Exposure duration	years	NA	NA	NA	30^b	NA	30^a /6^a
Body weight	kg	NA	NA	NA	70^a	NA	70^a /15^a
Carcinogen averaging time	days	NA	NA	NA	25550^a	NA	25550^a
Noncarcinogen averaging time	days	NA	NA	NA	10950^a	NA	10950^a

Note: Resident farmer is chosen instead of resident because the property would be used for farming if in the unlikely event it was released from military use. Further, the resident farmer is expected to result in greater, more conservative exposure intake when compared to the resident. In addition to the exposure factors contained below for this receptor, please refer to the following citation in order to fully evaluate this potential pathway: U.S. EPA 1991. OSWER Directive 9285.6-03

Surface soil will be 0-1 for all receptors except the National Guard Trainee. Surface to the Guard Trainee will be 0 to 4 feet bgs due to nature of ground training activities that result in tank depression down to 4 feet bgs. Please note that sometimes site data will be available from the 0-2 ft depth. Ohio EPA should be consulted on the suitability of using site data from this interval to represent surface soil exposure. Two receptors are likely to be exposed to subsurface soil the Guard trainee at 4-7 feet bgs because dismounted digging will be no greater than 7 feet bgs and the resident at 1 to 13 feet bgs.

NA = not applicable for this scenario.
[a] RAGS, Part B (EPA 1991a). Trespasser, Juvenile events assumed to be 1d/wk for 50 wks/yr (50d), while adult events include 1d/wk for 45 wks/yr plus 5d/wk for 5 wks/yr during hunting season (45d + 25d = 70d)
[b] Site-specific (value assumed for site or value obtained from site personnel). National Guard Trainee is 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 (i.e., 40 hours/year) for dust suppression. Both National Guard Receptors are assumed to remain at RVAAP and at the AOC of interest for their entire 25 year enlistment. The Hunter is assumed to be on-site 6 hours/day for 2 days/year. The trapper will be exposed less (i.e., 0.5 hours/day for 6 days/year); therefore, the hunter exposure is used as the more conservative scenario. The fisher is assumed to be on-site 4 hours/day for 5 days/year. The hunter/fisher is assumed to hunt/fish as long as he/she resides in the area, so the residential default exposure duration is used. The Security Guard/Maintenance Worker is assumed to visit each AOC for 1 hour/day for a standard worker default of 250 days/yr and 25 years. National Guard Trainee and Resident Farmer are assumed to ingest 0.05 L/hour [per RAGS Part A (EPA 1998)] for approximately 2 hours/day spent in the surface water. National Guard Fire/Dust Suppression receptors are assumed to ingest 0.1 L/day due to direct exposure while setting pumps/hoses in surface water or from ingesting mist while spraying. Hunter/fisher are assumed to ingest 0.05 L/day due to splashing while setting traps or wading. Hunter/trapper is assumed to catch and eat the bag limit for ducks and geese each year.
[c] Security Guard/Maintenance Worker = Adult Groundskeeper (95th percentile); Hunter/Trapper = Residential Default; National Guard Trainee = Construction Worker (95th percentile); Resident Farmer Adult= Adult Farmer (95th percentile) (RAGS, Vol. 1 Part E, Supplemental Guidance for Dermal Risk Assessment, Interim) EPA/540/R/99/005.

[d] Security Guard/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) (Note dermal contact for Hunter/Fisher during wading is 0.52 based on head, hands, forearms and lower legs from Exposure Factors Handbook.)

[e] Average surface area for head, hands, forearms, torso, and lower legs for a child (EPA 1992b).

[f] RAGS, Part A (EPA 1989a).

[g] Average total body surface area for an adult (EPA 1992b).

[h] Average total body surface area for a child (EPA 1992b).

[i] Plant mass loading factor for pasture (Hinton 1992).

[j] International Atomic Energy agency 1994.

[k] Soil ingestion by dairy cattle (Darwin 1990).

[l] *Exposure Factors Handbook* (EPA 1997). 50th percentile meat ingestion 2.1g/kg-day = 147 g/day for a 70 kg adult 95th percentile meat ingestion 5.1g/kg-day = 357 g/day for a 70 kg adult…50th percentile beef ingestion 2.327g/kg-day = 163 g/day for a 70 kg adult 95th percentile beef ingestion 0.626 g/kg-day = 44 g/day for a 70 kg adult

[m] Pao et al. (1982).

[n] Plant mass loading factor for vegetables (Pinder 1989).

[o] Standard default Exposure Factors for fish ingestion (EPA 1991b).

[p] Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment, Interim), EPA/540/R/99/005.

[q] Recommended value for child age 6-8 (EPA 1997a).

[r] 90th percentile value for child age 3-5 (EPA 1997a).

[s] 50th percentile value for male child age 6-7 (EPA 1997a).

[t] Per OEPA comment 2002.

[u] Ecological Risk Assessment. Ohio EPA/DERR. February 2003

Table 6. Chemical-Specific and Default Dermal Absorption Factor for Use in AOC/EU Human Health Risk Assessment, RVAAP Ohio[a]

Chemical	Dermal Absorption Factor (ABS)
Arsenic	0.03
Cadmium	0.001
Chlordane	0.04
2,4-Dichorophenoxyacetic acid	0.05
DDT	0.03
TCDD and other dioxins	0.03
if soil organic content is > 10%	0.001
Lindane	0.04
Benzo(a)pyrene and other PAHs	0.13
Aroclors 1254/1242 and other PCBs	0.14
Pentachlorophenol	0.25
Generic defaults for other chemicals	
Semivolatile Organic Compounds (SVOCs)	0.1
Volatile Organic Compounds (VOCs)[b]	0.01
Inorganics[b]	0.001

[a] Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim
http://www.epa.gov/superfund/programs/risk/ragse/

[b] From USEPA Region 4 Supplemental Guidance to RAGS: Region 4 Bulletins.

AREA USE FACTORS

The purpose of this section is to introduce the concept of Area Use Factors (AUFs) and to highlight the situations where these AUFs may be appropriate.

At some AOCs, there may be special exposure situations that were not considered in Tables 4 and 5 of this manual, such as an area that is visited for a short period of time by a utility worker repairing water lines or power lines or a groundskeeper that mows the land. Area use factors are variables that can be used to determine a receptor's intake for human health risk assessment, when exposure is short-lived or limited by characteristics specific to that particular AOC.

Listed below are data requirements necessary to support the calculation of AUFs. Equations for determining AUFs are also presented. **The application of the use of AUFs must first be discussed with the Ohio EPA before there use can be applied to the intake equations to follow in Section 4.2.**

Required Data to Support Calculation of Area Use Factors:
- Length of Site (Lt)
- Width of Site (Wt) – you may assume ¼ acre residential lot with dimensions of 130 ft by 80 ft
- Depth to Bedrock (Dr)
- Plume Length (Lp)(e.g., metal concentrations above background)
- Plume Width (Wp)
- Plume Depth (Dp)(e.g., metal concentrations above background)

- Total Surface Area (SAt)
- Surface Area Plume (CAD Dimensions) (SAp)
- Total Grass Covered Areas (GAt)(CAD Dimensions)
- Grass Covered Plume Areas (GAp)(CAD Dimensions)
- Total Areas Covered By Structures (CAst)(CAD Dimensions)
- Plume Areas Covered By Structures (CPst)
- Total Volume of Site (Vt)
- Volume of Plume(Vp)

Calculations in Percent:
Percent of Site Covered By Grass PSg= GAt/SAt
Percent of Plume Covered By Grass (PPg)= GAp/SAp
Percent of Site Contaminated (Vol) Pcv=Vp/Vt
Percent of Site Contaminated (surface area) PCa=SAp/SAt
% site covered by Structures PSst=CAst/SAt
% Plume Covered by Structures PPst=CPst/SAp
% Cont. in Grass Areas = Pcg=GAp/GAt
- Area Use Factors Enter Into Intake Equations for HHRA

4.2 ESTIMATION OF INTAKE

The quantification of exposure to receptors from contact with chemicals in different media involves estimating the amount of contaminant that is taken into the body via various routes of exposures. This section describes the models used to quantify intakes of contaminants by exposure pathways identified for the site. The intake of contaminants from environmental media (soils, groundwater, and surface water) and secondary sources (deer and fish) are discussed below.

