Naval Facilities Engineering Systems Command Washington
Washington, D.C.

Final

Engineering Evaluation and Cost Analysis Report
Munitions Response Site UXO-002, Former Small Arms Ranges, OU-2 Former Skeet Ranges

Naval Air Station Patuxent River
St. Mary's County, Maryland

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August 2024

Prepared for NAVFAC Washington
by CH2M HILL, Inc.
Reston, Virginia
Contract N62470-16-D-9000
CTO N4008020F5208

Executive Summary

This Engineering Evaluation and Cost Analysis (EE/CA) was prepared by CH2M HILL, Inc., a wholly owned subsidiary of Jacobs, under Naval Facilities Engineering Systems Command (NAVFAC) Atlantic's Comprehensive Long-term Environmental Action–Navy (CLEAN) Contract Number N62470-16-D-9000, Contract Task Order N4008020F5208 for submittal to NAVFAC Washington.

This EE/CA evaluates potential response actions at Operable Unit (OU)-2 (Former Skeet Ranges) of Munitions Response Site UXO-002 (Former Small Arms Ranges) at Naval Air Station (NAS) Patuxent River, St. Mary's County, Maryland. The EE/CA is for a Non-time Critical Removal Action to address unacceptable risk in soil at OU-2, Former Skeet Ranges (FSR).

UXO-002 consists of three former Small Arms Ranges, including one former Pistol Range (OU-1) and two former Skeet Ranges (OU-2), all in the northwestern portion of NAS Patuxent River. The FSR, which are adjacent to each other and north of the intersection of Cedar Point Road and Sully Road, were reportedly used for training between approximately 1943 and 1993. Although details about the construction and use of the FSR are not available, typical skeet ranges consist of multiple shooting positions along a semicircular boundary. Clay targets are typically launched into the air from "houses" at each of the open ends of the semicircular feature; fragments of the clay targets fall to the ground after being shot.

The EE/CA aims to present the removal action objectives (RAOs), identify removal action alternatives that satisfy those objectives, and evaluate the effectiveness, implementability, and cost of those alternatives. The RAO for OU-2 is as follows:

- **Prevent Unacceptable Human Health and Ecological Exposure:** Prevent the exposure of human and ecological receptors to concentrations of contaminants in soil that pose an unacceptable risk across all current and potential future complete exposure pathways.

Based on the results of soil, sediment, and groundwater sampling conducted during the 2010 Site Inspection and 2018 to 2020 Remedial Investigation (RI) field events, along with the Human Health Risk Assessment and Ecological Risk Assessment evaluations documented in the RI, polycyclic aromatic hydrocarbons (PAHs) in soil were identified as posing potentially unacceptable risk to future residents, and lead and PAHs in surface soil in an isolated area near the northern FSR were identified as posing potentially unacceptable risk to lower trophic level ecological receptors (soil invertebrates and potentially terrestrial plants). Potentially unacceptable human health and ecological risks were not identified in sediment and groundwater. Based on these conclusions, groundwater, surface water, and sediment are not part of this EE/CA.

To satisfy the RAO, the following three removal action alternatives were identified and evaluated:

- **Alternative 1—No Action**: No action would be conducted, and the site would be left as is. This alternative was included because the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires a no action alternative be included as a baseline against which to compare the performance and effectiveness of the other alternatives.

- **Alternative 2—Stabilization and Engineered Cover with Land Use Controls (LUCs)**: Excavation and onsite stabilization of impacted soil exceeding the remedial goals (RGs) for lead and PAHs and constructing an engineered, evapotranspiration soil cover over the stabilized soil mixture to eliminate human and ecological exposure and prevent surface water from percolating into the stabilized soil mass and underlying groundwater at OU-2. LUCs will be implemented to control potential exposure to the stabilized soil and ensure compatible land usage. Operations and maintenance (O&M) will be conducted to verify continued effectiveness and protectiveness of the alternative, including maintenance of the engineered cap, LUC maintenance (such as sign maintenance, administrative reviews, and annual inspections), and routine monitoring of site conditions. Annual inspections and Five-Year Reviews for a period of 30 years are anticipated for this remedy.

- **Alternative 3—Removal Acton with Stabilization and Offsite Disposal**: Excavation and onsite stabilization of impacted soil exceeding the RGs and offsite disposal of the stabilized soil mixture in a permitted Resource Conservation and Recovery Act Subtitle D landfill to eliminate human and ecological exposure at the FSR. No LUCs or O&M are required for this alternative.

Alternative 1 does not meet the objective of the RAO; however, it is provided as a basis for comparison, as required by the NCP. Alternatives 2 and 3 are comparable in their ability to protect human health and the environment, to achieve the RAO, ease of implementability, and compliance with applicable or relevant and appropriate requirements.

Alternative 3 is more implementable and technically feasible, and the removal action is expected to be completed in less than 1 year. Administrative feasibility and the availability of resources are expected to be similar for Alternatives 2 and 3. Alternatives 2 and 3 are comparable in cost over an estimated 30-year timeline. Alternative 3 requires an estimated $11,000 less in initial capital costs and has approximately $9,000 additional future costs. Alternative 2 requires approximately $940,000 more than Alternative 3 in O&M and periodic costs for LUCs and Five-Year Reviews. Relative to each other, Alternative 2 is considered more sustainable than Alternative 3.

Based on the evaluation of tradeoffs between the alternatives, the recommended removal alternative for OU-2, FSR is ***Alternative 3: Removal Action with Stabilization and Offsite Disposal.***

Alternative 3 results in the removal of impacted soil from OU-2, provides for unlimited use/unrestricted exposure, and does not require inspection, maintenance, or monitoring activities to ensure long-term protectiveness of human health and the environment. The Department of the Navy, U.S. Environmental Protection Agency, and Maryland Department of the Environment representatives were involved with developing the recommended alternative through the Tier I Partnering Team process.

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Acronyms and Abbreviations

°F	degree(s) Fahrenheit
µg/kg	microgram(s) per kilogram
bgs	below ground surface
ARAR	applicable or relevant and appropriate requirements
Bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CH2M	CH2M HILL, Inc.
COC	constituent of concern
COPC	constituent of potential concern
CSM	conceptual site model
Eco-SSL	ecological soil screening level
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERS	ecological risk screening
FS	Feasibility Study
FSR	Former Skeet Ranges
HHRA	human health risk assessment
HHRS	human health risk screening
HMW	high molecular weight
LMW	low molecular weight
LTM	long-term monitoring
LUC	land use control
MCL	maximum contaminant level
MDE	Maryland Department of the Environment
mgd	million gallon(s) per day
mg/kg	milligram(s) per kilogram
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Systems Command
Navy	Department of the Navy
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NTCRA	Non-time Critical Removal Action

O&M	operations and maintenance
OU-1	Operable Unit 1
OU-2	Operable Unit 2
PAH	polycyclic aromatic hydrocarbon
RAO	remedial action goals
RG	remediation goal
RI	Remedial Investigation
SI	Site Inspection
SVOC	semivolatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
U.S.C.	United States Code

SECTION 1

Introduction

This Engineering Evaluation and Cost Analysis (EE/CA) was prepared by CH2M HILL, Inc. (CH2M), a wholly owned subsidiary of Jacobs, under Naval Facilities Engineering Systems Command (NAVFAC) Atlantic's Comprehensive Long-term Environmental Action–Navy (CLEAN) Contract Number N62470-16-D-9000, Contract Task Order N4008020F5208 for submittal to NAVFAC Washington.

This EE/CA evaluates potential removal actions at Operable Unit 2 (OU-2), Former Skeet Range of Munitions Response Site UXO-002 (Former Small Arms Ranges) at Naval Air Station (NAS) Patuxent River, St. Mary's County, Maryland. This EE/CA presents potential removal actions for a Non-time Critical Removal Action (NTCRA) to address unacceptable risk in soil at OU-2.

NAS Patuxent River is at the confluence of the Patuxent River and Chesapeake Bay in St. Mary's County, Maryland (Figure 1). NAS Patuxent River began operating in 1942. Since its inception, NAS Patuxent River has been one of the main centers for testing naval aircraft and equipment for the Navy. OU-2 is owned by the Navy under the operational control of NAS Patuxent River (Figure 2).

1.1 Regulatory Framework

This document was prepared under the authority of the Navy in accordance with the January 1987 Executive Order 12580. This Executive Order delegated the President's authority under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act to federal agencies such as the Department of Defense and the Navy. As a result, the Navy was given responsibility for conducting response actions to cleanup actual or potential releases of hazardous substances, pollutants, or contaminants at its facilities. Section 104 of CERCLA allows an authorized agency to remove or arrange for removal and provide for remedial action relating to hazardous substances, pollutants, or contaminants at any time, or take any other response measures consistent with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) as deemed necessary to protect public health or welfare and the environment.

The NCP, Title 40 of the Code of Federal Regulations (CFR), Part 300.415, provides regulations specific to removal actions and requires the lead agency to conduct an EE/CA when an NTCRA is planned for a site. The NCP defines a removal action as:

> "…cleanup or removal of released hazardous substances from the environment, such actions as may be necessary to monitor, assess, and evaluate the threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release."

The EE/CA aims to present the removal action objectives (RAOs), identify removal action alternatives that satisfy those objectives, and evaluate the effectiveness, implementability, and cost of those alternatives. An EE/CA, therefore, documents the removal action alternatives and evaluation process. Where contamination is well-defined and limited in extent, NTCRAs also allow for the expedited cleanup of sites in comparison to developing a Feasibility Study and Record of Decision. This EE/CA has been prepared in accordance with *Guidance on Conducting Non-Time Critical Removal Actions under CERCLA* (EPA, 1993).

The NCP requires a 30-day public comment period for the alternatives presented in the EE/CA. An announcement of the 30-day public comment period is required in a local newspaper. All documents supporting the NTCRA are placed in the Administrative Record. The Administrative Record contains information about CERCLA activities at NAS Patuxent River. Written responses to comments are summarized in an Action Memorandum, signed by the Navy, and placed within the Administrative Record to document the selected removal action for the site.

The Navy, U.S. Environmental Protection Agency (EPA) Region 3, and the Maryland Department of the Environment (MDE) jointly issue this document.

1.2 Objectives of the Engineering Evaluation/Cost Analysis

This EE/CA discusses the development and comparison of three removal action alternatives, based on the following criteria:

- Effectiveness
- Implementability
- Cost

The objectives of this EE/CA are the following:

- Satisfy environmental review and public relations requirements for removal actions.
- Satisfy administrative record requirements for documenting the removal action selection.
- Establish RAOs and provide a framework for evaluating and selecting removal action alternatives to achieve those objectives.

1.3 Organization of the Engineering Evaluation/Cost Analysis

This EE/CA is divided into the following sections:

- **Section 1: Introduction**. This section explains the purpose, regulatory framework, and organization of the EE/CA.
- **Section 2: Site Characterization**. This section provides the descriptions, history, environmental setting, current and future land uses, previous investigations, and risk evaluation summary for the Former Skeet Ranges (FSR).
- **Section 3: Removal Action Objective, ARARs, and Media of Interest.** This section describes the objectives and scope of the removal action, as well as the applicable or relevant and appropriate requirements (ARARs).
- **Section 4: Description of Removal Action Alternatives**. This section describes the removal action alternatives.
- **Section 5: Assessment of Removal Action Alternatives.** This section compares the removal action alternatives through evaluation against effectiveness, implementability, and cost criteria.
- **Section 6: Recommended Removal Action Alternative**. This section recommends a removal action alternative based on the evaluation and comparative analysis described in **Section 5**.
- **Section 7: References**. This section presents references used to prepare this EE/CA

SECTION 2

Site Characterization

This section presents information that forms the basis for the site characterization. This information, which includes a site description, history, previous investigations, and conceptual site model (CSM) at the FSR, is based on the Site Inspection (SI) Report (CH2M, 2013) and the Final Remedial Investigation (RI) (CH2M, 2023). This section also includes a summary of the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) performed for the RI.

2.1 Site Description and Background

NAS Patuxent River is in St. Mary's County, Maryland, at the confluence of the Patuxent River and Chesapeake Bay (Figure 1). Since its inception in 1942, NAS Patuxent River has been one of the main centers for flight testing, pilot training, and development of weapons and avionics systems and radar applications for the Navy (General Physics Corporation, 1996). NAS Patuxent River was listed on the National Priorities List on June 30, 1994, and assigned EPA Identification No. MD7170024536. In December 2000, the Navy and EPA signed a Federal Facility Agreement. As part of the Federal Facility Agreement , the Navy formally identified Environmental Restoration Program sites at NAS Patuxent River requiring investigation and potential remediation under CERCLA.

The FSR (OU-2) are part of Munitions Response Site UXO-002, Former Small Arms Ranges (Figure 2). The FSR are north of the intersection of Cedar Point Road and Sully Road adjacent to the Former Pistol Range, which is referred to as Operable Unit 1 (OU-1).

Review of aerial photographs suggests use of the FSR began between 1943 and 1952 (a semicircular feature for skeet range shooting positions is visible on the 1952 aerial photograph but not on the 1943 photograph). The firing lines are still visible on the 1964 aerial photograph, but they appear overgrown and were purportedly out of use by that time. Although details about the construction and use of the FSR are unavailable, typical skeet ranges consist of multiple shooting positions along a semicircular boundary. Clay targets are typically launched into the air from "houses" at each of the open ends of the semicircular feature; fragments of the clay targets fall to the ground after being shot. A conceptual model of a typical skeet range illustrating what is believed to have been the former general layout and use of the FSR is provided on Figure 3.

The positions of the shooters along the semicircular firing line and the angles at which skeet targets are thrown results in a fan-shaped shotfall zone. Depending on the load, the angle at which the shot was fired, and the wind direction, typical lead skeet loads can reach approximately 680 feet from the shooter, with the highest density of shotfall expected between 375 to 600 feet from the shooter (ITRC, 2003). At the FSR, the direction of fire was toward the Patuxent River, and the highest density of shotfall would be expected to be in the river, while the clay target fragments would be expected to be on the terrestrial portion of the range and possibly the near-shore area in front of the range.

Potential munitions constituents typically consist of lead from the lead shot used in the shotguns and polycyclic aromatic hydrocarbons (PAHs) from the tar pitch used to hold the clay targets together. Lead is the primary constituent of small arms projectiles (more than 85 percent of the weight of the projectile) and constitutes the greatest environmental concern (ITRC, 2003). Small percentages of other metals such as antimony, arsenic, copper, and zinc may be present in specific types of projectiles; therefore, these metals may also be present at small arms ranges and are anticipated to be co-located with lead, which is the primary risk driver. As a result, characterizing the site for lead is anticipated to provide a conservative estimate of the nature and extent of the other metals.

2.1.1 Physiology, Topography, and Climate

The Patuxent River Basin occupies approximately 930 square miles and receives drainage from seven counties in Maryland. Near NAS Patuxent River, the river is estuarine, so tidal action overrides stream flow and is a major influence on river stage and stream velocity. Average flow in the Patuxent River at the Installation ranges from 620 to 876 million gallons per day (mgd), with a low flow between 36 and 94 mgd and a high flow between 4,000 and 4,550 mgd (Fred C. Hart Associates, Inc., 1984).

The drainage divide between the Potomac River and the Patuxent River closely follows Route 235, which borders portions of NAS Patuxent River to the southwest. Most streams draining to the Installation originate on the northeastern side of Route 235. Streams that originate on the Installation stay within the facility boundaries until draining directly or indirectly into the Patuxent River or Chesapeake Bay.

Surface drainage at NAS Patuxent River is to short streams that dissect the upland plateau. The streams occupy small valleys that descend rapidly toward the Patuxent River and Chesapeake Bay. Flow in these streams typically is intermittent, but several streams have continuous flow and discharge into ponds, the Patuxent River, or Chesapeake Bay. The largest stream on the Installation is Pine Hill Run (PHR), which flows along the base of the upland plateau. Both upland and lowland habitats drain into PHR, which is shallow and drains toward Chesapeake Bay (Fred C. Hart Associates, Inc., 1984).

Most of NAS Patuxent River is on a generally flat plain that protrudes into the Chesapeake Bay at the mouth of the Patuxent River. Elevations in the lowland areas range from sea level to 40 feet but are typically less than 20 feet. Elevations refer to North American Vertical Datum of 1988 (NAVD88). Units are in U.S. survey feet. In the southwestern part of NAS Patuxent River, the land rises to an upland plateau, where elevations range from 40 to 120 feet. The area of the FSR is relatively flat, with a shallow slope toward the river (Figure 4).

The climate of St. Mary's County is moderated by its proximity to Chesapeake Bay and the Atlantic Ocean. The climate is predominantly continental and characterized by seasonal and daily fluctuations. According to the Maryland State Office of Climatology, the average winter temperature is 36.6 degrees Fahrenheit (°F), whereas the average summer temperature is 74.9°F. The warmest and coldest months of the year are July (mean temperature of 77°F) and January (mean temperature of 35.5°F), respectively.

Annual precipitation averages 42 inches. July is typically the wettest month of the year, averaging 4.8 inches of precipitation. October is the driest month of the year, averaging 2.7 inches of precipitation. In general, precipitation is distributed evenly throughout the year.

2.1.2 Surface Water Hydrology

Surface water drainage channels were not observed at the FSR or in the surrounding area. Surface water drainage near the FSR would be expected to drain toward the Patuxent River. As shown on Figure 4, the theoretical shotfall zone for the FSR extends into the adjacent Patuxent River.

2.1.3 Geology

Based on observations made by General Physics Corporation during the 1996 sampling event for OU-1, surface soil near the FSR consists of unnamed Holocene formations deposited by the Patuxent River and Chesapeake Bay. These lowland deposits were characterized as poorly sorted gravelly sands to well sorted sands and are believed to range from 3 to 20 feet thick. Similar geology was observed during the 2020 monitoring well installations in support of the RI at the FSR. The Holocene deposits lie unconformably on the Upper Pleistocene Omar Formation. The Omar Formation consists of predominantly sandy clay and clayey sand and is believed to range in thickness from 10 feet to 50 feet.

At adjacent Site 1, previously installed wells encountered the St. Mary's Formation at depths ranging from 45 to 65 feet below ground surface (bgs).

2.1.4 Hydrogeology

The FSR is adjacent to the shoreline of the Patuxent River. Historical groundwater elevations, measured during prior investigations at a former landfill (Site 1) north of the FSR, indicate the primary groundwater flow direction is west and north toward the Patuxent River. Groundwater gauging data collected in April 2020 and June 2020 from seven monitoring wells installed during the RI field efforts also indicate a groundwater flow direction toward the Patuxent River; based on similarities between the two gauging efforts, only the June 2020 results are illustrated (Figure 5). Groundwater flow volume calculations documented in the 1998 RI Report for Sites 1 and 12, northeast of the FSR, suggest groundwater discharging into the Patuxent River is diluted approximately 10,000 times upon discharge (CH2M, 1998).

2.1.5 Ecological Setting

A site visit to observe the ecological setting was performed on February 19, 2009. Based on field observations, open grassy upland currently comprises the primary habitat in the areas of the FSR where shooting occurred. The gravel access road for the 2007/2008 Area E Excavation (discussed in Section 2.3.1) is also present in these areas, as shown on Figure 4. Because the grass and weeds around the FSR are still regularly maintained by mowing, there is limited refuge offered for upper trophic level receptors (such as birds, mammals, reptiles, and amphibians). However, this area is expected to maintain significant populations of soil invertebrates and provides foraging space for numerous upper trophic level receptors, especially because of its proximity to the Patuxent River and adjacent strip of heavily vegetated habitat to the west of the FSR and along the Patuxent River, which consists of a mixture of woodland, scrub/shrubland, and edge habitats. Including vegetated land within the shotfall zone but excluding the previous removal area at the former Rifle Range (northeast of the FSR, as shown on Figure 4), this area is approximately 7 acres in size. Minimal wildlife was observed during the site visit, but a wide variety of wildlife, such as birds, mammals, reptiles, amphibians, and invertebrates, are expected to live in or use habitats as that observed at the FSR. These types of habitats support a mixture of upland plant species that also frequently occur in various locations in the area (such as red cedar, multi-flora rose, blackberries, arrowwood, goldenrod, golden bamboo, red maple, persimmon, white pine, black cherry, sweet gum, mulberry, American holly, northern bayberry, autumn olive, sea myrtle, trumpet vine, and poison ivy).

As previously mentioned, the Patuxent River is directly adjacent to the FSR and within the theoretical shotfall zone. This river is one of the most significant aquatic habitats at NAS Patuxent River. Because of the proximity to Chesapeake Bay, the river is a slightly brackish, tidally influenced water body. Significant populations of aquatic biota occur within the river, including fish, benthic macroinvertebrates, and other invertebrates. Furthermore, wildlife such as raccoon, heron, or ducks are expected to reside close to the river and use it for foraging, especially in the shallow area of the river where it meets land (littoral zone).

2.1.6 Cultural and Historical Resources

Prehistoric use of the Patuxent River and Lexington Park area was generally light, and before the arrival of Europeans, the region of the lower Patuxent River was occupied by a variety of Algonquin groups (Ecology and Environment, 1996). The first English colony in Maryland was established in 1634 at the mouth of the St. Mary's River. The regional economy was based on tobacco farming throughout the seventeenth and eighteenth centuries. The area remained primarily agricultural in the nineteenth century, with the first major commercial fishery on the Patuxent River established at Solomon's Island in 1867. Small shoreline communities sprang up as the maritime industry was developed.

Naval development of the area began after the construction of a Flight Test Center, authorized by the Secretary of the Navy on December 22, 1941, with subsequent site commissioning on April 1, 1943. As the flight-testing program expanded, the U.S. Naval Test Pilot School was established in 1958. Test facilities were upgraded in the late 1970s, and in 1975, the Naval Air Test Center began to assume its role as the Naval Air Systems Command's principal site for development testing. Beginning in 1991, the Navy began consolidating its technical capabilities, in part with the relocation of the Naval Air Warfare Center to NAS Patuxent River and construction of new state-of-the-art laboratories, test facilities, the U.S. Naval Test Pilot School academic building, and the Aviation Survival Training Center.

Several pre–World War II-era structures remain standing at NAS Patuxent River (Ecology and Environment, 1996), including the Mattapany, the Trimble house, the Bell house, the Chapel, and early twentieth century farmhouses and summer homes. No cultural or historical resources have been identified at the FSR.

2.1.7 Current and Potential Future Land and Resources

The FSR are currently unused. Review of aerial photographs suggests use of the FSR began between 1943 and 1952. The firing lines are visible on the 1964 aerial photograph but appear overgrown and were purportedly out of use by the time the 1984 aerial photograph was taken. There are currently no structures related to the FSR. The western portions of the FSR are primarily wooded; the eastern portions are primarily grass covered.

Access to the FSR is unrestricted (other than being within the NAS Patuxent River boundaries, which are restricted to authorized personnel and visitors). Before entering the area, visitors to the former ranges are required to check in with NAS Patuxent River personnel at the Former Engine Test Facility. The Navy's objective is to achieve unrestricted use of the area occupied by UXO-002, including the FSR; however, there are no current plans for development, and future land use of the property is unknown at this time.

2.2 Conceptual Site Model

The CSM relates potentially exposed human and ecological receptor populations with potential source areas based on physical site characteristics and complete exposure pathways. Important components of the CSM are the identification of potential source areas, transport pathways, exposure media, exposure pathways and routes, and receptor groups. Actual or potential exposures of human health and ecological receptors associated with a site are determined by identifying the most likely, and most important, pathways of contaminant release and transport.

Actual or potential exposures of receptors are identified by identifying the most likely and most important pathways of contaminant release and transport. A complete exposure pathway has three components: (1) a source of constituents resulting in a release to the environment, (2) a pathway of constituent transport through an environmental medium, and (3) an exposure or contact point for human and ecological receptors.

The main objective of the CSM is to identify any complete and critical exposure pathways that may be present. Potentially complete and primary exposure pathways exist for human and ecological receptors at the FSR. Figure 3 presents a typical skeet range layout, and Figure 6 presents information pertinent to the CSM for the FSR. The following subsections discuss and present key human health and ecological components of the CSM. The CSM can be used to support potential risk management decisions and aid in evaluating the effectiveness of remedial alternatives, if necessary.

2.2.1 Potential Source Areas and Affected Media

Based on historical site background information, the primary source of potential contamination at the FSR is believed to be shotgun pellets (lead shot) and clay target fragments**.** A potential secondary source of contamination is believed to be soil in the impact and shotfall areas, which is potentially contaminated by constituents associated with shotgun pellets and clay targets used during previous shooting activities. These items potentially could release metals (lead, antimony, arsenic, copper, tin, and zinc) or PAHs (associated with tar pitch typically used to bind clay targets at skeet ranges) to soil/sediment via direct deposits and groundwater via leaching. Lead is typically considered the primary constituent of concern (COC) at shotgun range sites based on its prevalence and risk-driving potential (ITRC, 2003); concentrations of other metals and PAH compounds are expected to be collocated with lead. Although the theoretical shotfall zones associated with the FSR extend into the Patuxent River, if shot landed in the river when these ranges were in use, it is likely it is substantially buried in the sediment because of the dynamic nature of the river. However, investigation activities focused on onshore soils and offshore sediments (including shotgun pellet counts) to adequately characterize the Patuxent River sediments as a potential source area.

An RI at Site OU-2 conducted between 2018 and 2020 consisted of sampling surface and subsurface soil, surface and subsurface sediment, and groundwater**.** The RI was conducted to characterize the nature and extent of lead and PAHs in soil, sediment, and groundwater that may pose unacceptable risk to human health and the environment. Based on the findings of the RI, soil associated with portions of the FSR were identified as requiring action. As discussed in Section 2.4, groundwater and sediment were not identified in the RI as requiring action.

2.2.2 Transport Pathways

A transport pathway describes the release mechanisms whereby site-related constituents, once released, may be transported from a source area to exposure media (such as surface soil) where receptor exposures may occur. These transport pathways are shown on the OU-2 CSM presented on Figure 6. The primary mechanisms for chemical release and transport at the FSR include the following:

- Direct deposit of lead shot and clay target fragments across the shotfall zone into soils in the upland, vegetated, and wetland areas and into sediments of the Patuxent River
- Transport of impacted soil particulates via overland surface runoff to downgradient terrestrial areas or surface water bodies
- Transport of impacted soil particulates via wind- or soil-disturbing activities to surrounding terrestrial areas or surface water bodies
- Uptake by biota from soil (for example, vegetation, soil invertebrates) and trophic transfer to upper trophic level receptors (for example, birds and mammals)
- Surface runoff from the FSR to the Patuxent River
- Particulate emission emanating from surface soil to ambient air

2.2.3 Exposure Pathways

An exposure pathway links a source with one or more receptors through exposure via one or more media and exposure routes. Exposure, and thus potential risk, can only occur if complete exposure pathways exist. Potentially complete exposure pathways exist for human and ecological receptors at OU-2.

2.2.3.1 Human Receptors

Access to the FSR is not restricted, and humans can be exposed to site soil, surface water, and sediment under current and future exposure scenarios and potentially to groundwater under future exposure scenarios. Potential current receptors include industrial workers and trespassers/visitors exposed to surface soil through incidental ingestion, dermal contact, and inhalation. Potential future receptors include the current receptors and construction workers and, assuming hypothetical future development for residential use, future residents exposed to surface and subsurface soil through incidental ingestion, dermal contact, and inhalation. Future residential use is considered unlikely; however, future residential use was evaluated because the residential exposure scenario is the most conservative scenario and used to assess unrestricted land use. Future receptors could be exposed to surface soil and subsurface soil if future development activities occur at the site (such as future construction of residential housing or industrial buildings), or if piping or excavation work results in exposure to subsurface soil.

Shallow groundwater is not used as a water supply at NAS Patuxent River because the Base water supply is obtained from deep confined aquifers (that is, greater than 500 feet bgs). However, future residential exposure to groundwater was evaluated as the most conservative scenario for human exposure to site-related constituents to assess risks associated with unrestricted future land use. Hypothetical future residents could be exposed to shallow groundwater used as a potable water supply through ingestion, dermal contact, and inhalation of volatile compounds while showering/bathing. Additionally, future construction workers could be exposed to shallow groundwater in an excavation during construction activities because the depth to groundwater is within 10 to 15 feet of the ground surface through dermal contact and inhalation of volatile compounds during excavation and construction activities.

2.2.3.2 Ecological Receptors

Based on the ecological setting at the FSR, ecological receptors are expected to be supported by the habitats present on or adjacent to the site (open grassy upland near the skeet ranges and a mixture of woodland, scrub/shrubland, and edge habitats along the edge of the adjacent Patuxent River). In additional to an array of terrestrial plants, the terrestrial portions of the site are expected to support a diversity of soil invertebrates (for example, insects, spiders, and earthworms) and wildlife such as birds, mammals, reptiles, and amphibians that most likely live, take refuge, or forage within these areas. A diversity of aquatic biota is also expected to reside in the river, such as benthic macroinvertebrates (for example, aquatic insects, worms, and crustaceans), as well as fish and amphibians. Furthermore, wildlife such as birds and mammals are also likely using the river for foraging and as a drinking water source.

Based on the presence of the terrestrial and aquatic habitats, potentially complete exposure pathways exist for ecological receptors (plants, invertebrates, amphibians, birds, and mammals); however, surface water and groundwater are not media of concern. For lower trophic receptors, the primary exposure route is direct exposure to contaminated surface soil (terrestrial plants and soil invertebrates), surface water (aquatic plants, fish, invertebrates, and amphibians), and sediment (aquatic plants, fish, benthic macroinvertebrates, and amphibians). For plants, additional exposure can occur through roots during water and nutrient uptake. For upper trophic level receptors (birds and mammals), potential exposures can occur via the following:

- Incidental ingestion of contaminated abiotic media (soil or sediment) during feeding activities
- Ingestion of contaminated water
- Ingestion of contaminated plant or animal tissues for bioaccumulative constituents that have entered food webs
- Direct (dermal) contact with contaminated abiotic media

2.3 Previous Investigations

Previous investigations and remedial actions relevant to the FSR include an RI, Feasibility Study (FS), and remedial action conducted at adjacent Sites 1 and 12 (commonly referred to as Area E) from 1996 to 2008 and an SI conducted at the FSR in 2010.

The following sections summarize the activities and results of these previous investigations at OU-2.

2.3.1 Area E Remedial Investigation, Feasibility Study, and Remedial Action (1996 – 2008)

Sites 1 (Fishing Point Landfill) and 12 (Landfill Behind the Rifle Range) are in the northern portion of the Installation, adjacent to the Patuxent River and immediately north of the FSR. Sampling completed in Area E overlaps into the FSR shotfall area (Figure 4). Area E consists of approximately 2.5 acres of freshwater wetlands, and investigations targeted a former rifle range southeast of Area E and east of the FSR. The former rifle range, used for rifle training and target practice from 1943 until the early 1980s, consisted of an impact berm, a forward berm, and a low-lying area between the berms. Because the theoretical shotfall zones associated with the FSR overlap with the area impacted by the former rifle range, the Area E investigations and removal action are summarized in this section.

An RI conducted between 1996 and 1999 at Area E (CH2M, 1998) included sampling and analyses of soil, soil gas, sediment, surface water, and groundwater, in addition to a geophysical survey conducted over 3,850 linear feet along 10 transects to identify subsurface anomalies indicative of the presence of the landfill. Between 1996 and 1997, surface soil, soil gas, sediment, surface water, and groundwater samples were collected and analyzed for total lead and semivolatile organic compounds (SVOCs), which included the full list of PAH compounds. Samples collected from locations within the portion of Area E overlapping the FSR theoretical shotfall zone included one sediment sample, one surface water sample, and four groundwater samples. Between 1998 and 1999, an additional 30 surface soil and 26 subsurface soil samples collected to support the Area E RI were within the theoretical shotfall zone of the FSR and analyzed for total lead or Toxicity Characteristic Leaching Procedure (TCLP) lead.

Overall, RI sampling results demonstrated the wetland sediments and associated surface water in Area E were impacted by lead. The levels of lead detected in the wetland surface water exceeded the federal Ambient Water Quality Criteria. An FS was conducted to identify and evaluate appropriate actions to mitigate the lead contamination at Area E (CH2M, 2005a). The FS recommended the removal of known sources of lead to the Area E wetland, including the presumed source (the former rifle range impact berms) and sediment in the southern portion of the wetland. The selected remedy for Sites 1 and 12 (OU-2 Area E), documented in a Record of Decision in 2005 (CH2M, 2005b), consisted of: (1) excavation, stabilization, and offsite disposal of wetland sediments from an identified hot spot containing lead concentrations of more than the EPA residential soil Regional Screening Level of 400 milligrams per kilogram (mg/kg); (2) excavation, stabilization, and offsite disposal of soil with lead concentrations in excess of 400 mg/kg from the upland area of the wetland (the target area of the rifle range backstop berm); (3) application of a soil amendment to excavated areas to stabilize any residual lead and prevent further migration of residual lead to the wetland from the upland areas (up to 2 percent by volume of Apatite II™ to a depth of 18 inches); and (4) application of a surface layer of Apatite II™ to the remaining (unexcavated) wetland as a preventative measure against any future lead contamination (CH2M, 2005a).

The removal action at Area E was conducted in 2007 and 2008. The total excavated volume of soil and sediment was 5,775 cubic yards, and part of the excavation overlapped the theoretical shotfall zone of the FSR (Figure 4). All wetland areas, which include part of the FSR shotfall area, were backfilled to the original grade and restored to a wetland habitat. The disturbed wetland area was seeded with a wetland seed mix. As shown on Figure 4, the material handling area and gravel access road constructed for the

Area E removal action overlap with features of the FSR. The material handling area, which consisted of a bermed area underlain by an impermeable liner, was used to mix the excavated material with a stabilizing agent before offsite disposal. The material handling area was dismantled when the removal action was complete. The gravel road, which runs through the FSR and consists of 12 inches of Number 1 stone underlain by geotextile, is still present at the site.

2.3.2 Former Skeet Range Site Inspection (2010)

An SI was conducted at the FSR in 2010 (CH2M, 2013) to assess whether past activities at the FSR resulted in a release of munitions constituents to soil. Surface soil samples were collected from 0 to 6 inches bgs using stainless steel trowels and bowls at 26 locations throughout the FSR. Soil was carefully inspected and screened using a Number 10 sieve to remove debris and lead fragments prior to filling the sample containers. Lead fragments and clay target debris were not observed during sieving of samples at the FSR; however, clay target debris was observed in other locations near the FSR.

All samples collected at the FSR were analyzed for total lead. In addition, samples collected from 11 locations were analyzed for PAHs. Because PAHs would have potentially been derived from the skeet targets (material containing PAHs may have been used to bind the clay targets), these samples were in the area immediately west of the former shooting positions, where the clay targets and associated fragments would be expected to fall. Samples collected at four locations were also analyzed for pH, total organic carbon, and grain size to provide a representative measurement of these parameters to evaluate the lead and PAHs data. Three duplicate samples were collected.

Lead was detected at all 26 surface soil sample locations at concentrations ranging from 5.8 mg/kg to 330 mg/kg. The maximum concentration of lead (330 mg/kg) was detected at PX-FSR-SO-22, located in the wooded area immediately west of the northern former skeet range.

A total of 17 different PAH compounds were analyzed and all 17 compounds were detected, with 12 of the PAH compounds detected at all 11 sample locations. The maximum concentration for most PAH compounds was reported in the sample collected at PX-FSR-SO-22. This sample location was placed in the area that, based on typical skeet range setup, may have been directly under the crossing point where a large portion of the fragments from broken clay targets may have fallen. In general, lead and PAHs concentrations were greater in the samples collected from the locations closest to the FSR.

A human health risk screening (HHRS) evaluation performed based on the results of the SI sampling identified seven PAHs, including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene, as constituents of potential concern (COPCs) for human receptors at the FSR in surface soil (CH2M, 2013). Both the maximum detected concentrations and the 95 percent upper confidence limits of these PAHs exceeded the regional screening level for residential soil and the background threshold values. Eight of the 11 locations analyzed for PAHs had concentrations exceeding the human health screening level. Based on the SI data, lead was not identified as a COPC for human receptors at the FSR during the HHRS evaluation.

An ecological risk screening (ERS) evaluation also was performed based on the results of the SI sampling. The ERS evaluated direct exposure risks from range-related constituents (lead and PAHs) for lower trophic level receptors, such as soil invertebrates and terrestrial plant populations. Low molecular weight (LMW) and high molecular weight (HMW) PAHs were identified as ecological COPCs for surface soil at the FSR. Because of the coincidental nature of these constituents when dispersed in the environment and because the ecotoxicological data in the scientific literature are reported in the same manner, the ecological soil screening level (Eco-SSL) guidance recommends PAHs be screened on a cumulative (that is, total) concentration basis for two individual compound subgroupings according to molecular weight (EPA, 2007a). Therefore, compound concentrations were segregated for each sample into the following LMW PAHs and HMW PAHs subgroups:

- LMW PAHs: 2-methylnaphthalene; acenaphthene; acenaphthylene; anthracene; fluorine; phenanthrene; and naphthalene
- HMW PAHs: benzo(g,h,i)perylene; benzo(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; chrysene; dibenzo(a,h)anthracene; fluoranthene; indeno(1,2,3-cd)pyrene; and pyrene

Concentrations of LMW PAHs and HMW PAHs were compared to the corresponding soil invertebrate Eco-SSLs of 29,000 and 18,000 micrograms per kilogram (µg/kg), respectively (EPA, 2007b). There is no PAHs Eco-SSL available for terrestrial plants. Concentrations of both LMW PAHs and HMW PAHs at the FSR exceeded their soil invertebrate Eco-SSLs. The surface soil Eco-SSL exceedances for both LMW PAHs and HMW PAHs occurred in the theoretical shotfall zone immediately west of the FSR firing line. Based on the SI data, lead was not identified as a COPC for ecological receptors at the FSR during the ERS evaluation.

2.4 Risk Assessment

2.4.1 Human Health Risk Assessment

A baseline HHRA was conducted as part of the RI (CH2M, 2021) for Site OU-2 (FSR). The baseline HHRA was conducted using surface soil data collected during the 2010 SI field activities along with surface and subsurface soil, surface and subsurface sediment, and groundwater data collected during the 2018 to 2020 RI field activities. The HHRA evaluated the current and future potential human health risks associated with exposure to site-related constituents in environmental media at the FSR. Based on information provided in Section 2.1.7, current receptors evaluated in the HHRA included industrial workers and trespassers/visitors. Future receptors evaluated in the HHRA included residents, industrial workers, construction workers, and trespassers/visitors.

Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were identified as COCs for soil because they contributed to potentially unacceptable risks to future residents. No unacceptable risks were identified for current industrial workers, current trespasser/visitors, future industrial workers, future construction workers, and future trespassers/visitors. Also, the HHRA did not identify unacceptable risks associated with exposure to sediment or groundwater. The HHRA for the FSR is provided in its entirety as Appendix A.

2.4.2 Ecological Risk Assessment

As part of the RI, separate ERAs were prepared for both the terrestrial habitat (site soil) and aquatic habitat (Patuxent River sediment) associated with OU-2 FSR, included as Appendix B. The terrestrial and aquatic ERAs for the FSR are provided their entirety as Appendix B1 and Appendix B2, respectively. Both ERAs were conducted in accordance with Navy policy for ERAs (CNO, 1999) and Navy guidance for implementing this policy (NAVFAC, 2003). No risks were identified for the aquatic habitat. However, the terrestrial ERA identified lead and HMW PAHs as COPCs for lower trophic level receptors (soil invertebrates and potentially terrestrial plants) in an isolated area near the northern former skeet range (Appendix B1). Therefore, lead and HMW PAHs were carried forward as ecological Step 3A COPCs for lower trophic level receptors.

SECTION 3

Removal Action Objective, ARARs, and Media of Interest

This section presents information that forms the basis for the RAO at the FSR.

3.1 Removal Action Objective

RAOs are specific goals for protecting human health and the environment from risks and hazards associated with site-related contamination. RAOs can be accomplished by ensuring exposure pathways are not completed or reducing concentrations of COCs at exposure points to less than protective concentrations. RAOs define the extent to which sites require cleanup to meet the objectives of protecting human health.

The RAO developed for the FSR is as follows:

- **Prevent Unacceptable Human Health and Ecological Exposure:** Prevent the exposure of human and ecological receptors to concentrations of contaminants in soil that pose an unacceptable risk across all current and potential future complete exposure pathways.

Based on the results of the HHRA and ERA, unacceptable risks from lead and select PAHs in soil may exist at the FSR; therefore, a removal action is warranted to prevent potential exposure to human and ecological receptors.

3.2 Applicable or Relevant and Appropriate Requirements

As set forth in the NCP and EPA guidance, ARARs are either applicable to or relevant and appropriate to a specific response action being implemented at a site based on site-specific conditions (40 CFR 300). The distinctions are critical to understanding the constraints imposed on remedial alternatives by environmental regulations. ARARs can include any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-siting law more stringent than the associated federal standard, requirements, criterion, or limitation. Both the applicable requirements and the relevant and appropriate requirements pertain to a site, to the extent practicable. The definitions of ARARs presented as follows are from the *CERCLA Compliance with Other Laws Manual* (EPA, 1988):

- *Applicable requirements* are standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental law that specifically address a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance, as defined in the NCP, 40 CFR 300.5. For a requirement to be applicable, the removal action or the circumstances at the site must satisfy all the jurisdictional prerequisites of that requirement. Only those state standards identified by a state in a timely manner and more stringent than federal requirements may be considered as applicable requirements.

- *Relevant and appropriate requirements* are standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal and state law that (although not applicable to a hazardous substance, a pollutant, a contaminant, a removal action, or other circumstances at a CERCLA site) addresses problems or situations sufficiently similar to those encountered at the CERCLA site so their use is well suited to a site. Relevant and appropriate requirements also are defined in the NCP (40 CFR 300.5). For example, although

Resource Conservation and Recovery Act regulations are not applicable to closing in-place hazardous waste disposed of before 1980, they may be deemed relevant and appropriate for landfill closure with in-place hazardous substances. Only those state standards identified by a state in a timely manner and more stringent than federal requirements may be considered as relevant and appropriate requirements.

- Other "to be considered" criteria, such as federal and state non-promulgated policy and guidance documents, may also be useful in directing a response action at a site. To be considered criteria are not legally binding and do not have the status of potential ARARs (that is, they have not been promulgated in statutes or regulations). However, if there are no specific ARARs for a chemical or site condition, or if ARARs are deemed insufficiently protective, then guidance or advisory criteria should be identified and used to ensure the protection of human health and the environment.

Three classifications are defined by EPA in the ARAR determination process: chemical-specific, action-specific, and location-specific ARARs.

- *Chemical-specific* ARARs are health- or risk management-based numbers or methodologies that result in the establishment of numerical values for a given media that would meet the NCP "threshold criterion" of overall protection of human health and the environment. These requirements generally set protective cleanup concentrations for the COCs in the designated media or set safe concentrations of discharge for remedial activity. Chemical-specific ARARs may be concentration-based cleanup goals or may provide the basis for calculating such levels. In cases where no chemical-specific ARAR exists, chemical advisories may be used to develop remedial goals.
- *Location-specific* ARARs restrict remedial activities based on the geographic location of the site or characteristics of the surrounding environments. These ARARs are intended to limit activities within designated areas, zones, or regions. Location-specific ARARs may include restrictions on actions within at sensitive or hazard-prone locations such as populated areas; near or within wetlands, floodplains, and protected waterways; or adjacent to known endangered species and associated habitat.
- *Action-specific* ARARs are requirements that define acceptable procedures or technologies related specifically to the type of activity being performed and the hazardous substance being managed. These ARARs control or restrict hazardous substance- or pollutant-related management activities. These controls are considered when specific removal activities are planned for a site.

The project ARARs are summarized in Appendix C.

3.3 Remediation Goals

The remediation goals (RGs) are used to prevent the exposure of human and ecological receptors to COCs and COPCs in soils that pose an unacceptable risk across all current and potential future complete exposure pathways. The selected RG for each COC or COPC is the lower of the human health and ecological risk-based value.

The RGs for at-risk lower trophic level ecological receptors (soil invertebrates and potentially terrestrial plants) are 504 mg/kg for lead and 72,250 µg/kg for HMW PAHs, which are Apparent Effects Threshold values based on site-specific toxicity testing performed for the ERA (Appendix BB1).

Even though lead was not identified as a COC based on the results of the HHRA, it was decided that due to the few exceedances of MDE residential lead screening level, the value of 200 mg/kg would be used as the RG. Additionally, on January 17, 2024, EPA announced updated guidance for lead in residential soil at CERCLA sites. The new guidance recommends screening lead at 200 mg/kg. This value is lower than the ecological RG of 504 mg/kg for lead and, therefore, protective of ecological receptors. The human health RGs for the five HMW PAHs are calculated in Table 3-1 using the results from the HHRA included in the RI (CH2M, 2023) and a target cumulative cancer risk of 1E-04. A summary of the PAH human-health based remediation goals for soil are provided in Table 3-2. The RGs are as follows:

- **Benzo(a)anthracene:** 22,571 µg/kg based on calculated human health risk-based RG
- **Benzo(a)pyrene:** 2,296 µg/kg based on calculated human health risk-based RG
- **Benzo(b)fluoranthene:** 21,464 µg/kg based on calculated human health risk-based RG
- **Dibenz(a,h)anthracene:** 2,296 µg/kg based on calculated human health risk-based RG
- **Indeno(1,2,3-cd)pyrene:** 22,964 µg/kg based on calculated human health risk-based RG
- **Lead:** 200 mg/kg based on MDE and EPA residential soil cleanup level

The human health RGs for PAHs were selected because they are protective of both human health and ecological receptors and meet the criteria. Human health RGs address the protectiveness of ecological receptors because the summed total of the five individual PAHs (71,600 µg/kg) is less than the ecological RGs for summed total HWM PAHs (72,250 µg/kg).

3.4 Media and Areas Requiring Remediation

The media and areas requiring remediation are referred to as the target treatment zones. The target treatment zones are the areas with COCs concentrations exceeding the RGs in surface soil. This has been identified for PAHs and lead in the area immediately adjacent to the west of the FSR, and two areas for lead south and southwest of the FSR. COCs at all three areas go down to a depth of 1 foot bgs (Figure 7).

3.5 Risk Reduction

With the proposed removal of soil with lead and PAH concentrations exceeding the RGs, potential risks to current and future human receptors will be reduced to acceptable levels.

Potential risks to ecological receptors will also be reduced considerably with the removal of soil with lead and PAH concentrations exceeding the RGs. The soil removal would result in risk reductions for lower trophic level receptors (soil invertebrates and potentially terrestrial plants also) to acceptable levels. The post-removal average lead and PAH concentrations for soil would not exceed the RGs of 200 mg/kg for lead and five individual PAH RGs listed in Section 3.3.

3.6 Statutory Limits on Removal Actions

The NCP (40 CFR Part 300.415) dictates statutory limits of $2 million and a 12-month duration for EPA fund-financed removal actions, with statutory exemptions for emergencies and actions consistent with the removal action to be taken. However, this removal action will not be financed with EPA funding. The *Department of the Navy Environmental Restoration Program Manual* (NAVFAC, 2018) does not limit the cost or duration of the removal action; however, cost-effectiveness is a recommended criterion for evaluation of removal action alternatives. No other statutory limit exists for the proposed NTCRA.

Table 3-1. Calculation of Human-Health Based Remediation Goals for Soil
Site UXO-002, OU2 Engineering Evaluation and Cost Analysis
NAS Patuxent River, Maryland

Residential Adult, Noncarcinogenic based RG

Chemical	Exposure Point Concentration[1] (MG/KG)	Hazard Quotient[1] Inh	Ing	Der	Total	RG, HQ=0.1 (mg/kg)	RG, HQ=1.0 (mg/kg)	RG, HQ=3.0 (mg/kg)	Target Organ	Target HQ[2]	RG based on Target HQ
Benzo(a)anthracene	1.6E+01	NA	NA	NA	NA	NA	NA	NA			
Benzo(a)pyrene	1.2E+01	4.2E-03	4.8E-02	2.6E-02	7.8E-02	1.5E+01	1.5E+02	4.6E+02	Developmental	1	1.5E+02
Benzo(b)fluoranthene	2.2E+01	NA	NA	NA	NA	NA	NA	NA			
Dibenz(a,h)anthracene	3.0E+00	NA	NA	NA	NA	NA	NA	NA			
Indeno(1,2,3-cd)pyrene	1.4E+01	NA	NA	NA	NA	NA	NA	NA			

Residential Child, Noncarcinogenic based RG

Chemical	Exposure Point Concentration[1] (mg/kg)	Hazard Quotient[1] Inh	Ing	Der	Total	RG, HQ=0.1 (mg/kg)	RG, HQ=1.0 (mg/kg)	RG, HQ=3.0 (mg/kg)	Target Organ	Target HQ[2]	RG based on Target HQ
Benzo(a)anthracene	1.6E+01		NA	NA	0.0E+00	NA	NA	NA			
Benzo(a)pyrene	1.2E+01		5.1E-01	1.6E-01	6.7E-01	1.8E+00	1.8E+01	5.4E+01	Developmental	1	1.8E+01
Benzo(b)fluoranthene	2.2E+01		NA	NA	0.0E+00	NA	NA	NA			
Dibenz(a,h)anthracene	3.0E+00		NA	NA	0.0E+00	NA	NA	NA			
Indeno(1,2,3-cd)pyrene	1.4E+01		NA	NA	0.0E+00	NA	NA	NA			

Lifetime Resident, Carcinogenic based RG

Chemical	Exposure Point Concentration[1] (MG/KG)	Carcinogenic Risk[1] Inh	Ing	Der	Total	RG, CR=10-6 (mg/kg)	RG, CR=10-5 (mg/kg)	RG, CR=10-4 (mg/kg)	Target Risk[3]	RG based on Target Risk
Benzo(a)anthracene	1.6E+01	2.4E-07	1.0E-05	3.4E-06	1.4E-05	1.1E+00	1.1E+01	1.1E+02	2.0E-05	2.3E+01
Benzo(a)pyrene	1.2E+01	5.2E-09	7.8E-05	2.6E-05	1.0E-04	1.1E-01	1.1E+00	1.1E+01	2.0E-05	2.3E+00
Benzo(b)fluoranthene	2.2E+01	1.3E-06	1.4E-05	4.8E-06	2.0E-05	1.1E+00	1.1E+01	1.1E+02	2.0E-05	2.1E+01
Dibenz(a,h)anthracene	3.0E+00	1.3E-09	2.0E-05	6.6E-06	2.7E-05	1.1E-01	1.1E+00	1.1E+01	2.0E-05	2.3E+00
Indeno(1,2,3-cd)pyrene	1.4E+01	6.3E-10	9.5E-06	3.2E-06	1.3E-05	1.1E+00	1.1E+01	1.1E+02	2.0E-05	2.3E+01

Notes:
For noncarcinogens: RG = (Exposure Point Concentration x Target Hazard Quotient)/ Total Hazard Quotient
For carcinogens: RG = (Exposure Point Concentration x Target Risk)/Total Carcinogenic Risk
1. Exposure point concentrations, hazard quotients, and carcinogenic risks are from the human health risk assessment in the June 2023 *Final Remedial Investigation Report, Munitions Response Site UXO-002, Former Small Arms Ranges, OU-2 Former Skeet Ranges, Naval Air Station Patuxent River, St. Mary's County, Maryland.*
2. Target HQ chosen so that target organ/effect hazards do not exceed 1.
3. Target carcinogenic risk chosen so that total carcinogenic risk does not exceed 10^{-4}.

CR = cancer risk
Der = dermal
HQ = hazard quotient
Inh = inhalation
Ing = ingestion
mg/kg = milligram(s) per kilogram
NA = not applicable/not available
RG = remediation Goal

Table 3-2. Summary of Human-Health Based Remediation Goals for Soil
Site UXO-002, OU2 Engineering Evaluation and Cost Analysis
NAS Patuxent River, Maryland

Soil

Constituent	Residential		Background Concentration (MG/KG)
	RG (MG/KG)	Basis of RG	
Benzo(a)anthracene	2.3E+01	Lifetime Resident, CR = 2.0E-05	1.3E-01
Benzo(a)pyrene	2.3E+00	Lifetime Resident, CR = 2.0E-05	1.7E-01
Benzo(b)fluoranthene	2.1E+01	Lifetime Resident, CR = 2.0E-05	2.9E-01
Dibenz(a,h)anthracene	2.3E+00	Lifetime Resident, CR = 2.0E-05	1.2E+00
Indeno(1,2,3-cd)pyrene	2.3E+01	Lifetime Resident, CR = 2.0E-05	1.9E-01

Soil background concentration is surface soil background threshold value from October 2008 Final,
Facility-Wide Background Study, Naval Air Station Patuxent River, St. Mary's County, Maryland.
Target carcinogenic risk chosen so that total carcinogenic risk does not exceed 10-4.
Gray shading indicates selected PRG.

SECTION 4

Description of Removal Action Alternatives

A range of removal action alternatives have been identified to achieve the RAO and corresponding RGs. The No Action Alternative was included for comparative purposes, per the NCP.

4.1 Alternative 1 – No Action

Alternative 1 provides a baseline against which to compare the performance and effectiveness of the other alternatives. With this alternative, no action would be conducted to address impacted media at the site, and no controls would be implemented to control or monitor potential receptor exposures to site COCs. The area would be left as is, leaving soil in place that may pose unacceptable risks to current and potential future human and ecological receptors. Therefore, in accordance with CERCLA (Section 121[c]), as amended by Superfund Amendments and Reauthorization Act, the site would be reviewed every 5 years. It is assumed the current level of maintenance would be sustained. The No Action Alternative will not meet the RAO.

4.2 Alternative 2 – Stabilization and Engineered Cover with Land Use Controls and Long-term Monitoring

Alternative 2 consists of excavation and removal of soil in three areas with impacted soil exceeding the human health and ecological RGs onsite, stabilizing the impacted soil ex situ, disposing of the stabilized soil mixture in an offsite landfill, and placing an engineered soil cover to eliminate direct human and ecological exposure at the FSR. Figure 7 shows the proposed extent of excavation of Alternative 2. LUCs will be implemented to control potential future exposure to stabilized soil, ensure land usage is compatible with agreed upon land use determinations and remedial design assumptions, warn of potential site dangers, prevent impacted media from being transported offsite, and educate the public of access restrictions. Operations and maintenance (O&M) will be conducted to verify continued effectiveness or protectiveness of the remedial technology and ensure assumptions made during remedy selection remain valid. SiteWise® Version 3.2 (Battelle, 2018) was used to assess the sustainability footprint of this alternative, and the results will be used to help identify optimization opportunities to be considered in the design phase for the selected alternative. "Green" and sustainable remediation best management practices will be evaluated for excavation and considered for inclusion in the remedy.

The major components and assumptions for this alternative are as follows:

- **Excavation**
  - Clear vegetation in forested areas and access roadway planned for excavation.
  - Removal of soil at one area immediately adjacent to the FSR with concentrations of lead and PAHs above RGs; and removal of soil at two smaller areas to the south and southwest of the main area with lead exceeding RGs. The excavation in all three areas would be to a depth of 1 foot bgs and possibly more if overexcavation is needed to reach the RGs (Section 3.3). A total of 1,008 bank cubic yards of soil is estimated for excavation in the largest excavation area (Figure 7).
  - A total of 1,512 loose cubic yards (ex situ volume) has been estimated for the removal action.

  - Erosion and sedimentation controls will be implemented during excavation activities to prevent erosion of contaminated materials and sediment into the adjacent river.
  - The water table at the site is approximately 7 to 9 feet bgs and should not be encountered during excavation; therefore, no dewatering of the soil removal areas has been included.

- **Stabilization**
  - To stabilize lead such that TCLP analysis will characterize the soil as nonhazardous for offsite disposal, mix contaminated soil with 10 percent Portland cement. Then place the soil slurry within an onsite treatment cell to allow it to stiffen into a stabilized soil mass.

- **Engineered Cover**
  - The stabilized mass within the onsite treatment cell will then be covered with an engineered, evapotranspiration soil cover consisting of a minimum of 2 feet of clean soil cover or topsoil to allow for site restoration and revegetation. Imported fill for the "clean soil cover and/or topsoil" will be documented as "certified clean fill" determined by analysis.
  - After final grading, the engineered soil cover will be planted with suitable, native grass species to provide evapotranspiration and minimize erosion. Habitat restoration will consider native species based on the removal action contractor's site restoration plan.
  - The engineered soil cover will be designed to eliminate direct human and ecological exposure and prevent surface water from percolating into the stabilized soil mass and underlying groundwater.

- **Offsite Disposal and Waste Characterization**
  - Collect characterization samples of the stockpiled soils and analyze samples using TCLP to verify the waste is nonhazardous. For cost estimating purposes, it was assumed waste characterization sampling would be conducted at a frequency of 1 sample per 100 cubic yards (four samples) and analyzed using the full TCLP (VOCs, SVOCs, metals, herbicides, mercury, and pesticides), reactivity (cyanide and sulfide), ignitability, and corrosivity.
  - Transport of 3/4 full rolloff containers of nonhazardous, stabilized soil mixture offsite and dispose at a permitted Resource Conservation and Recovery Act Subtitle D landfill.

- **LUCs**
  - LUCs consisting of engineering controls, including signage and institutional controls such as deed restrictions, will be implemented at the FSR. LUCs will be used to control potential future exposure to soil remaining in place with concentrations exceeding human health and ecological RGs, ensure land usage is compatible with agreed upon land use determinations and remedial design assumptions (that is, land use remains industrial), warn of potential site dangers, prevent impacted media from being transported offsite, and educate the public of access restrictions.
  - Annual inspections and Five-Year Reviews for a period of 30 years are anticipated for this remedy.

- **Operation and Maintenance**
  - O&M will focus on verifying the continued effectiveness or protectiveness of the remedial technology and ensuring assumptions made during remedy selection remain valid. O&M will consist of maintenance of the engineered cap, LUC maintenance (such as sign maintenance, administrative reviews, and annual inspections), and routine monitoring of site conditions.

- **Long-term Monitoring (LTM)**

  - LTM generally focuses on verifying the continued effectiveness or protectiveness of the remedial technology and ensuring assumptions made during remedy selection remain valid. LTM consists of maintenance of the engineered cap, LUC maintenance (such as sign maintenance, administrative reviews, and annual inspections), routine review of site conditions, and monitoring of residual contamination through additional soil sampling (if necessary).

4.3 Alternative 3 - Removal Action with Stabilization and Offsite Disposal

Alternative 3 consists of excavation and removal of soil at three areas to eliminate direct human and ecological exposure at the FSR. No LUCs or O&M are required for this alternative because the impacted soil with concentrations exceeding unrestricted use criteria would be removed from the site. SiteWise® Version 3.1 (Battelle, 2018) was used to assess the sustainability footprint of this alternative, and the results will be used to help identify optimization opportunities to be considered in the design phase for the selected alternative. "Green" and sustainable remediation best management practices will be evaluated for excavation and considered for inclusion in the remedy.

The major components and assumptions for this alternative are as follows:

- **Excavation**
  - Clear vegetation in forested areas and access roadway planned for excavation.
  - Removal of soil at one area immediately adjacent to the FSR with concentrations of lead and PAHs exceeding RGs, and removal of soil at two smaller areas to the south and southwest of the main area with lead exceeding RGs. The excavation in all three areas would be to a depth of 1 foot bgs and possibly more if overexcavation is needed to reach the RGs (Section 3.3). A total of 1,008 bank cubic yards of soil is estimated for excavation in the largest excavation area (Figure 7).
  - A total of 1,512 loose cubic yards (ex situ volume) has been estimated for the removal action.
  - Erosion and sedimentation controls will be implemented during excavation activities to prevent erosion of contaminated materials and sediment into the adjacent river.
  - The water table at the site is approximately 7 to 9 feet bgs and should not be encountered during excavation; therefore, no dewatering of the soil removal areas has been included.
- **Post-excavation Confirmation Sampling**
  - Before backfilling of the excavation occurs, post-excavation confirmation samples would be collected to confirm the horizontal and vertical extent soil concentrations in the floor and sidewalls of the excavations are less than the RGs (Section 3.3). For cost estimating purposes, it was assumed confirmation sampling would be conducted at the excavation floor and sidewalls per the following frequency and locations based upon previous detections of COCs:

Soil Analysis	Frequency	Number of Samples (plus Quality Control)	Location Area
Lead/PAHs	Floor Samples: 30 by 30-foot grid; Sidewall Samples: every 40 linear feet	50	At combined lead/PAH excavation area (near FSR)

Lead	Floor Samples: center of excavation area; Sidewall Samples: one per sidewall	11	At both lead only excavation areas (south/southeast of the larger excavation area)

- **Stabilization**
  - To stabilize lead such that TCLP analysis will characterize the soil as nonhazardous for offsite disposal, mix contaminated soil with 10 percent Portland cement. Then place the soil slurry within an onsite treatment cell to allow it to stiffen into a stabilized soil mass.
- **Offsite Disposal and Waste Characterization**
  - Collect characterization samples of the stockpiled soils and analyze samples using TCLP to verify the waste is nonhazardous. For cost estimating purposes, it was assumed waste characterization sampling would be conducted at a frequency of 1 sample per 100 cubic yards (12 samples) and analyzed using the full TCLP (VOCs, SVOCs, metals, herbicides, mercury, and pesticides), reactivity (cyanide and sulfide), ignitability, and corrosivity.
  - Transport of 3/4 full rolloff containers of nonhazardous, stabilized soil mixture offsite and dispose at a permitted Resource Conservation and Recovery Act Subtitle D landfill.

Assessment of Removal Action Alternatives

Three removal action alternatives, including the No Action Alternative, were developed for evaluation against the RAOs. The alternatives were initially evaluated individually based on effectiveness, implementability, and cost, and then the results were compared and qualitatively ranked to ascertain their relative merits in accordance with *Guidance on Conducting Non-Time-Critical Removal Action Under CERCLA* (EPA, 1993). Additionally, in support of Navy and EPA guidance, the sustainability of each alternative was estimated and evaluated for comparison.

5.1 Individual Analysis

The removal action alternatives initially were evaluated individually regarding their overall effectiveness, implementability, and cost. Sustainability is not one of the evaluation criteria but was also evaluated. The findings from the individual analyses are qualitatively presented in Table 5-1.

5.1.1 Effectiveness

The *effectiveness* criterion addresses the expected results of the removal action alternatives and its ability to meet the RAO within the scope of the removal action. It includes five subcategories that address both protectiveness and the ability to achieve the RAO.

- **Protection of human health and the environment:** Evaluates how the alternative achieves and maintains the protection of human health and the environment and achieves site-specific objectives both during and after implementation.
- **Compliances with ARARs**: Evaluates the compliance with ARARs, or if a waiver is required, how it is justified.
- **Short-term effectiveness**: Evaluates the effectiveness in protecting human health and the environment during implementation of an alternative before the RAO has been met. The duration of time until the RAO has been met also is factored into this criterion. Protection of the community and workers, environmental impacts, and time until the RAO is achieved are all considered.
- **Long-term effectiveness and permanence**: Evaluates the long-term effectiveness in maintaining protection of human health and environment after the RAO has been met. The magnitude of residual risk and adequacy and reliability of post-removal site controls are taken into consideration.
- **Reduction of toxicity, mobility, or volume through treatment**: Evaluates the anticipated performance of the specific treatment technologies and methods it employs. As defined by the NCP, EPA expects the use of treatment to address principal threats posed by a site, wherever practicable (40 CFR 300.430[a][1][iii][A]). Removal is not the same as treatment (remedial action), which permanently reduces the toxicity, mobility, or volume of contamination (42 United States Code [USC] 9601[23]; 42 USC 6903[34]). Thus, CERCLA includes a statutory preference for alternatives that treat contaminants rather than disposing of them offsite. When considering treatment, factors such as volume of materials destroyed or treated, the degree of expected reductions, the degree to which treatment is irreversible, and the type and quantity of remaining residuals are taken into consideration.

5.1.2 Implementability

The *implementability* criterion encompasses the technical and administrative feasibility implementing an alternative and the availability of various services and materials required during it. It includes the following three subcategories that address both feasibility and availability of resources:

- **Technical feasibility**: Evaluates the ability of the technology to implement the remedy. Factors to be considered include reliability of the technology, constructability and operation, demonstrated performance and useful life, adaptability to environmental conditions, contribution to performance of long-term remedy effectiveness (42 U.S.C. 9604[a][2]), implementation within the allotted schedule, east of undertaking additional remedial action if necessary.
- **Administrative feasibility:** Evaluates those activities needed to coordinate with other stakeholders, agencies, and organizations. The need for permits, waivers, easements or rights-of-way, and adherence to applicable non-environmental laws are to be assessed. Statutory limits, impacts on adjoining property, the ability to impose LUCs, and concerns of other regulatory agencies should be considered.
- **Availability of resources**: Evaluates if necessary resources are available to implement the scope and schedule of an alternative. The availability of equipment; personnel; services; materials; prospective technology; treatment, storage, and disposal capacity; funding; and other resources should be assessed.

5.1.3 Cost

The *cost* criterion encompasses the life-cycle costs of a project, including the projected implementation costs and the long-term O&M costs of the removal action. It includes three subcategories that address overall cost of an alternative: capital costs, O&M costs, and periodic costs.

For the detailed cost analysis, the expenditures required to complete each alternative were estimated in terms of capital costs, including direct and indirect costs, to complete initial construction activities. Direct costs include the cost of construction, equipment, land and site development, treatment, transportation, and disposal. Indirect costs include engineering expenses, startup and turndown costs, permit costs, and contingency allowances. O&M costs include the cost of operation and maintenance, annual monitoring and reporting costs, and auxiliary support costs. Periodic costs include the cost of conducting periodic Five-Year Reviews, if needed.

The alternatives were analyzed using present value, which discounts all future costs to the expected value at present (in 2021 base year dollars). Present-value analysis allows the cost of the removal action to be compared based on a single figure representing the amount of money that, if invested in the base year (2021) and disbursed as needed, would be sufficient to cover all costs associated with the life of the removal action. The present-value calculations included an assumed discount rate of 2 percent (White House OMB, 2022).

The estimated costs are provided to an expected accuracy of +50 percent and -30 percent. The alternative cost estimates are in 2024 dollars, and the unit pricing is based on costs from similar projects, vendor quotes, or engineering estimates. The Engineer's Cost Estimates for each alternative are presented in Appendix E and summarized in Table 5-1.

5.1.4 Sustainability

This criterion addresses the impacts the technology could have on the surrounding environment and the ability of the technology to resist external impacts. To evaluate sustainability, an assessment was conducted using SiteWise® Version 3.2, a stand-alone tool that assesses the environmental footprint of a remedial alternative to compare the overall life-cycle environmental impacts of each alternative.

in terms of a consistent set of sustainability metrics: greenhouse gas emissions, energy use, criteria air emissions (including nitrogen oxides, sulfur oxides, and particulate matter less than 10 microns in diameter), water consumption, and worker safety. SiteWise® provides a comparative assessment of different remedial alternatives based on the significant life-cycle impacts of each alternative, including material production (soil, gravel, sand, and so forth); transportation of equipment, personnel, and materials to the site; use of equipment during implementation; and residuals handling (Battelle, 2018) (Appendix E).

5.2 Comparative Analysis

The purpose of the comparative analysis is to identify the relative technical advantages and disadvantages of each alternative so key tradeoffs affecting the selection of a removal action alternative can be identified. The findings of the individual analysis of the removal action alternatives are used to weigh and compare the alternatives relative to each another. Table 5-2 summarizes the comparative analysis of the removal alternatives, including the overall levels of conformance/desirability. Though not an evaluation criterion, the overall sustainability ranking initially presented in Table 5-1 is reiterated in Table 5-2 to aid in decision-making.

Table 5-1. Individual Analysis of Removal Action Alternatives

Evaluation Criterion	Ranking / Subcategories	Alternative 1 – No Action	Alternative 2 – Stabilization and Engineered Cover with Land Use Controls and Long-Term Monitoring	Alternative 3 – Removal Action with Stabilization and Offsite Disposal
Effectiveness	**Ranking**	**Unacceptable**	**High**	**High**
	Protection of human health and the environment	• Does not protect human and ecological receptors from unacceptable exposure to COCs in soil. • Does not achieve the RAO.	• Protects current and future human and ecological receptors from unacceptable exposure at the site by: 1) reducing the mobility of COCs in the soil through soil stabilization and 2) restricting direct access to contaminated soil and limiting migration-to-groundwater by installing an engineered, evapotranspiration soil cover and implementing LUCs. • Achieves the RAO	• Protects current and future human and ecological receptors from unacceptable exposure by: 1) removing the contaminated soil at the site and 2) reducing the mobility of COCs in the soil through soil stabilization and landfill containment. • Achieves the RAO
	Compliance with ARARs	• Does not comply with ARARs.	• Complies with chemical-, location- and action-specific ARARs	• Complies with chemical-, location- and action-specific ARARs
	Short-term effectiveness	• Does not provide protectiveness of the community or environment during implementation of the alternative. • Provides worker protection by limiting potential worker exposure. • Does not create additional environmental impacts. • The time until the RAO is achieved is infinite.	• Provides protectiveness of the community and environment during implementation by constructing an engineered cap and implementing LUCs. • Reduces worker protections by increasing the likelihood of worker exposure during implementation of the alternative. • Creates additional environmental impacts by excavation, construction earthwork, and possible migration of contaminated sediments/dust. • Will achieve the RAO within approximately 1-2 years.	• Provides protectiveness of the community and environment during implementation by removing onsite contamination from the site. • Reduces worker protections by increasing the likelihood of worker exposure during implementation of the alternative. • Creates additional environmental impacts by excavation, construction earthwork, and possible migration of contaminated sediments/dust. • Will achieve the RAO in less than 1 year.
	Long-term effectiveness and permanence	• Does not provide long-term effectiveness, adequacy, and reliability in maintaining protection to human health and the environment. • Residual risk to human health and the environment remain unchanged.	• Maintains protectiveness of the community and environment after the RAO is achieved. • The magnitude of residual risk remaining is minimal. • Provides adequate long-term measures for maintaining the protection of human health and the environment. • Long-term reliability of the technology and control measures are high.	• Maintains protectiveness of the community and environment after the RAO is achieved. • The magnitude of residual risk remaining is negligible. • Provides adequate long-term measures for maintaining the protection of human health and the environment. • Long-term reliability of the technology is very high.
	Reduction of toxicity, mobility or volume through treatment	• Does not reduce the toxicity, mobility, or volume of contamination through treatment. • The type and quantity of remaining residuals is unchanged.	• Reduces the toxicity of COCs by physically segregating metal bullets and fragments from the soil (removes the sources of metals contamination). • Reduces the mobility of COCs by stabilizing dispersed concentrations within the soil matrix. • Reduces the mobility of COCs by mitigating leaching and offsite transport implementing and maintaining an engineered, evapotranspiration soil cover and LUCs.	• Reduces the toxicity of COCs by physically segregating metal bullets and fragments from the soil (removes the sources of metals contamination). • Reduces the mobility of COCs by stabilizing dispersed concentrations within the soil matrix. • Reduces the mobility of COCs by containing the contaminated soil within a permitted RCRA Subtitle D landfill.
Implementability	**Ranking**	**Low**	**Moderate**	**High**
	Technical Feasibility	• Does not require implementing technology, construction, or operation. • Does not contribute to the efficient performance of any long-term remedial action of the contaminated soil onsite. • No construction and follow-on operation and maintenance is required, • Implementation is expected to be complete immediately once decisions documents are finalized. • Implementation of the alternative will have no construction impacts on the local community.	• Is an established technology with a moderate level of reliability and few delays during implementation. • Stabilization and construction of engineered covers are relatively common construction elements with moderate to high constructability and moderate follow-on operation and maintenance of the cover. • Performance of the technology and methods have been well demonstrated. • The technology will contribute to the efficient performance of any long-term remedial action of the contaminated soil onsite. • Implementation is expected to be complete in approximately 1-2 years with an useful design life of 30 years or more. • Potential impacts on the local community during construction operations is expected to be low.	• Is an established technology with a high level of reliability and minimal delays during implementation. • Removal, stabilization, and disposal are common construction methods with low to moderate constructability and minimal follow-on operation. • Performance of the technology and methods have been well demonstrated. • The technology will contribute to the efficient performance of any long-term remedial action of the contaminated soil onsite. • Implementation is expected to be complete in less than 1 year with an indefinite useful life. • Potential impacts on the local community during construction operations is expected to be moderate due to the additional truck traffic required.

Table 5-1. Individual Analysis of Removal Action Alternatives

Evaluation Criterion	Ranking / Subcategories	Alternative 1 – No Action	Alternative 2 – Stabilization and Engineered Cover with Land Use Controls and Long-Term Monitoring	Alternative 3 – Removal Action with Stabilization and Offsite Disposal
		• Does not provide effectiveness and protectiveness, therefore environmental conditions will have no change on the alternative. • If necessary, additional remedial action could be easily implemented.	• Environmental conditions have the potential to impact the effectiveness and protectiveness of the alternative because the source of contamination, though stabilized and covered, will remain onsite. For example, heavy precipitation and/or flooding may erode the engineered cover. Therefore, the site would be moderately adaptable to changing conditions. • Environmental and geographic conditions will have little effect on the set-up and construction phases. • If necessary, additional remedial action could be easily implemented.	• Environmental conditions will not impact the effectiveness and protectiveness of the alternative because the source of contamination has been removed. Therefore, the site would be highly adaptable to changing conditions. • Environmental and geographic conditions will have little effect on the set-up and construction phases. • If necessary, additional remedial action could be very easily implemented.
	Administrative Feasibility	• Requires coordination with USEPA, MDE, US Navy, and potentially other stakeholders. • Does not require any permits and/or waivers. • Statutory limits do not apply. • Impacts on adjoining property will not occur.	• Requires coordination with USEPA, MDE, US Navy, and potentially other stakeholders. • May require a Storm Water Pollution Prevention Plan (SWPPP) and potentially other permits and/or waivers. • The alternative will be not be USEPA funded, therefore no statutory limits apply. • Impacts on adjoining property will be minimal. • The site is owned by the US Navy which has full authority to impose LUCs on NAS Patuxent River property.	• Requires coordination with USEPA, MDE, US Navy, and potentially other stakeholders. • May require a Storm Water Pollution Prevention Plan (SWPPP) and potentially other permits and/or waivers. • The alternative will be not be USEPA funded, therefore no statutory limits apply. • Impacts on adjoining property will be minimal. • The site is owned by the US Navy which has full authority to impose LUCs on NAS Patuxent River property.
	Availability of Resources	• Does not require any equipment, materials, or technology. • May requires specialized professionals and/or vendors, including lawyers, engineers, and consultants which are reasonably available. • Does not required treatment, storage, and disposal (TSD) capacity. • Funding is adequate	• Requires common construction equipment and materials which are readily available. • Stabilization and soil cover technology is well-understood and available for full-scale implementation. • Some site-specific stabilization treatability studies are recommended. • Requires specialized professionals and/or vendors, including engineers, consultants, and specialized tradesman, which are reasonably available. • Requires personnel, equipment, and materials for installation of LUC engineering controls and conducting LTM, including the maintenance of the engineered cap, LUC maintenance, routine review of site conditions, and monitoring of residual contamination. • Contaminated soil will be stabilized and disposed onsite, so TSD capacity is expected to be sufficient. • Funding is adequate	• Requires common construction equipment and materials which are readily available. • Removal, stabilization, and landfilling technology is well-understood and available for full-scale implementation. • Some site-specific stabilization treatability studies are recommended. • Requires specialized professionals and/or vendors, including engineers, consultants, and specialized tradesman, which are reasonably available. • Several permitted RCRA D landfills are located nearby including in St. Mary's and Calvert Counties. • Offsite TSD capacity is expected to be sufficient. • Funding is adequate
Costs	**Ranking**	**No Cost**	**Moderate**	**Moderate**
	Total Present Worth	$0	$1,690,006	$1,600,000
	Estimated Cost Range	$0	$1,376,684 to $2,950,038	$1,120,000 to $2,400,000
	Estimated Total Cost	$0	$1,966,692	$1,600,000
	Capital Costs	$0	$1,275,000	$1,600,000
	O&M Costs	$0	$601,692	$0
	Periodic Costs	$0	$90,000	$0

Table 5-1. Individual Analysis of Removal Action Alternatives

Evaluation Criterion	Ranking / Subcategories	Alternative 1 – No Action	Alternative 2 – Stabilization and Engineered Cover with Land Use Controls and Long-Term Monitoring	Alternative 3 – Removal Action with Stabilization and Offsite Disposal
Sustainability	**Ranking**	**High**	**Moderate**	**Moderate**
	Greenhouse Gases (GHGs)	• None. No GHGs (carbon dioxide, methane, and nitrous oxide) are produced	• 470 metric tons of GHGs produced • The majority of the GHG production was associated with material production (cement and soil)	• 561 metric tons of GHGs produced • The majority of the GHG production was associated with cement production
	Energy Usage	• None. Does not require energy use	• 3,001 million British Thermal Units (MMBTU) of energy used • The majority of the energy use was associated with material production (cement and soil)	• 4,503 MMBTU of energy used • The majority of the energy use was associated with cement production
	Water Usage	• None. Does not require water use	• 10,000 gallons of water used • 100% of the water use from this alternative was attributed to dust suppression	• 10,000 gallons of water use • 100% of the water use from this alternative was attributed to dust suppression d
	Air Emissions	• None. No air emissions of criteria pollutants (nitrogen oxides, sulfur oxides, and particulate matter) are produced	• 1.01 metric tons of NOx emitted • 1.82 metric tons of SOx emitted • 0.389 metric tons of PM10 emitted • Material production accounted for approximately 92% of the NO_X, approximately 99% of the SO_X, and 98% of the PM_{10} footprints. • Equipment use and other activities contributed the remaining air pollutant footprints.	• 1.31 metric tons of NOx emitted • 1..92 metric tons of SOx emitted • 1.31 metric tons of PM10 emitted • Material production accounted for approximately 65% of the NO_X, approximately 88% of the SO_X, and 26% of the PM_{10} footprints. • Residual handing, equipment use, and other activities contributed the remaining air pollutant footprints.
	Accident Risk / Worker Safety	• None. No additional accidental risk of worker injury or fatality	• The risk of accidental fatality is 1 in 3,784 (0.000264) • The risk of accidental injury is 1 in 2,299 (0.000435) • The majority of accident risk is from onsite labor hours and personnel transportation.	• The risk of accidental fatality is 1 in 22 (0.0450) • The risk of accidental injury is 1 in 19 (0.0531) • The majority of accident risk is from equipment use and residual handling.

Table 5-2. Comparative Analysis of Removal Action Alternatives

	Evaluation Criteria			
Alternative	**Effectiveness**	**Implementation**	**Cost**	**Sustainability[1]**
Alternative 1 – No Action	Unacceptable	Low	No Cost	High
Alternative 2 – Stabilization and Engineered Cover with Land Use Controls and Long-Term Monitoring	High	Moderate	Moderately Expensive and Most Expensive of These Three Alternatives	Moderate
Alternative 3 – Removal with Stabilization and Offsite Disposal	High	High	Moderately Expensive	Moderate

[1] Sustainability is considered but is not an evaluation criterion. However, the overall qualitative level of sustainability conformance/desirability for each alternative is presented to aid in decision-making.

SECTION 6

Recommended Removal Action Alternative

Alternative 1 does not protect human and ecological receptors from unacceptable exposure to human health COCs or ecological Step 3A COPCs in soil and does not meet the objective of the RAO.

Alternatives 2 and 3 both protect human health and the environment and are comparable in their implementability, technical feasibility, and short-term effectiveness. The removal action for either Alternatives 2 or 3 is expected to be complete in less than 1 year. Alternative 3 has a higher rating for long-term effectiveness and reduction of the toxicity and mobility of site contaminants through removal because no soil with concentrations more than the human health or ecological RGs would be left onsite. Both alternatives achieve the RAO. Administrative feasibility and the availability of resources are expected to be similar for Alternatives 2 and 3.

Alternative 3 is more implementable and technically feasible, and the removal action is expected to be completed in less than 1 year. Administrative feasibility and the availability of resources are expected to be similar for Alternatives 2 and 3. Alternatives 2 and 3 are comparable in cost over an estimated 30-year timeline. Alternative 3 requires an estimated $11,000 less in initial capital costs and has approximately $9,000 additional future costs. Alternative 2 requires approximately $940,000 more than Alternative 3 in O&M and periodic costs for LUCs and Five-Year Reviews. Relative to each other, Alternative 2 is considered more sustainable than Alternative 3.

Relative to each other, Alternative 2 has a lower environmental footprint than Alternative 3 in all categories except water use (which has the same impact. Alternative 2 emits 41 percent less greenhouse gases, uses 14 percent less energy, produces between 25 to 60 percent less criteria air pollutants (nitrogen oxides, sulfur oxides, and particulate matter less than 10 microns in diameter), has a 38 percent lower risk of accidental fatality, and a 25 percent lower risk of accidental injury.

Based on the evaluation of the tradeoffs between the alternatives, the recommended removal alternative for the FSR is ***Alternative 3: Removal Action with Stabilization and Offsite Disposal.***

Alternative 2 does not allow for unlimited use/unrestricted exposure and will require LUCs and LTM. Alternative 3 consists of excavating soil exceeding the human health and ecological RGs for lead and PAHs, stabilizing the impacted soil, and disposing of the stabilized soil mixture in an offsite landfill. Alternative 3 provides for unlimited use/unrestricted exposure and does not require inspection, maintenance, or monitoring activities to ensure long-term protectiveness of human health and the environment. The removal of soil with elevated concentrations exceeding the RGs would reduce the risks to human and ecological receptors to acceptable levels.

Navy, EPA, and MDE representatives were involved with developing the recommended alternative through the Tier I Partnering Team process and will have the opportunity to comment on the recommendation during the regulatory review period for this EE/CA. Appendix F provides a copy of regulatory correspondence from EPA and MDE. Following the regulatory review period, a 30-day public comment period will be held to assess public acceptance of the recommended alternative. If comments are received, a Responsive Summary addressing significant comments will be prepared as part of the Action Memorandum and included in the Administrative Record, along with the final EE/CA report.

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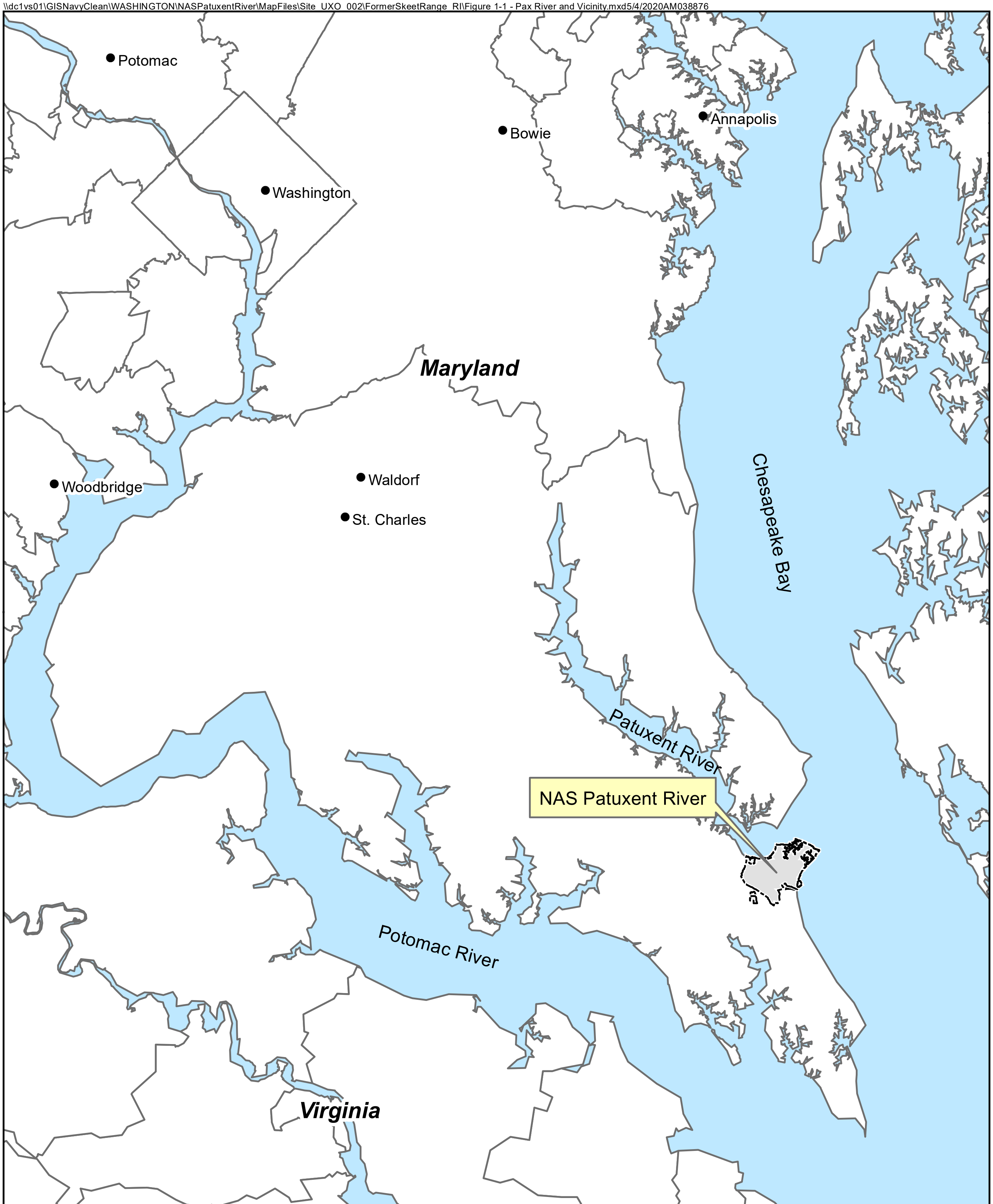
Figures

\\dc1vs01\GISNavyClean\WASHINGTON\NASPatuxentRiver\MapFiles\Site_UXO_002\FormerSkeetRange_RI\Figure 1-1 - Pax River and Vicinity.mxd5/4/2020AM038876



Legend

- Cities
- Installation Boundary

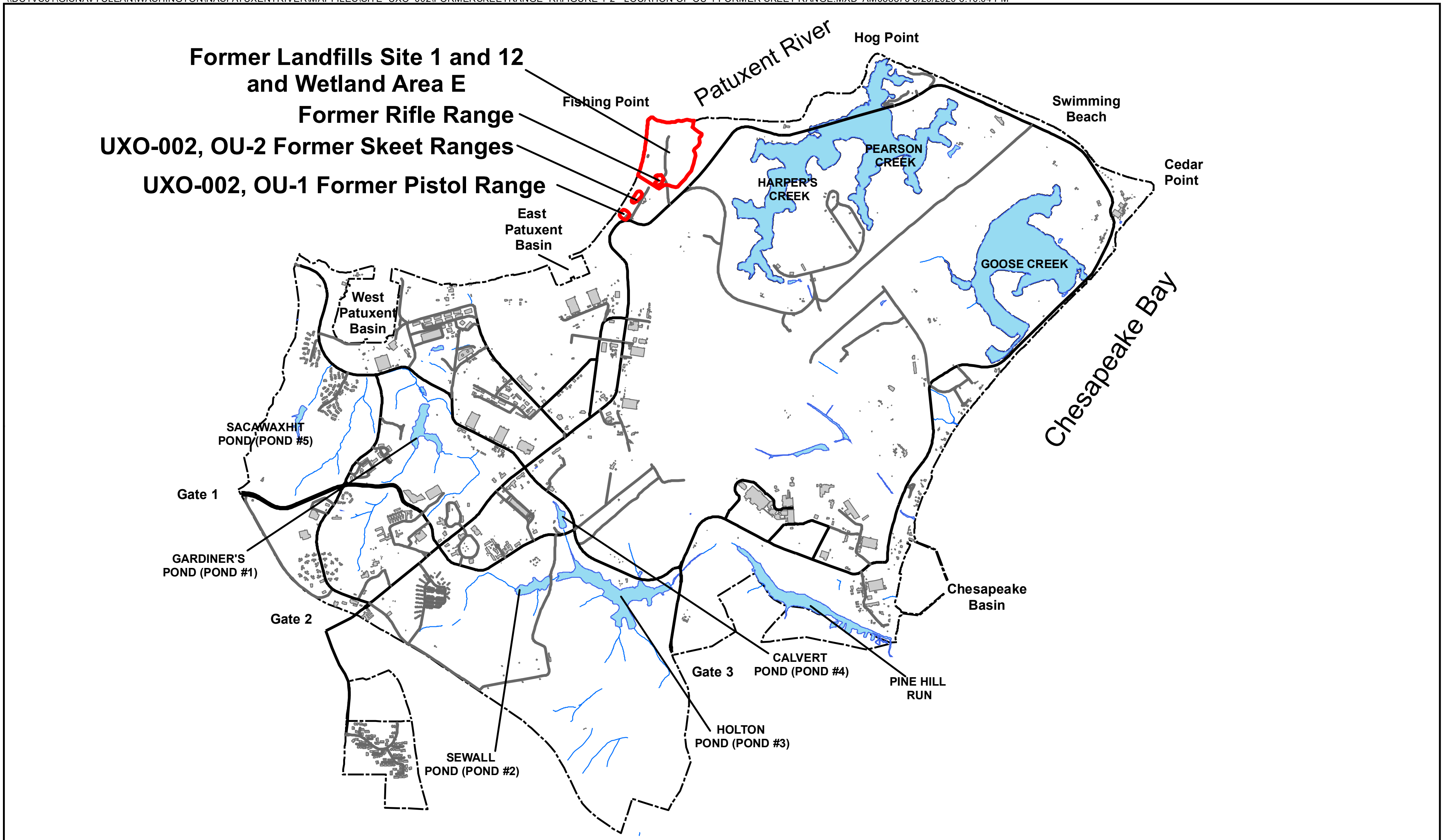
N W E S

0 22,500 45,000 Feet

Figure 1
Naval Air Station Patuxent River and Vicinity
UXO-002, OU-2 Former Skeet Ranges
Engineering Evaluation and Cost Analysis Report
NAS Patuxent River
St. Mary's County, Maryland

ch2m.

\\DC1VS01\GISNAVYCLEAN\WASHINGTON\NASPATUXENTRIVER\MAPFILES\SITE_UXO_002\FORMERSKEETRANGE_RI\FIGURE 1-2 - LOCATION OF OU-1 FORMER SKEET RANGE.MXD AM038876 5/26/2020 3:10:04 PM



Legend

Site Boundary
Primary Road
Secondary Road
Buildings
Stream
Permanent Water Body
Installation Boundary

N

0 2,000 4,000
Feet

Figure 2
Site Location Map
UXO-002, OU-2 Former Skeet Ranges
Engineering Evaluation and Cost Analysis Report
NAS Patuxent River
St. Mary's County, Maryland

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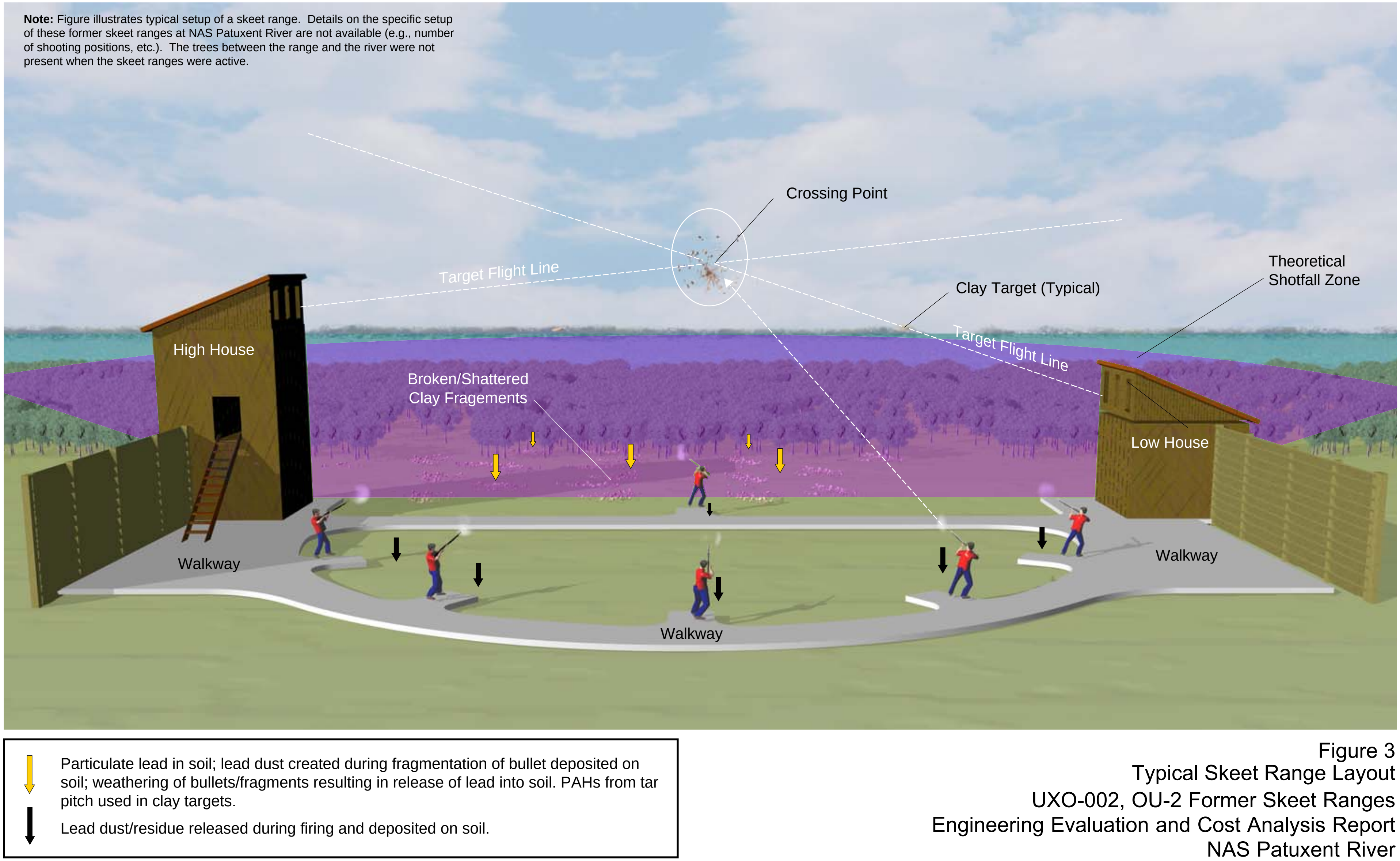
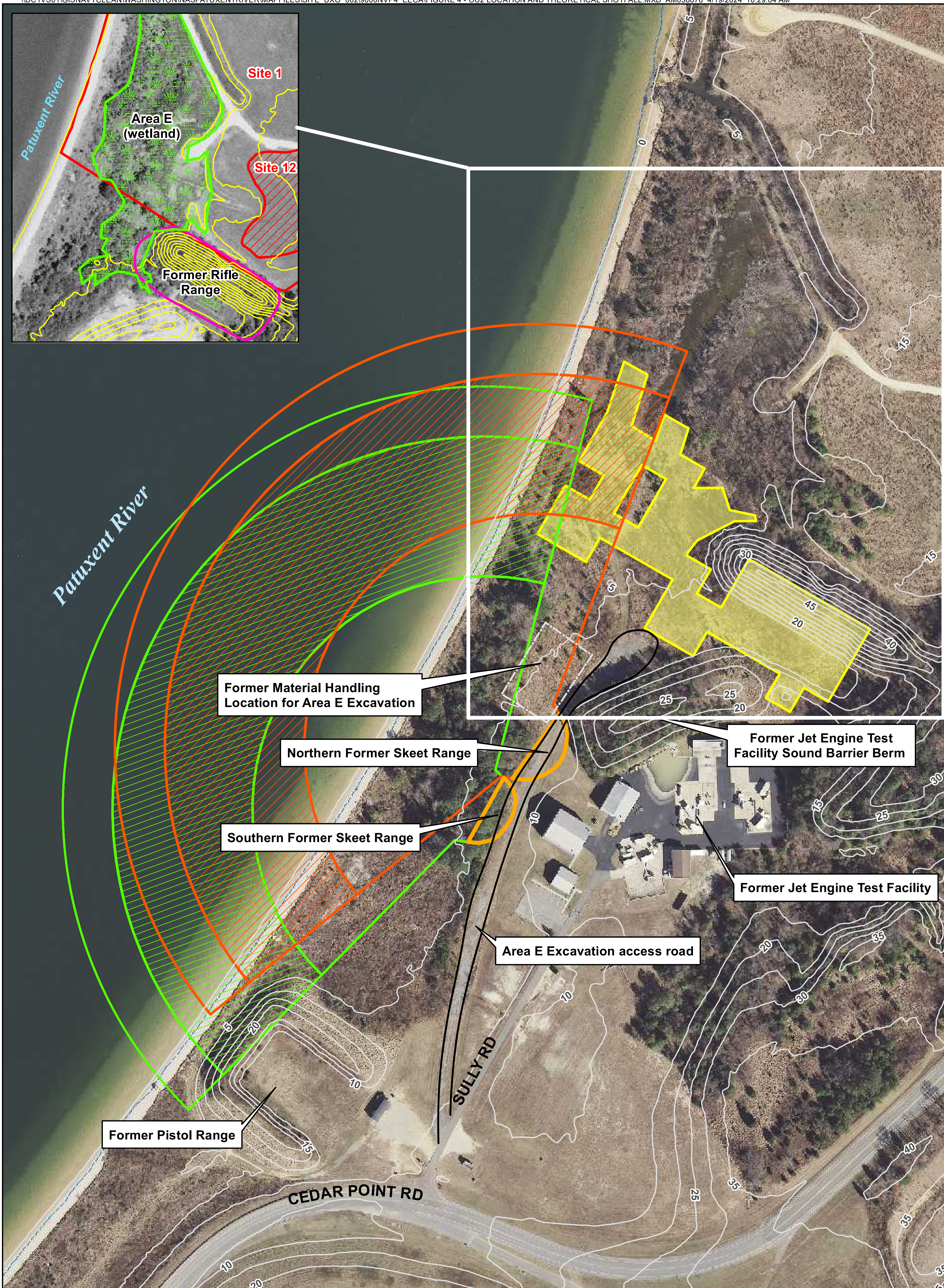


Figure 3
Typical Skeet Range Layout
UXO-002, OU-2 Former Skeet Ranges
Engineering Evaluation and Cost Analysis Report
NAS Patuxent River
St. Mary's County, Maryland



Legend
- Shoreline
- Access Road for 2007/2008 Area E Excavation
- Material Handling Area for 2007/2008 Area E Excavation
- Sites 1/12 OU-2 "Area E" Excavation Boundary
- Theoretical Shotfall Zone
- Theoretical Area with Maximum Density of Shotfall
- Theoretical Shotfall Zone
- Theoretical Area with Maximum Density of Shotfall
- Elevation Contour (5ft interval)

Figure 4
OU-2 Location and Theoretical Shotfall Zone Map
UXO-002, OU-2 Former Skeet Ranges
Engineering Evaluation and Cost Analysis Report
NAS Patuxent River
St. Mary's County, Maryland

ch2m

\\DC1VS01\GISNAVYCLEAN\WASHINGTON\NASPATUXENTRIVER\MAPFILES\SITE_UXO_002\9000NVP4_EECA\FIGURE 5 - GW CONTOURS JUNE 2020.MXD AM038876 4/19/2024 10:49:43 AM

Legend

- Monitoring Well Location
- Potentiometric contour, dashed where inferred
- Approximate Groundwater Flow Direction
- Shoreline
- Former Skeet Range Location

Notes:
Contours are approximate representations of the general spatial variation in groundwater elevations that existed at the time of measurements. Actual conditions may vary from point.

N

0 50 100
Feet

Figure 5
June 2020 Potentiometric Surface
UXO-002, OU-2 Former Skeet Ranges
Engineering Evaluation and Cost Analysis Report
NAS Patuxent River
St. Mary's County, Maryland

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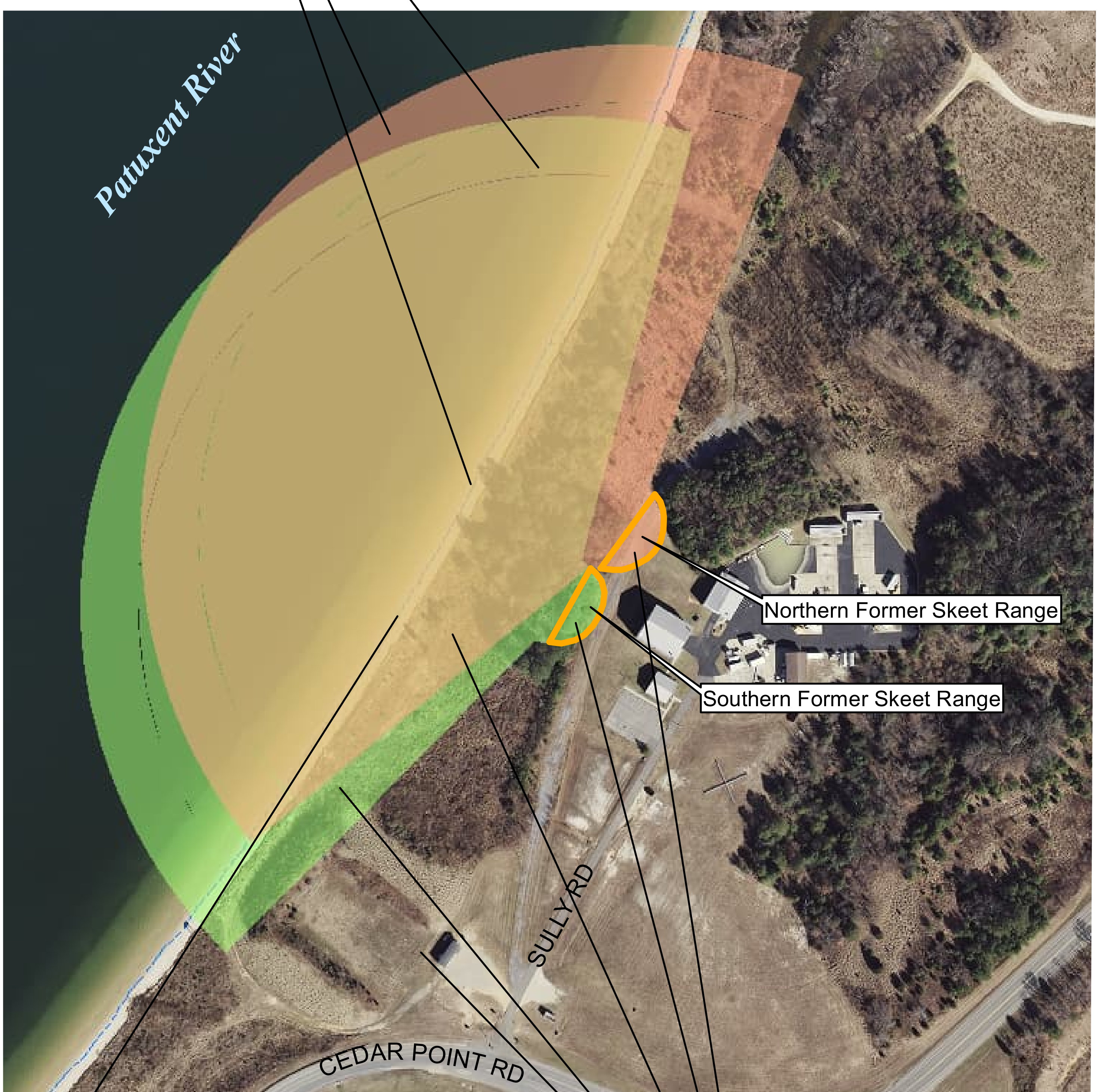
\\dc1vs01\GISNavyClean\WASHINGTON\NASPatuxentRiver\MapFiles\Site_UXO_002\9000NVP4_EECA\Figure 6 - Conceptual Site Model.mxd AM038876 4/19/2024

Aquatic Habitats	
Features	Patuxent River; littoral zone along edge of Patuxent River; drainage channels
Potential Receptors	Plants (submerged); fish; benthic macroinvertebrates (worms, insects, crustaceans); birds (great blue heron and osprey); mammals (muskrat)

Human Receptors	
Features	Surface and subsurface soil of former pistol range floor and impact berm; Surface soil of former skeet range floors and shotfall zones
Potential Receptors	Current/future resident/adolescent trespasser/visitor/recreator and construction workers exposed through incidental ingestion, dermal contact, and inhalation of particulate emissions



Semi-Aquatic Habitats	
Features	Seasonal (ephemeral) drainages/pools; along the edge of the Patuxent River)
Potential Receptors	Amphibians (frogs, salamanders); reptiles (snakes, turtles);birds (marsh wren); mammals (raccoon)

Terrestrial Habitats	
Features	All upland areas; edges of shrub/scrub land; open grassy areas
Potential Receptors	Plants (grasses, shrubs, trees); invertebrates (earthworms, insects); reptiles (snakes, turtles); birds (American robin, mourning dove, red-tailed hawk); mammals (white-footed mouse, short-tailed shrew)

Legend
- Sites 1/12 OU-2 "Area E" Excavation Boundary
- Former Skeet Range Location
- Theoretical Shotfall Zone, Northern Former Skeet Range
- Theoretical Shotfall Zone, Southern Former Skeet Range
- Shoreline

N

0 100 200 Feet

2016 Aerial Photograph

Figure 6
Former Skeet Range Conceptual Site Model
UXO-002, OU-2 Former Skeet Ranges
Engineering Evaluation and Cost Analysis Report
NAS Patuxent River
St. Mary's County, Maryland

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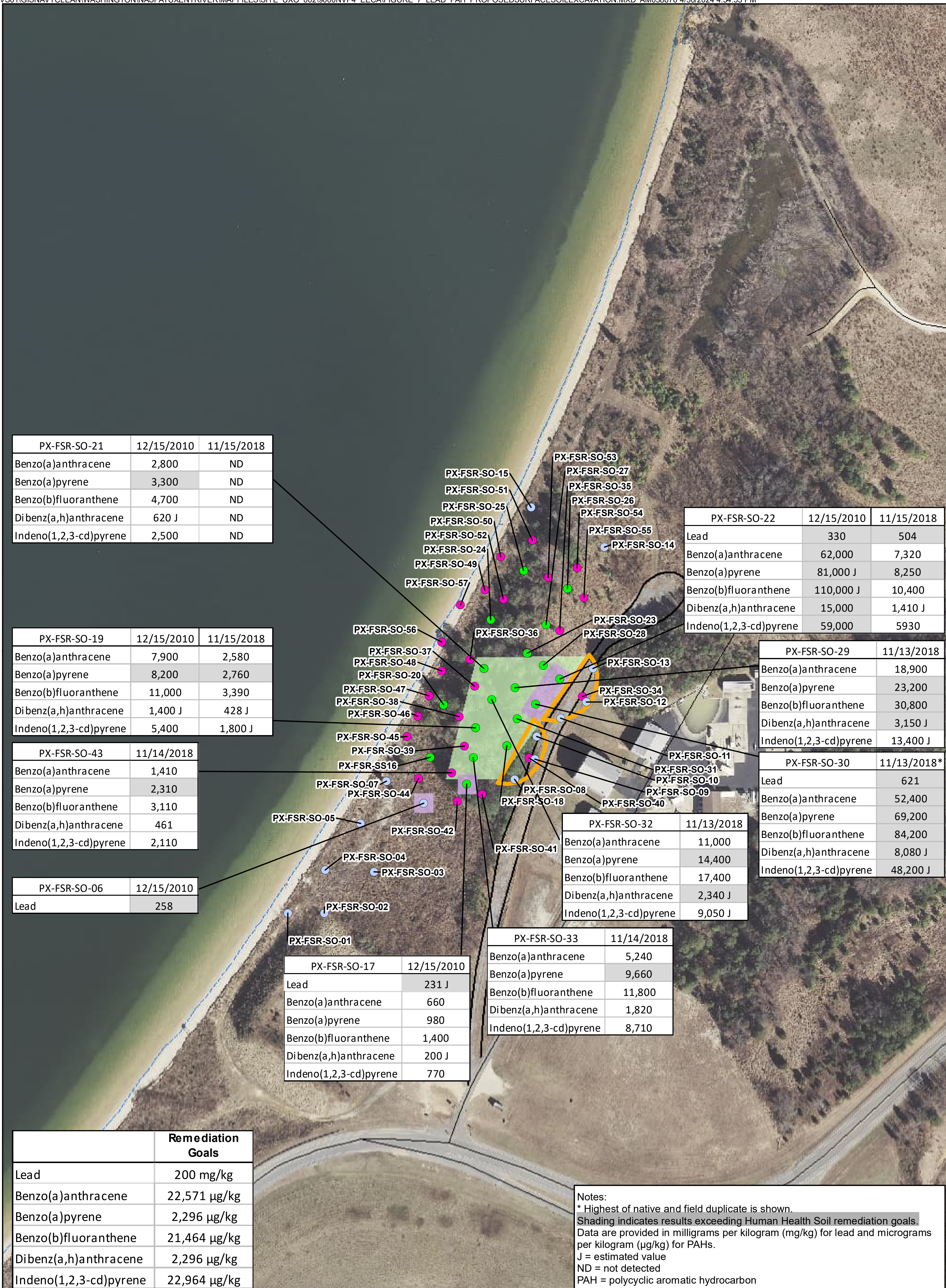

PX-FSR-SO-21	12/15/2010	11/15/2018
Benzo(a)anthracene	2,800	ND
Benzo(a)pyrene	3,300	ND
Benzo(b)fluoranthene	4,700	ND
Dibenz(a,h)anthracene	620 J	ND
Indeno(1,2,3-cd)pyrene	2,500	ND

PX-FSR-SO-22	12/15/2010	11/15/2018
Lead	330	504
Benzo(a)anthracene	62,000	7,320
Benzo(a)pyrene	81,000 J	8,250
Benzo(b)fluoranthene	110,000 J	10,400
Dibenz(a,h)anthracene	15,000	1,410 J
Indeno(1,2,3-cd)pyrene	59,000	5930

PX-FSR-SO-19	12/15/2010	11/15/2018
Benzo(a)anthracene	7,900	2,580
Benzo(a)pyrene	8,200	2,760
Benzo(b)fluoranthene	11,000	3,390
Dibenz(a,h)anthracene	1,400 J	428 J
Indeno(1,2,3-cd)pyrene	5,400	1,800 J

PX-FSR-SO-29	11/13/2018
Benzo(a)anthracene	18,900
Benzo(a)pyrene	23,200
Benzo(b)fluoranthene	30,800
Dibenz(a,h)anthracene	3,150 J
Indeno(1,2,3-cd)pyrene	13,400 J

PX-FSR-SO-43	11/14/2018
Benzo(a)anthracene	1,410
Benzo(a)pyrene	2,310
Benzo(b)fluoranthene	3,110
Dibenz(a,h)anthracene	461
Indeno(1,2,3-cd)pyrene	2,110

PX-FSR-SO-30	11/13/2018*
Lead	621
Benzo(a)anthracene	52,400
Benzo(a)pyrene	69,200
Benzo(b)fluoranthene	84,200
Dibenz(a,h)anthracene	8,080 J
Indeno(1,2,3-cd)pyrene	48,200 J

PX-FSR-SO-32	11/13/2018
Benzo(a)anthracene	11,000
Benzo(a)pyrene	14,400
Benzo(b)fluoranthene	17,400
Dibenz(a,h)anthracene	2,340 J
Indeno(1,2,3-cd)pyrene	9,050 J

PX-FSR-SO-06	12/15/2010
Lead	258

PX-FSR-SO-33	11/14/2018
Benzo(a)anthracene	5,240
Benzo(a)pyrene	9,660
Benzo(b)fluoranthene	11,800
Dibenz(a,h)anthracene	1,820
Indeno(1,2,3-cd)pyrene	8,710

PX-FSR-SO-17	12/15/2010
Lead	231 J
Benzo(a)anthracene	660
Benzo(a)pyrene	980
Benzo(b)fluoranthene	1,400
Dibenz(a,h)anthracene	200 J
Indeno(1,2,3-cd)pyrene	770

	Remediation Goals
Lead	200 mg/kg
Benzo(a)anthracene	22,571 µg/kg
Benzo(a)pyrene	2,296 µg/kg
Benzo(b)fluoranthene	21,464 µg/kg
Dibenz(a,h)anthracene	2,296 µg/kg
Indeno(1,2,3-cd)pyrene	22,964 µg/kg

Notes:
* Highest of native and field duplicate is shown.
Shading indicates results exceeding Human Health Soil remediation goals.
Data are provided in milligrams per kilogram (mg/kg) for lead and micrograms per kilogram (µg/kg) for PAHs.
J = estimated value
ND = not detected
PAH = polycyclic aromatic hydrocarbon

Legend

Surface Soil Sample Location Analyzed For
- Lead
- PAH
- Lead and PAHs

- Access Road for 2007/2008 Area E Excavation
- Former Skeet Range Location
- Proposed Excavation Boundary - Lead (1 ft depth)
- Proposed Excavation Boundary - PAH (1 ft depth)
- Shoreline

Figure 7
Lead and PAH Proposed Surface Soil Excavation Boundary
UXO-002, OU-2 Former Skeet Ranges
Remedial Investigation Report
NAS Patuxent River
St. Mary's County, Maryland

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Appendix A
Human Health Risk Assessment

APPENDIX A

Human Health Risk Assessment

A.1 Introduction

This appendix presents the human health risk assessment (HHRA) for Munitions Response Site (MRS) UXO-002 Former Small Arms Ranges, Operable Unit (OU)-2 Former Skeet Ranges, located at Naval Air Station (NAS) Patuxent River, St. Mary's County, Maryland. MRS UXO-002 consists of three Former Small Arms Ranges, including one Former Pistol Range (OU-1) and two Former Skeet Ranges (OU-2), which are located adjacent to each other in the northwest portion of the NAS. The HHRA was conducted to assess the nature, magnitude, and probability of potential harm to public health posed by exposure to site-related constituents in soil, sediment, and groundwater at MRS UXO-002, OU-2. The data evaluated in the HHRA are discussed in **Section 4** of the Remedial Investigation (RI) report (CH2M, 2023) and presented in **Appendix F** of the RI report. The HHRA incorporates the general methodology described in the following U.S. Environmental Protection Agency (EPA) documents:

- *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A)* (EPA, 1989)
- *RAGS: Volume I, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments)* (EPA, 2001)
- *RAGS, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (EPA, 2004)
- *RAGS, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)* (EPA, 2009a)
- *EPA Region 3 Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening* (EPA, 1993)
- *Conducting Human Health Risk Assessments Under the Environmental Restoration Program* (CNA, 2001)

There are differences between Navy and EPA guidance for conducting HHRAs; the most notable are related to the screening approaches used to identify chemicals of potential concern (COPCs). The Navy policy (Navy, 2008) allows for risk management decisions at earlier stages of the risk assessment (i.e., during any stage of the risk assessment process, including using background data to identify the COPCs). Once the COPCs are identified, both risk assessment approaches follow the EPA approach. The EPA approach does not involve making risk management decisions, including use of background data, until after the risks are calculated. For this RI, the EPA approach for conducting risk assessments was followed.

The HHRA consists of the following components:

- Data Evaluation and COPC Identification
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Assessment

The subsequent HHRA discussions were organized by the HHRA components above. Risk calculation spreadsheets for MRS UXO-002, OU-2 were prepared in accordance with *RAGS, Volume 1, Human*

Health Evaluation Manual, Part D (EPA, 2001) to identify COPCs and to estimate health risks associated with the COPCs. These spreadsheets are presented in **Attachment A-1**.

A.2 Data Evaluation and Constituent of Potential Concern Identification

The identification of COPCs includes data collection, evaluation, and screening steps. The data collection and evaluation steps involve gathering and reviewing the available site data and identifying a set of data for the risk assessment that meets project-specific data quality objectives. This data set is then further screened against concentrations that are protective of human health to reduce the data set to those constituents and media of potential concern.

A.2.1 Data Summary

All data used in the risk assessment were fully validated and are assumed to represent current conditions. Soil data collected in December 2010 and November 2018, sediment data collected in June 2019, and groundwater data collected in April and June 2020 were included in the HHRA. Trespasser/visitors were assumed to contact shallow sediment while wading in the water in Patuxent River; therefore, the sediment samples collected from the locations where surface water is relatively shallow (assumed to be around 3 feet deep) were used for the HHRA. Eleven sediment samples were evaluated in this HHRA. **Attachment A-2** (**Table 1**) lists the samples evaluated in the HHRA and the analytes for each sample.

The data collected during site investigations were evaluated to assess their reliability for use in the quantitative risk assessments. The following criteria were used to assess data usability based on past discussions with EPA and the Navy:

- Data qualified with a J or L (estimated) were treated as unqualified detected concentrations.
- Data qualified with a B (blank contamination) were used in the risk assessment as if the results were non-detects, with the blank-related concentrations of each constituent used as the sample detection limit. For duplicate samples, the maximum concentration between the two samples was used as the sample concentration. If the analyte was only detected in one of the samples, the detected concentration was used as the sample concentration. If the analyte was not detected in either of the samples, the higher detection limit was used as the sample detection limit.

Details regarding sampling that was performed at UXO-002, OU-2 are provided in **Section 3** of the RI Report.

A.2.2 Selection of Constituents of Potential Concern

The detected constituents were screened following the procedures described below. The selection of COPCs was based on the criteria presented in the EPA Region 3 technical guidance manual (EPA, 1993) and *RAGS: Volume I, Human Health Evaluation Manual (Part D)* (EPA, 2001).

The maximum detected concentration of each constituent in each medium was compared to the criteria discussed below to select the COPCs. If the maximum detected concentration exceeded the criteria, the constituent was identified as a COPC. Constituents that were not detected in any of the samples or were detected at concentrations less than the criteria were not retained as COPCs. The following screening criteria were used in the HHRA, as presented in **Attachment A-1, Tables 2.1 through 2.6**:

- **Comparison with Risk-based Criteria for Soil:** Soil data were compared to the EPA residential soil Regional Screening Levels (RSLs) (EPA, 2021a). RSLs based on noncarcinogenic effects were based on a target hazard quotient (HQ) of 0.1 to account for exposure to multiple constituents with the same target organ or target effect. RSLs based on carcinogenic effects were based on a target excess lifetime cancer risk (ELCR) of 1 x 10^{-6}. Lead concentrations in soil were compared to the EPA residential child soil screening value of 400 mg/kg (EPA, 2021a) and Maryland Department of the Environment (MDE) lead residential soil screening level of 200 mg/kg (2020).

- **Comparison with Risk-based Criteria for Sediment:** Sediment data were compared to 10 times the EPA residential soil RSLs based on a target HQ of 0.1 and a target ELCR of 1 x 10^{-6} (EPA, 2021a). This was done following EPA Region 3 guidance because exposure to sediment is expected to be significantly less than exposure to soil, and there are no human health screening levels for sediment. Lead concentrations in sediment were compared to the EPA residential child soil screening value of 400 mg/kg (EPA, 2021a) and MDE lead residential soil screening level of 200 mg/kg (2020).

- **Comparison with Risk-based Criteria for Groundwater:** Groundwater data were compared to the EPA RSLs for tap water (EPA, 2021a). RSLs that are based on noncarcinogenic effects were based on a target HQ of 0.1 to account for exposure to multiple constituents. RSLs based on carcinogenic effects were based on a target ELCR of 1x10^{-6}. Lead concentrations in groundwater were compared to the federal action level of 15 μg/L (EPA, 2021a, 2021b). Although Maximum Contaminant Levels (MCLs) are presented in the COPC selection table (**Attachment A-1, Table 2-4**), MCLs were not used to identify the COPCs.

- **Comparison with Risk-based Criteria for Vapor Intrusion from Groundwater to Indoor Air:** Groundwater data were compared to residential and commercial screening levels for protection of indoor air based on vapor intrusion (VI) from groundwater, obtained from the EPA's Vapor Intrusion Screening Level (VISL) Calculator (EPA, 2021c). VISLs for noncarcinogenic effects are based on a target HQ of 0.1 to account for exposure to multiple constituents. VISLs for carcinogenic effects are based on a target ELCR of 1 x 10^{-6}. A default groundwater temperature of 25 degrees Celsius was used to calculate the VISLs. If the maximum detected groundwater concentration was greater than the VISL, the constituent was identified as a COPC for the VI pathway. For the purpose of this evaluation, constituents with a Henry's Law constant greater than 1 x 10^{-5} atm-m^3/mole or a vapor pressure greater than 1 millimeter Hg are considered volatile and evaluated for this exposure pathway.

Some of the constituents detected in soil at UXO-002, OU-2 are not included on the EPA RSL table because toxicity values are not available. When possible, appropriate surrogate constituents were selected and their RSLs were used as the screening values, as noted in the RAGS Part D **Table 2 series** in **Attachment A-1**. The uncertainties associated with this screening approach are discussed in **Section A.6**.

A.2.3 Constituents of Potential Concern

Attachment A-2 (**Table 2**) lists the constituents identified as COPCs for each medium, as summarized below.

Surface Soil (0 to 0.5 foot below ground surface [bgs]):

- Six polycyclic aromatic hydrocarbons (PAHs) (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene)
- One metal (lead)

Combined Surface and Subsurface Soil (0 to 1 foot bgs):

- Six PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene)
- One metal (lead)

Sediment:

- None

Groundwater (Tap Water):

- One PAH (benzo(a)anthracene)
- One metal (lead)
- No COPC for potential VI pathway

A.3 Exposure Assessment

Exposure refers to the potential contact of an individual with a constituent. The exposure assessment identifies pathways and routes by which an individual may be exposed to the COPCs, and estimates the magnitude, frequency, and duration of potential exposure. COPC intakes and associated health risks are only quantified for complete exposure pathways.

The components of exposure assessment include the following:

- Development of the conceptual site model for human health
- Calculation of exposure point concentrations (EPCs)
- Development of exposure assumptions for potentially complete exposure pathways
- Calculation of intake for COPCs using calculated EPCs and exposure assumptions

A.3.1 Conceptual Site Model for Human Health

The human health conceptual site model (CSM), showing potential human health exposure scenarios for current and potential future site use, is provided in **Attachment A-1, Table 1** and shown in **Attachment A-2** (**Figure 1**). The CSM provides a current understanding of the source(s) of contamination, release and transport mechanisms, current and potential future land use, and identifies potentially complete human exposure pathways for UXO-002, OU-2.

A.3.1.1 Potential Source Areas

The primary source of potential contamination at the Former Skeet Ranges are lead shot and clay target fragments, as presented in **Section 5** of the RI Report**.** Potential secondary sources of contamination are soil, sediment, water in excavation trench, and groundwater in the shotfall areas, which are potentially contaminated by constituents associated with lead shot (metals) and clay target fragments (PAHs associated with tar pitch typically used to bind clay targets used at skeet ranges). Because these constituents have a relatively high adsorption to solids, this potential transport of contamination to the liquid phase is expected to be minimal. At range sites, lead is typically considered the primary constituent of concern based on its prevalence and risk-driving potential (ITRC, 2003).

A.3.1.2 Release Mechanisms and Environmental Transport Media

A transport pathway describes the mechanisms whereby site-related constituents, once released, may be transported from a source area to exposure media (such as surface soil) where receptor exposures may occur. These transport pathways are presented in **Section 5** of the RI Report.

The mechanisms for transport of the COPCs from the source through environmental media and to potential receptors include:

- Direct deposit of lead shot and clay target fragments into soils in the upland vegetated areas and direct deposit of lead shot into sediment in the near shore areas of the Patuxent River

- Transport of contaminated soil particulates via overland surface runoff to downgradient terrestrial and aquatic areas

- Particulate emission and volatilizing chemicals emanating from soil to ambient air
- Transport of contaminated soil particulates via wind- or soil-disturbing activities to surrounding terrestrial areas
- Leaching of chemicals from surface and subsurface soils into groundwater via infiltrating precipitation, although this is expected to be negligible based on the relatively high adsorption to solids of potential contaminants
- Future household use of groundwater from wells, including volatilization of chemicals in groundwater from showering or household activities (groundwater is not currently used as a potable water supply)
- Volatilizing chemicals emanating from groundwater in an excavation trench during construction/excavation activities
- Volatilizing chemicals emanating from groundwater to indoor air in potential future residential and industrial buildings constructed at the site (there are currently no buildings at the site)

A.3.1.3 Characterization of Current and Future Land Use

The terrestrial area potentially affected by past use of the site is mostly grassy, wooded, or sandy and is adjacent to the Patuxent River. The site is in an area of the NAS with land use that is mostly undeveloped and in proximity to some mission-related operational facilities. Based on past site use, the media of potential concern for human exposure under the current land use is surface soil and sediment.

The terrestrial portion of the site is not fenced and access to the site is not restricted; therefore, potential current receptors include employees of the adjacent industrial facility and trespassers exposed to surface soil through incidental ingestion, dermal contact, and inhalation of particulates and volatile emissions. For persons with authorized access to the base, the beach area of the site is not officially designated as a restricted area, but it is also not located in a recreational area and generally is not accessed (the public beach area at NAS Patuxent River is located at Cedar Point, east of the site at the intersection of the Patuxent River and Chesapeake Bay).

Groundwater at the site is not currently used as a potable water supply; therefore, there are no current complete exposure pathways for groundwater. As volatile constituents are not detected in soil and groundwater sampling locations within 30 feet of current site buildings, there is no potential for VI from soil and groundwater into current site buildings and inhalation of indoor air by current site workers. Additionally, the target analytes for the site (lead and PAHs associated with tar pitch) are typically not considered highly volatile compounds.

In summary, the current site use exposure routes for quantitative evaluation are as follows:

- **Industrial Worker:** Incidental ingestion, dermal contact, and inhalation of COPCs in surface soil
- **Trespasser/Visitor (adult and adolescent):** incidental ingestion, dermal contact, and inhalation of COPCs in surface soil; Incidental ingestion and dermal contact of COPCs in sediment (however, since no COPC is identified in sediment, a quantitative evaluation of sediment exposure was not performed)

There are no plans for future site development; however, future site use is unknown. Potential future receptors who could be exposed to surface soil include the current receptors, and if the site is developed for future use, future residents, construction workers, and industrial workers. Exposure characteristics for future exposure to surface soil are considered the same as those for current exposure to surface soil. Subsurface soil at the Former Skeet Ranges could be a medium for future human exposure if intrusive work is performed in the future or if the site is converted to residential or industrial use and development activities result in exposing subsurface soil. Exposure routes for subsurface soil are the same as those for surface soil.

Potential future receptors who could be exposed to groundwater include future residents and construction workers, if the site is developed for future use. Therefore, although unlikely, unrestricted land use (residential land use) was included to evaluate the most conservative future site use. Shallow groundwater from the site is not used as a current potable water supply, and it is unlikely that it will be used as a future water supply based on the characteristics of the surficial aquifer (that is, likely brackish and tidally influenced because of its proximity to the Patuxent River and thus is not potable). Furthermore, use of the surficial aquifer for potable supply is not permitted by the St. Mary's County Health Department, as outlined in a letter received from the St. Mary's County Health Department which states that "with the exception of Amish and Mennonite properties, the construction of shallow surface wells for drinking water has not been permitted in St. Mary's County since 1976" (Rose, 1998). However, it was conservatively assumed that groundwater from the surficial aquifer could be used as a future potable water supply and risks associated with residential potable use were evaluated in the HHRA.

Although the exposure pathways associated with potable use of groundwater are likely incomplete for future human receptor populations at the site, there is potential for VI of volatile constituents in groundwater into future buildings. Future residents and site workers could be exposed to the groundwater through VI into a building and subsequent inhalation of indoor air if a building is constructed at the site. Therefore, groundwater concentrations were screened against VISLs but no COPCs were identified.

Exposure to groundwater was also evaluated for construction workers as groundwater at the site ranges from approximately 4 to 10 feet bgs. Construction workers may be exposed to the shallow groundwater during excavation and construction activities.

To summarize, potential future exposure pathways are as follows:

- **Resident (adult and child):** Incidental ingestion, dermal contact, and inhalation of COPCs in combined surface and subsurface soil; Ingestion of and dermal contact with groundwater, and inhalation of volatile COPC from groundwater while showering (adult exposure only). Inhalation of volatile COPC in indoor air from VI from groundwater (however, since no COPC is identified in groundwater for the VI to indoor air pathway, no further evaluation of this exposure pathway was performed).
- **Industrial worker:** Incidental ingestion, dermal contact, and inhalation of COPCs in combined surface and subsurface soil; Inhalation of volatile COPC in indoor air from VI from groundwater (however, since no COPC is identified in groundwater for the VI to indoor air pathway, no further evaluation of this exposure pathway was performed).
- **Trespasser/Visitor (adult and adolescent):** Incidental ingestion, dermal contact, and inhalation of COPCs in combined surface and subsurface soil; Incidental ingestion and dermal contact of COPCs in sediment; however, because no COPC is identified in sediment, a quantitative evaluation of sediment exposure was not performed).
- **Construction worker:** Incidental ingestion, dermal contact, and inhalation of COPCs in combined surface and subsurface soil; Dermal contact with shallow groundwater and inhalation of volatile emissions from shallow groundwater in an open excavation.

Although the site is not expected to be developed for residential use, an unrestricted land use scenario (i.e., residential land use) was conservatively evaluated in the HHRA.

A.3.2 Calculation of Exposure Point Concentrations

Exposure is quantified by estimating the EPCs for COPCs in environmental media and COPC intake by the receptor. EPCs are the estimated COPC concentrations that a receptor may contact. The EPCs for UXO-002, OU-2 are provided in **Attachment A-1, Tables 3.1.RME through 3.5.RME**.

EPCs may be directly measured or estimated using environmental fate and transport models. Measured COPC concentrations in each exposure medium were used to estimate exposure through ingestion and dermal contact exposure routes. Fate and transport modeling was used to estimate COPC concentrations for the following inhalation exposure pathways:

- COPCs in ambient air resulting from particulate and volatile emissions from soil
- COPCs in water vapors from groundwater while showering
- COPCs in ambient air volatilized from groundwater in an open excavation

Concentrations in particulate emissions from soil were estimated using the PEF approach presented in EPA's Soil Screening Guidance (EPA, 2002). EPA's default PEF value of 1.36×10^9 cubic meters per kilogram (m^3/kg) was used in the calculation (SEPA, 2002). One COPC (benzo(a)anthracene) was identified as a volatile constituent; therefore, a PEF and a volatilization factor (VF) were used to estimate the potential ambient air concentrations for benzo(a)anthracene. The VF was calculated using site-specific input parameters, and the calculation is provided in **Attachment A-1, Table 3.2.RME Supplement A**. The calculated air concentrations are shown in **Attachment A-1**, **Tables 3.2.RME** (surface soil) and **3.4.RME** (combined surface and subsurface soil).

One of the groundwater COPCs (benzo(a)anthracene) is a volatile constituent. The concentration of benzo(a)anthracene in water vapors while showering was estimated using the Foster and Chrostowski shower model (Foster and Chrostowski, 1987), as provided in **Attachment A-1**, **Table 7.4.RME Supplement B**. The concentration of benzo(a)anthracene in ambient air resulting from volatilization from shallow groundwater in an open excavation was calculated using a two-film volatilization model, as provided in **Attachment A-1, Table 7.10.RME Supplement B**.

ProUCL software Version 5.1.001 (EPA, 2016a) was used to calculate the EPCs. ProUCL was used to determine the distribution of the data and calculate upper confidence levels (UCLs) on the mean concentrations (typically 95% UCL) that were used as the EPCs. The recommendations outlined in the ProUCL software documentation (EPA, 2015) were followed to select the appropriate UCL on the mean concentration. The arithmetic mean concentration was used as the EPC for lead.

A.3.3 Estimation of Chemical Intakes for Individual Pathways

Chemical intake is the amount of the COPC entering the receptor's body. The quantification of exposure is based on an estimate of the chronic or subchronic daily intake (DI), the average amount of the COPC entering the receptor's body per day. Chemical intake estimates for the ingestion exposure pathway are expressed as follows:

$$DI = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

DI	=	daily intake (milligrams per kilogram per day [mg/kg-day])
C	=	chemical concentration in exposure medium (mg/kg or micrograms per liter [µg/L])
IR	=	ingestion rate (milligrams per day [mg/day] or liters per day [L/day])
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kilograms [kg])
AT	=	averaging time (days)

The DI of COPCs in soil for the dermal contact pathway is calculated as follows:

$$DI = \frac{C \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$$

Where:

DI	=	daily intake (mg/kg-day)
C	=	chemical concentration in soil (mg/kg)
SA	=	skin surface area (square centimeter [cm^2])
SSAF	=	soil to skin adherence factor (milligram per square centimeter per day [mg/cm^2-day])
DABS	=	dermal absorption factor (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

The absorption fractions for soil were obtained from EPA guidance (2004), which recommends 13 percent for PAHs. The intake equation for the dermal exposure pathway is shown in the RAGS Part D **Table 4 series** in **Attachment A-1**.

The DI of COPCs in groundwater for the dermal contact pathway is calculated as follows:

$$DI = \frac{DAevent \times SA \times EV \times EF \times ED}{BW \times AT}$$

Where:

DI	=	daily intake (mg/kg-day)
DAevent	=	Absorbed dose per event (mg/cm^2 per event)
SA	=	surface area (cm^2)
EV	=	event frequency (events/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

Dermally absorbed dose per event (DAevent) is calculated based primarily on chemical concentration in groundwater (µg/L converted to mg/cm^3), exposure time/duration per event (hours/event), and chemical-specific dermal permeability coefficient in water (cm/hour), in accordance with EPA's Dermal Exposure Assessment Guidance (EPA, 2004). The DAevent is calculated in **Attachment A-1, Tables 7.4.RME Supplement A**, **7.5.RME Supplement A, and 7.10.RME Supplement A**.

Chemical exposure estimates for the inhalation pathway are expressed as follows:

$$EC = \frac{Ca \times ET \times EF \times ED \times CF}{AT}$$

Where:

EC	=	exposure concentration (milligrams per cubic meter [mg/m^3])
Ca	=	chemical concentration in air (mg/m^3)
ET	=	exposure time (hours per day [hours/day])
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF	=	conversion factor (days/hour)
AT	=	averaging time (days)

The intake and exposure equations require exposure parameters that are specific to each exposure pathway. Many of the exposure parameters used in the HHRA are default exposure values (e.g., body weights, media intake levels, and exposure frequencies and duration) obtained from EPA guidance (EPA, 1989; 1991; 2002; 2004; 2011; 2014). Other assumptions (for example, for the trespasser and construction worker scenarios) require consideration of scenario-specific information and were determined using professional judgment. The HHRA assumed potential trespassers/visitors would be exposed to soil four hours per day, one day per week throughout the year (52 days/year). It was also assumed that adolescent trespassers/visitors are 9 to 18 years of age. Additionally, it was assumed a future worker would work on construction projects for 125 days per year for 1 year.

Attachment A-1, Tables 4.1.RME through 4.7.RME and **Attachment A-1, Tables 4.1.CTE and 4.2.CTE** present the exposure parameters that were used for the exposure scenarios evaluated in the HHRA. Reasonable maximum exposure (RME) scenario exposure parameters were compiled for all scenarios. Central tendency exposure (CTE) parameters were compiled only for scenarios where the RME noncarcinogenic hazard or carcinogenic risk for an environmental medium was greater than the noncarcinogenic hazard or carcinogenic risk target levels (cumulative noncarcinogenic hazard index [HI] > 1, and carcinogenic risk > 1×10^{-4}).

A.4 Toxicity Assessment

Toxicity assessment defines the relationship between the magnitude of exposure and possible severity of adverse effects and weighs the quality of available toxicological evidence. Toxicity assessment generally consists of two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining the potential adverse effects from exposure to the chemical and the type of health effect involved. Dose-response assessment is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the constituent administered or received and the incidence of adverse health effects in the exposed population. Toxicity criteria (for example, reference doses [RfDs], inhalation reference concentrations [RfCs], cancer slope factors [CSFs], and inhalation unit risk factors [IURs] are derived from the dose-response relationship.

EPA recommends that a tiered approach be used to obtain the toxicity values (such as RfDs and CSFs) that are used to estimate noncarcinogenic hazards and carcinogenic risks (EPA, 2003a). The hierarchy of toxicity value sources is the following:

1. Integrated Risk Information System (IRIS) (EPA, 2021d)
2. Provisional Peer-Reviewed Toxicity Values
3. Other EPA and non-EPA sources (as referenced in the RSL table [EPA, 2021a]), including the Agency for Toxic Substances and Disease Registry Minimum Risk Levels (MRLs), California Office of Environmental Health Hazard Assessment Chemical Database, the Health Effects Assessment Summary Tables (HEAST).

One COPC (benzo(a)pyrene) elicits both noncarcinogenic and carcinogenic effects and was evaluated for both toxicological endpoints. The health risks for noncarcinogenic and carcinogenic effects were estimated separately based on different toxicity values.

A.4.1 Toxicity Information for Noncarcinogenic Effects

Noncarcinogenic health effects include a variety of toxic effects on body systems, ranging from toxicity to the kidneys to central nervous system disorders. The toxicity of a chemical is assessed through a review of toxic effects noted in short-term (acute) animal studies, long-term (chronic) animal studies, and epidemiological investigations.

EPA (1989) defines the chronic RfD as a dose that is likely to be without appreciable risk of deleterious effects during a lifetime of exposure. A chronic RfC is defined as an estimate of a continuous inhalation exposure to the human population that is likely to be without appreciable risk of deleterious effects during a lifetime (EPA, 2009a). Chronic RfDs and RfCs are specifically developed to be protective for long-term exposure to a compound (for example, 7 years to a lifetime), and consider uncertainty in the toxicological database and sensitive receptors. Subchronic RfDs and RfCs are applicable for exposures from two weeks to less than 7 years. Chronic toxicity values were available for one COPC (benzo(a)pyrene) and subchronic toxicity values were not available for any of the COPCs. Therefore, the chronic RfD and RfC for benzo(a)pyrene were used to estimate potential noncarcinogenic hazards for subchronic exposures to future construction workers. Additionally, the chronic RfD and RfC values were used to evaluate noncarcinogenic hazards to all other receptors evaluated in the HHRA.

In the development of RfDs and RfCs, all available studies examining the toxicity of a chemical following exposure are considered on the basis of scientific merit. The lowest dose level at which an observed toxic effect occurs is identified as the lowest observed adverse effect level (LOAEL), and the dose at which no effect is observed is identified as the no observed adverse effect level (NOAEL). Several uncertainty factors (UFs) may be applied to account for uncertainties such as limited data, extrapolation of data from animal studies to human exposures, or the use of subchronic studies to develop chronic criteria. These UFs generally range from 10 to 10,000 and are based on professional judgment. Consequently, there are varying degrees of uncertainty in the toxicity criteria, which range from 300 to 3,000 for the COPCs identified for this site.

Per EPA (2004) guidance, the oral RfDs are adjusted from administered dose (oral) to absorbed dose (dermal) to evaluate dermal toxicity. This adjustment is performed only when a chemical has a gastrointestinal absorption factor of less than 50 percent. PAHs selected as COPCs have a gastrointestinal absorption factor ranging from 58% to 89% (EPA, 2004); therefore, the oral RfD was used as the dermal RfD without adjustment, as shown in **Attachment A-1, Table 5.1**.

A.4.2 Toxicity Information for Carcinogenic Effects

Potential carcinogenic effects are quantified as CSFs that convert estimated exposures directly to incremental lifetime carcinogenic risks.

CSFs may be derived from the results of chronic animal bioassays, human epidemiological studies, or both. Animal bioassays are usually conducted at dose levels that are much higher than are likely to be encountered in the environment. This design detects possible adverse effects in the relatively small test populations used in the studies. The actual risks from exposure to a potential carcinogen are not likely to exceed the estimated risks.

As was done for the oral RfD for benzo(a)pyrene, the oral CSFs for the PAHs were used as the dermal CSFs, without adjustment, because the gastrointestinal absorption factors for the PAHs ranged from 58% to 89% (EPA, 2004). The oral and dermal CSFs are provided in **Attachment A-1, Table 6.1**.

A.4.3 Approach for Potential Mutagenic Effects

Consistent with the Cancer Guidelines and Supplemental Guidance (EPA, 2005a; 2005b), carcinogenic risks were estimated using age-dependent adjustment factors (ADAFs) for COPCs which act via a mutagenic mode of action (MMOA). The six carcinogenic PAHs were COPCs that are categorized as chemicals with a MMOA.

The calculation of cancer risk using ADAFs is presented in **Attachment A-1, Table 7.6.RME**. As chemical-specific data are not available for the carcinogenic PAHs, default ADAFs, as included in the EPA Region 3 Memorandum, *Derivation of RBCs for Carcinogens that Act Via a Mutagenic Mode of Action and Incorporate Default ADAFs* (EPA, 2006), were used for the MMOA evaluation. The default ADAFs used to adjust the CSF and IUR are 10 for newborns to 2-year-olds, 3 for 2- to 6-year-olds, 3 for 6- to 12-year-olds, and 1 for 16- to 26-year-olds. The CSF (and IUR) were multiplied by the appropriate ADAF to derive the age-specific CSF (and IUR) for a receptor to calculate the total carcinogenic risk. Additionally, the exposure factors for children 0 to 2 years old and 2 to 6 years old were assumed to be the same as the parameters for a child 0 to 6 years old, except for the exposure durations, which were 2 years and 4 years, respectively. The exposure factors for the adult residential receptor were used for residents 6 to 16 years old and 16 to 26 years old, except for the exposure duration, which was 10 years for both age ranges. For the adolescent receptors, the exposure factors for the 9- to 16-year-old adolescents were used, and an ADAF of 3 (for 6- to 12-year-olds) was used to adjust the CSFs and IUR.

A.4.4 Constituents for Which EPA Toxicity Values Are Not Available

Detected chemicals that did not have RSLs were compared to RSLs for appropriate surrogate chemicals during the COPC selection process. Surrogates were selected based on previous recommendations from EPA Region 3. The surrogates are identified in the RAGS Part D **Table 2 series** in **Attachment A-1**.

Quantitative oral toxicity criteria are not available for lead. Lead is screened against 400 mg/kg (EPA, 2021a) and 200 mg/kg (MDE, 2020) in soil and 15 µg/L in groundwater (EPA, 2021a; 2021b), based on residential exposure. Lead was identified as a COPC in surface soil, combined surface and subsurface soil, and groundwater at UXO-002, OU-2. A discussion of lead exposure analysis is included in **Section A.5.2**. Detected lead concentrations exceed the residential soil screening levels of 400 mg/kg and 200 mg/kg in two surface soil samples (504 mg/kg in the 0 to 0.5-foot bgs interval at SO-22 [PX-FSR-SS22-000H] and 621 mg/kg in the 0 to 0.5-foot bgs interval at SO-30 [PX-FSR-SS30-000H]) among 48 combined surface and subsurface samples analyzed for lead. Detected lead concentrations exceed the drinking water action level of 15 µg/L in two groundwater samples collected at MW07 (60.2 and 29.5 µg/L) among 12 groundwater samples analyzed for lead.

A.5 Risk Characterization

Risk characterization combines the results of the previous elements of the risk assessment to evaluate the potential health risks associated with exposure to the COPCs. The risk characterization is then used as an integral component in remedial decision making and selection of potential remedies or actions, as necessary.

A.5.1 Methods for Estimating Risks

Potential human health risks are discussed independently for carcinogenic and noncarcinogenic constituents because of the different toxicological endpoints, relevant exposure duration, and methods used to characterize effects. Exposure to a COPC may result in both noncarcinogenic and carcinogenic effects (that is, benzo(a)pyrene), and therefore, it was evaluated for both health endpoints. The methodology used to estimate noncarcinogenic hazards and carcinogenic risks are described below.

A.5.1.1 Noncarcinogenic Hazard Estimation

Noncarcinogenic hazard is estimated by comparing the calculated COPC exposures to RfDs or the exposure concentrations to RfCs. The calculated intake divided by the RfD, or exposure concentration divided by RfC, is equal to the HQ:

$$HQ = \text{Intake}/\text{RfD or Exposure Concentration}/\text{RfC}$$

The intake and RfD, or exposure concentration and RfC, represent the same exposure route (i.e., oral intakes are divided by oral RfDs, inhalation exposure concentrations are divided by inhalation RfCs). An HQ that exceeds 1 (i.e., intake exceeds the RfD) indicates that there is a potential for adverse health effects associated with exposure to that chemical.

To assess the potential for noncarcinogenic health effects posed by exposure to multiple COPCs, an HI approach is used (EPA, 1986). This approach assumes that noncarcinogenic hazards associated with exposure to more than one COPC are additive (HI = sum of the HQs). Synergistic or antagonistic interactions between multiple COPCs are not considered. The HI may exceed 1 even if all of the individual HQs are less than 1. HIs may be added across exposure routes to estimate the total noncarcinogenic health effects to a receptor posed by exposure through multiple routes. Additionally, separate HIs are estimated for each target organ to assess whether the HI for a specific target organ is greater than 1. A target organ-specific HI greater than 1 indicates there is some potential for adverse noncarcinogenic health effects associated with exposure to the COPCs, possibility warranting remedial action. If the HI for each target organ does not exceed 1, noncarcinogenic hazards are not expected.

A.5.1.2 Carcinogenic Risk Estimation

The potential for carcinogenic effects due to exposure to site-related chemicals is evaluated by estimating the ELCR. ELCR is the incremental increase in the probability of developing cancer during one's lifetime in addition to developing cancer associated with exposure to all non-site-related sources of carcinogens. Carcinogenic risk is calculated by multiplying the intake by the CSF or multiplying the exposure concentration by the IUR.

$$\text{ELCR} = \text{Intake} \times \text{CSF or Exposure Concentration x IUR}$$

The combined risk from exposure to multiple COPCs was evaluated by adding the risks from individual COPCs. Risks were also added across the exposure routes if an individual would be exposed through multiple routes.

As required under the National Contingency Plan (EPA, 1994b), "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} to 10^{-6} using information on the relationship between dose and response." When a cumulative carcinogenic risk to a receptor under the assumed RME exposure conditions exceeds 1 in 10 thousand (i.e., 10^{-4} ELCR), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) generally requires remedial action to reduce risks at the site.

A.5.1.3 Approach for Lead

Lead was identified as a COPC for surface soil, combined surface and subsurface soil, and groundwater. Lead does not have available published toxicity factors, and therefore, potential risks associated with exposure to lead are evaluated differently than the other COPCs. The potential impacts from exposure to lead are evaluated by EPA based on blood-lead uptake using a physiologically based pharmacokinetic model called the Integrated Exposure Uptake Biokinetic (IEUBK) model. To estimate potential risks from exposure to lead in the HHRA, exposure to children was evaluated using the IEUBK, and nonresidential adult exposure to lead in soil was estimated using the adult lead methodology (ALM).

The potential risks associated with residential child exposures to lead were addressed using the IEUBK Lead Model for Windows, Version 2.0, Build 1 (EPA, 2021e). The IEUBK model provides predictions of the probability of elevated blood-lead levels for children from ages 0 to 7 years with potential exposure to lead in various media. This model addresses three components of environmental risk assessments: the multimedia nature of exposures to lead, lead pharmacokinetics, and significant variability in exposure and risk, through estimation of probability distributions of blood-lead levels for children exposed to similar environmental concentrations. The IEUBK model was used to evaluate potential risks associated with future residential child exposures to lead in surface and subsurface soil and groundwater. The arithmetic mean of the lead concentration in combined surface and subsurface soil (82.7 mg/kg in **Attachment A-1, Table 3.2.RME**) and groundwater (9.06 µg/L in **Attachment A-1, Table 3.5.RME**) was used with the default input parameters to represent site-specific exposures to lead. All the other default model input parameters were used in the model. Additionally, following current EPA guidance (OLEM Directive 9200.2-177, EPA, 2017b), the lead exposure was assessed for a child age range of 12 to 72 months. The IEUBK model results are expressed as the predicted geometric mean blood-lead level for children and the percent of the population potentially experiencing blood-lead levels above EPA's current recommended level of 10 micrograms per deciliter (µg/dL) as described in the 1994 Office of Solid Waste and Emergency Response (OSWER) directive (EPA, 1994a). Additionally, the percent of the population potentially experiencing blood-lead levels above the reference level of 5 µg/dL used by the Centers for Disease Control and Prevention (CDC) and MDE (2020) was estimated.

An interim approach to assessing risks associated with adult exposures to lead in soil was developed by EPA's Technical Review Workgroup for Lead (EPA, 2003b). This methodology is a variation of the IEUBK model used to evaluate lead exposures to children. The ALM is used to evaluate risks to the fetus of a nonresidential adult exposed to lead in soil. The model focuses on estimating fetal blood concentrations in women exposed to lead in soil (EPA, 2003b). Because the lead model is a probabilistic model, several of the EPA default parameters are based on central tendency (that is, average) values (EPA, 2003b). Therefore, the arithmetic mean lead concentration in surface soil or in combined surface and subsurface soil served as the input value for the soil concentration. Additionally, central tendency values for ingestion rate and exposure frequency were used in the ALM, as recommended in the ALM frequently asked questions (FAQs) accessed online via the EPA website (http://www.epa.gov/superfund/lead/almfaq.htm). A central tendency soil ingestion rate of 50 mg/day was used for the industrial worker and trespasser/visitor, and a central tendency soil ingestion rate of 100 mg/day was used for the construction worker. An exposure frequency of 52 days/year was used for the trespasser/visitor, and an exposure frequency of 125 days/year was used for the construction worker. The CTE frequency of 219 days/year was used for the industrial worker. Following the the ALM FAQs accessed online via the EPA webite (http://www.epa.gov/superfund/lead/almfaq.htm), an averaging time of one-half of a year was used for the construction worker, as this was the expected duration of a construction/excavation project.

The ALM uses a geometric standard deviation (GSD) and baseline blood-lead level for U.S. women of child-bearing age. The GSD is a measure of the inter-individual variability in blood-lead concentrations in a population whose members are exposed to the same nonresidential environmental lead levels. The baseline blood-lead concentration is intended to represent the best estimate of a reasonable central value of blood-lead concentrations in women of child-bearing age that are not exposed to lead-contaminated nonresidential soil or dust at the site (EPA, 2003b). The GSD and baseline blood-lead concentrations from the most recent 6 years (2009-2014) of blood-lead data from the National Health and Nutrition Examination Survey, as recommended in OLEM Directive 9285.6-56 (EPA, 2017a), were used in the ALM model. The GSD and baseline blood-lead levels from additional survey years were used for additional calculations to provide a range of blood-lead concentrations.

ALM spreadsheets provided by EPA (2017c) were used to calculate blood-lead levels for the various scenarios. The model results are expressed as the predicted geometric mean blood-lead level for adults (that is, women of child-bearing age) and the corresponding 95th percentile fetal blood-lead concentrations and the percent of the population potentially experiencing concentrations above EPA's current recommended level of 10 µg/dL as described in the 1994 OSWER directive (EPA, 1994a). Additionally, the percent of the population potentially experiencing blood-lead levels above the reference level of 5 µg/dL used by the CDC and MDE (2020) was estimated.

A.5.2 Risk Assessment Results

The results of the risk estimates for MRS UXO-002, OU-2 are summarized below by receptor. Summaries of the RME and CTE risk results are presented in **Attachment G-2** (**Table 3** and **Table 4**, respectively). The RME risk calculations are presented in **Attachment A-1, Tables 7.1.RME through 7.10.RME**. **Attachment A-1, Tables 9.1.RME through 9.10.RME** summarize the RME hazards and risks to each receptor. The CTE risk calculations are presented in **Attachment A-1, Table 7.1.CTE**. **Attachment A-1, Table 9.1.CTE** summarizes the CTE hazards and risks to each receptor. The constituents of concern (COCs) are identified below for each receptor. The COCs are those COPCs that contribute an HI greater than 0.1 to a cumulative target organ HI that exceeds 1, or a carcinogenic risk greater than 1×10^{-6} to a cumulative carcinogenic risk that exceeds 1×10^{-4}. Additionally, when the lead exposure analysis indicates that the percent of the population potentially experiencing blood-lead levels above 10 µg/dL (EPA, 1994) or 5 µg/dL (the reference level used by the CDC and MDE [2020]) exceeds 5 percent, lead is identified as a COC.

Factors such as nature of contamination source (i.e., site relatedness), data quality (i.e., laboratory contamination), and common pesticide use (unrelated to spills, improper storage disposal or use) are also considered when identifying COCs.

A.5.2.1 Current/Future Industrial Worker (Attachment A-1, Table 9.1.RME)

The HHRA assumed that a current/future industrial worker could be exposed to surface soil through incidental ingestion, dermal contact, and inhalation. The cumulative RME noncarcinogenic hazard (HI = 0.02) is less than the target HI of 1 and the cumulative RME carcinogenic risk (3×10^{-6}) is within the target risk range of 1×10^{-6} to 1×10^{-4}.

Lead was identified as a COPC in surface soil. Exposure to the average concentration of lead in surface soil was evaluated using the ALM. The model results are presented in **Attachment A-1, Tables 11.1a and 11.1b**. The probabilities that the fetal blood-lead levels exceed 10 µg/dL are below 1 percent. The probabilities that the fetal blood-lead levels exceed 5 µg/dL are all below 5. These values are less than the current blood-lead goal as described in the 1994 OSWER directive (EPA, 1994a) of no more than 5 percent of children (fetuses of exposed women) exceeding the 10 µg/dL blood-lead level and the 5 µg/dL blood-lead reference level used by the CDC and MDE (2020). Additionally, no detected concentration of lead in surface soil exceeds the current industrial soil RSL of 800 mg/kg (EPA, 2019).

A.5.2.2 Current/Future Adult Trespasser/Visitor (Attachment A-1, Table 9.2.RME)

The HHRA assumed that a current/future adult trespasser could be exposed to surface soil via incidental ingestion, dermal contact, and inhalation. The RME noncarcinogenic hazard (HI = 0.02) is less than the target HI of 1. The RME carcinogenic risk (ELCR = 2×10^{-6}) is within the regulatory target risk range of 1×10^{-6} to 1×10^{-4}.

Lead was identified as a COPC in surface soil. Exposure to the average concentration of lead in surface soil was evaluated using the ALM. The model results are presented in **Attachment A-1, Tables 11.2a and 11.2b**. The probabilities that the fetal blood-lead levels exceed 10 µg/dL are below 0.5 percent. The probabilities that the fetal blood-lead levels exceed 5 µg/dL are all below 5. These values are less than the current blood-lead goal as described in the 1994 OSWER directive (EPA, 1994a) of no more than 5 percent of children (fetuses of exposed women) exceeding the 10 µg/dL blood-lead level and the 5 µg/dL blood-lead reference level used by the CDC and MDE (2020).

A.5.2.3 Current/Future Adolescent Trespasser/Visitor (Attachment A-1, Table 9.3.RME)

The HHRA assumed that a current adolescent trespasser could be exposed to surface soil through incidental ingestion, dermal contact, and inhalation. The RME noncarcinogenic hazard (HI = 0.04) is less than the target HI of 1. The RME carcinogenic risk (ELCR = 7×10^{-6}) is within the regulatory target risk range of 1×10^{-6} to 1×10^{-4}. Lead was identified as a COPC for surface soil. Exposure to lead in surface soil was evaluated using the ALM for the adult trespasser/visitor, as presented in **Section A.5.2.2**.

A.5.2.4 Future Adult Resident (Noncarcinogenic Hazard, Attachment A-1, Table 9.4.RME)

The HHRA assumed that a future adult resident could be exposed to combined surface and subsurface soil through incidental ingestion, dermal contact, and inhalation and groundwater through ingestion, dermal contact, and inhalation during showering. Carcinogenic risks were not calculated for an adult resident because they were calculated for a lifetime child/adult resident following EPA guidance. The RME noncarcinogenic hazard (HI = 0.08) is less than the target HI of 1.

Lead was identified as a COPC for combined surface and subsurface soil. Exposure to lead in combined surface and subsurface soil was evaluated using the IEUBK for the child resident, as presented in **Section A.5.2.5**.

A.5.2.5 Future Child Resident (Noncarcinogenic Hazard, Attachment A-1, Table 9.5.RME)

The HHRA assumed that a future child resident could be exposed to combined surface and subsurface soil through incidental ingestion, dermal contact, and inhalation and groundwater through ingestion, dermal contact, and inhalation during showering. Carcinogenic risks were not calculated for a child resident because they were calculated for a lifetime child/adult resident in accordance with EPA guidance. The RME noncarcinogenic hazard (HI = 0.7) does not exceed the target HI of 1.

Lead was identified as a COPC in combined surface and subsurface soil. Exposure to the average concentration of lead in combined surface and subsurface soil was evaluated using the IEUBK model. The results of the model, along with the probability distribution plot are presented in **Attachment A-1 (Tables 11.3a and 11.3b; Figures 11.1a and 11.1b)**. The predicted geometric mean blood-lead level for a young child was 2.3 µg/dL with 0.09 percent of the population potentially experiencing concentrations exceeding 10 µg/dL and 4.9 % of children above a blood-lead level of 5 µg/dL. This is below the current blood-lead goal as described in the 1994 OSWER directive (EPA, 1994a) of no more than 5 percent of children exceeding the 10 µg/dL blood-lead level and the 5 µg/dL blood-lead reference level used by the CDC and MDE (2020). Detected lead concentrations exceed the residential soil screening levels of 400 mg/kg and 200 mg/kg in two surface soil samples (504 mg/kg in 0 to 0.5-foot bgs at SO-22 [PX-FSR-SS22-000H] and 621 mg/kg in 0 to 0.5 foot bgs at SO-30 [PX-FSR-SS30-000H]) among 48 combined surface and subsurface samples analyzed for lead.

A.5.2.6 Future Lifetime Resident (Carcinogenic Risk, Attachment A-1, Tables 9.6.RME and 9.1.CTE)

The HHRA assumed that a future lifetime child/adult resident could be exposed to combined surface and subsurface soil through ingestion, dermal contact, and inhalation and groundwater through ingestion, dermal contact, and inhalation during showering. The cumulative RME carcinogenic risk (ELCR = 2×10^{-4}) exceeds the upper end of the acceptable risk range of 1×10^{-6} to 1×10^{-4}. The majority of the estimated carcinogenic risk originates from exposure to soil (ELCR = 2×10^{-4}), while the contribution from groundwater exposure is minimal (ELCR = 2×10^{-6}). The cumulative CTE carcinogenic risk (ELCR = 5×10^{-5}) is within the acceptable risk range of 1×10^{-6} to 1×10^{-4}.

A.5.2.7 Future Industrial Worker (Attachment A-1, Table 9.7.RME)

The HHRA assumed that a future industrial worker could be exposed to combined surface and subsurface soil through ingestion, dermal contact, and inhalation. The cumulative RME noncarcinogenic hazard (HI = 0.05) is less than the target HI of 1 and the cumulative RME carcinogenic risk (1×10^{-5}) is within the target risk range of 1×10^{-6} to 1×10^{-4}.