INHALATION OF CONTAMINANTS IN AIR

The following equation is used to estimate intake of COPCs in air:

$$I_a = (C_a)(IR_a)(FI_a)(ET_a)(EF)(ED)/(BW)(AT)$$

where:

I_a = inhaled intake of COPC (mg/kg-day)
C_a = concentration of COPC in air (mg/m^3)
IR_a = inhalation rate (m^3/hour)
FI_a = fraction of exposure attributed to site media (unitless)
ET_a = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

INCIDENTAL INHALATION OF CHEMICALS IN SOIL OR DRY SEDIMENT

Inhalation of soils or dry sediments was calculated using Eq. 3:

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

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 noncarcinogens.

The general PEF value for receptors except the National Guard is the default value for Cleveland Ohio assuming a 0.5-acre source area (9.24E+08 m^3/kg). This PEF value was calculated using the EPA Soil Screening Guidance on-line at http://risk.lsd.ornl.gov/epa/ssl1.htm. 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 x 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 µg/m^3 (DOE 1993) as:

PEF = 1/(DLF x Conversion Factor) = 1/(600 µg/m^3 x 1E-09 kg/µg) = 1.67E+06 m^3/kg

4.2.1 INCIDENTAL INGESTION OF CHEMICALS IN SOIL OR DRY SEDIMENT
The following equation is used to estimate Incidental ingestion of soils and sediments:

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

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 noncarcinogens.

4.2.2 INGESTION OF CHEMICALS IN FOODSTUFFS
The intake of the chemical ingested in food in the resident farmer and hunter/fisher scenarios is estimated from the equation:

$$Chemical\ Intake\ (mg/kg \text{-} d) = \frac{C_f \times IR_f \times EF \times ED}{BW \times AT},$$

where

C_f	=	chemical concentration in food (mg/kg),
IR_f	=	ingestion rate of food (kg/day),
EF	=	exposure frequency (day/year),
ED	=	exposure duration (years),
BW	=	body weight (kg),
AT	=	averaging time (days) for carcinogens and noncarcinogens.

<u>Equations for calculating the concentration of chemical in the food source are provided below and should be discussed in your 'white paper' (if needed) so that Ohio EPA can evaluate their use prior to beginning the risk characterization for the respective AOC/EU.</u>

CONTAMINANT CONCENTRATION IN BEEF

Concentrations in beef cattle are calculated from the concentration in the cattle's food sources due to soil and water contamination. The contaminant levels in pastures are estimated by the equation:

$$C_p = C_s \text{ x } (R_{upp} + R_{es}),$$

where

C_p	=	concentration of contaminant in pasture (mg/kg, calculated),
C_s	=	concentration of contaminant in soil (mg/kg),
R_{upp}	=	multiplier for dry root uptake for pasture (unitless),
R_{es}	=	resuspension multiplier (unitless).

The multiplier for dry root uptake for pasture, R_{upp}, is estimated as:
$$R_{upp} = Bv_{dry},$$

where

R_{upp}	=	multiplier for dry root uptake for pasture (unitless),
Bv_{dry}	=	soil-to-plant uptake, dry weight (kg/kg, chemical-specific, or 38 x $K_{ow}^{-0.58}$),
K_{ow}	=	octanol-water partitioning coefficient (unitless, chemical-specific).

The resuspension multiplier is estimated as:
$$R_{es} = MLF,$$

where

R_{es} = resuspension multiplier (unitless),
MLF = plant mass loading factor (unitless, 0.25 for pasture).

The concentration of contaminants in beef cattle from ingestion of contaminated pasture, soil, and water is estimated using the following equation:
$$C_b = BTF_{beef} \times [(C_p \times Q_{pb} \times f_{pb} \times f_{sb}) + (C_s \times Q_{sb} \times f_{pb}) + (C_w \times Q_{wb})],$$

where

C_b = concentration of contaminant in beef (mg/kg dry weight),
BTF_{beef} = beef transfer coefficient (day/kg, chemical-specific, or $2.5 \times 10^{-8} \times K_{ow}$),
K_{ow} = octanol-water partitioning coefficient (unitless, chemical-specific),
C_p = concentration of contaminant in pasture (mg/kg, calculated),
Q_{pb} = quantity of pasture ingested by beef cattle (kg/day),
f_{pb} = fraction of year beef cattle is on-site (kg/day),
f_{sb} = fraction of beef cattle's food that is from the site (kg/day),
C_s = concentration of contaminant in soil (mg/kg),
Q_{sb} = quantity of soil ingested by beef cattle (kg/day),
C_w = concentration of contaminant in water (mg/L),
Q_{wb} = quantity of water ingested by beef cattle (L/day).

CONTAMINANT CONCENTRATION IN MILK

Milk concentrations from dairy cattle are calculated from the concentration in the cattle's food sources due to soil and water contamination. The contaminant levels in pastures are estimated in the same fashion as for beef cattle.

The concentration of contaminants in dairy cattle's milk, from ingestion of contaminated pasture, soil, and water, is estimated using the following equation:

$$C_m = BTF_{milk} \times [(C_p \times Q_{pd} \times f_{pd} \times f_{sd}) + (C_s \times Q_{sd} \times f_{pd}) + (C_w \times Q_{wd})],$$

where

C_m = concentration of contaminant in milk (mg/kg),
BTF_{milk} = milk transfer coefficient (day/kg, chemical-specific, or $7.9 \times 10^{-9} \times K_{ow}$),
K_{ow} = octanol-water partitioning coefficient (unitless, chemical-specific),
C_p = concentration of contaminant in pasture (mg/kg, calculated),

Q_{pd} = quantity of pasture ingested by dairy cattle (kg/day),
f_{pd} = fraction of year dairy cattle is on-site (kg/day),
f_{sd} = fraction of dairy cattle's food that is from the site (kg/day),
C_s = concentration of contaminant in soil (mg/kg),
Q_{sd} = quantity of soil ingested by dairy cattle (kg/day),
C_w = concentration of contaminant in water (mg/L),
Q_{wd} = quantity of water ingested by dairy cattle (L/day).

CONTAMINANT CONCENTRATION IN VEGETABLES

The model to estimate the chemical concentration in homegrown vegetables is comprised of contributions from irrigation and soil resuspension.

The root uptake from the irrigation component is estimated by the equation:

$$Irr_{rup} = (Ir \times F \times Bv_{wet} \times [1 - e^{(-\lambda_B \times t_b)}]) / (P \times \lambda_B),$$

where

Irr_{rup} = multiplier in vegetable equation for root uptake from irrigation (L/kg),
Ir = irrigation rate (L/m^2-day),
F = irrigation period as a fraction (unitless),
Bv_{wet} = soil-to-plant uptake factor, wet weight (kg/kg),
λ_B = effective rate for removal (1/day, calculated as $\lambda_i + \lambda_{HL}$),
λ_i = decay rate (1/day, assume 0 for chemicals),
λ_{HL} = soil leaching rate (1/day),
t_b = long-term deposition and buildup (days),
P = area density for root zone (kg/m^2).

The resuspension from irrigation component is estimated by the equation:

$$Irr_{res} = (Ir \times F \times MLF \times [1 - e^{(-\lambda_B \times t_b)}]) / (P \times \lambda_B),$$

where

Irr_{res} = multiplier in vegetable equation for resuspension from irrigation (L/kg),
Ir = irrigation rate (L/m^2-day),
F = irrigation period as a fraction (unitless),
MLF = plant mass loading factor (unitless, 0.26 for vegetables),
λ_B = effective rate for removal (1/day, calculated as $\lambda_i + \lambda_{HL}$),
λ_i = decay rate (1/day, assume 0 for chemicals),
λ_{HL} = soil leaching rate (1/day),
t_b = long-term deposition and buildup (days),
P = area density for root zone (kg/m^2).