Lead was identified as a COPC in combined surface and subsurface soil. Exposure to the average concentration of lead in combined surface and subsurface soil was evaluated using the ALM. The model results are presented in **Attachment A-1, Tables 11.4a and 11.4b**. The probabilities that the fetal blood-lead levels exceed 10 µg/dL are below 1 percent. The probabilities that the fetal blood-lead levels exceed 5 µg/dL are all below 5. These values are less than the current blood-lead goal as described in the 1994 OSWER directive (EPA, 1994a) of no more than 5 percent of children (fetuses of exposed women) exceeding the 10 µg/dL blood-lead level and the 5 µg/dL blood-lead reference level used by the CDC and MDE (2020). Additionally, no detected concentration of lead in surface soil exceeds the current industrial soil RSL of 800 mg/kg (EPA, 2019).

A.5.2.8 Future Adult Trespasser/Visitor (Attachment A-1, Table 9.8.RME)

The HHRA assumed that a future adult trespasser could be exposed to combined surface and subsurface soil via incidental ingestion, dermal contact, and inhalation. The cumulative RME noncarcinogenic hazard (HI = 0.01) is less than the target HI of 1. The cumulative RME carcinogenic risk (ELCR = 2×10^{-6}) is within the target risk range of 1×10^{-6} to 1×10^{-4}.

Lead was identified as a COPC in combined surface and subsurface soil. Exposure to the average concentration of lead in combined surface and subsurface was evaluated using the ALM. The model results are presented in **Attachment A-1, Tables 11.5a and 11.5b**. The probabilities that the fetal blood-lead levels exceed 10 µg/dL are below 0.5 percent. The probabilities that the fetal blood-lead levels exceed 5 µg/dL are all below 5. These values are less than the current blood-lead goal as described in the 1994 OSWER directive (EPA, 1994a) of no more than 5 percent of children (fetuses of exposed women) exceeding the 10 µg/dL blood-lead level and the 5 µg/dL blood-lead reference level used by the CDC and MDE (2020).

A.5.2.9 Future Adolescent Trespasser/Visitor (Attachment A-1, Table 9.9.RME)

The HHRA assumed that a future adolescent trespasser could be exposed to combined surface and subsurface soil via incidental ingestion, dermal contact, and inhalation. The cumulative RME noncarcinogenic hazard (HI = 0.03) is less than the target HI of 1. The cumulative RME carcinogenic risk (ELCR = 5×10^{-6}) is within the target risk range of 1×10^{-6} to 1×10^{-4}. Lead was identified as a COPC for combined surface and subsurface soil. Exposure to lead in combined surface and subsurface soil was evaluated using the ALM for the adult trespasser/visitor, as presented in **Section A.5.2.8**.

A.5.2.10 Future Construction Worker (Attachment A-1, Table 9.10.RME)

The HHRA assumed that a future construction worker could be exposed to combined surface and subsurface soil through incidental ingestion, dermal contact, and inhalation and shallow groundwater in an excavation through dermal contact and inhalation of volatile emissions.

The cumulative RME noncarcinogenic hazard (HI = 0.08) is less than the target HI of 1. The cumulative RME carcinogenic risk (ELCR = 6×10^{-7}) is less than the target risk range of 1×10^{-6} to 1×10^{-4}.

Lead was identified as a COPC in combined surface and subsurface soil. Exposure to the average concentration of lead in combined surface and subsurface was evaluated using the ALM. The model results are presented in **Attachment A-1, Tables 11.6a and 11.6b**. The probabilities that the fetal blood-lead levels exceed 10 µg/dL are below 1 percent. The probabilities that the fetal blood-lead levels exceed 5 µg/dL are below 5 percent except when calculated using the GSDi and PbBo from the NHANES III (Phase 1&2), the oldest NHANES study. The values based on the NHANES III study are below the blood-lead goal as described in the 1994 OSWER Directive of no more than 5 percent of children (fetuses of exposed women) exceeding the 10 µg/dL blood-lead level but above the 5 µg/dL blood-lead reference level used by the CDC and MDE (2020). Since results using more recent NHANES study data are within acceptable levels, it is assumed there are no unacceptable risks associated with exposure to lead in soil by future construction workers.

A.6 Uncertainty Associated with Human Health Assessment

The risk measures used in site risk assessments are not fully probabilistic estimates of risk, but are conditional estimates given that a set of assumptions about exposure and toxicity are realized. Thus, it is important to specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective.

A.6.1 Uncertainty in Data Evaluation and COPC Selection

The sampling of site media focused on areas most likely impacted by past site activities. Therefore, the uncertainty associated with missing a contaminated location is expected to be minimal, as the investigation was focused to find the most likely and potentially highest areas of contamination. The uncertainty associated with the data analysis is minimal, and all of the data were validated prior to being used in the HHRA. A data quality evaluation was performed on all analytical data evaluated in the HHRA, as discussed in **Section 3** of the RI Report.

The general assumptions used in the COPC selection process were conservative to ensure that true COPCs were not eliminated from the quantitative risk assessment, and that the greatest possible risk was estimated. RSLs based on residential assumptions were used to select the COPCs for all exposure scenarios, including nonresidential scenarios.

A comparison of site concentrations to background concentrations was not used to select the COPCs in accordance with EPA Region 3 guidance. It is noted that Navy policy (2008) does allow such comparisons to be performed during the COPC screening process. Following the EPA approach may result in the inclusion of risks that may be associated with background conditions and are not necessarily site related. If warranted, a background comparison and discussion is performed for the constituents identified as risk drivers in the risk characterization and risk summary sections.

Chemical surrogates were used in the COPC screening step because screening levels were not available for some detected chemicals. Chemical surrogates were selected based on structural similarity, chemical activity, and mechanisms of toxicity. Use of a surrogate chemical relies on the toxicological principle that chemicals having similar structures will often share a similar mechanism of toxic action and produce similar types of toxic responses. This principle allows the toxicity of a chemical for which toxicity criteria are not available to be predicted based on the data that exist for a structurally similar compound. The types of structural similarities used to identify surrogates included functional groups, elements present in the compounds, bond order and types of bonds (for example, single or double bonds) between elements, and aromaticity. Based on these criteria, the following surrogates were used in the COPC screening:

Chemicals without Screening Levels	Surrogate Chemicals Used for Screening
Acenaphthylene	Acenaphthene
Benzo(g,h,i)perylene	Pyrene
Phenanthrene	Anthracene

Although chemical surrogates were selected using best professional judgment and are based on structural similarities between compounds, using chemical surrogates could underestimate or overestimate the toxicity of chemicals that lack published screening levels.

A.6.2 Uncertainty Associated with Exposure Assessment

Uncertainty in the exposure assessment was generally treated with conservative decision rules and assumptions, and therefore the uncertainty likely overestimates actual exposure to COPCs. Several exposure pathways evaluated by this HHRA, such as residential land use, are hypothetical and are not anticipated to occur in the future at MRS UXO-002, OU-2. Most of the exposure factors used for quantitation of exposure are generally conservative and reflect worst-case, or upper-bound, assumptions for the exposure.

In accordance with EPA guidance, an upper-bound estimate (i.e., the UCL of the arithmetic mean) was used as the EPC for each COPC, except for lead, in site media. This approach likely results in an overestimation of actual exposure because receptors are assumed to be exposed to the UCL of the mean for the entire exposure duration.

The percent of a constituent absorbed through the skin is another source of uncertainty and is likely to be affected by many parameters, including soil loading, moisture content, organic content, pH, and presence of other constituents. The availability of a constituent for absorption through the skin depends on site-specific fate and transport properties of the chemical species available for eventual absorption. Constituent concentrations, specific properties of the constituent, and the kinetics of constituents being released from sediment all affect the amount of a constituent that is absorbed. These factors contribute to the uncertainty associated with dermal absorption estimates and make it difficult to quantify the number of certain constituents absorbed through the skin from soil, and even more for sediment.

A.6.3 Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the noncarcinogenic toxicity factors is included in the toxicity tables for MRS UXO-002, OU-2 in **Attachment A-1**. Several UFs were applied to extrapolate dose levels from animal studies to humans. These UFs range between 300 and 3,000 for benzo(a)pyrene. Therefore, there is a varying degree of uncertainty in the noncarcinogenic toxicity criteria for benzo(a)pyrene based on the available scientific data. Additional uncertainty lies in the prediction of relative sensitivities of different species of animals and the applicability of animal data to humans. The noncarcinogenic toxicity factors for benzo(a)pyrene are most likely an overestimate of actual toxicity. Noncancer toxicity values were not available for the other carcinogenic PAHs, which could lead to an underestimation of noncancer hazards, although the extent cannot be determined.

The uncertainty associated with CSFs is mostly due to the low dose extrapolation where carcinogenicity at low doses is assumed to be a linear response. This is a conservative assumption, which introduces a high uncertainty into CSFs that are extrapolated from this area of the dose-response curve. The CSFs are based on the assumption that there is no threshold level for carcinogenicity; however, most of the experimental studies indicate the existence of a threshold level. Therefore, CSFs developed by EPA represent upper-bound estimates. Carcinogenic risks generated in this assessment should be regarded as an upper-bound estimate on potential carcinogenic risks, rather than an accurate representation of carcinogenic risk. The true carcinogenic risk is likely to be less than the predicted value (EPA, 1989). Uncertainty is also associated with the application of the MMOA for carcinogenic PAHs; this may overestimate or underestimate risks. Additionally, generic ADAFs were used in the MMOA calculations, as no chemical-specific ADAFs are available for the COPCs.

A large degree of uncertainty is associated with the ELCR estimates for the dermal contact exposure. EPA (1989) states that “It is inappropriate to use the oral slope factor to evaluate the risks associated with dermal exposure to carcinogens such as benzo(a)pyrene, which cause skin cancer through a direct action at the point of application. These types of skin carcinogens and other locally active compounds must be evaluated separately from the above method.” However, in this HHRA, cancer risks associated with dermal exposure to carcinogenic PAHs were evaluated based on the oral slope factor, following the methodology used in the development of the EPA RSLs (2019). According to EPA’s toxicological review of benzo(a)pyrene (2017d), “Carcinogenicity studies in animals by the dermal route of exposure are available for benzo[a]pyrene and are supportive of the overall cancer hazard. A quantitative estimate of skin cancer risk from dermal exposure is not included in this assessment, as methodology for interspecies extrapolation of dermal toxicokinetics and carcinogenicity are still under development.”

EPA released a memorandum (OLEM Directive 9200.2-167) in December 2016 (2016b) indicating that the current scientific literature on lead toxicology and epidemiology provides evidence that adverse health effects are associated with blood-lead levels less than the current target blood-lead level of 10 µg/dL, and the current target blood-lead level is no longer considered health-protective; however, formal policy regarding the implementation of a target blood-lead level less than 10 µg/dL has yet to be released by the EPA. However, use of a revised target blood-lead level of 5 µg/dL would not change the results of the HHRA. Exposures to the average lead concentration in soil would not result in exceedance of this revised blood-lead goal.

A large degree of uncertainty is associated with the oral-to-dermal adjustment factors (based on constituent-specific gastrointestinal absorption factors) used to transform the oral RfDs based on administered doses to dermal RfDs based on absorbed doses. It is not known if the adjustment factor results in an underestimate or overestimate of the actual toxicity associated with dermal exposure.

A.6.4 Uncertainty in Risk Characterization

The uncertainties identified in each component of risk assessment ultimately contribute to uncertainty in risk characterization. The addition of risks and HIs across pathways and constituents contributes to uncertainty based on chemical interactions such as additivity, synergism, potentiation, and susceptibility of exposed receptors.

The potential risk of adverse health effects is characterized based on potential exposures and potential dose-response relationships. An important additional source of uncertainty is introduced in this phase of the HHRA—the combination of upper-bound intake estimates with upper-bound toxicity values. Generally, the goal of a baseline risk assessment is to estimate an upper-bound, but reasonable, potential risk. HHRAs combine several upper-bound assumptions to estimate potential risk. The result of combining several such upper-bound assumptions is that the final estimate of potential exposure or potential risk is often conservative.

A.7 Human Health Risk Summary

The HHRA was conducted to evaluate the current and future potential human health risks associated with exposure to surface soil, combined surface and subsurface soil, sediment, and groundwater at MRS UXO-002, OU-2 based on potential but unlikely and conservative receptor populations and exposure scenarios assuming no additional remedial action is implemented at the site.

Attachment G-2 (**Table 3** and **Table 4**) and **Attachment A-1, Tables 9.1.RME through 9.10.RME and 9.1.CTE** summarize the RME and CTE potential hazards and risks to each receptor scenario. The COCs are defined as those COPCs that contribute an HI greater than 0.1 to a cumulative target organ HI that exceeds 1 or a carcinogenic risk greater than 1×10^{-6} to a cumulative carcinogenic risk that exceeds 1×10^{-4}. Five COCs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) were identified in soil for the future residential exposure scenario evaluated at MRS UXO-002, OU-2. A summary of the HHRA results for each receptor scenario are summarized below:

- **Industrial Worker**
  - Current exposure to surface soil and future exposure to combined surface and subsurface soil.
  - HIs and ELCRs (RME) for both current and future exposures are within target regulatory levels.
- **Trespasser/visitor receptors (adult and adolescent):**
  - Current exposure to surface soil and sediment and future exposure to combined surface and subsurface soil and sediment.
  - HIs and ELCRs (RME) for both current and future exposures are within regulatory target levels.
- **Resident (adult and child)**
  - Future exposure to combined surface and subsurface soil and groundwater.

 - HIs (RME) for future exposure are within target regulatory levels but the ELCR (RME) exceeds the regulatory carcinogenic risk target level.
 - ELCR (CTE) for future exposure is within regulatory target levels.

- **Construction Worker**
  - Future exposure to combined surface and subsurface soil and shallow groundwater in an excavation.
  - HIs and ELCRs (RME) are within target regulatory levels.

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Attachment A-1
RAGS Tables

TABLE 1
SELECTION OF EXPOSURE PATHWAYS
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Surface Soil (0-0.5 foot bgs)	Surface Soil	Surface Soil	Industrial Worker	Adult	Dermal	On-site	Quant	Industrial workers of the adjacent industrial facility may visit the site and contact surface soil on the site.
						Ingestion	On-site	Quant	
				Trespasser/Visitor[1]	Adult	Dermal	On-site	Quant	Trespassers/visitors may contact surface soil while on the site.
						Ingestion	On-site	Quant	
					Adolescent	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	
		Air	Emissions from Surface Soil	Industrial Worker	Adult	Inhalation	On-site	Quant	Industrial workers of the adjacent industrial facility may visit the site and inhale dust emanating from surface soil while on the site.
				Trespasser/Visitor[1]	Adult	Inhalation	On-site	Quant	Trespassers/visitors may inhale dust emanating from surface soil while on the site.
					Adolescent	Inhalation	On-site	Quant	
	Sediment	Sediment	Sediment	Trespasser/Visitor[1]	Adult	Dermal	On-site	Quant	Trespassers/visitors may contact sediment in Patuxent River.
						Ingestion	On-site	Quant	
					Adolescent	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	
Future	Soil* (0-1 foot bgs)	Soil*	Soil*	Resident[2]	Adult	Dermal	On-site	Quant	The site is not expected to be developed for residential use; however, the residential scenario is included for a conservative evaluation of unrestricted land use. Exposure to resident could occur if surface and subsurface soil are mixed during excavation.
						Ingestion	On-site	Quant	
					Child	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	
					Child/Adult	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	
				Industrial Worker	Adult	Dermal	On-site	Quant	If the site is developed for future industrial use, industrial workers may be exposed to surface and subsurface soil that are mixed during site development. Additionally, industrial workers of the adjacent industrial facility may visit the site and contact soil on the site.
						Ingestion	On-site	Quant	
				Trespasser/Visitor[1]	Adult	Dermal	On-site	Quant	Trespassers/visitors may contact soil while on the site.
						Ingestion	On-site	Quant	
					Adolescent	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	
				Construction Worker	Adult	Ingestion	On-site	Quant	Construction workers could contact soil while performing construction.
						Dermal	On-site	Quant	
		Air	Emissions from Soil*	Resident[2]	Adult	Inhalation	On-site	Quant	The site is not expected to be developed for residential use; however, the residential scenario is included for a conservative evaluation of unrestricted land use. Residents could inhale dust emanating from soil.
					Child	Inhalation	On-site	Quant	
					Child/Adult	Inhalation	On-site	Quant	
				Industrial Worker	Adult	Inhalation	On-site	Quant	If the site is developed for future industrial use, industrial workers may inhale dust emanating from soil. Additionally, industrial workers of the adjacent industrial facility may visit the site and inhlale dust emanating from soil.
				Trespasser/Visitor[1]	Adult	Inhalation	On-site	Quant	Trespassers/visitors may inhale dust emanating from soil while on the site.
					Adolescent	Inhalation	On-site	Quant	
				Construction Worker	Adult	Inhalation	On-site	Quant	Construction workers may inhale dust emanating from soil.
	Sediment	Sediment	Sediment	Trespasser/Visitor[1]	Adult	Dermal	On-site	Quant	Trespassers/visitors may contact surface sediment in Patuxent River.
						Ingestion	On-site	Quant	
					Adolescent	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	

TABLE 1

SELECTION OF EXPOSURE PATHWAYS

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future (cont.)	Groundwater	Groundwater	Tap Water	Resident[2]	Adult	Dermal	On-site	Quant	Water supply wells are not installed in the surficial aquifer at NAS Patuxent River because such wells are not permitted[4]. Although the site is not expected to be developed for residential use, future potable use of groundwater in a residential scenario is included for a conservative evaluation of unrestricted land use.
						Ingestion	On-site	Quant	
					Child	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	
					Child/Adult	Dermal	On-site	Quant	
						Ingestion	On-site	Quant	
			Water in Excavation Trench	Construction Worker	Adult	Dermal	On-site	Quant	Construction workers could be exposed to shallow groundwater during excavation activities.
						Ingestion	On-site	None	Incidental ingestion of groundwater by construction workers would be minimal during construction or excavation activities.
		Air	Water Vapors at Showerhead	Resident[2]	Adult	Inhalation	On-site	Quant	Groundwater is not currently used on-site as a water supply and the site is not expected to be developed for residential use; however, the residential scenario is included for a conservative evaluation of unrestricted land use, and future adult residents could inhale VOCs from groundwater while showering.
					Child	Inhalation	On-site	None	Children not expected to shower, inhalation of VOCs from groundwater while bathing considered minimal. Therefore, iinhalation of water vapors at showerhead is evaluated for adult only.
					Child/Adult	Inhalation	On-site	Quant	
			Vapor Intrusion to Indoor Air	Resident[2]	Adult	Inhalation	On-site	Qual[3]	The site is not expected to be developed for residential use; however, the residential scenario, including inhalation of volatiles from groundwater and soil in indoor air, is included for a conservative evaluation of unrestricted land use.
					Child	Inhalation	On-site	Qual[3]	
					Child/Adult	Inhalation	On-site	Qual[3]	
				Industrial Worker	Adult	Inhalation	On-site	Qual[3]	The site is not expected to be developed in the future; however, inhalation of volatiles from groundwater and soil in indoor air is included for a conservative evaluation for potential industrial buildings.
			Volatiles in Air in Excavation Trench	Construction Worker	Adult	Inhalation	On-site	Quant	Construction workers could inhale VOCs from groundwater in air in an excavation during construction and excavation activities.

[1] Access to Naval Air Station (NAS) limited to base residents and workers.

[2] Noncarcinogenic hazard evaluated separately for adult and child residential receptors, combined lifetime carcinogenic risk evaluated on an age-adjusted basis for residential scenario.

[3] A screening assessment of groundwater data was performed to identify COPCs for potential vapor intrusion (VI) pathway. However, a quantitative evaluation of health risks was not performed because no COPCs were identified for this exposure pathway.

* Combined surface and subsurface soil.

bgs = below ground surface

COPC = chemical of potential concern.

Quant: the pathway is quantitatively evaluated.

Qual = the pathway is qualitatively evaluated.

VOC = volatile organic compounds

TABLE 2.1

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 foot bgs)
Exposure Medium: Surface Soil / Air

Exposure Point	CAS Number	Chemical	Minimum Concentration Qualifier [1]	Maximum Concentration Qualifier [2]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening [2]	Background Value [3]	Screening Toxicity Value [4]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection [5]
Surface Soil and Emissions from Surface Soil	90-12-0	1-Methylnaphthalene	9.0E-04 J	3.7E-01	mg/kg	PX-FSR-SS30-000H	14/39	0.0034 - 4.05	3.7E-01	N/A	1.8E+01 C	6.0E-03	SSL	NO	BSL
	91-57-6	2-Methylnaphthalene	9.5E-04 J	4.1E-01	mg/kg	PX-FSR-SS30-000H	21/50	0.0034 - 4.05	4.1E-01	2.1E-01	2.4E+01 N	1.9E-02	SSL	NO	BSL
	83-32-9	Acenaphthene	2.3E-03 J	2.5E+00	mg/kg	PX-FSR-SS30-000H	26/50	0.0034 - 14	2.5E+00	4.1E-01	3.6E+02 N	5.5E-01	SSL	NO	BSL
	208-96-8	Acenaphthylene	2.2E-03 J	5.5E-03	mg/kg	PX-FSR-SS54-000H	3/50	0.0034 - 4.05	5.5E-03	1.4E-01	3.6E+02 N	5.5E-01	SSL	NO	BSL
	120-12-7	Anthracene	4.0E-04 J	9.4E+00	mg/kg	PX-FSR-SS22-0001	48/50	0.0034 - 14	9.4E+00	1.1E+00	1.8E+03 N	5.8E+00	SSL	NO	BSL
	56-55-3	**Benzo(a)anthracene**	**2.3E-03 J**	**6.2E+01**	**mg/kg**	**PX-FSR-SS22-0001**	**50/50**	**0.0034 - 14**	**6.2E+01**	**1.3E-01**	**1.1E+00 C**	**1.1E-02**	**SSL**	**YES**	**ASL**
	50-32-8	**Benzo(a)pyrene**	**1.9E-03 J**	**8.1E+01 J**	**mg/kg**	**PX-FSR-SS22-0001**	**50/50**	**0.0034 - 14**	**8.1E+01**	**1.7E-01**	**1.1E-01 C**	**2.9E-02**	**SSL**	**YES**	**ASL**
	205-99-2	**Benzo(b)fluoranthene**	**3.3E-03 J**	**1.1E+02 J**	**mg/kg**	**PX-FSR-SS22-0001**	**48/50**	**0.0034 - 14**	**1.1E+02**	**2.9E-01**	**1.1E+00 C**	**3.0E-01**	**SSL**	**YES**	**ASL**
	191-24-2	Benzo(g,h,i)perylene	1.6E-03 J	5.1E+01	mg/kg	PX-FSR-SS22-0001	48/50	0.0034 - 14	5.1E+01	2.7E-01	1.8E+02 N	1.3E+00	SSL	NO	BSL
	207-08-9	**Benzo(k)fluoranthene**	**1.1E-03 J**	**4.3E+01 J**	**mg/kg**	**PX-FSR-SS22-0001**	**49/50**	**0.0034 - 14**	**4.3E+01**	**1.9E-01**	**1.1E+01 C**	**2.9E+00**	**SSL**	**YES**	**ASL**
	218-01-9	Chrysene	2.9E-03 J	7.6E+01 J	mg/kg	PX-FSR-SS22-0001	50/50	0.0034 - 14	7.6E+01	2.2E-01	1.1E+02 C	9.0E+00	SSL	NO	BSL
	53-70-3	**Dibenz(a,h)anthracene**	**1.2E-03 J**	**1.5E+01**	**mg/kg**	**PX-FSR-SS22-0001**	**42/50**	**0.0034 - 14**	**1.5E+01**	**1.2E+00**	**1.1E-01 C**	**9.6E-02**	**SSL**	**YES**	**ASL**
	206-44-0	Fluoranthene	4.6E-03	8.6E+01	mg/kg	PX-FSR-SS22-0001	50/50	0.0034 - 14	8.6E+01	2.5E-01	2.4E+02 N	8.9E+00	SSL	NO	BSL
	86-73-7	Fluorene	1.7E-03 J	1.5E+00	mg/kg	PX-FSR-SS30-000H	27/50	0.0034 - 4.05	1.5E+00	3.5E-01	2.4E+02 N	5.4E-01	SSL	NO	BSL
	193-39-5	**Indeno(1,2,3-cd)pyrene**	**1.9E-03 J**	**5.9E+01**	**mg/kg**	**PX-FSR-SS22-0001**	**49/50**	**0.0034 - 14**	**5.9E+01**	**1.9E-01**	**1.1E+00 C**	**9.8E-01**	**SSL**	**YES**	**ASL**
	91-20-3	Naphthalene	2.2E-03 J	1.3E+00	mg/kg	PX-FSR-SS30-000H	23/50	0.0034 - 4.05	1.3E+00	1.2E-01	2.0E+00 C	3.8E-04	SSL	NO	BSL
	85-01-8	Phenanthrene	2.2E-03 J	3.3E+01	mg/kg	PX-FSR-SS22-0001 : PX-FSR-SS30P-000H	50/50	0.0034 - 14	3.3E+01	1.7E-01	1.8E+03 N	5.8E+00	SSL	NO	BSL
	129-00-0	Pyrene	3.9E-03	7.8E+01	mg/kg	PX-FSR-SS22-0001	50/50	0.0034 - 14	7.8E+01	2.6E-01	1.8E+02 N	1.3E+00	SSL	NO	BSL
	7439-92-1	**Lead**	**5.4E+00**	**6.2E+02**	**mg/kg**	**PX-FSR-SS30-000H**	**41/41**	**0.29 - 1.06**	**6.2E+02**	**4.4E+01**	**4.0E+02 / 2.0E+02 NL**	**N/A**	**N/A**	**YES**	**ASL**

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] CH2M HILL. 2008. Final, Facility-Wide Background Study, Naval Air Station Patuxent River, St. Mary's County, Maryland. October.
Surface soil background levels were selected.

[4] USEPA. May, 2021. Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs).
Residential soil RSLs (based on target risk of 10^{-6} for carcinogens and HQ of 0.1 for noncarcinogens).
https://www.epa.gov/risk/regional-screening-levels-rsls. Accessed May 12, 2021.
RSL value for acenaphthene used as surrogate for acenaphthylene.
RSL value for pyrene used as surrogate for benzo(g,h,i)perylene.
RSL value for anthracene used as surrogate for phenanthrene.
The residential soil RSL of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.
RCRA Corrective Action Facilities, USEPA, July 14, 1994.
The soil value of 200 mg/kg for lead is Maryland Department of Environment (MDE) residential soil screening level (2020).

[5] Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
bgs = below ground surface
C = Carcinogenic
COPC = Chemical of Potential Concern
HQ = Hazard Quotient
J = Estimated Value
mg/kg = milligram per kilogram
N = Noncarcinogenic
N/A = Not Available
NL = lead residential soil RSL
SSL = Soil Screening Levels from RSL table (based on HQ = 0.1)

TABLE 2.2

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil* / Air

Exposure Point	CAS Number	Chemical	Minimum Concentration Qualifier [1]	Maximum Concentration Qualifier [2]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening [2]	Background Value [3]	Screening Toxicity Value [4]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection [5]
Soil* and Emissions from Soil*	90-12-0	1-Methylnaphthalene	5.9E-04 J	3.7E-01	mg/kg	PX-FSR-SS30-000H	28/60	0.0034 - 4.05	3.7E-01	N/A	1.8E+01 C	6.0E-03	SSL	NO	BSL
	91-57-6	2-Methylnaphthalene	7.0E-04 J	4.1E-01	mg/kg	PX-FSR-SS30-000H	35/71	0.0034 - 4.05	4.1E-01	2.1E-01	2.4E+01 N	1.9E-02	SSL	NO	BSL
	83-32-9	Acenaphthene	2.3E-03 J	2.5E+00	mg/kg	PX-FSR-SS30-000H	40/71	0.0034 - 14	2.5E+00	4.1E-01	3.6E+02 N	5.5E-01	SSL	NO	BSL
	208-96-8	Acenaphthylene	2.2E-03 J	5.5E-03	mg/kg	PX-FSR-SS54-000H	4/71	0.0034 - 4.05	5.5E-03	1.4E-01	3.6E+02 N	5.5E-01	SSL	NO	BSL
	120-12-7	Anthracene	4.0E-04 J	9.4E+00	mg/kg	PX-FSR-SS22-0001	68/71	0.0034 - 14	9.4E+00	1.1E+00	1.8E+03 N	5.8E+00	SSL	NO	BSL
	56-55-3	**Benzo(a)anthracene**	**2.3E-03 J**	**6.2E+01**	**mg/kg**	**PX-FSR-SS22-0001**	**71/71**	**0.0034 - 14**	**6.2E+01**	**1.3E-01**	**1.1E+00 C**	1.1E-02	**SSL**	**YES**	**ASL**
	50-32-8	**Benzo(a)pyrene**	**1.9E-03 J**	**8.1E+01 J**	**mg/kg**	**PX-FSR-SS22-0001**	**71/71**	**0.0034 - 14**	**8.1E+01**	**1.7E-01**	**1.1E-01 C**	2.9E-02	**SSL**	**YES**	**ASL**
	205-99-2	**Benzo(b)fluoranthene**	**3.3E-03 J**	**1.1E+02 J**	**mg/kg**	**PX-FSR-SS22-0001**	**69/71**	**0.0034 - 14**	**1.1E+02**	**2.9E-01**	**1.1E+00 C**	3.0E-01	**SSL**	**YES**	**ASL**
	191-24-2	Benzo(g,h,i)perylene	1.6E-03 J	5.1E+01	mg/kg	PX-FSR-SS22-0001	69/71	0.0034 - 14	5.1E+01	2.7E-01	1.8E+02 N	1.3E+00	SSL	NO	BSL
	207-08-9	**Benzo(k)fluoranthene**	**1.1E-03 J**	**4.3E+01 J**	**mg/kg**	**PX-FSR-SS22-0001**	**70/71**	**0.0034 - 14**	**4.3E+01**	**1.9E-01**	**1.1E+01 C**	2.9E+00	**SSL**	**YES**	**ASL**
	218-01-9	Chrysene	2.9E-03 J	7.6E+01 J	mg/kg	PX-FSR-SS22-0001	71/71	0.0034 - 14	7.6E+01	2.2E-01	1.1E+02 C	9.0E+00	SSL	NO	BSL
	53-70-3	**Dibenz(a,h)anthracene**	**1.2E-03 J**	**1.5E+01**	**mg/kg**	**PX-FSR-SS22-0001**	**63/71**	**0.0034 - 14**	**1.5E+01**	**1.2E+00**	**1.1E-01 C**	**9.6E-02**	**SSL**	**YES**	**ASL**
	206-44-0	Fluoranthene	4.6E-03	8.6E+01	mg/kg	PX-FSR-SS22-0001	71/71	0.0034 - 14	8.6E+01	2.5E-01	2.4E+02 N	8.9E+00	SSL	NO	BSL
	86-73-7	Fluorene	7.4E-04 J	1.5E+00	mg/kg	PX-FSR-SS30-000H	42/71	0.0034 - 4.05	1.5E+00	3.5E-01	2.4E+02 N	5.4E-01	SSL	NO	BSL
	193-39-5	**Indeno(1,2,3-cd)pyrene**	**1.9E-03 J**	**5.9E+01**	**mg/kg**	**PX-FSR-SS22-0001**	**70/71**	**0.0034 - 14**	**5.9E+01**	**1.9E-01**	**1.1E+00 C**	**9.8E-01**	**SSL**	**YES**	**ASL**
	91-20-3	Naphthalene	2.2E-03 J	1.3E+00	mg/kg	PX-FSR-SS30-000H	35/71	0.0034 - 4.05	1.3E+00	1.2E-01	2.0E+00 C	3.8E-04	SSL	NO	BSL
	85-01-8	Phenanthrene	2.2E-03 J	3.3E+01	mg/kg	PX-FSR-SS22-0001 : PX-FSR-SS30P-000H	71/71	0.0034 - 14	3.3E+01	1.7E-01	1.8E+03 N	5.8E+00	SSL	NO	BSL
	129-00-0	Pyrene	3.9E-03	7.8E+01	mg/kg	PX-FSR-SS22-0001	71/71	0.0034 - 14	7.8E+01	2.6E-01	1.8E+02 N	1.3E+00	SSL	NO	BSL
	7439-92-1	**Lead**	**5.4E+00**	**6.2E+02**	**mg/kg**	**PX-FSR-SS30-000H**	**48/48**	**0.29 - 1.06**	**6.2E+02**	**4.4E+01**	**4.0E+02 / 2.0E+02 NL**	**N/A**	**N/A**	**YES**	**ASL**

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] CH2M HILL. 2008. Final, Facility-Wide Background Study, Naval Air Station Patuxent River, St. Mary's County, Maryland. October.
Surface soil background levels were selected.

[4] USEPA. May, 2021. Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs).
Residential soil RSLs (based on target risk of 10^{-6} for carcinogens and HQ of 0.1 for noncarcinogens).
https://www.epa.gov/risk/regional-screening-levels-rsls. Accessed May 12, 2021.
RSL value for acenaphthene used as surrogate for acenaphthylene.
RSL value for pyrene used as surrogate for benzo(g,h,i)perylene.
RSL value for anthracene used as surrogate for phenanthrene.
The residential soil RSL of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.
RCRA Corrective Action Facilities, USEPA, July 14, 1994.
The soil value of 200 mg/kg for lead is Maryland Department of Environment (MDE) residential soil screening level (2020).

[5] Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
bgs = below ground surface
C = Carcinogenic
COPC = Chemical of Potential Concern
HQ = Hazard Quotient
J = Estimated Value
mg/kg = milligram per kilogram
N = Noncarcinogenic
N/A = Not Available
NL = lead residential soil RSL
SSL = Soil Screening Levels from RSL table (based on HQ = 0.1)
* Combined surface and subsurface soil.

TABLE 2.3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration Qualifier [1]	Maximum Concentration Qualifier [2]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening [2]	Background Value [3]	Screening Toxicity Value [4]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection [5]
Sediment	120-12-7	Anthracene	4.0E-03 J	4.5E-03	mg/kg	PX-FSR-SD33-000H	2/6	0.00194 - 0.00205	4.5E-03	N/A	1.8E+04 N	N/A	N/A	NO	BSL
	56-55-3	Benzo(a)anthracene	5.3E-03	1.1E-02	mg/kg	PX-FSR-SD47-000H	4/6	0.00194 - 0.00205	1.1E-02	N/A	1.1E+01 C	N/A	N/A	NO	BSL
	50-32-8	Benzo(a)pyrene	6.8E-03	1.2E-02	mg/kg	PX-FSR-SD47-000H	4/6	0.00194 - 0.00205	1.2E-02	N/A	1.1E+00 C	N/A	N/A	NO	BSL
	205-99-2	Benzo(b)fluoranthene	6.7E-03	1.1E-02	mg/kg	PX-FSR-SD47-000H	4/6	0.00194 - 0.00205	1.1E-02	N/A	1.1E+01 C	N/A	N/A	NO	BSL
	191-24-2	Benzo(g,h,i)perylene	5.1E-03	1.3E-02	mg/kg	PX-FSR-SD10-000H	4/6	0.00194 - 0.00205	1.3E-02	N/A	1.8E+03 N	N/A	N/A	NO	BSL
	207-08-9	Benzo(k)fluoranthene	5.3E-03	8.7E-03	mg/kg	PX-FSR-SD47-000H	4/6	0.00194 - 0.00205	8.7E-03	N/A	1.1E+02 C	N/A	N/A	NO	BSL
	218-01-9	Chrysene	6.6E-03	1.2E-02	mg/kg	PX-FSR-SD47-000H	4/6	0.00194 - 0.00205	1.2E-02	N/A	1.1E+03 C	N/A	N/A	NO	BSL
	53-70-3	Dibenz(a,h)anthracene	6.8E-03	1.4E-02	mg/kg	PX-FSR-SD10-000H	3/6	0.00194 - 0.00205	1.4E-02	N/A	1.1E+00 C	N/A	N/A	NO	BSL
	206-44-0	Fluoranthene	3.7E-03 J	2.1E-02	mg/kg	PX-FSR-SD33-000H	3/6	0.00194 - 0.00205	2.1E-02	N/A	2.4E+03 N	N/A	N/A	NO	BSL
	86-73-7	Fluorene	1.8E-03 J	1.8E-03 J	mg/kg	PX-FSR-SD47-000H	1/6	0.00194 - 0.00205	1.8E-03	N/A	2.4E+03 N	N/A	N/A	NO	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	4.6E-03	1.4E-02	mg/kg	PX-FSR-SD10-000H	4/6	0.00194 - 0.00205	1.4E-02	N/A	1.1E+01 C	N/A	N/A	NO	BSL
	85-01-8	Phenanthrene	1.2E-02	1.2E-02	mg/kg	PX-FSR-SD33-000H	2/6	0.00194 - 0.00205	1.2E-02	N/A	1.8E+04 N	N/A	N/A	NO	BSL
	129-00-0	Pyrene	3.1E-03 J	1.5E-02	mg/kg	PX-FSR-SD33-000H	3/6	0.00194 - 0.00205	1.5E-02	N/A	1.8E+03 N	N/A	N/A	NO	BSL
	7439-92-1	Lead	1.3E+00 J	3.3E+00 J	mg/kg	PX-FSR-SD47-000H	11/11	0.2 - 0.25	3.3E+00	N/A	4.0E+02 / 2.0E+02 NL	N/A	N/A	NO	BSL

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values not available.

[4] USEPA. May, 2021. Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs).

Residential soil RSLs were multiplied by 10 for exposures to sediment. Concentrations based on non-carcinogenic health effects are based on HQ=0.1

https://www.epa.gov/risk/regional-screening-levels-rsls.

RSL value for pyrene used as surrogate for benzo(g,h,i)perylene.

RSL value for anthracene used as surrogate for phenanthrene.

The residential soil RSL of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.

RCRA Corrective Action Facilities, USEPA, July 14, 1994.

The soil value of 200 mg/kg for lead is Maryland Department of Environment (MDE) residential soil screening level (2020).

[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)

Deletion Reason: Below Screening Level (BSL)

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered

C = Carcinogenic

COPC = Chemical of Potential Concern

HQ = Hazard Quotient

J = Estimated Value

mg/kg = milligram per kilogram

N = Noncarcinogenic

N/A = Not Available

NL = lead residential soil RSL

TABLE 2.4

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater / Air

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Tap Water /	**56-55-3**	**Benzo(a)anthracene**	**2.7E-02 J**	**3.1E-02 J**	**µg/l**	**PX-FSR-GW03-0420**	**2/12**	**0.05 - 0.052**	3.1E-02	**N/A**	**3.0E-02 C**	**N/A**		**YES**	**ASL**
Water Vapors at	205-99-2	Benzo(b)fluoranthene	3.8E-02 J	3.8E-02 J	µg/l	PX-FSR-GW03-0620	1/12	0.05 - 0.052	3.8E-02	N/A	2.5E-01 C	N/A		NO	BSL
Showerhead	191-24-2	Benzo(g,h,i)perylene	2.6E-02 J	2.6E-02 J	µg/l	PX-FSR-GW03-0620	1/12	0.05 - 0.052	2.6E-02	N/A	1.2E+01 N	N/A		NO	BSL
and	218-01-9	Chrysene	3.1E-02 J	3.2E-02 J	µg/l	PX-FSR-GW03-0420	2/12	0.05 - 0.052	3.2E-02	N/A	2.5E+01 C	N/A		NO	BSL
Water in	206-44-0	Fluoranthene	5.9E-02 J	1.2E-01	µg/l	PX-FSR-GW03-0420	2/12	0.05 - 0.052	1.2E-01	N/A	8.0E+01 N	N/A		NO	BSL
Excavation Trench /	193-39-5	Indeno(1,2,3-cd)pyrene	2.6E-02 J	2.6E-02 J	µg/l	PX-FSR-GW03-0620	1/12	0.05 - 0.052	2.6E-02	N/A	2.5E-01 C	N/A		NO	BSL
Volatiles in Air in	85-01-8	Phenanthrene	9.0E-02 J	9.0E-02 J	µg/l	PX-FSR-GW03-0420	1/12	0.05 - 0.052	9.0E-02	N/A	1.8E+02 N	N/A		NO	BSL
Excavation Trench	129-00-0	Pyrene	5.0E-02 J	9.2E-02 J	µg/l	PX-FSR-GW03-0420	2/12	0.05 - 0.052	9.2E-02	N/A	1.2E+01 N	N/A		NO	BSL
	7439-92-1	**Lead**	**2.8E-01 J**	**6.0E+01**	**µg/l**	**PX-FSR-GW07-0420**	**9/12**	**0.5 - 0.5**	6.0E+01	**N/A**	**1.5E+01 AL**	**1.5E+01**	**AL**	**YES**	**ASL**

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values not available.

[4] USEPA. May, 2021. Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs).
Tap water RSLs (based on target risk of 10^{-6} for carcinogens and HQ of 0.1 for noncarcinogens).
https://www.epa.gov/risk/regional-screening-levels-rsls. Accessed May 12, 2021.
RSL value for pyrene used as surrogate for benzo(g,h,i)perylene.
RSL value for anthracene used as surrogate for phenanthrene.

[5] Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
C = Carcinogenic
N = Noncarcinogenic
AL = EPA Action Level in water
µg/l = microgram per liter

TABLE 2.5
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air (Residential)

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Vapor Intrusion to Indoor Air	56-55-3	Benzo(a)anthracene	2.7E-02 J	3.1E-02 J	µg/l	PX-FSR-GW03-0420	2/12	0.05 - 0.052	3.1E-02	N/A	3.4E+01 C	N/A		NO	BSL
	129-00-0	Pyrene	5.0E-02 J	9.2E-02 J	µg/l	PX-FSR-GW03-0420	2/12	0.05 - 0.052	9.2E-02	N/A	N/A	N/A		NO	NTX

[1] Minimum/Maximum detected concentrations.
[2] Maximum concentration is used for screening.
[3] Background values not available.
[4] U.S. Environmental Protection Agency (USEPA). Vapor Intrusion Screening Level (VISL) Calculator. Accessed on May 20, 2021.
Target groundwater concentrations for residential scenario (based on target risk of 10^{-6} for carcinogens and HQ of 0.1 for noncarcinogens, default groundwater to indoor air attenuation factor of 0.001, and default groundwater temperature of 25 ^{o}C).
[Online]. https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator
[5] Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)
No Toxicity Information (NTX)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
C = Carcinogenic
µg/l = microgram per liter

TABLE 2.6
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air (Industrial)

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Vapor Intrusion to Indoor Air	56-55-3	Benzo(a)anthracene	2.7E-02 J	3.1E-02 J	µg/l	PX-FSR-GW03-0420	2/12	0.05 - 0.052	3.1E-02	N/A	4.2E+02 C	N/A		NO	BSL
	129-00-0	Pyrene	5.0E-02 J	9.2E-02 J	µg/l	PX-FSR-GW03-0420	2/12	0.05 - 0.052	9.2E-02	N/A	N/A	N/A		NO	NTX

[1] Minimum/Maximum detected concentrations.
[2] Maximum concentration is used for screening.
[3] Background values not available.
[4] U.S. Environmental Protection Agency (USEPA). Vapor Intrusion Screening Level (VISL) Calculator. Accessed on May 20, 2021.
Target groundwater concentrations for industrial scenario (based on target risk of 10^{-6} for carcinogens and HQ of 0.1 for noncarcinogens, default groundwater to indoor air attenuation factor of 0.001, and default groundwater temperature of 25 ^{o}C).
[Online]. https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator
[5] Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)
No Toxicity Information (NTX)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
C = Carcinogenic
µg/l = microgram per liter

TABLE 3.1.RME

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 foot bgs)
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)		Exposure Point Concentration			
								Value	Units	Statistic	Rationale
Surface Soil	Benzo(a)anthracene	mg/kg	4.5E+00	1.6E+01		6.2E+01		1.6E+01	mg/kg	97.5% Cheb-m	1
	Benzo(a)pyrene	mg/kg	5.8E+00	2.0E+01		8.1E+01	J	2.0E+01	mg/kg	97.5% Cheb-m	1
	Benzo(b)fluoranthene	mg/kg	6.6E+00	1.9E+01		1.1E+02	J	1.9E+01	mg/kg	95% KM-c	1
	Benzo(k)fluoranthene	mg/kg	2.8E+00	9.9E+00		4.3E+01	J	9.9E+00	mg/kg	97.5% KM-c	1
	Dibenz(a,h)anthracene	mg/kg	8.9E-01	2.5E+00		1.5E+01		2.5E+00	mg/kg	95% KM-c	1
	Indeno(1,2,3-cd)pyrene	mg/kg	3.9E+00	1.4E+01		5.9E+01		1.4E+01	mg/kg	97.5% KM-c	1
	Lead	mg/kg	9.2E+01	1.3E+02	G	6.2E+02		9.2E+01	mg/kg	Mean	2

ProUCL, Version 5.1.002 used to determine distribution of data using the Shapiro-Wilk W Test. ProUCL used to calculate RME EPC, following recommendations based on distribution and standard deviation in users guide (EPA. June, 2016. ProUCL, Version 5.1 Prepared by Lockheed Martin Environmental Services).

Options: 97.5% Chebyshev (Mean, Sd) UCL (97.5% Cheb-m); 95% Kaplan-Meier Chebyshev UCL (95% KM-c); 97.5% Kaplan-Meier Chebyshev UCL (97.5% KM-c); Mean

UCL Rationale:

(1) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).

(2) Mean concentration used for lead.

bgs = below ground surface
G = gamma distribution
J = Estimated Value
mg/kg = milligrams per kilogram
UCL = Upper confidence limit on mean concentration

TABLE 3.2.RME

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 foot bgs)
Exposure Medium: Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Emissions from Surface Soil	Benzo(a)anthracene	mg/m^3	1.2E-06	4.1E-06	1.6E-05	4.1E-06	mg/m^3	97.5% Cheb-m	1
	Benzo(a)pyrene	mg/m^3	4.2E-09	1.5E-08	6.0E-08 J	1.5E-08	mg/m^3	97.5% Cheb-m	1
	Benzo(b)fluoranthene	mg/m^3	4.9E-09	1.4E-08	8.1E-08 J	1.4E-08	mg/m^3	95% KM-c	1
	Benzo(k)fluoranthene	mg/m^3	2.1E-09	7.3E-09	3.2E-08 J	7.3E-09	mg/m^3	97.5% KM-c	1
	Dibenz(a,h)anthracene	mg/m^3	6.5E-10	1.8E-09	1.1E-08	1.8E-09	mg/m^3	95% KM-c	1
	Indeno(1,2,3-cd)pyrene	mg/m^3	2.8E-09	1.0E-08	4.3E-08	1.0E-08	mg/m^3	97.5% KM-c	1
	Lead	mg/m^3	6.8E-08	9.4E-08 G	4.6E-07	6.8E-08	mg/m^3	Mean	2

Ambient air exposure point concentrations (EPCs) were calculated based on soil EPCs, particulate emission factors (PEFs), and volatilization factors (VFs). PEF from USEPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. (USEPA, December 2002). VF was calculated using site-specific parameters and is shown on Table 3.2 Supplement A. Only one chemical (benzo(a)anthracene) is considered sufficiently volatile. The following equation was used to calculate the ambient air EPCs:

Air EPC (mg/m^3) = Soil EPC (mg/kg) x (1/PEF + 1/VF) (m^3/kg)

ProUCL, Version 5.1.002 used to determine distribution of data and calculate 95% UCL, following recommendations in users guide (USEPA. June, 2016. Prepared by Lockheed Martin Environmental Services).

Options: 97.5% Chebyshev (Mean, Sd) UCL (97.5% Cheb-m); 95% Kaplan-Meier Chebyshev UCL (95% KM-c);
97.5% Kaplan-Meier Chebyshev UCL (97.5% KM-c); Mean

UCL Rationale:

(1) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).

(2) Mean concentration used for lead.

bgs = below ground surface
G = gamma distribution
J = Estimated Value
UCL = Upper confidence limit on mean concentration
mg/m^3 = milligram per cubic meter

TABLE 3.2.RME SUPPLEMENT A

Calculation of Volatilization Factor - Surface Soil and Subsurface Soil

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Chemical	Diffusivity in Air (D_i) (cm^2/s)	Henry's Law Constant (H') (unitless)	Diffusivity in Water (D_w) (cm^2/s)	Soil Organic Carbon Partition Coeff. (K_{oc}) (cm^3/g)	Soil Water Partition Coeff. ($K_d = K_{oc} \times F_{oc}$) ($g/cm^3$)	Solubility in Water (S) (mg/L)	Apparent Diffusivity (D_A) (cm^2/s)	Volatilization Factor (VF) (m^3/kg)
Benzo(a)anthracene	2.6E-02	4.9E-04	6.7E-06	1.8E+05	1.1E+03	9.4E-03	6.8E-10	3.9E+06

$$\text{Volatilization factor (VF)} = \frac{Q/C * (3.14 * D_A * T)^{1/2} * 10^{-4}\ m^2/cm^2}{2 * r_b * D_A}$$
(m^3/kg)

$$\text{Apparent Diffusivity } (D_A) = \frac{[(Q_a^{10/3} * D_i * H' + Q_w^{10/3} * D_w)/n^2]}{(r_b * K_d + Q_w + Q_a * H')}$$
(cm^2/s)

Parameters	Values
Q/Cvol - Inverse of the geometric mean air concentration to the volatilization flux at the center of a 0.5-acre-square source (g/m2-s per kg/m3)	56
T - Exposure interval(s)	9.5E+08
r_b - Soil bulk density (g/cm^3)	1.5
Q_a - Air-filled soil porosity (L_{air}/L_{water}) = n - Q_w	0.28
n - Total soil porosity (Lpore/Lsoil) = 1 - (r_b/r_s)	0.43
Q_w - Water-filled soil porosity (Lwater/Lsoil)	0.15
r_s - Soil particle density (g/cm^3)	2.65
f_{oc} - fraction organic carbon in soil (g/g)	0.006

Equations from USEPA, 1996. *Soil Screening Guidance: User's Guide.* EPA/540/R-96/018.

Physical/chemical properties from Oak Ridge National Laboratory (ORNL). November 2019. Regional Screening Levels for Chemical Contaminants at Superfund Sites.

TABLE 3.3.RME

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)		Exposure Point Concentration			
								Value	Units	Statistic	Rationale
Soil*	Benzo(a)anthracene	mg/kg	3.6E+00	1.6E+01	T	6.2E+01		1.6E+01	mg/kg	95% H-UCL	1
	Benzo(a)pyrene	mg/kg	4.7E+00	1.2E+01		8.1E+01	J	1.2E+01	mg/kg	95% Cheb-m	2
	Benzo(b)fluoranthene	mg/kg	5.2E+00	2.2E+01	T	1.1E+02	J	2.2E+01	mg/kg	KM H-UCL	1
	Benzo(k)fluoranthene	mg/kg	2.3E+00	9.2E+00	T	4.3E+01	J	9.2E+00	mg/kg	KM H-UCL	1
	Dibenz(a,h)anthracene	mg/kg	7.2E-01	3.0E+00	T	1.5E+01		3.0E+00	mg/kg	KM H-UCL	1
	Indeno(1,2,3-cd)pyrene	mg/kg	3.1E+00	1.4E+01	T	5.9E+01		1.4E+01	mg/kg	KM H-UCL	1
	Lead	mg/kg	8.3E+01	1.3E+02	T	6.2E+02		8.3E+01	mg/kg	Mean	3

ProUCL, Version 5.1.002 used to determine distribution of data using the Shapiro-Wilk W Test. ProUCL used to calculate RME EPC, following recommendations based on distribution and standard deviation in users guide (EPA. June, 2016. ProUCL, Version 5.1 Prepared by Lockheed Martin Environmental Services).
Options: 95% H-UCL; 95% Chebyshev (Mean, Sd) UCL (95% Cheb-m); Kaplan-Meier H-UCL (KM H-UCL); Mean

UCL Rationale:

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.

(2) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).

(3) Mean concentration used for lead.

bgs = below ground surface

J = Estimated Value

mg/kg = milligrams per kilogram

T = lognormal distribution

UCL = Upper confidence limit on mean concentration

* Combined surface and subsurface soil.

TABLE 3.4.RME

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)		Maximum Concentration (Qualifier)		Exposure Point Concentration			
								Value	Units	Statistic	Rationale
Emissions from Soil*	Benzo(a)anthracene	mg/m^3	9.3E-07	4.1E-06	T	1.6E-05		4.1E-06	mg/m^3	95% H-UCL	1
	Benzo(a)pyrene	mg/m^3	3.4E-09	8.8E-09		6.0E-08	J	8.8E-09	mg/m^3	95% Cheb-m	2
	Benzo(b)fluoranthene	mg/m^3	3.8E-09	1.6E-08	T	8.1E-08	J	1.6E-08	mg/m^3	KM H-UCL	1
	Benzo(k)fluoranthene	mg/m^3	1.7E-09	6.8E-09	T	3.2E-08	J	6.8E-09	mg/m^3	KM H-UCL	1
	Dibenz(a,h)anthracene	mg/m^3	5.3E-10	2.2E-09	T	1.1E-08		2.2E-09	mg/m^3	KM H-UCL	1
	Indeno(1,2,3-cd)pyrene	mg/m^3	2.3E-09	1.1E-08	T	4.3E-08		1.1E-08	mg/m^3	KM H-UCL	1
	Lead	mg/m^3	6.1E-08	9.3E-08	T	4.6E-07		6.1E-08	mg/m^3	Mean	3

Ambient air exposure point concentrations (EPCs) were calculated based on soil EPCs, particulate emission factors (PEFs), and volatilization factors (VFs). PEF from USEPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. (USEPA, December 2002). VF was calculated using site-specific parameters and is shown on Table 3.2 Supplement A. Only one chemical (benzo(a)anthracene) is considered sufficiently volatile. The following equation was used to calculate the ambient air EPCs:

Air EPC (mg/m^3) = Soil EPC (mg/kg) x (1/PEF + 1/VF) (m^3/kg)

ProUCL, Version 5.1.002 used to determine distribution of data and calculate 95% UCL, following recommendations in users guide (USEPA. June, 2016. Prepared by Lockheed Martin Environmental Services).

Options: 95% H-UCL; 95% Chebyshev (Mean, Sd) UCL (95% Cheb-m); Kaplan-Meier H-UCL (KM H-UCL); Mean

UCL Rationale:

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.

(2) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).

(3) Mean concentration used for lead.

bgs = below ground surface

J = Estimated Value

T = lognormal distribution

UCL = Upper confidence limit on mean concentration

mg/m^3 = milligram per cubic meter

* Combined surface and subsurface soil.

TABLE 3.5.RME

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater / Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Tap Water / Water Vapors at Showerhead and Water in Excavation Trench / Volatiles in Air in Excavation Trench	Benzo(a)anthracene	µg/l	2.9E-02	N/A	3.1E-02	3.1E-02	µg/l	Max	1
	Lead	µg/l	9.1E+00	N/A	6.0E+01	9.1E+00	µg/l	Mean	2

(1) The maximum detected concentration was used as the EPC because there were too few detected concentrations (only two detected concentrations).

(2) Mean concentration used for lead. Non-detected concentrations are estimated using a proxy value of 1/2 of detection limit.

TABLE 4.1.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 foot bgs)
Exposure Medium: Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Industrial Worker	Adult	Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1.RME	mg/kg	See Table 3.1.RME	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2014	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	25	years	EPA, 2014	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	
	Trespasser/Visitor	Adult	Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1.RME	mg/kg	See Table 3.1.RME	CDI (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2014 (2)	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	52	days/year	(3)	
				ED	Exposure Duration	20	years	EPA, 2014 (2)	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Adolescent	Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1.RME	mg/kg	See Table 3.1.RME	CDI (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2014 (2)	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	52	days/year	(3)	
				ED	Exposure Duration	9	years	(4)	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	55	kg	EPA, 2011 (5)	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
Dermal	Industrial Worker	Adult	Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1.RME	mg/kg	See Table 3.1.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,527	cm^2	EPA, 2014 (6)	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.12	mg/cm^2-day	EPA, 2014	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	25	years	EPA, 2014	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 foot bgs)
Exposure Medium: Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Trespasser/Visitor	Adult	Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1.RME	mg/kg	See Table 3.1.RME	CDI (mg/kg-day) =
(cont.)				SA	Skin Surface Area Available for Contact	6,032	cm^2	EPA, 2014 (2, 8)	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm^2-day	EPA, 2014 (2)	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	52	days/year	(3)	
				ED	Exposure Duration	20	years	EPA, 2014	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Adolescent	Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1.RME	mg/kg	See Table 3.1.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,600	cm^2	EPA, 2011 (7)	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.3	mg/cm^2-day	EPA, 2004 (9)	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	52	days/year	(3)	
				ED	Exposure Duration	9	years	(4)	
				BW	Body Weight	55	kg	EPA, 2011 (5)	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	

Notes:

(1) Professional judgment assuming 1 day per week for 52 weeks per year.

(2) Assumed same value as for adult resident.

(3) Professional judgment assuming 2 day per week for 26 weeks per year.

(4) Professional judgment assuming adolescents from 9 to 18 years of age.

(5) Body weight is average value for the 9 year old to 18 year old male and female body weight.

(6) Surface area includes head, forearms, and hands.

(7) Surface area includes face, forearms, hands, and lower legs for children 9 to 18 years of age.

(8) Surface area includes head, forearms, hands, and lower legs .

(9) Soil to skin adherence factor is based on 95th percentile adherence factor for soccer players #1 (13 to 15 years of age).

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.2.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 foot bgs)
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Industrial Worker	Adult	Emissions from Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1	mg/kg	See Table 3.1	Exposure Concentration (EC) (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.2	mg/m^3	See Table 3.2	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	8	hr/day	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	52	days/year	(1)	For sufficiently volatile chemicals:
				ED	Exposure Duration	25	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	
	Trespasser/Visitor	Adult	Emissions from Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1	mg/kg	See Table 3.1	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.2	mg/m^3	See Table 3.2	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	4	hr/day	(2)	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	52	days/year	(2)	For sufficiently volatile chemicals:
				ED	Exposure Duration	20	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Adolescent	Emissions from Surface Soil	CS	Chemical Concentration in Soil	See Table 3.1	mg/kg	See Table 3.1	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.2	mg/m^3	See Table 3.2	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	4	hr/day	(2)	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	52	days/year	(2)	For sufficiently volatile chemicals:
				ED	Exposure Duration	9	years	(3)	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	

TABLE 4.2.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 foot bgs)
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name

Notes:

(1) Professional judgment assuming 1 day per week for 52 weeks per year, for 8 hours each event.

(2) Professional judgment assuming 2 day per week for 26 weeks per year, for 4 hours each event.

(3) Professional judgment assuming adolescents from 9 to 18 years of age.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.4.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2014	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Child	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	200	mg/day	EPA, 2014	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				IR-S-A	Ingestion Rate of Soil, Adult	100	mg/day	EPA, 2014	CS x IR-S-Adj x EF x CF1 x 1/AT
				IR-S-C	Ingestion Rate of Soil, Child	200	mg/day	EPA, 2014	
				IR-S-Adj	Ingestion Rate of Soil, Age-adjusted	105	mg-year/kg-day	Calculated	IR-S-Adj (mg-year/kg-day) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	(ED-C x IR-S-C / BW-C) + (ED-A x IR-S-A / BW-A)
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

TABLE 4.4.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Industrial Worker	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2014	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	250	days/year	EPA, 2014	
				ED	Exposure Duration	25	years	EPA, 2014	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	
	Trespasser/Visitor	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2014 (1)	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	52	days/year	(2)	
				ED	Exposure Duration	20	years	EPA, 2014 (1)	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Adolescent	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2014 (1)	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	52	days/year	(2)	
				ED	Exposure Duration	9	years	(3)	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	55	kg	EPA, 2011 (4)	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
	Construction Worker	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	Subchronic Daily Intake (SDI) (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	330	mg/day	EPA, 2002	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	125	days/year	(5)	
				ED	Exposure Duration	1	years	EPA, 1991	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	
Dermal	Resident	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	6,032	cm^2	EPA, 2014	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm^2-day	EPA, 2014	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	

TABLE 4.4.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal (cont.)	Resident (cont).	Child	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	2,373	cm^2	EPA, 2014	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2-day	EPA, 2014	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA-A	Skin Surface Area Available for Contact, Adult	6,032	cm^2	EPA, 2014	CS x DA-Adj x DABS x CF1 x EF x 1/AT
				SA-C	Skin Surface Area Available for Contact, Child	2,373	cm^2	EPA, 2014	
				SSAF-A	Soil to Skin Adherence Factor, Adult	0.07	mg/cm^2-day	EPA, 2014	DA-Adj (mg-year/kg-day) =
				SSAF-C	Soil to Skin Adherence Factor, Child	0.2	mg/cm^2-day	EPA, 2014	
				DA-Adj	Dermal Absorption, Age-adjusted	295	mg-year/kg-day	Calculated	(ED-C x SA-C x SSAF-C / BW-C) + (ED-A x SA-A x SSAF-A / BW-A)
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
	Industrial Worker	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,527	cm^2	EPA, 2014 (6)	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.12	mg/cm^2-day	EPA, 2014	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	250	days/year	EPA, 2014	
				ED	Exposure Duration	25	years	EPA, 2014	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	

TABLE 4.4.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
	Trespasser/Visitor	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	6,032	cm^2	EPA, 2014 (1, 6)	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm^2-day	EPA, 2014 (1)	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	52	days/year	(2)	
				ED	Exposure Duration	20	years	EPA, 2014	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Adolescent	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,600	cm^2	EPA, 2011 (7)	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.3	mg/cm^2-day	EPA, 2004 (8)	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	52	days/year	(2)	
				ED	Exposure Duration	9	years	(3)	
				BW	Body Weight	55	kg	EPA, 2011 (4)	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
	Construction Worker	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	SDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,527	cm^2	EPA, 2014 (9)	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.3	mg/cm^2-day	EPA, 2004 (10)	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	125	days/year	(5)	
				ED	Exposure Duration	1	years	EPA, 1991	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	

TABLE 4.4.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name

Notes:

(1) Assumed same value as for adult resident.

(2) Professional judgment assuming 2 day per week for 26 weeks per year.

(3) Professional judgment assuming adolescents from 9 to 18 years of age.

(4) Body weight is average value for the 9 year old and 18 year old male and female body weight.

(5) Assumed a worker working on a construction project for 125 days per year for 1 year.

(6) Surface area includes head, forearms, hands, and lower legs .

(7) Surface area includes face, forearms, hands, and lower legs for children 9 to 18 years of age.

(8) Soil to skin adherence factor is based on 95th percentile adherence factor for soccer players #1 (13 to 15 years of age).

(9) Surface area includes head, forearms, and hands.

(10) Soil to skin adherence factor is based on 95th percentile adherence factor for construction workers.

* Combined surface and subsurface soil.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.5.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Adult	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	Exposure Concentration (EC) (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	24	hour/day	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	350	days/year	EPA, 2014	For sufficiently volatile chemicals:
				ED	Exposure Duration	20	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Child	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	24	hour/day	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	350	days/year	EPA, 2014	For sufficiently volatile chemicals:
				ED	Exposure Duration	6	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				EF	Exposure Frequency	350	days/year	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				ET	Exposure Time	24	hr/day	EPA, 2014	For sufficiently volatile chemicals:
				ED	Exposure Duration	26	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
	Industrial Worker	Adult	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	8	hr/day	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	250	days/year	EPA, 2014	For sufficiently volatile chemicals:
				ED	Exposure Duration	25	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	

TABLE 4.5.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation (cont.)	Trespasser/Visitor	Adult	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	4	hr/day	(2)	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	52	days/year	(2)	For sufficiently volatile chemicals:
				ED	Exposure Duration	20	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 1989	
		Adolescent	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	4	hr/day	(2)	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	52	days/year	(2)	For sufficiently volatile chemicals:
				ED	Exposure Duration	9	years	(3)	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
	Construction Worker	Adult	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	8	hr/day	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	125	days/year	(4)	For sufficiently volatile chemicals:
				ED	Exposure Duration	1	years	EPA, 2002	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	

Notes:

(1) Professional judgment assuming 1 day per week for 52 weeks per year, for 8 hours each event.

(2) Professional judgment assuming 2 day per week for 26 weeks per year, for 4 hours each event.

(3) Professional judgment assuming adolescents from 9 to 18 years of age.

(4) Assumed a worker working on a construction project for 125 days per year for 1 year.

* Combined surface and subsurface soil.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.6.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-W	Ingestion Rate of Water	2.5	liters/day	EPA, 2014	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	CDI (mg/kg-day) =
				IR-W	Ingestion Rate of Water	0.78	liters/day	EPA, 2014	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	CDI (mg/kg-day) =
				IR-W-A	Ingestion Rate of Water, Adult	2.5	liters/day	EPA, 2014	CW x IR-W-Adj x EF x CF1 x 1/AT
				IR-W-C	Ingestion Rate of Water, Child	0.78	liters/day	EPA, 2014	
				IR-W-Adj	Ingestion Rate of Water, Age-adjusted	0.94	liter-year/kg-day	calculated	IR-W-Adj (liter-year/kg-day) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	(ED-C x IR-W-C / BW-C) +
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	(ED-A x IR-W-A / BW-A)
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

TABLE 4.6.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				t	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.71	hr/event	EPA, 2014	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	19,652	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x t x t_{event})/p))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x t x
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				t	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.54	hr/event	EPA, 2014	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	6,365	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x t x t_{event})/p))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	15	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x t x
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

TABLE 4.6.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	CDI (mg/kg-day) = DA-Adj x EF x 1/AT
(cont'd)	(cont'd)			DAevent-A	Dermally Absorbed Dose per Event, Adult	Calculated	mg/cm^2-event	calculated	
				DAevent-C	Dermally Absorbed Dose per Event, Child	Calculated	mg/cm^2-event	calculated	DA-Adj = (DAevent-A x SA-A x ED-A x 1/BW-A)
				DA-Adj	Dermally Absorbed Dose, Age-adjusted	Calculated	mg-year/event-kg	calculated	+ (DAevent-C x SA-C x ED-C x 1/BW-C)
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				t	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}-A	Event Time, Adult	0.71	hr/event	EPA, 2014	t_{event}<t*: DAevent (mg/cm^2-event) =
				t_{event}-C	Event Time, Child	0.54	hr/event	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x t x t_{event})/p))
				SA-A	Skin Surface Area, Adult	19,652	cm^2	EPA, 2014	x CF1 x CF2
				SA-C	Skin Surface Area, Child	6,365	cm^2	EPA, 2014	
				EV	Event Frequency	1	events/day	EPA, 2004	t_{event}>t*: DAevent (mg/cm^2-event) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x t x
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	$((1 + 3B + 3B^2)/(1+B)^2)$) x CF1 x CF2
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				BW-A	Body Weight, Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

TABLE 4.6.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal (cont'd)	Construction Worker	Adult	Water in Excavation Trench	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	chemical specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	chemical specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				t	Lag Time	chemical specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
				t*	Time to Reach Steady-state	chemical specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	chemical specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	8	hr/day	EPA, 2014 (1)	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	6,032	cm^2	EPA, 2014 (2)	2 x FA x Kp x CW x (sqrt((6 x t x t_{event})/p))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	125	days/year	(3)	
				ED	Exposure Duration	1	years	EPA, 1991	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x t x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	$((1 + 3B + 3B^2)/(1+B)^2)$) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	
				CF1	Conversion Factor 2	0.001	mg/µg	- -	
				CF2	Conversion Factor 3	0.001	l/cm^3	- -	

(1) Professional judgment based on construction activities that would occur 8 hrs per day for the Reasonable Maximum Exposure (RME) scenario.

(2) Assumed surface area for construction worker exposed to groundwater is same as surface area for adult resident exposed to soil from EPA, 2014, includes weighted average of mean values for head, hands, forearms, and lower legs.

(3) Assumed duration of construction project is 1/2 the working days in a year.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.7.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Industrial Worker	Adult	Shallow Aquifer - Indoor Air	CW	Chemical Concentration in Water	See Table 3.3	µg/l	See Table 3.3	(EC) (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.5	mg/m^3	See Table 3.5	CA x ET x EF x ED x CF x 1/AT
				ET	Exposure Time	8	hr/day	(1)	
				EF	Exposure Frequency	250	days/year	EPA, 2014	CA calculated using an attenuation factor and Henry's Law Constant at site groundwater temperature (refer to Table 3.5 Supplement A).
				ED	Exposure Duration	25	years	EPA, 2014	
				CF	Conversion Factor	1/24	day/hour	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	
Inhalation	Resident	Adult	Water Vapors at Showerhead	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	Exposure Concentration (EC) (mg/m^3) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x EF x ED x ET x CF x 1/AT
				ET	Exposure Time (for shower model)	0.71	hours/day	EPA, 2014	Use Foster & Chrostowski Shower model to calculate CA.
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration , Adult	20	years	EPA, 2014	
				CF	Conversion Factor	1/24	day/hour	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	
Inhalation	Construction Worker	Adult	Volatiles in Air in Excavation Trench	CW	Chemical Concentration in Water	See Table 3.5	µg/l	See Table 3.5	Chronic Daily Intake (CDI) (mg/m^3) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x ET x EF x ED x CF x 1/AT
				ET	Exposure Time	8	hr/day	(1)	CA calculated using two-film model
				EF	Exposure Frequency	125	days/year	(2)	
				ED	Exposure Duration	1	years	EPA, 1991	
				CF	Conversion Factor	1/24	day/hour	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	

Notes:

(1) Professional Judgment based on construction activities that would occur 8 hrs per day for the Reasonable Maximum Exposure (RME) scenario.

(2) Assumed duration of construction project is 1/2 the working days in a year.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.1.CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	30	mg/day	EPA, 2017 (1)	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	9	years	EPA, 2011 (2)	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
		Child	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				IR-S	Ingestion Rate of Soil	64	mg/day	EPA, 2017 (3)	CS x IR-S x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				IR-S-A	Ingestion Rate of Soil, Adult	30	mg/day	EPA, 2017 (1)	CS x IR-S-Adj x EF x CF1 x 1/AT
				IR-S-C	Ingestion Rate of Soil, Child	64	mg/day	EPA, 2017 (3)	
				IR-S-Adj	Ingestion Rate of Soil, Age-adjusted	29	mg-year/kg-day	Calculated	IR-S-Adj (mg-year/kg-day) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	(ED-C x IR-S-C / BW-C) + (ED-A x IR-S-A / BW-A)
				ED-A	Exposure Duration, Adult	9	years	EPA, 2011 (2)	
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

TABLE 4.1.CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	6,032	cm^2	EPA, 2014	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	9	years	EPA, 2011 (2)	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
		Child	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	2,373	cm^2	EPA, 2014	CS x SA x SSAF x DABS x CF1 x EF x
				SSAF	Soil to Skin Adherence Factor	0.04	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Soil*	CS	Chemical Concentration in Soil	See Table 3.3.RME	mg/kg	See Table 3.3.RME	CDI (mg/kg-day) =
				SA-A	Skin Surface Area Available for Contact, Adult	6,032	cm^2	EPA, 2014	CS x DA-Adj x DABS x CF1 x EF x 1/AT
				SA-C	Skin Surface Area Available for Contact, Child	2,373	cm^2	EPA, 2014	
				SSAF-A	Soil to Skin Adherence Factor, Adult	0.01	mg/cm^2-day	EPA, 2004	DA-Adj (mg-year/kg-day) =
				SSAF-C	Soil to Skin Adherence Factor, Child	0.04	mg/cm^2-day	EPA, 2004	
				DA-Adj	Dermal Absorption, Age-adjusted	45	mg-year/kg-day	Calculated	(ED-C x SA-C x SSAF-C / BW-C) + (ED-A x SA-A x SSAF-A / BW-A)
				DABS	Dermal Absorption Factor Solids	Chemical-specific	--	EPA, 2004	
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED-A	Exposure Duration, Adult	9	years	EPA, 2011 (2)	
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name

Notes:

(1) Table 5-1, general population central tendency value for adult.

(2) Table 16-108, 50th percentile value for both sexes. This is the 50th percentile exposure duration for a resident and includes exposure as a child and/or adult. However, for the lifetime resident exposure (child/adult), it is conservatively assumed the ED is 6 years as a child and 9 years as an adult, for a total ED of 15 years.

(3) Table 5-1, calculated using the general population central tendency values for birth to <6 years, based on time-weighted average, as follows: ((0.5 years x 40 mg/day)+(0.5 years x 70 mg/day) + (1 year x 90 mg/day)+ (4 years x 60 mg/day))/6 years.

* Combined surface and subsurface soil.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

EPA, 2017. Update for Chapter 5 of the Exposure Factors Handbook. Soil and Dust Ingestion. EPA/600/R-17/384F. September.

TABLE 4.2.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Adult	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	Exposure Concentration (EC) (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	24	hour/day	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	350	days/year	EPA, 2014	For sufficiently volatile chemicals:
				ED	Exposure Duration	9	years	EPA, 2011 (1)	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 1989	
		Child	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				ET	Exposure Time	24	hour/day	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				EF	Exposure Frequency	350	days/year	EPA, 2014	For sufficiently volatile chemicals:
				ED	Exposure Duration	6	years	EPA, 2014	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Emissions from Soil*	CS	Chemical Concentration in Soil	See Table 3.3	mg/kg	See Table 3.3	EC (mg/m^3) =
				CA	Chemical Concentration in Air	See Table 3.4	mg/m^3	See Table 3.4	CA x ET x EF x ED x CF x 1/AT
				PEF	Particulate Emissions Factor	1.36E+09	m^3/kg	EPA, 2002	For chemicals not sufficently volatile:
				EF	Exposure Frequency	350	days/year	EPA, 2014	CA (mg/m^3) = CS x (1/PEF)
				ET	Exposure Time	24	hr/day	EPA, 2014	For sufficiently volatile chemicals:
				ED	Exposure Duration	15	years	(2)	CA (mg/m^3) = CS x (1/PEF + 1/VF)
				CF	Conversion Factor	1/24	day/hr	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

Notes:

(1) Table 16-108, 50th percentile value for both sexes.

(2) ED for the child/adult resident is equal to the sum of the ED for child resident and the ED for adult resident.

* Combined surface and subsurface soil.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 5.1
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Benzo(a)anthracene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	Chronic	3.0E-04	mg/kg-day	58 - 89%	3.0E-04	mg/kg-day	Developmental	300	IRIS	05/18/2021
	Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	Chronic/Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1. EPA recommends that the oral RfD should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%. Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

(2) Adjusted based on RAGS Part E.

Definitions:
IRIS = Integrated Risk Information System
mg/kg-day = milligram per kilogram per day
NA = Not Available/Not Applicable
RfD = Reference Dose

TABLE 5.2
NON-CANCER TOXICITY DATA -- INHALATION
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Benzo(a)anthracene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	Chronic	2.0E-06	mg/m^3	Developmental	3000	IRIS	05/18/2021
	Subchronic	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	Chronic/Subchronic	NA	NA	NA	NA	NA	NA
Lead	Chronic/Subchronic	NA	NA	NA	NA	NA	NA

Definitions:

IRIS = Integrated Risk Information System

mg/m^3 = milligram per cubic meter

NA = Not Available/Not Applicable

RfC = Reference Concentration

TABLE 6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Benzo(a)anthracene (3)	1.0E-01	$(mg/kg\text{-}day)^{-1}$	58 - 89%	1.0E-01	$(mg/kg\text{-}day)^{-1}$	B2	RSL (4)	05/2021
Benzo(a)pyrene (3)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	58 - 89%	1.0E+00	$(mg/kg\text{-}day)^{-1}$	Carcinogenic to humans	IRIS	05/18/2021
Benzo(b)fluoranthene (3)	1.0E-01	$(mg/kg\text{-}day)^{-1}$	58 - 89%	1.0E-01	$(mg/kg\text{-}day)^{-1}$	B2	RSL (4)	05/2021
Benzo(k)fluoranthene (3)	1.0E-02	$(mg/kg\text{-}day)^{-1}$	58 - 89%	1.0E-02	$(mg/kg\text{-}day)^{-1}$	B2	RSL (4)	05/2021
Dibenz(a,h)anthracene (3)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	58 - 89%	1.0E+00	$(mg/kg\text{-}day)^{-1}$	B2	RSL (4)	05/2021
Indeno(1,2,3-cd)pyrene (3)	1.0E-01	$(mg/kg\text{-}day)^{-1}$	58 - 89%	1.0E-01	$(mg/kg\text{-}day)^{-1}$	B2	RSL (4)	05/2021
Lead	NA	NA	NA	NA	NA	B2	IRIS	05/18/2021

Notes:

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1. USEPA recommends that the oral slope factor should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%. Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

(2) Adjusted based on RAGS Part E.

(3) This chemical operates with a mutagenic mode of action.
Chemical-specific data are not available; therefore, default age-dependent adjustment factors (ADAF) will be applied to the CSF as follows:

AGE	AGE ADAF	EXPOSURE DURATION (years)
0-<2	10	2
2-<6	3	4
6-<16	3	10
16-<26	1	10

(4) CSF was calculated using relative potency factors based on to the carcinogenic potency of the compound relative to that of benzo(a)pyrene.

Weight of Evidence definitions:

Group B2 chemicals (probable human carcinogens) are agents for which there is sufficient evidence of carcinogenicity in animals but inadequate or a lack of evidence in humans.

Definitions:

CSF = Cancer Slope Factor

IRIS = Integrated Risk Information System

mg/kg-day = milligram per kilogram per day

NA = Not Available/Not Applicable

RSL = regional screening level

TABLE 6.2
CANCER TOXICITY DATA -- INHALATION
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Chemical of Potential Concern	Unit Risk		Weight of Evidence/ Cancer Guideline Description	Unit Risk	
	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Benzo(a)anthracene (1)	6.0E-05	$(\mu g/m^3)^{-1}$	B2	RSL (2)	05/2021
Benzo(a)pyrene (1)	6.0E-04	$(\mu g/m^3)^{-1}$	Carcinogenic to humans	IRIS	05/18/2021
Benzo(b)fluoranthene (1)	6.0E-05	$(\mu g/m^3)^{-1}$	B2	RSL (2)	05/2021
Benzo(k)fluoranthene (1)	6.0E-06	$(\mu g/m^3)^{-1}$	B2	RSL (2)	05/2021
Dibenz(a,h)anthracene (1)	6.0E-04	$(\mu g/m^3)^{-1}$	B2	RSL (2)	05/2021
Indeno(1,2,3-cd)pyrene (1)	6.0E-05	$(\mu g/m^3)^{-1}$	B2	RSL (2)	05/2021
Lead	NA	NA	B2	IRIS	05/18/2021

Notes:

(1) This chemical operates with a mutagenic mode of action.

Chemical-specific data are not available; therefore, default age-dependent adjustment factors (ADAF) will be applied to the slope factor as follows:

AGE	AGE ADAF	EXPOSURE DURATION (years)
0-<2	10	2
2-<6	3	4
6-<16	3	10
16-<26	1	10

(2) Unit risk factor was calculated using relative potency factors based on to the carcinogenic potency of the compound relative to that of benzo(a)pyrene.

Weight of Evidence definitions:
Group B2 chemicals (probable human carcinogens) are agents for which there is sufficient evidence of carcinogenicity in animals but inadequate or a lack of evidence in humans.