The aerial deposition from irrigation component is estimated by the equation:

$$Irr_{dep} = (Ir \times F \times I_f \times T \times [1 - e^{(-\lambda_E \times t_v)}]) / (Y_v \times \lambda_E),$$

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where

Irr_{dep} = multiplier in vegetable equation for aerial deposition from irrigation (L/kg),

Ir = irrigation rate (L/m^2-day),
F = irrigation period as a fraction (unitless),
I_f = interception fraction (unitless),
T = translocation factor (unitless),
λ_E = decay for removal on produce (1/day, calculated as $\lambda_i + 0.693/t_w$),
λ_i = decay rate (1/day, assume 0 for chemicals),
t_w = weathering half-life (days),
t_v = above-ground exposure time (days),
Y_v = plant yield (wet) (kg/m^2).

The chemical concentration in homegrown vegetables is estimated with the equation:

$$C_{veg} = C_w \times (Irr_{rup} + Irr_{res} + Irr_{dep}) + C_s \times (Bv_{wet} + MLF),$$

where

C_w = concentration of contaminant in water (mg/L),
Irr_{rup} = multiplier in vegetable equation for root uptake from irrigation (L/kg),
Irr_{res} = multiplier in vegetable equation for resuspension from irrigation (L/kg),
Irr_{dep} = multiplier in vegetable equation for aerial deposition from irrigation (L/kg),
C_s = concentration of contaminant in soil (mg/kg),
Bv_{wet} = soil-to-plant uptake, wet weight (kg/kg, chemical-specific, or $7.7 \times K_{ow}^{-0.58}$),
K_{ow} = octanol-water partitioning coefficient (unitless, chemical-specific),
MLF = plant mass loading factor (unitless, 0.26 for vegetables).

CONTAMINANT CONCENTRATION IN VENISON

Concentrations in venison are estimated by calculating the concentration in venison food sources due to soil contamination. The contaminant levels in forage are estimated by the following:

$$C_p = (CF)(C_s)(B_p)$$

where

C_p = concentration of contaminant in forage (mg/kg dry weight),
CF = conversion factor to adjust for soil containing 20% moisture (1.25 unitless),
C_s = concentration of contaminant in soil (mg/kg),
B_p = soil-to-forage biotransfer factor (mg chemical per kg of dry plant/mg of chemical per kg or dry soil)(chemical-specific).

The B_p for metals is taken from the available literature. The B_p for SVOCs is calculated using the following formulas:

$$\log B_p = 1.588 - 0.578 \log K_{ow}$$

where

$\log B_p$ =   soil-to-forage biotransfer factor (mg chemical per kg of dry plant/mg of chemical per kg or dry soil)(chemical-specific),

K_{ow} =   octanol-water partitioning coefficient (unitless, chemical-specific).

A B_p is not estimated for VOCs, because these chemicals are expected to volatilize rapidly from soils and plants and thus are insignificant in food chain pathways.

The concentration of contaminants in venison from ingestion of contaminated forage is estimated using the following equation:

$$C_v = (Q_p)(C_p)(FI_e)(B_v)$$

where

C_v =   contaminant concentration in venison (mg/kg),
Q_p =   browse ingestion rate (0.87 kg dry weight/day),
C_p =   contaminant concentration in browse (mg/kg dry weight),
FI_e =   fraction browse ingested from the contaminated site (site area/home range),
B_v =   biotransfer factor for venison (days/kg).

The B_v for beef is used for deer due to a lack of available literature values for deer. Both of these animals are ruminants; therefore, the uptake and bioaccumulation of contaminants is likely to be similar. The meat of deer contains less fat than commercial beef—14.4% fat for beef as compared to 2.9% for venison. Organic chemicals have a greater affinity to fat and thus would not accumulate as much in venison. Therefore, the beef biotransfer factors for organics are adjusted by 2.9/14.4 (0.20) to reflect this lower accumulation rate. The fraction browse ingested from the contaminated site is exposure unit-specific based on a 175-hactare home range for deer.

The B_v values for metals are taken from the published literature. The B_v values for organics are calculated as follows:

$$B_v = R_f \, x \, 10^{-7.6 + logK_{ow}},$$

where

B_v =   biotransfer factor for venison (days/kg),
R_f =   ratio of the fat content in venison to the fat content of beef (0.20),
K_{ow} =   octanol-water partitioning coefficient (unitless, chemical-specific).

CONTAMINANT CONCENTRATION IN WATERFOWL

The mallard will be used as a representative species for the development of RGOs for human health COPCs. Ducks are assumed to be exposed by the following routes:

- ingestion of aquatic plants exposed to surface water, sediment and sediment porewater;

- ingestion of sediment invertebrates exposed to surface water, sediment and sediment porewater;
- ingestion of surface water; and
- incidental ingestion of sediment.

The concentration of contaminants in waterfowl from ingestion of contaminated aquatic plants, sediment invertebrates, surface water, and sediment is estimated using bioaccumulation factors (BAF_vs) for small birds in the following equation:

Duck Tissue Concentration (mg/kg) = BAF_v x (S_{EC} x FS + SW_{EC} x FW + AP_{EC} x FP + SI_{EC} x FA)

where

$$
\begin{aligned}
BAF_v &= \text{bioaccumulation factor for bird (days/kg),} \\
S_{EC} &= \text{exposure concentration in sediment (mg/kg),} \\
FS &= S_{EC} \text{ x IRS/}(S_{EC} \text{ x IRS} + SW_{EC} \text{ x IRW} + AP_{EC} \text{ x IRP} + SI_{EC} \text{ x IRA)} \\
SW_{EC} &= \text{exposure concentration in surface water (mg/L),} \\
FW &= SW_{EC} \text{ x IRW/}(S_{EC} \text{ x IRS} + SW_{EC} \text{ x IRW} + AP_{EC} \text{ x IRP} + SI_{EC} \text{ x IRA)} \\
AP_{EC} &= \text{exposure concentration in aquatic plants (mg/kg),} \\
FP &= AP_{EC} \text{ x IRP/}(S_{EC} \text{ x IRS} + SW_{EC} \text{ x IRW} + AP_{EC} \text{ x IRP} + SI_{EC} \text{ x IRA)} \\
SI_{EC} &= \text{exposure concentration in sediment invertebrates (mg/kg),} \\
FA &= SI_{EC} \text{ x IRA/}(S_{EC} \text{ x IRS} + SW_{EC} \text{ x IRW} + AP_{EC} \text{ x IRP} + SI_{EC} \text{ x IRA)} \\
IRS &= \text{ingestion rate of sediment (kg/kg/d),} \\
IRW &= \text{ingestion rate of surface water (L/kg/d),} \\
IRP &= \text{ingestion rate of aquatic plants (kg/kg/d),} \\
IRA &= \text{ingestion rate of sediment invertebrates (kg/kg/d).}
\end{aligned}
$$

A diet of 50% plant matter and 50% animal matter is used in the calculation of mallard whole tissue concentrations.

ESTIMATING AQUATIC PLANT TISSUE CONCENTRATIONS

The concentrations of inorganic COPCs (metals) in aquatic plant tissues (Aquatic Plant EC) resulting from uptake from sediment are estimated using soil-to-plant uptake factors (Bv), because it is assumed that the root uptake into plants of inorganics in sediment and soil is similar. For organic COPCs, plant tissue concentrations are estimated from water-to-algae uptake factors. The Bv is multiplied by the larger of the measured surface water exposure concentration (EC) and estimated sediment porewater concentrations. That is, for inorganic COPCs,

$$\text{Aquatic Plant EC} = \text{Bv x Sediment EC}$$

and for organic COPCs,

$$\text{Aquatic Plant EC} = \text{Bv x Surface Water EC}$$

or

$$\text{Aquatic Plant EC} = \text{Bv x Sediment Porewater EC.}$$

The method of estimating sediment porewater ECs is described below.

ESTIMATING SEDIMENT INVERTEBRATE TISSUE CONCENTRATIONS
Water-to-tissue bioconcentration factors (BCF_{inv}) and sediment-to-tissue bioaccumulation factors (BSAFs) are required to predict the tissue concentration in sediment invertebrates (Sediment Invertebrate EC) exposed to COPCs in sediment. For organic COPCs with log $K_{ow} \leq 5$, the sediment porewater EC and BCF_{inv} are used to estimate the tissue concentration in sediment invertebrates. For inorganic COPCs and organic COPCs with log $K_{ow} > 5$, the sediment EC and BSAF are used. That is, for inorganic COPCs and organic COPCs with log Kow > 5,

$$\text{Sediment Invertebrate EC} = \text{BSAF x Sediment EC,}$$

and for organic COPCs with log $K_{ow} \leq 5$,

$$\text{Sediment Invertebrate EC} = BCF_{inv} \text{ x Sediment Porewater EC.}$$

This approach recognizes that sediment invertebrates primarily take up COPCs either from bulk sediment or sediment porewater based on the COPCs' different affinities for sediment.

ESTIMATING SEDIMENT POREWATER CONCENTRATIONS
Sediment porewater concentrations for organic COPCs are estimated from sediment concentrations using the product of the octanol-water partitioning coefficient (K_{ow}) and fraction organic carbon (foc) assuming equilibrium partitioning (EPA 1993a), that is,

$$\text{Sediment Porewater EC} = \text{Sediment EC/}(K_{ow} \text{ x foc}).$$

INTAKE OF CONTAMINANT FROM FISH

The intake of the chemical ingested in fish in the sportsman scenario is estimated from the equation:

$$I_g = [(C_f)(IR_f)(FI_f)][(EF)(ED)/(BW)(AT)]$$

where:
I_g = ingested intake of the chemical in fish (mg/kg-day)
C_f = concentration of the chemical in fish (mg/kg)
IR_f = ingestion rate of fish (kg/day)
FI_f = fraction of daily intake of fish from contaminated sources (unitless)
EF = exposure frequency (days/yr)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

CONTAMINANT CONCENTRATION IN FISH

The contaminant concentration in fish should be calculated by the following equation:

$$C_f = (C_w)(BCF)$$

where:
C_f = contaminant concentration in fish (mg/kg)
C_w = contaminant concentration in water (mg/L)
BCF = fish bioconcentration factor (L/Kg)

BCF values for metals should be taken from EPA (1986a). Use chemical specific BCF values for SVOCs (USEPA. 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.* Solid Waste and Emergency Response. EPA530-D-99-001A). However in absence of chemical specific values BCF values for SVOCs should be calculated from the following formula (Bintein and Devillers, 1993):

$$logBCF=0.910logK_{ow}-1.975log[(6.8E-7)(logK_{ow}+1)]-0.786$$

where:

BCF = fish bioconcentration factor (L/Kg)
K_{ow} = octanol-water partition coefficient.

Please note that if the algorithms result in contaminants in fish that pose a human health concern, then it is the option of the risk manager to propose actual fish sampling to validate the contaminant concentrations in the edible portions of the fish.

INGESTION OF CHEMICALS IN DRINKING WATER

The intake of the chemical ingested in drinking water in the resident scenario is estimated from the equation:

$$I_w = (C_w)(IR_w)(FI_w)(EF)(ED)/(BW)(AT)$$

where:

I_w = ingested intake of the chemical in drinking water (mg/kg-day)
C_w = concentration of the chemical in drinking water (mg/L)
IR_w = ingestion rate of drinking water (L/day)
FI_w = fraction of daily intake of drinking water from contaminated sources (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

DERMAL CONTACT WITH CHEMICALS FOR RISK ANALYSIS IN SOIL, SEDIMENT, AND WATER

The following approach must conform to Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim (The U.S. Environmental Protection Agency (EPA) has developed and is requesting public comment; http://www.epa.gov). Ensure that RAGS Part E is reviewed and consultation with Ohio EPA occurs prior to using dermal intake equations.

Unlike the methodologies for estimating inhaled or ingested intake of COPC, which quantify the constituent presented to the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), dermal intake is estimated as the amount of constituent that crosses the skin and is systematically absorbed. For this reason, dermal toxicity values are also based on absorbed intake. The absorbed intake of the COPC is estimated from the equation (EPA, 1992b):

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

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)
        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. It is calculated from the equation (EPA, 1992b):

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

where:
        DA_{event} = COPC absorbed per unit body surface area per day (mg/cm^2-event)
        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 been empirically determined for very few chemicals. EPA (1992b) discussed the available empirical data, as well as several

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predictive approaches for estimating ABS, but refrains from recommending any single approach. EPA (1991d) 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).

Quantification of dermal uptake of constituents from water depends on a permeability coefficient (PC), which describes the rate of movement of a constituent, from water across the dermal barrier to systemic circulation (EPA, 1992b). The equation for dermal uptake of chemicals from water is the same as the equation for dermal uptake of chemicals in soil and sediment. Separate calculation methods are applied to estimate DA_{event} for inorganic and organic chemicals. For inorganic chemicals, DA_{event} is calculated from the following equation:

$$DA_{event} = (C_w)(FI_{sw})(PC)(ET_d)(CF)$$
where:

DA_{event} = COPC absorbed per unit body surface area per day (mg/cm^2-event)
C_w = concentration of COPC in water (mg/L)
PC = permeability coefficient (cm/hour)
ET_d = time of exposure (hours/event)
CF = conversion factor ($0.001L/cm^3$)
FI_{sw} = fraction of exposure attributed to surface water (unitless)

PC has been determined for very few inorganic compounds. For those inorganic compounds for which empirical data are not available, EPA (1992b) recommends a default of 10^{-3} cm/hr.

PC for organic chemicals varies by several orders of magnitude (EPA, 1992b). PC for organic chemicals is highly dependent on lipophilicity, expressed as a function of the octanol/water partition coefficient (K_{ow}). Because the stratum corneum (the outer skin layer) is rich in lipid content, it may act as a sink, initially reducing the transport of the chemical to the systemic circulation. With continued exposure and the attainment of steady-state conditions, the rate of dermal uptake increases. Therefore, different equations are used to estimate DA_{event}, depending on whether the exposure time is lesser or greater than the estimated time to reach steady state. When steady state has not been reached, which is the usual case for relatively short exposure times, DA_{event}, is calculated from the following equation (EPA, 1992b):

$$DA_{event} = 2(FI_{sw})(PC)(C_w)(CF) \sqrt{(6\tau (ET_d)/\pi)}$$
where:

DA_{event} = COPC absorbed per unit body surface area per day (mg/cm^2-event)
PC = permeability coefficient (cm/hour)
C_w = concentration of constituent in water (mg/kg)
CF = conversion factor ($0.001l/cm^3$)
τ = time for concentration of contaminant in stratum corneum to reach steady state hours

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ET_d = exposure time (hours)
FI_{sw} = fraction of exposure attributed to surface water (unitless).