Definitions:

IRIS = Integrated Risk Information System

NA = Not Available/Not Applicable

RSL = regional screening level

$\mu g/m^3$ = microgram per cubic meter

TABLE 7.1.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil (0 to 0.5 feet bgs)	Surface Soil	Surface Soil	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	1.0E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-07	2.8E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	2.0E+01	mg/kg	1.3E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	1E-06	3.6E-06	mg/kg/day	3.0E-04	mg/kg/day	1.2E-02
				Benzo(b)fluoranthene	1.9E+01	mg/kg	1.2E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-07	3.4E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.9E+00	mg/kg	6.3E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	6E-09	1.8E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	2.5E+00	mg/kg	1.6E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	2E-07	4.4E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	8.8E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	9E-08	2.5E-06	mg/kg/day	NA	NA	NA
				Lead	9.2E+01	mg/kg	5.9E-06	mg/kg/day	NA	NA	NA	1.6E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								2E-06					1E-02
Surface Soil (0 to 0.5 feet bgs)	Surface Soil	Surface Soil	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	5.5E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	6E-08	1.5E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	2.0E+01	mg/kg	7.1E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	7E-07	2.0E-06	mg/kg/day	3.0E-04	mg/kg/day	6.7E-03
				Benzo(b)fluoranthene	1.9E+01	mg/kg	6.6E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	7E-08	1.8E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.9E+00	mg/kg	3.5E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	3E-09	9.7E-07	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	2.5E+00	mg/kg	8.7E-08	mg/kg/day	1.0E+00	1/(mg/kg/day)	9E-08	2.4E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	4.8E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	5E-08	1.4E-06	mg/kg/day	NA	NA	NA
				Lead	9.2E+01	mg/kg	2.5E-07	mg/kg/day	NA	NA	NA	6.9E-07	mg/kg/day	NA	NA	NA
			Exp. Route Total								1E-06					7E-03
		Exposure Point Total									3E-06					2E-02
	Exposure Medium Total										3E-06					2E-02
Surface Soil (0 to 0.5 feet bgs)	Ambient Air	Emissions from Surface Soil	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	6.9E-08	mg/m^3	6.0E-05	1/(ug/m^3)	4E-09	1.9E-07	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	1.5E-08	mg/m^3	2.5E-10	mg/m^3	6.0E-04	1/(ug/m^3)	2E-10	7.1E-10	mg/m^3	2.0E-06	mg/m^3	4E-04
				Benzo(b)fluoranthene	1.4E-08	mg/m^3	2.4E-10	mg/m^3	8.4E-02	1/(ug/m^3)	2E-08	6.6E-10	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	7.3E-09	mg/m^3	1.2E-10	mg/m^3	6.0E-06	1/(ug/m^3)	7E-13	3.5E-10	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	1.8E-09	mg/m^3	3.1E-11	mg/m^3	6.0E-04	1/(ug/m^3)	2E-11	8.7E-11	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.0E-08	mg/m^3	1.7E-10	mg/m^3	6.0E-05	1/(ug/m^3)	1E-11	4.8E-10	mg/m^3	NA	NA	NA
				Lead	6.8E-08	mg/m^3	1.1E-09	mg/m^3	NA	NA	NA	3.2E-09	mg/m^3	NA	NA	NA
			Exp. Route Total								2E-08					4E-04
		Exposure Point Total									2E-08					4E-04
	Exposure Medium Total										2E-08					4E-04
Soil Total											3E-06					2E-02
Receptor Total											3E-06					2E-02

Notes:

bgs = below ground surface

CSF = Cancer slope factor

EPC = Exposure point concentration

NA = Not applicable/Not available

RfC = Reference concentration

RfD = Reference dose

TABLE 7.2.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil (0 to 0.5 feet bgs)	Surface Soil	Surface Soil	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	8.0E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	8E-08	2.8E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	2.0E+01	mg/kg	1.0E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	1E-06	3.6E-06	mg/kg/day	3.0E-04	mg/kg/day	1.2E-02
				Benzo(b)fluoranthene	1.9E+01	mg/kg	9.6E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-07	3.4E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.9E+00	mg/kg	5.1E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	5E-09	1.8E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	2.5E+00	mg/kg	1.3E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	1E-07	4.4E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	7.0E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	7E-08	2.5E-06	mg/kg/day	NA	NA	NA
				Lead	9.2E+01	mg/kg	4.7E-06	mg/kg/day	NA	NA	NA	1.6E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								1E-06					1E-02
Surface Soil (0 to 0.5 feet bgs)	Surface Soil	Surface Soil	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	4.4E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-08	1.5E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	2.0E+01	mg/kg	5.7E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	6E-07	2.0E-06	mg/kg/day	3.0E-04	mg/kg/day	6.6E-03
				Benzo(b)fluoranthene	1.9E+01	mg/kg	5.3E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	5E-08	1.8E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.9E+00	mg/kg	2.8E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	3E-09	9.7E-07	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	2.5E+00	mg/kg	6.9E-08	mg/kg/day	1.0E+00	1/(mg/kg/day)	7E-08	2.4E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	3.9E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-08	1.4E-06	mg/kg/day	NA	NA	NA
				Lead	9.2E+01	mg/kg	2.0E-07	mg/kg/day	NA	NA	NA	6.9E-07	mg/kg/day	NA	NA	NA
			Exp. Route Total								8E-07					7E-03
		Exposure Point Total									2E-06					2E-02
	Exposure Medium Total										2E-06					2E-02
Surface Soil (0 to 0.5 feet bgs)	Ambient Air	Emissions from Surface Soil	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	2.8E-08	mg/m^3	6.0E-05	$1/(ug/m^3)$	2E-09	9.6E-08	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	1.5E-08	mg/m^3	1.0E-10	mg/m^3	6.0E-04	$1/(ug/m^3)$	6E-11	3.6E-10	mg/m^3	2.0E-06	mg/m^3	2E-04
				Benzo(b)fluoranthene	1.4E-08	mg/m^3	9.4E-11	mg/m^3	8.4E-02	$1/(ug/m^3)$	8E-09	3.3E-10	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	7.3E-09	mg/m^3	5.0E-11	mg/m^3	6.0E-06	$1/(ug/m^3)$	3E-13	1.7E-10	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	1.8E-09	mg/m^3	1.2E-11	mg/m^3	6.0E-04	$1/(ug/m^3)$	7E-12	4.3E-11	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.0E-08	mg/m^3	6.9E-11	mg/m^3	6.0E-05	$1/(ug/m^3)$	4E-12	2.4E-10	mg/m^3	NA	NA	NA
				Lead	6.8E-08	mg/m^3	4.6E-10	mg/m^3	NA	NA	NA	1.6E-09	mg/m^3	NA	NA	NA
			Exp. Route Total								1E-08					2E-04
		Exposure Point Total									1E-08					2E-04
	Exposure Medium Total										1E-08					2E-04
Soil Total											2E-06					2E-02
Receptor Total											2E-06					2E-02

Notes:

bgs = below ground surface

CSF = Cancer slope factor

EPC = Exposure point concentration

NA = Not applicable/Not available

RfC = Reference concentration

RfD = Reference dose

TABLE 7.3.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil (0 to 1 foot bgs)	Surface Soil	Surface Soil	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	5.3E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	4.1E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	2.0E+01	mg/kg	6.8E-07	mg/kg/day	3.0E+00	1/(mg/kg/day)	2E-06	5.3E-06	mg/kg/day	3.0E-04	mg/kg/day	1.8E-02
				Benzo(b)fluoranthene	1.9E+01	mg/kg	6.3E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	4.9E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.9E+00	mg/kg	3.3E-07	mg/kg/day	3.0E-02	1/(mg/kg/day)	1E-08	2.6E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	2.5E+00	mg/kg	8.3E-08	mg/kg/day	3.0E+00	1/(mg/kg/day)	2E-07	6.5E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	4.6E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	1E-07	3.6E-06	mg/kg/day	NA	NA	NA
				Lead	9.2E+01	mg/kg	3.1E-06	mg/kg/day	NA	NA	NA	2.4E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								3E-06					2E-02
Surface Soil (0 to 1 foot bgs)	Surface Soil	Surface Soil	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	7.5E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	5.8E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	2.0E+01	mg/kg	9.6E-07	mg/kg/day	3.0E+00	1/(mg/kg/day)	3E-06	7.5E-06	mg/kg/day	3.0E-04	mg/kg/day	2.5E-02
				Benzo(b)fluoranthene	1.9E+01	mg/kg	8.9E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	3E-07	6.9E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.9E+00	mg/kg	4.7E-07	mg/kg/day	3.0E-02	1/(mg/kg/day)	1E-08	3.6E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	2.5E+00	mg/kg	1.2E-07	mg/kg/day	3.0E+00	1/(mg/kg/day)	4E-07	9.1E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	6.5E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	5.1E-06	mg/kg/day	NA	NA	NA
				Lead	9.2E+01	mg/kg	3.3E-07	mg/kg/day	NA	NA	NA	2.6E-06	mg/kg/day	NA	NA	NA
			Exp. Route Total								4E-06					2E-02
		Exposure Point Total									7E-06					4E-02
	Exposure Medium Total										7E-06					4E-02
Surface Soil (0 to 1 foot bgs)	Ambient Air	Emissions from Surface Soil	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	1.2E-08	mg/m^3	1.8E-04	$1/(ug/m^3)$	2E-09	9.6E-08	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	1.5E-08	mg/m^3	4.6E-11	mg/m^3	1.8E-03	$1/(ug/m^3)$	8E-11	3.6E-10	mg/m^3	2.0E-06	mg/m^3	2E-04
				Benzo(b)fluoranthene	1.4E-08	mg/m^3	4.2E-11	mg/m^3	2.5E-01	$1/(ug/m^3)$	1E-08	3.3E-10	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	7.3E-09	mg/m^3	2.2E-11	mg/m^3	1.8E-05	$1/(ug/m^3)$	4E-13	1.7E-10	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	1.8E-09	mg/m^3	5.6E-12	mg/m^3	1.8E-03	$1/(ug/m^3)$	1E-11	4.3E-11	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.0E-08	mg/m^3	3.1E-11	mg/m^3	1.8E-04	$1/(ug/m^3)$	6E-12	2.4E-10	mg/m^3	NA	NA	NA
				Lead	6.8E-08	mg/m^3	2.1E-10	mg/m^3	NA	NA	NA	1.6E-09	mg/m^3	NA	NA	NA
			Exp. Route Total								1E-08					2E-04
		Exposure Point Total									1E-08					2E-04
	Exposure Medium Total										1E-08					2E-04
Soil Total											7E-06					4E-02
Receptor Total											7E-06					4E-02

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

TABLE 7.4.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC Value	EPC Units	Cancer Risk Calculations: Intake/Exposure Concentration Value	Intake/Exposure Concentration Units	CSF/Unit Risk Value	CSF/Unit Risk Units	Cancer Risk	Non-Cancer Hazard Calculations: Intake/Exposure Concentration Value	Intake/Exposure Concentration Units	RfD/RfC Value	RfD/RfC Units	Hazard Quotient
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	NA	NA	NA	NA	NA	1.9E-05	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	NA	NA	NA	NA	NA	1.4E-05	mg/kg/day	3.0E-04	mg/kg/day	4.8E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	NA	NA	NA	NA	NA	2.6E-05	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	NA	NA	NA	NA	NA	1.1E-05	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	NA	NA	NA	NA	NA	3.6E-06	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	NA	NA	NA	NA	NA	1.7E-05	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	NA	NA	NA	NA	NA	9.9E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					5E-02
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	NA	NA	NA	NA	NA	1.0E-05	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	NA	NA	NA	NA	NA	7.9E-06	mg/kg/day	3.0E-04	mg/kg/day	2.6E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	NA	NA	NA	NA	NA	1.4E-05	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	NA	NA	NA	NA	NA	6.0E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	NA	NA	NA	NA	NA	2.0E-06	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	NA	NA	NA	NA	NA	9.5E-06	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	NA	NA	NA	NA	NA	4.2E-06	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					3E-02
		Exposure Point Total									NA					7E-02
	Exposure Medium Total										NA					7E-02
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	NA	NA	NA	NA	NA	3.9E-06	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	NA	NA	NA	NA	NA	8.4E-09	mg/m^3	2.0E-06	mg/m^3	4E-03
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	NA	NA	NA	NA	NA	1.5E-08	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	NA	NA	NA	NA	NA	6.5E-09	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	NA	NA	NA	NA	NA	2.1E-09	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	NA	NA	NA	NA	NA	1.0E-08	mg/m^3	NA	NA	NA
				Lead	6.1E-08	mg/m^3	NA	NA	NA	NA	NA	5.8E-08	mg/m^3	NA	NA	NA
			Exp. Route Total								NA					4E-03
		Exposure Point Total									NA					4E-03
	Exposure Medium Total										NA					4E-03
Soil Total											NA					8E-02
Groundwater	Groundwater	Tap Water	Ingestion	Benzo(a)anthracene	3.1E-02	µg/L	NA	NA	NA	NA	NA	9.3E-07	mg/kg/day	NA	NA	NA
				Lead	9.1E+00	µg/L	NA	NA	NA	NA	NA	2.7E-04	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					NA
Groundwater	Groundwater	Tap Water	Dermal	Benzo(a)anthracene	3.1E-02	µg/L	NA	NA	NA	NA	NA	1.4E-05	mg/kg/day	NA	NA	NA
				Lead	9.1E+00	µg/L	NA	NA	NA	NA	NA	1.6E-07	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					NA
		Exposure Point Total									NA					NA
	Exposure Medium total										NA					NA

TABLE 7.4.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Air	Water Vapor at Showerhead	Inhalation	Benzo(a)anthracene	9.6E-08	mg/m^3	NA	NA	NA	NA	NA	2.7E-09	mg/m^3	NA	NA	NA
			Exp. Route Total								NA					NA
		Exposure Point Total									NA					NA
	Exposure Medium total										NA					NA
Groundwater Total											NA					NA
Receptor Total											NA					8E-02

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.4.RME SUPPLEMENT A
CALCULATION OF DAEVENT
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Chemical of Potential Concern	Groundwater Concentration (CW) (ug/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Benzo(a)anthracene	3.10E-02	5.5E-01	3.2E+00	2.0E+00	8.5E+00	1.0E+00	0.71	5.6E-08	2
Lead	9.06E+00	1.0E-04	NA	NA	NA	1.0E+00	0.71	6.4E-10	1

Inorganics: DAevent (mg/cm^2-event):

DA_{event} = Kp x CW x tevent x CF1 x CF2 (Eq 1)

Organics: DAevent (mg/cm^2-event):

DA_{event} = $t_{event} \leq t^*$: DA_{event} (mg/cm^2-event) =
2 x FA x Kp x Cw x (sqrt((6 x τ x t_{event}) / (3.1415))) x CF1 x CF2 (Eq 2)

$t_{event} > t^*$: DA_{event} (mg/cm^2-event) =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x ((1 + 3B + 3B^2)/(1+B)^2)) xCF1 x CF2 (Eq 3)

Notes:

Values for permeability constants, B, tau, t*, and FA are from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005.

B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).

cm/hr - centimeter per hour

hr - hour

mg/cm^2-event - milligram per square centimeter per event

µg/L - microgram per liter

NA - Not applicable

t* - Time to reach steady-state

CF1 - Conversion Factor 1 (0.001 mg/µg), CF2 - Conversion Factor 2 (0.001 L/cm^3)

TABLE 7.4.RME SUPPLEMENT B
Inhalation Exposure Concentrations from Foster and Chrostowski Shower Model
Adult Resident
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Chemical of Potential Concern	Exposure Point Concentration Cwo (µg/L)	Molecular weight (MW) (g/mole)	Henry's Law Constant (H) (atm-m^3/mole)	Kg (VOC) (cm/hr)	Kl (VOC) (cm/hr)	KL (cm/hr)	Kal (cm/hr)	Cwd (µg/L)	S (µg/m^3 -min)	Ca (mg/m^3)
Benzo(a)anthracene	3.1E-02	2.3E+02	1.2E-05	8.4E+02	8.8E+00	4.0E-01	5.4E-01	1.4E-04	1.2E-04	9.6E-08

Variables	Units	Exposure Assumptions
Kg(VOC) = gas-film mass transfer coefficient	cm/hr	Solved by Eq 1
Kl(VOC) = liquid-film mass transfer coefficient	cm/hr	Solved by Eq 2
KL = overall mass transfer coefficient	cm/hr	Solved by Eq 3
Kal = adjusted overall mass transfer coeff.	cm/hr	Solved by Eq 4
Tl = Calibration temp. of water	K (20C +273)	293
Ts = Shower water temperature	k (45C)	318
Us = water viscosity at Ts	centipoise	0.596
Ul = water viscosity at Tl	cp	1.002
Cwd = conc. leaving droplets after time sdt	µg/l	Solved by Eq 5
sdt = shower droplet drop time	sec	0.5
d = shower droplet diameter	mm	1
FR = shower water flow rate	l/min	10
SV = shower room air volume	m^3	12
S = indoor VOC generation rate	µg/m^3-min	Solved by Eq 6
Ds = duration of shower	min	42.6
Dt = total duration in shower room	min	60
R = air exchange rate	min^{-1}	0.01667
Ca = indoor air concentration of VOCs	µg/m^3	Solved by Eq 7

Equation 1:	Kg(VOC) =	$3000 * (18 / MW)^{0.5}$
Equation 2:	Kl(VOC) =	$20 * (44 / MW)^{0.5}$
Equation 3:	KL =	$((1 / Kl(VOC)) + (0.024 / (Kg (VOC) * H)))^{-1}$
Equation 4:	Kal =	$(KL * (((Tl * Us) / (Ts * Ul))^{-0.5}))$
Equation 5:	Cwd =	(Cwo * (1-EXP((-1 * Kal * sdt)/(60 * d))))
Equation 6:	S =	(Cwd * FR / SV)
Equation 7:	Ca = (If t>Ds)	[(S / R) * (Ds + (EXP(-R * Dt) / R)-(EXP(R *(Ds - Dt)) / R)] * 1/1440 min/day * 1/1000 ug/mg

Notes:
MW and Henry's Law Constant were obtained from U.S. Environmental Protection Agency (USEPA).
Regional Screening Levels. Parameters table. May 2021.
[Online]. Available: https://www.epa.gov/risk/regional-screening-levels-rsls

TABLE 7.5.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
					Value	Units	Value	Units	Value	Units		Value	Units	Value	Units	
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	NA	NA	NA	NA	NA	2.0E-04	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	NA	NA	NA	NA	NA	1.5E-04	mg/kg/day	3.0E-04	mg/kg/day	5.1E-01
				Benzo(b)fluoranthene	2.2E+01	mg/kg	NA	NA	NA	NA	NA	2.8E-04	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	NA	NA	NA	NA	NA	1.2E-04	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	NA	NA	NA	NA	NA	3.9E-05	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	NA	NA	NA	NA	NA	1.9E-04	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	NA	NA	NA	NA	NA	1.1E-03	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					5E-01
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	NA	NA	NA	NA	NA	6.2E-05	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	NA	NA	NA	NA	NA	4.7E-05	mg/kg/day	3.0E-04	mg/kg/day	1.6E-01
				Benzo(b)fluoranthene	2.2E+01	mg/kg	NA	NA	NA	NA	NA	8.7E-05	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	NA	NA	NA	NA	NA	3.6E-05	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	NA	NA	NA	NA	NA	1.2E-05	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	NA	NA	NA	NA	NA	5.7E-05	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	NA	NA	NA	NA	NA	2.5E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					2E-01
		Exposure Point Total									NA					7E-01
	Exposure Medium Total										NA					7E-01
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	NA	NA	NA	NA	NA	3.9E-06	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	NA	NA	NA	NA	NA	8.4E-09	mg/m^3	2.0E-06	mg/m^3	4E-03
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	NA	NA	NA	NA	NA	1.5E-08	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	NA	NA	NA	NA	NA	6.5E-09	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	NA	NA	NA	NA	NA	2.1E-09	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	NA	NA	NA	NA	NA	1.0E-08	mg/m^3	NA	NA	NA
				Lead	6.1E-08	mg/m^3	NA	NA	NA	NA	NA	5.8E-08	mg/m^3	NA	NA	NA
			Exp. Route Total								NA					4E-03
		Exposure Point Total									NA					4E-03
	Exposure Medium Total										NA					4E-03
Soil Total											NA					7E-01
Groundwater	Groundwater	Tap Water	Ingestion	Benzo(a)anthracene	3.1E-02	µg/L	NA	NA	NA	NA	NA	1.5E-06	mg/kg/day	NA	NA	NA
				Lead	9.1E+00	µg/L	NA	NA	NA	NA	NA	4.5E-04	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					NA
Groundwater	Groundwater	Tap Water	Dermal	Benzo(a)anthracene	3.1E-02	µg/L	NA	NA	NA	NA	NA	2.0E-05	mg/kg/day	NA	NA	NA
				Lead	9.1E+00	µg/L	NA	NA	NA	NA	NA	2.0E-07	mg/kg/day	NA	NA	NA
			Exp. Route Total								NA					NA
		Exposure Point Total									NA					NA
	Exposure Medium total										NA					NA

TABLE 7.5.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater Total											NA					NA
Receptor Total											NA					7E-01

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.5.RME SUPPLEMENT A
CALCULATION OF DAEVENT
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Chemical of Potential Concern	Groundwater Concentration (CW) (ug/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Benzo(a)anthracene	3.10E-02	5.5E-01	3.2E+00	2.0E+00	8.5E+00	1.0E+00	0.54	4.9E-08	2
Lead	9.06E+00	1.0E-04	NA	NA	NA	1.0E+00	0.54	4.9E-10	1

Inorganics: DAevent (mg/cm^2-event):

DA_{event} = Kp x CW x tevent x CF1 x CF2 (Eq 1)

Organics: DAevent (mg/cm^2-event):

DA_{event} = $t_{event} \leq t^*$: DA_{event} (mg/cm^2-event) =
2 x FA x Kp x Cw x (sqrt((6 x τ x t_{event}) / (3.1415))) x CF1 x CF2 (Eq 2)

$t_{event} > t^*$: DA_{event} (mg/cm^2-event) =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x ((1 + 3B + 3B^2)/(1+B)^2)) xCF1 x CF2 (Eq 3)

Notes:
Values for permeability constants, B, tau, t*, and FA are from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005.
B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).
cm/hr - centimeter per hour
hr - hour
mg/cm^2-event - milligram per square centimeter per event
µg/L - microgram per liter
NA - Not applicable
t* - Time to reach steady-state
CF1 - Conversion Factor 1 (0.001 mg/µg), CF2 - Conversion Factor 2 (0.001 L/cm^3)

TABLE 7.6.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	2.3E-05	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-05	NA	NA	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	1.7E-05	mg/kg/day	1.0E+00	1/(mg/kg/day)	8E-05	NA	NA	NA	NA	NA
				Benzo(b)fluoranthene	2.2E+01	mg/kg	3.2E-05	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-05	NA	NA	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	1.3E-05	mg/kg/day	1.0E-02	1/(mg/kg/day)	6E-07	NA	NA	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	4.4E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	2E-05	NA	NA	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	2.1E-05	mg/kg/day	1.0E-01	1/(mg/kg/day)	9E-06	NA	NA	NA	NA	NA
				Lead	8.3E+01	mg/kg	1.2E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								1E-04					NA
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	8.3E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	3E-06	NA	NA	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	6.3E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	3E-05	NA	NA	NA	NA	NA
				Benzo(b)fluoranthene	2.2E+01	mg/kg	1.2E-05	mg/kg/day	1.0E-01	1/(mg/kg/day)	5E-06	NA	NA	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	4.8E-06	mg/kg/day	1.0E-02	1/(mg/kg/day)	2E-07	NA	NA	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	1.6E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	7E-06	NA	NA	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	7.6E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	3E-06	NA	NA	NA	NA	NA
				Lead	8.3E+01	mg/kg	3.3E-06	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								4E-05					NA
		Exposure Point Total									2E-04					NA
	Exposure Medium Total										2E-04					NA
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	1.4E-06	mg/m^3	6.0E-05	1/(ug/m^3)	2E-07	NA	NA	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	3.1E-09	mg/m^3	6.0E-04	1/(ug/m^3)	5E-09	NA	NA	NA	NA	NA
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	5.8E-09	mg/m^3	8.4E-02	1/(ug/m^3)	1E-06	NA	NA	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	2.4E-09	mg/m^3	6.0E-06	1/(ug/m^3)	4E-11	NA	NA	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	8.0E-10	mg/m^3	6.0E-04	1/(ug/m^3)	1E-09	NA	NA	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	3.8E-09	mg/m^3	6.0E-05	1/(ug/m^3)	6E-10	NA	NA	NA	NA	NA
				Lead	6.1E-08	mg/m^3	2.2E-08	mg/m^3	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								2E-06					NA
		Exposure Point Total									2E-06					NA
	Exposure Medium Total										2E-06					NA
Soil Total											2E-04					NA
Groundwater	Groundwater	Tap Water	Ingestion	Benzo(a)anthracene	3.1E-02	µg/L	4.0E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	7E-08	NA	NA	NA	NA	NA
				Lead	9.1E+00	µg/L	1.2E-04	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								7E-08					
Groundwater	Groundwater	Tap Water	Dermal	Benzo(a)anthracene	3.1E-02	µg/L	5.7E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	2E-06	NA	NA	NA	NA	NA
				Lead	9.1E+00	µg/L	6.3E-08	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								2E-06					NA
		Exposure Point Total									2E-06					NA
	Exposure Medium total										2E-06					NA

TABLE 7.6.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Air	Water Vapor at Showerhead	Inhalation	Benzo(a)anthracene	9.6E-08	mg/m^3	1.3E-08	mg/m^3	6.0E-05	$1/(ug/m^3)$	3E-09	NA	NA	NA	NA	NA
			Exp. Route Total								3E-09					NA
		Exposure Point Total									2E-06					NA
	Exposure Medium total										2E-06					NA
Groundwater Total											2E-06					NA
Receptor Total											2E-04					NA

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.7.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	4.8E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	5E-07	1.4E-05	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	3.7E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	4E-06	1.0E-05	mg/kg/day	3.0E-04	mg/kg/day	3.4E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	6.7E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	7E-07	1.9E-05	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	2.8E-06	mg/kg/day	1.0E-02	1/(mg/kg/day)	3E-08	7.9E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	9.3E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	9E-07	2.6E-06	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	4.4E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-07	1.2E-05	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	2.5E-05	mg/kg/day	NA	NA	NA	7.1E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								6E-06					3E-02
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	2.7E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	3E-07	7.5E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	2.0E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	2E-06	5.6E-06	mg/kg/day	3.0E-04	mg/kg/day	1.9E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	3.7E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-07	1.0E-05	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	1.5E-06	mg/kg/day	1.0E-02	1/(mg/kg/day)	2E-08	4.3E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	5.1E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	5E-07	1.4E-06	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	2.4E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	2E-07	6.8E-06	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	1.1E-06	mg/kg/day	NA	NA	NA	3.0E-06	mg/kg/day	NA	NA	NA
			Exp. Route Total								3E-06					2E-02
		Exposure Point Total									1E-05					5E-02
	Exposure Medium Total										1E-05					5E-02
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	3.3E-07	mg/m^3	6.0E-05	$1/(ug/m^3)$	2E-08	9.3E-07	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	7.2E-10	mg/m^3	6.0E-04	$1/(ug/m^3)$	4E-10	2.0E-09	mg/m^3	2.0E-06	mg/m^3	1E-03
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	1.3E-09	mg/m^3	8.4E-02	$1/(ug/m^3)$	1E-07	3.7E-09	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	5.5E-10	mg/m^3	6.0E-06	$1/(ug/m^3)$	3E-12	1.5E-09	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	1.8E-10	mg/m^3	6.0E-04	$1/(ug/m^3)$	1E-10	5.1E-10	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	8.7E-10	mg/m^3	6.0E-05	$1/(ug/m^3)$	5E-11	2.4E-09	mg/m^3	NA	NA	NA
				Lead	6.1E-08	mg/m^3	5.0E-09	mg/m^3	NA	NA	NA	1.4E-08	mg/m^3	NA	NA	NA
			Exp. Route Total								1E-07					1E-03
		Exposure Point Total									1E-07					1E-03
	Exposure Medium Total										1E-07					1E-03
Soil Total											1E-05					5E-02
Receptor Total											1E-05					5E-02

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.8.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	8.0E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	8E-08	2.8E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	6.1E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	6E-07	2.1E-06	mg/kg/day	3.0E-04	mg/kg/day	7.1E-03
				Benzo(b)fluoranthene	2.2E+01	mg/kg	1.1E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-07	3.9E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	4.7E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	5E-09	1.6E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	1.5E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	2E-07	5.4E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	7.4E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	7E-08	2.6E-06	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	4.2E-06	mg/kg/day	NA	NA	NA	1.5E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								1E-06					7E-03
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	4.4E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-08	1.5E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	3.3E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	3E-07	1.2E-06	mg/kg/day	3.0E-04	mg/kg/day	3.9E-03
				Benzo(b)fluoranthene	2.2E+01	mg/kg	6.1E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	6E-08	2.1E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	2.6E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	3E-09	9.0E-07	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	8.5E-08	mg/kg/day	1.0E+00	1/(mg/kg/day)	8E-08	3.0E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	4.0E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-08	1.4E-06	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	1.8E-07	mg/kg/day	NA	NA	NA	6.2E-07	mg/kg/day	NA	NA	NA
			Exp. Route Total								6E-07					4E-03
		Exposure Point Total									2E-06					1E-02
	Exposure Medium Total										2E-06					1E-02
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	2.8E-08	mg/m^3	6.0E-05	1/(ug/m^3)	2E-09	9.7E-08	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	6.0E-11	mg/m^3	6.0E-04	1/(ug/m^3)	4E-11	2.1E-10	mg/m^3	2.0E-06	mg/m^3	1E-04
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	1.1E-10	mg/m^3	8.4E-02	1/(ug/m^3)	9E-09	3.8E-10	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	4.6E-11	mg/m^3	6.0E-06	1/(ug/m^3)	3E-13	1.6E-10	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	1.5E-11	mg/m^3	6.0E-04	1/(ug/m^3)	9E-12	5.3E-11	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	7.2E-11	mg/m^3	6.0E-05	1/(ug/m^3)	4E-12	2.5E-10	mg/m^3	NA	NA	NA
				Lead	6.1E-08	mg/m^3	4.1E-10	mg/m^3	NA	NA	NA	1.4E-09	mg/m^3	NA	NA	NA
			Exp. Route Total								1E-08					1E-04
		Exposure Point Total									1E-08					1E-04
	Exposure Medium Total										1E-08					1E-04
Soil Total											2E-06					1E-02
Receptor Total											2E-06					1E-02

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.9.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	5.3E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	4.1E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	4.0E-07	mg/kg/day	3.0E+00	1/(mg/kg/day)	1E-06	3.1E-06	mg/kg/day	3.0E-04	mg/kg/day	1.0E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	7.4E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	5.7E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	3.1E-07	mg/kg/day	3.0E-02	1/(mg/kg/day)	9E-09	2.4E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	1.0E-07	mg/kg/day	3.0E+00	1/(mg/kg/day)	3E-07	7.9E-07	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	4.9E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	1E-07	3.8E-06	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	2.8E-06	mg/kg/day	NA	NA	NA	2.2E-05	mg/kg/day	NA	NA	NA
			Exp. Route Total								2E-06					1E-02
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	7.5E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	5.8E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	5.6E-07	mg/kg/day	3.0E+00	1/(mg/kg/day)	2E-06	4.4E-06	mg/kg/day	3.0E-04	mg/kg/day	1.5E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	1.0E-06	mg/kg/day	3.0E-01	1/(mg/kg/day)	3E-07	8.1E-06	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	4.3E-07	mg/kg/day	3.0E-02	1/(mg/kg/day)	1E-08	3.4E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	1.4E-07	mg/kg/day	3.0E+00	1/(mg/kg/day)	4E-07	1.1E-06	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	6.8E-07	mg/kg/day	3.0E-01	1/(mg/kg/day)	2E-07	5.3E-06	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	3.0E-07	mg/kg/day	NA	NA	NA	2.3E-06	mg/kg/day	NA	NA	NA
			Exp. Route Total								3E-06					1E-02
		Exposure Point Total									5E-06					3E-02
	Exposure Medium Total										5E-06					3E-02
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	1.2E-08	mg/m^3	1.8E-04	$1/(ug/m^3)$	2E-09	9.7E-08	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	2.7E-11	mg/m^3	1.8E-03	$1/(ug/m^3)$	5E-11	2.1E-10	mg/m^3	2.0E-06	mg/m^3	1E-04
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	4.9E-11	mg/m^3	2.5E-01	$1/(ug/m^3)$	1E-08	3.8E-10	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	2.1E-11	mg/m^3	1.8E-05	$1/(ug/m^3)$	4E-13	1.6E-10	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	6.8E-12	mg/m^3	1.8E-03	$1/(ug/m^3)$	1E-11	5.3E-11	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	3.2E-11	mg/m^3	1.8E-04	$1/(ug/m^3)$	6E-12	2.5E-10	mg/m^3	NA	NA	NA
				Lead	6.1E-08	mg/m^3	1.9E-10	mg/m^3	NA	NA	NA	1.4E-09	mg/m^3	NA	NA	NA
			Exp. Route Total								1E-08					1E-04
		Exposure Point Total									1E-08					1E-04
	Exposure Medium Total										1E-08					1E-04
Soil Total											5E-06					3E-02
Receptor Total											5E-06					3E-02

Notes:

bgs = below ground surface

CSF = Cancer slope factor

EPC = Exposure point concentration

NA = Not applicable/Not available

RfC = Reference concentration

RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.10.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	3.2E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	3E-08	2.2E-05	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	2.4E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	2E-07	1.7E-05	mg/kg/day	3.0E-04	mg/kg/day	5.6E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	4.4E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-08	3.1E-05	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	1.9E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	2E-09	1.3E-05	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	6.1E-08	mg/kg/day	1.0E+00	1/(mg/kg/day)	6E-08	4.3E-06	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	2.9E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	3E-08	2.0E-05	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	1.7E-06	mg/kg/day	NA	NA	NA	1.2E-04	mg/kg/day	NA	NA	NA
			Exp. Route Total								4E-07					6E-02
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	1.3E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-08	9.3E-06	mg/kg/day	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	1.0E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	1E-07	7.0E-06	mg/kg/day	3.0E-04	mg/kg/day	2.3E-02
				Benzo(b)fluoranthene	2.2E+01	mg/kg	1.8E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	2E-08	1.3E-05	mg/kg/day	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	7.7E-08	mg/kg/day	1.0E-02	1/(mg/kg/day)	8E-10	5.4E-06	mg/kg/day	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	2.6E-08	mg/kg/day	1.0E+00	1/(mg/kg/day)	3E-08	1.8E-06	mg/kg/day	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	1.2E-07	mg/kg/day	1.0E-01	1/(mg/kg/day)	1E-08	8.5E-06	mg/kg/day	NA	NA	NA
				Lead	8.3E+01	mg/kg	5.4E-08	mg/kg/day	NA	NA	NA	3.7E-06	mg/kg/day	NA	NA	NA
			Exp. Route Total								2E-07					2E-02
		Exposure Point Total									6E-07					8E-02
	Exposure Medium Total										6E-07					8E-02
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	6.6E-09	mg/m^3	6.0E-05	1/(ug/m^3)	4E-10	4.6E-07	mg/m^3	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	1.4E-11	mg/m^3	6.0E-04	1/(ug/m^3)	9E-12	1.0E-09	mg/m^3	2.0E-06	mg/m^3	5E-04
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	2.6E-11	mg/m^3	8.4E-02	1/(ug/m^3)	2E-09	1.8E-09	mg/m^3	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	1.1E-11	mg/m^3	6.0E-06	1/(ug/m^3)	7E-14	7.7E-10	mg/m^3	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	3.6E-12	mg/m^3	6.0E-04	1/(ug/m^3)	2E-12	2.6E-10	mg/m^3	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	1.7E-11	mg/m^3	6.0E-05	1/(ug/m^3)	1E-12	1.2E-09	mg/m^3	NA	NA	NA
				Lead	6.1E-08	mg/m^3	9.9E-11	mg/m^3	NA	NA	NA	6.9E-09	mg/m^3	NA	NA	NA
			Exp. Route Total								3E-09					5E-04
		Exposure Point Total									3E-09					5E-04
	Exposure Medium Total										3E-09					5E-04
Soil Total											6E-07					8E-02
Groundwater	Groundwater	Water In Excavation Trench	Dermal	Benzo(a)anthracene	3.1E-02	µg/L	6.97E-08	mg/kg/day	1.0E-01	1/(mg/kg/day)	7E-09	4.88E-06	mg/kg/day	NA	NA	NA
				Lead	9.1E+00	µg/L	2.67E-09	mg/kg/day	NA	NA	NA	1.87E-07	mg/kg/day	NA	NA	NA
			Exp. Route Total								7E-09					NA
		Exposure Point Total									7E-09					NA
	Exposure Medium total										7E-09					NA

TABLE 7.10.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Air	Volatiles in Air In Excavation Trench	Inhalation	Benzo(a)anthracene	1.2E-06	mg/m^3	2.0E-09	mg/m^3	6.0E-05	1/(ug/m^3)	1E-10	1.4E-07	mg/m^3	NA	NA	NA
			Exp. Route Total								1E-10					NA
		Exposure Point Total									7E-09					NA
	Exposure Medium total										7E-09					NA
Groundwater Total											7E-09					NA
Receptor Total											6E-07					8E-02

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.10.RME SUPPLEMENT A
CALCULATION OF DAEVENT
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Chemical of Potential Concern	Groundwater Concentration (CW) (ug/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
Benzo(a)anthracene	3.10E-02	5.5E-01	3.2E+00	2.0E+00	8.5E+00	1.0E+00	8.00	1.9E-07	2
Lead	9.06E+00	1.0E-04	NA	NA	NA	1.0E+00	8.00	7.3E-09	1

Inorganics: DAevent (mg/cm^2-event):

DA_{event} = Kp x CW x tevent x CF1 x CF2 (Eq 1)

Organics: DAevent (mg/cm^2-event):

DA_{event} = $t_{event} \leq t^*$: DA_{event} (mg/cm^2-event) =
2 x FA x Kp x Cw x (sqrt((6 x τ x t_{event}) / (3.1415))) x CF1 x CF2 (Eq 2)

$t_{event} > t^*$: DA_{event} (mg/cm^2-event) =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x ((1 + 3B + 3B^2)/(1+B)^2)) xCF1 x CF2 (Eq 3)

Notes:
Values for permeability constants, B, tau, t*, and FA are from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005.
B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).
cm/hr - centimeter per hour
hr - hour
mg/cm^2-event - milligram per square centimeter per event
µg/L - microgram per liter
NA - Not applicable
t* - Time to reach steady-state
CF1 - Conversion Factor 1 (0.001 mg/µg), CF2 - Conversion Factor 2 (0.001 L/cm^3)

TABLE 7.10.RME SUPPLEMENT B

Inhalation of Volatiles from Groundwater During Construction—Inhalation Exposure Concentrations Calculated Using a Two-Film Volatilization Model

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Chemical	**Cw** (µg/L)	**MW_i** (gram/mole)	**H_i** (atm-m3/mole)	**k_{iL}** (cm/sec)	**k_{iG}** (cm/sec)	**K_v** (cm/sec)	**ER** (mg/sec-cm^2)	**ERa** (g/sec-m^2)	**Ca** (µg/m^3)	**Ca** (mg/m^3)
Benzo(a)anthracene	3.1E-02	2.3E+02	1.2E-05	7.5E-04	3.6E-01	1.4E-04	4.4E-12	4.4E-11	1.2E-03	1.2E-06

Equations

Equation 1	$K_v =$	$1/(1/k_{iL} + RT/H_ik_{iG})$
Equation 2	$ki_G =$	$(MW_{H2O}/MW_i)^{0.335}(T/298)^{1.005}(k_G,H_2O)$
Equation 3	$ki_L =$	$(MW_{O2}/MW_1)^{0.5}(T/298)(k_L,O_2)$
Equation 4	ER =	Kv * Cw * L/1000 cm^3 * mg/1000 µg
Equation 5	ERa =	ER * g/1000 mg *10000 cm^2/m^2

Variables	Units	Exposure Assumptions
Cw = groundwater concentration	(µg/L)	chem-specific
MW = molecular weight	(mol/gram)	chem-specific
Hi - Henry's Law Constant	(unitless)	chem-specific
Kv = volatilization rate	(cm/hr)	Solved by Eq 1
ki_G = gas phase transfer coefficient	(cm/hr)	Solved by Eq 2
k_{iL} = liquid phase transfer coefficient	(cm/hr)	Solved by Eq 3
MW_{O2} = molecular weight of oxygen	(gram/mole)	32
T = temperature	(^{0}K)	298
$k_{L,O2}$ = liquid phase mass transfer coefficient for oxygen at 25 ^{0}C	(cm/sec)	0.002
MW_{H2O} = molecular weight of water	(gram/mole)	18
$k_{G,H2O}$ = gass phase mass transfer coefficient for oxygen at 25 ^{0}C	(cm/sec)	0.833
R = Ideal gas constant	(atm-m^3/mole-K)	0.000082
ER = emission rate	(mg/sec-cm^2)	Solved by Eq 4
A = area of excavation (based on utility ditch)	(m^2)	2,700
ERa = area emission rate	(g/sec-m^2)	Solved by Eq 5
Ca = air concentration	(mg/m^3)	Solved using SCREEN3 model

MW and H from Oak Ridge National Laboratory (ORNL). May 2021, Regional Screening Level Table, Chemical Specific Parameters Table.

TABLE 7.1.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	6.3E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	3E-06	NA	NA	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	4.7E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	2E-05	NA	NA	NA	NA	NA
				Benzo(b)fluoranthene	2.2E+01	mg/kg	8.7E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	4E-06	NA	NA	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	3.6E-06	mg/kg/day	1.0E-02	1/(mg/kg/day)	2E-07	NA	NA	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	1.2E-06	mg/kg/day	1.0E+00	1/(mg/kg/day)	6E-06	NA	NA	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	5.7E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	3E-06	NA	NA	NA	NA	NA
				Lead	8.3E+01	mg/kg	3.3E-05	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								4E-05					NA
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	1.3E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	6E-07	NA	NA	NA	NA	NA
				Benzo(a)pyrene	1.2E+01	mg/kg	9.5E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	5E-06	NA	NA	NA	NA	NA
				Benzo(b)fluoranthene	2.2E+01	mg/kg	1.8E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	9E-07	NA	NA	NA	NA	NA
				Benzo(k)fluoranthene	9.2E+00	mg/kg	7.3E-07	mg/kg/day	1.0E-02	1/(mg/kg/day)	4E-08	NA	NA	NA	NA	NA
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	2.4E-07	mg/kg/day	1.0E+00	1/(mg/kg/day)	1E-06	NA	NA	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	1.2E-06	mg/kg/day	1.0E-01	1/(mg/kg/day)	6E-07	NA	NA	NA	NA	NA
				Lead	8.3E+01	mg/kg	5.1E-07	mg/kg/day	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								8E-06					NA
		Exposure Point Total									5E-05					NA
	Exposure Medium Total										5E-05					NA
Soil* (0 to 1 foot bgs)	Ambient Air	Emissions from Soil*	Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	8.4E-07	mg/m^3	6.0E-05	$1/(ug/m^3)$	2E-07	NA	NA	NA	NA	NA
				Benzo(a)pyrene	8.8E-09	mg/m^3	1.8E-09	mg/m^3	6.0E-04	$1/(ug/m^3)$	4E-09	NA	NA	NA	NA	NA
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	3.3E-09	mg/m^3	8.4E-02	$1/(ug/m^3)$	1E-06	NA	NA	NA	NA	NA
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	1.4E-09	mg/m^3	6.0E-06	$1/(ug/m^3)$	3E-11	NA	NA	NA	NA	NA
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	4.6E-10	mg/m^3	6.0E-04	$1/(ug/m^3)$	1E-09	NA	NA	NA	NA	NA
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	2.2E-09	mg/m^3	6.0E-05	$1/(ug/m^3)$	5E-10	NA	NA	NA	NA	NA
				Lead	6.1E-08	mg/m^3	1.2E-08	mg/m^3	NA	NA	NA	NA	NA	NA	NA	NA
			Exp. Route Total								1E-06					NA
		Exposure Point Total									1E-06					NA
	Exposure Medium Total										1E-06					NA
Soil Total											5E-05					NA
Receptor Total											5E-05					NA

Notes:
bgs = below ground surface
CSF = Cancer slope factor
EPC = Exposure point concentration
NA = Not applicable/Not available
RfC = Reference concentration
RfD = Reference dose

* Combined surface and subsurface soil

TABLE 7.1.CTE SUPPLEMENT A

CALCULATION OF CHEMICAL CANCER RISKS FOR COPC WITH MUTAGENIC MODE OF ACTION

CENTRAL TENDENCY EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations										
							Intake					CSF/Unit Risk					Cancer Risk
					Value	Units	Value				Units	Value				Units	
							0-2 yrs	2-6 yrs	6-16 years	16-26 yrs		0-2 yrs (ADAF=10)	2-6 yrs (ADAF=3)	6-16 yrs (ADAF=3)	16-26 yrs (ADAF=1)		
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Ingestion	Benzo(a)anthracene	1.6E+01	mg/kg	1.8E-06	3.7E-06	7.3E-07	NA	mg/kg/day	1.0E+00	3.0E-01	3.0E-01	1.0E-01	1/(mg/kg-day)	3.2E-06
				Benzo(a)pyrene	1.2E+01	mg/kg	1.4E-06	2.8E-06	5.5E-07	NA	mg/kg/day	1.0E+01	3.0E+00	3.0E+00	1.0E+00	1/(mg/kg-day)	2.4E-05
				Benzo(b)fluoranthene	2.2E+01	mg/kg	2.6E-06	5.1E-06	1.0E-06	NA	mg/kg/day	1.0E+00	3.0E-01	3.0E-01	1.0E-01	1/(mg/kg-day)	4.4E-06
				Benzo(k)fluoranthene	9.2E+00	mg/kg	1.1E-06	2.1E-06	4.2E-07	NA	mg/kg/day	1.0E-01	3.0E-02	3.0E-02	1.0E-02	1/(mg/kg-day)	1.8E-07
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	3.6E-07	7.1E-07	1.4E-07	NA	mg/kg/day	1.0E+01	3.0E+00	3.0E+00	1.0E+00	1/(mg/kg-day)	6.1E-06
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	1.7E-06	3.4E-06	6.7E-07	NA	mg/kg/day	1.0E+00	3.0E-01	3.0E-01	1.0E-01	1/(mg/kg-day)	2.9E-06
			Dermal	Benzo(a)anthracene	1.6E+01	mg/kg	3.6E-07	7.1E-07	1.9E-07	NA	mg/kg/day	1.0E+00	3.0E-01	3.0E-01	1.0E-01	1/(mg/kg-day)	6.3E-07
				Benzo(a)pyrene	1.2E+01	mg/kg	2.7E-07	5.4E-07	1.4E-07	NA	mg/kg/day	1.0E+01	3.0E+00	3.0E+00	1.0E+00	1/(mg/kg-day)	4.7E-06
				Benzo(b)fluoranthene	2.2E+01	mg/kg	4.9E-07	9.9E-07	2.7E-07	NA	mg/kg/day	1.0E+00	3.0E-01	3.0E-01	1.0E-01	1/(mg/kg-day)	8.7E-07
				Benzo(k)fluoranthene	9.2E+00	mg/kg	2.1E-07	4.1E-07	1.1E-07	NA	mg/kg/day	1.0E-01	3.0E-02	3.0E-02	1.0E-02	1/(mg/kg-day)	3.6E-08
				Dibenz(a,h)anthracene	3.0E+00	mg/kg	6.9E-08	1.4E-07	3.7E-08	NA	mg/kg/day	1.0E+01	3.0E+00	3.0E+00	1.0E+00	1/(mg/kg-day)	1.2E-06
				Indeno(1,2,3-cd)pyrene	1.4E+01	mg/kg	3.3E-07	6.5E-07	1.7E-07	NA	mg/kg/day	1.0E+00	3.0E-01	3.0E-01	1.0E-01	1/(mg/kg-day)	5.7E-07
			Inhalation	Benzo(a)anthracene	4.1E-06	mg/m^3	1.1E-07	2.2E-07	5.0E-07	NA	mg/m^3	6.0E-04	1.8E-04	1.8E-04	6.0E-05	1/(ug/m^3)	2.0E-07
				Benzo(a)pyrene	8.8E-09	mg/m^3	2.4E-10	4.8E-10	1.1E-09	NA	mg/m^3	6.0E-03	1.8E-03	1.8E-03	6.0E-04	1/(ug/m^3)	4.3E-09
				Benzo(b)fluoranthene	1.6E-08	mg/m^3	4.4E-10	8.8E-10	2.0E-09	NA	mg/m^3	8.4E-01	2.5E-01	2.5E-01	8.4E-02	1/(ug/m^3)	1.1E-06
				Benzo(k)fluoranthene	6.8E-09	mg/m^3	1.9E-10	3.7E-10	8.3E-10	NA	mg/m^3	6.0E-05	1.8E-05	1.8E-05	6.0E-06	1/(ug/m^3)	3.3E-11
				Dibenz(a,h)anthracene	2.2E-09	mg/m^3	6.1E-11	1.2E-10	2.8E-10	NA	mg/m^3	6.0E-03	1.8E-03	1.8E-03	6.0E-04	1/(ug/m^3)	1.1E-09
				Indeno(1,2,3-cd)pyrene	1.1E-08	mg/m^3	2.9E-10	5.8E-10	1.3E-09	NA	mg/m^3	6.0E-04	1.8E-04	1.8E-04	6.0E-05	1/(ug/m^3)	5.2E-10

Note

The 9-year exposure during adulthood is conservatively assumed to occur between 6 and 16 years of age.

TABLE 9.1.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil (0 to 0.5 feet bgs)	Surface Soil	Surface Soil	Benzo(a)anthracene	1E-07	NA	6E-08	2E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	1E-06	NA	7E-07	2E-06	Developmental	1E-02	NA	7E-03	2E-02
			Benzo(b)fluoranthene	1E-07	NA	7E-08	2E-07	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	6E-09	NA	3E-09	1E-08	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	2E-07	NA	9E-08	2E-07	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	9E-08	NA	5E-08	1E-07	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		2E-06	NA	1E-06	3E-06		1E-02	NA	7E-03	2E-02
	Exposure Medium Total			2E-06	NA	1E-06	3E-06		1E-02	NA	7E-03	2E-02
	Ambient Air	Emissions from Surface Soil	Benzo(a)anthracene	NA	4E-09	NA	4E-09	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	2E-10	NA	2E-10	Developmental	NA	4E-04	NA	4E-04
			Benzo(b)fluoranthene	NA	2E-08	NA	2E-08	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	7E-13	NA	7E-13	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	2E-11	NA	2E-11	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	1E-11	NA	1E-11	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	2E-08	NA	2E-08		NA	4E-04	NA	4E-04
	Exposure Medium Total			NA	2E-08	NA	2E-08		NA	4E-04	NA	4E-04
Soil Total				2E-06	2E-08	1E-06	3E-06		1E-02	4E-04	7E-03	2E-02
Receptor Total				2E-06	2E-08	1E-06	3E-06		1E-02	4E-04	7E-03	2E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

Total Developmental HI Across Media = 0.02

TABLE 9.2.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil (0 to 0.5 feet bgs)	Surface Soil	Surface Soil	Benzo(a)anthracene	8E-08	NA	4E-08	1E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	1E-06	NA	6E-07	2E-06	Developmental	1E-02	NA	7E-03	2E-02
			Benzo(b)fluoranthene	1E-07	NA	5E-08	1E-07	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	5E-09	NA	3E-09	8E-09	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	1E-07	NA	7E-08	2E-07	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	7E-08	NA	4E-08	1E-07	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		1E-06	NA	8E-07	2E-06		1E-02	NA	7E-03	2E-02
	Exposure Medium Total			1E-06	NA	8E-07	2E-06		1E-02	NA	7E-03	2E-02
	Ambient Air	Emissions from Surface Soil	Benzo(a)anthracene	NA	2E-09	NA	2E-09	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	6E-11	NA	6E-11	Developmental	NA	2E-04	NA	2E-04
			Benzo(b)fluoranthene	NA	8E-09	NA	8E-09	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	3E-13	NA	3E-13	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	7E-12	NA	7E-12	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	4E-12	NA	4E-12	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	1E-08	NA	1E-08		NA	2E-04	NA	2E-04
	Exposure Medium Total			NA	1E-08	NA	1E-08		NA	2E-04	NA	2E-04
Soil Total				1E-06	1E-08	8E-07	2E-06		1E-02	2E-04	7E-03	2E-02
Receptor Total				1E-06	1E-08	8E-07	2E-06		1E-02	2E-04	7E-03	2E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

Total Developmental HI Across Media = 0.02

TABLE 9.3.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil (0 to 0.5 feet bgs)	Surface Soil	Surface Soil	Benzo(a)anthracene	2E-07	NA	2E-07	4E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	2E-06	NA	3E-06	5E-06	Developmental	2E-02	NA	2E-02	4E-02
			Benzo(b)fluoranthene	2E-07	NA	3E-07	5E-07	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	1E-08	NA	1E-08	2E-08	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	2E-07	NA	4E-07	6E-07	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	1E-07	NA	2E-07	3E-07	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		3E-06	NA	4E-06	7E-06		2E-02	NA	2E-02	4E-02
	Exposure Medium Total			3E-06	NA	4E-06	7E-06		2E-02	NA	2E-02	4E-02
	Ambient Air	Emissions from Surface Soil	Benzo(a)anthracene	NA	2E-09	NA	2E-09	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	8E-11	NA	8E-11	Developmental	NA	2E-04	NA	2E-04
			Benzo(b)fluoranthene	NA	1E-08	NA	1E-08	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	4E-13	NA	4E-13	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	1E-11	NA	1E-11	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	6E-12	NA	6E-12	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	1E-08	NA	1E-08		NA	2E-04	NA	2E-04
	Exposure Medium Total			NA	1E-08	NA	1E-08		NA	2E-04	NA	2E-04
Soil Total				3E-06	1E-08	4E-06	7E-06		2E-02	2E-04	2E-02	4E-02
Receptor Total				3E-06	1E-08	4E-06	7E-06		2E-02	2E-04	2E-02	4E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

Total Developmental HI Across Media = 0.04

TABLE 9.4.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	NA	NA	NA	Developmental	5E-02	NA	3E-02	7E-02
			Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	NA	NA		5E-02	NA	3E-02	7E-02
	Exposure Medium Total			NA	NA	NA	NA		5E-02	NA	3E-02	7E-02
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	NA	NA	NA	Developmental	NA	4E-03	NA	4E-03
			Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	NA	NA		NA	4E-03	NA	4E-03
	Exposure Medium Total			NA	NA	NA	NA		NA	4E-03	NA	4E-03
Soil Total				NA	NA	NA	NA		5E-02	4E-03	3E-02	8E-02

TABLE 9.4.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	NA	NA		NA	NA	NA	NA
	Exposure Medium Total			NA	NA	NA	NA		NA	NA	NA	NA
	Air	Water Vapor at Showerhead	Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	NA	NA		NA	NA	NA	NA
	Exposure Medium Total			NA	NA	NA	NA		NA	NA	NA	NA
Groundwater Total				NA	NA	NA	NA		NA	NA	NA	NA
Receptor Total				NA	NA	NA	NA		5E-02	4E-03	3E-02	8E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

* Combined surface and subsurface soil.

Total Developmental HI Across Media = 0.08

TABLE 9.5.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	NA	NA	NA	Developmental	5E-01	NA	2E-01	7E-01
			Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	NA	NA		5E-01	NA	2E-01	7E-01
	Exposure Medium Total			NA	NA	NA	NA		5E-01	NA	2E-01	7E-01
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	NA	NA	NA	Developmental	NA	4E-03	NA	4E-03
			Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	NA	NA		NA	4E-03	NA	4E-03
	Exposure Medium Total			NA	NA	NA	NA		NA	4E-03	NA	4E-03
Soil Total				NA	NA	NA	NA		5E-01	4E-03	2E-01	7E-01
Groundwater	Groundwater	Tap Water	Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	NA	NA		NA	NA	NA	NA
	Exposure Medium Total			NA	NA	NA	NA		NA	NA	NA	NA
Groundwater Total				NA	NA	NA	NA		NA	NA	NA	NA
Receptor Total				NA	NA	NA	NA		5E-01	4E-03	2E-01	7E-01

Notes: NA = Not applicable or not available; HI = Hazard Index.

* Combined surface and subsurface soil.

Total Developmental HI Across Media = 0.7

TABLE 9.6.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	1E-05	NA	3E-06	1E-05	NA	NA	NA	NA	NA
			Benzo(a)pyrene	8E-05	NA	3E-05	1E-04	Developmental	NA	NA	NA	NA
			Benzo(b)fluoranthene	1E-05	NA	5E-06	2E-05	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	6E-07	NA	2E-07	8E-07	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	2E-05	NA	7E-06	3E-05	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	9E-06	NA	3E-06	1E-05	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		1E-04	NA	4E-05	2E-04		NA	NA	NA	NA
	Exposure Medium Total			1E-04	NA	4E-05	2E-04		NA	NA	NA	NA
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	2E-07	NA	2E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	5E-09	NA	5E-09	Developmental	NA	NA	NA	NA
			Benzo(b)fluoranthene	NA	1E-06	NA	1E-06	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	4E-11	NA	4E-11	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	1E-09	NA	1E-09	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	6E-10	NA	6E-10	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	2E-06	NA	2E-06		NA	NA	NA	NA
	Exposure Medium Total			NA	2E-06	NA	2E-06		NA	NA	NA	NA
Soil Total				1E-04	2E-06	4E-05	2E-04		NA	NA	NA	NA

TABLE 9.6.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	Benzo(a)anthracene	7E-08	NA	2E-06	2E-06	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		7E-08	NA	2E-06	2E-06		NA	NA	NA	NA
	Exposure Medium Total			7E-08	NA	2E-06	2E-06		NA	NA	NA	NA
	Air	Water Vapor at Showerhead	Benzo(a)anthracene	NA	3E-09	NA	3E-09	NA	NA	NA	NA	NA
		Exposure Point Total		NA	3E-09	NA	3E-09		NA	NA	NA	NA
	Exposure Medium Total			NA	3E-09	NA	3E-09		NA	NA	NA	NA
Groundwater Total				7E-08	3E-09	2E-06	2E-06		NA	NA	NA	NA
Receptor Total				1E-04	2E-06	5E-05	2E-04		NA	NA	NA	NA

Notes:

* Combined surface and subsurface soil.

TABLE 9.7.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	5E-07	NA	3E-07	7E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	4E-06	NA	2E-06	6E-06	Developmental	3E-02	NA	2E-02	5E-02
			Benzo(b)fluoranthene	7E-07	NA	4E-07	1E-06	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	3E-08	NA	2E-08	4E-08	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	9E-07	NA	5E-07	1E-06	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	4E-07	NA	2E-07	7E-07	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		6E-06	NA	3E-06	1E-05		3E-02	NA	2E-02	5E-02
	Exposure Medium Total			6E-06	NA	3E-06	1E-05		3E-02	NA	2E-02	5E-02
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	2E-08	NA	2E-08	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	4E-10	NA	4E-10	Developmental	NA	1E-03	NA	1E-03
			Benzo(b)fluoranthene	NA	1E-07	NA	1E-07	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	3E-12	NA	3E-12	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	1E-10	NA	1E-10	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	5E-11	NA	5E-11	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	1E-07	NA	1E-07		NA	1E-03	NA	1E-03
	Exposure Medium Total			NA	1E-07	NA	1E-07		NA	1E-03	NA	1E-03
Soil Total				6E-06	1E-07	3E-06	1E-05		3E-02	1E-03	2E-02	5E-02
Receptor Total				6E-06	1E-07	3E-06	1E-05		3E-02	1E-03	2E-02	5E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

* Combined surface and subsurface soil.

Total Developmental HI Across Media = 0.05

TABLE 9.8.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	8E-08	NA	4E-08	1E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	6E-07	NA	3E-07	9E-07	Developmental	7E-03	NA	4E-03	1E-02
			Benzo(b)fluoranthene	1E-07	NA	6E-08	2E-07	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	5E-09	NA	3E-09	7E-09	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	2E-07	NA	8E-08	2E-07	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	7E-08	NA	4E-08	1E-07	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		1E-06	NA	6E-07	2E-06		7E-03	NA	4E-03	1E-02
	Exposure Medium Total			1E-06	NA	6E-07	2E-06		7E-03	NA	4E-03	1E-02
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	2E-09	NA	2E-09	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	4E-11	NA	4E-11	Developmental	NA	1E-04	NA	1E-04
			Benzo(b)fluoranthene	NA	9E-09	NA	9E-09	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	3E-13	NA	3E-13	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	9E-12	NA	9E-12	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	4E-12	NA	4E-12	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	1E-08	NA	1E-08		NA	1E-04	NA	1E-04
	Exposure Medium Total			NA	1E-08	NA	1E-08		NA	1E-04	NA	1E-04
Soil Total				1E-06	1E-08	6E-07	2E-06		7E-03	1E-04	4E-03	1E-02
Receptor Total				1E-06	1E-08	6E-07	2E-06		7E-03	1E-04	4E-03	1E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

* Combined surface and subsurface soil.

Total Developmental HI Across Media = 0.01

TABLE 9.9.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Trespasser/Visitor
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	2E-07	NA	2E-07	4E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	1E-06	NA	2E-06	3E-06	Developmental	1E-02	NA	1E-02	3E-02
			Benzo(b)fluoranthene	2E-07	NA	3E-07	5E-07	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	9E-09	NA	1E-08	2E-08	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	3E-07	NA	4E-07	7E-07	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	1E-07	NA	2E-07	4E-07	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		2E-06	NA	3E-06	5E-06		1E-02	NA	1E-02	3E-02
	Exposure Medium Total			2E-06	NA	3E-06	5E-06		1E-02	NA	1E-02	3E-02
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	2E-09	NA	2E-09	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	5E-11	NA	5E-11	Developmental	NA	1E-04	NA	1E-04
			Benzo(b)fluoranthene	NA	1E-08	NA	1E-08	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	4E-13	NA	4E-13	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	1E-11	NA	1E-11	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	6E-12	NA	6E-12	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	1E-08	NA	1E-08		NA	1E-04	NA	1E-04
	Exposure Medium Total			NA	1E-08	NA	1E-08		NA	1E-04	NA	1E-04
Soil Total				2E-06	1E-08	3E-06	5E-06		1E-02	1E-04	1E-02	3E-02
Receptor Total				2E-06	1E-08	3E-06	5E-06		1E-02	1E-04	1E-02	3E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

* Combined surface and subsurface soil.

Total Developmental HI Across Media = 0.03

TABLE 9.10.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	3E-08	NA	1E-08	5E-08	NA	NA	NA	NA	NA
			Benzo(a)pyrene	2E-07	NA	1E-07	3E-07	Developmental	6E-02	NA	2E-02	8E-02
			Benzo(b)fluoranthene	4E-08	NA	2E-08	6E-08	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	2E-09	NA	8E-10	3E-09	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	6E-08	NA	3E-08	9E-08	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	3E-08	NA	1E-08	4E-08	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		4E-07	NA	2E-07	6E-07		6E-02	NA	2E-02	8E-02
	Exposure Medium Total			4E-07	NA	2E-07	6E-07		6E-02	NA	2E-02	8E-02
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	4E-10	NA	4E-10	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	9E-12	NA	9E-12	Developmental	NA	5E-04	NA	5E-04
			Benzo(b)fluoranthene	NA	2E-09	NA	2E-09	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	7E-14	NA	7E-14	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	2E-12	NA	2E-12	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	1E-12	NA	1E-12	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	3E-09	NA	3E-09		NA	5E-04	NA	5E-04
	Exposure Medium Total			NA	3E-09	NA	3E-09		NA	5E-04	NA	5E-04
Soil Total				4E-07	3E-09	2E-07	6E-07		6E-02	5E-04	2E-02	8E-02

TABLE 9.10.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Water In Excavation Trench	Benzo(a)anthracene	NA	NA	7E-09	7E-09	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	NA	7E-09	7E-09		NA	NA	NA	NA
	Exposure Medium Total			NA	NA	7E-09	7E-09		NA	NA	NA	NA
	Air	Volatiles in Air In Excavation Trench	Benzo(a)anthracene	NA	1E-10	NA	1E-10	NA	NA	NA	NA	NA
		Exposure Point Total		NA	1E-10	NA	1E-10		NA	NA	NA	NA
	Exposure Medium Total			NA	1E-10	NA	1E-10		NA	NA	NA	NA
Groundwater Total				NA	1E-10	7E-09	7E-09		NA	NA	NA	NA
Receptor Total				4E-07	3E-09	2E-07	6E-07		6E-02	5E-04	2E-02	8E-02

Notes: NA = Not applicable or not available; HI = Hazard Index.

* Combined surface and subsurface soil.

Total Developmental HI Across Media = 0.08

TABLE 9.1.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	3E-06	NA	6E-07	4E-06	NA	NA	NA	NA	NA
			Benzo(a)pyrene	2E-05	NA	5E-06	3E-05	Developmental	NA	NA	NA	NA
			Benzo(b)fluoranthene	4E-06	NA	9E-07	5E-06	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	2E-07	NA	4E-08	2E-07	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	6E-06	NA	1E-06	7E-06	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	3E-06	NA	6E-07	3E-06	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		4E-05	NA	8E-06	5E-05		NA	NA	NA	NA
	Exposure Medium Total			4E-05	NA	8E-06	5E-05		NA	NA	NA	NA
	Ambient Air	Emissions from Soil*	Benzo(a)anthracene	NA	2E-07	NA	2E-07	NA	NA	NA	NA	NA
			Benzo(a)pyrene	NA	4E-09	NA	4E-09	Developmental	NA	NA	NA	NA
			Benzo(b)fluoranthene	NA	1E-06	NA	1E-06	NA	NA	NA	NA	NA
			Benzo(k)fluoranthene	NA	3E-11	NA	3E-11	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	NA	1E-09	NA	1E-09	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	NA	5E-10	NA	5E-10	NA	NA	NA	NA	NA
			Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Exposure Point Total		NA	1E-06	NA	1E-06		NA	NA	NA	NA
	Exposure Medium Total			NA	1E-06	NA	1E-06		NA	NA	NA	NA
Soil Total				4E-05	1E-06	8E-06	5E-05		NA	NA	NA	NA
Receptor Total				4E-05	1E-06	8E-06	5E-05		NA	NA	NA	NA

Notes:

* Combined surface and subsurface soil.

TABLE 10.1.RME

RISK SUMMARY

REASONABLE MAXIMUM EXPOSURE

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil* (0 to 1 foot bgs)	Soil*	Soil*	Benzo(a)anthracene	1E-05	NA	3E-06	1E-05	NA	NA	NA	NA	NA
			Benzo(a)pyrene	8E-05	NA	3E-05	1E-04	Developmental	NA	NA	NA	NA
			Benzo(b)fluoranthene	1E-05	NA	5E-06	2E-05	NA	NA	NA	NA	NA
			Dibenz(a,h)anthracene	2E-05	NA	7E-06	3E-05	NA	NA	NA	NA	NA
			Indeno(1,2,3-cd)pyrene	9E-06	NA	3E-06	1E-05	NA	NA	NA	NA	NA
		Exposure Point Total		1E-04	NA	4E-05	2E-04		NA	NA	NA	NA
	Exposure Medium Total			1E-04	NA	4E-05	2E-04		NA	NA	NA	NA
Soil Total				1E-04	NA	4E-05	2E-04		NA	NA	NA	NA
Receptor Total				1E-04	NA	4E-05	2E-04		NA	NA	NA	NA

Notes:

* Combined surface and subsurface soil.

TABLE 11.1a
RAGS D ADULT LEAD WORKSHEET
Calculations of Blood Lead Concentrations –Industrial Worker
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Surface Soil	92.1	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 6/14/2017
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Table 11.1b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Mean surface soil concentration; See Appendix E-1 Table 3.1.
What was the point of exposure and location?	UXO-002 OU2
Where are the output values located in the risk assessment report?	Attached as Table 11.1b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix.	Default values were used (1.7 through 2.1).
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix.	Default values from ALM were used (0.6 through 1.5 ug/dL).
Was the default exposure frequency (EF; 219 days/year) used?	Yes
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Default values were used.

3. Final Result

Medium	Result	Comment/RBRG [1]
Soil	92.1 mg/kg lead soil results in geometric mean blood lead levels ranging from 0.7 to 1.6 ug/dL for women of child-bearing age in homogeneous and heterogeneous populations. The 95th percentile fetal blood lead concentrations range from 1.7 to 5.0 ug/dL. The probabilities that the fetal blood lead levels exceed 10 ug/dL are all below 1%. The probabilities that the fetal blood lead levels exceed 5 ug/dL are all below 5%. These values are below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead and 5 ug/dL blood lead (the reference level used by the Centers for Disease Control and Prevention and MDE (2020).	PRG not calculated.

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

TABLE 11.1b
Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee, Version date 6/14/2017
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future
Medium: Surface Soil (0-0.5 feet bgs)
Exposure Medium: Surface Soil
Receptor: Industrial Worker

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 2004-2007	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	µg/g or ppm	92.1	92.1	92.1	92.1
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.7	0.8	1.1	1.6
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.7	1.8	2.7	5.0
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5**	**5**	**5**	**5**
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**10**	**10**	**10**	**10**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 5 µg/dL, assuming lognormal distribution**	**%**	**0.03%**	**0.02%**	**0.3%**	**4.9%**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 10 µg/dL, assuming lognormal distribution**	**%**	**0.0002%**	**0.00005%**	**0.005%**	**0.5%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE 11.2a
RAGS D ADULT LEAD WORKSHEET
Calculations of Blood Lead Concentrations –Adult Trespasser/Visitor
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Surface Soil	92.1	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 6/14/2017
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Table 11.2b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Mean surface soil concentration; See Appendix E-1 Table 3.1.
What was the point of exposure and location?	UXO-002 OU2
Where are the output values located in the risk assessment report?	Attached as Table 11.2b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix.	Default values were used (1.7 through 2.1).
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix.	Default values from ALM were used (0.6 through 1.5 ug/dL).
Was the default exposure frequency (EF; 219 days/year) used?	No. A value of 52 days/year was used for the trespasser/visitor scenario.
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Appendix E-1, Section E.5.3.

3. Final Result

Medium	Result	Comment/RBRG [1]
Soil	92.1 mg/kg lead in soil results in geometric mean blood lead levels ranging from 0.6 to 1.5 ug/dL for women of child-bearing age in homogeneous and heterogeneous populations. The 95th percentile fetal blood lead concentrations range from 1.5 to 4.7 ug/dL. The probabilities that the fetal blood lead levels exceed 10 ug/dL are all below 0.5%. The probabilities that the fetal blood lead levels exceed 5 ug/dL are all below 5%. These values are below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead and 5 ug/dL blood lead (the reference level used by the Centers for Disease Control and Prevention and MDE (2020).	PRG not calculated.

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

TABLE 11.2b
Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee, Version date 6/14/2017
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Current/Future Medium: Surface Soil (0-0.5 feet bgs) Exposure Medium: Surface Soil Receptor: Trespasser/Visitor

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 2004-2007	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	µg/g or ppm	92.1	92.1	92.1	92.1
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--
$AF_{S,\ D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,\ D}$	Exposure frequency (same for soil and dust)	days/yr	52	52	52	52
$AT_{S,\ D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.6	0.7	1.0	1.5
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.5	1.6	2.4	4.7
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5**	**5**	**5**	**5**
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**10**	**10**	**10**	**10**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 5 µg/dL, assuming lognormal distribution**	**%**	**0.01%**	**0.007%**	**0.2%**	**4.1%**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 10 µg/dL, assuming lognormal distribution**	**%**	**0.00005%**	**0.00001%**	**0.003%**	**0.4%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE 11.3a
RAGS D IEUBK LEAD WORKSHEET
Child (Age 12 – 72 Months), Child Resident
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

1. Lead Screening Questions

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil*	82.7	mg/kg	Average Detected Value in Soil	400	mg/kg	Recommended Soil Screening Level
Water	9.06	µg/L	IEUBK Model Default Value	15	µg/L	Recommended Drinking Water Action Level

* Combined surface and subsurface soil.

2. Lead Model Questions

Question	Response for Residential Lead Model
What lead model (version and date was used)?	Lead Model for Windows, Version 2.0 Build 1 (May, 2021)
Where are the input values located in the risk assessment report?	Located in IEUBKwin OUTPUT (Attached as Table 11.3b and Figure 11.1)
What range of media concentrations were used for the model?	5.35 – 621 mg/kg (soil)
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Mean surface and subsurface soil concentration; Data are located in Appendix E-1, Table 3.2.
Was soil sample taken from top 2 cm? If not, why?	No, concentrations in combined surface (0-0.5 feet) and subsurface (0-1 foot) soil was used to be consistent with the data set for the other COPCs.
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	No
What was the point of exposure/location?	UXO-002 OU2
Where are the output values located in the risk assessment report?	IEUBKwin OUTPUT (Attached as Table 11.3b and Figure 11.1)
Was the model run using default values only?	No – Assumed site-specific arithmetic mean concentration of lead in soil/groundwater.
Was the default soil bioavailability used?	Yes -- Default is 30%
Was the default soil ingestion rate used?	Yes -- Default values for 5 age groups are 94 (1-2 yrs old), 67 (2-3 yrs old), 63 (3-4 yrs old), 67 (4-5 yrs old), and 52 (5-6 yrs old) mg/day
If non-default values were used, where is the rationale for the values located in the risk assessment report?	Section E4.4 in Appendix E-1.

3. Final Result

Medium	Result	Comment/PRG [1]
Soil*	82.7 mg/kg lead in soil and 9.06 µg/L in groundwater results in 0.088 % of children above a blood lead level of 10 µg/dL and 4.897% of children above a blood lead level of 5 µg/dL. Geometric mean blood lead = 2.297 µg/dL. This is below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 µg/dL blood lead and 5 ug/dL blood lead (the reference level used by the Centers for Disease Control and Prevention and MDE (2020).	PRG not calculated.

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

TABLE 11.3b
IEUBK- Surface and Subsurface Soil, Former Debris Removal Areas, Child Resident
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

LEAD MODEL FOR WINDOWS Version 2.0

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.

While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

==
Model Version: 2.0 Build1
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Month	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

TABLE 11.3b

IEUBK- Surface and Subsurface Soil, Former Debris Removal Areas, Child Resident

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

****** Diet ******

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

****** Drinking Water ******

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 9.064 µg Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used

Average multiple source concentration: 67.890 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000

Use alternate indoor dust Pb sources? No

TABLE 11.3b

IEUBK- Surface and Subsurface Soil, Former Debris Removal Areas, Child Resident

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	82.700	67.890
12-24	82.700	67.890
24-36	82.700	67.890
36-48	82.700	67.890
48-60	82.700	67.890
60-72	82.700	67.890
72-84	82.700	67.890

****** Alternate Intake ******

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 0.600 µg Pb/dL

****

CALCULATED BLOOD LEAD AND LEAD UPTAKES:

****

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.259	0.000	1.717
12-24	0.057	2.382	0.000	1.846
24-36	0.075	2.489	0.000	2.209
36-48	0.093	2.585	0.000	2.352
48-60	0.102	2.719	0.000	2.491
60-72	0.111	2.924	0.000	2.633
72-84	0.118	2.886	0.000	2.770

TABLE 11.3b

IEUBK- Surface and Subsurface Soil, Former Debris Removal Areas, Child Resident

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	1.821	4.831	2.6
12-24	1.991	6.276	2.6
24-36	1.432	6.205	2.3
36-48	1.354	6.383	2.2
48-60	1.445	6.758	2.2
60-72	1.126	6.793	2.1
72-84	1.193	6.967	2.0

TABLE 11.4a
RAGS D ADULT LEAD WORKSHEET
Calculations of Blood Lead Concentrations –Industrial Worker
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil*	82.7	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level

* Combined surface and subsurface soil.

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 6/14/2017
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Table 11.4b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Mean surface and subsurface soil concentration; See Appendix E-1 Table 3.2.
What was the point of exposure and location?	UXO-002 OU2
Where are the output values located in the risk assessment report?	Attached as Table 11.4b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix.	Default values were used (1.7 through 2.1).
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix.	Default values from ALM were used (0.6 through 1.5 ug/dL).
Was the default exposure frequency (EF; 219 days/year) used?	Yes
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Default values were used.

3. Final Result

Medium	Result	Comment/RBRG [1]
Soil*	82.7 mg/kg lead soil results in geometric mean blood lead levels ranging from 0.7 to 1.6 ug/dL for women of child-bearing age in homogeneous and heterogeneous populations. The 95th percentile fetal blood lead concentrations range from 1.7 to 4.9 ug/dL. The probabilities that the fetal blood lead levels exceed 10 ug/dL are all below 1%. The probabilities that the fetal blood lead levels exceed 5 ug/dL are all below 5%. These values are below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead and 5 ug/dL blood lead (the reference level used by the Centers for Disease Control and Prevention and MDE (2020).	PRG not calculated.

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

TABLE 11.4b
Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee, Version date 6/14/2017
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*
Receptor: Industrial Worker

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 2004-2007	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	µg/g or ppm	82.7	82.7	82.7	82.7
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.7	0.8	1.1	1.6
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.7	1.8	2.6	4.9
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5**	**5**	**5**	**5**
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**10**	**10**	**10**	**10**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 5 µg/dL, assuming lognormal distribution**	**%**	**0.03%**	**0.02%**	**0.3%**	**4.8%**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 10 µg/dL, assuming lognormal distribution**	**%**	**0.0002%**	**0.00004%**	**0.005%**	**0.5%**

* Combined surface and subsurface soil.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE 11.5a
RAGS D ADULT LEAD WORKSHEET
Calculations of Blood Lead Concentrations –Adult Trespasser/Visitor
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil*	82.7	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level

* Combined surface and subsurface soil.

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 6/14/2017
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Table 11.5b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Mean surface and subsurface soil concentration; See Appendix E-1 Table 3.2.
What was the point of exposure and location?	UXO-002 OU2
Where are the output values located in the risk assessment report?	Attached as Table 11.5b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix.	Default values were used (1.7 through 2.1).
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix.	Default values from ALM were used (0.6 through 1.5 ug/dL).
Was the default exposure frequency (EF; 219 days/year) used?	No. A value of 52 days/year was used for the trespasser/visitor scenario.
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Appendix E-1, Section E.5.3.

3. Final Result

Medium	Result	Comment/RBRG [1]
Soil*	82.7 mg/kg lead in soil results in geometric mean blood lead levels ranging from 0.6 to 1.5 ug/dL for women of child-bearing age in homogeneous and heterogeneous populations. The 95th percentile fetal blood lead concentrations range from 1.5 to 4.7 ug/dL. The probabilities that the fetal blood lead levels exceed 10 ug/dL are all below 0.5%. The probabilities that the fetal blood lead levels exceed 5 ug/dL are all below 5%. These values are below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead and 5 ug/dL blood lead (the reference level used by the Centers for Disease Control and Prevention and MDE (2020).	PRG not calculated.

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

TABLE 11.5b
Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee, Version date 6/14/2017
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Scenario Timeframe: Future Medium: Soil* (0-1 foot bgs) Exposure Medium: Soil* Receptor: Trespasser/Visitor

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 2004-2007	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	µg/g or ppm	82.7	82.7	82.7	82.7
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	52	52	52	52
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.6	0.7	1.0	1.5
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.5	1.6	2.4	4.7
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5**	**5**	**5**	**5**
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**10**	**10**	**10**	**10**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 5 µg/dL, assuming lognormal distribution**	**%**	**0.01%**	**0.006%**	**0.2%**	**4.1%**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 10 µg/dL, assuming lognormal distribution**	**%**	**0.00005%**	**0.00001%**	**0.003%**	**0.4%**

* Combined surface and subsurface soil.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE 11.6a
RAGS D ADULT LEAD WORKSHEET
Calculations of Blood Lead Concentrations –Construction Worker
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil*	82.7	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level

* Combined surface and subsurface soil.