When steady state has been reached, DA_{event} is calculated from the following equation (EPA, 1992b):

$$DA_{event} = (FI_{sw})(PC)(C_w)(CF)[ET_d/[(1+B) + 2\tau(1+3B/1+B)]$$

where:

DA_{event} = dose absorbed per unit body surface area per day (mg/cm^2-event)
PC = permeability coefficient (cm/hour)
C_w = concentration of constituent in water (mg/kg)
CF = conversion factor (0.001 L/cm^3)
τ = time for concentration of contaminant in stratum corneum to reach steady state (hours)
ET_d = exposure time (hours)
FI_{sw} = fraction of exposure attributed to surface water (unitless).
B = numerical relationship between log octanol/water partition coefficient and time to reach steady state, i.e., the relative contributions of the permeability of the stratum corneum and the viable epidermis (unitless)

When possible, values for PC, τ, B, and T_s are taken from EPA (1992b). If PC values are not available, they will be calculated from the formula:

$$Log(PC) = -2.72 + 0.71(logK_{ow}) - 0.0061(MW)$$

where:

PC = permeability coefficient (cm/hour)
log K_{ow} = log of the octanol/water partition coefficient
MW = molecular weight

If the values of t are not available, they will be calculated from the equation (EPA, 1992b):

$$\tau = L_{sc}/6 * 10^{(-2.72 - 0.0061*MW)}$$

where:

τ = time for concentration of contaminant in stratum corneum to reach steady state (hours)
L_{sc} = effective thickness of the stratum corneum (10E-3 cm)
MW = molecular weight

If the values are not available for B, they are calculated from the equation (EPA, 1992b):

$$B = K_{ow}/10E-4$$

where:

B =   numerical relationship between log octanol/water partition coefficient and
       time to reach steady state, i.e., the relative contributions of the
       permeability of the stratum corneum and the viable epidermis (unitless)

K_{ow} = octanol/water partition coefficient

If values are not available for the time for the concentration of the contaminant in the
stratum corneum and viable epidermis to reach steady state (T_s), they are calculated using
equations from EPA (1992b). If B is less than 0.1, the following equation is used:

$$T_s = 2.4 \, \tau$$

where:

T_s =   time for concentration of contaminant in stratum corneum and viable
          epidermis to reach steady state (hours)

τ = time for concentration of contaminant in stratum
corneum to reach steady state (hours)

If B is between 0.1 and 1.17, the following equation will be used:

$$T_s = t(8.4 + 6*logB)$$

where:

T_s =   time for concentration of contaminant in stratum corneum and viable
          epidermis to reach steady state (hours)

τ =   time for concentration of contaminant in stratum corneum to reach steady
          state (hours)

B =   numerical relationship between log octanol/water partition coefficient and
       time to reach steady state, i.e., the relative contributions of the
       permeability of the stratum corneum and the viable epidermis (unitless)

If B is greater than 1.17, the following equation will be used:

$$T_s = 6(b-\sqrt{b^2-c^2})\tau$$

where:

T_s =   time for concentration of contaminant in stratum corneum and viable
          epidermis to reach steady state (hours)

$$b = 2/л(1+B)^2-c$$

and

$$c = 1+3B/3$$

SURFACE WATER EXPOSURE PATHWAYS

Incidental ingestion of surface water is estimated by using the following equation:

$$\text{Chemical Intake (mg/kg-day)} = \frac{C_w \text{ x } IR_w \text{ x } EF \text{ x } ED}{BW \text{ x } AT}$$

Where

C_w =   chemical concentration in water (mg/L),
IR_w =   ingestion rate (L/day),
EF =   exposure frequency (days/year),
ED =   exposure duration (years),
BW =   body weight (kg),
AT =   averaging time (days) for carcinogens or noncarcinogens

The dermally absorbed dose from dermal contact with chemicals in surface water is calculated by using methodology in Section 4.2.5, above.

Inhalation of VOCs from surface water is quantified when volatile COPCs have been identified in surface water. Per July 2002 comment resolution meeting for LL1, Ohio EPA will provide box model equations for future reports to be used for volume of air moving across a surface water source area with partitioning from the source to air, based on Henry's Law 0.0005 x 1000 L m^3 now displayed in Table 5 under surface water volatilization factor.

5.0 TOXICITY ASSESSMENT

The recommended hierarchy of toxicological sources of information which Regional risk assessors and managers should initially consider for site-specific risk assessments is as follows:

Tier 1- EPA's IRIS

Tier 2- EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical specific basis when requested by EPA's Superfund program.

Tier 3- Other Toxicity Values – Tier 3 includes additional EPA and non-EPA sources of toxicity information. Priority should be given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed.

IRIS remains in the first tier of the recommended hierarchy as the generally preferred source of human health toxicity values. IRIS generally contains reference doses (RfDs), reference concentrations (RfCs), cancer slope factors, drinking water unit risk values, and inhalation unit risk values that have gone through a peer review and EPA consensus review process.   IRIS normally represents the official Agency scientific position regarding the toxicity of the chemicals based on the data available at the time of the review.

Dermal CSFs and RfDs will be estimated from the oral toxicity values using chemical-specific gastrointestinal absorption factors (GAFs) to calculate the total absorbed dose. Chemical-specific GAF values available from EPA Region V (USACE 2000c) will be used (rounded to one significant figure) whenever possible. Not all COPCs have specific GAF values. When quantitative data are insufficient, default GAF is used. A default value of 1.0 for organic chemicals will be used (USACE 2000c).

5.1 SLOPE FACTORS

The slope factor (SF) is expressed as risk per mg/kg-day. In order to be conservative, the SF is usually the 95% upper bound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. The EPA (1986b) assumes that there are no thresholds for carcinogenic expression: therefore, any exposure represents some quantifiable risk.

The oral SF is usually derived directly from the experimental dose data, because oral dose is usually expressed as mg/kg-day. When the test chemical was administered in the diet or drinking water, oral dose must first be estimated from data for the concentration of the test chemical in the food or water, food or water intake data, and body weight data. The dermal SF is derived by dividing the oral SF by the GAF. The oral SF is divided, rather than multiplied, by the GAF because SF is expressed as reciprocal dose.

The EPA Integrated Risk Information System (IRIS) expresses inhalation cancer potency as a unit risk-based on concentration, or risk per (ug) of a chemical/m^3 of ambient air. Because cancer risk characterization requires potency expressed as risk per mg/kg-day, the unit risk must be converted to the mathematical equivalent of an inhalation cancer SF, or risk per unit dose. Because the inhalation unit risk is based on continuous lifetime exposure of an adult human (assumed to inhale 20 m^3 of air/day and to weigh 70kg), the mathematical conversion consists of multiplying the unit risk (per ug/m^3) by 70kg and by 1,000 ug/mg, and dividing the result by 20 m^3/day.

5.2 NONCANCER EFFECTS

Many chemicals, whether or not associated with carcinogenicity, are associated with non-carcinogenic effects. The evaluation of non-cancer effects (EPA, 1989b) involves:
- Qualitative identification of adverse effect(s) associated with the chemical; these may differ depending on the duration (acute or chronic) or route (oral or inhalation) of exposure.
- Identification of the critical effect for each duration of exposure (i.e., the first adverse effect that occurs as dose is increased).
- Estimation of the threshold dose for the critical effect for each duration of exposure.
- Development of the uncertainty factor, i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of critical effect and slope of dose-response curve, and deficiencies of the data base in regard to developing a reference dose (RfD) for human exposure.

- Identification of target organ for critical effect for each route of exposure.

The information points are used to derive an exposure route- and duration-specific toxicity value called an RfD, expressed as mg/kg-day, which is considered to be the dose for humans, with uncertainty of an order of magnitude or greater, at which adverse effects are not expected to occur. Mathematically, it is estimated as the ratio of the threshold dose to the uncertainty factor. For purposes of risk assessment, chronic exposure is defined as equal to or greater than seven years, i.e., at least 10% of the expected life-span; subchronic exposure is defied as two weeks to seven years.

IRIS and Health Effects Summary Tables (HEAST) (EPA, 1994c) express the inhalation non-cancer reference value as a reference concentration (RfC) in units of mg/m^3. Because non-cancer risk characterization requires a reference value expressed as mg/kg-day, the RfC must be converted to an inhalation RfD. Because the inhalation RfC is based on continuous exposure of an adult human (assumed to inhale 20 m^3 of air/day and weigh 70kg), the mathematical conversion consists of multiplying the RfC (mg/m^3) by 20 m^3/day and dividing the result by 70 kg.