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 6/14/2017
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Table 11.6b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Mean surface and subsurface soil concentration; See Appendix E-1 Table 3.2.
What was the point of exposure and location?	UXO-002 OU2
Where are the output values located in the risk assessment report?	Attached as Table 11.6b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix.	Default values were used (1.7 through 2.1).
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix.	Default values from ALM were used (0.6 through 1.5 ug/dL).
Was the default exposure frequency (EF; 219 days/year) used?	No. A value of 125 days/year was used for the construction worker scenario, assuming duration of construction project is ½-year (i.e., 182 days).
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	No. An IR value of 100 mg/day was used, based on recommendation in the Adult Lead Model FAQs. http://www.epa.gov/superfund/lead/almfaq.htm#soil ingestion rate.
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Appendix E-1, Section E.5.3.

3. Final Result

Medium	Result	Comment/RBRG [1]
Soil*	82.7 mg/kg lead in soil results in geometric mean blood lead levels ranging from 0.9 to 1.8 ug/dL for women of child-bearing age in homogeneous and heterogeneous populations. The 95th percentile fetal blood lead concentrations range from 2.1 to 5.4 ug/dL. The probabilities that the fetal blood lead levels exceed 10 ug/dL are all below 1%. The probabilities that the fetal blood lead levels exceed 5 ug/dL are below 5% except when calculated using the GSDi and PbBo from the NHANES III (Phase 1&2), the oldest NHANES study. The values based on the NHANES III study are below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead but above 5 ug/dL blood lead, the reference level used by the CDC and MDE (2020).Since results using more recent NHANES study data are within acceptable levels, it is assumed there are no unacceptable risks associated with exposure to lead in soil by future construction workers.	PRG not calculated.

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

TABLE 11.6b
Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee, Version date 6/14/2017
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

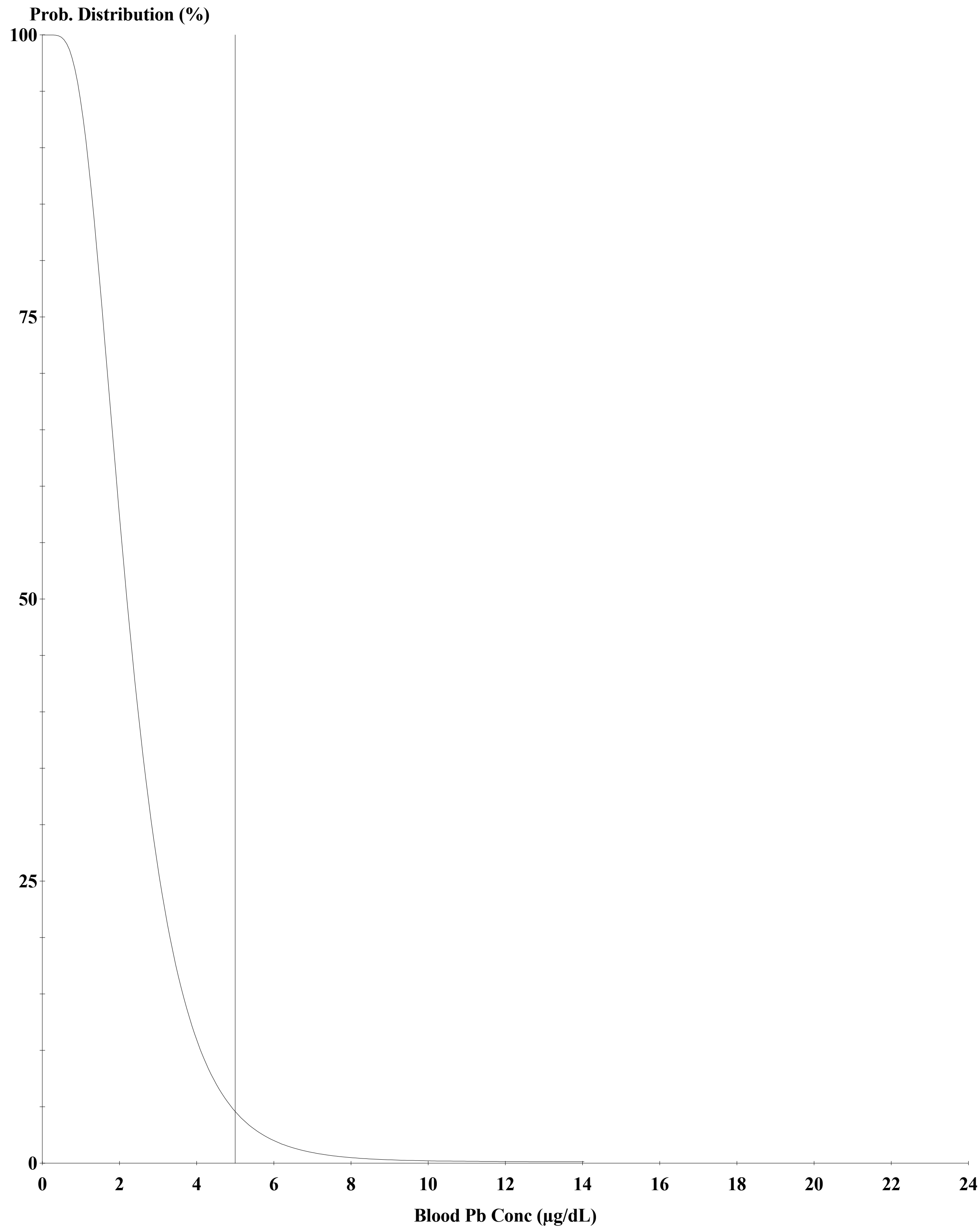
Scenario Timeframe: Future
Medium: Soil* (0-1 foot bgs)
Exposure Medium: Soil*
Receptor: Construction Worker

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 2004-2007	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	µg/g or ppm	82.7	82.7	82.7	82.7
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	0.100	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	125	125	125	125
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	182	182	182	182
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.9	1.0	1.3	1.8
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	2.1	2.1	3.0	5.4
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5**	**5**	**5**	**5**
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**10**	**10**	**10**	**10**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 5 µg/dL, assuming lognormal distribution**	**%**	**0.08%**	**0.05%**	**0.6%**	**6.2%**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB of 10 µg/dL, assuming lognormal distribution**	**%**	**0.0008%**	**0.0002%**	**0.0114%**	**0.7%**

* Combined surface and subsurface soil.

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Figure 11.1a
IEUBK - Surface and Subsurface Soil, Future Resident Child, with Target Pb of 5 µg/dL
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland



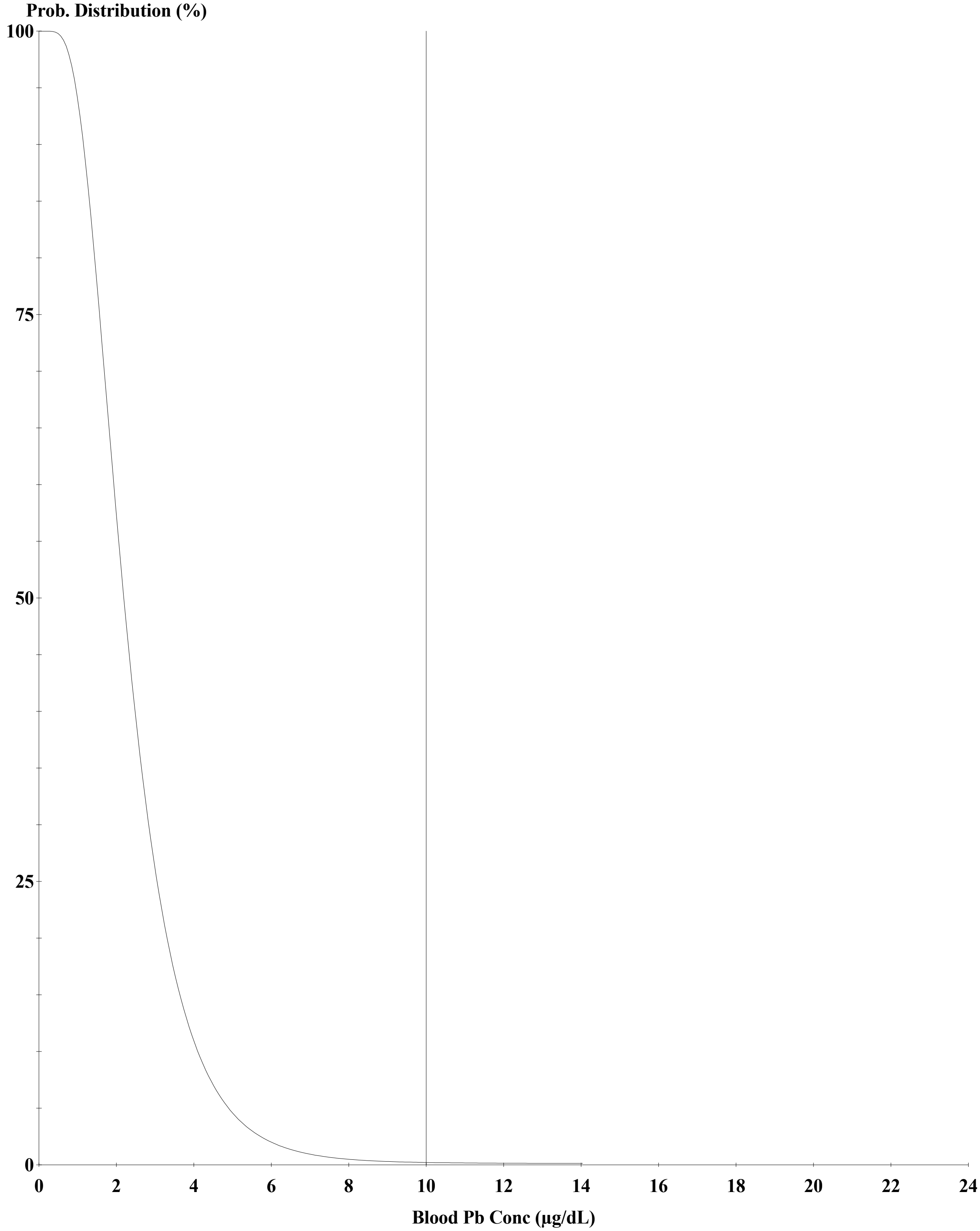
Cutoff = 5.000 µg/dl
Geo Mean = 2.297
GSD = 1.600
% Above = 4.897

Age Range = 12 to 72 months

Run Mode = Research

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate. While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

Figure 11.1b
IEUBK - Surface and Subsurface Soil, Future Resident Child, with Target Pb of 10 µg/dL
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland



Cutoff = 10.000 µg/dl
Geo Mean = 2.297
GSD = 1.600
% Above = 0.088

Age Range = 12 to 72 months

Run Mode = Research

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate. While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

Attachment A-2
Tables and Figures

Table 1
Summary of Data Used in Baseline Human Health Risk Assessment
Site UXO-002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Media	Sample Location	Sample ID	Sample ID (duplicate sample)	Sample Depth (ft)	Sample Date	Analytes
Surface Soil	PX-FSR-SO-01	PX-FSR-SS01-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-02	PX-FSR-SS02-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-03	PX-FSR-SS03-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-04	PX-FSR-SS04-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-05	PX-FSR-SS05-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-06	PX-FSR-SS06-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-07	PX-FSR-SS07-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-08	PX-FSR-SS08-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-09	PX-FSR-SS09-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-10	PX-FSR-SS10-0001	PX-FSR-SS10P-0001	0-0.5	12/15/2010	Lead
	PX-FSR-SO-11	PX-FSR-SS11-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-12	PX-FSR-SS12-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-13	PX-FSR-SS13-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-14	PX-FSR-SS14-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-15	PX-FSR-SS15-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-16	PX-FSR-SS16-0001		0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-17	PX-FSR-SS17-0001		0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-18	PX-FSR-SS18-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SS18-000H	PX-FSR-SS18P-000H	0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-19	PX-FSR-SS19-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SS19-000H		0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-20	PX-FSR-SS20-0001	PX-FSR-SS20P-0001	0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-21	PX-FSR-SS21-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SS21-000H		0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-22	PX-FSR-SS22-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SS22-000H		0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-23	PX-FSR-SS23-0001		0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-24	PX-FSR-SS24-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SS24-000H		0-0.5	11/16/2018	Lead, PAHs
	PX-FSR-SO-25	PX-FSR-SS25-0001		0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-26	PX-FSR-SS26-0001	PX-FSR-SS26P-0001	0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SS26-000H		0-0.5	11/16/2018	Lead, PAHs
	PX-FSR-SO-27	PX-FSR-SS27-000H	PX-FSR-SS27P-000H	0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-28	PX-FSR-SS28-000H		0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-29	PX-FSR-SS29-000H		0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-30	PX-FSR-SS30-000H	PX-FSR-SS30P-000H	0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-31	PX-FSR-SS31-000H		0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-32	PX-FSR-SS32-000H		0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-33	PX-FSR-SS33-000H		0-0.5	11/14/2018	Lead, PAHs
	PX-FSR-SO-34	PX-FSR-SS34-000H	PX-FSR-SS34P-000H	0-0.5	11/13/2018	PAHs
	PX-FSR-SO-35	PX-FSR-SS35-000H		0-0.5	11/13/2018	PAHs
	PX-FSR-SO-36	PX-FSR-SS36-000H		0-0.5	11/13/2018	PAHs
	PX-FSR-SO-37	PX-FSR-SS37-000H	PX-FSR-SS37P-000H	0-0.5	11/13/2018	PAHs
	PX-FSR-SO-38	PX-FSR-SS38-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-39	PX-FSR-SS39-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-40	PX-FSR-SS40-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-41	PX-FSR-SS41-000H	PX-FSR-SS41P-000H	0-0.5	11/14/2018	PAHs
	PX-FSR-SO-42	PX-FSR-SS42-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-43	PX-FSR-SS43-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-44	PX-FSR-SS44-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-45	PX-FSR-SS45-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-46	PX-FSR-SS46-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-47	PX-FSR-SS47-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-48	PX-FSR-SS48-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-49	PX-FSR-SS49-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-50	PX-FSR-SS50-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-51	PX-FSR-SS51-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-52	PX-FSR-SS52-000H		0-0.5	11/14/2018	PAHs

Table 1
Summary of Data Used in Baseline Human Health Risk Assessment
Site UXO-002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Media	Sample Location	Sample ID	Sample ID (duplicate sample)	Sample Depth (ft)	Sample Date	Analytes
Surface Soil (cont'd)	PX-FSR-SO-53	PX-FSR-SS53-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-54	PX-FSR-SS54-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-55	PX-FSR-SS55-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-56	PX-FSR-SS56-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-57	PX-FSR-SS57-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-58	PX-FSR-SS58-000H		0-0.5	11/16/2018	Lead, PAHs
	PX-FSR-SO-59	PX-FSR-SS59-000H		0-0.5	11/16/2018	Lead, PAHs
Soil*	PX-FSR-SO-01	PX-FSR-SS01-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-02	PX-FSR-SS02-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-03	PX-FSR-SS03-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-04	PX-FSR-SS04-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-05	PX-FSR-SS05-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-06	PX-FSR-SS06-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-07	PX-FSR-SS07-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-08	PX-FSR-SS08-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-09	PX-FSR-SS09-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-10	PX-FSR-SS10-0001	PX-FSR-SS10P-0001	0-0.5	12/15/2010	Lead
	PX-FSR-SO-11	PX-FSR-SS11-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-12	PX-FSR-SS12-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-13	PX-FSR-SS13-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-14	PX-FSR-SS14-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-15	PX-FSR-SS15-0001		0-0.5	12/15/2010	Lead
	PX-FSR-SO-16	PX-FSR-SS16-0001		0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-17	PX-FSR-SS17-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB17-0H01		0.5-1	11/15/2018	PAHs
	PX-FSR-SO-18	PX-FSR-SS18-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB18-0H01		0.5-1	11/15/2018	PAHs
		PX-FSR-SS18-000H	PX-FSR-SS18P-000H	0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-19	PX-FSR-SS19-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB19-0H01		0.5-1	11/15/2018	PAHs
		PX-FSR-SS19-000H		0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-20	PX-FSR-SS20-0001	PX-FSR-SS20P-0001	0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-21	PX-FSR-SS21-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB21-0H01		0.5-1	11/15/2018	PAHs
		PX-FSR-SS21-000H		0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-22	PX-FSR-SS22-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB22-0H01		0.5-1	11/15/2018	PAHs
		PX-FSR-SS22-000H		0-0.5	11/15/2018	Lead, PAHs
	PX-FSR-SO-23	PX-FSR-SS23-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB23-0H01		0.5-1	11/15/2018	PAHs
	PX-FSR-SO-24	PX-FSR-SS24-0001		0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB24-0H01		0.5-1	11/16/2018	PAHs
		PX-FSR-SS24-000H		0-0.5	11/16/2018	Lead, PAHs
	PX-FSR-SO-25	PX-FSR-SS25-0001		0-0.5	12/15/2010	Lead, PAHs
	PX-FSR-SO-26	PX-FSR-SS26-0001	PX-FSR-SS26P-0001	0-0.5	12/15/2010	Lead, PAHs
		PX-FSR-SB26-0H01		0.5-1	11/16/2018	PAHs
		PX-FSR-SS26-000H		0-0.5	11/16/2018	Lead, PAHs
	PX-FSR-SO-27	PX-FSR-SB27-0H01		0.5-1	11/13/2018	Lead, PAHs
		PX-FSR-SS27-000H	PX-FSR-SS27P-000H	0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-28	PX-FSR-SB28-0H01		0.5-1	11/13/2018	Lead, PAHs
		PX-FSR-SS28-000H		0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-29	PX-FSR-SB29-0H01		0.5-1	11/13/2018	Lead, PAHs
		PX-FSR-SS29-000H		0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-30	PX-FSR-SB30-0H01		0.5-1	11/13/2018	Lead, PAHs
		PX-FSR-SS30-000H	PX-FSR-SS30P-000H	0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-31	PX-FSR-SB31-0H01		0.5-1	11/13/2018	Lead, PAHs
		PX-FSR-SS31-000H		0-0.5	11/13/2018	Lead, PAHs

Table 1
Summary of Data Used in Baseline Human Health Risk Assessment
Site UXO-002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Media	Sample Location	Sample ID	Sample ID (duplicate sample)	Sample Depth (ft)	Sample Date	Analytes
Soil* (cont'd)	PX-FSR-SO-32	PX-FSR-SB32-0H01		0.5-1	11/13/2018	Lead, PAHs
		PX-FSR-SS32-000H		0-0.5	11/13/2018	Lead, PAHs
	PX-FSR-SO-33	PX-FSR-SB33-0H01		0.5-1	11/14/2018	Lead, PAHs
		PX-FSR-SS33-000H		0-0.5	11/14/2018	Lead, PAHs
	PX-FSR-SO-34	PX-FSR-SB34-0H01		0.5-1	11/13/2018	PAHs
		PX-FSR-SS34-000H	PX-FSR-SS34P-000H	0-0.5	11/13/2018	PAHs
	PX-FSR-SO-35	PX-FSR-SB35-0H01		0.5-1	11/13/2018	PAHs
		PX-FSR-SS35-000H		0-0.5	11/13/2018	PAHs
	PX-FSR-SO-36	PX-FSR-SB36-0H01		0.5-1	11/13/2018	PAHs
		PX-FSR-SS36-000H		0-0.5	11/13/2018	PAHs
	PX-FSR-SO-37	PX-FSR-SB37-0H01		0.5-1	11/13/2018	PAHs
		PX-FSR-SS37-000H	PX-FSR-SS37P-000H	0-0.5	11/13/2018	PAHs
	PX-FSR-SO-38	PX-FSR-SB38-0H01		0.5-1	11/14/2018	PAHs
		PX-FSR-SS38-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-39	PX-FSR-SB39-0H01		0.5-1	11/14/2018	PAHs
		PX-FSR-SS39-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-40	PX-FSR-SS40-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-41	PX-FSR-SS41-000H	PX-FSR-SS41P-000H	0-0.5	11/14/2018	PAHs
	PX-FSR-SO-42	PX-FSR-SS42-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-43	PX-FSR-SS43-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-44	PX-FSR-SS44-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-45	PX-FSR-SS45-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-46	PX-FSR-SS46-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-47	PX-FSR-SS47-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-48	PX-FSR-SS48-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-49	PX-FSR-SS49-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-50	PX-FSR-SS50-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-51	PX-FSR-SS51-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-52	PX-FSR-SS52-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-53	PX-FSR-SS53-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-54	PX-FSR-SS54-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-55	PX-FSR-SS55-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-56	PX-FSR-SS56-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-57	PX-FSR-SS57-000H		0-0.5	11/14/2018	PAHs
	PX-FSR-SO-58	PX-FSR-SS58-000H		0-0.5	11/16/2018	Lead, PAHs
	PX-FSR-SO-59	PX-FSR-SS59-000H		0-0.5	11/16/2018	Lead, PAHs

Notes:
Soil* - combined surface and subsurface soil
PAH - polycyclic aromatic hydrocarbon

Table 2
Summary of Chemicals of Potential Concern for the Human Health Risk Assessment
Site UXO-002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Surface Soil	Soil*
Benzo(a)anthracene	Benzo(a)anthracene
Benzo(a)pyrene	Benzo(a)pyrene
Benzo(b)fluoranthene	Benzo(b)fluoranthene
Benzo(k)fluoranthene	Benzo(k)fluoranthene
Dibenz(a,h)anthracene	Dibenz(a,h)anthracene
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene
Lead	Lead

*Soil = combined surface and subsurface soil

Table 3

Summary of RME Cancer Risks and Hazard Indices

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $>10^{-4}$	Chemicals with Cancer Risks $>10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $>10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals with HI>1	Chemicals with HI>0.1 Contributing to Target Organ Total HI > 1	COC[1]
Current/Future Industrial Worker	Surface Soil	Ingestion	2E-06				0.01			
		Dermal Contact	1E-06				0.007			
		Inhalation	2E-08				0.0004			
		Total	3E-06			Benzo(a)pyrene	0.02			
Current/Future Trespasser/Visitor Adult	Surface Soil	Ingestion	1E-06				0.01			
		Dermal Contact	8E-07				0.007			
		Inhalation	1E-08				0.0002			
		Total	2E-06			Benzo(a)pyrene	0.02			
Current/Future Trespasser/Visitor Adolescent	Surface Soil	Ingestion	3E-06			Benzo(a)pyrene	0.02			
		Dermal Contact	4E-06			Benzo(a)pyrene	0.02			
		Inhalation	1E-08				0.0002			
		Total	7E-06			Benzo(a)pyrene	0.04			
Future Resident Adult	Soil*	Ingestion	N/A				0.05			
		Dermal Contact	N/A				0.03			
		Inhalation	N/A				0.004			
		Total	N/A				0.08			
Future Resident Child	Soil*	Ingestion	N/A				0.5			
		Dermal Contact	N/A				0.2			
		Inhalation	N/A				0.004			
		Total	N/A				0.7			
Future Resident Child/Adult	Soil*	Ingestion	1E-04		Benzo(a)pyrene, Dibenz(a,h)anthracene	Benzo(a)anthracene, Benzo(b)fluoranthene, Indeno(1,2,3-cd)pyrene	N/A			
		Dermal Contact	4E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene. Indeno(1,2,3-cd)pyrene	N/A			Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene. Indeno(1,2,3-cd)pyrene
		Inhalation	2E-06				N/A			
		Total	2E-04		Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene	Benzo(a)anthracene, Indeno(1,2,3-cd)pyrene	N/A			
Future Industrial Worker	Soil*	Ingestion	6E-06			Benzo(a)pyrene	0.03			
		Dermal Contact	3E-06			Benzo(a)pyrene	0.02			
		Inhalation	1E-07				0.001			
		Total	1E-05			Benzo(a)pyrene	0.05			
Future Trespasser/Visitor Adult	Soil*	Ingestion	1E-06				0.007			
		Dermal Contact	6E-07				0.004			
		Inhalation	1E-08				0.0001			
		Total	2E-06				0.01			
Future Trespasser/Visitor Adolescent	Soil*	Ingestion	2E-06				0.01			
		Dermal Contact	3E-06			Benzo(a)pyrene	0.01			
		Inhalation	1E-08				0.0001			
		Total	5E-06			Benzo(a)pyrene	0.03			

Table 3

Summary of RME Cancer Risks and Hazard Indices

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5} and ≤10^{-4}	Chemicals with Cancer Risks >10^{-6} and ≤10^{-5}	Hazard Index	Chemicals with HI>1	Chemicals with HI>0.1 Contributing to Target Organ Total HI > 1	COC[1]
Future Construction Worker	Soil*	Ingestion	4E-07				0.06			
		Dermal Contact	2E-07				0.02			
		Inhalation	3E-09				0.0005			
		Total	6E-07				0.08			

[1] Includes analytes with an cancer risk greater than 1E-06 that contribute to a total risk greater than 1E-04 and/or analytes with an HI greater than 0.1 that contribute to a target organ HI greater than 1.

Soil* = Combined surface and subsurface soil

COC = Chemical of concern

HI = Hazard index

N/A = Not available/not applicable

Table 4

Summary of CTE Cancer Risks and Hazard Indices

UXO 002, OU2 Remedial Investigation

NAS Patuxent River, Maryland

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5} and ≤10^{-4}	Chemicals with Cancer Risks >10^{-6} and ≤10^{-5}
Future Resident Child/Adult	Soil*	Ingestion	4E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene
		Dermal Contact	8E-06			Benzo(a)pyrene
		Inhalation	1E-06			
		Total	5E-05		Benzo(a)pyrene	Benzo(a)anthracene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene

Soil* = combined surface and subsurface soil

HI = Hazard index

N/A = Not available/not applicable

Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Exposure Point	Exposure Route	Current/Future: Industrial Worker (adult)	Current/Future: Trespasser/ Visitor[1] (adult/ adolescent)	Future: Resident[2] (adult/child)	Future: Industrial Worker (adult)	Future: Trespasser/ Visitor (adult/ adolescent)	Future: Construction Worker (adult)
Lead shot and clay target fragments	Direct Contact	Surface Soil		Surface Soil	Ingestion	X	X				
					Dermal	X	X				
			Emissions	Ambient Air	Inhalation	X	X				
	Leaching	Soil*		Soil*	Ingestion			X	X	X	X
					Dermal			X	X	X	X
			Emissions	Ambient Air	Inhalation			X	X	X	X
	Direct Contact	Sediment		Sediment	Ingestion		X[3]			X[3]	
					Dermal		X[3]			X[3]	
	Leaching	Water in Excavation Trench		Water in Excavation Trench	Dermal						X
			Volatilization	Volatiles in Air in Excavation Trench	Inhalation						X
		Groundwater		Tap Water	Ingestion			X			
					Dermal			X			
			Volatilization	Water Vapor[3]	Inhalation			X[4]			
			Vapor Intrusion	Indoor Air[4]	Inhalation			X[5]	X[5]		

Legend

X Potentially complete exposure pathways.

* Combined surface and subsurface soil.

1 Access to Naval Air Station (NAS) limited to base residents and workers.

2 Noncarcinogenic hazard evaluated separately for adult and child residential receptors, combined lifetime carcinogenic risk evaluated on an age-adjusted basis for residential scenario.

3 No Chemical of Potential Concern (COPC) was identified in sediment.

4 Children are assumed not to shower, inhalation of Volatile Organic Compounds (VOCs) from groundwater while bathing considered minimal.

5 A screening assessment of groundwater data was performed to identify COPCs for potential vapor intrusion (VI) pathway. However, no COPC was identified for this exposure pathway.

Figure 1
Human Health Risk Assessment Conceptual Site Model
UXO 002, OU2 Remedial Investigation
NAS Patuxent River, Maryland

Appendix B
Ecological Risk Assessment

Appendix B1
Ecological Risk Assessment – Terrestrial Habitat (Soil)

Ecological Risk Assessment: Terrestrial Habitat (Soil)

This subappendix presents the ecological risk assessment (ERA) for the terrestrial habitat at Munitions Response Site (MRS) UXO-002 Former Small Arms Ranges, Operable Unit (OU)-2 Former Skeet Ranges, which consists of the screening-level ecological risk assessment (SERA), specifically Steps 1 and 2 of the ERA process, and the first step (Step 3A) of the baseline ecological risk assessment (BERA). This ERA was conducted in accordance with Department of the Navy (Navy) policy for ERAs (CNO, 1999) and Navy guidance for implementing this ERA policy (NAVFAC, 2003).

The ERA in this subappendix is for the terrestrial habitat of the Former Skeet Ranges and is based on the soil investigation performed in support of the Remedial Investigation (RI). A sediment investigation was also performed in the Patuxent River directly adjacent to the Former Skeet Ranges, also in support of the RI. The aquatic habitat ERA that was conducted with those sediment data is presented as Appendix B2 of the Engineering Estimate and Cost Analysis (EE/CA).

The primary objectives of the terrestrial ERA are as follows:

- Perform a direct exposure risk evaluation for lower trophic-level receptors and terrestrial plants (soil invertebrate and terrestrial plant communities) through screening chemical analytical surface soil sample results against ecological screening levels (ESLs) and using surface soil sample earthworm toxicity testing results (soil invertebrate community).
- Perform an indirect (food web) exposure evaluation for upper trophic-level receptors (birds and mammals) through standardized food web (ingestion) exposure modeling and screening.
- Perform an additional exposure evaluation for upland birds to lead shot as grit using surface soil pellet count and grit characterization data.

The layout and key site features of MRS UXO-002 Former Small Arms Ranges, OU-2 Former Skeet Ranges are presented in the main body of the RI Report.

B1.1 Investigation History

B1.1.1 Site Inspection (2010)

B1.1.1.1 Sampling

CH2M conducted a Site Inspection (SI) between December 14 and 16, 2010, the report for which was finalized in 2013 (CH2M, 2013). Surface soil samples were collected from 0 to 6 inches below ground surface (bgs) at 26 locations throughout the Former Skeet Ranges. Surface soil samples were collected using stainless steel trowels and bowls. Soil was carefully inspected and screened using a Number 10 sieve (2 mm sieve opening) to remove debris and lead fragments prior to filling the sample containers. Lead fragments and clay target debris were not observed during sieving of samples at the Former Skeet Ranges. Clay target debris was observed in other locations near the Former Skeet Ranges.

All samples collected at the Former Skeet Ranges were analyzed for total lead. In addition, surface soil samples collected from 11 locations were analyzed for polycyclic aromatic hydrocarbons (PAHs). Because PAHs would have potentially been derived from the skeet targets (material containing PAHs may have been used to bind the clay targets), these samples were located in the area immediately west of the former shooting positions, where the clay targets and associated fragments would be expected to fall. A total of 17 different PAH compounds were analyzed. Surface soil samples collected at four locations were also analyzed for total organic carbon (TOC), pH, and grain size to provide a representative measurement of these parameters to evaluate the lead and PAH data. Three duplicate samples were also collected. Sample locations and detected concentrations are presented in the main body of the RI Report.

B1.1.1.2 Ecological Risk Screening

The ecological risk screening evaluation for the SI Report evaluated direct exposure risks from range-related constituents (lead and PAHs) for lower trophic-level receptors, such as soil invertebrates and terrestrial plant populations. The evaluation did not include food web exposure screening for upper trophic-level terrestrial receptors. For the lower trophic-level (direct exposure) ecological screening, all sample-specific concentrations as well as mean and 95 percent (%) upper confidence limit (UCL) concentrations were compared to U.S. Environmental Protection Agency (EPA) Ecological Soil Screening Levels (Eco-SSLs). Table B1-1 (Lead) and Table B1-2 (PAHs) contain the Eco-SSL comparisons presented in the SI ecological risk screening evaluation. If the 95% UCL exceeded the Eco-SSL, the constituent was identified as a constituent of potential concern (COPC) warranting further consideration. The SI results are summarized as follows:

- Lead was detected at all 26 surface soil sampling locations at concentrations ranging from 5.8 milligrams per kilogram (mg/kg) to 330 mg/kg. The maximum concentration of lead (330 mg/kg) was detected in the surface soil sample collected at PX-FSR-SO-22[1] (SS22), which was collected in the wooded area immediately west of the northernmost Former Skeet Range. Lead concentrations were compared to the Eco-SSL of 120 mg/kg, which is the terrestrial plant Eco-SSL, or the lower (most conservative) of the plant and soil invertebrate Eco-SSLs. The detected lead concentrations at 5 of 26 sample locations exceeded 120 mg/kg (samples SS04, 06, 17, 19, and 22). However, neither the mean (70.7 mg/kg) nor the 95% UCL (104 mg/kg) lead concentrations exceeded the Eco-SSL. While several concentrations (12 of the 26 sample locations), including the mean and UCL, exceeded the background threshold value (BTV) for lead of 44.4.mg/kg, the screening results for lead suggested this constituent should not be considered a lower trophic-level ecological COPC for the Former Skeet Ranges.
- All 17 PAH compounds were detected, with 12 compounds detected at all sampling locations. The maximum concentration for most PAH compounds was detected at SS22, located in the wooded area immediately west of the northernmost Former Skeet Range. The Eco-SSL guidance recommends that PAHs be screened on a cumulative (that is, total) concentration basis for two individual compound subgroupings according to molecular weight (EPA, 2007). This is due to the coincidental nature of these constituents when dispersed in the environment and because the ecotoxicological data in the scientific literature are reported in the same manner. Therefore, compound concentrations were segregated for each sample into low molecular weight (LMW) and high molecular weight (HMW) PAH subgroups:
  - LMW PAHs: 2-methylnaphthalene; acenaphthene; acenaphthylene; anthracene; fluorine; phenanthrene; and naphthalene
  - HMW PAHs: benzo(g,h,i)perylene; benzo(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; chrysene; dibenzo(a,h)anthracene; fluoranthene; indeno(1,2,3-cd)pyrene; and pyrene

[1] This sample location was placed in the area that may have been directly under the crossing point and, therefore, the area where a large portion of the fragments from broken clay targets may have fallen (based on a typical skeet range setup).

The concentrations of the LMW and HMW PAHs detected in each sample were summed to calculate total LMW and HMW PAH concentrations for each sample. For undetected PAH compounds, one half the reporting limit was used as a surrogate concentration. These total LMW and HMW PAH concentrations were compared to the corresponding soil invertebrate Eco-SSLs (29,000 micrograms per kilogram [µg/kg] and 18,000 µg/kg, respectively) (EPA, 2007). There is currently no PAH Eco-SSL available for terrestrial plants.

For LMW PAHs, concentrations ranged from 41.8 µg/kg (SS20) to 47,167 µg/kg (SS22), with only one individual sample concentration exceeding the lower trophic-level Eco-SSL of 29,000 µg/kg (SS22). While the mean concentration of LMW PAHs (5,087 µg/kg) did not exceed the Eco-SSL of 29,000 µg/kg, the 95% UCL (47,137 µg/kg) did exceed this benchmark. For HMW PAHs, concentrations ranged from 231.9 µg/kg (SS20) to 661,000 µg/kg (SS22). The HMW PAH concentrations at three sample locations (SS19, SS21, and SS22), as well as both the mean and 95% UCL concentrations, exceeded the lower trophic-level HMW Eco-SSL of 18,000 µg/kg. Therefore, PAHs were identified as an ecological COPC for surface soil at the Former Skeet Ranges. The surface soil sample exceedances for both LMW and HWM PAHs occurred in relatively close proximity to each other in the theoretical shotfall zone immediately west of the Former Skeet Range firing line.

B1.1.2 Remedial Investigation (2018)

Based on the results of the human health and ecological risk screenings for the SI, the RI was conducted to further characterize the nature and extent of PAHs and lead at the Former Skeet Ranges and determine if concentrations pose unacceptable risks to human and/or ecological receptors as well as to evaluate nearshore sediments of the Patuxent River within the Former Skeet Ranges shotfall zones. The RI activities included the following:

1. Soil sampling
2. Sediment sampling in the nearshore area, adjacent to the site and within the estimated shotfall zone
3. Background sediment sampling
4. Groundwater monitoring well installation and sampling

The sediment sampling and subsequent evaluation of the nearshore sediments of the Patuxent River within the Former Skeet Ranges shotfall zones are not discussed in this appendix; the focus here is on the soil sampling in the terrestrial habitat at the site. The sediment ERA is presented and discussed in Appendix B2 of the EE/CA, and the groundwater monitoring well installation and sampling efforts are presented in the main body of the RI Report.

Soil samples were collected to complete the delineation of the PAHs for more quantitative ecological and human health risk assessments for the RI Report. Additionally, surface soil was also collected at select locations for laboratory-based toxicity testing (earthworm) to determine if there are actual site-specific exposure risk from PAHs for the soil invertebrate community that was predicted by the SI ecological risk screening evaluation. The following summarizes the RI field investigation activities:

- **Delineation samples for lead and/or PAHs** – Additional surface (0 to 6 inches bgs) and shallow subsurface (6 to 12 inches bgs) soil sampling was conducted at 39 discrete locations to better delineate the horizontal and vertical extent of lead and/or PAHs.
- **Pellet count/grit analysis in soil** – Certain grit-ingesting birds (such as the mourning dove) may also directly ingest lead particles (pellets) that are in the same size range as the grit they normally consume. Thus, exposure to lead for such birds might be increased beyond what might be accumulated in their food. Therefore, surface soil samples were collected for pellet count/grit analysis. These samples were collected between the former firing point and shoreline, primarily along transects used to establish sediment sample locations in the river. A total of 11 soil grit

samples were collected. For 10 of the locations, a composite of three grabs from each transect line were combined. The eleventh sample was assembled from grabs at three discrete surface soil sample locations – at the center of the upland area, between the former firing point and shoreline, and where there were no transect lines established.

- **Earthworm Toxicity Testing** – Toxicity testing was performed on six surface soil samples covering the range of PAHs concentrations observed during the 2010 SI. Testing a range of PAH concentrations allows for better dose/response analyses and interpretation of the toxicity test results. Two reference locations were identified in areas unaffected by the range activities but in a similar setting (for example, similar distance from the beach and a similar soil type as the site samples). The 28-day earthworm (*Eisenia fetida*) laboratory-based toxicity test method from American Society for Testing and Materials (ASTM) (2018) and EPA (1989) was used for conducting for these samples. Test endpoints included survival and growth. Splits of all toxicity test samples were sent to the chemical analytical laboratory for analysis of PAHs and lead.
- **Supplemental Analytical Parameters for Surface Soil Samples** – To help evaluate contaminant fate, transport, and bioavailability with regard to ecological receptors, supplemental parameters were also analyzed for some surface soil samples. Surface soil samples from the six site locations identified for toxicity testing were also analyzed for pH, TOC, and grain size. Additionally, one half of all other surface soil samples were analyzed for pH, TOC, and grain size.

B1.2 Problem Formulation

Step 1 of the ERA process includes problem formulation establishes the goals, scope, and focus of the ERA. As part of the screening problem formulation, the environmental setting of the Former Skeet Range was characterized in terms of the habitats and biota known or likely to be present. The types and concentrations of constituents present in ecologically-relevant media were also described based on available analytical data. A conceptual site model (CSM) was developed that describes potential source areas, transport pathways and exposure media, exposure pathways and routes, and receptors for the SERA. Assessment and measurement endpoints were selected to evaluate those receptors for which critical exposure pathways exist. The fate, transport, and toxicological properties of the constituents present, particularly the potential for bioaccumulation, were also considered during this process.

B1.2.1 Ecological Setting

CH2M ecologists performed a site visit to observe the ecological setting on February 19, 2009. Based on field observations, open grassy upland comprises the primary habitat at the areas of the Former Skeet Ranges where shooting occurred. The gravel access road for the 2007/2008 Area E Excavation is also present in these areas, as shown in the main body of the RI Report. Because the grass and weeds of the range are still regularly maintained by mowing and the gravel access road underlies a portion of the area, there is limited refuge offered for upper trophic-level receptors (such as birds, mammals, reptiles, and amphibians). However, this area is expected to maintain significant populations of soil invertebrates and provides foraging space for numerous upper trophic-level receptors, especially because of its proximity to the Patuxent River and the adjacent strip of heavily vegetated habitat to the west of the former shooting positions and along the Patuxent River.

The strip of heavily vegetated habitat in the western side of the Former Skeet Ranges and along the Patuxent River consists of a mixture of woodland, scrub/shrubland and edge habitats. Including vegetated land within the shotfall zone but excluding the Area E Excavation at the Former Rifle Range, this area is approximately 7 acres in size. Minimal wildlife was observed on site during the site visit, but a wide variety of wildlife, such as birds, mammals, reptiles, amphibians, and invertebrates are expected to live in or use these habitats. This habitat supports a mixture of upland plant species that also frequently occur at similar Naval Air Station (NAS) Patuxent River sites (such as red cedar, multi-flora rose, blackberries, arrowwood, goldenrod, golden bamboo, red maple, persimmon, white pine, black cherry, sweet gum, mulberry, American holly, northern bayberry, autumn olive, sea myrtle, trumpet vine, and poison ivy).

The Patuxent River is directly adjacent to the ranges and within the shotfall zone. This river is one of the most significant aquatic habitats at NAS Patuxent River. Due to the proximity to the Chesapeake Bay, the river is a slightly brackish, tidally influenced water body. Significant populations of aquatic biota occur within the river, including fish, benthic macroinvertebrates, and other invertebrates. Furthermore, wildlife (such as raccoon, heron, ducks) are expected to reside close to the river and utilize it for foraging, especially in the littoral zone (that is, the shallow area of the river where it meets land).

B1.2.2 Conceptual Site Model

The CSM relates potentially exposed ecological receptor populations with potential source areas based on physical site characteristics and complete exposure pathways. The CSM focuses on exposures to ecological receptors and is a component of the sitewide CSM presented in Section 2.2 of the EE/CA. Important components of the model are:

- Identification of potential source areas
- Transport pathways
- Exposure media
- Exposure pathways and routes
- Receptor groups

Actual or potential exposures of ecological receptors associated with any site are identified by identifying the most likely and most important pathways of contaminant release and transport. A complete exposure pathway has three components: (1) a source of constituents that results in a release to the environment; (2) a pathway of constituent transport through an environmental medium; and (3) an exposure or contact point for an ecological receptor. As illustrated in the main body of the RI Report, the main objective of the CSM in the ERA is to identify any complete and critical exposure pathways that could be present for ecological receptors. Key components of the model are discussed in the following sections.

B1.2.2.1 Potential Source Areas

The primary sources of potential contamination at the Former Skeet Ranges are lead shot and clay target fragments that were deposited from above ground during target shooting activities when the ranges were active. A potential secondary source of contamination is soil and sediment in the shotfall areas, which is potentially contaminated by constituents associated with lead shot (metals) and clay target fragments (PAHs associated with tar pitch typically used to bind clay targets used at skeet ranges). Although these constituents have a relatively high adsorption to solids, this potential secondary source of contamination is expected to be minimal. At range sites, lead is typically considered the primary constituent of concern based on its prevalence and risk-driving potential (ITRC, 2003). The results of the SI did not identify lead in the terrestrial portion as a COPC for human or ecological receptors, but PAHs in surface soil in the terrestrial portion were identified as an ecological COPC. The majority of the theoretical shotfall zones are located in the Patuxent River and are evaluated separately in Appendix B2 of the EE/CA.

B1.2.2.2 Transport Pathways and Exposure Media

A transport pathway describes the mechanisms whereby site-related constituents, once released, may be transported from a source area to exposure media (such as surface soil) and where receptor exposures may occur. The primary mechanisms for chemical release and transport from the source in the upland areas are as follows:

- Direct deposit of lead shot and clay target fragments into soils in the upland vegetated areas and direct deposit for lead shot into sediment in the nearshore areas of the Patuxent River
- Transport of contaminated soil particulates via overland surface runoff to downgradient terrestrial and aquatic areas
- Transport of contaminated soil particulates via wind- or soil-disturbing activities to surrounding terrestrial areas
- Leaching of chemicals from surface and subsurface soils into groundwater via infiltrating precipitation (and potential discharge of contaminated groundwater into downgradient surface water bodies), although based on the relatively high adsorption to solids of potential contaminants, this is expected to be negligible
- Leaching from sediment in the Patuxent River to the surface water, although based on the relatively high adsorption to solids of potential contaminants and flow velocity of the river, this is expected to be negligible
- Uptake by biota from soil and sediment (for example, vegetation, soil invertebrates, aquatic and semiaquatic species) and transfer to upper trophic-level receptors (for example, birds and mammals)

B1.2.2.3 Exposure Pathways and Routes

Based on the understanding of the source of contamination and the habitats and biota present in the investigation area, there are potentially complete exposure pathways for terrestrial receptors (plants, invertebrates, reptiles, birds, and mammals). That is, these receptors may potentially be exposed to contaminated surface soil of the open grassy area, woodland, scrub/shrubland, and edge habitats.

An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical or metal present in an environmental medium. Terrestrial plants are exposed to chemicals and metals present in surface soil mainly via root surfaces during water and nutrient uptake. Direct contact to contaminated media is considered the primary exposure route for lower trophic-level receptors (soil invertebrates). Upper trophic-level receptors (birds and mammals) at this site are most likely exposed to constituents through:

- Uptake by biota from soil and trophic transfer to upper trophic-level receptors
- Inhalation of chemicals adhered to particulate matter (dust)
- Incidental ingestion of contaminated abiotic media (soil) during feeding activities
- Ingestion of contaminated drinking water
- Ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs
- Direct (dermal) contact with contaminated abiotic media

Based on the general fate properties (such as relatively high adsorption to solids) of the site-related constituents present (lead and PAHs) and the protection offered by hair or feathers, potential dermal exposures for upper trophic-level receptors are not considered significant relative to ingestion exposures. The upper trophic-level receptors considered in this ERA are unlikely to be exposed via inhalation to significant airborne sources of chemicals because metals and PAHs typically adsorb to soils and do not volatilize, suggesting that exposure via inhalation is limited. Incidental ingestion of soil during feeding, preening, or grooming activities is, however, considered in the risk estimates. Ingestion of contaminated drinking water is not considered relevant since there is no surface water at the Former Skeet Ranges (onsite) that receptors could drink, and any potential site-related contamination in the Patuxent River is expected to be bound up in sediment. Furthermore, the Patuxent River is not considered a source of drinking water since the salinity is too high for wildlife consumption.

B1.2.2.4 Assessment and Measurement Endpoints

Problem formulation includes the selection of ecological endpoints based on the CSM. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process (EPA, 1997). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic related to the component or value chosen as the assessment endpoint. The considerations for selecting assessment and measurement endpoints are summarized in EPA (1997) and discussed in detail in Suter (1989, 1990, 1993).

Endpoints define ecological attributes to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) used to gauge the degree of impact that has occurred or could occur. Assessment endpoints most often relate to attributes of biological populations or communities, and they are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by chemicals attributable to a site (EPA, 1997). Assessment endpoints contain an entity (for example, raccoon population) and an attribute of that entity (for example, survival rate). Individual assessment endpoints usually encompass a group of species or populations (the receptor) with some common characteristic, such as specific exposure route or contaminant sensitivity, with the receptor then used to represent the assessment endpoint in the risk evaluation.

Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem itself. Effects on individual organisms are important for some receptors, such as rare and endangered species. However, population- and community-level effects are typically more relevant to ecosystems. Population- and community-level effects are usually difficult to evaluate directly without long-term and extensive study. Measurement endpoint evaluations at the individual level, such as an evaluation of the effects of chemical exposure on reproduction, can be used to predict effects on an assessment endpoint at the population or community level. Table B1-3 shows the assessment and measurement endpoints used for the ERA.

B1.2.2.5 Receptors

Ecological receptors for evaluation by this ERA were previously identified as part of the Uniform Federal Policy Sampling and Analysis Plan approach (CH2M, 2018). Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, specific receptor species (for example, American robin) or species groups (for example, soil invertebrates) were selected as surrogates to evaluate potential risks to larger components of the ecological community (guilds, such as omnivorous birds) that were used to represent assessment endpoints (for example, survival and reproduction of omnivorous mammals). Selection criteria included species that:

- Are known to occur, or are likely to occur, in the area.
- Have an ecological, economic, or aesthetic value.
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present for which complete exposure pathways are likely to exist.
- Can be expected to represent potentially sensitive populations because of toxicological sensitivity or potential exposure magnitude.

The following upper trophic- level receptors were selected for exposure modeling based on the criteria listed above and consideration of site conditions:

- American robin (*Turdus migratorius*) – terrestrial avian invertivore/omnivore

- Mourning dove (*Zenaida macroura*) – terrestrial avian herbivore
- Red-tailed hawk (*Buteo jamaicensis*) – terrestrial avian carnivore
- Short-tailed shrew (*Blarina brevicauda*) – terrestrial mammalian invertivore
- White-footed mouse (*Peromyscus leucopus*) – terrestrial mammalian omnivore

Upper trophic-level receptor species that were quantitatively evaluated were limited to birds and mammals, the taxonomic groups with the most available information regarding exposure and toxicological effects.

Lower trophic-level receptor species were evaluated based on those taxonomic groupings for which medium-specific screening values have been developed. The potential for adverse effects to terrestrial plants and soil invertebrates (earthworms are the standard surrogate) were evaluated using surface soil screening values developed specifically for these groups.

Reptiles are also a potential receptor group. Individual species of reptiles were not, however, selected for evaluation because of the general lack of available toxicological information for these taxonomic groups for direct effects and effects from exposures via food webs. Potential risks to reptiles from food web exposures were evaluated using other fauna (birds and mammals) as surrogates.

B1.2.3 Available Analytical Data

B1.2.3.1 Selection Criteria for Analytical Data

Available analytical data were selected for the ERA based on the following:

- Data must have been validated by a qualified data validator using acceptable data validation methods. Rejected ("R" qualifier) values were not used. Unqualified data and data qualified as "J," "L," or "K" were treated as detected. Data qualified as "U" or "B" were treated as not detected.
- For samples with duplicate analyses, the greater of the two concentrations was used when both results were detections or when both reported values were not detections. In cases where one result for the duplicates was a detection and the other result was not, the detected value was used in the assessment.
- For constituents that were not detected, the sample quantitation (reporting) limit (SQL) was used to represent the concentration. When calculating statistics (for example, arithmetic mean), one half of the SQL was used for constituents that were not detected. In cases where the SQL was not provided, the method detection limit was used.
- Soil samples collected from 0 to 6 inches bgs were used because the releases were above ground (shotfall). The surficial depth range represents the most relevant potential exposures for most of the ecological receptors evaluated and represents the worst-case exposure scenario based on the CSM.

B1.2.3.2 Lead and PAHs

Lead and PAHs results were available from samples collected during the 2010 SI and the 2018 RI. Table B1-4 lists the available samples for which data were used for the ERA, and these samples are summarized as follows:

- **SI (2010) samples** – Surface soil samples collected at 26 locations throughout the Former Skeet Ranges (SO-01 to -26); all samples were analyzed for total lead and PAHs; four samples were analyzed for TOC, pH, and grain size. The lead and PAHs results for all of the 2010 samples were presented in Table B1-1 and Table B1-2, respectively.
- **RI (2018) samples** – Surface soil samples at the following 39 locations (the detections for all samples are presented in Table B1-5):

- 6 locations for lead, PAHs, and earthworm toxicity testing where there were 2010 SI exceedances (SO-18, 19, 21, 22, 24, and 26)
- 7 locations for lead and PAH delineation to close data gaps in the area immediately west of the Former Skeet Ranges (SO-27, 28, 29, 30, 31, 32, and 33)
- 6 locations for PAHs around the 3 highest 2010 SI PAH exceedances (SO-34, 35, 36, 37, 38, and 39)
- 8 locations for PAHs to expand area delineation (SO-44, 45, 46, 47, 48, 49, 50 and 51)
- 8 locations for PAHs around 2010 SI surface soil PAH exceedances (SO-40, 41, 42, 43, 52, 53, 54 and 55)
- 2 locations at beach in area of upland PAH exceedances (SO-56 and 57)
- 2 earthworm toxicity test reference locations for PAHs and lead (SO-58 and 59)

B1.2.3.3 Other Analytical Parameters

Additional parameters were analyzed for surface soil samples collected during the 2010 SI and 2018 RI sampling events to physically characterize the terrestrial habitat and to potentially inform the distribution of contaminants. The frequency of analyzing these parameters and results are summarized as follows:

- **SI (2010) samples** – Surface soil samples collected from 4 of the 26 locations (SO-03, 10, 19, and 26) were analyzed for TOC, pH, and grain size. The detections of these parameters in these 4 samples are presented in Table B1-6.
- **RI (2018) samples** – Of the 39 surface soil sample locations listed in Section B1.2.3.2, % solids, pH, TOC, and grain size were analyzed for samples collected at 23 locations as follows (detections of these parameters in these 23 samples are presented in Table B1-7):
  - All 6 locations for lead, PAHs, and earthworm toxicity testing where there were 2010 SI exceedances (SO-18, 19, 21, 22, 24, and 26)
  - 4 of the 7 locations for lead and PAH delineation to close data gaps in the area immediately west of the Former Skeet Ranges (SO-27, 29, 31, and 33)
  - 3 of the 6 locations for PAHs around the 3 highest 2010 SI PAH exceedances (SO-34, 36, and 39)
  - 4 of the 8 locations for PAHs to expand area delineation (SO-44, 46, 48, and 50)
  - 4 of the 8 locations for PAHs around 2010 SI surface soil PAH exceedances (SO-40, 42, 52, and 54)
  - Both earthworm toxicity testing reference locations (2) for PAHs and lead (SO-58 and 59)

The results for these additional parameters in all surface soil samples are summarized graphically on Figure B1-1 (grain size), Figure B1-2 (% solids), Figure B1-3 (pH), and Figure B1-4 (TOC).

B1.2.3.4 Pellet Count/Grit Characterization

Pellet count and grit characterization results were available for 11 surface soil samples. For 10 of the samples (SS60, 61, 62, 63, 64, 66, 67, 68, 69, and 70), a composite of three grabs from each transect line were combined. The final sample was assembled from grabs at three discrete surface soil sample locations – at the center of the upland area (SS29), between the former firing point and shoreline (SS31), and where there are no transect lines proposed (SS32). These results are discussed in the final Risk Evaluation (Section B1.7).

B1.2.3.5 Earthworm Toxicity Testing

Toxicity testing results were available for six site samples (SS18, 19, 21, 22, 24 and 26) and two reference samples (SS58 and 59). Splits of these samples were sent to the chemical analytical laboratory for analysis of lead, PAHs, pH, TOC, and grain size. The toxicity testing consisted of laboratory-based 28-day earthworm (*Eisenia fetida*) exposures for two test endpoints (survival and growth) (ASTM, 2012). In November 2018, EnviroSystems, an affiliate of Enthalpy Analytical LLC, performed the toxicity testing using surface soil samples CH2M collected. Survival is the number of number of organisms at start of test that survived the 28-day exposure. The growth results were obtained on both a wet-weight basis (wet-weight for a replicate divided by the number of surviving organisms) and wet biomass basis (wet-weight obtained for a replicate and divided by the number of organisms exposed at start of test). In addition to the survival and growth results, results of the statistical analyses whereby site samples were compared to control and reference samples results (alpha level of 0.05), were also available. These results are discussed in the final Risk Evaluation (Section B1.7).

B1.2.3.6 Special Data Treatment

For PAHs, LMW and HMW total PAH concentrations were previously calculated for each 2010 SI sample for use in the SI/ecological risk screening evaluation (Table B1-2). Therefore, LMW and HMW total PAH concentrations were calculated for each 2018 RI sample using the same methods employed for the 2010 SI/ecological risk screening evaluation (summed detections, using one half the reporting limit for undetected compounds). The LMW and HMW total PAH concentration calculations for the 2018 RI samples are provided as Attachment B1-1.

For lead, individual PAH compounds, LMW PAHs, and HMW PAHs, 95% UCLs of the mean were calculated for a combined dataset (2010 SI samples plus 2018 RI samples). All 95% UCL concentrations were calculated with ProUCL version 5.1.002 (EPA, 2015) using parametric, nonparametric, and bootstrapping methods. The ProUCL version 5.1.002 output for the combined soil dataset 95% UCL calculations are provided in Attachment B1-2. It should be noted that an older version of ProUCL (version 4.00.05) was used to calculate 95% UCLs for the ecological risk screening evaluation conducted as part of the 2010 SI. This resulted in a slight discrepancy with 95% UCL concentrations presented in this appendix (see Section B1.6.2) compared to those presented in the 2010 SI Report, as shown in Table B1-1 and Table B1-2. The differences in these results are insignificant and are not expected to impact the ERA.

B1.3 Screening Effects Assessment

The screening effects assessment is the other part of Step 1 of the ERA process. The purpose of the screening effects assessment is to establish chemical-specific ESLs that represent thresholds for adverse ecological effects. Screening values are selected in alignment with the assessment endpoints.

B1.3.1 Direct Exposure Screening Values

Samples analyzed for lead were compared to the EPA Eco-SSL of 1,700 mg/kg (soil invertebrates) and 120 mg/kg (terrestrial plants) (EPA, 2005a). The total LMW and HMW PAH concentrations were compared to the corresponding soil invertebrate Eco-SSLs (29,000 µg/kg and 18,000 µg/kg, respectively) (EPA, 2007). There is currently no PAH Eco-SSL available for terrestrial plants.

B1.3.2 Ingestion Screening Values

The ecological risk screening conduced for the 2010 SI Report did not include food web exposure screening for upper trophic-level terrestrial receptors. Because both lead and 15 of the PAH compounds are considered important bioaccumulative constituents (EPA, 2000), there are potentially complete exposure pathways for upper trophic-level receptors via food web exposure. Therefore, these constituents were screened using upper trophic-level receptor food web models. Ingestion screening values for these constituents and the receptor species evaluated (or suitable surrogate species) through food web modeling were obtained from the literature. Toxicological information for wildlife species most closely related to the receptor species was used, where available, but was supplemented by laboratory studies of non-wildlife species (for example, laboratory mice) where necessary. Toxicity studies involving long-term (chronic) exposure were used preferentially. Survival, growth, and reproduction were emphasized as toxicological endpoints because these are the most relevant to maintaining viable populations, and because these are generally the most-studied chronic toxicological endpoints for ecological receptors. If several chronic toxicological studies were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint, and test species.

Ingestion-based screening values were derived for both chronic no observed adverse effect level (NOAEL) and chronic lowest observed effect level (LOAEL) endpoints. Ingestion screening values for mammals and birds are presented in Table B1-8 and Table B1-9, respectively.

B1.4 Screening Exposure Assessment

Step 2 of the ERA process begins with the screening exposure assessment. The principal activity associated with the exposure assessment is the estimation of constituent concentrations in applicable media to which receptors might be exposed. This concentration is termed an exposure point concentration (EPC). EPCs are estimated by following the selection of appropriate sets of the available analytical data using a set of criteria (for example, validation status, sampling date; see Section B1.2.3). Once the analytical data sets are selected, EPCs are calculated as a particular point on the distribution of concentrations. The following subsections summarize the EPC approach for each portion of the assessment.

B1.4.1 Direct Exposure

Because of the focus on only three COPCs (lead, LMW PAHs, and HMW PAHs), each sample-specific concentration was considered in the screening exposure assessment. That is, each sample concentration was screened individually against the ESLs.

B1.4.2 Food Web Exposure

EPCs for lead and the 15 individual bioaccumulative PAH compounds were used in food web models to estimate exposures to upper trophic-level receptors. These food web EPCs were calculated by estimating the concentrations of detected bioaccumulative constituents in each dietary component using the maximum surface soil concentration and the uptake and food web models described in the sections below. The maximum lead concentration was collected during the 2018 RI (621 mg/kg at SS30; Table B1-5). Table B1-10 summarizes the 2010 SI and 2018 RI sample analytical results for the 15 individual bioaccumulative PAH compounds. The maximum concentration was used for estimating the dose of each constituent in the diets of each receptor.

Dietary items for which tissue concentrations were modeled include terrestrial plants, soil invertebrates (earthworms), and small mammals. Incidental ingestion of soil was also included when calculating the total level of exposure. The models and parameter values for calculating food item concentrations are outlined in the following subsections. For the screening exposure estimates of detected bioaccumulative constituents, uptake from surface soil into these food items was based on a conservative (90th percentile) bioconcentration factor (BCF) or bioaccumulation factor (BAF) from the literature, where available. The use of 90th percentile values is generally recommended to provide a conservative screening assessment (Sample et al., 1998a, 1998b; Bechtel Jacobs, 1998a). Default BCFs or BAFs of 1.0 were used only when values were not available in the literature for a constituent.

B1.4.2.1 Plants

Tissue concentrations in the aboveground vegetative portion of plants were estimated by multiplying the maximum soil concentration for each chemical by chemical-specific soil-to-plant BAFs obtained from the literature. These BAFs are listed in Table B1-11.

The BAF values were based on root uptake from soil and the ratio between dry-weight soil and dry-weight plant tissue. Literature values based on the ratio between dry-weight soil and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BAF by an estimated solids content for terrestrial plants (15%; Sample et al., 1997).

B1.4.2.2 Soil Invertebrates (Earthworms)

Tissue concentrations in soil invertebrates (earthworms) were estimated by multiplying the maximum soil concentration for each metal by metal-specific soil-to-invertebrate BCF or BAF obtained from the literature. These BCF/BAF values are listed in Table B1-11.

BCFs are calculated by dividing the concentration of a chemical in organism tissue by the concentration of that same chemical in the surrounding environmental medium (in this case, soil) without accounting for uptake through the diet. BAFs consider both direct exposure to soil and exposure through the diet. Because earthworms consume soil, BAFs are more appropriate than BCFs and were used where available. BAFs based on depurated analyses (soil purged from the gut of the earthworm before analysis) were given preference over undepurated analyses when selecting BAF values because the direct ingestion of soil was accounted for separately in the food web model.

The BCF/BAF values selected were based on the ratio between dry-weight soil and dry-weight earthworm tissue. Literature values based on the ratio between dry-weight soil and wet-weight earthworm tissue were converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for earthworms (16%; EPA, 1993).

B1.4.2.3 Small Mammals

The only chosen receptor that would consume small mammals is the red-tailed hawk (avian terrestrial carnivore). The small mammal tissue concentration that the hawk might consume was obtained by multiplying the maximum surface soil concentration for each metal by a metal-specific soil-to-small mammal BAF obtained from the literature. It was assumed that exactly one-third (33%) of a hawk’s diet at the site by small mammal insectivores, herbivores, and omnivores (dietary composition and exposure factors are discussed in Section B1.4.3). The BAF values used were based on the ratio between dry-weight soil and whole-body dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for small mammals (32%; EPA, 1993). BAFs for shrews were those reported in Sample et al. (1998b) for insectivores (or for general small mammals if insectivore values were unavailable), for voles were those reported for herbivores, and for mice were those reported for omnivores. The soil-to-small mammal BAFs used are listed in Table B1-12.

B1.4.3 Dietary Intakes

For receptor species used in food web modeling, the dietary intake (dose) of each constituent (in milligrams of chemical per kilogram of body weight per day) was calculated by using species-specific life history information, where available, and the following formula (modified from EPA, 1993a):

$$DI_x = \frac{[[\sum_i (FIR)\,(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)]]}{BW}(AUF)$$

where:

DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Food ingestion rate (kg/day, dry-weight)
FC_{xi}	=	Concentration of chemical x in food item i (mg/kg, dry-weight)
PDF_i	=	Proportion of diet composed of food item i (dry-weight basis)
SC_x	=	Concentration of chemical x in soil (mg/kg, dry-weight)
PDS	=	Proportion of diet composed of soil (dry-weight basis)
BW	=	Body weight (kg, wet-weight)
AUF	=	Area use factor; % (decimal) of habitat used by receptor

Receptor-specific values used as inputs to this equation are provided in Table B1-13. It was assumed that constituents were 100% bioavailable to the receptor and that each receptor spent 100% of its time at the site (that is, an AUF of 1.0 was assumed). Minimum body weights and maximum ingestion rates were used to develop conservative exposure estimates. Surface water (drinking water) was not included when calculating the total level of exposure because surface water is not present on the site.

B1.5 Screening Risk Calculation

The screening risk calculation is the final step of the SERA (Step 2). In this step, the sample-specific concentrations (abiotic media) or estimated exposure doses (upper trophic-level receptor species) were compared with the corresponding screening values to derive screening risk estimates. The outcome of this step is a list of detected COPCs for each medium-pathway-receptor combination evaluated or a conclusion of acceptable risk.

For the direct exposure evaluation (lower trophic-level receptors), COPCs were identified if one or more sample-specific concentration exceeded the screening value. For the food web evaluation, COPCs were identified using the hazard quotient (HQ) method. HQs were calculated by dividing the exposure dose by the corresponding ingestion screening value. Constituents with NOAEL-based HQs greater than 1.0 were considered COPCs for the SERA (Step 2). Detected constituents for which toxicological data were not available were also retained as COPCs for the SERA.

Sample concentrations exceeding screening values or HQs exceeding 1.0 indicate the potential for risk because the constituent concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure estimates were derived using intentionally conservative assumptions such that HQs greater than 1.0 do not necessarily indicate risks are present or impacts are occurring. Rather, it identifies constituent-pathway-receptor combinations requiring further evaluation. HQs less than 1.0 indicate risks are very unlikely (EPA, 1997), enabling a conclusion of no unacceptable risk to be reached with high confidence.

B1.5.1 Direct Exposure

Comparisons of all sample concentrations from the 2010 SI and 2018 RI are compared to direct exposure screening values in Table B1-14. The screening values (Eco-SSLs) for lead included terrestrial plants (120 mg/kg) and soil invertebrates (1,700 mg/kg), and only soil invertebrates for PAHs (29,000 µg/kg for LMW PAHs and 18,000 µg/kg for HMW PAHs). Following these comparisons, concentrations of lead (terrestrial plants ESL only), LMW PAHs and HMW PAHs exceeded screening values in one or more sample during each event. Therefore, lead, LMW PAHs and HMW PAHs carried through to Step 3A (Refined Risk Characterization).

B1.5.2 Food Web Exposure

A summary of the food web exposure-based HQs, reflecting a comparison of maximum concentration-based estimated exposure doses for detected bioaccumulative metals to ingestion-based screening values, is presented in Table B1-15. Lead and seven PAH compounds (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene) yielded NOAEL-based HQs greater than 1.0. Therefore, these eight constituents were identified as COPCs and carried through to Step 3A (Refined Risk Characterization).

B1.6 Refined Risk Characterization

Following Step 2, several surface soil COPCs were identified for lower trophic-level receptor direct contact and through food web exposures for upper trophic-level receptors. Therefore, Step 3 of the ERA process was initiated to further evaluate these constituents.

B1.6.1 Refinement of Conservative Screening Assumptions

The objective of the refinement is to identify potential risk-driving COPCs, called "refined COPCs," requiring more-focused consideration in the Risk Evaluation. Therefore, Step 3A was initiated. According to Superfund guidance (EPA, 1997), Step 3 initiates the problem formulation phase of the BERA. Under Navy policy/guidance (CNO, 1999; NAVFAC, 2003), the BERA begins with a preliminary step (Step 3A) in which the conservative assumptions used in the SERA are refined and risk estimates are recalculated using the same CSM. In addition, the re-evaluation may include consideration of other factors such as background and upgradient data, detection frequency, and chemical-specific bioavailability (CNO, 1999; NAVFAC, 2003).

Only complete and critical pathways identified by the SERA were carried forward to Step 3A of the BERA. Similarly, only detected COPCs and receptors identified in the SERA as requiring further evaluation (Table B1-14 and Table B1-15) were addressed in Step 3A. COPCs that are not based on a constituent detection were not considered risk drivers and are discussed in the uncertainty section. The assumptions, parameter values, and methods that were modified for the Step 3A re-evaluation of the Step 2 COPCs included:

- <u>EPCs</u> – Risk estimates based on maximum constituent concentrations were supplemented by risk estimates based on central tendency EPCs. For surface soil, 95% UCLs were used along with mean concentrations for direct exposure risk calculations. However, only the 95% UCL concentrations were used to estimate doses for food web modeling.
- <u>BAFs/BCFs</u> – BAFs and BCFs were based on, or modeled from, central tendency estimates (for example, median or mean) from the literature as opposed to the maximum or high-end (for example, 90th percentile) estimates used in the SERA for many constituents. In the BERA, using central tendency estimates (rather than high-end or maximums) for exposure parameters such as BAFs provides a more-representative estimate of potential exposures and risks to receptor populations (the focus of the assessment endpoints) of upper trophic-level receptors. Because these species are highly mobile, receptor exposure would effectively be averaged over time as these organisms forage within the area defining their home range (which will extend to areas beyond the Former Skeet Ranges study area). Average prey concentrations at Step 3A are most appropriately estimated using central tendency estimates of media concentrations and accumulation factors. For example, the wildlife dietary exposure models contained in the *Wildlife Exposure Factors Handbook* (EPA, 1993a) specify the calculation of an average daily dose. Increasing the representativeness of the exposure estimates relative to population-level effects is consistent with the intent of the Step 3A evaluation. In cases where adequate spatial sampling coverage exists, mean concentrations are also appropriate for evaluating potential risks to populations of lower trophic-level receptors because the members of the population are expected to be found throughout a site (where suitable habitat is present), rather than concentrated in one area. Although effects on individual organisms might be important for some receptors, such as rare and endangered species, population- and community-level effects are typically more relevant to ecosystems. Refined BAF and BCF values used in Step 3A for the identified COPCs are provided in Table B1-16 and Table B1-17.

- Receptor Exposure Parameters – Central tendency estimates (mean, median, or midpoint) for body weight and ingestion rate (Table B1-18) were used to develop exposure estimates for upper trophic-level receptors, rather than the minimum body weights and maximum ingestion rates used in the SERA. Central tendency estimates for these exposure parameters are more relevant for a BERA because these better represent the characteristics of a greater proportion of the individuals in the population. Populations (rather than individual organisms) were emphasized during the development of the assessment endpoints for the ERA.
- Basis for Food Web Exposure Risks – The SERA conservatively identified a chemical as a food web COPC if the estimated dose for at least one upper trophic-level receptor exceeded the NOAEL. The actual dose that is protective of an individual receptor, however, will fall between the NOAEL and the LOAEL. Both the NOAEL and LOAEL were used to identify the refined list of COPCs in Step 3A. A constituent would have to yield a LOAEL-based HQ greater than 1.0 to be identified as a refined COPC.

B1.6.2 Direct Exposure

Table B1-19 presents a comparison of the mean and 95% UCL surface soil COPC EPCs with screening values. This comparison includes concentrations derived from the 2010 SI sample dataset, the 2018 RI sample dataset and a combined/overall dataset (2010 SI plus 2018 RI samples). Based on these comparisons the Eco-SSL exceedances by COPC and dataset are as follows:

- **Lead EPCs**
  - Mean – 2018 dataset
  - 95% UCL – 2018 and combined/overall datasets
- **LMW PAHs EPCs**
  - Mean – none
  - 95% UCL – 2010 dataset
- **HMW PAHs EPCs**
  - Mean – 2010, 2018 and combined/overall datasets
  - 95% UCL – 2010, 2018 and combined/overall datasets

Based on the refined screening results for the overall dataset, lead (9 of 39 samples exceed) and HMW PAHs (10 or 48 samples exceed) were retained as refined COPCs.

B1.6.3 Food Web Exposure

The HQs for upper trophic-level receptors are provided in Table B1-20. There were no NOAEL- *and* LOAEL-based HQs greater than 1.0 for any receptor and COPC. Therefore, no unacceptable food web exposure risk is expected from lead or PAHs.

B1.7 Risk Evaluation

This section discusses the risk evaluation for the refined COPCs identified in Section B1.6. The risk evaluation helped determine if these refined COPCs are likely to pose unacceptable risks to receptor populations. This evaluation was performed with consideration of the following lines of evidence:

- **Earthworm toxicity testing results** – The 28-day earthworm survival and growth (wet-weight and wet biomass) results can be used to establish site-specific effects or lack thereof for soil invertebrates directly exposed to site-specific surface soil contaminants in a subset of site samples. While not all samples were subjected to toxicity testing, the samples that were tested represent a range of COPC concentration to which soil invertebrate surrogates (earthworm) were exposed. The range of concentrations in the six samples tested (SS18, 19, 21, 22, 24 and 26) were:

– **Lead** – 5.4 mg/kg (SS26) to 504 mg/kg (SS22) with none exceeding the soil invertebrate ESL (1,700 mg/kg);

– **LMW PAHs** – 73.9 µg/kg (SS21) to 14,486 µg/kg (SS22) with none exceeding the soil invertebrate ESL (29,000 µg/kg); and

– **HMW PAHs** – 316 µg/kg (SS21) to 72,250 µg/kg (SS22) with 2 samples (SS19 and SS22) exceeding the soil invertebrate ESL (18,000 µg/kg).

The earthworm response results for site-specific samples were statistically compared to control and reference sample results to establish effects or lack thereof. The toxicity test results are presented in Table B1-21 (survival), Table B1-22 (growth, wet-weight), and Table B1-23 (growth, biomass). The toxicity test report from EnviroSystems is provided as Attachment B1-3.

There was no significantly reduced survival for any sample after 28 days as compared to control and reference samples. Additionally, there was no significantly reduced growth (wet-weight and wet biomass) for any sample after 28 days as compared to control and one of two reference samples (SS58). There was a slight, yet statistically significant, reduction in growth for SS19 and SS21 as compared to the other reference sample (SS59). Some characteristics might explain the difference in growth for these site samples. For example, both SS19 and SS21 had higher components of medium-to-coarse sand, compared to SS59, which had more of a fine sand fraction (Figure B1-1). Additionally, both SS19 and SS21 had above average pH for site samples and higher pH than SS59 (Figure B1-3). The pH for SS21 was the highest measured in any sample (7.97). Finally, SS21 had the lowest TOC content of the samples that were toxicity tested (Figure B1-4). Sample SS21 was relatively uncontaminated by lead or PAHs (Table B1-14), suggesting the different in response could be due to a natural impact. Concentrations of lead were well below the soil invertebrate ESL but did slightly exceed the HMW PAH ESL. However, given the survival results (no significant differences) and growth results compared to control and SS58 (no significant differences), this is not considered indicative of an impact. Therefore, it can be assumed that soil invertebrates (earthworm) can be exposed without impact to concentrations of the refined COPCs equal to, if not higher than, the maximum concentrations in the toxicity test samples. These results were used to identify a concentration threshold for the refined COPCs based on the Apparent Effects Threshold (AET) approach (EPA 1992). The AET approach, developed by Barrick et al. (1985), is a quantitative application used to determine the relationship between site-specific chemistry and site-specific biological information (for example, laboratory toxicity) for field collected samples (Malek, 1992). The AET approach is based on the probability of incidence of adverse biological alterations or effects. According to the approach, once biological alterations or effects are established for each sample through laboratory or field evaluations, the samples are identified as “impacted” or “unimpacted” according to predetermined criteria. The chemical results of all unimpacted samples are evaluated and the AET becomes the maximum chemical concentration in all unimpacted samples, representing the concentration above which biological effects would be expected.

The advantage of this approach is that it considers site-specific conditions, such as sediment chemistry, toxicity, physical properties, and bioavailability, that are ignored by other general approaches, such as using published toxicity values (such as Eco-SSLs). The following general assumptions, adapted from Malek (1992), are necessary when using the site-specific AET approach:

– For a chemical or chemical group, concentrations can be as high as the site-specific AET value and not be associated with statistically significant ecological effects.

– An AET concentration for a chemical can be higher in unimpacted samples than the concentration of the same chemical in impacted samples.

- If toxicity is observed at concentrations lower than the site-specific AET, the impacts may be related to another chemical, chemical interactive effects, or other environmental factors (for example, physical stressors).

The site-specific AET approach is consistent with the concept/relationship that increasing chemical concentrations result in increasing toxicity, or ecological effects. In the case of the toxicity tests performed for this site, all six samples (SS18, 19, 21, 22, 24, and 26) from the Former Skeet Ranges are identified as "unimpacted." Therefore, the AET for each refined COPC is the maximum COPC concentrations in those six samples (504 mg/kg lead and 72,250 µg/kg HMW PAHs both measured in SS22; Table B1-14).

- **Background Threshold Values** – The background soil report (CH2M, 2008) provides a compilation of approved BTVs for use at NAS Patuxent River sites. These BTVs, which represent estimates of the upper range of background concentrations, are meant to be compared with concentrations measured at Environmental Restoration Program sites to learn whether or not COPC occurrences are likely due to ambient or site-influenced conditions. BTVs are available for the refined surface soil COPCs. The BTVs for PAHs are provided on an individual compound basis. Therefore, the BTVs for HWM PAH compounds were compiled and summed by subgroup to generate HWM PAHs BTVs. Table B1-24 summarizes the lead and HMW PAHs BTVs. All sample concentrations as well as the range of detected concentrations of refined surface soil COPCs (maximum, mean and 95% UCL) were compared with BTVs. The results of this comparison are discussed below in Section B1.7.1.
- **Pellet Count and Grit Characterization** – Pellet count and grit characterization results were available for 11 surface soil samples (10 transect composite samples and one composite sample of SS29, 31 and 32). Per the grit analysis procedures, "grit-sized" particles were identified in soil sample as anything in the #7 or #35 sieves in Procedure 1 (Pellet Counts). All subsample results from Procedure 1, were supposed to move on to Procedure 2 (Grit Characterization) to determine what portion of that particle-sized subset is associated with lead. However, GCAL did not perform Procedure 2, assuming that the pellet count and the grain size results were sufficient. The Pellet Count and Grit Characterization results are presented in Table B1-25.
- <u>**General Lines of Evidence**</u>**—**In addition to the medium-specific considerations discussed above, the following general lines of evidence were used in a weight-of-evidence approach to help decide if refined COPCs should be considered risk drivers and be the subject of further consideration or investigation:
  - <u>*Exceedance Frequency and HQ Magnitude*</u> – Because the magnitude of COPC-specific concentrations and the frequency in which they exceed screening values reveals information on the severity and probability of potential effects, both were considered in addition to other evaluation factors to better evaluate risks. For example, if detected concentrations of a COPC infrequently exceed the screening value, it was suggested that this COPC is not likely driving risk.
  - <u>*Frequency of Detection*</u> – Infrequently detected COPCs were considered for exclusion if other lines of evidence suggested their presence was naturally occurring or concentrations were marginally high (for example, HQ magnitude). It is unlikely that infrequently detected constituents represent a risk to receptor populations, due to limited spatial exposure. However, a qualitative evaluation was conducted to ensure that "hot spot" areas were not eliminated from consideration based on this line of evidence.
  - <u>*Spatial Distribution*</u> – The spatial pattern(s) of refined COPCs was considered relative to site-specific factors. This included the coincidental occurrence of refined COPCs at known site source areas, at particular site features, and/or with other COPCs (contamination "hot spots").

The following subsections discuss the risk evaluation for refined COPCs with consideration of the above-mentioned lines of evidence.

B1.7.1 Direct Exposure

A comparison of site-specific concentrations of the refined COPCs (lead and HMW PAHs) to BTVs is presented in Table B1-26 (sample-by-sample comparison) and Table B1-27 (range of concentration, mean and 95% UCL). The maximum and the mean/UCL concentrations for both lead and HMW PAHs exceeded their BTVs. These results suggest that lead and HMW PAHs concentrations are artificially elevated above natural conditions as a result of activities at the Former Skeet Ranges. However, when applying the AET for the refined COPCs derived from the earthworm toxicity test results (504 mg/kg lead and 72,250 µg/kg HMW PAHs), a smaller number of sample locations are identified as posing direct exposure risk for soil invertebrates (Table B1-28). These locations include the following:

- **Lead** – 2018 RI Location SS30 (directly in front of the Northern Former Skeet Range location)
- **HWM PAHs** – 2010 SI location SS22 and 2018 RI Locations SS28, 29, 30, and 32 (all samples are directly in front of the Northern Former Skeet Range location)

Based on this evaluation, the area represented by these locations, that exceed ESLs, BTVs, and the AET concentrations could pose unacceptable risks to the soil invertebrate community. There is potential for the lead concentration at some locations to also pose unacceptable risks to the terrestrial plant community since the ESL for plants (120 mg/kg) is lower than the ESL for soil invertebrates (1,700 mg/kg) and terrestrial plants were not evaluated via laboratory toxicity testing. However, the lead concentration for 9 of 39 samples (5 from 2010 and 4 from 2018) exceeded the plant ESL (Table B1-19). The mean lead concentration (96.09 mg/kg) did not exceed and the lead 95% UCL (135 mg/kg) only slightly exceeded the ESL (Table B1-19). Therefore, it is unlikely that terrestrial plant populations are impacted by lead. There is uncertainty associated with the impact of PAHs on plants, since there are no ESLs for this receptor group.

B1.7.2 Food Web Exposure

No refined COPCs were identified for upper trophic-level receptors (Table B1-20). An additional line of evidence was evaluated for birds using the pellet count and grit characterization results (Table B1-25). Certain grit-ingesting birds (such as the mourning dove and American robin) may also directly ingest lead particles (pellets or pellet fragments) that are in the same size range as the grit they normally consume. Thus, exposure to lead for such birds might be increased beyond what might be accumulated in their food. However, grit-sized particles were only identified for four of the 11 samples (SS62, 64, 65 and 66) with total % grit-sized particle content ranging from 0.01% (SS62) to 0.32% (SS65). Because the laboratory did not perform Procedure 2 (Grit Characterization) to determine what portion of that particle-sized subset is associated with lead, it is assumed that the % of grit that is lead based would be even lower. Therefore, even without the actual grit characterization data, it is expected that there would be insignificant additional exposure for birds through grit-based lead given the very low number of grit-sized particles found in the soil at this site.

B1.8 Uncertainties

Uncertainties are present in all ERAs because of the limitations of available data and the need to make certain assumptions and extrapolations based on incomplete information. In addition, the use of various models (for example, uptake and food web exposures) each carries with it some associated uncertainty as to how well the model reflects actual conditions. The uncertainties in this ERA are mainly attributable to the following factors:

- <u>Undetected Constituents</u> – Thallium was not detected in the surface soil samples. Because it was not detected, it is assumed that thallium is not present in the surface soil. There is some uncertainty associated with this assumption because the reporting limit was higher than the screening value. However, because standardized analytical methods were used, this uncertainty is considered low.

- Rejected Data – Results were rejected for selenium results in some of the surface soil samples. Therefore, according to the analytical data selection criteria (Section B1.2.3.1), these data were excluded. However, given that selenium was detected in only 2 of the 83 samples where the sample results were not rejected, the potential impact of this uncertainty on the ERA is considered low.
- Duplicate Analyses – When evaluating samples with field duplicates, the value used in the ERA was always the detected concentration when one result was a detection and the constituent was not detected in the duplicate, regardless of whether the nondetected value was higher. In these cases, the use of the detected concentration has less uncertainty because it represents an actual measured value (versus an upper limit bound) and the two samples will have similar if not identical reporting limits.
- Receptor Species Selection – Reptiles were selected as receptors for the ERA but were not evaluated quantitatively even when exposure pathways were likely to be complete. For food web exposures, these taxonomic groups were evaluated using other fauna (birds and mammals) as surrogates because of the general lack of taxon-specific ingestion-based toxicological data. This represents an uncertainty in the ERA.

  It was also assumed that reptiles were not exposed to significantly higher concentrations of metals and were not more sensitive to metals than other receptor species evaluated by the ERA. This assumption was a source of uncertainty in the ERA. In addition, there is some uncertainty associated with the use of specific receptor species to represent larger groups of organisms (for example, guilds).
- Direct Exposure ESLs – There are no ESLs for terrestrial plants and both LMW and HMW PAHs and terrestrial plants were not included in laboratory toxicity testing. Therefore, there is an uncertainty with the impacts of measured PAH concentrations. At a minimum, plants should also be assumed to be at risk for the most elevated concentrations identified through comparison with the AET (2010 SI location SS22 and 2018 RI Locations SS28, 29, 30, and 32 all near the Northern Former Skeet Range location).
- Food Web Exposure Modeling – Metals concentrations in terrestrial food items (plants, soil invertebrates, and small mammals) were estimated from surface soil concentrations and were not directly measured. The use of generic, literature-derived exposure models and bioaccumulation factors introduces some uncertainty into the resulting estimates. The values selected, and methodology employed were intended to provide a conservative SERA or more- reasonable (Step 3A) estimate of potential food web exposure concentrations.

  AUFs were assumed to equal 1.0. This is also a conservative assumption because a significant percentage of time for each upper trophic-level receptor species could be spent foraging offsite in unaffected areas or in areas where chemical concentrations are expected to be significantly less.
- Mean/95% UCL of the Mean versus Maximum Media Concentrations – As is typical for an ERA, a finite number of environmental media samples were used to develop the exposure estimates. The maximum measured concentration provides a conservative estimate for immobile biota or those species with a limited home range. The most realistic exposure estimates for mobile species with relatively large home ranges and for species populations (even those that are immobile or have limited home ranges) are based on the 95% UCL concentrations in surface soil to which these receptors are exposed. This is reflected in the wildlife dietary exposure models (EPA, 1993), which specify the use of average media concentrations. Given the mobility of upper trophic-level receptor species used in the ERA, the use of maximum metal concentrations (rather than mean concentrations) in the SERA to estimate the exposure through food webs is very conservative. This conservatism was reduced to more-realistic levels in the values selected for use in the Step 3A evaluation. Additionally, the use of the latest version of ProUCL (version 5.1.00) reduces the

uncertainty because it is the latest recommended for use and is an improved version from what was available and used for the SI ecological risk screening evaluation.

B1.9 Conclusions

Lead, LMW PAHs, HMW PAHs, and individual PAH compounds were identified as COPCs for upper and/or lower trophic-level receptor populations based on maximum concentrations (Step 2), suggesting risks are possible following exposure to these constituents in surface soil. However, based on Step 3A refined screening results and/or the risk evaluation, potential risks are unlikely for upper trophic-level receptors. Through Step 3A refined screening results and/or the risk evaluation, it was also determined that there is potentially unacceptable risk from lead and HMW PAHs to lower trophic-level receptors (soil invertebrates and potentially terrestrial plants also) in an isolated area near the Northern Former Skeet Range (2010 SI location SS22 and 2018 RI Locations SS28, 29, 30, and 32).

B1.10 References

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Tables

Table B1-1. 2010 SI Ecological Risk Evaluation - Comparison of Surface Soil Lead to Ecological Screening Values

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Station ID	Sample ID	Sample Date	Lead (mg/kg)	Exceeds BTV[3]
PX-FSR-SO-01	PX-FSR-SS01-0001	12/15/10	5.8	
PX-FSR-SO-02	PX-FSR-SS02-0001	12/15/10	31.6	
PX-FSR-SO-03	PX-FSR-SS03-0001	12/15/10	80.3	x
PX-FSR-SO-04	PX-FSR-SS04-0001	12/15/10	133	x
PX-FSR-SO-05	PX-FSR-SS05-0001	12/15/10	82.6	x
PX-FSR-SO-06	PX-FSR-SS06-0001	12/15/10	258	x
PX-FSR-SO-07	PX-FSR-SS07-0001	12/15/10	12.4	
PX-FSR-SO-08	PX-FSR-SS08-0001	12/15/10	55.6	x
PX-FSR-SO-09	PX-FSR-SS09-0001	12/15/10	10.1	
PX-FSR-SO-10	PX-FSR-SS10-0001	12/15/10	52.4	x
	PX-FSR-SS10P-0001	duplicate	56	x
PX-FSR-SO-11	PX-FSR-SS11-0001	12/15/10	80.3	x
PX-FSR-SO-12	PX-FSR-SS12-0001	12/15/10	12.6	
PX-FSR-SO-13	PX-FSR-SS13-0001	12/15/10	21.2	
PX-FSR-SO-14	PX-FSR-SS14-0001	12/15/10	14.2	
PX-FSR-SO-15	PX-FSR-SS15-0001	12/15/10	10.2	
PX-FSR-SO-16	PX-FSR-SS16-0001	12/15/10	57.4	x
PX-FSR-SO-17	PX-FSR-SS17-0001	12/15/10	231 **J**	x
PX-FSR-SO-18	PX-FSR-SS18-0001	12/15/10	28.4	
PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	163 **J**	x
PX-FSR-SO-20	PX-FSR-SS20-0001	12/15/10	11.7	
	PX-FSR-SS20P-0001	duplicate	9.8	
PX-FSR-SO-21	PX-FSR-SS21-0001	12/15/10	55.2	x
PX-FSR-SO-22	PX-FSR-SS22-0001	12/15/10	330	x
PX-FSR-SO-23	PX-FSR-SS23-0001	12/15/10	27.8	
PX-FSR-SO-24	PX-FSR-SS24-0001	12/15/10	30.8	
PX-FSR-SO-25	PX-FSR-SS25-0001	12/15/10	32	
PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	7.6	
	PX-FSR-SS26P-0001	duplicate	8	
	Mean		70.74	x
	95% UCL[2]		104	x

Notes:

1 - Shaded concentrations exceed the ecological soil screening level (Eco-SSL) of 120 mg/kg (USEPA, 2005)

2 - 95% Upper Confidence Limits (UCLs) calculated with USEPA ProUCL version 4.00.05

3 - NAS Paxutent River Background Threshold Value (BTV) for surface soil (CH2M HILL, 2008); 44.4 mg/kg

J - Analyte present, value may or may not be accurate or precise

Table B1-2. 2010 SI Ecological Risk Evaluation - Comparison of Surface Soil PAHs to Ecological Screening Values

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

			Low Molecular Weight PAHs (UG/KG)								High Molecular Weight PAHs (UG/KG)										
Station ID	**Sample ID**	**Sample Date**	**2-Methylnaphthalene**	**Acenaphthene**	**Acenaphthylene**	**Anthracene**	**Fluorene**	**Naphthalene**	**Phenanthrene**	**TOTAL LMW [1]**	**Benzo(a)anthracene**	**Benzo(a)pyrene**	**Benzo(b)fluoranthene**	**Benzo(g,h,i)perylene**	**Benzo(k)fluoranthene**	**Chrysene**	**Dibenz(a,h)anthracene**	**Fluoranthene**	**Indeno(1,2,3-cd)pyrene**	**Pyrene**	**TOTAL HMW [1]**
PX-FSR-SO-16	PX-FSR-SS16-0001	12/15/10	10 UJ	10 UJ	2.2 J	9.9 J	10 UJ	5 B	49 J	78.6	120 J	180 J	280 J	140 J	82 J	150 J	41 J	150 J	160 J	170 J	1,473
PX-FSR-SO-17	PX-FSR-SS17-0001	12/15/10	23 UL	21 L	23 UL	57 L	13 L	16 B	240 L	362	660	980	1,400	700	440	810	200 J	810 L	770	690	7,460
PX-FSR-SO-18	PX-FSR-SS18-0001	12/15/10	11 UL	17 L	11 UL	54 L	9.2 L	17 B	260 L	359.7	760	1,100	1,600	800	550	950	180	960 L	930	960	8,790
PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	40 L	230 L	14 UL	760 L	120 L	96	3,200 L	4,453	7,900	8,200	11,000	4,400	4,400	8,700	1,400 J	10,000 L	5,400	9,900	**71,300**
PX-FSR-SO-20	PX-FSR-SS20-0001	12/15/10	3 L	10 UL	10 UL	3.8 L	10 UL	10 U	15 L	41.8	19 J	27	42	19 J	12 J	22	4.9 J	32 L	23	31	231.9
	PX-FSR-SS20P-0001	duplicate	3.1 L	10 UL	2.9 L	18 L	7.5 L	10 U	69 L	110.5	46	49	70	29	22	40	10 J	94 L	42	87	489
PX-FSR-SO-21	PX-FSR-SS21-0001	12/15/10	13 L	75 L	10 UL	220 L	38 L	39	1,500 L	1,890	2,800	3,300	4,700	2,200	1,800	3,400	620 J	4,500 L	2,500	3,500	**29,320**
PX-FSR-SO-22	PX-FSR-SS22-0001	12/15/10	310 L	2,400 L	34 UL	9,400 L	840 J	1,200 J	33,000 L	**47,167**	62,000	81,000 J	110,000 J	51,000	43,000 J	76,000 J	15,000	86,000 L	59,000	78,000	**661,000**
PX-FSR-SO-23	PX-FSR-SS23-0001	12/15/10	5.6 J	20 J	11 UL	130 J	20 J	13 B	620 L	807.6	1,000	1,400	1,600	840	250 J	1,200	250	1,800 L	260 J	1,700	10,300
PX-FSR-SO-24	PX-FSR-SS24-0001	12/15/10	3.6 L	4 L	10 UL	28 L	10 UL	10 U	110 L	160.6	200	260	400	190	140	220	53	300 L	230	270	2,263
PX-FSR-SO-25	PX-FSR-SS25-0001	12/15/10	3.9 L	2.7 L	10 UL	10 L	3.6 L	3.6 B	46 L	73	54	64	89	41	32	57	12 J	94 L	50	81	574
PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	10 UL	26 L	10 UL	84 L	11 L	11 B	360 L	496.5	840	1,000	1,400	620	580	1,000	180	1,100 L	720	1,000	8,440
	PX-FSR-SS26P-0001	duplicate	3.7 L	9.7 L	10 UL	52 L	6.8 L	4.1 B	240 L	319.3	490	620	920	390	250	590	100	700 L	480	600	5,140
Mean										5,087.1											**72,855**
95% UCL [2]										**47,137**											**661,342**

Notes:

Detected values are shaded

Bolded concentrations exceed the ecological soil screening level (Eco-SSL) of 29,000 mg/kg for LMW PAHs and 18,000 µg/kg HMW PAHs (USEPA, 2007)

1 - Nondetect values (U,UL, UJ and B) were included in total at one-half the reporting lmiit.

2 - 95% Upper Confidence Limits (UCLs) calculated with USEPA ProUCL version 4.00.05

B - Analyte not detected above the level reported in blanks

J - Analyte present, value may or may not be accurate or precise

L - Analyte present, value may be biased low, actual value may be higher

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

UL - Analyte not detected, quantitation limit is probably higher

Table B1-3. Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor
Survival, growth, and reproduction of terrestrial soil invertebrate communities	Are site-related constituent concentrations in surface soils sufficient to adversely affect soil invertebrate communities?	Comparison of constituent concentrations in surface soils with soil screening values; 28-day earthworm (*Eisenia fetida*) laboratory-based toxicity test	Soil invertebrates (earthworms)
Survival, growth, and reproduction of terrestrial plant communities	Are site-related constituent concentrations in surface soils sufficient to adversely affect terrestrial plant communities?	Comparison of constituent concentrations in surface soils with soil screening values	Terrestrial plants
Survival, growth, and reproduction of terrestrial reptile populations	Are site-related constituent concentrations in surface soil sufficient to adversely affect terrestrial reptile populations?	Comparison of constituent concentrations in surface soils with soil screening values	Reptiles
	Are site-related constituent concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to terrestrial reptile populations?	Evidence of potential risk to other upper trophic level terrestrial receptors evaluated in the ERA	
Survival, growth, and reproduction of avian terrestrial insectivore/omnivore populations	Are site-related constituent concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume terrestrial plants and soil invertebrates from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect; Grit characterization results for additional/potential lead exposure	American robin
Survival, growth, and reproduction of avian terrestrial herbivore populations	Are site-related constituent concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume terrestrial plants from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect; Grit characterization results for additional/potential lead exposure	Mourning dove
Survival, growth, and reproduction of avian terrestrial carnivore populations	Are site-related constituent concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume small mammals from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Red-tailed hawk
Survival, growth, and reproduction of mammalian terrestrial invertivore populations	Are site-related constituent concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume soil invertebrates from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	Short-tailed shrew
Survival, growth, and reproduction of mammalian terrestrial omnivore populations	Are site-related constituent concentrations in surface soils sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume terrestrial plants and soil invertebrates from the site?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect	White-footed mouse

Table B1-4. Sample List - Surface Soil

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Analytical Parameters Measured							Notes
				PAHs	Lead	% Solids	pH	TOC	Grain Size	Pellet Count	
Site Inspection (2010)	PX-FSR-SO-01	PX-FSR-SS01-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-02	PX-FSR-SS02-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-03	PX-FSR-SS03-0001	12/15/10		x		x	x	x		Discrete Sample
	PX-FSR-SO-04	PX-FSR-SS04-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-05	PX-FSR-SS05-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-06	PX-FSR-SS06-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-07	PX-FSR-SS07-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-08	PX-FSR-SS08-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-09	PX-FSR-SS09-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-10	PX-FSR-SS10-0001	12/15/10		x		x	x	x		Discrete Sample
		PX-FSR-SS10P-0001	12/15/10		x						Discrete Sample; field duplicate
	PX-FSR-SO-11	PX-FSR-SS11-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-12	PX-FSR-SS12-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-13	PX-FSR-SS13-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-14	PX-FSR-SS14-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-15	PX-FSR-SS15-0001	12/15/10		x						Discrete Sample
	PX-FSR-SO-16	PX-FSR-SS16-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-17	PX-FSR-SS17-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-18	PX-FSR-SS18-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	x	x		x	x	x		Discrete Sample
	PX-FSR-SO-20	PX-FSR-SS20-0001	12/15/10	x	x						Discrete Sample
		PX-FSR-SS20P-0001	12/15/10	x	x						Discrete Sample; field duplicate
	PX-FSR-SO-21	PX-FSR-SS21-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-22	PX-FSR-SS22-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-23	PX-FSR-SS23-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-24	PX-FSR-SS24-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-25	PX-FSR-SS25-0001	12/15/10	x	x						Discrete Sample
	PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	x	x		x	x	x		Discrete Sample
		PX-FSR-SS26P-0001	12/15/10	x	x						Discrete Sample; field duplicate

Table B1-4. Sample List - Surface Soil

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Analytical Parameters Measured							Notes
				PAHs	Lead	% Solids	pH	TOC	Grain Size	Pellet Count	
Remedial Investigation (2018)	PX-FSR-SO-18	PX-FSR-SS18-000H	11/15/18	x	x	x	x	x	x		Discrete Sample
		PX-FSR-SS18P-000H	11/15/18	x	x						Discrete Sample; field duplicate
	PX-FSR-SO-19	PX-FSR-SS19-000H	11/15/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-21	PX-FSR-SS21-000H	11/15/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-22	PX-FSR-SS22-000H	11/15/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-24	PX-FSR-SS24-000H	11/16/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-26	PX-FSR-SS26-000H	11/16/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-27	PX-FSR-SS27-000H	11/13/18	x	x	x	x	x	x		Discrete Sample
		PX-FSR-SS27P-000H	11/13/18	x	x						Discrete Sample; field duplicate
	PX-FSR-SO-28	PX-FSR-SS28-000H	11/13/18	x	x						Discrete Sample
	PX-FSR-SO-29	PX-FSR-SS29-000H	11/13/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-30	PX-FSR-SS30-000H	11/13/18	x	x						Discrete Sample
		PX-FSR-SS30P-000H	11/13/18	x	x						Discrete Sample; field duplicate
	PX-FSR-SO-31	PX-FSR-SS31-000H	11/13/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-32	PX-FSR-SS32-000H	11/13/18	x	x						Discrete Sample
	PX-FSR-SO-33	PX-FSR-SS33-000H	11/14/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-34	PX-FSR-SS34-000H	11/13/18	x		x	x	x	x		Discrete Sample
		PX-FSR-SS34P-000H	11/13/18	x							Discrete Sample; field duplicate
	PX-FSR-SO-35	PX-FSR-SS35-000H	11/13/18	x							Discrete Sample
	PX-FSR-SO-36	PX-FSR-SS36-000H	11/13/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-37	PX-FSR-SS37-000H	11/13/18	x							Discrete Sample
		PX-FSR-SS37P-000H	11/13/18	x							Discrete Sample; field duplicate
	PX-FSR-SO-38	PX-FSR-SS38-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-39	PX-FSR-SS39-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-40	PX-FSR-SS40-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-41	PX-FSR-SS41-000H	11/14/18	x							Discrete Sample
		PX-FSR-SS41P-000H	11/14/18	x							Discrete Sample; field duplicate
	PX-FSR-SO-42	PX-FSR-SS42-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-43	PX-FSR-SS43-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-44	PX-FSR-SS44-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-45	PX-FSR-SS45-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-46	PX-FSR-SS46-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-47	PX-FSR-SS47-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-48	PX-FSR-SS48-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-49	PX-FSR-SS49-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-50	PX-FSR-SS50-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-51	PX-FSR-SS51-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-52	PX-FSR-SS52-000H	11/14/18	x		x	x	x	x		Discrete Sample
	PX-FSR-SO-53	PX-FSR-SS53-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-54	PX-FSR-SS54-000H	11/14/18	x		x	x	x	x		Discrete Sample

Table B1-4. Sample List - Surface Soil

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Analytical Parameters Measured							Notes
				PAHs	Lead	% Solids	pH	TOC	Grain Size	Pellet Count	
Remedial Investigation (2018), cont.	PX-FSR-SO-55	PX-FSR-SS55-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-56	PX-FSR-SS56-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-57	PX-FSR-SS57-000H	11/14/18	x							Discrete Sample
	PX-FSR-SO-58	PX-FSR-SS58-000H	11/16/18	x	x	x	x	x	x		Discrete Sample
	PX-FSR-SO-59	PX-FSR-SS59-000H	11/16/18	x	x	x	x	x	x		Discrete Sample
	--	PX-FSR-SS60-000H	4/24/19							x	Transect composite
	--	PX-FSR-SS61-000H	4/24/19							x	Transect composite
	--	PX-FSR-SS62-000H	4/18/19							x	Transect composite
	--	PX-FSR-SS63-000H	4/24/19							x	Transect composite
	--	PX-FSR-SS64-000H	4/17/19							x	Transect composite
	--	PX-FSR-SS65-000H	11/15/19							x	Composite or SS29, 31 and 32
	--	PX-FSR-SS66-000H	4/17/19							x	Transect composite
	--	PX-FSR-SS67-000H	4/18/19							x	Transect composite
	--	PX-FSR-SS68-000H	4/17/19							x	Transect composite
	--	PX-FSR-SS69-000H	4/18/19							x	Transect composite
	--	PX-FSR-SS70-000H	4/17/19							x	Transect composite

Table B1-5. Soil Sample Results - Remedial Investigation (2018)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Station ID	PX-FSR-SO-18		PX-FSR-SO-19	PX-FSR-SO-21	PX-FSR-SO-22	PX-FSR-SO-24	PX-FSR-SO-26	PX-FSR-SO-27		PX-FSR-SO-28	PX-FSR-SO-29	PX-FSR-SO-30	
Sample ID	PX-FSR-SS18-000H	PX-FSR-SS18P-000H	PX-FSR-SS19-000H	PX-FSR-SS21-000H	PX-FSR-SS22-000H	PX-FSR-SS24-000H	PX-FSR-SS26-000H	PX-FSR-SS27-000H	PX-FSR-SS27P-000H	PX-FSR-SS28-000H	PX-FSR-SS29-000H	PX-FSR-SS30-000H	PX-FSR-SS30P-000H
Sample Date	11/15/18	11/15/18	11/15/18	11/15/18	11/15/18	11/16/18	11/16/18	11/13/18	11/13/18	11/13/18	11/13/18	11/13/18	11/13/18
Semivolatile Organic Compounds (UG/KG)													
1-Methylnaphthalene	98.6 U	95.7 U	985 U	18.2 U	2,050 U	8.65	1.4 J	1.55 J	1.62 J	240 J	131 J	365	301 J
2-Methylnaphthalene	98.6 U	95.7 U	985 U	18.2 U	2,050 U	11.9	1.61 J	1.64 J	1.85 J	257 J	135 J	410	341 J
Acenaphthene	98.6 U	95.7 U	157 J	18.2 U	411 J	1.89 U	1.85 U	1.94 U	9.4	1,580 J	788	2,520	2,130
Acenaphthylene	98.6 U	95.7 U	985 U	18.2 U	2,050 U	1.89 U	1.85 U	1.94 U	1.94 U	964 U	177 U	114 U	455 U
Anthracene	98.6 U	28.1 J	302 J	18.2 U	1,800 J	50.6	16.6	41.5 J	27 J	6,960	3,050	8,960	8,080
Benzo(a)anthracene	65.5 J	108 J	2,580	25.3 J	7,320	195 J	110 J	252	252	42,400	18,900	52,400	45,800
Benzo(a)pyrene	126 J	118 J	2,760	41.3	8,250	228 J	129 J	302	353	51,800	23,200	69,200	60,000
Benzo(b)fluoranthene	163 J	155 J	3,390	53.4	10,400	461 J	178 J	448	532	25,200	30,800	84,200	76,600
Benzo(g,h,i)perylene	105 J	75.8 J	1,390 J	34.9 J	4,920	88.5	77	122 J	138 J	24,000 J	10,900 J	40,500 J	28,500 J
Benzo(k)fluoranthene	51.3 J	58 J	1,270 J	19.1 J	3,750 J	171 J	67.8 J	167	190	25,700	11,500	27,400	28,900
Chrysene	87.5 J	118 J	2,700	32.7 J	7,970	270	140	315	329	53,300	23,100	61,700	56,700
Dibenz(a,h)anthracene	98.6 U	95.7 U	428 J	8.09 J	1,410 J	31.6	20.3	34.2 J	41.6 J	7,150 J	3,150 J	3,610 J	8,080 J
Fluoranthene	63.4 J	215	3,860	33.1 J	12,200	271	200	425	361	79,100	32,000	57,200	75,100
Fluorene	98.6 U	95.7 U	985 U	18.2 U	2,050 U	1.89 U	3.82	6.25	5.19	871 J	427	1,540	1,340
Indeno(1,2,3-cd)pyrene	107 J	89.1 J	1,800 J	37.9	5,930	123	87.6	150 J	169 J	27,500 J	13,400 J	48,200 J	33,000 J
Naphthalene	98.6 U	95.7 U	985 U	18.2 U	2,050 U	9.39	3.32 J	3.89	5.41	747 J	513	1,270	1,010
Phenanthrene	98.6 U	123 J	1,200 J	10.2 J	7,150	71.9	83.7	188	127	32,700	13,400	28,300	33,000
Pyrene	63.2 J	165 J	3,230	30.6 J	10,100	225 J	148 J	331	304	56,100	22,500	43,400	52,900
Total Metals (MG/KG)													
Lead	38.8	41.8	129	60.3	504	23.7	5.35	6.61	7.99	151	81	621	454

Notes:

Shading indicates detections

NA - Not analyzed

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

MG/KG - Milligrams per kilogram

UG/KG - Micrograms per kilogram

Table B1-5. Soil Sample Results - Remedial Investigation (2018)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Station ID	PX-FSR-SO-31	PX-FSR-SO-32	PX-FSR-SO-33	PX-FSR-SO-34		PX-FSR-SO-35	PX-FSR-SO-36	PX-FSR-SO-37		PX-FSR-SO-38	PX-FSR-SO-39	PX-FSR-SO-40
Sample ID	PX-FSR-SS31-000H	PX-FSR-SS32-000H	PX-FSR-SS33-000H	PX-FSR-SS34-000H	PX-FSR-SS34P-000H	PX-FSR-SS35-000H	PX-FSR-SS36-000H	PX-FSR-SS37-000H	PX-FSR-SS37P-000H	PX-FSR-SS38-000H	PX-FSR-SS39-000H	PX-FSR-SS40-000H
Sample Date	11/13/18	11/13/18	11/14/18	11/13/18	11/13/18	11/13/18	11/13/18	11/13/18	11/13/18	11/14/18	11/14/18	11/14/18
Semivolatile Organic Compounds (UG/KG)												
1-Methylnaphthalene	1.41 J	67.8 J	47.5 U	1.92 J	1.27 J	0.904 J	37.7 U	35.8 U	7.39 J	21 U	23.6 U	19.3 U
2-Methylnaphthalene	1.6 J	77.6 J	47.5 U	2.42 J	1.37 J	0.946 J	37.7 U	35.8 U	35.9 U	21 U	23.6 U	19.3 U
Acenaphthene	8.06	500	203	2.04 U	2.03 U	1.85 U	22.8 J	42.7 J	37.3 J	42.7	22.9 J	17.5 J
Acenaphthylene	1.84 U	93.9 U	47.5 U	2.04 U	2.03 U	1.85 U	37.7 U	35.8 U	35.9 U	21 U	23.6 U	19.3 U
Anthracene	26.2	1,640	384	17.4 J	11.3	6.84	65.9 J	227	194	100	69	85.6
Benzo(a)anthracene	205	11,000	5,240	173 J	136	79.9	716	1,460	1,220	1,310	549	651
Benzo(a)pyrene	286	14,400	9,660	240 J	199 J	108 J	853 J	1,690 J	1,410 J	2,240	881	891
Benzo(b)fluoranthene	384	17,400	11,800	119 J	278 J	56 J	458 J	841 J	697 J	2,830	1,150	1,250
Benzo(g,h,i)perylene	160 J	7,880 J	8,010	157 J	120	56.8	482	798	756	1,730	670	691
Benzo(k)fluoranthene	142	6,800	4,400	122 J	284 J	57.4 J	468 J	860 J	715 J	1,030	436	441
Chrysene	269	13,600	6,590	245 J	190	105	945	1,750	1,520	1,540	655	784
Dibenz(a,h)anthracene	42.4 J	2,340 J	1,820	41.5 J	32.7	16.1	134	238	215	396	148	156
Fluoranthene	327	17,800	5,340	290 J	221	132	1,290	2,620	2,330	1,460	738	1,020
Fluorene	4.72	272	90.8 J	4.21	2.43 J	1.71 J	11.1 J	31.9 J	28.9 J	19.9 J	23.6 U	19.3 U
Indeno(1,2,3-cd)pyrene	188 J	9,050 J	8,710	177 J	131	67.1	570	922	838	1,730	718	733
Naphthalene	4.18	222	122	5.98	3.43 J	1.85 U	11.8 J	15 J	18.2 J	21 U	23.6 U	19.3 U
Phenanthrene	125	6,880	1,660	108 J	70.3 J	44.9	371	1,030	920	443	332	454
Pyrene	233	12,600	5,260	218 J	161 J	97.2 J	920 J	1,800 J	1,600 J	1,450	721	910
Total Metals (MG/KG)												
Lead	93.8	74.2	115	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Shading indicates detections

NA - Not analyzed

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

MG/KG - Milligrams per kilogram

UG/KG - Micrograms per kilogram

Table B1-5. Soil Sample Results - Remedial Investigation (2018)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Station ID	PX-FSR-SO-41		PX-FSR-SO-42	PX-FSR-SO-43	PX-FSR-SO-44	PX-FSR-SO-45	PX-FSR-SO-46	PX-FSR-SO-47	PX-FSR-SO-48	PX-FSR-SO-49	PX-FSR-SO-50	PX-FSR-SO-51	PX-FSR-SO-52
Sample ID	PX-FSR-SS41-000H	PX-FSR-SS41P-000H	PX-FSR-SS42-000H	PX-FSR-SS43-000H	PX-FSR-SS44-000H	PX-FSR-SS45-000H	PX-FSR-SS46-000H	PX-FSR-SS47-000H	PX-FSR-SS48-000H	PX-FSR-SS49-000H	PX-FSR-SS50-000H	PX-FSR-SS51-000H	PX-FSR-SS52-000H
Sample Date	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18
Semivolatile Organic Compounds (UG/KG)													
1-Methylnaphthalene	11.2 U	10.7 U	4.96 U	33.1 U	1.34 J	1.77 U	1.75 U	1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U
2-Methylnaphthalene	11.2 U	10.7 U	4.96 U	33.1 U	1.57 J	1.77 U	1.75 U	1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U
Acenaphthene	11.2 U	15.5 J	4.96 U	33.1 U	1.83 U	1.77 U	1.75 U	1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U
Acenaphthylene	11.2 U	10.7 U	4.96 U	33.1 U	1.83 U	1.77 U	1.75 U	1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U
Anthracene	26.7	74.4	27.3	144	3.74	0.988 J	0.403 J	1.03 J	1.75 J	3.03 J	4.19 J	2.19 J	1.95 J
Benzo(a)anthracene	259 J	428 J	313	1,410	26.6	5.45	2.29 J	6.03	7.79	13.4 J	18.4 J	14	25.3
Benzo(a)pyrene	367 J	548 J	527	2,310	36.4	4.83	2.5 J	6.51	8.57	9.03 J	12.9 J	14.1	20.6
Benzo(b)fluoranthene	507 J	798 J	798	3,110	72.2	15.1	6.29	20.3	24.9	44.7	51.9	34.8	49.9
Benzo(g,h,i)perylene	304	430	328	2,210	20.5	4.17	1.58 J	5.6	8.93	9.03 U	29.6	9.42	13.3 J
Benzo(k)fluoranthene	190	267	239	1,100	23.2	4.55	2.32 J	7.6	7.59	13.8 J	13.4 J	9.31	16.3 J
Chrysene	320 J	508 J	397	1,730	37.8	9.26	3.43 J	11.2	13	23.5	37.6	20.9	34
Dibenz(a,h)anthracene	68.9	92.5	79.5	461	4.38	1.77 U	1.75 U	1.21 J	1.94 J	9.03 U	14.2 U	1.97 J	4.4 J
Fluoranthene	361 J	758 J	364	1,660	42	9.04	4.59	12.4	13.3	25.7	45.8	36.7	54.2
Fluorene	11.2 U	13.1 J	7.92 J	33.1 U	2.23 J	1.77 U	1.75 U	1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U
Indeno(1,2,3-cd)pyrene	314	441	367	2,110	22.5	4.61	1.9 J	7.07	10.2	10.4 J	22 J	13	20.2
Naphthalene	11.2 U	10.7 U	7.8 J	37.9 J	1.83 U	1.77 U	1.75 U	1.74 U	1.73 U	9.03 U	14.2 U	2.49 J	9.01 U
Phenanthrene	135 J	380 J	111	632	13.7	3.25 J	2.18 J	4.35	3.73	5.62 J	12.3 J	15	17.7 J
Pyrene	361 J	680 J	379	1,640	47.4	9.24	3.92	10.6	13.2	20.7	37.1	26.9	38.4
Total Metals (MG/KG)													
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Shading indicates detections

NA - Not analyzed

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

MG/KG - Milligrams per kilogram

UG/KG - Micrograms per kilogram

Table B1-5. Soil Sample Results - Remedial Investigation (2018)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Station ID	PX-FSR-SO-53	PX-FSR-SO-54	PX-FSR-SO-55	PX-FSR-SO-56	PX-FSR-SO-57	PX-FSR-SO-58	PX-FSR-SO-59
Sample ID	PX-FSR-SS53-000H	PX-FSR-SS54-000H	PX-FSR-SS55-000H	PX-FSR-SS56-000H	PX-FSR-SS57-000H	PX-FSR-SS58-000H	PX-FSR-SS59-000H
Sample Date	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/16/18	11/16/18
Semivolatile Organic Compounds (UG/KG)							
1-Methylnaphthalene	11.7 U	1.88 U	8.99 U	1.72 U	1.75 U	9.9	9.78
2-Methylnaphthalene	11.7 U	1.88 U	8.99 U	1.72 U	1.75 U	11.6	11.8
Acenaphthene	11.7 U	2.26 J	17.3 J	1.72 U	1.75 U	2.17 U	1.94 U
Acenaphthylene	11.7 U	5.47	8.99 U	1.72 U	1.75 U	2.17 U	1.94 U
Anthracene	3.39 J	10.9	33.2	9.25	0.503 J	2.17 U	1.32 J
Benzo(a)anthracene	35	78.9	334	34.8	3.03 J	8.28 J	4.8 J
Benzo(a)pyrene	28.2	81.3	429	25.1	1.87 J	9.23 J	5.45 J
Benzo(b)fluoranthene	63.5	164	694	39.9	3.28 J	2.17 UJ	1.94 UJ
Benzo(g,h,i)perylene	24.1	54.3	194	21.4	1.57 J	2.17 U	2.41 J
Benzo(k)fluoranthene	20.9 J	56.3	200	15.6	1.13 J	6.4 J	1.94 UJ
Chrysene	48.4	97.9	423	39.3	2.94 J	14.7	8.02
Dibenz(a,h)anthracene	5.65 J	14	52.3	4.96	1.75 U	2.17 U	1.94 U
Fluoranthene	68.1	180	639	69.7	6.52	23.9	13.6
Fluorene	11.7 U	3.29 J	7.99 J	1.72 U	1.75 U	2.17 U	1.94 U
Indeno(1,2,3-cd)pyrene	30	75	279	22.6	1.98 J	2.17 U	2.83 J
Naphthalene	11.7 U	2.23 J	13.2 J	42.7	1.75 U	4.09 J	2.9 J
Phenanthrene	26.1	77.7	209	49.1	3.26 J	10.6	7.02
Pyrene	46.8	124	533	67.8	4.37	18.3 J	10.9 J
Total Metals (MG/KG)							
Lead	NA	NA	NA	NA	NA	20.7	9.92

Notes:

Shading indicates detections

NA - Not analyzed

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

MG/KG - Milligrams per kilogram

UG/KG - Micrograms per kilogram

Table B1-6. Soil Sample Results for Other Analytical Parameters - Site Inspection (2010)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

			Grain Size					Other Parameters	
Station ID	**Sample ID**	**Sample Date**	**Fines (%)**	**Fine Sand (%)**	**Medium Sand (%)**	**Coarse Sand (%)**	**Gravel (%)**	**pH**	**TOC (mg/kg)**
PX-FSR-SO-03	PX-FSR-SS03-0001	12/15/10	6.7	37.8	35.3	6.8	13.4	5.0	10,000
PX-FSR-SO-10	PX-FSR-SS10-0001	12/15/10	45.0	32.5	14.0	1.9	6.6	5.7	22,000
PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	11.0	42.9	31.3	9.3	5.5	6.4	61,000
PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	4.9	67.3	22.0	1.3	4.5	4.6	10,000
	Mean		*16.9*	*45.1*	*25.7*	*4.8*	*7.5*	*5.4*	*25,750*

Notes:

Shading indicates detections

TOC - Total organic carbon

MG/KG - Milligrams per kilogram

Table B1-7. Soil Sample Results for Other Analytical Parameters - Remedial Investigation (2018)
Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)
NAS Patuxent River, St. Mary's County, Maryland

				Grain Size					Other Parameters		
Sample Location	**Station ID**	**Sample ID**	**Sample Date**	**Fines (%)**	**Fine Sand (%)**	**Medium Sand (%)**	**Coarse Sand (%)**	**Gravel (%)**	**% Solids**	**pH**	**TOC (mg/kg)**
Former Skeet Range Samples	PX-FSR-SO-18	PX-FSR-SS18-000H	11/15/18	29.7	37.5	23.6	7.3	1.9	86.7	5.05	13,600
	PX-FSR-SO-19	PX-FSR-SS19-000H	11/15/18	9.7	43.6	24.9	19.5	2.3	71.0	6.67	24,000
	PX-FSR-SO-21	PX-FSR-SS21-000H	11/15/18	2.3	41.2	22.1	33.5	0.8	93.5	7.97	2,520
	PX-FSR-SO-22	PX-FSR-SS22-000H	11/15/18	33.6	26.1	26.9	11.4	2.0	81.2	5.91	28,100
	PX-FSR-SO-24	PX-FSR-SS24-000H	11/16/18	2.0	50.4	46.5	0.3	0.8	86.5	6.20	8,930
	PX-FSR-SO-26	PX-FSR-SS26-000H	11/16/18	6.8	52.6	34.8	4.9	0.9	89.5	4.97	2,580
	PX-FSR-SO-27	PX-FSR-SS27-000H	11/13/18	7.7	63.9	27.2	0.0	1.2	81.6	5.91	2,770
	PX-FSR-SO-29	PX-FSR-SS29-000H	11/13/18	3.9	60.6	34.8	0.0	0.6	93.1	5.36	5,070
	PX-FSR-SO-31	PX-FSR-SS31-000H	11/13/18	28.7	39.3	31.5	0.0	0.5	89.6	6.13	6,030
	PX-FSR-SO-33	PX-FSR-SS33-000H	11/14/18	5.4	62.1	30.3	0.0	2.2	61.1	6.43	9,510
	PX-FSR-SO-34	PX-FSR-SS34-000H	11/13/18	64.7	26.0	8.3	0.3	0.7	82.0	6.42	8,160
	PX-FSR-SO-36	PX-FSR-SS36-000H	11/13/18	5.1	45.1	49.3	0.3	0.2	86.8	6.80	4,910
	PX-FSR-SO-39	PX-FSR-SS39-000H	11/14/18	3.3	61.6	35.7	0.0	0.0	67.4	6.06	7,710
	PX-FSR-SO-40	PX-FSR-SS40-000H	11/14/18	38.0	41.7	16.1	1.7	2.5	86.0	6.76	7,030
	PX-FSR-SO-42	PX-FSR-SS42-000H	11/14/18	20.1	53.2	21.3	0.6	4.8	28.6	5.32	50,000
	PX-FSR-SO-44	PX-FSR-SS44-000H	11/14/18	4.2	35.5	59.2	0.1	1.1	89.3	5.64	3,650
	PX-FSR-SO-46	PX-FSR-SS46-000H	11/14/18	0.4	9.8	88.9	0.0	0.8	95.4	6.68	726
	PX-FSR-SO-48	PX-FSR-SS48-000H	11/14/18	0.6	21.2	77.1	0.0	1.0	96.2	6.31	1,570
	PX-FSR-SO-50	PX-FSR-SS50-000H	11/14/18	0.8	20.6	77.1	0.0	1.6	92.5	6.60	3,400
	PX-FSR-SO-52	PX-FSR-SS52-000H	11/14/18	1.1	27.8	70.5	0.0	0.7	92.6	6.84	1,480
	PX-FSR-SO-54	PX-FSR-SS54-000H	11/14/18	5.7	61.1	32.8	0.0	0.5	88.8	6.60	11,300
		Mean		*13.0*	*41.9*	*40.0*	*3.8*	*1.3*	*82.8*	*6.22*	*9,669*
Toxicity Testing Reference Samples	PX-FSR-SO-58	PX-FSR-SS58-000H	11/16/18	22.6	42.0	24.9	9.1	1.5	72.3	7.09	15,200
	PX-FSR-SO-59	PX-FSR-SS59-000H	11/16/18	8.6	61.0	18.6	8.5	3.4	89.0	5.37	6,590
		Mean		*15.6*	*51.5*	*21.7*	*8.8*	*2.4*	*80.7*	*6.23*	*10,895*

Notes:
Shading indicates detections
TOC - Total organic carbon
MG/KG - Milligrams per kilogram

Table B1-8. Ingestion Screening Values - Mammals

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Selection by Receptor: Short-tailed Shrew	Selection by Receptor: White-footed mouse
Inorganics										
Lead	rat	0.35	3 generations	oral in diet	reproduction	80.0	8.00	Sample et al. 1996	x	x
Semivolatile Organics										
Acenaphthene	mouse	0.03	13 weeks	oral (gavage)	reproduction	700	350	ATSDR 1995	x	x
Acenaphthylene	mouse	0.03	13 weeks	oral (gavage)	reproduction	700	350	ATSDR 1995	x	x
Anthracene	mouse	0.03	13 weeks	oral (gavage)	reproduction	5,000	1,000	ATSDR 1995	x	x
Benzo(a)anthracene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Benzo(a)pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Benzo(b)fluoranthene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Benzo(g,h,i)perylene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Benzo(k)fluoranthene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Chrysene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Dibenz(a,h)anthracene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Fluoranthene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995	x	x
Fluorene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995	x	x
Indeno(1,2,3-cd)pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x
Phenanthrene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995	x	x
Pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996	x	x

Table B1-9. Ingestion Screening Values - Birds

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Selection by Receptor		
									American robin	Mourning dove	Red-tailed Hawk
Inorganics											
Lead	Japanese quail	0.15	12 weeks	oral in diet	reproduction	11.3	1.13	Sample et al. 1996		x	
Lead	American kestrel	0.13	7 months	oral in diet	reproduction	19.3	3.85	Sample et al. 1996	x		x
Semivolatile Organics											
Acenaphthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Acenaphthylene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Benzo(a)anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Benzo(a)pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Benzo(b)fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Benzo(g,h,i)perylene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Benzo(k)fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Chrysene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Dibenz(a,h)anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Fluorene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Indeno(1,2,3-cd)pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Phenanthrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x
Pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963	x	x	x

Table B1-10. Summary of Bioaccumulative PAH Compound Results Used for Food Web Modeling - Combined Dataset (2010 SI + 2018 RI)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Station ID	Sample ID	Sample Date	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Phenanthrene	Pyrene
PX-FSR-SO-18	PX-FSR-SS18-000H	11/15/18	98.6 U	98.6 U	98.6 U	65.5 J	126 J	163 J	105 J	51.3 J	87.5 J	98.6 U	63.4 J	98.6 U	107 J	98.6 U	63.2 J
	PX-FSR-SS18P-000H	Field Duplicate	95.7 U	95.7 U	28.1 J	108 J	118 J	155 J	75.8 J	58 J	118 J	95.7 U	215	95.7 U	89.1 J	123 J	165 J
PX-FSR-SO-19	PX-FSR-SS19-000H	11/15/18	157 J	985 U	302 J	2,580	2,760	3,390	1,390 J	1,270 J	2,700	428 J	3,860	985 U	1,800 J	1,200 J	3,230
PX-FSR-SO-21	PX-FSR-SS21-000H	11/15/18	18.2 U	18.2 U	18.2 U	25.3 J	41.3	53.4	34.9 J	19.1 J	32.7 J	8.09 J	33.1 J	18.2 U	37.9	10.2 J	30.6 J
PX-FSR-SO-22	PX-FSR-SS22-000H	11/15/18	411 J	2,050 U	1,800 J	7,320	8,250	10,400	4,920	3,750 J	7,970	1,410 J	12,200	2,050 U	5,930	7,150	10,100
PX-FSR-SO-24	PX-FSR-SS24-000H	11/16/18	1.89 U	1.89 U	50.6	195 J	228 J	461 J	88.5	171 J	270	31.6	271	1.89 U	123	71.9	225 J
PX-FSR-SO-26	PX-FSR-SS26-000H	11/16/18	1.85 U	1.85 U	16.6	110 J	129 J	178 J	77	67.8 J	140	20.3	200	3.82	87.6	83.7	148 J
PX-FSR-SO-27	PX-FSR-SS27-000H	11/13/18	1.94 U	1.94 U	41.5 J	252	302	448	122 J	167	315	34.2 J	425	6.25	150 J	188	331
	PX-FSR-SS27P-000H	Field Duplicate	9.4	1.94 U	27 J	252	353	532	138 J	190	329	41.6 J	361	5.19	169 J	127	304
PX-FSR-SO-28	PX-FSR-SS28-000H	11/13/18	1,580 J	964 U	6,960	42,400	51,800	25,200	24,000 J	25,700	53,300	7,150 J	79,100	871 J	27,500 J	32,700	56,100
PX-FSR-SO-29	PX-FSR-SS29-000H	11/13/18	788	177 U	3,050	18,900	23,200	30,800	10,900 J	11,500	23,100	3,150 J	32,000	427	13,400 J	13,400	22,500
PX-FSR-SO-30	PX-FSR-SS30-000H	11/13/18	2,520	114 U	8,960	52,400	69,200	84,200	40,500 J	27,400	61,700	3,610 J	57,200	1,540	48,200 J	28,300	43,400
	PX-FSR-SS30P-000H	Field Duplicate	2,130	455 U	8,080	45,800	60,000	76,600	28,500 J	28,900	56,700	8,080 J	75,100	1,340	33,000 J	33,000	52,900
PX-FSR-SO-31	PX-FSR-SS31-000H	11/13/18	8.06	1.84 U	26.2	205	286	384	160 J	142	269	42.4 J	327	4.72	188 J	125	233
PX-FSR-SO-32	PX-FSR-SS32-000H	11/13/18	500	93.9 U	1,640	11,000	14,400	17,400	7,880 J	6,800	13,600	2,340 J	17,800	272	9,050 J	6,880	12,600
PX-FSR-SO-33	PX-FSR-SS33-000H	11/14/18	203	47.5 U	384	5,240	9,660	11,800	8,010	4,400	6,590	1,820	5,340	90.8 J	8,710	1,660	5,260
PX-FSR-SO-34	PX-FSR-SS34-000H	11/13/18	2.04 U	2.04 U	17.4 J	173 J	240 J	119 J	157 J	122 J	245 J	41.5 J	290 J	4.21	177 J	108 J	218 J
	PX-FSR-SS34P-000H	Field Duplicate	2.03 U	2.03 U	11.3	136	199 J	278 J	120	284 J	190	32.7	221	2.43 J	131	70.3 J	161 J
PX-FSR-SO-35	PX-FSR-SS35-000H	11/13/18	1.85 U	1.85 U	6.84	79.9	108 J	56 J	56.8	57.4 J	105	16.1	132	1.71 J	67.1	44.9	97.2 J
PX-FSR-SO-36	PX-FSR-SS36-000H	11/13/18	22.8 J	37.7 U	65.9 J	716	853 J	458 J	482	468 J	945	134	1,290	11.1 J	570	371	920 J
PX-FSR-SO-37	PX-FSR-SS37-000H	11/13/18	42.7 J	35.8 U	227	1,460	1,690 J	841 J	798	860 J	1,750	238	2,620	31.9 J	922	1,030	1,800 J
	PX-FSR-SS37P-000H	Field Duplicate	37.3 J	35.9 U	194	1,220	1,410 J	697 J	756	715 J	1,520	215	2,330	28.9 J	838	920	1,600 J
PX-FSR-SO-38	PX-FSR-SS38-000H	11/14/18	42.7	21 U	100	1,310	2,240	2,830	1,730	1,030	1,540	396	1,460	19.9 J	1,730	443	1,450
PX-FSR-SO-39	PX-FSR-SS39-000H	11/14/18	22.9 J	23.6 U	69	549	881	1,150	670	436	655	148	738	23.6 U	718	332	721
PX-FSR-SO-40	PX-FSR-SS40-000H	11/14/18	17.5 J	19.3 U	85.6	651	891	1,250	691	441	784	156	1,020	19.3 U	733	454	910
PX-FSR-SO-41	PX-FSR-SS41-000H	11/14/18	11.2 U	11.2 U	26.7	259 J	367 J	507 J	304	190	320 J	68.9	361 J	11.2 U	314	135 J	361 J
	PX-FSR-SS41P-000H	Field Duplicate	15.5 J	10.7 U	74.4	428 J	548 J	798 J	430	267	508 J	92.5	758 J	13.1 J	441	380 J	680 J
PX-FSR-SO-42	PX-FSR-SS42-000H	11/14/18	4.96 U	4.96 U	27.3	313	527	798	328	239	397	79.5	364	7.92 J	367	111	379
PX-FSR-SO-43	PX-FSR-SS43-000H	11/14/18	33.1 U	33.1 U	144	1,410	2,310	3,110	2,210	1,100	1,730	461	1,660	33.1 U	2,110	632	1,640
PX-FSR-SO-44	PX-FSR-SS44-000H	11/14/18	1.83 U	1.83 U	3.74	26.6	36.4	72.2	20.5	23.2	37.8	4.38	42	2.23 J	22.5	13.7	47.4
PX-FSR-SO-45	PX-FSR-SS45-000H	11/14/18	1.77 U	1.77 U	0.988 J	5.45	4.83	15.1	4.17	4.55	9.26	1.77 U	9.04	1.77 U	4.61	3.25 J	9.24
PX-FSR-SO-46	PX-FSR-SS46-000H	11/14/18	1.75 U	1.75 U	0.403 J	2.29 J	2.5 J	6.29	1.58 J	2.32 J	3.43 J	1.75 U	4.59	1.75 U	1.9 J	2.18 J	3.92
PX-FSR-SO-47	PX-FSR-SS47-000H	11/14/18	1.74 U	1.74 U	1.03 J	6.03	6.51	20.3	5.6	7.6	11.2	1.21 J	12.4	1.74 U	7.07	4.35	10.6
PX-FSR-SO-48	PX-FSR-SS48-000H	11/14/18	1.73 U	1.73 U	1.75 J	7.79	8.57	24.9	8.93	7.59	13	1.94 J	13.3	1.73 U	10.2	3.73	13.2
PX-FSR-SO-49	PX-FSR-SS49-000H	11/14/18	9.03 U	9.03 U	3.03 J	13.4 J	9.03 J	44.7	9.03 U	13.8 J	23.5	9.03 U	25.7	9.03 U	10.4 J	5.62 J	20.7
PX-FSR-SO-50	PX-FSR-SS50-000H	11/14/18	14.2 U	14.2 U	4.19 J	18.4 J	12.9 J	51.9	29.6	13.4 J	37.6	14.2 U	45.8	14.2 U	22 J	12.3 J	37.1
PX-FSR-SO-51	PX-FSR-SS51-000H	11/14/18	1.91 U	1.91 U	2.19 J	14	14.1	34.8	9.42	9.31	20.9	1.97 J	36.7	1.91 U	13	15	26.9
PX-FSR-SO-52	PX-FSR-SS52-000H	11/14/18	9.01 U	9.01 U	1.95 J	25.3	20.6	49.9	13.3 J	16.3 J	34	4.4 J	54.2	9.01 U	20.2	17.7 J	38.4
PX-FSR-SO-53	PX-FSR-SS53-000H	11/14/18	11.7 U	11.7 U	3.39 J	35	28.2	63.5	24.1	20.9 J	48.4	5.65 J	68.1	11.7 U	30	26.1	46.8
PX-FSR-SO-54	PX-FSR-SS54-000H	11/14/18	2.26 J	5.47	10.9	78.9	81.3	164	54.3	56.3	97.9	14	180	3.29 J	75	77.7	124
PX-FSR-SO-55	PX-FSR-SS55-000H	11/14/18	17.3 J	8.99 U	33.2	334	429	694	194	200	423	52.3	639	7.99 J	279	209	533
PX-FSR-SO-56	PX-FSR-SS56-000H	11/14/18	1.72 U	1.72 U	9.25	34.8	25.1	39.9	21.4	15.6	39.3	4.96	69.7	1.72 U	22.6	49.1	67.8

Table B1-10. Summary of Bioaccumulative PAH Compound Results Used for Food Web Modeling - Combined Dataset (2010 SI + 2018 RI)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Station ID	Sample ID	Sample Date	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Phenanthrene	Pyrene
PX-FSR-SO-57	PX-FSR-SS57-000H	11/14/18	1.75 U	1.75 U	0.503 J	3.03 J	1.87 J	3.28 J	1.57 J	1.13 J	2.94 J	1.75 U	6.52	1.75 U	1.98 J	3.26 J	4.37
PX-FSR-SO-16	PX-FSR-SS16-0001	12/15/10	10 UJ	2.2 J	9.9 J	120 J	180 J	280 J	140 J	82 J	150 J	41 J	150 J	10 UJ	160 J	49 J	170 J
PX-FSR-SO-17	PX-FSR-SS17-0001	12/15/10	21 L	23 UL	57 L	660	980	1,400	700	440	810	200 J	810 L	13 L	770	240 L	690
PX-FSR-SO-18	PX-FSR-SS18-0001	12/15/10	17 L	11 UL	54 L	760	1,100	1,600	800	550	950	180	960 L	9.2 L	930	260 L	960
PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	230 L	14 UL	760 L	7,900	8,200	11,000	4,400	4,400	8,700	1,400 J	10,000 L	120 L	5,400	3,200 L	9,900
PX-FSR-SO-20	PX-FSR-SS20-0001	12/15/10	10 UL	10 UL	3.8 L	19 J	27	42	19 J	12 J	22	4.9 J	32 L	10 UL	23	15 L	31
	PX-FSR-SS20P-0001	12/15/10	10 UL	2.9 L	18 L	46	49	70	29	22	40	10 J	94 L	7.5 L	42	69 L	87
PX-FSR-SO-21	PX-FSR-SS21-0001	12/15/10	75 L	10 UL	220 L	2,800	3,300	4,700	2,200	1,800	3,400	620 J	4,500 L	38 L	2,500	1,500 L	3,500
PX-FSR-SO-22	PX-FSR-SS22-0001	12/15/10	2,400 L	34 UL	9,400 L	62,000	81,000 J	110,000 J	51,000	43,000 J	76,000 J	15,000	86,000 L	840 J	59,000	33,000 L	78,000
PX-FSR-SO-23	PX-FSR-SS23-0001	12/15/10	20 J	11 UL	130 J	1,000	1,400	1,600	840	250 J	1,200	250	1,800 L	20 J	260 J	620 L	1,700
PX-FSR-SO-24	PX-FSR-SS24-0001	12/15/10	4 L	10 UL	28 L	200	260	400	190	140	220	53	300 L	10 UL	230	110 L	270
PX-FSR-SO-25	PX-FSR-SS25-0001	12/15/10	2.7 L	10 UL	10 L	54	64	89	41	32	57	12 J	94 L	3.6 L	50	46 L	81
PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	26 L	10 UL	84 L	840	1,000	1,400	620	580	1,000	180	1,100 L	11 L	720	360 L	1,000
	PX-FSR-SS26P-0001	12/15/10	9.7 L	10 UL	52 L	490	620	920	390	250	590	100	700 L	6.8 L	480	240 L	600
Maximum			2,520	5.5	9,400	62,000	81,000	110,000	51,000	43,000	76,000	15,000	86,000	1,540	59,000	33,000	78,000
Mean			193.3	55.3	727.8	4,684	6,019	6,882	3,481	2,913	5,669	924.7	7,171	125.7	4,036	2,925	5,625
95% UCL[1]			688.6	2.456	2,624	16,430	21,187	25,119	12,346	10,326	19,961	3,296	25,055	279.3	14,390	10,286	19,690

Notes:

Shading indicates detections

All concentrations are in micrograms per kilogram (ug/kg)

1 - 95% Upper Confidence Limits (UCLs) calculated with USEPA ProUCL version 5.1.002

B - Analyte not detected above the level reported in blanks

J - Analyte present, value may or may not be accurate or precise

L - Analyte present, value may be biased low, actual value may be higher

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

UL - Analyte not detected, quantitation limit is probably higher

Table B1-11. Soil Bioconcentration Factors For Plants and Soil Invertebrates - Step 2

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics				
Lead	0.468	Bechtel Jacobs 1998b	1.522	Sample et al. 1998b
Semivolatile Organics				
Acenaphthene	1.3367	USEPA 2005b	0.30	Beyer and Stafford 1993
Acenaphthylene	1.2156	USEPA 2005b	0.22	Beyer and Stafford 1993
Anthracene	0.9588	USEPA 2005b	0.32	Beyer and Stafford 1993
Benzo(a)anthracene	0.5229	USEPA 2005b	0.27	Beyer and Stafford 1993
Benzo(a)pyrene	0.4212	USEPA 2005b	0.34	Beyer and Stafford 1993
Benzo(b)fluoranthene	0.4017	USEPA 2005b	0.21	Beyer and Stafford 1993
Benzo(g,h,i)perylene	0.3086	USEPA 2005b	0.15	Beyer and Stafford 1993
Benzo(k)fluoranthene	0.4017	USEPA 2005b	0.21	Beyer and Stafford 1993
Chrysene	0.5229	USEPA 2005b	0.44	Beyer and Stafford 1993
Dibenz(a,h)anthracene	0.3102	USEPA 2005b	0.49	Beyer and Stafford 1993
Fluoranthene	0.7099	USEPA 2005b	0.37	Beyer and Stafford 1993
Fluorene	1.1471	USEPA 2005b	0.20	Beyer and Stafford 1993
Indeno(1,2,3-cd)pyrene	0.3168	USEPA 2005b	0.41	Beyer and Stafford 1993
Phenanthrene	0.9588	USEPA 2005b	0.28	Beyer and Stafford 1993
Pyrene	0.7137	USEPA 2005b	0.39	Beyer and Stafford 1993

Table B1-12. Soil Bioaccumulation Factors For Small Mammals - Step 2

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

	Soil-Mouse BAF (dry weight)		Soil-Vole BAF (dry weight)		Soil-Shrew BAF (dry weight)	
Chemical	**Value**	**Reference**	**Value**	**Reference**	**Value**	**Reference**
Inorganics						
Lead	0.286	Sample et al. 1998b	0.187	Sample et al. 1998b	0.339	Sample et al. 1998b
Semivolatile Organics						
Acenaphthene	--	see text	--	see text	--	see text
Acenaphthylene	--	see text	--	see text	--	see text
Anthracene	--	see text	--	see text	--	see text
Benzo(a)anthracene	--	see text	--	see text	--	see text
Benzo(a)pyrene	--	see text	--	see text	--	see text
Benzo(b)fluoranthene	--	see text	--	see text	--	see text
Benzo(g,h,i)perylene	--	see text	--	see text	--	see text
Benzo(k)fluoranthene	--	see text	--	see text	--	see text
Chrysene	--	see text	--	see text	--	see text
Dibenz(a,h)anthracene	--	see text	--	see text	--	see text
Fluoranthene	--	see text	--	see text	--	see text
Fluorene	--	see text	--	see text	--	see text
Indeno(1,2,3-cd)pyrene	--	see text	--	see text	--	see text
Phenanthrene	--	see text	--	see text	--	see text
Pyrene	--	see text	--	see text	--	see text

Table B1-13. Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 2

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Dietary Composition (percent)				Soil Ingestion (percent)	
Receptor	Value	Reference	Value	Reference	Terr. Plants	Soil Invert.	Small Mammals	Reference	Value	Reference
Birds										
American robin	0.064	USEPA 1993	0.0074	Levey and Karasov 1989	51.9	43.5	0	Martin et al. 1951	4.6	Sample and Suter 1994
Mourning dove	0.105	Tomlinson et al. 1994	0.0209	allometric equation	95.0	0	0	Tomlinson et al. 1994	5.0	Assumed based on diet
Red-tailed hawk	0.957	USEPA 1993	0.0395	Sample and Suter 1994	0	0	100	USEPA 1993; Sample and Suter 1994	0	Sample and Suter 1994
Mammals										
Short-tailed shrew	0.013	USEPA 1993	0.0019	USEPA 1993	4.7	82.3	0	USEPA 1993; Sample and Suter 1994	13.0	Sample and Suter 1994
White-footed mouse	0.014	Silva and Downing 1995	0.0007	Sample and Suter 1994	51.0	47.0	0	Martin et al. 1951; Sample and Suter 1994	2.0	Beyer et al. 1994

Table B1-14. Surface Soil Results and Screening Summary - Step 2

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Lead[1] (mg/kg)	LMW PAHs[1] (ug/kg)	HMW PAHs[1] (ug/kg)
Site Inspection (2010)	PX-FSR-SO-01	PX-FSR-SS01-0001	12/15/10	5.8	*NA*	*NA*
	PX-FSR-SO-02	PX-FSR-SS02-0001	12/15/10	31.6	*NA*	*NA*
	PX-FSR-SO-03	PX-FSR-SS03-0001	12/15/10	80.3	*NA*	*NA*
	PX-FSR-SO-04	PX-FSR-SS04-0001	12/15/10	133	*NA*	*NA*
	PX-FSR-SO-05	PX-FSR-SS05-0001	12/15/10	82.6	*NA*	*NA*
	PX-FSR-SO-06	PX-FSR-SS06-0001	12/15/10	258	*NA*	*NA*
	PX-FSR-SO-07	PX-FSR-SS07-0001	12/15/10	12.4	*NA*	*NA*
	PX-FSR-SO-08	PX-FSR-SS08-0001	12/15/10	55.6	*NA*	*NA*
	PX-FSR-SO-09	PX-FSR-SS09-0001	12/15/10	10.1	*NA*	*NA*
	PX-FSR-SO-10	PX-FSR-SS10-0001	12/15/10	52.4	*NA*	*NA*
		PX-FSR-SS10P-0001	duplicate	56	*NA*	*NA*
	PX-FSR-SO-11	PX-FSR-SS11-0001	12/15/10	80.3	*NA*	*NA*
	PX-FSR-SO-12	PX-FSR-SS12-0001	12/15/10	12.6	*NA*	*NA*
	PX-FSR-SO-13	PX-FSR-SS13-0001	12/15/10	21.2	*NA*	*NA*
	PX-FSR-SO-14	PX-FSR-SS14-0001	12/15/10	14.2	*NA*	*NA*
	PX-FSR-SO-15	PX-FSR-SS15-0001	12/15/10	10.2	*NA*	*NA*
	PX-FSR-SO-16	PX-FSR-SS16-0001	12/15/10	57.4	78.6	1,473
	PX-FSR-SO-17	PX-FSR-SS17-0001	12/15/10	231	362.0	7,460
	PX-FSR-SO-18	PX-FSR-SS18-0001	12/15/10	28.4	359.7	8,790
	PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	163	4,453	71,300
	PX-FSR-SO-20	PX-FSR-SS20-0001	12/15/10	11.7	41.8	231.9
		PX-FSR-SS20P-0001	Field duplicate	9.8	110.5	489.0
	PX-FSR-SO-21	PX-FSR-SS21-0001	12/15/10	55.2	1,890	29,320
	PX-FSR-SO-22	PX-FSR-SS22-0001	12/15/10	330	47,167	661,000
	PX-FSR-SO-23	PX-FSR-SS23-0001	12/15/10	27.8	807.6	10,300
	PX-FSR-SO-24	PX-FSR-SS24-0001	12/15/10	30.8	160.6	2,263
	PX-FSR-SO-25	PX-FSR-SS25-0001	12/15/10	32	73.0	574.0
	PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	7.6	496.5	8,440
		PX-FSR-SS26P-0001	Field duplicate	8	319.3	5,140

Table B1-14. Surface Soil Results and Screening Summary - Step 2
Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)
NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Lead[1] (mg/kg)	LMW PAHs[1] (ug/kg)	HMW PAHs[1] (ug/kg)
Remedial Investigation (2018)	PX-FSR-SO-18	PX-FSR-SS18-000H	11/15/18	38.8	394.4	881
		PX-FSR-SS18P-000H	Field Duplicate	41.8	438.2	1,150
	PX-FSR-SO-19	PX-FSR-SS19-000H	11/15/18	129	4,121.5	23,408
	PX-FSR-SO-21	PX-FSR-SS21-000H	11/15/18	60.3	73.9	316
	PX-FSR-SO-22	PX-FSR-SS22-000H	11/15/18	504	14,486.0	72,250
	PX-FSR-SO-24	PX-FSR-SS24-000H	11/16/18	23.7	155.3	2,064
	PX-FSR-SO-26	PX-FSR-SS26-000H	11/16/18	5.35	112.3	1,158
	PX-FSR-SO-27	PX-FSR-SS27-000H	11/13/18	6.61	244.8	2,546
		PX-FSR-SS27P-000H	Field Duplicate	7.99	178.4	2,670
	PX-FSR-SO-28	PX-FSR-SS28-000H	11/13/18	151	43,837.0	392,250
	PX-FSR-SO-29	PX-FSR-SS29-000H	11/13/18	81	18,532.5	189,450
	PX-FSR-SO-30	PX-FSR-SS30-000H	11/13/18	621	43,422.0	487,810
		PX-FSR-SS30P-000H	Field Duplicate	454	46,429.5	465,580
	PX-FSR-SO-31	PX-FSR-SS31-000H	11/13/18	93.8	172.1	2,236
	PX-FSR-SO-32	PX-FSR-SS32-000H	11/13/18	74.2	9,706.4	112,870
	PX-FSR-SO-33	PX-FSR-SS33-000H	11/14/18	115	2,531.1	66,830
	PX-FSR-SO-34	PX-FSR-SS34-000H	11/13/18	*NA*	142.0	1,783
		PX-FSR-SS34P-000H	Field Duplicate	*NA*	92.1	1,753
	PX-FSR-SO-35	PX-FSR-SS35-000H	11/13/18	*NA*	58.1	776
	PX-FSR-SO-36	PX-FSR-SS36-000H	11/13/18	*NA*	539.2	6,836
	PX-FSR-SO-37	PX-FSR-SS37-000H	11/13/18	*NA*	1,400.3	12,979
		PX-FSR-SS37P-000H	Field Duplicate	*NA*	1,241.7	11,301
	PX-FSR-SO-38	PX-FSR-SS38-000H	11/14/18	*NA*	647.6	15,716
	PX-FSR-SO-39	PX-FSR-SS39-000H	11/14/18	*NA*	482.9	6,666
	PX-FSR-SO-40	PX-FSR-SS40-000H	11/14/18	*NA*	605.4	7,527
	PX-FSR-SO-41	PX-FSR-SS41-000H	11/14/18	*NA*	195.3	3,052
		PX-FSR-SS41P-000H	Field Duplicate	*NA*	504.4	4,951
	PX-FSR-SO-42	PX-FSR-SS42-000H	11/14/18	*NA*	163.9	3,792

Table B1-14. Surface Soil Results and Screening Summary - Step 2
Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)
NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Lead[1] (mg/kg)	LMW PAHs[1] (ug/kg)	HMW PAHs[1] (ug/kg)
Remedial Investigation (2018), cont.	PX-FSR-SO-43	PX-FSR-SS43-000H	11/14/18	*NA*	896.7	17,741
	PX-FSR-SO-44	PX-FSR-SS44-000H	11/14/18	*NA*	25.3	333
	PX-FSR-SO-45	PX-FSR-SS45-000H	11/14/18	*NA*	9.5	67
	PX-FSR-SO-46	PX-FSR-SS46-000H	11/14/18	*NA*	7.8	30
	PX-FSR-SO-47	PX-FSR-SS47-000H	11/14/18	*NA*	10.6	89
	PX-FSR-SO-48	PX-FSR-SS48-000H	11/14/18	*NA*	10.7	109
	PX-FSR-SO-49	PX-FSR-SS49-000H	11/14/18	*NA*	35.7	170
	PX-FSR-SO-50	PX-FSR-SS50-000H	11/14/18	*NA*	59	276
	PX-FSR-SO-51	PX-FSR-SS51-000H	11/14/18	*NA*	24.5	181.1
	PX-FSR-SO-52	PX-FSR-SS52-000H	11/14/18	*NA*	46.7	276.6
	PX-FSR-SO-53	PX-FSR-SS53-000H	11/14/18	*NA*	65	371
	PX-FSR-SO-54	PX-FSR-SS54-000H	11/14/18	*NA*	104	926
	PX-FSR-SO-55	PX-FSR-SS55-000H	11/14/18	*NA*	294.2	3,777
	PX-FSR-SO-56	PX-FSR-SS56-000H	11/14/18	*NA*	105.4	341
	PX-FSR-SO-57	PX-FSR-SS57-000H	11/14/18	*NA*	9.0	27.6
			Toxicity Test Reference Samples			
	PX-FSR-SO-58	PX-FSR-SS58-000H	11/16/18	20.7	40.5	85.2
	PX-FSR-SO-59	PX-FSR-SS59-000H	11/16/18	9.92	35.7	50.9

Notes:
NA = not analyzed
1 - Shaded concentrations exceed the ecological soil screening level (Eco-SSL) of:
Lead = 120 mg/kg (USEPA, 2005)
LMW PAHs = 29,000 µg/kg (USEPA, 2007)
HMW PAHs = 18,000 µg/kg (USEPA, 2007)

Table B1-15. Food Web Model Results - Step 2

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Short-tailed shrew		White-footed mouse		American robin		Mourning dove		Red-tailed hawk	
	NOAEL	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Inorganics										
Lead	0.78	0.08	0.10	0.01	0.68	0.14	1.94	0.19	0.12	0.02
Semivolatile Organics										
Acenaphthene	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	0.09	0.02	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	0.10	0.02	0.25	0.05	0.01	<0.01
Benzo(a)anthracene	1.66	0.33	0.67	0.13	0.44	0.09	0.95	0.19	0.05	<0.01
Benzo(a)pyrene	2.47	0.49	0.83	0.17	0.55	0.11	1.02	0.20	0.06	0.01
Benzo(b)fluoranthene	2.51	0.50	0.92	0.18	0.62	0.12	1.33	0.27	0.07	0.01
Benzo(g,h,i)perylene	0.97	0.19	0.33	0.07	0.23	0.05	0.49	0.10	0.03	<0.01
Benzo(k)fluoranthene	0.98	0.20	0.36	0.07	0.24	0.05	0.52	0.10	0.03	<0.01
Chrysene	2.78	0.56	0.97	0.19	0.63	0.13	1.16	0.23	0.07	0.01
Dibenz(a,h)anthracene	0.58	0.12	0.16	0.03	0.10	0.02	0.14	0.03	0.01	<0.01
Fluoranthene	0.01	<0.01	<0.01	<0.01	0.81	0.16	1.75	0.35	0.09	0.02
Fluorene	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.05	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	2.02	0.40	0.57	0.11	0.37	0.07	0.58	0.12	0.04	<0.01
Phenanthrene	<0.01	<0.01	<0.01	<0.01	0.36	0.07	0.89	0.18	0.04	<0.01
Pyrene	2.68	0.54	1.15	0.23	0.75	0.15	1.59	0.32	0.08	0.02

Notes:

Shaded values are greater than 1.

Table B1-16. Soil Bioconcentration Factors For Plants and Soil Invertebrates - Step 3

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	**Reference**	**Value**	**Reference**
Inorganics				
Lead	0.038	Bechtel Jacobs 1998a	0.307	Sample et al. 1998a
Semivolatile Organics				
Benzo(a)anthracene	0.5229	USEPA 2005b	0.27	Beyer and Stafford 1993
Benzo(a)pyrene	0.4212	USEPA 2005b	0.34	Beyer and Stafford 1993
Benzo(b)fluoranthene	0.4017	USEPA 2005b	0.21	Beyer and Stafford 1993
Chrysene	0.5229	USEPA 2005b	0.44	Beyer and Stafford 1993
Fluoranthene	0.7099	USEPA 2005b	0.37	Beyer and Stafford 1993
Indeno(1,2,3-cd)pyrene	0.3168	USEPA 2005b	0.41	Beyer and Stafford 1993
Pyrene	0.7137	USEPA 2005b	0.39	Beyer and Stafford 1993

Table B1-17. Soil Bioaccumulation Factors For Small Mammals - Step 3

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

	Soil-Mouse BAF (dry weight)		Soil-Vole BAF (dry weight)		Soil-Shrew BAF (dry weight)	
Chemical	**Value**	**Reference**	**Value**	**Reference**	**Value**	**Reference**
Inorganics						
Lead	0.055	Sample et al. 1998b	0.041	Sample et al. 1998b	0.148	Sample et al. 1998b
Semivolatile Organics						
Benzo(a)anthracene	--	see text	--	see text	--	see text
Benzo(a)pyrene	--	see text	--	see text	--	see text
Benzo(b)fluoranthene	--	see text	--	see text	--	see text
Chrysene	--	see text	--	see text	--	see text
Fluoranthene	--	see text	--	see text	--	see text
Indeno(1,2,3-cd)pyrene	--	see text	--	see text	--	see text
Pyrene	--	see text	--	see text	--	see text

Table B1-18. Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 3

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Dietary Composition (percent)				Soil Ingestion (percent)	
Receptor	**Value**	**Reference**	**Value**	**Reference**	**Terr. Plants**	**Soil Invert.**	**Small Mammals**	**Reference**	**Value**	**Reference**
Birds										
American robin	0.077	USEPA 1993	0.0055	Levey and Karasov 1989	51.9	43.5	0	Martin et al. 1951	4.6	Sample and Suter 1994
Mourning dove	0.127	Tomlinson et al. 1994	0.0176	allometric equation	95.0	0	0	Tomlinson et al. 1994	5.0	Assumed based on diet
Red-tailed hawk	1.13	Sample and Suter 1994	0.0360	Sample and Suter 1994	0	0	100	USEPA 1993; Sample and Suter 1994	0	Sample and Suter 1994
Mammals										
Short-tailed shrew	0.017	USEPA 1993	0.0015	USEPA 1993a	4.7	82.3	0	USEPA 1993; Sample and Suter 1994	13.0	Sample and Suter 1994
White-footed mouse	0.021	Silva and Downing 1995	0.0005	Sample and Suter 1994	51.0	47.0	0	Martin et al. 1951; Sample and Suter 1994	2.0	Beyer et al. 1994

Table B1-19. Surface Soil Results and Screening Summary - Step 3

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

COPC	Minimum		Maximum		Fequency of Exceeding ESL	Mean[1]	95% UCL[1]
2010 SI							
Lead	5.8	PX-FSR-SS01-0001	330	PX-FSR-SS22-0001	5 / 26	70.74	106.8
LMW PAHs	41.8	PX-FSR-SS20-0001	47,167	PX-FSR-SS22-0001	1 / 11	5,087	47,137
HMW PAHs	231.9	PX-FSR-SS20-0001	661,000	PX-FSR-SS22-0001	3 / 11	72,855	661,342
2018 RI							
Lead	5.35	PX-FSR-SS26-000H	621	PX-FSR-SS30-000H	4 / 13	146.8	314.8
LMW PAHs	7.8	PX-FSR-SS46-000H	46,430	PX-FSR-SS30-000H	2 / 37	3,975	15,023
HMW PAHs	27.6	PX-FSR-SS57-000H	487,810	PX-FSR-SS30-000H	7 / 37	38,921	146,545
Overall							
Lead	5.35	PX-FSR-SS26-000H	621	PX-FSR-SS30-000H	9 / 39	96.09	135
LMW PAHs	7.8	PX-FSR-SS46-000H	47,167	PX-FSR-SS22-0001	3 / 48	4,230	14,536
HMW PAHs	27.6	PX-FSR-SS57-000H	661,000	PX-FSR-SS22-0001	10 / 48	46,700	163,573

Notes:

NA = not analyzed

Shaded concentrations exceed the ecological soil screening level (Eco-SSL) of:

120 mg/kg (USEPA, 2005)

29,000 mg/kg (USEPA, 2007)

18,000 µg/kg (USEPA, 2007)

1 - 95% Upper Confidence Limits (UCLs) calculated with USEPA ProUCL version 5.1.002

Table B1-20. Food Web Model Results - Step 3

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

	Short-tailed shrew		White-footed mouse		American robin		Mourning dove		Red-tailed hawk	
Chemical	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Inorganics										
Lead	0.57	0.06	0.07	<0.01	0.50	0.10	1.42	0.14	0.09	0.02
Semivolatile Organics										
Benzo(a)anthracene	0.27	0.05	0.08	0.02	0.07	0.01	0.18	0.04	<0.01	<0.01
Benzo(a)pyrene	0.40	0.08	0.10	0.02	0.09	0.02	0.19	0.04	<0.01	<0.01
Benzo(b)fluoranthene	0.36	0.07	0.10	0.02	0.09	0.02	0.21	0.04	<0.01	<0.01
Chrysene	0.46	0.09	0.12	0.02	0.10	0.02	0.21	0.04	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	0.15	0.03	0.36	0.07	0.01	<0.01
Indeno(1,2,3-cd)pyrene	0.31	0.06	0.06	0.01	0.06	0.01	0.10	0.02	<0.01	<0.01
Pyrene	0.42	0.08	0.13	0.03	0.12	0.02	0.28	0.06	<0.01	<0.01

Notes:

Shaded values are greater than 1.