RfD and RfC values are derived for both chronic and subchronic exposure. Under the assumption of monotonicity (incidence, intensity, or severity of effects can increase, but cannot decrease, with increasing magnitude of duration of exposure), a chronic RfD may be considered sufficiently protective for subchronic exposure, but a subchronic RfD may not be protective for chronic exposure. Currently, subchronic RfD values exist for few chemicals. Subchronic RfD values can be derived from chronic RfD values as follows:

- If the uncertainty factor applied in the derivation of the chronic RfD does not provide for expansion from subchronic to chronic exposure (e.g., if the chronic RfD was derived from chronic study), the chronic RfD is adopted as being sufficiently protective for subchronic exposure.
- If the uncertainty factor applied in the derivation of the chronic RfD contains a component to expand from subchronic to chronic exposure. The subchronic RfD is derived by multiplying the chronic RfD by the factor used to expand from subchronic to chronic exposure (e.g., if a factor of 10 was used to expand from subchronic to chronic exposure, the subchronic RfD will be 10 times as large as the chronic RfD).

TARGET ORGAN TOXICITY

As a matter of science policy, the EPA assumes dose- and effect-additivity for non-carcinogenic effects (EPA, 1989a). This assumption provides the justification for adding the Hazard Quotients (HQ) or Hazard Indices (HI) in the risk characterization for non-cancer effects resulting from exposure to multiple chemicals, pathways, or media. The EPA (1989a), however, acknowledges that adding all HQ or HI values may overestimate risk, because the assumption of additivity is probably appropriate only for those chemicals that exert their toxicity by the same mechanism.

Mechanisms of toxicity data sufficient for predicting additivity with high level of confidence are available for very few chemicals. In the absence of such data, EPA

(1989a) assumes that chemicals that act on the same target organ may do so by the same mechanism of toxicity, i.e., target organ serves as a surrogate for mechanism of toxicity. When total HI for all media for a receptor exceeds 1 due to the contributions of several chemicals, it is appropriate to segregate the chemicals by route of exposure and mechanism of toxicity (i.e., target organ) and estimate separate HI values for each.

As a practical matter, since human environmental exposures are likely to involve near- or sub-threshold doses the target organ chosen for the given chemical is one associated with the critical effect. When multiple organs are identified at the threshold concentration, then all identified organs should be listed as target organs. For example, if the liver and kidneys were identified to be adversely affected by a compound at the NOAEL or LOAEL in the critical study, then the compound would be cumulatively considered with both the hepatoxins and nephrotoxins in the risk assessment.

Target organ is also selected on the basis of duration of exposure (i.e., the target organ for chronic or subchronic exposure to low or moderate doses is selected rather the target organ for acute exposures to high doses) and route of exposure. Because dermal RfD values are derived from oral RfD values, the oral target organ is adopted as the dermal target organ. For some chemicals no target organ is identified. This may arise when no adverse effects are observed or when adverse effects such as reduced longevity or growth rate are not accompanied by recognized organ- or system-specific functional or morphological alteration.

DERMAL TOXICITY

Dermal RfD values and SFs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. In the derivation of the dermal RfD, the oral RfD is multiplied by the gastrointestinal absorption factor (GAF), expressed as a decimal fraction. The resulting dermal RfD, therefore, is based on absorbed dose. The RfD based on absorbed dose is appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure doses.

GASTROINTESTINAL ABSORPTION FACTOR

GAFs used to derive RfD values and SFs from corresponding oral toxicity values, are obtained from the following sources:
- The EPA's on-line IRIS database.
- Oral absorption efficiency data compiled by the Environmental Criteria Assessment Office for Superfund Health Risk Technical Support Center of the EPA.
- Federal Agency reviews of empirical data, such as Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological profiles and various EPA criteria documents.
- Other published reviews of empirical data.
- The primary literature.

GAFs obtained from reviews are compared to empirical (especially more recent) data, when possible, and are evaluated for suitability for use for deriving dermal toxicity values from oral toxicity values. The suitability of the GAF increases when the following similarities are present in the oral pharmacokinetics study from which the GAF is derived and in the key toxicity study from which the oral toxicity value is derived:

- The same strain, sex, ages, and species of test animal was used.
- The same chemical form (e.g., the same salt or complex of an inorganic element or organic compound) was used.
- The same mode of administration (e.g., diet, drinking water or gavage vehicle) was used.
- Similar dose rates are used.

The most defensible GAF for each chemical is used in the risk analysis. When quantitative data are insufficient, default GAF is used. As noted by EPA, RAGS, Vol 1. Supplemental Guidance Dermal Risk Assessment (May 7, 1998, Interim Guidance), "Adjustment of an oral slope factor RfD should be performed when the following conditions are met: (1) The critical study upon which the toxicity value is based employed an administrative dose (e.g., delivery in a diet or by gavage) in its study design; (2) A scientifically defensible data base exists and demonstrates that the gastrointestinal absorption of the chemical in question from a media (e.g., water, feed) similar to the one employed in the critical study, is significantly less than 100% (e.g. < 50%). A cutoff of 50% GI absorption is recommended to reflect the intrinsic variability in the analysis of absorption studies. Thus this cutoff level obviates the need to make comparatively small adjustments in the toxicity value that would otherwise impart on the process a level of accuracy that is not existent." "Recommended GI absorption values for those compounds with chemical-specific dermal absorption factors from soil are presented in [Table 9 of RAGS Part E, Interim Guidance]. A review of the GI absorption values shows that only cadmium meets the criterion of less than 50% GI absorption. This criterion is also recommended for the adjustment of toxicity values for water contact. In the event that the aforementioned criteria are not met, it is recommended that the default value of complete (i.e., 100%) oral absorption be assumed, thereby eliminating the need for oral toxicity-value adjustment. It should be noted in the uncertainty analysis that employing the oral absorption default value may result in an underestimation of risk; the magnitude of the underestimation being inversely proportional to the true oral absorption of the chemical in question." [RAGS Vol. 1, Part E, Interim Guidance. May 7, 1998]

5.3 CHEMICAL SPECIFIC CONSIDERATIONS.

Individual profiles may be presented for the COPCs. If the profile is not provided it is because the toxicity information and its documentation are sufficient for quantitative risk characterization and uncertainty analysis. Chemicals for which the toxicity information is insufficient for quantitative risk characterization are evaluated qualitatively in this section. In addition, chemicals for which there are controversies or issues that would impact risk characterization will need to be discussed in this report.

LEAD

There is no oral RfD or inhalation RfC/RfD values for lead.   Primary effects may occur at doses as low as to appear to be without thresholds, and because lead is ubiquitous in all environmental media so that the contribution to total body intake from one exposure pathway (e.g., ingestion of contaminated soil) cannot be quantified (EPA, 1990b). The appropriate lead soil concentration presented in EPA guidance (1994d) on lead-contaminated soil will be used as an RBC for screening lead as a COPC. If lead is selected as a COPC, then reference should be made to US EPA Memorandum, Revised Interim Soil Lead Guidance for CERCLA and RCRA Corrective Action Facilities, July 1994.

5.3.1 POLYCYLIC AROMATIC HYDROCARBONS

Toxicity Equivalency Factors (TEFs) are applied to carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) [EPA 1994]. The following TEFs are used to convert the cPAHs identified as COPCs to an equivalent concentration of benzo(a)pyrene.

cPAH	TEF
Benzo(a)pyrene	1
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1
Indeno(1,2,3-c,d)pyrene	0.1

6.0 RISK CHARACTERIZATION

Risk characterization is a combination of the results of the exposure assessment and toxicity assessment to yield a quantitative expression of risk for the exposed receptors. This quantitative expression is the probability of developing cancer, or a non-probabilistic comparison of estimated dose with a reference dose for non-cancer effects. Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor. The risk characterization is used to guide risk management decisions.