Table B1-21. Earthworm Toxcity Test Summary - Survival

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample ID	Designation	Reps	Day 28 Survival				Statistically Significant Difference Compared to:		
			Mean	Minimum	Maximum	CV	Lab Control	SS58	SS59
Laboratory Control		5	94%	80%	100%	10%	--	No	No
PX-FSR-SS18-000H	Site	4	100%	100%	100%	0%	No	No	No
PX-FSR-SS19-000H	Site	5	100%	100%	100%	0%	No [a]	No/No	No
PX-FSR-SS21-000H	Site	5	98%	90%	100%	5%	No	No/No	No
PX-FSR-SS22-000H	Site	5	100%	100%	100%	0%	No [a]	No	No
PX-FSR-SS24-000H	Site	5	100%	100%	100%	0%	No [a]	No	No
PX-FSR-SS26-000H	Site	4	100%	100%	100%	0%	No	No	No
PX-FSR-SS58-000H	Reference	4	100%	100%	100%	0	No	--	--
PX-FSR-SS59-000H	Reference	5	96%	90%	100%	6%	No	--	--

Notes:

CV - coefficient of variation

No/No indicates that there was no difference in outcome when an outlier was excluded from the statistical analysis

a - Could not calculate a finding of significance with an outlier removed following the standard USEPA decision tree because there was not enough variance, or there was insufficient replication or there were too many groups selected to run the Wilcoxon Rank Sum Two-Sample Test (nonparametric). The Mann-Whitney U Two-Sample Test and the Kolmogorov-Smirnov Two-Sample Test (both non-parametric tests) were also used for statistical comparisons. All statistical analyses resulted in a finding of no significance.

"--" Indicates that statistical analysis was not conducted.

Table B1-22. Earthworm Toxcity Test Summary - Growth (Wet Weight)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample ID	Designation	Reps	Growth - Day 28 Wet Weight				Statistically Significant Difference Compared to:		
			Mean (mg)	**Minimum (mg)**	**Maximum (mg)**	**CV**	**Lab Control**	**SS58**	**SS59**
Laboratory Control		5	0.24	0.20	0.29	15%	--	No	No
PX-FSR-SS18-000H	Site	4	0.33	0.33	0.34	1%	No	No	No
PX-FSR-SS19-000H	Site	5	0.24	0.22	0.25	5%	No	No	Yes
PX-FSR-SS21-000H	Site	5	0.21	0.17	0.25	19%	No	No	Yes
PX-FSR-SS22-000H	Site	5	0.25	0.20	0.30	19%	No	No	No
PX-FSR-SS24-000H	Site	5	0.30	0.21	0.36	19%	No	No	No/No
PX-FSR-SS26-000H	Site	4	0.26	0.24	0.27	0.06	No	No	No
PX-FSR-SS58-000H	Reference	4	0.24	0.19	0.30	20%	No	--	--
PX-FSR-SS59-000H	Reference	5	0.27	0.26	0.29	5%	No	--	--

Note:

CV - coefficient of variation

No/No indicates that there was no difference in outcome when an outlier was excluded from the statistical analysis

"--" indicates that statistical analysis was not conducted.

Table B1-23. Earthworm Toxcity Test Summary - Growth (Wet Biomass)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample ID	Designation	Reps	Growth - Day 28 Wet Biomass				Statistically Significant Difference Compared to:		
			Mean (mg)	Minimum (mg)	Maximum (mg)	CV	Lab Control	SS58	SS59
Laboratory Control		5	0.23	0.16	0.29	22%	--	No	No
PX-FSR-SS18-000H	Site	4	0.33	0.33	0.34	1%	No	No	No
PX-FSR-SS19-000H	Site	5	0.24	0.22	0.25	5%	No	No	Yes
PX-FSR-SS21-000H	Site	5	0.20	0.17	0.25	17%	No	No	Yes
PX-FSR-SS22-000H	Site	5	0.25	0.20	0.30	19%	No	No	No
PX-FSR-SS24-000H	Site	5	0.30	0.21	0.36	19%	No	No	No/No
PX-FSR-SS26-000H	Site	4	0.26	0.24	0.27	0.06	No	No	No
PX-FSR-SS58-000H	Reference	4	0.24	0.19	0.30	20%	No	--	--
PX-FSR-SS59-000H	Reference	5	0.26	0.24	0.28	5%	No	--	--

Note:

CV - coefficient of variation

No/No indicates that there was no difference in outcome when an outlier was excluded from the statistical analysis

"--" indicates that statistical analysis was not conducted.

Table B1-24. Summary of NAS Paxutent River Background Threshold Value (BTV) for Surface Soil

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Refined COPCs	**BTVs**	
Lead	**44.4**	**mg/kg**
High Melecular Weight PAHs		
Benzo(a)anthracene	130	ug/kg
Benzo(a)pyrene	170	ug/kg
Benzo(b)fluoranthene	290	ug/kg
Benzo(g,h,i)perylene	270	ug/kg
Benzo(k)fluoranthene	190	ug/kg
Chrysene	220	ug/kg
Dibenz(a,h)anthracene	1,200	ug/kg
Fluoranthene	250	ug/kg
Indeno(1,2,3-cd)pyrene	190	ug/kg
Pyrene	260	ug/kg
Sum (Total HMW PAHs)	**3,170**	**ug/kg**

Notes:

Source of BTVs is CH2M HILL (2008)

Table B1-25. Pellet Count and Grit Characterization - 2018 Surface Soil Samples

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

	Field Sample ID	PX-FSR-SS60-000H	PX-FSR-SS61-000H	PX-FSR-SS62-000H	PX-FSR-SS63-000H	PX-FSR-SS64-000H	PX-FSR-SS65-000H	PX-FSR-SS66-000H	PX-FSR-SS67-000H	PX-FSR-SS68-000H	PX-FSR-SS69-000H	PX-FSR-SS70-000H
	Lab Sample ID	**21904131610**	**21904131609**	**21904131608**	**21904131607**	**21904131606**	**21811164717**	**21904131605**	**21904131604**	**21904131603**	**21904131602**	**21904131601**
	Sample Date	**4/24/19**	**4/24/19**	**4/18/19**	**4/24/19**	**4/17/19**	**11/15/19**	**4/17/19**	**4/18/19**	**4/17/19**	**4/18/19**	**4/17/19**
Post Drying Intial Weight		1,037.9	1,039.8	1,121.5	1,060.5	1,060.6	1,118.4	1,078.1	1,157.0	1,117.5	1,086.5	1,079.0
Weight of Debris/Removed Clay fragments Set Aside		12.4	44.1	45.0	8.2	21.0	913.1	87.3	7.0	19.8	26.1	38.6
Post Debris Weight (sample + pan)		1,025.5	995.7	1,076.5	1,052.3	1,039.6	205.3	990.8	1,150.0	1,097.7	1,060.4	1,040.4
Sieve #5	Sub Sample Soil with Sieve	401.9	444.3	442.7	395.4	462.7	450.0	479.8	391.9	396.7	399.4	390.6
	Weight of Sieve	378.8	378.8	378.8	378.8	380.0	378.7	379.0	378.8	378.4	378.8	379.9
	Sub Sample Soil Weight	23.1	65.5	63.9	16.6	82.7	71.4	100.8	13.1	18.3	20.6	10.7
	Sub Pellet/ Fragment Weight	0.0	1.2	1.2	0.0	2.6	19.3	1.0	0.0	0.0	0.0	0.0
	# Clay Fragments	0.0	1.0	2.0	0.0	5.0	na	2.0	0.0	0.0	0.0	0.0
	# of Pellet/ Fragments	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve #7	Sub Sample Soil with Sieve	386.4	389.0	406.8	383.1	441.5	401.9	437.9	407.0	380.9	388.2	381.6
	Weight of Sieve	371.8	371.6	371.6	371.5	372.0	371.2	374.9	373.3	371.1	371.8	372.7
	Sub Sample Soil Weight	14.6	17.4	35.2	11.6	69.5	30.7	63.0	33.7	9.8	16.4	8.9
	Sub Pellet/ Fragment Weight	0.0	0.0	0.1	0.0	0.2	2.4	0.3	0.0	0.0	0.0	0.0
	# Clay Fragments	0	0	1	0	2	?	3	0	0	0	0
	# of Pellet/ Fragments	0	0	0	0	0	0	0	0	0	0	0
Sieve #35	Sub Sample Soil with Sieve	697.1	632.1	898.7	912.4	899.2	467.1	744.0	952.2	771.0	378.4	665.0
	Weight of Sieve	259.9	259.9	259.9	259.8	259.8	260.0	260.5	260.0	260.0	260.1	255.3
	Sub Sample Soil Weight	437.2	372.2	638.8	652.6	639.4	207.1	483.5	692.2	511.0	118.3	409.7
	Sub Pellet/ Fragment Weight	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
	# Clay Fragments	0	0	0	0	0	na	0	0	0	0	0
	# of Pellet/ Fragments	0	0	0	0	0	0	0	0	0	0	0
Collection Pan	Sub Sample Soil with Sieve	799.1	794.5	592.5	371.5	493.4	915.5	583.1	666.9	1,064.2	768.8	867.6
	Weight of Sieve	255.3	255.3	255.3	255.3	255.3	369.5	255.4	255.3	255.1	255.3	260.0
	Sub Sample Soil Weight	543.8	539.2	337.2	116.2	238.1	546.0	327.7	411.6	809.1	513.5	607.6
	Sub Pellet/ Fragment Weight	0.0	0.0	0.0	0.0	0.0	na	0.0	0.0	0.0	0.0	0.0
	# Clay Fragments	0	0	0	0	0	na	0	0	0	0	0
	# of Pellet/ Fragments	0	0	0	0	0	na	0	0	0	0	0
Cumulative Final Sample Weight		1,018.7	995.5	1,076.4	797.0	1,032.5	877.4	976.3	1,150.6	1,348.2	668.8	1,036.9
Grit Characterization	From Sieve #7	0.00%	0.00%	0.01%	0.00%	0.02%	0.27%	0.03%	0.00%	0.00%	0.00%	0.00%
	From Sieve #35	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	0.00%	0.00%	0.01%	0.00%	0.02%	0.32%	0.03%	0.00%	0.00%	0.00%	0.00%

Notes:

All weights in grams (g)

"?" indicates no data reported by lab

Table B1-26. Sample-by-Sample Concentrations of Refined COPCs Compared to BTVs

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Lead[1,2] (mg/kg)	HMW PAHs[1,2] (ug/kg)
Site Inspection (2010)	PX-FSR-SO-01	PX-FSR-SS01-0001	12/15/10	5.8	*NA*
	PX-FSR-SO-02	PX-FSR-SS02-0001	12/15/10	31.6	*NA*
	PX-FSR-SO-03	PX-FSR-SS03-0001	12/15/10	**80.3**	*NA*
	PX-FSR-SO-04	PX-FSR-SS04-0001	12/15/10	**133**	*NA*
	PX-FSR-SO-05	PX-FSR-SS05-0001	12/15/10	**82.6**	*NA*
	PX-FSR-SO-06	PX-FSR-SS06-0001	12/15/10	**258**	*NA*
	PX-FSR-SO-07	PX-FSR-SS07-0001	12/15/10	12.4	*NA*
	PX-FSR-SO-08	PX-FSR-SS08-0001	12/15/10	**55.6**	*NA*
	PX-FSR-SO-09	PX-FSR-SS09-0001	12/15/10	10.1	*NA*
	PX-FSR-SO-10	PX-FSR-SS10-0001	12/15/10	**52.4**	*NA*
		PX-FSR-SS10P-0001	duplicate	**56**	*NA*
	PX-FSR-SO-11	PX-FSR-SS11-0001	12/15/10	**80.3**	*NA*
	PX-FSR-SO-12	PX-FSR-SS12-0001	12/15/10	12.6	*NA*
	PX-FSR-SO-13	PX-FSR-SS13-0001	12/15/10	21.2	*NA*
	PX-FSR-SO-14	PX-FSR-SS14-0001	12/15/10	14.2	*NA*
	PX-FSR-SO-15	PX-FSR-SS15-0001	12/15/10	10.2	*NA*
	PX-FSR-SO-16	PX-FSR-SS16-0001	12/15/10	**57.4**	1,473
	PX-FSR-SO-17	PX-FSR-SS17-0001	12/15/10	**231**	**7,460**
	PX-FSR-SO-18	PX-FSR-SS18-0001	12/15/10	28.4	**8,790**
	PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	**163**	**71,300**
	PX-FSR-SO-20	PX-FSR-SS20-0001	12/15/10	11.7	231.9
		PX-FSR-SS20P-0001	Field duplicate	9.8	489.0
	PX-FSR-SO-21	PX-FSR-SS21-0001	12/15/10	**55.2**	**29,320**
	PX-FSR-SO-22	PX-FSR-SS22-0001	12/15/10	**330**	**661,000**
	PX-FSR-SO-23	PX-FSR-SS23-0001	12/15/10	27.8	**10,300**
	PX-FSR-SO-24	PX-FSR-SS24-0001	12/15/10	30.8	2,263
	PX-FSR-SO-25	PX-FSR-SS25-0001	12/15/10	32	574.0
	PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	7.6	**8,440**
		PX-FSR-SS26P-0001	Field duplicate	8	**5,140**
Remedial Investigation (2018)	PX-FSR-SO-18	PX-FSR-SS18-000H	11/15/18	38.8	881
		PX-FSR-SS18P-000H	Field Duplicate	41.8	1,150
	PX-FSR-SO-19	PX-FSR-SS19-000H	11/15/18	**129**	**23,408**
	PX-FSR-SO-21	PX-FSR-SS21-000H	11/15/18	**60.3**	316
	PX-FSR-SO-22	PX-FSR-SS22-000H	11/15/18	**504**	**72,250**
	PX-FSR-SO-24	PX-FSR-SS24-000H	11/16/18	23.7	2,064
	PX-FSR-SO-26	PX-FSR-SS26-000H	11/16/18	5.35	1,158
	PX-FSR-SO-27	PX-FSR-SS27-000H	11/13/18	6.61	2,546
		PX-FSR-SS27P-000H	Field Duplicate	7.99	2,670
	PX-FSR-SO-28	PX-FSR-SS28-000H	11/13/18	**151**	**392,250**
	PX-FSR-SO-29	PX-FSR-SS29-000H	11/13/18	**81**	**189,450**
	PX-FSR-SO-30	PX-FSR-SS30-000H	11/13/18	**621**	**487,810**
		PX-FSR-SS30P-000H	Field Duplicate	**454**	**465,580**
	PX-FSR-SO-31	PX-FSR-SS31-000H	11/13/18	**93.8**	2,236
	PX-FSR-SO-32	PX-FSR-SS32-000H	11/13/18	**74.2**	**112,870**
	PX-FSR-SO-33	PX-FSR-SS33-000H	11/14/18	**115**	**66,830**
	PX-FSR-SO-34	PX-FSR-SS34-000H	11/13/18	*NA*	1,783
		PX-FSR-SS34P-000H	Field Duplicate	*NA*	1,753
Remedial Investigation (2018), cont.	PX-FSR-SO-35	PX-FSR-SS35-000H	11/13/18	*NA*	776
	PX-FSR-SO-36	PX-FSR-SS36-000H	11/13/18	*NA*	**6,836**
	PX-FSR-SO-37	PX-FSR-SS37-000H	11/13/18	*NA*	**12,979**
		PX-FSR-SS37P-000H	Field Duplicate	*NA*	**11,301**
	PX-FSR-SO-38	PX-FSR-SS38-000H	11/14/18	*NA*	**15,716**
	PX-FSR-SO-39	PX-FSR-SS39-000H	11/14/18	*NA*	**6,666**
	PX-FSR-SO-40	PX-FSR-SS40-000H	11/14/18	*NA*	**7,527**
	PX-FSR-SO-41	PX-FSR-SS41-000H	11/14/18	*NA*	3,052
		PX-FSR-SS41P-000H	Field Duplicate	*NA*	**4,951**
	PX-FSR-SO-42	PX-FSR-SS42-000H	11/14/18	*NA*	**3,792**
	PX-FSR-SO-43	PX-FSR-SS43-000H	11/14/18	*NA*	**17,741**
	PX-FSR-SO-44	PX-FSR-SS44-000H	11/14/18	*NA*	333
	PX-FSR-SO-45	PX-FSR-SS45-000H	11/14/18	*NA*	67
	PX-FSR-SO-46	PX-FSR-SS46-000H	11/14/18	*NA*	30
	PX-FSR-SO-47	PX-FSR-SS47-000H	11/14/18	*NA*	89
	PX-FSR-SO-48	PX-FSR-SS48-000H	11/14/18	*NA*	109
	PX-FSR-SO-49	PX-FSR-SS49-000H	11/14/18	*NA*	170
	PX-FSR-SO-50	PX-FSR-SS50-000H	11/14/18	*NA*	276
	PX-FSR-SO-51	PX-FSR-SS51-000H	11/14/18	*NA*	181.1
	PX-FSR-SO-52	PX-FSR-SS52-000H	11/14/18	*NA*	276.6
	PX-FSR-SO-53	PX-FSR-SS53-000H	11/14/18	*NA*	371
	PX-FSR-SO-54	PX-FSR-SS54-000H	11/14/18	*NA*	926
	PX-FSR-SO-55	PX-FSR-SS55-000H	11/14/18	*NA*	**3,777**
	PX-FSR-SO-56	PX-FSR-SS56-000H	11/14/18	*NA*	341
	PX-FSR-SO-57	PX-FSR-SS57-000H	11/14/18	*NA*	27.6
	Toxicity Test Reference Samples				
	PX-FSR-SO-58	PX-FSR-SS58-000H	11/16/18	20.7	85.2
	PX-FSR-SO-59	PX-FSR-SS59-000H	11/16/18	9.92	50.9

Notes:

NA = not analyzed

1 - Shaded concentrations exceed the ecological soil screening level (Eco-SSL) of:

Lead = 120 mg/kg (USEPA, 2005)

HMW PAHs = 18,000 µg/kg (USEPA, 2007)

2 - Bolded concentrations exceed NAS Paxutent River Background Threshold Value (BTV) for surface soil (CH2M HILL, 2008) are:

Lead = 44.4 mg/kg

HMW PAHs = 3,170 ug/kg (estimated from the sume of individual BTVs for HMW PAHs)

Table B1-27. Range of Concentrations for Refined COPCs Compared to BTVs - Combined/Overall Datset (2010 + 2018)

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Refined COPC	Minimum		Maximum		Fequency of Exceeding BTV	Mean[2]	95% UCL[2]
Lead	5.35	PX-FSR-SS26-000H	621	PX-FSR-SS30-000H	21 / 39	96.09	135
HMW PAHs	27.6	PX-FSR-SS57-000H	661,000	PX-FSR-SS22-0001	26 / 48	46,700	163,573

Notes:

NA = not analyzed

Shaded concentrations NAS Paxutent River Background Threshold Value (BTV) for surface soil (CH2M HILL, 2008);

Lead = 44.4 mg/kg

HMW PAHs = 3,170 ug/kg (estimated from the sume of individual BTVs for HMW PAHs)

2 - 95% Upper Confidence Limits (UCLs) calculated with USEPA ProUCL version 5.1.002

Table B1-28. Sample-by-Sample Concentrations of Refined COPCs Compared to the AET

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Investigation	Station ID	Sample ID	Sample Date	Lead[1] (mg/kg)	HMW PAHs[1] (ug/kg)
Site Inspection (2010)	PX-FSR-SO-01	PX-FSR-SS01-0001	12/15/10	5.8	*NA*
	PX-FSR-SO-02	PX-FSR-SS02-0001	12/15/10	31.6	*NA*
	PX-FSR-SO-03	PX-FSR-SS03-0001	12/15/10	80.3	*NA*
	PX-FSR-SO-04	PX-FSR-SS04-0001	12/15/10	133	*NA*
	PX-FSR-SO-05	PX-FSR-SS05-0001	12/15/10	82.6	*NA*
	PX-FSR-SO-06	PX-FSR-SS06-0001	12/15/10	258	*NA*
	PX-FSR-SO-07	PX-FSR-SS07-0001	12/15/10	12.4	*NA*
	PX-FSR-SO-08	PX-FSR-SS08-0001	12/15/10	55.6	*NA*
	PX-FSR-SO-09	PX-FSR-SS09-0001	12/15/10	10.1	*NA*
	PX-FSR-SO-10	PX-FSR-SS10-0001	12/15/10	52.4	*NA*
		PX-FSR-SS10P-0001	duplicate	56	*NA*
	PX-FSR-SO-11	PX-FSR-SS11-0001	12/15/10	80.3	*NA*
	PX-FSR-SO-12	PX-FSR-SS12-0001	12/15/10	12.6	*NA*
	PX-FSR-SO-13	PX-FSR-SS13-0001	12/15/10	21.2	*NA*
	PX-FSR-SO-14	PX-FSR-SS14-0001	12/15/10	14.2	*NA*
	PX-FSR-SO-15	PX-FSR-SS15-0001	12/15/10	10.2	*NA*
	PX-FSR-SO-16	PX-FSR-SS16-0001	12/15/10	57.4	1,473
	PX-FSR-SO-17	PX-FSR-SS17-0001	12/15/10	231	7,460
	PX-FSR-SO-18	PX-FSR-SS18-0001	12/15/10	28.4	8,790
	PX-FSR-SO-19	PX-FSR-SS19-0001	12/15/10	163	71,300
	PX-FSR-SO-20	PX-FSR-SS20-0001	12/15/10	11.7	231.9
		PX-FSR-SS20P-0001	Field duplicate	9.8	489.0
	PX-FSR-SO-21	PX-FSR-SS21-0001	12/15/10	55.2	29,320
	PX-FSR-SO-22	PX-FSR-SS22-0001	12/15/10	330	661,000
	PX-FSR-SO-23	PX-FSR-SS23-0001	12/15/10	27.8	10,300
	PX-FSR-SO-24	PX-FSR-SS24-0001	12/15/10	30.8	2,263
	PX-FSR-SO-25	PX-FSR-SS25-0001	12/15/10	32	574.0
	PX-FSR-SO-26	PX-FSR-SS26-0001	12/15/10	7.6	8,440
		PX-FSR-SS26P-0001	Field duplicate	8	5,140
Remedial Investigation (2018)	PX-FSR-SO-18	PX-FSR-SS18-000H	11/15/18	38.8	881
		PX-FSR-SS18P-000H	Field Duplicate	41.8	1,150
	PX-FSR-SO-19	PX-FSR-SS19-000H	11/15/18	129	23,408
	PX-FSR-SO-21	PX-FSR-SS21-000H	11/15/18	60.3	316
	PX-FSR-SO-22	PX-FSR-SS22-000H	11/15/18	504	72,250
	PX-FSR-SO-24	PX-FSR-SS24-000H	11/16/18	23.7	2,064
	PX-FSR-SO-26	PX-FSR-SS26-000H	11/16/18	5.35	1,158
	PX-FSR-SO-27	PX-FSR-SS27-000H	11/13/18	6.61	2,546
		PX-FSR-SS27P-000H	Field Duplicate	7.99	2,670
	PX-FSR-SO-28	PX-FSR-SS28-000H	11/13/18	151	392,250
	PX-FSR-SO-29	PX-FSR-SS29-000H	11/13/18	81	189,450
	PX-FSR-SO-30	PX-FSR-SS30-000H	11/13/18	621	487,810
		PX-FSR-SS30P-000H	Field Duplicate	454	465,580
	PX-FSR-SO-31	PX-FSR-SS31-000H	11/13/18	93.8	2,236
	PX-FSR-SO-32	PX-FSR-SS32-000H	11/13/18	74.2	112,870
	PX-FSR-SO-33	PX-FSR-SS33-000H	11/14/18	115	66,830
	PX-FSR-SO-34	PX-FSR-SS34-000H	11/13/18	*NA*	1,783
		PX-FSR-SS34P-000H	Field Duplicate	*NA*	1,753
Remedial Investigation (2018), cont.	PX-FSR-SO-35	PX-FSR-SS35-000H	11/13/18	*NA*	776
	PX-FSR-SO-36	PX-FSR-SS36-000H	11/13/18	*NA*	6,836
	PX-FSR-SO-37	PX-FSR-SS37-000H	11/13/18	*NA*	12,979
		PX-FSR-SS37P-000H	Field Duplicate	*NA*	11,301
	PX-FSR-SO-38	PX-FSR-SS38-000H	11/14/18	*NA*	15,716
	PX-FSR-SO-39	PX-FSR-SS39-000H	11/14/18	*NA*	6,666
	PX-FSR-SO-40	PX-FSR-SS40-000H	11/14/18	*NA*	7,527
	PX-FSR-SO-41	PX-FSR-SS41-000H	11/14/18	*NA*	3,052
		PX-FSR-SS41P-000H	Field Duplicate	*NA*	4,951
	PX-FSR-SO-42	PX-FSR-SS42-000H	11/14/18	*NA*	3,792
	PX-FSR-SO-43	PX-FSR-SS43-000H	11/14/18	*NA*	17,741
	PX-FSR-SO-44	PX-FSR-SS44-000H	11/14/18	*NA*	333
	PX-FSR-SO-45	PX-FSR-SS45-000H	11/14/18	*NA*	67
	PX-FSR-SO-46	PX-FSR-SS46-000H	11/14/18	*NA*	30
	PX-FSR-SO-47	PX-FSR-SS47-000H	11/14/18	*NA*	89
	PX-FSR-SO-48	PX-FSR-SS48-000H	11/14/18	*NA*	109
	PX-FSR-SO-49	PX-FSR-SS49-000H	11/14/18	*NA*	170
	PX-FSR-SO-50	PX-FSR-SS50-000H	11/14/18	*NA*	276
	PX-FSR-SO-51	PX-FSR-SS51-000H	11/14/18	*NA*	181.1
	PX-FSR-SO-52	PX-FSR-SS52-000H	11/14/18	*NA*	276.6
	PX-FSR-SO-53	PX-FSR-SS53-000H	11/14/18	*NA*	371
	PX-FSR-SO-54	PX-FSR-SS54-000H	11/14/18	*NA*	926
	PX-FSR-SO-55	PX-FSR-SS55-000H	11/14/18	*NA*	3,777
	PX-FSR-SO-56	PX-FSR-SS56-000H	11/14/18	*NA*	341
	PX-FSR-SO-57	PX-FSR-SS57-000H	11/14/18	*NA*	27.6
	Toxicity Test Reference Samples				
	PX-FSR-SO-58	PX-FSR-SS58-000H	11/16/18	20.7	85.2
	PX-FSR-SO-59	PX-FSR-SS59-000H	11/16/18	9.92	50.9

Notes:

NA = not analyzed

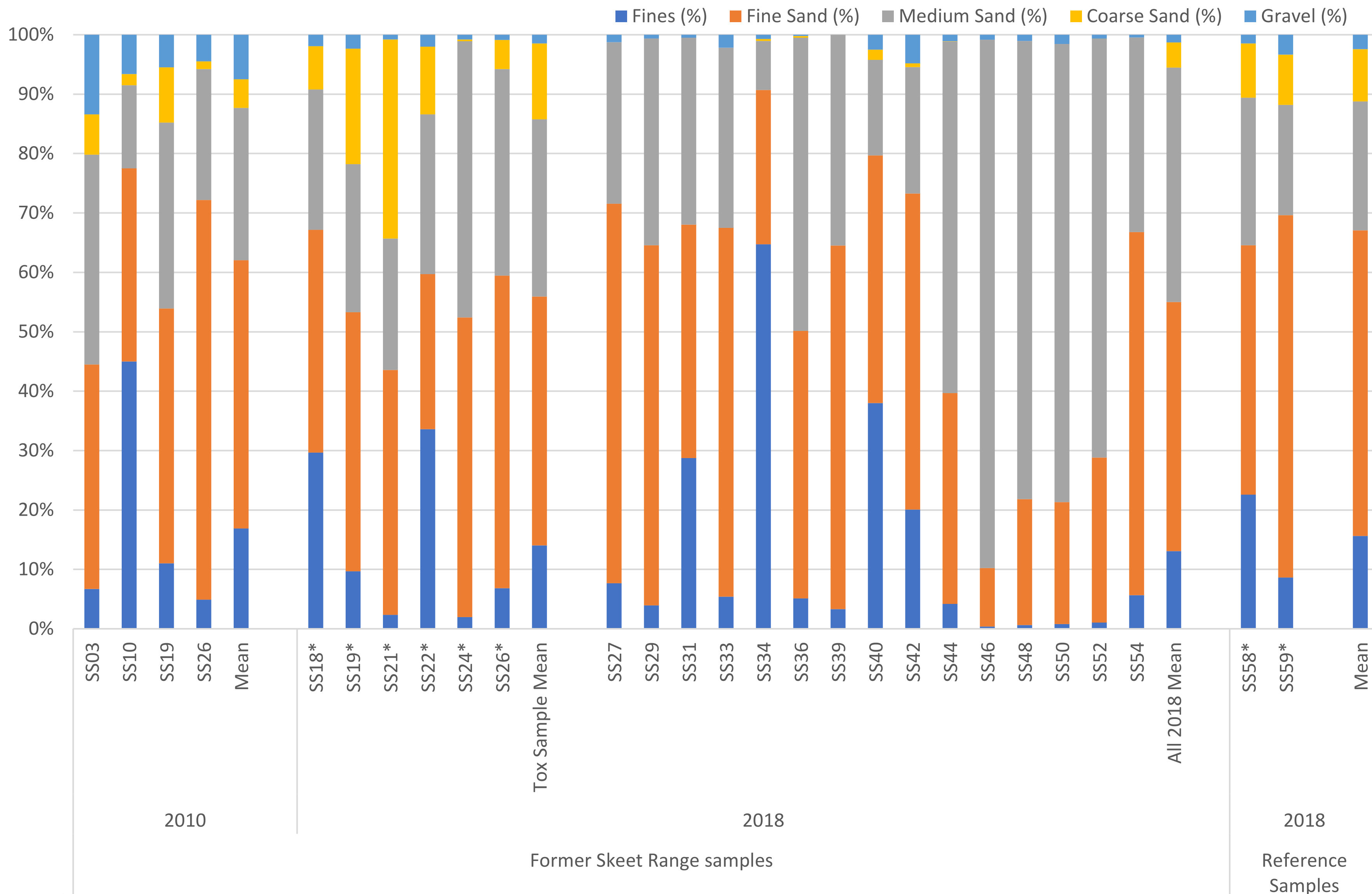
1 - Shaded concentrations exceed the Apparent Effects Thresholds (AETs), or the highest concentration in "unimpacted" samples from the 28-day earthworm toxicity tested samples; The AETs for refined COPCs are:

Lead = 504 mg/kg

HMW PAHs = 72,250 µg/kg

Figures

Figure B1-1. Grain Size Results Summary - 2010 SI and 2018 RI Surface Soil Samples



*sample used for 28-day earthworm toxicity test

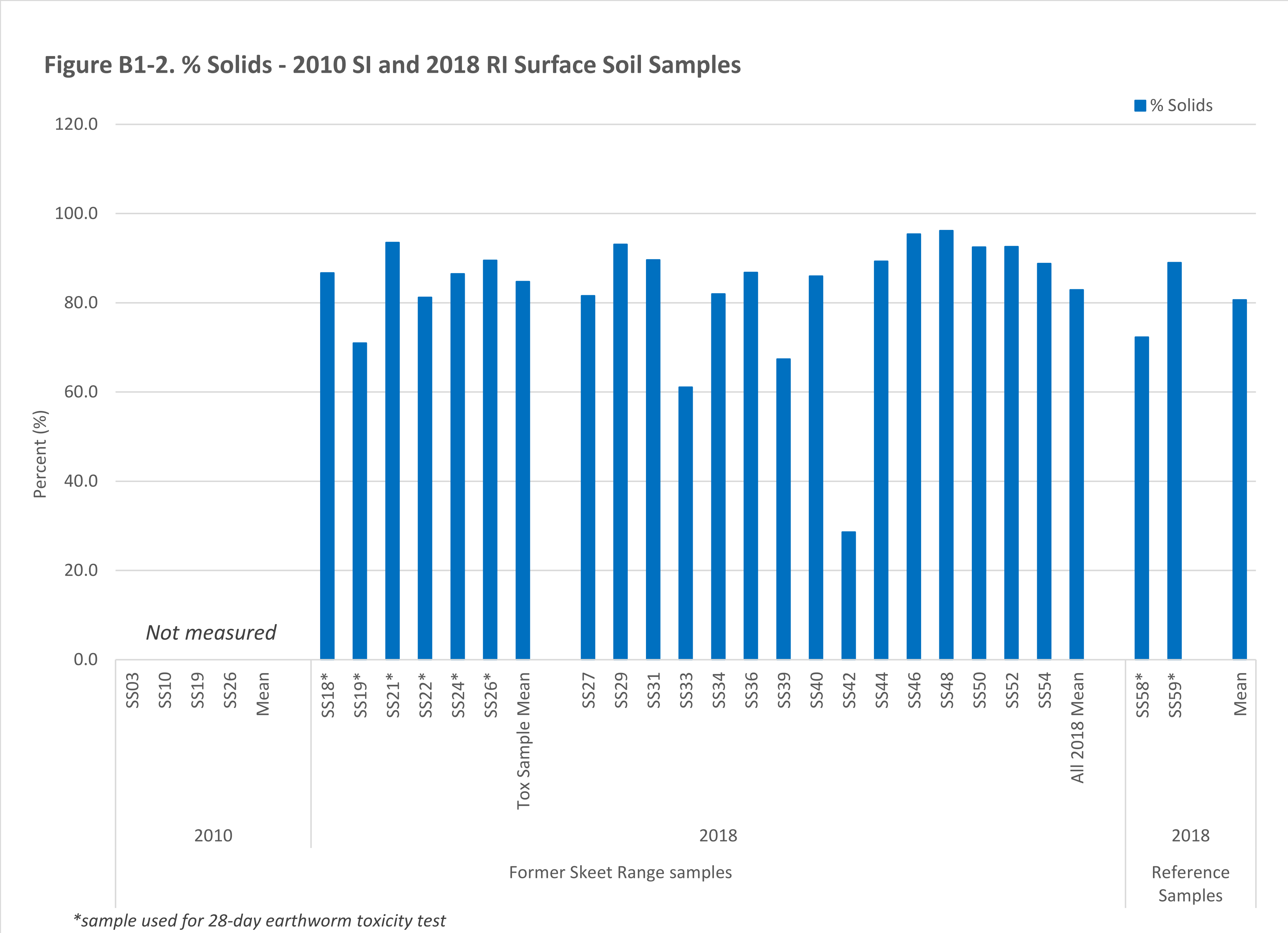


Figure B1-2. % Solids - 2010 SI and 2018 RI Surface Soil Samples
% Solids
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Percent (%)
Not measured
SS03
SS10
SS19
SS26
Mean
SS18*
SS19*
SS21*
SS22*
SS24*
SS26*
Tox Sample Mean
SS27
SS29
SS31
SS33
SS34
SS36
SS39
SS40
SS42
SS44
SS46
SS48
SS50
SS52
SS54
All 2018 Mean
SS58*
SS59*
Mean
2010
2018
2018
Former Skeet Range samples
Reference Samples
*sample used for 28-day earthworm toxicity test

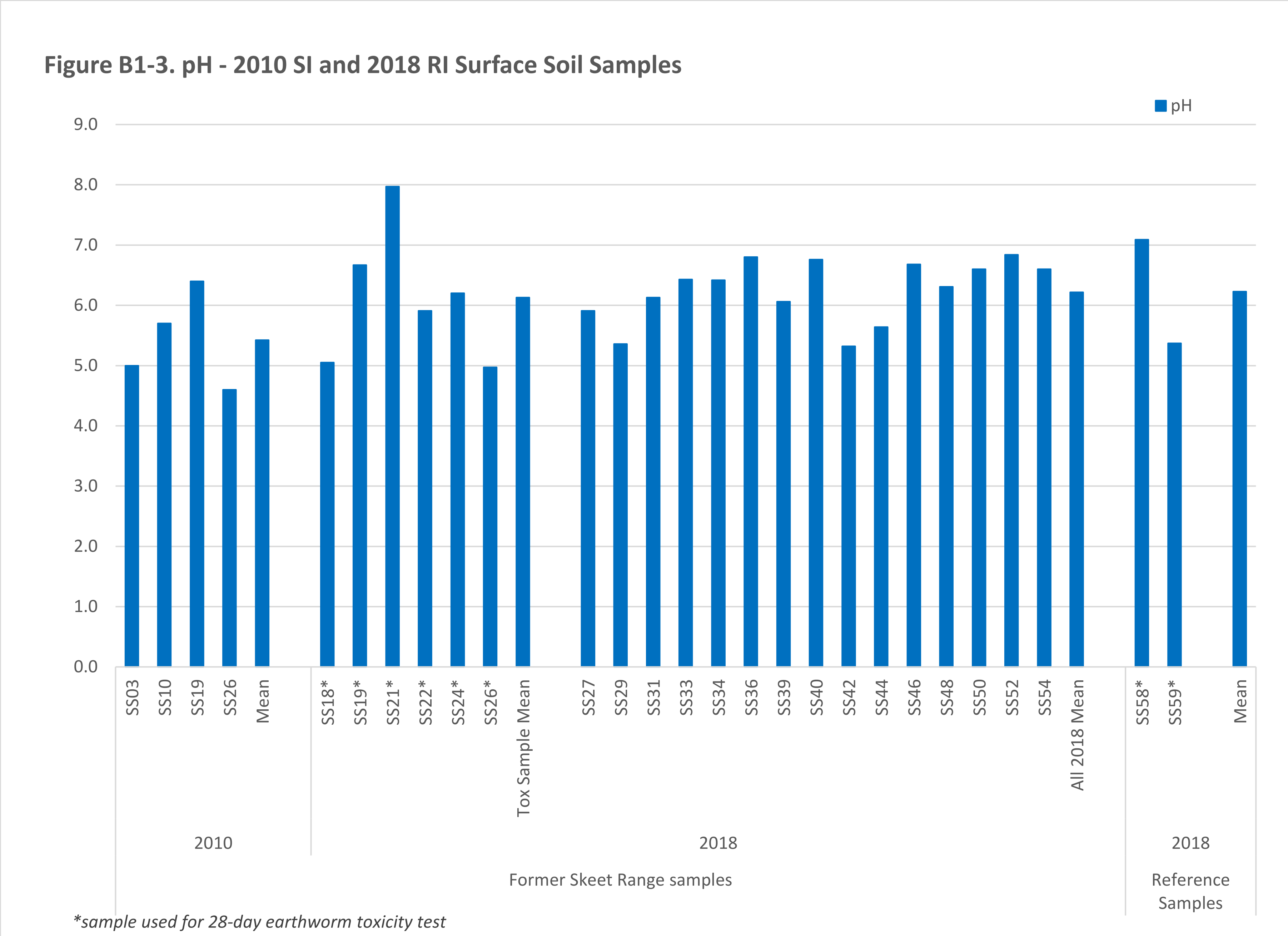
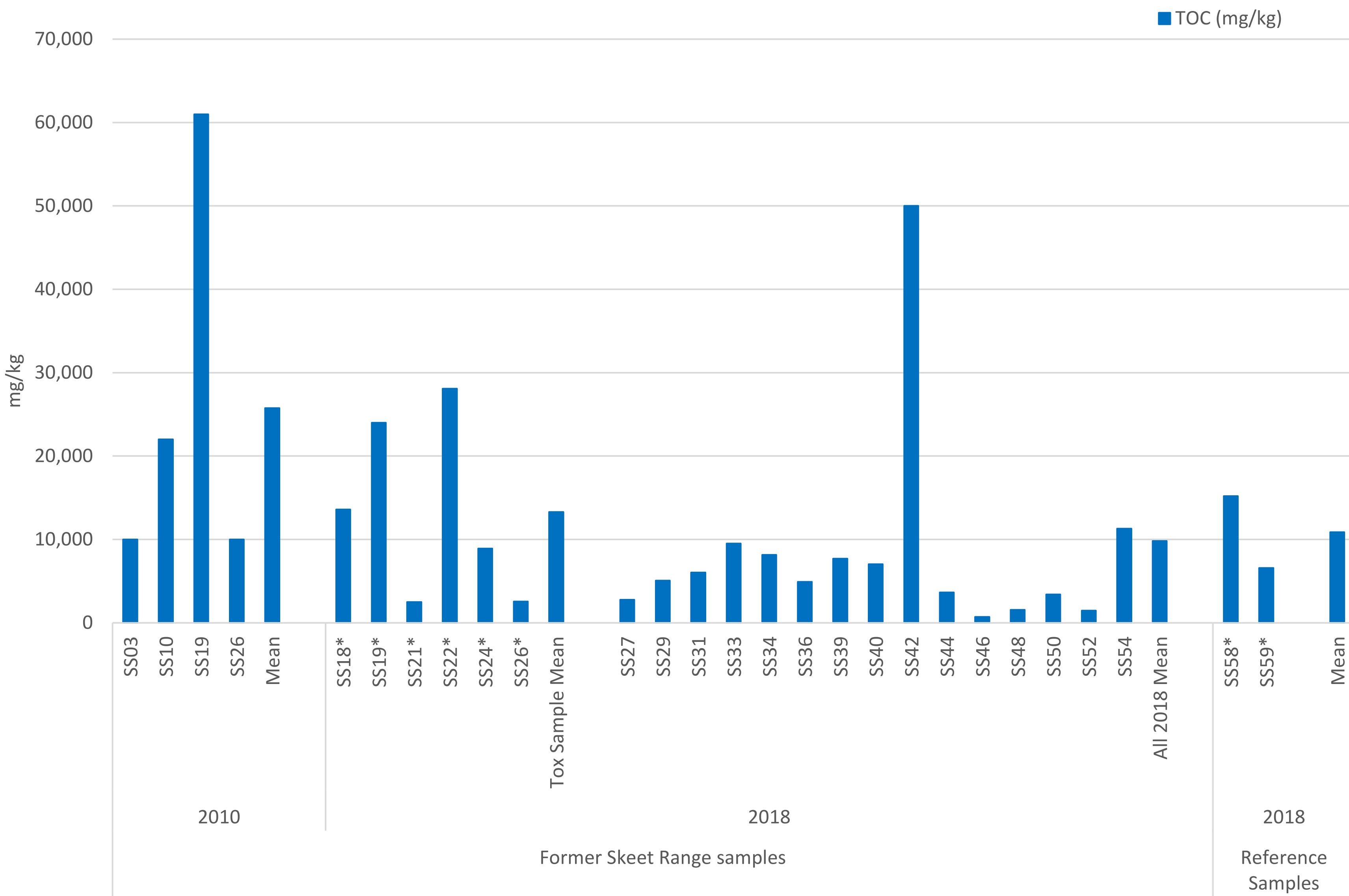


Figure B1-3. pH - 2010 SI and 2018 RI Surface Soil Samples
pH
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
SS03
SS10
SS19
SS26
Mean
SS18*
SS19*
SS21*
SS22*
SS24*
SS26*
Tox Sample Mean
SS27
SS29
SS31
SS33
SS34
SS36
SS39
SS40
SS42
SS44
SS46
SS48
SS50
SS52
SS54
All 2018 Mean
SS58*
SS59*
Mean
2010
2018
2018
Former Skeet Range samples
Reference Samples
*sample used for 28-day earthworm toxicity test

Figure B1-4. Total Organic Carbon - 2010 SI and 2018 RI Surface Soil Samples



*sample used for 28-day earthworm toxicity test

Attachments

Attachment B1-1

Total LMW and HMW PAHs Calculations

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Marys County, Maryland

Station ID		PX-FSR-SO-18		PX-FSR-SO-19	PX-FSR-SO-21	PX-FSR-SO-22	PX-FSR-SO-24	PX-FSR-SO-26	PX-FSR-SO-27		PX-FSR-SO-28	PX-FSR-SO-29	PX-FSR-SO-30		PX-FSR-SO-31	PX-FSR-SO-32	PX-FSR-SO-33
Sample ID		PX-FSR-SS18-000H	PX-FSR-SS18P-000H	PX-FSR-SS19-000H	PX-FSR-SS21-000H	PX-FSR-SS22-000H	PX-FSR-SS24-000H	PX-FSR-SS26-000H	PX-FSR-SS27-000H	PX-FSR-SS27P-000H	PX-FSR-SS28-000H	PX-FSR-SS29-000H	PX-FSR-SS30-000H	PX-FSR-SS30P-000H	PX-FSR-SS31-000H	PX-FSR-SS32-000H	PX-FSR-SS33-000H
Sample Date		11/15/18	Field Duplicate	11/15/18	11/15/18	11/15/18	11/16/18	11/16/18	11/13/18	Field Duplicate	11/13/18	11/13/18	11/13/18	Field Duplicate	11/13/18	11/13/18	11/14/18
Total LMW PAHs (UG/KG)																	
1-Methylnaphthalene		98.6 U	95.7 U	985 U	18.2 U	2,050 U	8.65	1.4 J	1.55 J	1.62 J	240 J	131 J	365	301 J	1.41 J	67.8 J	47.5 U
2-Methylnaphthalene		98.6 U	95.7 U	985 U	18.2 U	2,050 U	11.9	1.61 J	1.64 J	1.85 J	257 J	135 J	410	341 J	1.6 J	77.6 J	47.5 U
Acenaphthene		98.6 U	95.7 U	157 J	18.2 U	411 J	1.89 U	1.85 U	1.94 U	9.4	1,580 J	788	2,520	2,130	8.06	500	203
Acenaphthylene		98.6 U	95.7 U	985 U	18.2 U	2,050 U	1.89 U	1.85 U	1.94 U	1.94 U	964 U	177 U	114 U	455 U	1.84 U	93.9 U	47.5 U
Anthracene		98.6 U	28.1 J	302 J	18.2 U	1,800 J	50.6	16.6	41.5 J	27 J	6,960	3,050	8,960	8,080	26.2	1,640	384
Fluorene		98.6 U	95.7 U	985 U	18.2 U	2,050 U	1.89 U	3.82	6.25	5.19	871 J	427	1,540	1,340	4.72	272	90.8 J
Naphthalene		98.6 U	95.7 U	985 U	18.2 U	2,050 U	9.39	3.32 J	3.89	5.41	747 J	513	1,270	1,010	4.18	222	122
Phenanthrene		98.6 U	123 J	1,200 J	10.2 J	7,150	71.9	83.7	188	127	32,700	13,400	28,300	33,000	125	6,880	1,660
Total HMW PAHs (UG/KG)																	
Benzo(a)anthracene		65.5 J	108 J	2,580	25.3 J	7,320	195 J	110 J	252	252	42,400	18,900	52,400	45,800	205	11,000	5,240
Benzo(a)pyrene		126 J	118 J	2,760	41.3	8,250	228 J	129 J	302	353	51,800	23,200	69,200	60,000	286	14,400	9,660
Benzo(b)fluoranthene		163 J	155 J	3,390	53.4	10,400	461 J	178 J	448	532	25,200	30,800	84,200	76,600	384	17,400	11,800
Benzo(g,h,i)perylene		105 J	75.8 J	1,390 J	34.9 J	4,920	88.5	77	122 J	138 J	24,000 J	10,900 J	40,500 J	28,500 J	160 J	7,880 J	8,010
Benzo(k)fluoranthene		51.3 J	58 J	1,270 J	19.1 J	3,750 J	171 J	67.8 J	167	190	25,700	11,500	27,400	28,900	142	6,800	4,400
Chrysene		87.5 J	118 J	2,700	32.7 J	7,970	270	140	315	329	53,300	23,100	61,700	56,700	269	13,600	6,590
Dibenz(a,h)anthracene		98.6 U	95.7 U	428 J	8.09 J	1,410 J	31.6	20.3	34.2 J	41.6 J	7,150 J	3,150 J	3,610 J	8,080 J	42.4 J	2,340 J	1,820
Fluoranthene		63.4 J	215	3,860	33.1 J	12,200	271	200	425	361	79,100	32,000	57,200	75,100	327	17,800	5,340
Indeno(1,2,3-cd)pyrene		107 J	89.1 J	1,800 J	37.9	5,930	123	87.6	150 J	169 J	27,500 J	13,400 J	48,200 J	33,000 J	188 J	9,050 J	8,710
Pyrene		63.2 J	165 J	3,230	30.6 J	10,100	225 J	148 J	331	304	56,100	22,500	43,400	52,900	233	12,600	5,260
Total LMW PAHs																	
Sum Detects		*Lowest of Parent & Duplicate excluded*	151	1,659	10	9,361	152	110	243	*Lowest of Parent & Duplicate excluded*	43,355	18,444	*Lowest of Parent & Duplicate excluded*	46,202	171	9,659	2,460
Sum Non-Detects (1/2 DL)			287.1	2462.5	63.7	5125	2.835	1.85	1.94		482	88.5		227.5	0.92	46.95	71.25
Sum Total			438	4,122	74	14,486	155	112	245		43,837	18,533		46,430	172	9,706	2,531
Detects Only																	
Minimum	2.6																
Maximum	46,202.0																
Mean	3,720.6																
Standard Deviation	10,588.4																
Samples	37.0																
Detects	37.0																
Exceedances	2.0																
Totals																	
Minimum	7.8																
Maximum	46,429.5																
Mean	3,975.3																
95% UCL	15,023.0																
Standard deviation	10,760.5																
Samples	37.0																
Detects	37.0																
Exceedances	2.0																
Total HMW PAHs																	
Sum Detects		*Lowest of Parent & Duplicate excluded*	1,102	23,408	316	72,250	2,064	1,158	2,546	*Lowest of Parent & Duplicate excluded*	392,250	189,450	487,810	*Lowest of Parent & Duplicate excluded*	2,236	112,870	66,830
Sum Non-Detects (1/2 DL)			47.85	0	0	0	0	0	0		0	0	0		0	0	0
Sum Total			1,150	23,408	316	72,250	2,064	1,158	2,546		392,250	189,450	487,810		2,236	112,870	66,830
Detects Only																	
Minimum	26.7																
Maximum	487,810.0																
Mean	38,919.2																
Standard Deviation	104,827.2																
Samples	37.0																
Detects	37.0																
Exceedances	7.0																
Totals																	
Minimum	27.6																
Maximum	487,810.0																
Mean	38,921.0																
95% UCL	146,543.0																
Standard deviation	104,826.5																
Samples	37.0																
Detects	37.0																
Exceedances	7.0																

Attachment B1-1

Total LMW and HMW PAHs Calculations

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Marys County, Maryland

Station ID		PX-FSR-SO-34		PX-FSR-SO-35	PX-FSR-SO-36	PX-FSR-SO-37		PX-FSR-SO-38	PX-FSR-SO-39	PX-FSR-SO-40	PX-FSR-SO-41		PX-FSR-SO-42	PX-FSR-SO-43	PX-FSR-SO-44	PX-FSR-SO-45	PX-FSR-SO-46
Sample ID		PX-FSR-SS34-000H	PX-FSR-SS34P-000H	PX-FSR-SS35-000H	PX-FSR-SS36-000H	PX-FSR-SS37-000H	PX-FSR-SS37P-000H	PX-FSR-SS38-000H	PX-FSR-SS39-000H	PX-FSR-SS40-000H	PX-FSR-SS41-000H	PX-FSR-SS41P-000H	PX-FSR-SS42-000H	PX-FSR-SS43-000H	PX-FSR-SS44-000H	PX-FSR-SS45-000H	PX-FSR-SS46-000H
Sample Date		11/13/18	Field Duplicate	11/13/18	11/13/18	11/13/18	Field Duplicate	11/14/18	11/14/18	11/14/18	11/14/18	Field Duplicate	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18
Total LMW PAHs (UG/KG)																	
1-Methylnaphthalene		1.92 J	1.27 J	0.904 J	37.7 U	35.8 U	7.39 J	21 U	23.6 U	19.3 U	11.2 U	10.7 U	4.96 U	33.1 U	1.34 J	1.77 U	1.75 U
2-Methylnaphthalene		2.42 J	1.37 J	0.946 J	37.7 U	35.8 U	35.9 U	21 U	23.6 U	19.3 U	11.2 U	10.7 U	4.96 U	33.1 U	1.57 J	1.77 U	1.75 U
Acenaphthene		2.04 U	2.03 U	1.85 U	22.8 J	42.7 J	37.3 J	42.7	22.9 J	17.5 J	11.2 U	15.5 J	4.96 U	33.1 U	1.83 U	1.77 U	1.75 U
Acenaphthylene		2.04 U	2.03 U	1.85 U	37.7 U	35.8 U	35.9 U	21 U	23.6 U	19.3 U	11.2 U	10.7 U	4.96 U	33.1 U	1.83 U	1.77 U	1.75 U
Anthracene		17.4 J	11.3	6.84	65.9 J	227	194	100	69	85.6	26.7	74.4	27.3	144	3.74	0.988 J	0.403 J
Fluorene		4.21	2.43 J	1.71 J	11.1 J	31.9 J	28.9 J	19.9 J	23.6 U	19.3 U	11.2 U	13.1 J	7.92 J	33.1 U	2.23 J	1.77 U	1.75 U
Naphthalene		5.98	3.43 J	1.85 U	11.8 J	15 J	18.2 J	21 U	23.6 U	19.3 U	11.2 U	10.7 U	7.8 J	37.9 J	1.83 U	1.77 U	1.75 U
Phenanthrene		108 J	70.3 J	44.9	371	1,030	920	443	332	454	135 J	380 J	111	632	13.7	3.25 J	2.18 J
Total HMW PAHs (UG/KG)																	
Benzo(a)anthracene		173 J	136	79.9	716	1,460	1,220	1,310	549	651	259 J	428 J	313	1,410	26.6	5.45	2.29 J
Benzo(a)pyrene		240 J	199 J	108 J	853 J	1,690 J	1,410 J	2,240	881	891	367 J	548 J	527	2,310	36.4	4.83	2.5 J
Benzo(b)fluoranthene		119 J	278 J	56 J	458 J	841 J	697 J	2,830	1,150	1,250	507 J	798 J	798	3,110	72.2	15.1	6.29
Benzo(g,h,i)perylene		157 J	120	56.8	482	798	756	1,730	670	691	304	430	328	2,210	20.5	4.17	1.58 J
Benzo(k)fluoranthene		122 J	284 J	57.4 J	468 J	860 J	715 J	1,030	436	441	190	267	239	1,100	23.2	4.55	2.32 J
Chrysene		245 J	190	105	945	1,750	1,520	1,540	655	784	320 J	508 J	397	1,730	37.8	9.26	3.43 J
Dibenz(a,h)anthracene		41.5 J	32.7	16.1	134	238	215	396	148	156	68.9	92.5	79.5	461	4.38	1.77 U	1.75 U
Fluoranthene		290 J	221	132	1,290	2,620	2,330	1,460	738	1,020	361 J	758 J	364	1,660	42	9.04	4.59
Indeno(1,2,3-cd)pyrene		177 J	131	67.1	570	922	838	1,730	718	733	314	441	367	2,110	22.5	4.61	1.9 J
Pyrene		218 J	161 J	97.2 J	920 J	1,800 J	1,600 J	1,450	721	910	361 J	680 J	379	1,640	47.4	9.24	3.92
Total LMW PAHs																	
Sum Detects		140	*Lowest of Parent & Duplicate excluded*	55	483	1,347	*Lowest of Parent & Duplicate excluded*	606	424	557	*Lowest of Parent & Duplicate excluded*	483	154	814	23	4	3
Sum Non-Detects (1/2 DL)		2.04		2.775	56.55	53.7		42	59	48.25		21.4	9.92	82.75	2.745	5.31	5.25
Sum Total		142		58	539	1,400		648	483	605		504	164	897	25	10	8
Detects Only																	
Minimum	2.6																
Maximum	46,202.0																
Mean	3,720.6																
Standard Deviation	10,588.4																
Samples	37.0																
Detects	37.0																
Exceedances	2.0																
Totals																	
Minimum	7.8																
Maximum	46,429.5																
Mean	3,975.3																
95% UCL	15,023.0																
Standard deviation	10,760.5																
Samples	37.0																
Detects	37.0																
Exceedances	2.0																
Total HMW PAHs																	
Sum Detects		1,783	*Lowest of Parent & Duplicate excluded*	776	6,836	12,979	*Lowest of Parent & Duplicate excluded*	15,716	6,666	7,527	*Lowest of Parent & Duplicate excluded*	4,951	3,792	17,741	333	66	29
Sum Non-Detects (1/2 DL)		0		0	0	0		0	0	0		0	0	0	0	0.885	0.875
Sum Total		1,783		776	6,836	12,979		15,716	6,666	7,527		4,951	3,792	17,741	333	67	30
Detects Only																	
Minimum	26.7																
Maximum	487,810.0																
Mean	38,919.2																
Standard Deviation	104,827.2																
Samples	37.0																
Detects	37.0																
Exceedances	7.0																
Totals																	
Minimum	27.6																
Maximum	487,810.0																
Mean	38,921.0																
95% UCL	146,543.0																
Standard deviation	104,826.5																
Samples	37.0																
Detects	37.0																
Exceedances	7.0																

Attachment B1-1

Total LMW and HMW PAHs Calculations

Former Skeet Range, Ecological Risk Assessment (Terrestrial Habitat)

NAS Patuxent River, St. Marys County, Maryland

													Reference Sample	Reference Sample
Station ID		PX-FSR-SO-47	PX-FSR-SO-48	PX-FSR-SO-49	PX-FSR-SO-50	PX-FSR-SO-51	PX-FSR-SO-52	PX-FSR-SO-53	PX-FSR-SO-54	PX-FSR-SO-55	PX-FSR-SO-56	PX-FSR-SO-57	PX-FSR-SO-58	PX-FSR-SO-59
Sample ID		PX-FSR-SS47-000H	PX-FSR-SS48-000H	PX-FSR-SS49-000H	PX-FSR-SS50-000H	PX-FSR-SS51-000H	PX-FSR-SS52-000H	PX-FSR-SS53-000H	PX-FSR-SS54-000H	PX-FSR-SS55-000H	PX-FSR-SS56-000H	PX-FSR-SS57-000H	PX-FSR-SS58-000H	PX-FSR-SS59-000H
Sample Date		11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/14/18	11/16/18	11/16/18
Total LMW PAHs (UG/KG)														
1-Methylnaphthalene		1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U	11.7 U	1.88 U	8.99 U	1.72 U	1.75 U	9.9	9.78
2-Methylnaphthalene		1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U	11.7 U	1.88 U	8.99 U	1.72 U	1.75 U	11.6	11.8
Acenaphthene		1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U	11.7 U	2.26 J	17.3 J	1.72 U	1.75 U	2.17 U	1.94 U
Acenaphthylene		1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U	11.7 U	5.47	8.99 U	1.72 U	1.75 U	2.17 U	1.94 U
Anthracene		1.03 J	1.75 J	3.03 J	4.19 J	2.19 J	1.95 J	3.39 J	10.9	33.2	9.25	0.503 J	2.17 U	1.32 J
Fluorene		1.74 U	1.73 U	9.03 U	14.2 U	1.91 U	9.01 U	11.7 U	3.29 J	7.99 J	1.72 U	1.75 U	2.17 U	1.94 U
Naphthalene		1.74 U	1.73 U	9.03 U	14.2 U	2.49 J	9.01 U	11.7 U	2.23 J	13.2 J	42.7	1.75 U	4.09 J	2.9 J
Phenanthrene		4.35	3.73	5.62 J	12.3 J	15	17.7 J	26.1	77.7	209	49.1	3.26 J	10.6	7.02
Total HMW PAHs (UG/KG)														
Benzo(a)anthracene		6.03	7.79	13.4 J	18.4 J	14	25.3	35	78.9	334	34.8	3.03 J	8.28 J	4.8 J
Benzo(a)pyrene		6.51	8.57	9.03 J	12.9 J	14.1	20.6	28.2	81.3	429	25.1	1.87 J	9.23 J	5.45 J
Benzo(b)fluoranthene		20.3	24.9	44.7	51.9	34.8	49.9	63.5	164	694	39.9	3.28 J	2.17 UJ	1.94 UJ
Benzo(g,h,i)perylene		5.6	8.93	9.03 U	29.6	9.42	13.3 J	24.1	54.3	194	21.4	1.57 J	2.17 U	2.41 J
Benzo(k)fluoranthene		7.6	7.59	13.8 J	13.4 J	9.31	16.3 J	20.9 J	56.3	200	15.6	1.13 J	6.4 J	1.94 UJ
Chrysene		11.2	13	23.5	37.6	20.9	34	48.4	97.9	423	39.3	2.94 J	14.7	8.02
Dibenz(a,h)anthracene		1.21 J	1.94 J	9.03 U	14.2 U	1.97 J	4.4 J	5.65 J	14	52.3	4.96	1.75 U	2.17 U	1.94 U
Fluoranthene		12.4	13.3	25.7	45.8	36.7	54.2	68.1	180	639	69.7	6.52	23.9	13.6
Indeno(1,2,3-cd)pyrene		7.07	10.2	10.4 J	22 J	13	20.2	30	75	279	22.6	1.98 J	2.17 U	2.83 J
Pyrene		10.6	13.2	20.7	37.1	26.9	38.4	46.8	124	533	67.8	4.37	18.3 J	10.9 J
Total LMW PAHs														
Sum Detects		5	5	9	16	20	20	29	102	281	101	4	36	33
Sum Non-Detects (1/2 DL)		5.22	5.19	27.09	42.6	4.775	27.03	35.1	1.88	13.485	4.3	5.25	4.34	2.91
Sum Total		11	11	36	59	24	47	65	104	294	105	9	41	36
Detects Only														
Minimum	2.6													
Maximum	46,202.0													
Mean	3,720.6													
Standard Deviation	10,588.4													
Samples	37.0													
Detects	37.0													
Exceedances	2.0													
Totals														
Minimum	7.8													
Maximum	46,429.5													
Mean	3,975.3													
95% UCL	15,023.0													
Standard deviation	10,760.5													
Samples	37.0													
Detects	37.0													
Exceedances	2.0													
Total HMW PAHs														
Sum Detects		89	109	161	269	181	277	371	926	3,777	341	27	81	48
Sum Non-Detects (1/2 DL)		0	0	9.03	7.1	0	0	0	0	0	0	0.875	4.34	2.91
Sum Total		89	109	170	276	181	277	371	926	3,777	341	28	85	51
Detects Only														
Minimum	26.7													
Maximum	487,810.0													
Mean	38,919.2													
Standard Deviation	104,827.2													
Samples	37.0													
Detects	37.0													
Exceedances	7.0													
Totals														
Minimum	27.6													
Maximum	487,810.0													
Mean	38,921.0													
95% UCL	146,543.0													
Standard deviation	104,826.5													
Samples	37.0													
Detects	37.0													
Exceedances	7.0													

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.11/6/2020 3:15:33 PM
From File	Pb input.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Lead-2010

General Statistics

Total Number of Observations	26	Number of Distinct Observations	25
		Number of Missing Observations	0
Minimum	5.8	Mean	70.74
Maximum	330	Median	31.8
SD	85.14	Std. Error of Mean	16.7
Coefficient of Variation	1.204	Skewness	1.89

Normal GOF Test

Shapiro Wilk Test Statistic	0.732	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.92	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.255	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.17	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	99.26	95% Adjusted-CLT UCL (Chen-1995)	104.8
		95% Modified-t UCL (Johnson-1978)	100.3

Gamma GOF Test

A-D Test Statistic	0.74	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.776	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.164	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.177	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.947	k star (bias corrected MLE)	0.863
Theta hat (MLE)	74.72	Theta star (bias corrected MLE)	81.96
nu hat (MLE)	49.23	nu star (bias corrected)	44.88
MLE Mean (bias corrected)	70.74	MLE Sd (bias corrected)	76.14
		Approximate Chi Square Value (0.05)	30.51
Adjusted Level of Significance	0.0398	Adjusted Chi Square Value	29.73

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	104	95% Adjusted Gamma UCL (use when n<50)	106.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.959	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.92	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.115	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.17	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.758	Mean of logged Data	3.645
Maximum of Logged Data	5.799	SD of logged Data	1.141

Assuming Lognormal Distribution

95% H-UCL	135.7	90% Chebyshev (MVUE) UCL	126
95% Chebyshev (MVUE) UCL	151.1	97.5% Chebyshev (MVUE) UCL	185.9
99% Chebyshev (MVUE) UCL	254.3		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	98.2	95% Jackknife UCL	99.26
95% Standard Bootstrap UCL	97.71	95% Bootstrap-t UCL	113
95% Hall's Bootstrap UCL	105.2	95% Percentile Bootstrap UCL	100.2
95% BCA Bootstrap UCL	108.3		
90% Chebyshev(Mean, Sd) UCL	120.8	95% Chebyshev(Mean, Sd) UCL	143.5
97.5% Chebyshev(Mean, Sd) UCL	175	99% Chebyshev(Mean, Sd) UCL	236.9

Suggested UCL to Use

95% Adjusted Gamma UCL	106.8

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Lead-2018

General Statistics

Total Number of Observations	13	Number of Distinct Observations	13
		Number of Missing Observations	0
Minimum	5.35	Mean	146.8
Maximum	621	Median	81
SD	191.3	Std. Error of Mean	53.06
Coefficient of Variation	1.303	Skewness	2

Normal GOF Test

Shapiro Wilk Test Statistic	0.683	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.337	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.234	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	241.3	95% Adjusted-CLT UCL (Chen-1995)	265.5
		95% Modified-t UCL (Johnson-1978)	246.2

Gamma GOF Test

A-D Test Statistic	0.435	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.768	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.19	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.245	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.804	k star (bias corrected MLE)	0.67
Theta hat (MLE)	182.5	Theta star (bias corrected MLE)	219.1
nu hat (MLE)	20.91	nu star (bias corrected)	17.42
MLE Mean (bias corrected)	146.8	MLE Sd (bias corrected)	179.3
		Approximate Chi Square Value (0.05)	8.974
Adjusted Level of Significance	0.0301	Adjusted Chi Square Value	8.123

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	284.9	95% Adjusted Gamma UCL (use when n<50)	314.8

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.949	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.866	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.148	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.234	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.677	Mean of logged Data	4.252
Maximum of Logged Data	6.431	SD of logged Data	1.377

Assuming Lognormal Distribution

95% H-UCL	741.6	90% Chebyshev (MVUE) UCL	364.5
95% Chebyshev (MVUE) UCL	456.8	97.5% Chebyshev (MVUE) UCL	584.9
99% Chebyshev (MVUE) UCL	836.6		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	234.1	95% Jackknife UCL	241.3
95% Standard Bootstrap UCL	229.3	95% Bootstrap-t UCL	474.2
95% Hall's Bootstrap UCL	793.5	95% Percentile Bootstrap UCL	240.5
95% BCA Bootstrap UCL	269.5		
90% Chebyshev(Mean, Sd) UCL	306	95% Chebyshev(Mean, Sd) UCL	378.1
97.5% Chebyshev(Mean, Sd) UCL	478.1	99% Chebyshev(Mean, Sd) UCL	674.7

Suggested UCL to Use

95% Adjusted Gamma UCL 314.8

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Lead-ALL

General Statistics

Total Number of Observations	39	Number of Distinct Observations	38
		Number of Missing Observations	0
Minimum	5.35	Mean	96.09
Maximum	621	Median	55.6
SD	132.8	Std. Error of Mean	21.27
Coefficient of Variation	1.382	Skewness	2.644

Normal GOF Test

Shapiro Wilk Test Statistic	0.663	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.939	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.258	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.14	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	131.9	95% Adjusted-CLT UCL (Chen-1995)	140.7
		95% Modified-t UCL (Johnson-1978)	133.4

Gamma GOF Test

A-D Test Statistic	0.749	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.786	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.122	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.146	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.824	k star (bias corrected MLE)	0.777
Theta hat (MLE)	116.7	Theta star (bias corrected MLE)	123.6
nu hat (MLE)	64.24	nu star (bias corrected)	60.63
MLE Mean (bias corrected)	96.09	MLE Sd (bias corrected)	109
		Approximate Chi Square Value (0.05)	43.73
Adjusted Level of Significance	0.0437	Adjusted Chi Square Value	43.16

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	133.2	95% Adjusted Gamma UCL (use when n<50)	135

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.969	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.939	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0909	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.14	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.677	Mean of logged Data	3.847
Maximum of Logged Data	6.431	SD of logged Data	1.24

Assuming Lognormal Distribution

95% H-UCL	174	90% Chebyshev (MVUE) UCL	169.6
95% Chebyshev (MVUE) UCL	202.1	97.5% Chebyshev (MVUE) UCL	247.1
99% Chebyshev (MVUE) UCL	335.7		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	131.1	95% Jackknife UCL	131.9
95% Standard Bootstrap UCL	130.7	95% Bootstrap-t UCL	151.5
95% Hall's Bootstrap UCL	161.6	95% Percentile Bootstrap UCL	132.8
95% BCA Bootstrap UCL	138.6		
90% Chebyshev(Mean, Sd) UCL	159.9	95% Chebyshev(Mean, Sd) UCL	188.8
97.5% Chebyshev(Mean, Sd) UCL	228.9	99% Chebyshev(Mean, Sd) UCL	307.7

Suggested UCL to Use

95% Adjusted Gamma UCL	135

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.112/20/2019 12:23:27 PM
From File	PAH compounds.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acenaphthene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	44
		Number of Missing Observations	7
Number of Detects	26	Number of Non-Detects	22
Number of Distinct Detects	25	Number of Distinct Non-Detects	19
Minimum Detect	2.26	Minimum Non-Detect	1.72
Maximum Detect	2520	Maximum Non-Detect	98.6
Variance Detects	502175	Percent Non-Detects	45.83%
Mean Detects	352.1	SD Detects	708.6
Median Detects	24.45	CV Detects	2.012
Skewness Detects	2.445	Kurtosis Detects	5.114
Mean of Logged Detects	3.995	SD of Logged Detects	2.038

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.548	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.92	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.338	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.17	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	192	KM Standard Error of Mean	79.52
KM SD	540.2	95% KM (BCA) UCL	350.8
95% KM (t) UCL	325.5	95% KM (Percentile Bootstrap) UCL	330.7
95% KM (z) UCL	322.8	95% KM Bootstrap t UCL	470.1
90% KM Chebyshev UCL	430.6	95% KM Chebyshev UCL	538.6
97.5% KM Chebyshev UCL	688.6	99% KM Chebyshev UCL	983.3

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.782	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.839	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.255	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.184	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.358	k star (bias corrected MLE)	0.343
Theta hat (MLE)	982.4	Theta star (bias corrected MLE)	1027
nu hat (MLE)	18.64	nu star (bias corrected)	17.82
Mean (detects)	352.1		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	190.8
Maximum	2520	Median	3.35
SD	546.4	CV	2.864
k hat (MLE)	0.148	k star (bias corrected MLE)	0.153
Theta hat (MLE)	1288	Theta star (bias corrected MLE)	1249
nu hat (MLE)	14.22	nu star (bias corrected)	14.67
Adjusted Level of Significance (β)	0.045		
Approximate Chi Square Value (14.67, α)	7.03	Adjusted Chi Square Value (14.67, β)	6.866
95% Gamma Approximate UCL (use when n>=50)	398	95% Gamma Adjusted UCL (use when n<50)	407.5

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	192	SD (KM)	540.2
Variance (KM)	291863	SE of Mean (KM)	79.52
k hat (KM)	0.126	k star (KM)	0.132
nu hat (KM)	12.13	nu star (KM)	12.7
theta hat (KM)	1520	theta star (KM)	1451
80% gamma percentile (KM)	186.7	90% gamma percentile (KM)	557.1
95% gamma percentile (KM)	1081	99% gamma percentile (KM)	2641

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (12.70, α)	5.694	Adjusted Chi Square Value (12.70, β)	5.548
95% Gamma Approximate KM-UCL (use when n>=50)	428.4	95% Gamma Adjusted KM-UCL (use when n<50)	439.7

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.933	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.92	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.18	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.17	Detected Data Not Lognormal at 5% Significance Level	

Detected Data appear Approximate Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	191.1	Mean in Log Scale	1.889
SD in Original Scale	546.3	SD in Log Scale	2.798
95% t UCL (assumes normality of ROS data)	323.4	95% Percentile Bootstrap UCL	333.5
95% BCA Bootstrap UCL	361.4	95% Bootstrap t UCL	464.1
95% H-UCL (Log ROS)	2303		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.496	KM Geo Mean	12.13
KM SD (logged)	2.227	95% Critical H Value (KM-Log)	3.921
KM Standard Error of Mean (logged)	0.332	95% H-UCL (KM -Log)	517.5
KM SD (logged)	2.227	95% Critical H Value (KM-Log)	3.921
KM Standard Error of Mean (logged)	0.332		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	193.3	Mean in Log Scale	2.552
SD in Original Scale	545.6	SD in Log Scale	2.315
95% t UCL (Assumes normality)	325.4	95% H-Stat UCL	733.6

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

97.5% KM (Chebyshev) UCL 688.6

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Acenaphthylene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	42
		Number of Missing Observations	7
Number of Detects	3	Number of Non-Detects	45
Number of Distinct Detects	3	Number of Distinct Non-Detects	39
Minimum Detect	2.2	Minimum Non-Detect	1.72
Maximum Detect	5.47	Maximum Non-Detect	2050
Variance Detects	2.965	Percent Non-Detects	93.75%
Mean Detects	3.523	SD Detects	1.722
Median Detects	2.9	CV Detects	0.489
Skewness Detects	1.416	Kurtosis Detects	N/A
Mean of Logged Detects	1.184	SD of Logged Detects	0.467

Warning: Data set has only 3 Detected Values.

This is not enough to compute meaningful or reliable statistics and estimates.