Generally, the risk characterization follows the methodology prescribed by EPA (1989a), as modified by more recent information and guidance (EPA publications). The EPA methods are, appropriately, designed to be health-protective, and tend to over estimate, rather than under estimate risk. The risk results, however, are generally over conservative, because risk characterization involves multiplication of the conservatism built into the estimation source-term and exposure-point concentrations, the exposure (intake) estimates and the toxicity dose-response assessments.

6.1 CARCINOGENIC EFFECTS OF CHEMICALS

The risk of exposure to potential chemical carcinogens is estimated as the probability of an individual developing cancer over lifetime. In the low-dose range, which would be expected for most environmental exposures, cancer risk is estimated from the following linear equation (EPA, 1989a):

$$ILCR = (CDI)(SF)$$

where:

        $ILCR$ = incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence.

        CDI = chronic daily intake, averaged over 70 years (mg/kg-day).

        SF = cancer slope factor $(mg/kg\text{-}day)^{-1}$

The use of $ILCR = (CDI)(SF)$ assumes that the chemical carcinogenesis does not exhibit a threshold, and that the dose response relationship is linear in the low dose range. Because $ILCR = (CDI)(SF)$ could generate theoretical cancer risks less than 1 for high dose levels, it is considered to be inaccurate at cancer risks less than 1*10E-2. In these cases, cancer risk is estimated by the one-hit model (EPA, 1989a):

$$ILCR = 1 - e^{-[(CDI)(SF)]}$$

where:

        $ILCR$ = incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence.

        $e^{-[(CDI)(SF)]}$ = the exponential of the negative of the risk calculated by $ILCR = (CDI)(SF)$.

As a matter of policy, the EPA (1989b) considers the carcinogenic potency of simultaneous exposure to low doses of carcinogenic chemicals to be additive, regardless of the chemical's mechanisms of toxicity or sites (organs of the body) of action. The cancer risk arising from simultaneous exposure by a given pathway to multiple chemical is estimated from the equation (EPA, 1989a):

$$Risk_p = ILCR_{(chem\ 1)} + ILCR_{(chem\ 2)} +...ILCR_{(chem\ i)}$$

where:

        $Risk_p$ = total pathway risk of cancer incidence.
        $ILCR_{(chem\ i)}$ = individual chemical cancer risk.

Cancer risk for a given receptor across pathways and across media is summed in the same manner.

6.2 NON-CARCINOGENIC EFFECTS OF CHEMICALS

The risks associated with the non-carcinogenic effects of chemicals are evaluated by comparing an exposure level or intake with an RfD. The HQ, defined as the ratio of intake to RfD, is defined as (EPA, 1989a):

$$HQ = I/RfD$$

where:

HQ =   hazard quotient (unitless).
I =   intake of chemical (mg/kg-day).
RfD = reference dose (mg/kg-day).

Chemical non-carcinogenic effects are evaluated on a subchronic or chronic basis, using subchronic or chronic RfD values, respectively. This approach is different from the approach based on probability used to evaluate carcinogenic effects. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates that the estimated intake is 100 times lower than the RfD. A HQ of unity indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be concern for potential adverse health effects.

In the case of simultaneous exposure of a receptor to several chemicals, the HI is calculated as the sum of the HQs by:

$$HI = I_1/RfD_1 + I_2/RfD_2 + ...I_i/RfD_i$$

where:

HI = hazard index (unitless).
I_i = intake for the ith toxicant.
RfD_i = reference dose for the ith toxicant.

If the HI for a given pathway exceeds 1.0, individual HI values are calculated for each target organ.

6.3 REPORTING RISK ASSESSMENTS

A cumulative risk worksheet should be prepared specific to exposure media, on-site receptors, and constituents of concern. Cumulative risks are tabulated for constituents per media, per receptor. Likewise, when exposures are expected via multiple media, then total risk and hazards are to be calculated for those potentially exposed receptors.

Please refer to RAGS Vol. I: Human Health Evaluation Manual (Part D) for example standard tables relevant for reporting respective risk characterizations at RVAAP.
http://www.epa.gov/superfund/programs/risk/ragsd/tara.htm

7.0 DERIVE RISK-BASED REMEDIAL GOAL OBJECTIVES

Comparable AOCs will use media specific chemical concentrations that are associated with acceptable levels of chemical intake. In identifying media specific chemical cleanup objectives Remedial Goal Objectives (RGOs) are considered along with other factors, such as ARARS.

RGOs differ from Region 9 PRGs in that site-specific factors are considered during their development. RGOs are developed via the rearrangement of the risk and hazard equations from the Baseline Risk Assessment (BRA). The risk and hazard levels are set equal to acceptable levels; the exposure route-specific intake factors developed during the BRA are applied, and the chemical concentration associated with the intake factors and risk/hazard levels are calculated.

The RGOs are chemical specific. If more than one chemical is identified on an AOC above a level of concern then the application of RGOs developed by this approach can result in residual risks exceeding the target risk or hazard level.

Therefore RGOs should be based upon all significant exposure pathways assessed in the BRA for that medium. However, since the pathways resulting in the highest degree of exposure will most greatly influence the RGO, exposure pathways that have minimal contribution to overall risks can be excluded from the RGO development with little or no impact.

During the process of remedy selection for the site, the contractor is to ensure that the final RGOs meet the risk and hazard goals. This may include an evaluation of exposure via multiple media and multiple exposure routes as appropriate. Specifically, in the derivation of the remedial goal objective the target risk and threshold hazard index may have to be set at values lower than 10^{-5} or 1.0, respectively to account for exposure to multiple contaminants. This information is to be reviewed by the Ohio EPA prior to remedy selection.

Risk assessment and analyses could provide substantive inputs into the risk-management decision-making process by identifying the principal threat constituents and exposure pathways for action. But, risk assessment results must be evaluated along with the associated uncertainties. These results should then be considered along with the recommended acceptable risk range and HI for decision making.

The magnitude of cancer risk relative to Superfund site remediation goals in the National Contingency Plan (NCP) ranges from $1\text{x}10^{-4}$ (which can be expressed as one-in-ten-thousand or 1E-4) to $1\text{x}10^{-6}$ (which can be expressed as one-in-one million or 1E-6) depending on the site, proposed usage, and chemicals of concern (USEPA, 1989a). Within this range, the level of risk that is considered to be acceptable at a specific site is a risk management decision, and is decided on a case-specific basis.

Unlike the method adopted to evaluate carcinogens, noncarcinogens have not had an acceptable range defined for Hazard Index (HI). When evaluating the acceptability of a HI, a threshold comparison value of unity (1) is applied. If the overall HI exceeds 1, there may be some concern regarding the potential for noncarcinogenic effects occurring. HIs less than 1 probably do not pose concern of the possibility of noncarcinogenic effects. The threshold comparison value of 1 is not a clear demarcation, and slight exceedances over 1 should not be interpreted as indicating a noncarcinogenic hazard. However, as the HI increases, the concern for the occurrence of noncarcinogenic effects also increases (but not in a linear manner).

7.1 RISK BASED CLEANUP OBJECTIVES

Potential risks from exposure to contaminants may occur simultaneously via multiple pathways. To assess the overall potential for carcinogenic and noncarcinogenic effects for each chemical posed by several pathways, the chemical-specific risks for each exposure pathway are summed to give an aggregate Hazard Index (HI) or cancer risk for each chemical. Chemical specific risk-based action levels will be developed for chemicals and/or metals that have significantly contributed to an unacceptable hazard or risk.

Risk-based RGOs will be calculated for the exposure routes identified in the baseline risk assessment considering the methodologies given in the USEPA RAGS guidance documents. The methodology requires that the following parameters be specified:
- exposure parameters for a given exposure route and receptor population;
- target-level; carcinogenic or noncarcinogenic risk or hazard level, respectively;
- toxicity values (RfD or SF).

In order to establish RGOs for carcinogens and noncarcinogens, a risk level is assumed which is considered protective. The USEPA RAGS guidance does not distinguish between Class A and Class B carcinogens with regard to acceptable carcinogenic risk level. RGOs will be derived using only the 1E-5 target excess individual lifetime cancer risk (TR). The acceptable Target Hazard Index (THI) for noncarcinogens is assumed to be 1.0. [The TR and THI may need to be adjusted to account for exposure to multiple chemicals. For example TR as 1E-6 and THI as 0.1]

The following equation from USEPA RAGS Part B guidance will be used to calculate RGOs for constituents of interest in soil and sediment (USEPA, 1991b):

$$C_s = \frac{TL*BW*AT}{ED*EF*[(1/RfD_o*CF*SA*AF*ABS)+(1/RfD_o*CF*IR*FI)+ (1/RfD_i*IR_{air}*ET*1/PEF)]}$$

Where:
C_s = constituent concentration (e.g., for soil, in units of mg/kg)
*TL = target level; for noncarcinogens, it has a hazard index (unitless), equal to 1.0; for carcinogens, it is the acceptable risk level equal to (10^{-4}, 10^{-5}, or 10^{-6}.)
BW = Body Weight (kg, see Table-5).
AT = Averaging Time (days, see Table-5).

ED = Exposure Duration (years, see Table-5).
EF = Exposure Frequency (days/year, see Table-5).
CF = Conversion Factor (10^{-6} kg/mg).
SA = Skin Surface Available for Contact (m^2/event, see Table-5).
AF = Soil to Skin Adherence Factor (mg/cm^2, see Table-5).
ABS = Absorption Factor (unitless; see Table-5).
IR = Ingestion Rate (mg/day, see Table 5).
FI = Fraction Ingested from Source (1 unitless).
*RfD_o = Oral Chronic Reference Dose (chemical specific, g/kg/day). For carcinogens use the oral slope factor.
IR_{air} = Inhalation Rate (m^3/day, see Table 5)
ET = Exposure Time (days/year, see Table 5).
PEF = Particulate Emission Factor ($4.63*10E+09$ m^3/kg).
*RfD_i=Inh Chronic Reference Dose (chemical specific, mg/kg/day). For carcinogens use the inhalation slope factor.

The above equation considers the potential exposure routes of incidental ingestion, dermal contact, and inhalation of particulates. The equation is essentially the same for carcinogenic constituents, with only the parameters with asterisks (*) changed. In addition to the carcinogenic target level previously discussed, the carcinogenic equation would substitute the chemical-specific slope factor (SF) for the '1/RfD' terms. The particulate emission factor (PEF) is defined in the Soil Screening Guidance on-line at http://risk.lsd.ornl.gov/epa/ssll.htm.

The general PEF value used for 'end-state' receptors, except the National Guard Trainee, is the default value for Cleveland, Ohio assuming a 0.5-acre source area (9.24E+08 m^3/kg). This PEF value was calculated using EPA Soil Screening Guidance on-line at http://risk.lsd.ornl.gov/epa/ssl1.htm.

A smaller PEF value (1.67×10^6) is used for the National Guard Trainee scenario because the activities of this receptor are assumed to generate more dust. The PEF should be calculated from the dust-loading factor (DLF) of 600 ug/m^3 (DOE 1993) as:

PEF = 1/(DLF x Conversion Factor) = 1/(600 ug/m^3 x 1E-09 kg/ug) = 1.67E+06 m^3/kg

The following equation from USEPA RAGS Part B guidance will be used to calculate RGOs for constituents of interest in groundwater (USEPA, 1991b):

C (mg/L; risk-based)   =   [*TL*BW*AT]/EF*ED*[(1/RfDi*K*IRa) + (1/1/RfDo*IRw)]

Where:
C = chemical concentration in water (mg/L)
TL = target level; for noncarcinogens, it has a hazard index (unitless), equal to 1.0; for carcinogens, it is the acceptable risk level equal to (10^{-4}, 10^{-5}, or 10^{-6}.)
*RfDo = oral chronic reference dose (mg/kg-day, chemical specific)
*RfDi = inhalation chronic reference dose (mg/kg-day, chemical specific)
BW = Body Weight (kg, see Table-5)

AT = Averaging Time (days, see table-5)
EF = Exposure Frequency (days/yr, see table-5)
ED = Exposure Duration (years, see table-5)
IRa = Daily Indoor Inhalation rate (m^3/day, see Table-5)
IRw = Daily water Ingestion Rate (L/day, see table-5)
K = Volatilization Factor (unitless, 0.0005*1000 L/m^3)

The equation is essentially the same for carcinogenic constituents, with only the parameters with asterisks (*) changed. In addition to the carcinogenic target level previously discussed, the carcinogenic equation would substitute the chemical-specific slope factor (SF) for the '1/RfD' terms.

Please note the aforementioned equation considers the potential exposure routes due primarily to direct ingestion and to inhalation of volatiles from household water use. For other than household a different volatilization factor is required, most likely developed via a "box model". The derivation of any volatilization factor will require that the model be developed in consultation with the Ohio EPA.

8.0 UNCERTAINTY ANALYSIS

This section briefly introduces the evaluation of uncertainties inherent in the RA process. Uncertainty is a factor in each step of the exposure and toxicity assessments presented in the preceding sections. Uncertainties associated with earlier stages of the process become magnified when they are concatenated with other uncertainties in the latter stages of the process. Such uncertainty includes variations in sample analytical results, the values of variables used as input to a given model, the accuracy with which the given model itself represents actual environmental processes, the manner in which the exposure scenarios are developed, and the high-to-low dose and interspecies extrapolations for dose response relationships. It is not possible to eliminate all uncertainty; however, a recognition of the uncertainties is fundamental to the understanding and reasonable use of HHRA results.

Generally, HHRAs carry two types of uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements, e.g., instrument uncertainty (accuracy and precision) associated with contaminant concentrations. The results of a RA reflect the accumulated variances of the individual measured values used to develop it. A different kind of uncertainty stems from data gaps, i.e., additional information needed to complete the database for the assessment. Often, the data gap is significant, such as the absence of information on the effects of human exposure to a chemical or on the biological mechanism of action of an agent (EPA, 1992c).

In many cases the added effort described in this paragraph does not improve the decision being made at the site. If Monte Carlo analysis is performed it would require a separate work plan detailing parameter distributions. EPA (1992c) guidance on HHRA urges risk assessors to address or provide descriptions of individual risk to include the 'high

end' portions and 'central tendency' of risk distribution. Therefore, if either cancer or non-cancer risk exceed generally acceptable limits (cancer risk more than 10E-4 or target organ-specific HI more than 1), the risk calculations *may be requested for reevaluation* using central tendency (CT) values for as many intake model variables as possible. A quantitative uncertainty analysis <u>may</u> be performed for cancer risks exceeding 1E-6 and HQs exceeding 1, on those chemicals that drive the site- related results. The Monte-Carlo simulation technique (EPA 1994e) <u>may</u> be used to perform the uncertainty analysis. Monte-Carlo is a statistical simulation technique whereby distributions of risks and/or HQs caused by input variable distributions can be analyzed. The results of this analysis will illustrate how the variability and uncertainty in input variables affect the site risks and/or HQs. The distributions for the input parameters will be determined from appropriate EPA guidance and/or published literature.

9.0 PREPARE DRAFT REPORT OUTLINING THE FINDINGS OF THE BASELINE RISK ASSESSMENT TO INCLUDE THE FOLLOWING:

Please note that while a format for the risk assessment report is presented below it is recommended that reference be made to: Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting and Review of Superfund Risk Assessments) Final December 2001
http://www.epa.gov/superfund/programs/risk/ragsd/

Section 1.0 - Executive Summary
Section 2.0 - Introduction
Section 3.0 - Data Evaluation
Section 4.0 - Exposure Analysis
Section 5.0 - Toxicity Analysis
Section 6.0 - Risk Characterization
Section 7.0 - Uncertainty Analysis
Section 8.0 - Risk Assessment Summary (Punch-lines)
Section 9.0 - References

10.0   References

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