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.902	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.308	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.425	Detected Data appear Normal at 5% Significance Level

Detected Data appear Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	2.026	KM Standard Error of Mean	0.256
KM SD	0.885	95% KM (BCA) UCL	N/A
95% KM (t) UCL	2.456	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	2.448	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	2.795	95% KM Chebyshev UCL	3.144
97.5% KM Chebyshev UCL	3.627	99% KM Chebyshev UCL	4.577

Gamma GOF Tests on Detected Observations Only

Not Enough Data to Perform GOF Test

Gamma Statistics on Detected Data Only

k hat (MLE)	6.806	k star (bias corrected MLE)	N/A
Theta hat (MLE)	0.518	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	40.84	nu star (bias corrected)	N/A
Mean (detects)	3.523		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	0.254
Maximum	5.47	Median	0.01
SD	0.94	CV	3.694
k hat (MLE)	0.255	k star (bias corrected MLE)	0.253
Theta hat (MLE)	0.997	Theta star (bias corrected MLE)	1.005
nu hat (MLE)	24.49	nu star (bias corrected)	24.3
Adjusted Level of Significance (β)	0.045		
Approximate Chi Square Value (24.30, α)	14.07	Adjusted Chi Square Value (24.30, β)	13.83
95% Gamma Approximate UCL (use when n>=50)	0.439	95% Gamma Adjusted UCL (use when n<50)	N/A

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	2.026	SD (KM)	0.885
Variance (KM)	0.783	SE of Mean (KM)	0.256
k hat (KM)	5.242	k star (KM)	4.929
nu hat (KM)	503.3	nu star (KM)	473.2
theta hat (KM)	0.387	theta star (KM)	0.411
80% gamma percentile (KM)	2.728	90% gamma percentile (KM)	3.248
95% gamma percentile (KM)	3.723	99% gamma percentile (KM)	4.726

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (473.16, α)	423.7	Adjusted Chi Square Value (473.16, β)	422.3
95% Gamma Approximate KM-UCL (use when n>=50)	2.263	95% Gamma Adjusted KM-UCL (use when n<50)	2.27

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.951	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.268	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.425	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.814	Mean in Log Scale	-0.393
SD in Original Scale	0.816	SD in Log Scale	0.505
95% t UCL (assumes normality of ROS data)	1.012	95% Percentile Bootstrap UCL	1.022
95% BCA Bootstrap UCL	1.109	95% Bootstrap t UCL	1.313
95% H-UCL (Log ROS)	0.882		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	0.652	KM Geo Mean	1.919
KM SD (logged)	0.286	95% Critical H Value (KM-Log)	1.794
KM Standard Error of Mean (logged)	0.0832	95% H-UCL (KM -Log)	2.155
KM SD (logged)	0.286	95% Critical H Value (KM-Log)	1.794
KM Standard Error of Mean (logged)	0.0832		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	55.3	Mean in Log Scale	1.839
SD in Original Scale	175.4	SD in Log Scale	1.814
95% t UCL (Assumes normality)	97.78	95% H-Stat UCL	78.97

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL 2.456

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Anthracene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	7
Number of Detects	47	Number of Non-Detects	1
Number of Distinct Detects	47	Number of Distinct Non-Detects	1
Minimum Detect	0.403	Minimum Non-Detect	18.2
Maximum Detect	9400	Maximum Non-Detect	18.2
Variance Detects	4508121	Percent Non-Detects	2.083%
Mean Detects	743.1	SD Detects	2123
Median Detects	33.2	CV Detects	2.857
Skewness Detects	3.427	Kurtosis Detects	11.06
Mean of Logged Detects	3.677	SD of Logged Detects	2.53

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.397	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.946	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.418	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.128	Detected Data Not Normal at 5% Significance Level	

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	727.7	KM Standard Error of Mean	303.6
KM SD	2081	95% KM (BCA) UCL	1286
95% KM (t) UCL	1237	95% KM (Percentile Bootstrap) UCL	1243
95% KM (z) UCL	1227	95% KM Bootstrap t UCL	1740
90% KM Chebyshev UCL	1639	95% KM Chebyshev UCL	2051
97.5% KM Chebyshev UCL	2624	99% KM Chebyshev UCL	3749

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	3.843	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.89	Detected Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.247	**Kolmogorov-Smirnov GOF**	
5% K-S Critical Value	0.142	Detected Data Not Gamma Distributed at 5% Significance Level	

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.243	k star (bias corrected MLE)	0.242
Theta hat (MLE)	3056	Theta star (bias corrected MLE)	3073
nu hat (MLE)	22.86	nu star (bias corrected)	22.73
Mean (detects)	743.1		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	727.6
Maximum	9400	Median	30.65
SD	2103	CV	2.891
k hat (MLE)	0.233	k star (bias corrected MLE)	0.232
Theta hat (MLE)	3125	Theta star (bias corrected MLE)	3134
nu hat (MLE)	22.35	nu star (bias corrected)	22.29
Adjusted Level of Significance (β)	0.045		
Approximate Chi Square Value (22.29, α)	12.56	Adjusted Chi Square Value (22.29, β)	12.33
95% Gamma Approximate UCL (use when n>=50)	1292	95% Gamma Adjusted UCL (use when n<50)	1315

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	727.7	SD (KM)	2081

Variance (KM)	4331353	SE of Mean (KM)	303.6
k hat (KM)	0.122	k star (KM)	0.129
nu hat (KM)	11.74	nu star (KM)	12.34
theta hat (KM)	5952	theta star (KM)	5663
80% gamma percentile (KM)	687.1	90% gamma percentile (KM)	2098
95% gamma percentile (KM)	4114	99% gamma percentile (KM)	10165

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (12.34, α)	5.45	Adjusted Chi Square Value (12.34, β)	5.308
95% Gamma Approximate KM-UCL (use when n>=50)	1647	95% Gamma Adjusted KM-UCL (use when n<50)	1691

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.963	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.946	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0821	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.128	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	727.7	Mean in Log Scale	3.631
SD in Original Scale	2103	SD in Log Scale	2.523
95% t UCL (assumes normality of ROS data)	1237	95% Percentile Bootstrap UCL	1256
95% BCA Bootstrap UCL	1365	95% Bootstrap t UCL	1646
95% H-UCL (Log ROS)	4511		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	3.628	KM Geo Mean	37.63
KM SD (logged)	2.505	95% Critical H Value (KM-Log)	4.322
KM Standard Error of Mean (logged)	0.366	95% H-UCL (KM -Log)	4209
KM SD (logged)	2.505	95% Critical H Value (KM-Log)	4.322
KM Standard Error of Mean (logged)	0.366		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	727.8	Mean in Log Scale	3.646
SD in Original Scale	2103	SD in Log Scale	2.512
95% t UCL (Assumes normality)	1237	95% H-Stat UCL	4399

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

97.5% KM (Chebyshev) UCL 2624

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Benzo(a)anthracene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	47
		Number of Missing Observations	7
Minimum	2.29	Mean	4684
Maximum	62000	Median	228.5
SD	13031	Std. Error of Mean	1881
Coefficient of Variation	2.782	Skewness	3.517

Normal GOF Test

Shapiro Wilk Test Statistic	0.411	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.391	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	7840	95% Adjusted-CLT UCL (Chen-1995)	8798
		95% Modified-t UCL (Johnson-1978)	7999

Gamma GOF Test

A-D Test Statistic	3.002	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.887	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.217	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.25	k star (bias corrected MLE)	0.248
Theta hat (MLE)	18749	Theta star (bias corrected MLE)	18879
nu hat (MLE)	23.98	nu star (bias corrected)	23.82
MLE Mean (bias corrected)	4684	MLE Sd (bias corrected)	9403
		Approximate Chi Square Value (0.05)	13.71
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	13.47

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	8137	95% Adjusted Gamma UCL (use when n<50)	8281

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.971	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0557	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.829	Mean of logged Data	5.608
Maximum of Logged Data	11.03	SD of logged Data	2.603

Assuming Lognormal Distribution

95% H-UCL	43914	90% Chebyshev (MVUE) UCL	17005
95% Chebyshev (MVUE) UCL	21901	97.5% Chebyshev (MVUE) UCL	28696
99% Chebyshev (MVUE) UCL	42044		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	7777	95% Jackknife UCL	7840
95% Standard Bootstrap UCL	7848	95% Bootstrap-t UCL	11546
95% Hall's Bootstrap UCL	7913	95% Percentile Bootstrap UCL	7787
95% BCA Bootstrap UCL	8878		
90% Chebyshev(Mean, Sd) UCL	10326	95% Chebyshev(Mean, Sd) UCL	12882
97.5% Chebyshev(Mean, Sd) UCL	16430	99% Chebyshev(Mean, Sd) UCL	23398

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	16430

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Benzo(a)pyrene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	7
Minimum	1.87	Mean	6019
Maximum	81000	Median	319.5
SD	16827	Std. Error of Mean	2429
Coefficient of Variation	2.795	Skewness	3.581

Normal GOF Test

Shapiro Wilk Test Statistic	0.409	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.398	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	10095	95% Adjusted-CLT UCL (Chen-1995)	11356
		95% Modified-t UCL (Johnson-1978)	10304

Gamma GOF Test

A-D Test Statistic	2.612	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.89	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.197	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.141	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.244	k star (bias corrected MLE)	0.243
Theta hat (MLE)	24662	Theta star (bias corrected MLE)	24801
nu hat (MLE)	23.43	nu star (bias corrected)	23.3
MLE Mean (bias corrected)	6019	MLE Sd (bias corrected)	12218
		Approximate Chi Square Value (0.05)	13.32
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	13.08

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	10531	95% Adjusted Gamma UCL (use when n<50)	10720

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.973	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0551	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.626	Mean of logged Data	5.781
Maximum of Logged Data	11.3	SD of logged Data	2.73

Assuming Lognormal Distribution

95% H-UCL	85857	90% Chebyshev (MVUE) UCL	28130
95% Chebyshev (MVUE) UCL	36389	97.5% Chebyshev (MVUE) UCL	47851
99% Chebyshev (MVUE) UCL	70366		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	10014	95% Jackknife UCL	10095
95% Standard Bootstrap UCL	9984	95% Bootstrap-t UCL	14567
95% Hall's Bootstrap UCL	10646	95% Percentile Bootstrap UCL	10325
95% BCA Bootstrap UCL	11742		
90% Chebyshev(Mean, Sd) UCL	13306	95% Chebyshev(Mean, Sd) UCL	16606
97.5% Chebyshev(Mean, Sd) UCL	21187	99% Chebyshev(Mean, Sd) UCL	30186

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	21187

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Benzo(b)fluoranthene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	45
		Number of Missing Observations	7
Minimum	3.28	Mean	6882
Maximum	110000	Median	459.5
SD	20232	Std. Error of Mean	2920
Coefficient of Variation	2.94	Skewness	4.209

Normal GOF Test

Shapiro Wilk Test Statistic	0.388	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.381	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	11782	95% Adjusted-CLT UCL (Chen-1995)	13581
		95% Modified-t UCL (Johnson-1978)	12078

Gamma GOF Test

A-D Test Statistic	2.965	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.879	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.228	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.265	k star (bias corrected MLE)	0.263
Theta hat (MLE)	25938	Theta star (bias corrected MLE)	26204
nu hat (MLE)	25.47	nu star (bias corrected)	25.21
MLE Mean (bias corrected)	6882	MLE Sd (bias corrected)	13429
		Approximate Chi Square Value (0.05)	14.78
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	14.53

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	11745	95% Adjusted Gamma UCL (use when n<50)	11945

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.974	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0927	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.188	Mean of logged Data	6.185
Maximum of Logged Data	11.61	SD of logged Data	2.467

Assuming Lognormal Distribution

95% H-UCL	47220	90% Chebyshev (MVUE) UCL	21509
95% Chebyshev (MVUE) UCL	27558	97.5% Chebyshev (MVUE) UCL	35953
99% Chebyshev (MVUE) UCL	52443		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	11686	95% Jackknife UCL	11782
95% Standard Bootstrap UCL	11682	95% Bootstrap-t UCL	20721
95% Hall's Bootstrap UCL	30972	95% Percentile Bootstrap UCL	12158
95% BCA Bootstrap UCL	13682		
90% Chebyshev(Mean, Sd) UCL	15643	95% Chebyshev(Mean, Sd) UCL	19611
97.5% Chebyshev(Mean, Sd) UCL	25119	99% Chebyshev(Mean, Sd) UCL	35938

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	25119

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Benzo(g,h,i)perylene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	7
Number of Detects	47	Number of Non-Detects	1
Number of Distinct Detects	47	Number of Distinct Non-Detects	1
Minimum Detect	1.57	Minimum Non-Detect	9.03
Maximum Detect	51000	Maximum Non-Detect	9.03
Variance Detects	98498066	Percent Non-Detects	2.083%
Mean Detects	3555	SD Detects	9925
Median Detects	190	CV Detects	2.791
Skewness Detects	3.832	Kurtosis Detects	14.95
Mean of Logged Detects	5.454	SD of Logged Detects	2.601

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.411	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.946	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.384	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.128	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	3481	KM Standard Error of Mean	1419
KM SD	9729	95% KM (BCA) UCL	6025
95% KM (t) UCL	5863	95% KM (Percentile Bootstrap) UCL	5966
95% KM (z) UCL	5816	95% KM Bootstrap t UCL	8558
90% KM Chebyshev UCL	7740	95% KM Chebyshev UCL	9669
97.5% KM Chebyshev UCL	12346	99% KM Chebyshev UCL	17605

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.494	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.882	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.215	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.142	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.259	k star (bias corrected MLE)	0.257
Theta hat (MLE)	13708	Theta star (bias corrected MLE)	13835
nu hat (MLE)	24.38	nu star (bias corrected)	24.16
Mean (detects)	3555		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	3481
Maximum	51000	Median	175
SD	9832	CV	2.824
k hat (MLE)	0.245	k star (bias corrected MLE)	0.243
Theta hat (MLE)	14219	Theta star (bias corrected MLE)	14302
nu hat (MLE)	23.5	nu star (bias corrected)	23.37
Adjusted Level of Significance (β)	0.045		
Approximate Chi Square Value (23.37, α)	13.37	Adjusted Chi Square Value (23.37, β)	13.13
95% Gamma Approximate UCL (use when n>=50)	6085	95% Gamma Adjusted UCL (use when n<50)	6194

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	3481	SD (KM)	9729
Variance (KM)	94651214	SE of Mean (KM)	1419
k hat (KM)	0.128	k star (KM)	0.134
nu hat (KM)	12.29	nu star (KM)	12.86
theta hat (KM)	27187	theta star (KM)	25993
80% gamma percentile (KM)	3426	90% gamma percentile (KM)	10126
95% gamma percentile (KM)	19553	99% gamma percentile (KM)	47584

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (12.86, α)	5.797	Adjusted Chi Square Value (12.86, β)	5.65
95% Gamma Approximate KM-UCL (use when n>=50)	7721	95% Gamma Adjusted KM-UCL (use when n<50)	7923

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.976	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.946	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0604	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.128	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	3481	Mean in Log Scale	5.363
SD in Original Scale	9832	SD in Log Scale	2.648
95% t UCL (assumes normality of ROS data)	5863	95% Percentile Bootstrap UCL	6124
95% BCA Bootstrap UCL	7041	95% Bootstrap t UCL	8884
95% H-UCL (Log ROS)	40987		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	5.366	KM Geo Mean	214.1
KM SD (logged)	2.618	95% Critical H Value (KM-Log)	4.487
KM Standard Error of Mean (logged)	0.382	95% H-UCL (KM -Log)	36546
KM SD (logged)	2.618	95% Critical H Value (KM-Log)	4.487
KM Standard Error of Mean (logged)	0.382		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	3481	Mean in Log Scale	5.372
SD in Original Scale	9832	SD in Log Scale	2.635
95% t UCL (Assumes normality)	5863	95% H-Stat UCL	39297

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

97.5% KM (Chebyshev) UCL 12346

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Benzo(k)fluoranthene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	47
		Number of Missing Observations	7
Minimum	1.13	Mean	2913
Maximum	43000	Median	195
SD	8223	Std. Error of Mean	1187
Coefficient of Variation	2.823	Skewness	3.742

Normal GOF Test

Shapiro Wilk Test Statistic	0.41	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.392	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	4905	95% Adjusted-CLT UCL (Chen-1995)	5551
		95% Modified-t UCL (Johnson-1978)	5012

Gamma GOF Test

A-D Test Statistic	3.03	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.884	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.219	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.256	k star (bias corrected MLE)	0.254
Theta hat (MLE)	11361	Theta star (bias corrected MLE)	11456
nu hat (MLE)	24.62	nu star (bias corrected)	24.41
MLE Mean (bias corrected)	2913	MLE Sd (bias corrected)	5777
		Approximate Chi Square Value (0.05)	14.16
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	13.92

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	5022	95% Adjusted Gamma UCL (use when n<50)	5109

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.973	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0844	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.122	Mean of logged Data	5.219
Maximum of Logged Data	10.67	SD of logged Data	2.543

Assuming Lognormal Distribution

95% H-UCL	23717	90% Chebyshev (MVUE) UCL	9887
95% Chebyshev (MVUE) UCL	12706	97.5% Chebyshev (MVUE) UCL	16617
99% Chebyshev (MVUE) UCL	24301		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	4866	95% Jackknife UCL	4905
95% Standard Bootstrap UCL	4841	95% Bootstrap-t UCL	6912
95% Hall's Bootstrap UCL	5185	95% Percentile Bootstrap UCL	4995
95% BCA Bootstrap UCL	5466		
90% Chebyshev(Mean, Sd) UCL	6474	95% Chebyshev(Mean, Sd) UCL	8087
97.5% Chebyshev(Mean, Sd) UCL	10326	99% Chebyshev(Mean, Sd) UCL	14723

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	10326

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Chrysene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	7
Minimum	2.94	Mean	5669
Maximum	76000	Median	299.5
SD	15856	Std. Error of Mean	2289
Coefficient of Variation	2.797	Skewness	3.519

Normal GOF Test

Shapiro Wilk Test Statistic	0.409	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.39	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	9509	95% Adjusted-CLT UCL (Chen-1995)	10676
		95% Modified-t UCL (Johnson-1978)	9703

Gamma GOF Test

A-D Test Statistic	3.188	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.885	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.222	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.254	k star (bias corrected MLE)	0.252
Theta hat (MLE)	22344	Theta star (bias corrected MLE)	22519
nu hat (MLE)	24.36	nu star (bias corrected)	24.17
MLE Mean (bias corrected)	5669	MLE Sd (bias corrected)	11299
		Approximate Chi Square Value (0.05)	13.98
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	13.73

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	9803	95% Adjusted Gamma UCL (use when n<50)	9975

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.969	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0741	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.078	Mean of logged Data	5.85
Maximum of Logged Data	11.24	SD of logged Data	2.54

Assuming Lognormal Distribution

95% H-UCL	44132	90% Chebyshev (MVUE) UCL	18459
95% Chebyshev (MVUE) UCL	23718	97.5% Chebyshev (MVUE) UCL	31017
99% Chebyshev (MVUE) UCL	45354		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	9433	95% Jackknife UCL	9509
95% Standard Bootstrap UCL	9387	95% Bootstrap-t UCL	12807
95% Hall's Bootstrap UCL	9519	95% Percentile Bootstrap UCL	9773
95% BCA Bootstrap UCL	11209		
90% Chebyshev(Mean, Sd) UCL	12535	95% Chebyshev(Mean, Sd) UCL	15645
97.5% Chebyshev(Mean, Sd) UCL	19961	99% Chebyshev(Mean, Sd) UCL	28441

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	19961

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Dibenz(a,h)anthracene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	46
		Number of Missing Observations	7
Number of Detects	42	Number of Non-Detects	6
Number of Distinct Detects	41	Number of Distinct Non-Detects	5
Minimum Detect	1.21	Minimum Non-Detect	1.75
Maximum Detect	15000	Maximum Non-Detect	98.6
Variance Detects	7769539	Percent Non-Detects	12.5%
Mean Detects	1055	SD Detects	2787
Median Detects	86	CV Detects	2.641
Skewness Detects	3.863	Kurtosis Detects	16.26
Mean of Logged Detects	4.52	SD of Logged Detects	2.409

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.434	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.942	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.372	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.135	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	924.1	KM Standard Error of Mean	379.7
KM SD	2599	95% KM (BCA) UCL	1633
95% KM (t) UCL	1561	95% KM (Percentile Bootstrap) UCL	1628
95% KM (z) UCL	1549	95% KM Bootstrap t UCL	2346
90% KM Chebyshev UCL	2063	95% KM Chebyshev UCL	2579
97.5% KM Chebyshev UCL	3296	99% KM Chebyshev UCL	4702

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.23	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.867	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.206	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.149	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.285	k star (bias corrected MLE)	0.28
Theta hat (MLE)	3704	Theta star (bias corrected MLE)	3764
nu hat (MLE)	23.93	nu star (bias corrected)	23.55
Mean (detects)	1055		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	923.4
Maximum	15000	Median	47.35
SD	2627	CV	2.845
k hat (MLE)	0.212	k star (bias corrected MLE)	0.212
Theta hat (MLE)	4365	Theta star (bias corrected MLE)	4351
nu hat (MLE)	20.31	nu star (bias corrected)	20.37
Adjusted Level of Significance (β)	0.045		
Approximate Chi Square Value (20.37, α)	11.13	Adjusted Chi Square Value (20.37, β)	10.91
95% Gamma Approximate UCL (use when n>=50)	1691	95% Gamma Adjusted UCL (use when n<50)	1724

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	924.1	SD (KM)	2599
Variance (KM)	6757000	SE of Mean (KM)	379.7
k hat (KM)	0.126	k star (KM)	0.132
nu hat (KM)	12.13	nu star (KM)	12.71
theta hat (KM)	7312	theta star (KM)	6981
80% gamma percentile (KM)	898.8	90% gamma percentile (KM)	2681
95% gamma percentile (KM)	5200	99% gamma percentile (KM)	12709

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (12.71, α)	5.696	Adjusted Chi Square Value (12.71, β)	5.551
95% Gamma Approximate KM-UCL (use when n>=50)	2061	95% Gamma Adjusted KM-UCL (use when n<50)	2115

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.927	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.942	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0665	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.135	Detected Data appear Lognormal at 5% Significance Level

Detected Data appear Approximate Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	923.8	Mean in Log Scale	4.01
SD in Original Scale	2627	SD in Log Scale	2.668
95% t UCL (assumes normality of ROS data)	1560	95% Percentile Bootstrap UCL	1626
95% BCA Bootstrap UCL	1875	95% Bootstrap t UCL	2296
95% H-UCL (Log ROS)	11438		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	4.06	KM Geo Mean	58
KM SD (logged)	2.564	95% Critical H Value (KM-Log)	4.409
KM Standard Error of Mean (logged)	0.377	95% H-UCL (KM -Log)	8086
KM SD (logged)	2.564	95% Critical H Value (KM-Log)	4.409
KM Standard Error of Mean (logged)	0.377		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	924.7	Mean in Log Scale	4.101
SD in Original Scale	2627	SD in Log Scale	2.569
95% t UCL (Assumes normality)	1561	95% H-Stat UCL	8575

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

97.5% KM (Chebyshev) UCL 3296

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Fluoranthene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	47
		Number of Missing Observations	7
Minimum	4.59	Mean	7171
Maximum	86000	Median	345.5
SD	19840	Std. Error of Mean	2864
Coefficient of Variation	2.767	Skewness	3.356

Normal GOF Test

Shapiro Wilk Test Statistic	0.405	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.391	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	11976	95% Adjusted-CLT UCL (Chen-1995)	13364
		95% Modified-t UCL (Johnson-1978)	12207

Gamma GOF Test

A-D Test Statistic	3.376	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.884	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.23	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.255	k star (bias corrected MLE)	0.253
Theta hat (MLE)	28106	Theta star (bias corrected MLE)	28335
nu hat (MLE)	24.49	nu star (bias corrected)	24.3
MLE Mean (bias corrected)	7171	MLE Sd (bias corrected)	14255
		Approximate Chi Square Value (0.05)	14.07
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	13.83

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	12380	95% Adjusted Gamma UCL (use when n<50)	12596

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.967	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0599	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.524	Mean of logged Data	6.103
Maximum of Logged Data	11.36	SD of logged Data	2.504

Assuming Lognormal Distribution

95% H-UCL	49761	90% Chebyshev (MVUE) UCL	21721
95% Chebyshev (MVUE) UCL	27870	97.5% Chebyshev (MVUE) UCL	36405
99% Chebyshev (MVUE) UCL	53169		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	11882	95% Jackknife UCL	11976
95% Standard Bootstrap UCL	11953	95% Bootstrap-t UCL	14969
95% Hall's Bootstrap UCL	11420	95% Percentile Bootstrap UCL	12368
95% BCA Bootstrap UCL	13217		
90% Chebyshev(Mean, Sd) UCL	15762	95% Chebyshev(Mean, Sd) UCL	19654
97.5% Chebyshev(Mean, Sd) UCL	25055	99% Chebyshev(Mean, Sd) UCL	35664

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	25055

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Fluorene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	46
		Number of Missing Observations	7
Number of Detects	27	Number of Non-Detects	21
Number of Distinct Detects	27	Number of Distinct Non-Detects	19
Minimum Detect	1.71	Minimum Non-Detect	1.72
Maximum Detect	1540	Maximum Non-Detect	2050
Variance Detects	131081	Percent Non-Detects	43.75%
Mean Detects	162.3	SD Detects	362.1
Median Detects	11.1	CV Detects	2.231
Skewness Detects	2.829	Kurtosis Detects	8.133
Mean of Logged Detects	3.081	SD of Logged Detects	1.953

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.514	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.923	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.375	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.167	Detected Data Not Normal at 5% Significance Level	

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	96.07	KM Standard Error of Mean	42.05
KM SD	281.5	95% KM (BCA) UCL	174.1
95% KM (t) UCL	166.6	95% KM (Percentile Bootstrap) UCL	170.5
95% KM (z) UCL	165.2	95% KM Bootstrap t UCL	232.2
90% KM Chebyshev UCL	222.2	95% KM Chebyshev UCL	279.3
97.5% KM Chebyshev UCL	358.7	99% KM Chebyshev UCL	514.4

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.748	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.845	Detected Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.287	**Kolmogorov-Smirnov GOF**	
5% K-S Critical Value	0.182	Detected Data Not Gamma Distributed at 5% Significance Level	

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.337	k star (bias corrected MLE)	0.324
Theta hat (MLE)	481.6	Theta star (bias corrected MLE)	500.6
nu hat (MLE)	18.19	nu star (bias corrected)	17.5
Mean (detects)	162.3		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	91.28
Maximum	1540	Median	3.445
SD	281.3	CV	3.082
k hat (MLE)	0.159	k star (bias corrected MLE)	0.163
Theta hat (MLE)	574.4	Theta star (bias corrected MLE)	560.4
nu hat (MLE)	15.26	nu star (bias corrected)	15.64
Adjusted Level of Significance (β)	0.045		
Approximate Chi Square Value (15.64, α)	7.706	Adjusted Chi Square Value (15.64, β)	7.533
95% Gamma Approximate UCL (use when n>=50)	185.2	95% Gamma Adjusted UCL (use when n<50)	189.5

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	96.07	SD (KM)	281.5
Variance (KM)	79252	SE of Mean (KM)	42.05
k hat (KM)	0.116	k star (KM)	0.123
nu hat (KM)	11.18	nu star (KM)	11.81
theta hat (KM)	824.9	theta star (KM)	780.6
80% gamma percentile (KM)	86.65	90% gamma percentile (KM)	274
95% gamma percentile (KM)	546.4	99% gamma percentile (KM)	1373

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (11.81, α)	5.105	Adjusted Chi Square Value (11.81, β)	4.968
95% Gamma Approximate KM-UCL (use when n>=50)	222.3	95% Gamma Adjusted KM-UCL (use when n<50)	228.5

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.888	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.923	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.195	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.167	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	92.22	Mean in Log Scale	1.89
SD in Original Scale	281	SD in Log Scale	2.098
95% t UCL (assumes normality of ROS data)	160.3	95% Percentile Bootstrap UCL	168
95% BCA Bootstrap UCL	187.9	95% Bootstrap t UCL	225.5
95% H-UCL (Log ROS)	187.9		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	2.205	KM Geo Mean	9.073
KM SD (logged)	1.851	95% Critical H Value (KM-Log)	3.394
KM Standard Error of Mean (logged)	0.285	95% H-UCL (KM -Log)	125.7
KM SD (logged)	1.851	95% Critical H Value (KM-Log)	3.394
KM Standard Error of Mean (logged)	0.285		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	125.7	Mean in Log Scale	2.479
SD in Original Scale	314.8	SD in Log Scale	2.078
95% t UCL (Assumes normality)	201.9	95% H-Stat UCL	318.3

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL 279.3

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Indeno(1,2,3-cd)pyrene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	7
Minimum	1.9	Mean	4036
Maximum	59000	Median	209
SD	11487	Std. Error of Mean	1658
Coefficient of Variation	2.846	Skewness	3.868

Normal GOF Test

Shapiro Wilk Test Statistic	0.404	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.387	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	6818	95% Adjusted-CLT UCL (Chen-1995)	7752
		95% Modified-t UCL (Johnson-1978)	6972

Gamma GOF Test

A-D Test Statistic	2.811	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.885	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.219	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.254	k star (bias corrected MLE)	0.252
Theta hat (MLE)	15898	Theta star (bias corrected MLE)	16023
nu hat (MLE)	24.37	nu star (bias corrected)	24.18
MLE Mean (bias corrected)	4036	MLE Sd (bias corrected)	8041
		Approximate Chi Square Value (0.05)	13.99
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	13.74

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	6978	95% Adjusted Gamma UCL (use when n<50)	7100

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.974	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0549	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.642	Mean of logged Data	5.512
Maximum of Logged Data	10.99	SD of logged Data	2.592

Assuming Lognormal Distribution

95% H-UCL	38339	90% Chebyshev (MVUE) UCL	15040
95% Chebyshev (MVUE) UCL	19363	97.5% Chebyshev (MVUE) UCL	25363
99% Chebyshev (MVUE) UCL	37149		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	6763	95% Jackknife UCL	6818
95% Standard Bootstrap UCL	6724	95% Bootstrap-t UCL	10946
95% Hall's Bootstrap UCL	8915	95% Percentile Bootstrap UCL	6893
95% BCA Bootstrap UCL	8136		
90% Chebyshev(Mean, Sd) UCL	9010	95% Chebyshev(Mean, Sd) UCL	11263
97.5% Chebyshev(Mean, Sd) UCL	14390	99% Chebyshev(Mean, Sd) UCL	20533

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	14390

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Phenanthrene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	47
		Number of Missing Observations	7
Minimum	2.18	Mean	2925
Maximum	33000	Median	124
SD	8166	Std. Error of Mean	1179
Coefficient of Variation	2.792	Skewness	3.313

Normal GOF Test

Shapiro Wilk Test Statistic	0.395	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.416	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	4903	95% Adjusted-CLT UCL (Chen-1995)	5466
		95% Modified-t UCL (Johnson-1978)	4997

Gamma GOF Test

A-D Test Statistic	3.7	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.888	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.243	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.141	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.249	k star (bias corrected MLE)	0.247
Theta hat (MLE)	11760	Theta star (bias corrected MLE)	11839
nu hat (MLE)	23.88	nu star (bias corrected)	23.72
MLE Mean (bias corrected)	2925	MLE Sd (bias corrected)	5885
		Approximate Chi Square Value (0.05)	13.63
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	13.4

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	5088	95% Adjusted Gamma UCL (use when n<50)	5178

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.958	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0757	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.779	Mean of logged Data	5.123
Maximum of Logged Data	10.4	SD of logged Data	2.522

Assuming Lognormal Distribution

95% H-UCL	20000	90% Chebyshev (MVUE) UCL	8540
95% Chebyshev (MVUE) UCL	10966	97.5% Chebyshev (MVUE) UCL	14333
99% Chebyshev (MVUE) UCL	20946		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	4864	95% Jackknife UCL	4903
95% Standard Bootstrap UCL	4865	95% Bootstrap-t UCL	5992
95% Hall's Bootstrap UCL	4557	95% Percentile Bootstrap UCL	5023
95% BCA Bootstrap UCL	5894		
90% Chebyshev(Mean, Sd) UCL	6461	95% Chebyshev(Mean, Sd) UCL	8063
97.5% Chebyshev(Mean, Sd) UCL	10286	99% Chebyshev(Mean, Sd) UCL	14653

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL 10286

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Pyrene

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	7
Minimum	3.92	Mean	5625
Maximum	78000	Median	300.5
SD	15604	Std. Error of Mean	2252
Coefficient of Variation	2.774	Skewness	3.583

Normal GOF Test

Shapiro Wilk Test Statistic	0.414	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.388	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	9404	95% Adjusted-CLT UCL (Chen-1995)	10574
		95% Modified-t UCL (Johnson-1978)	9598

Gamma GOF Test

A-D Test Statistic	3.119	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.882	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.223	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.261	k star (bias corrected MLE)	0.259
Theta hat (MLE)	21553	Theta star (bias corrected MLE)	21755
nu hat (MLE)	25.05	nu star (bias corrected)	24.82
MLE Mean (bias corrected)	5625	MLE Sd (bias corrected)	11062
		Approximate Chi Square Value (0.05)	14.47
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	14.23

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	9645	95% Adjusted Gamma UCL (use when n<50)	9812

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.971	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0567	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.366	Mean of logged Data	5.932
Maximum of Logged Data	11.26	SD of logged Data	2.49

Assuming Lognormal Distribution

95% H-UCL	39854	90% Chebyshev (MVUE) UCL	17679
95% Chebyshev (MVUE) UCL	22672	97.5% Chebyshev (MVUE) UCL	29601
99% Chebyshev (MVUE) UCL	43213		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	9329	95% Jackknife UCL	9404
95% Standard Bootstrap UCL	9301	95% Bootstrap-t UCL	12035
95% Hall's Bootstrap UCL	9420	95% Percentile Bootstrap UCL	9611
95% BCA Bootstrap UCL	11001		
90% Chebyshev(Mean, Sd) UCL	12381	95% Chebyshev(Mean, Sd) UCL	15442
97.5% Chebyshev(Mean, Sd) UCL	19690	99% Chebyshev(Mean, Sd) UCL	28034

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	19690

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.112/19/2019 1:46:26 PM
From File	TPAHs.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

LMW-PAHs-2010

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	73	Mean	5087
Maximum	47167	Median	362
SD	14017	Std. Error of Mean	4226
Coefficient of Variation	2.755	Skewness	3.266

Normal GOF Test

Shapiro Wilk Test Statistic	0.409	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.427	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.251	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	12747	95% Adjusted-CLT UCL (Chen-1995)	16486
		95% Modified-t UCL (Johnson-1978)	13441

Gamma GOF Test

A-D Test Statistic	1.365	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.818	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.296	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.275	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.313	k star (bias corrected MLE)	0.288
Theta hat (MLE)	16246	Theta star (bias corrected MLE)	17643
nu hat (MLE)	6.889	nu star (bias corrected)	6.343
MLE Mean (bias corrected)	5087	MLE Sd (bias corrected)	9474
		Approximate Chi Square Value (0.05)	1.818
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	1.451

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	17752	95% Adjusted Gamma UCL (use when n<50)	22232

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.899	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.165	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.251	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.29	Mean of logged Data	6.348
Maximum of Logged Data	10.76	SD of logged Data	1.954

Assuming Lognormal Distribution

95% H-UCL	87068	90% Chebyshev (MVUE) UCL	7678
95% Chebyshev (MVUE) UCL	9945	97.5% Chebyshev (MVUE) UCL	13092
99% Chebyshev (MVUE) UCL	19273		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	12039	95% Jackknife UCL	12747
95% Standard Bootstrap UCL	11726	95% Bootstrap-t UCL	127738
95% Hall's Bootstrap UCL	99714	95% Percentile Bootstrap UCL	13344
95% BCA Bootstrap UCL	18051		
90% Chebyshev(Mean, Sd) UCL	17766	95% Chebyshev(Mean, Sd) UCL	23509
97.5% Chebyshev(Mean, Sd) UCL	31480	99% Chebyshev(Mean, Sd) UCL	47137

Suggested UCL to Use

99% Chebyshev (Mean, Sd) UCL	47137

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

LMW-PAHs-2018

General Statistics

Total Number of Observations	37	Number of Distinct Observations	37
		Number of Missing Observations	0
Minimum	7.833	Mean	3975
Maximum	46430	Median	163.9
SD	10761	Std. Error of Mean	1769
Coefficient of Variation	2.707	Skewness	3.363

Normal GOF Test

Shapiro Wilk Test Statistic	0.421	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.936	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.405	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.144	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	6962	95% Adjusted-CLT UCL (Chen-1995)	7930
		95% Modified-t UCL (Johnson-1978)	7125

Gamma GOF Test

A-D Test Statistic	3.272	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.879	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.272	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.159	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.257	k star (bias corrected MLE)	0.255
Theta hat (MLE)	15444	Theta star (bias corrected MLE)	15617
nu hat (MLE)	19.05	nu star (bias corrected)	18.84
MLE Mean (bias corrected)	3975	MLE Sd (bias corrected)	7879
		Approximate Chi Square Value (0.05)	9.999
Adjusted Level of Significance	0.0431	Adjusted Chi Square Value	9.719

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	7489	95% Adjusted Gamma UCL (use when n<50)	7705

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.939	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.936	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.106	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.144	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.058	Mean of logged Data	5.542
Maximum of Logged Data	10.75	SD of logged Data	2.387

Assuming Lognormal Distribution

95% H-UCL	24485	90% Chebyshev (MVUE) UCL	9269
95% Chebyshev (MVUE) UCL	11912	97.5% Chebyshev (MVUE) UCL	15579
99% Chebyshev (MVUE) UCL	22784		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	6885	95% Jackknife UCL	6962
95% Standard Bootstrap UCL	6869	95% Bootstrap-t UCL	11330
95% Hall's Bootstrap UCL	10986	95% Percentile Bootstrap UCL	7034
95% BCA Bootstrap UCL	8149		
90% Chebyshev(Mean, Sd) UCL	9282	95% Chebyshev(Mean, Sd) UCL	11686
97.5% Chebyshev(Mean, Sd) UCL	15023	99% Chebyshev(Mean, Sd) UCL	21577

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL 15023

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

LMW-PAHs-ALL

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	0
Minimum	7.833	Mean	4230
Maximum	47167	Median	208.4
SD	11433	Std. Error of Mean	1650
Coefficient of Variation	2.703	Skewness	3.241

Normal GOF Test

Shapiro Wilk Test Statistic	0.413	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.394	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	6999	95% Adjusted-CLT UCL (Chen-1995)	7769
		95% Modified-t UCL (Johnson-1978)	7128

Gamma GOF Test

A-D Test Statistic	4.269	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.878	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.263	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.268	k star (bias corrected MLE)	0.265
Theta hat (MLE)	15800	Theta star (bias corrected MLE)	15970
nu hat (MLE)	25.7	nu star (bias corrected)	25.43
MLE Mean (bias corrected)	4230	MLE Sd (bias corrected)	8219
		Approximate Chi Square Value (0.05)	14.94
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	14.69

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	7200	95% Adjusted Gamma UCL (use when n<50)	7322

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.941	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.102	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.058	Mean of logged Data	5.726
Maximum of Logged Data	10.76	SD of logged Data	2.301

Assuming Lognormal Distribution

95% H-UCL	16734	90% Chebyshev (MVUE) UCL	9089
95% Chebyshev (MVUE) UCL	11562	97.5% Chebyshev (MVUE) UCL	14994
99% Chebyshev (MVUE) UCL	21736		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	6944	95% Jackknife UCL	6999
95% Standard Bootstrap UCL	6882	95% Bootstrap-t UCL	8465
95% Hall's Bootstrap UCL	6642	95% Percentile Bootstrap UCL	6945
95% BCA Bootstrap UCL	7974		
90% Chebyshev(Mean, Sd) UCL	9181	95% Chebyshev(Mean, Sd) UCL	11423
97.5% Chebyshev(Mean, Sd) UCL	14536	99% Chebyshev(Mean, Sd) UCL	20650

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	14536

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

HMW-PAHs-2010

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
		Number of Missing Observations	0
Minimum	489	Mean	72855
Maximum	661000	Median	8440
SD	196162	Std. Error of Mean	59145
Coefficient of Variation	2.692	Skewness	3.252

Normal GOF Test

Shapiro Wilk Test Statistic	0.418	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.412	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.251	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	180054	95% Adjusted-CLT UCL (Chen-1995)	232106
		95% Modified-t UCL (Johnson-1978)	189719

Gamma GOF Test

A-D Test Statistic	1.086	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.818	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.307	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.276	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.309	k star (bias corrected MLE)	0.285
Theta hat (MLE)	235969	Theta star (bias corrected MLE)	255497
nu hat (MLE)	6.792	nu star (bias corrected)	6.273
MLE Mean (bias corrected)	72855	MLE Sd (bias corrected)	136434
		Approximate Chi Square Value (0.05)	1.781
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	1.42

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	256609	95% Adjusted Gamma UCL (use when n<50)	321946

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.945	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.177	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.251	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	6.192	Mean of logged Data	8.973
Maximum of Logged Data	13.4	SD of logged Data	2.127

Assuming Lognormal Distribution

95% H-UCL	2953321	90% Chebyshev (MVUE) UCL	143440
95% Chebyshev (MVUE) UCL	186846	97.5% Chebyshev (MVUE) UCL	247091
99% Chebyshev (MVUE) UCL	365431		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	170140	95% Jackknife UCL	180054
95% Standard Bootstrap UCL	162421	95% Bootstrap-t UCL	1641031
95% Hall's Bootstrap UCL	1158775	95% Percentile Bootstrap UCL	188079
95% BCA Bootstrap UCL	244435		
90% Chebyshev(Mean, Sd) UCL	250291	95% Chebyshev(Mean, Sd) UCL	330663
97.5% Chebyshev(Mean, Sd) UCL	442216	99% Chebyshev(Mean, Sd) UCL	661342

Suggested UCL to Use

99% Chebyshev (Mean, Sd) UCL	661342

Recommended UCL exceeds the maximum observation

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

HMW-PAHs-2018

General Statistics

Total Number of Observations	37	Number of Distinct Observations	37
		Number of Missing Observations	0
Minimum	27.57	Mean	38924
Maximum	487810	Median	2064
SD	104825	Std. Error of Mean	17233
Coefficient of Variation	2.693	Skewness	3.492

Normal GOF Test

Shapiro Wilk Test Statistic	0.429	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.936	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.397	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.144	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	68019	95% Adjusted-CLT UCL (Chen-1995)	77843
		95% Modified-t UCL (Johnson-1978)	69668

Gamma GOF Test

A-D Test Statistic	2.375	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.883	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.217	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.159	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.25	k star (bias corrected MLE)	0.248
Theta hat (MLE)	155786	Theta star (bias corrected MLE)	157196
nu hat (MLE)	18.49	nu star (bias corrected)	18.32
MLE Mean (bias corrected)	38924	MLE Sd (bias corrected)	78222
		Approximate Chi Square Value (0.05)	9.625
Adjusted Level of Significance	0.0431	Adjusted Chi Square Value	9.351

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	74101	95% Adjusted Gamma UCL (use when n<50)	76274

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.965	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.936	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.108	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.144	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.317	Mean of logged Data	7.726
Maximum of Logged Data	13.1	SD of logged Data	2.608

Assuming Lognormal Distribution

95% H-UCL	511984	90% Chebyshev (MVUE) UCL	140176
95% Chebyshev (MVUE) UCL	181560	97.5% Chebyshev (MVUE) UCL	238999
99% Chebyshev (MVUE) UCL	351827		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	67270	95% Jackknife UCL	68019
95% Standard Bootstrap UCL	67044	95% Bootstrap-t UCL	116625
95% Hall's Bootstrap UCL	156683	95% Percentile Bootstrap UCL	69776
95% BCA Bootstrap UCL	81118		
90% Chebyshev(Mean, Sd) UCL	90624	95% Chebyshev(Mean, Sd) UCL	114042
97.5% Chebyshev(Mean, Sd) UCL	146545	99% Chebyshev(Mean, Sd) UCL	210392

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL	146545

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

HMW-PAHs-ALL

General Statistics

Total Number of Observations	48	Number of Distinct Observations	48
		Number of Missing Observations	0
Minimum	27.57	Mean	46700
Maximum	661000	Median	2466
SD	129659	Std. Error of Mean	18715
Coefficient of Variation	2.776	Skewness	3.656

Normal GOF Test

Shapiro Wilk Test Statistic	0.416	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.387	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.127	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	78102	95% Adjusted-CLT UCL (Chen-1995)	88036
		95% Modified-t UCL (Johnson-1978)	79748

Gamma GOF Test

A-D Test Statistic	2.954	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.883	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.208	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.14	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.258	k star (bias corrected MLE)	0.256
Theta hat (MLE)	181027	Theta star (bias corrected MLE)	182608
nu hat (MLE)	24.77	nu star (bias corrected)	24.55
MLE Mean (bias corrected)	46700	MLE Sd (bias corrected)	92346
		Approximate Chi Square Value (0.05)	14.27
Adjusted Level of Significance	0.045	Adjusted Chi Square Value	14.02

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	80355	95% Adjusted Gamma UCL (use when n<50)	81751

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.971	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.947	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0663	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.127	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.317	Mean of logged Data	8.012
Maximum of Logged Data	13.4	SD of logged Data	2.54

Assuming Lognormal Distribution

95% H-UCL	383892	90% Chebyshev (MVUE) UCL	160525
95% Chebyshev (MVUE) UCL	206259	97.5% Chebyshev (MVUE) UCL	269737
99% Chebyshev (MVUE) UCL	394426		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	77483	95% Jackknife UCL	78102
95% Standard Bootstrap UCL	77028	95% Bootstrap-t UCL	110558
95% Hall's Bootstrap UCL	83422	95% Percentile Bootstrap UCL	79786
95% BCA Bootstrap UCL	89475		
90% Chebyshev(Mean, Sd) UCL	102844	95% Chebyshev(Mean, Sd) UCL	128276
97.5% Chebyshev(Mean, Sd) UCL	163573	99% Chebyshev(Mean, Sd) UCL	232909

Suggested UCL to Use

97.5% Chebyshev (Mean, Sd) UCL 163573

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Appendix B2
Ecological Risk Assessment – Aquatic Habitat (Sediment)

APPENDIX B2

Ecological Risk Assessment: Aquatic Habitat (Sediment)

This subappendix presents the ecological risk assessment (ERA) for the aquatic habitat at Munitions Response Site (MRS) UXO-002 Former Small Arms Ranges, Operable Unit (OU)-2 Former Skeet Ranges, which consists of the screening-level ecological risk assessment (SERA), specifically Steps 1 and 2 of the ERA process, and the first step (Step 3A) of the baseline ecological risk assessment (BERA). This ERA was conducted in accordance with Navy policy for ERAs (CNO, 1999) and Navy guidance for implementing this ERA policy (NAVFAC, 2003).

The ERA in this subappendix is for the aquatic habitat of the Patuxent River adjacent to the Former Skeet Ranges and is based on the sediment investigation performed in 2019 in support of the Remedial Investigation (RI). A soil investigation was also performed onsite at the Former Skeet Ranges, also in support of the RI. The terrestrial habitat ERA that was conducted with those soil data is presented as Appendix B1 of the Engineering Estimate and Cost Analysis (EE/CA).

The primary objectives of the aquatic ERA are to:

- Perform a direct exposure risk evaluation for lower trophic level-receptors (benthic macroinvertebrate community) through screening chemical analytical sediment sample results against ecological screening levels (ESLs).
- Perform an indirect (food web) exposure evaluation for upper trophic-level receptors (birds and mammals) through standardized food web (ingestion) exposure modeling and screening.

The layout and key site features of MRS UXO-002 Former Small Arms Ranges, OU-2 Former Skeet Ranges are presented in the main body of the RI Report.

B2.1 Investigation History

B2.1.1 Site Inspection (2010)

CH2M conducted a Site Inspection (SI) between December 14 and 16, 2010, the report for which was finalized in 2013 (CH2M, 2013). The SI focused on the onsite terrestrial habitat. During the SI, surface soil samples were collected from 0 to 6 inches below ground surface (bgs) at 26 locations throughout the Former Skeet Ranges. An ecological risk screening evaluation was performed for the SI Report using these soil data to evaluate direct exposure risks from the range-related constituents of lead and polycyclic aromatic hydrocarbons (PAHs) for lower trophic-level receptors, such as soil invertebrates and terrestrial plant populations. The evaluation did not include food web exposure screening for upper trophic-level terrestrial receptors.

The SI and ecological risk screening are summarized in more detail in the terrestrial habitat ERA included as Appendix B1 of the EE/CA. In general, PAHs, which were evaluated on a low molecular weight (LMW) and high molecular weight (HMW) total PAH concentration basis, were identified as a constituent of potential concern (COPC) during the SI. However, lead was not identified as a COPC during the SI. The surface soil sample exceedances for both LMW and HMW total PAHs occurred near each other in the theoretical shotfall zone immediately west of the Former Skeet Range firing line.

B2.1.2 Remedial Investigation (2018–2019)

Based on the results of the human health and ecological risk screenings for the SI, the RI was conducted to further characterize the nature and extent of PAHs and lead at the Former Skeet Ranges and determine if concentrations pose unacceptable risks to human or ecological receptors as well as to evaluate nearshore sediments of the Patuxent River within the Skeet Range shotfall zone. The RI activities included:

1. Soil sampling
2. Sediment sampling in the nearshore area of the Patuxent River, adjacent to the site and within the estimated shotfall zone
3. Background sediment sampling in the Patuxent River and outside the estimated shotfall zone
4. Groundwater monitoring well installation and sampling

The soil sampling and subsequent evaluation of the terrestrial habitat are not discussed in this appendix; the focus here is on the nearshore sediment sampling adjacent to the Former Skeet Ranges in the Patuxent River. The soil ERA is presented and discussed in Appendix B1 of the EE/CA, and the groundwater monitoring well installation and sampling efforts are presented in the main body of the RI Report.

Sediment samples were collected in two phases to complete the delineation of lead and PAHs and additional quantitative ecological and human health risk assessments for the RI Report. Additionally, background samples were collected from offsite reference locations outside of the theoretical shotfall zone of the Former Skeet Ranges. Athena Technologies, Inc. assisted CH2M with collecting all sediment samples. All sample analyses except grain size were performed by Gulf Coast Analytical Laboratories in Baton Rouge, Louisiana. All samples for grain size were analyzed by ALS in Baton Rouge, Louisiana.

The following summarizes the RI field investigation sampling activities:

- **Phase 1 (June 2019)**: From June 11 through 16, 2019, surface sediment samples (0 to 6 inches bgs) were collected using a boat-based ponar dredge at the following locations:
  - Background Area: Surface samples were collected from 19 locations along 5 transects radiating from the shoreline into the Patuxent River outside of the Former Skeet Range shotfall zone. The transects were lettered A through E. Four samples were collected per transect with sample IDs consisting of PX-BG-SD02-000H through PX-BG-SD20-000H. One sample (SD01) that was proposed for Transect A could not be collected due to refusal of the substrate with the ponar sampler. These samples were analyzed for lead and PAHs. One-half of these samples were also analyzed for pH, total organic carbon (TOC), acid volatile sulfide (AVS)/simultaneously extracted metals (SEM), and grain size.
  - Shotfall Zone: Surface samples were collected at 59 locations radiating from the shoreline into 10 transects in the Patuxent River and within the theoretical shotfall zone of the Former Skeet Ranges. These shotfall zone transects were numbered Transect 1 through 10 and included 3 to 8 sample locations depending on the transect. As proposed, the sample IDs consisted of PX-FSR-SD01-000H through PX-FSR-SD62-000H. However, one sample from each of Transect 5 (SD31), Transect 7 (SD45), and Transect 8 (SD53) could not be collected due to refusal of the substrate with the ponar sampler. All locations were analyzed for lead and pellet counts. The 10 closest locations were also analyzed for PAHs. Finally, one-half of all shotfall samples were also analyzed for pH, TOC, AVS/SEM, and grain size.
- **Phase 2 (August 2019)**: The Naval Air Station (NAS) Patuxent River Partnering Team (Team) met on August 6, 2019, to evaluate and discuss the Phase 1 sampling results to refine the sample strategy for Phase 2. Based on that discussion, the Team decided no additional background area samples

were necessary during Phase 2. Based on the elevated lead concentration detected at SD36 during Phase 1, the Team agreed that only focused sampling was necessary in the shotfall zone during Phase 2 to better delineate that location. Subsequently, the following Phase 2 sampling activities took place August 21 through 22, 2019:

- Surface sediment (0 to 6 inches bgs): Another surface sediment sample was collected at SD36 along Transect 2 during Phase 2 to verify the previously elevated detection of lead during Phase 1. This sample was identified as PX-FSR-SD36A-000H and analyzed for lead and pellet count. Additionally, two rings of four step-out surface sediment samples each were also collected at 10-foot intervals from SD36A for lead and pellet count analyses. The closest ring (10 feet out) included samples SD63 through SD66, which were analyzed for lead and pellet count. The second ring (20 feet out) included samples SD67 through SD70. However, samples SD67 through SD70 were held without analyses at the lab while the Team considered the results for SD36A and closet ring of step-out samples (SD63 through SD66). The Team met on October 8, 2019, to consider those initial Phase 2 results and it was decided there was no need to analyze the second ring of step-out surface sediment samples due to low levels of detections for SD36A and SD63 through SD66.
- Subsurface sediment (6 to 24 inches bgs): A collocated subsurface sampled was collected with the surface sample at SD36A and analyzed for lead and pellet count. Subsurface samples were also collected at all four surface sediment samples collected at the first step-out ring (SD63 through SD66) and were held at the lab for the Team to consider the results of the analyzed Phase 2 samples. Subsequently, the Team also decided not to analyze these subsurface samples for SD63 through SD66 based on the other Phase 2 results.

B2.2 Problem Formulation

Step 1 of the ERA process includes problem formulation establishes the goals, scope, and focus of the ERA. As part of the screening problem formulation, the environmental setting of the Former Skeet Range was characterized in terms of the habitats and biota known or likely to be present. The types and concentrations of constituents present in ecologically relevant media were also described based on available analytical data. A conceptual site model (CSM) was developed that describes potential source areas, transport pathways and exposure media, exposure pathways and routes, and receptors for the SERA. Assessment and measurement endpoints were selected to evaluate those receptors for which critical exposure pathways exist. The fate, transport, and toxicological properties of the constituents present, particularly the potential for bioaccumulation, were also considered during this process.

B2.2.1 Ecological Setting

The Patuxent River, which forms the northern coastline of NAS Patuxent River, flows 110 miles to its confluence with the Chesapeake Bay at Solomon's Island. The Patuxent River is directly adjacent to the Former Skeet Ranges and within the theoretical shotfall zone. This river is one of the most significant aquatic habitats associated with NAS Patuxent River. While not officially listed on the National Wild and Scenic Rivers System, the Patuxent River is listed in the Nationwide Rivers Inventory as having the significant resource values required for potential inclusion (Navy, 2017). Due to the proximity to the Chesapeake Bay, the Patuxent River is a slightly brackish, tidally influenced water body. Significant populations of aquatic biota occur within the river, including fish and benthic macroinvertebrates (worms, bivalves, crustaceans). The fishery of the Patuxent River is diverse with a prevalence of multiple forage fish species (for example, silverside spot, croaker, menhaden) as well as commercially and recreationally important species (for example, flounder, seatrout, striped bass, and rockfish). Furthermore, an abundance of wildlife (birds and mammals) are expected to reside close to the river and utilize it for foraging, especially in the littoral zone of the nearshore (that is, the shallow area of the river where it meets land).

B2.2.2 Conceptual Site Model

The CSM relates potentially exposed ecological receptor populations with potential source areas based on physical site characteristics and complete exposure pathways. The CSM focuses on exposures to ecological receptors and is a component of the sitewide CSM presented in Section 2.2 of the EE/CA. Important components of the model are:

- Potential source areas
- Transport pathways
- Exposure media
- Exposure pathways and routes
- Receptor groups

The most likely and most important pathways of contaminant release and transport are identified to determine actual or potential complete exposure pathways for ecological receptors at the site. A complete exposure pathway has three components: (1) a source of constituents that results in a release to the environment; (2) a pathway of constituent transport through an environmental medium; and (3) an exposure or contact point for an ecological receptor. As illustrated in the main body of the RI Report, the main objective of the CSM in the ERA is to identify any complete and critical exposure pathways that could be present for ecological receptors. Key components of the model are discussed in the following sections.

B2.2.2.1 Potential Source Areas

The primary sources of potential contamination are lead shot (metal) and clay target fragments (PAHs associated with tar pitch typically used to bind clay targets used at skeet ranges) that were deposited from above ground or surface water during target shooting activities at the Former Skeet Ranges when they were active. The majority of the theoretical shotfall zone is in the Patuxent River. At range sites, lead is typically considered the primary constituent of concern based on its prevalence and risk-driving potential (ITRC, 2003).

B2.2.2.2 Transport Pathways and Exposure Media

A transport pathway describes the mechanisms whereby site-related constituents, once released, may be transported from a source area to an exposure medium (such as sediment) and where receptor exposures may occur. The primary mechanisms for chemical release and transport from the upland source area(s) to the Patuxent River are:

- Direct deposit of lead shot and clay target fragments into soils in the upland vegetated areas and direct deposit of lead shot into sediment in the nearshore areas of the Patuxent River
- Transport of contaminated soil particulates via overland surface runoff to downgradient terrestrial and aquatic areas
- Leaching of chemicals from surface and subsurface soils into groundwater via infiltrating precipitation (and potential discharge of contaminated groundwater into downgradient surface water bodies) although based on the relatively high adsorption to solids of potential contaminants, this is expected to be negligible
- Leaching from sediment in the Patuxent River to the surface water, although based on the relatively high adsorption to solids of potential contaminants and the flow velocity of the river, this is expected to be negligible

- Uptake by biota from sediment (e.g., aquatic vegetation, benthic invertebrates, aquatic and semi-aquatic species) and transfer to upper trophic-level receptors (e.g., birds and mammals)

B2.2.2.3 Exposure Pathways and Routes

Based on the understanding of the source of contamination and the habitats and biota present in the investigation area, there are potentially complete exposure pathways for aquatic receptors (aquatic plants, benthic macroinvertebrates, fish, birds, and mammals). That is, these receptors may potentially be exposed to contaminated sediment in the Patuxent River in the area of the theoretical shotfall zone. While surface water might play a role in the movement of contamination, surface water was not included as an environmental medium in this investigation. Surface water was excluded because of the Patuxent River is a large flowing water body and site-related contamination would not be expected to remain in surface water in the investigation. Additionally, the primary constituents of concern (lead and PAHs) are expected to remain in the sediment.

An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical or metal present in an environmental medium. Aquatic plants are exposed to chemicals and metals present in sediment via root surfaces during nutrient uptake. Direct contact to contaminated media is considered the primary exposure route for lower trophic-level receptors (benthic macroinvertebrates). Upper trophic-level receptors (birds and mammals) at this site are most likely exposed to constituents through:

- Uptake by biota from surface water or sediment and trophic transfer to upper trophic-level receptors
- Incidental ingestion of contaminated abiotic media (sediment) during feeding activities
- Ingestion of contaminated drinking water
- Ingestion of contaminated plant or animal tissues for chemicals that have entered food webs
- Direct (dermal) contact with contaminated abiotic media

Based on the general fate properties (such as relatively high adsorption to solids) of the site-related constituents present (lead and PAHs) and the protection offered by hair or feathers, potential dermal exposures for upper trophic-level receptors are not considered significant relative to ingestion exposures. Incidental ingestion of sediment during feeding, preening, or grooming activities is, however, considered in the risk estimates. Ingestion of contaminated drinking water is not considered as an exposure route because the salinity of the Patuxent River is too high for wildlife consumption, and there is no onsite surface water at the Former Skeet Ranges that receptors could drink. Additionally, the potential site-related contamination in the Patuxent River is expected to be bound up in sediment.

B2.2.2.4 Assessment and Measurement Endpoints

Problem formulation includes the selection of ecological endpoints based on the CSM. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process (EPA, 1997). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic related to the component or value chosen as the assessment endpoint. The considerations for selecting assessment and measurement endpoints are summarized in EPA (1997) and discussed in detail in Suter (1989, 1990, 1993).

Endpoints define ecological attributes to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) used to gauge the degree of impact that has occurred or could occur. Assessment endpoints most often relate to attributes of biological populations or communities, and they are intended to focus the risk assessment on components of the ecosystem that could be adversely affected by chemicals attributable to a site (EPA, 1997). Assessment endpoints contain an entity (for example, raccoon population) and an attribute of that entity (for example, survival rate). Individual assessment endpoints usually encompass a group of species or populations (the receptor) with some common characteristic, such as specific exposure route or contaminant sensitivity, with the receptor then used to represent the assessment endpoint in the risk evaluation.

Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem itself. Effects on individual organisms are important for some receptors, such as rare and endangered species. However, population- and community-level effects are typically more relevant to ecosystems. Population- and community-level effects are usually difficult to evaluate directly without long-term and extensive study. Measurement endpoint evaluations at the individual level, such as an evaluation of the effects of chemical exposure on reproduction, can be used to predict effects on an assessment endpoint at the population or community-level. Table B2-1 shows the assessment and measurement endpoints used for this assessment.

B2.2.2.5 Receptors

The ecological receptors evaluated were previously identified via the Uniform Federal Policy Sampling and Analysis Plan approach (CH2M, 2018). Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, specific receptor species (for example, osprey) or species groups (for example, benthic macroinvertebrates) were selected as surrogates to evaluate potential risks to larger components of the ecological community (guilds, such as omnivorous birds) that were used to represent assessment endpoints (for example, survival and reproduction of omnivorous mammals). Selection criteria included species that:

- Are known to occur, or are likely to occur, in the area
- Have an ecological, economic, or aesthetic value
- Are representative of taxonomic groups, life history traits, or trophic levels in the habitats present for which complete exposure pathways are likely to exist
- Can be expected to represent potentially sensitive populations because of toxicological sensitivity or potential exposure magnitude

The following upper trophic-level receptors were selected for exposure modeling based on the criteria listed above and consideration of site conditions:

- Great blue heron (*Ardea herodias*): aquatic avian piscivore
- Osprey (*Pandion haliaetus*): aquatic avian piscivore
- Marsh wren (*Cistothorus palustris*): semi-aquatic avian insectivore
- Spotted sandpiper[1] (*Actitis macularius*): semi-aquatic avian insectivore
- Muskrat (*Ondatra zibethicus*): aquatic mammalian herbivore
- Raccoon (*Procyon lotor*): semi-aquatic mammalian omnivore

Upper trophic-level receptor species that were quantitatively evaluated were limited to birds and mammals, the taxonomic groups with the most available information regarding exposure and toxicological effects.

Lower trophic-level receptor species were evaluated based on those taxonomic groupings for which medium-specific screening values have been developed. The potential for adverse effects to aquatic

[1] Sandpiper was not originally proposed as a receptor species via the UFP-SAP (CH2M, 2018). However, it was added given the habitat characteristics at the shoreline (sandy beach), feeding habits, and sensitivity.

plants and benthic macroinvertebrates were evaluated using sediment screening values developed specifically for these groups.

Reptiles are also a potential receptor group. Individual species of reptiles were not, however, selected for evaluation because of the general lack of available toxicological information for these taxonomic groups for direct effects and effects from exposures via food webs. Potential risks to reptiles from food web exposures were evaluated using other fauna (birds and mammals) as surrogates.

B2.2.3 Available Analytical Data

This section focuses on the data that were available from the Phase 1 event conducted June 11 through 16, 2019. The following subsections summarize what samples were collected and the subsequent data that were generated for use in this assessment.

B2.2.3.1 Selection Criteria for Analytical Data

Available analytical data were selected for the ERA based on the following:

- Data must have been validated by a qualified data validator using acceptable data validation methods. Rejected (‘R’ qualifier) values were not used. Unqualified data and data qualified as ‘J,’ ‘L,’ or ‘K’ were treated as detected. Data qualified as ‘U’ or ‘B’ were treated as not detected.
- For samples with duplicate analyses, the greater of the two concentrations was used when both results were detections or when both reported values were not detections. In cases where one result for the duplicates was a detection and the other result was not, the detected value was used in the assessment.
- For constituents that were not detected, the sample quantitation (reporting) limit (SQL) was used to represent the concentration. When calculating statistics (for example, arithmetic mean), one-half of the SQL was used for constituents that were not detected. In cases where the SQL was not provided, the method detection limit was used.
- Sediment samples collected from 0 to 6 inches bgs were used because the releases were above ground (shotfall). The surficial depth range represents the most relevant potential exposures for most the ecological receptors evaluated and represents the worst-case exposure scenario based on the CSM.

B2.2.3.2 Habitat Characteristics

During the Phase 1 investigation, the field team recorded basic habitat characteristics related to the substrate that was sampled at each of the shotfall zone locations and well as the background area location. These observations included qualitative descriptions of the substrate materials (for example, general particle size, color and consistency) and incidences of any observed biota in the sample (for example, worms or bivalves). Those observations are summarized in Table B2-2.

B2.2.3.3 Physical and Chemical Analyses

A summary of the laboratory-based physical and chemical analyses performed on the Phase 1 samples is summarized in Table B2-3.

For the site-related shotfall zone samples, this included analyses of lead and pellet counts on all 59 sample locations and PAH analysis for 10 nearshore locations. Additionally, AVS/SEM, % solids, pH, TOC, and grain size were analyzed for samples collected from roughly one-half of all locations (30 of the 59 shotfall zone sample locations).

In the background area, lead, PAHs, and pellet counts were analyzed for samples collected at all 19 locations. Additionally, AVS/SEM, % solids, and grain size were analyzed for samples collected from nine background locations, and pH and TOC were analyzed for samples collected from 13 background locations. The % solids and grain size results are presented in Table B2-4. The results for all other parameters are presented in association with the screening risk calculation (Section B2.5).

B2.2.3.4 Special Data Treatment

In preparation for the screening effects assessment (Section B2.3) and screening exposure assessment (Section B2.4), some special data treatment was necessary for the Phase 1 AVS/SEM and PAHs data. The following describes the special treatment of those data.

AVS/SEM

It has been shown AVS can be associated with the bioavailability of some divalent cationic metals (SEM), such as cadmium, copper, lead, nickel, and zinc (DiToro et al., 1990; EPA, 2005). The AVS and SEM results were used to evaluate potential risks related to metals within the investigation area. Analytical results for both AVS and SEM are reported in micromoles/gram (µmol/g). The SEM results for cadmium, copper, lead, nickel, and zinc are used to calculate a total SEM concentration. To calculate total SEM, the detected concentrations and one-half the reporting limits for undetected SEM are summed (∑) to get a total SEM concentration (∑SEM). The ∑SEM are then compared to the AVS concentration by calculating a ∑SEM:AVS ratio.

Total PAHs

Analytical results for PAHs are presented for both individual compounds and the total concentration of PAHs as a group for the screening effects and exposure assessment. Potential food web exposure risks for upper trophic-level receptors were evaluated using individual compound concentrations, while the total PAH concentrations are used to evaluate potential direct exposure risks from direct exposure for lower trophic-level receptors. The semivolatile organic compound analyses for sediment samples included 18 individual PAH compounds. Total PAH concentrations were calculated on a sample-by-sample basis by summing the detected concentrations and one-half the reporting limit for undetected concentrations for all 18 compounds.

B2.3 Screening Effects Assessment

The screening effects assessment is the other part of Step 1 of the ERA process. The purpose of the screening effects assessment is to establish chemical-specific ESLs that represent thresholds for adverse ecological effects. Screening values are selected in alignment with the assessment endpoints.

B2.3.1 Direct Exposure Screening Values

The ESLs selected for lead and total PAHs are those recommended by the EPA Region 3 Biological Technical Assistance Group. Each ESL represents a consensus-based sediment quality guideline that exists as a Threshold Effect Concentration (TEC) from MacDonald et al. (2000). The TECs for lead and total PAHs are 35.8 mg/kg and 1,610 µg/kg, respectively.

For AVS/SEM, effects are determined through calculation of the ∑SEM:AVS ratio. If this ratio is below 1.0 (AVS concentration surpasses the ∑SEM concentration), then the sediment is likely not to be toxic. If the ratio is greater than 1.0 (∑SEM exceeds AVS), then a sediment sample may or may not be toxic. Previous investigations suggest that the incidence of metals toxicity is predicted as most likely when the ∑SEM:AVS ratio is greater than 8.0 (Burton et al., 2005). The ∑SEM and ∑SEM:AVS ratio calculations are presented in Section B2.5.

B2.3.2 Ingestion Screening Values

Because both lead and 15 of the PAH compounds analyzed in sediment are considered important bioaccumulative constituents (EPA, 2000), there are potentially complete exposure pathways for upper trophic-level receptors via food web exposure. Therefore, these constituents were screened using upper trophic-level receptor food web models. Ingestion screening values for these constituents and the receptor species evaluated (or suitable surrogate species) through food web modeling were obtained from the literature. Toxicological information for wildlife species most closely related to the receptor species was used, where available, but was supplemented by laboratory studies of non-wildlife species (for example, laboratory chicken) where necessary. Toxicity studies involving long-term (chronic) exposure were used preferentially. Survival, growth, and reproduction were emphasized as toxicological endpoints because these are the most relevant to maintaining viable populations, and because these are generally the most-studied chronic toxicological endpoints for ecological receptors. If several chronic toxicological studies were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint, and test species.

Ingestion-based screening values were derived for both chronic no observed adverse effect level (NOAEL) and chronic lowest observed effect level (LOAEL) endpoints. Ingestion screening values for mammals and birds are presented in Table B2-5 and Table B2-6, respectively.

B2.4 Screening Exposure Assessment

Step 2 of the ERA process begins with the screening exposure assessment. The principal activity associated with the exposure assessment is the estimation of constituent concentrations in applicable media to which receptors might be exposed. This concentration is termed an exposure point concentration (EPC). EPCs are estimated by following the selection of appropriate sets of the available analytical data using a set of criteria (for example, validation status, sampling date; see Section B2.2.3). Once the analytical data sets are selected, EPCs are calculated as a point on the distribution of concentrations. The following subsections summarize the EPC approach for each portion of the assessment.

B2.4.1 Direct Exposure

Because of the focus on only two COPCs (lead, total PAHs), each sample-specific concentration was considered in the screening exposure assessment. That is, each sample concentration was screened individually against the ESLs.

B2.4.2 Food Web Exposure

EPCs for lead and the 15 individual bioaccumulative PAH compounds were used in food web models to estimate exposures to upper trophic-level receptors. These food web EPCs were calculated by estimating the concentrations of detected bioaccumulative constituents in each dietary component using the maximum surface soil concentration and the uptake and food web models described in the sections below. Except for lead, the maximum concentration was used for estimating the dose of each constituent in the diets of each receptor. For lead, the maximum concentration during Phase 1 was detected in PX-FSR-SD36-000H along Transect 6 at 85,600 mg/kg (results are presented in Section B2.5). This concentration was considered anomalous with what was most likely interferences from a lead-containing item. While its possible this was related to lead pellet, or pellet fragment, it is not considered representative of a realistic level of contamination even from a skeet range (discussed below in Section B2.5.1). Therefore, the second highest concentration of lead from the Phase 1 sampling was used as the EPC for screening (27.9 mg/kg at PX-FSR-SD34-000H along Transect 6).

Dietary items for which tissue concentrations were modeled include aquatic plants, benthic invertebrates and fish. Incidental ingestion of sediment was also included when calculating the total level of exposure. The models and parameter values for calculating food item concentrations are outlined in the following subsections. For the screening exposure estimates of detected bioaccumulative constituents, uptake from sediment into these food items was based on a conservative (90th percentile) bioconcentration factor (BCF) or bioaccumulation factor (BAF) from the literature, where available. The use of 90th percentile values is generally recommended to provide a conservative screening assessment (Sample et al., 1998a, 1998b; Bechtel Jacobs, 1998). Default BCFs or BAFs of 1.0 were used only when values were not available in the literature for a constituent.

B2.4.2.1 Aquatic Plants

Tissue concentrations in the aboveground vegetative portion of plants were estimated by multiplying the maximum sediment concentration (or second highest for lead) for each chemical by chemical-specific soil-to-plant BAFs (extrapolated to sediments) obtained from the literature. These BAFs are listed in Table B2-7.

The BAF values were based on root uptake from soil (extrapolated to sediment) and the ratio between dry-weight sediment and dry-weight plant tissue. Literature values based on the ratio between dry-weight sediment and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BAF by an estimated solids content for plants (15 percent; Sample et al., 1997).

B2.4.2.2 Benthic Macroinvertebrates

Tissue concentrations in benthic invertebrates were estimated by multiplying the maximum sediment concentration (or second highest for lead) for each chemical/metal by chemical/metal-specific sediment-to-invertebrate BAF values obtained from the literature. These values are also listed in Table B2-7.

The BAF values used were based on the ratio between dry-weight sediment and dry-weight invertebrate tissue. BAFs based on depurated analyses (sediment purged from the gut of the organism before analysis) were given preference over undepurated analyses when selecting BAF values because direct ingestion of sediment was accounted for separately in the food web model. Literature values based on the ratio between dry-weight sediment and wet-weight invertebrate tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for benthic invertebrates (21 percent) (EPA, 1993).

B2.4.2.3 Fish

Tissue concentrations in fish were estimated by multiplying the maximum sediment concentration (or second highest for lead) for each chemical by chemical-specific sediment-to-fish BAFs obtained from the literature. These values are listed in Table B2-7.

The BAF values were based on the ratio between dry-weight sediment and dry-weight tissue. Literature values based on the ratio between dry-weight sediment and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for fish (15 percent) (EPA, 1993).

B2.4.3 Dietary Intakes

For receptor species used in food web modeling, the dietary intake (dose) of each constituent (in milligrams of chemical per kilogram of body weight per day) was calculated by using species-specific life history information, where available, and the following formula (modified from EPA, 1993):

$$DI_x = \frac{[[\sum_i (FIR)\,(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)]]}{BW}(AUF)$$

where:

DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Food ingestion rate (kg/day, dry-weight)
FC_{xi}	=	Concentration of chemical x in food item i (mg/kg, dry-weight)

PDF_i	=	Proportion of diet composed of food item i (dry-weight basis)
SC_x	=	Concentration of chemical x in sediment (mg/kg, dry-weight)
PDS	=	Proportion of diet composed of sediment (dry-weight basis)
BW	=	Body weight (kg, wet-weight)
AUF	=	Area use factor; % (decimal) of habitat used by receptor

Receptor-specific values used as inputs to this equation are provided in Table B2-8. It was assumed that constituents were 100% bioavailable to the receptor and that each receptor spent 100% of its time at the site (i.e., an AUF of 1.0 was assumed). Minimum body weights and maximum ingestion rates were used to develop conservative exposure estimates. Surface water (drinking water) was not included when calculating the total level of exposure because surface water is not present on the site.

B2.5 Screening Risk Calculation

The screening risk calculation is the final step of the SERA (Step 2). In this step, the sample-specific sediment concentrations or estimated exposure doses (upper trophic-level receptor species) were compared with the corresponding screening values to derive screening risk estimates. The outcome of this step is a list of detected COPCs for each medium-pathway-receptor combination evaluated or a conclusion of acceptable risk.

For the direct exposure evaluation (lower trophic-level receptors), COPCs were identified if one or more sample-specific concentration exceeded the screening value. For the food web evaluation, COPCs were identified using the hazard quotient (HQ) method. HQs were calculated by dividing the exposure dose by the corresponding ingestion screening value. Constituents with NOAEL-based HQs greater than 1.0 were considered COPCs for the SERA (Step 2). Detected constituents for which toxicological data were not available were also retained as COPCs for the SERA.

Sample concentrations exceeding screening values or resulting in HQs exceeding 1.0 indicate the potential for risk because the constituent concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure estimates were derived using intentionally conservative assumptions such that HQs greater than 1.0 do not necessarily indicate risks are present or impacts are occurring. Rather, it identifies constituent-pathway-receptor combinations requiring further evaluation. HQs less than 1.0 indicate risks are very unlikely (EPA, 1997), enabling a conclusion of no unacceptable risk to be reached with high confidence.

B2.5.1 Direct Exposure

Comparisons of each sample-specific concentration of lead to the ESL (35.8 mg/kg) are provided in Table B2-9. Table B2-9 also summarizes the pellet counts. Pellets were found in 4 samples across 3 transects (Transect 4, SD21 [2 pellets]; Transect 5, SD28 [10 pellets] and SD30 [1 pellet]; Transect 6, SD37 [2 pellets]). Lead was detected in all shotfall zone samples, but the detected concentration at only one location along Transect 6 (SD36) exceeded the ESL. There were no pellets found in sample SD36. The concentration in SD36 was 85,600 mg/kg, with all other shotfall zone sample detections ranging from 1.02 to 27.9 mg/kg. The range of lead concentrations in background samples was 0.38 to 12.9 mg/kg. The concentration at SD36 was considered biased high due to an analytical interference that does not reflect the actual level of bioavailability of lead or a realistic level of contamination in sediment even from a skeet range. One possible interference could have been a pellet, or pellet fragments that were missed in that sample prior to analysis. While no pellets were found in SD36, some pellets were found nearby along Transect 6 (two pellets in SD37). To test the validity of the detection of 85,600 mg/kg, the chemical analytical laboratory was asked to reanalyze archived digestate from the original analytical run for SD36, as well as return to the stock SD36 sediment to also re-digest and re-analyze another portion of the original sample. The re-analysis of the original digestate yielded a concentration of 85,100 mg/kg, and the re-digested/re-analyzed sample yielded a concentration of 11.9 mg/kg. These results suggest there was likely a lead pellet, pellet fragment or some other source of lead in the original portion of the sample that was analyzed, driving the concentration to a level that does not represent an actual direct exposure concentration.

The ∑SEM:AVS ratios are summarized in Table B2-10. The ∑SEM:AVS ratios at SD36 or other samples closest to this sample/transect do not indicate significant bioavailability that would suggest an impact is likely from metals. The ∑SEM:AVS ratios at only two shotfall zone sample locations were greater than 8.0 (Transect 2, SD09 [14.2] and Transect 3, SD14 [28.7]). However, total lead concentrations were not greater than the ESL for either location (Table B2-9). Therefore, even though conditions at these two locations suggest metals could be bioavailable, contributing to exposure impacts to the benthic community from metals, site-related lead would not be the cause of such impacts. Regardless, as a conservative approach, lead was identified as a Phase 1 COPC and carried through to Step 3A (Refined Risk Characterization) under Phase 2 of the investigation because of the high concentration at SD36 and uncertainty associated this detection.

Finally, comparisons of each sample-specific concentration of total PAHs to the ESL (1,610 ug/kg) is provided in Table B2-11. None of the total PAH concentrations estimated in shotfall zone samples exceed the ESL. The highest concentration of total PAHs in the shotfall zone was 132.0 ug/kg. Therefore, total PAHs are not expected to pose direct exposure risk for the benthic community and were eliminated for further consideration.

B2.5.2 Food Web Exposure

A summary of the food web exposure-based HQs, reflecting a comparison of maximum concentration-based estimated exposure doses for lead and detected bioaccumulative PAH compounds to ingestion-based screening values, is presented in Table B2-12. Only lead exposure for spotted sandpiper yielded a NOAEL-based HQ greater than 1.0. Therefore, lead was identified as COPCs and carried through to Step 3A (Refined Risk Characterization) under Phase 2 of the investigation.

B2.6 Refined Risk Characterization

Following Step 2, sediment-associated lead was identified as a COPC for direct contact (benthic community) and through food web exposure for spotted sandpiper. Therefore, Step 3 of the ERA process was initiated to further evaluate these constituents.

B2.6.1 Refinement of Conservative Screening Assumptions

The objective of the refinement is to identify potential risk-driving COPCs, called “refined COPCs,” requiring more-focused consideration in the Risk Evaluation. Therefore, Step 3A was initiated. According to Superfund guidance (EPA, 1997), Step 3 initiates the problem formulation phase of the BERA. Under Navy policy/guidance (CNO, 1999; NAVFAC, 2003), the BERA begins with a preliminary step (Step 3A) in which the conservative assumptions used in the SERA are refined and risk estimates are recalculated using the same CSM. In addition, the re-evaluation may include consideration of other factors such as background and upgradient data, detection frequency, and chemical-specific bioavailability (CNO, 1999; NAVFAC, 2003).

Only complete and critical pathways identified by the SERA were carried forward to Step 3A of the BERA. Similarly, only detected COPCs and receptors identified in the SERA as requiring further evaluation (lead, benthic community, and spotted sandpiper) were addressed in Step 3A. The assumptions, parameter values, and methods that were modified for the Step 3A re-evaluation of the Step 2 COPC (lead) included:

- Phase 2 Sampling Results: As discussed in Section B2.1.2, the Team agreed that a very focused follow-up Phase 2 investigation was necessary in the shotfall zone to better delineate the elevated lead concentration at SD36 during Phase 1. Therefore, another surface sediment sample (PX-FSR-SD36A-000H) and a subsurface sample (6 to 24 inches bgs; PX-FSR-SD36A-0624) were collected on August 21, 2019, at SD36 along Transect 6 to verify the previously elevated detection of lead during Phase 1. Two rings of four step-out surface sediment samples each were also collected at 10-foot intervals from SD36A (SD63 through SD66 were 10 feet out and SD67 through SD70 were 20 feet out). All Phase 2 samples were analyzed for lead and pellet count. At the Team's agreement, analyses were not performed for SD67 through SD70 given low levels of detections for SD36A and SD63 through SD66. All Phase 2 sample results were considered for the Step 3A Refined Risk Characterization.

- Spotted Sandpiper Food Web Modeling Refinements: The same food model that was used for the SERA (Step 2) was used for Step 3A of the BERA with the following refinements:

  – **Soil-Invertebrate BAF**: The soil-invertebrate BAF used to estimate dietary tissue concentrations was based on central tendency estimates (for example, median or mean) from the literature as opposed to the maximum or high-end (for example, 90th percentile) estimates used in the SERA for many constituents. In the BERA, using a central tendency estimate (rather than high-end or maximums) for exposure parameters such as BAFs provides a more-representative estimate of potential exposures and risks to receptor populations (the focus of the assessment endpoints) of upper trophic-level receptors. Because these species are highly mobile, receptor exposure would effectively be averaged over time as these organisms forage within the area defining their home range (which will extend to areas beyond the Former Skeet Ranges study area). Average prey concentrations at Step 3A are most appropriately estimated using central tendency estimates of media concentrations and accumulation factors. For example, the wildlife dietary exposure models contained in the *Wildlife Exposure Factors Handbook* (EPA, 1993) specify the calculation of an average daily dose. Increasing the representativeness of the exposure estimates relative to population-level effects is consistent with the intent of the Step 3A evaluation. The refined soil-invertebrate BAF value used in Step 3A for lead was 0.307 (Sample et al. 1998b).

  – **Exposure Parameters**: Central tendency estimates (mean, median, or midpoint) for body weight and food ingestion rate were used for spotted sandpiper to develop exposure estimates, rather than the minimum body weights and maximum ingestion rates used in the SERA. Central tendency estimates for these exposure parameters are more relevant for a BERA because these better represent the characteristics of a greater proportion of the individuals in the population. Populations (rather than individual organisms) were emphasized during the development of the assessment endpoints for the ERA. The body weight and food ingestion rate used for spotted sandpiper for Step 3A food web modeling were 0.04 kg (Dunning, 1993) and 0.0080 kg/day-dry (based on allometric equation from Nagy [2001]).

  - **EPC**: Even though it is typical to use a central tendency concentration from the available dataset as the EPC for Step 3A of the BERA (for example, mean of 95 percent upper tolerance level), the maximum concentration for lead was used to be conservative. This was done since results for this assessment are generally being assessed on a sample-by-sample basis, this approach also enables incorporation of the Phase 2 results. Excluding the Phase 1 SD36 results, the maximum concentration across both investigation phases was detected during Phase 2 at SD36A (29.1 mg/kg), which was the re-sampling of SD36. Therefore, 29.1 mg/kg was used as the EPC to estimate the exposure dose for spotted sandpiper.

  – **Basis for Exposure Risks**: The SERA (Step 2) conservatively identified a chemical as a food web COPC if the estimated dose for at least one upper trophic-level receptor exceeded the NOAEL. The actual dose that is protective of an individual receptor, however, will fall between the NOAEL and the LOAEL. Both the NOAEL and LOAEL were used to determine whether lead was a refined COPC in Step 3A of the BERA. Lead would have to yield a LOAEL-based HQ greater than 1.0 to be identified as a refined COPC.

B2.6.2 Direct Exposure

All Phase 2 results are summarized in Table B2-13. While a larger number of pellet counts were found in Phase 2 samples relative to Phase 1, none of the Phase 2 samples yielded lead concentrations in excess of the ESL. Therefore, lead is not considered a risk-driving or refined COPC and is not expected to pose unacceptable risk for the benthic macroinvertebrate community. No further action is warranted.

B2.6.3 Food Web Exposure

Using the same food web model with the above-stated parameter refinements, the NOAEL- and LOAEL-based Step 3A HQs were 0.37 and 0.07 for spotted sandpiper, respectively. Therefore, lead is not considered a risk-driving or refined COPC and is not expected to pose unacceptable risk for upper trophic-level receptors. No further action is warranted.

B2.7 Uncertainties

Uncertainties are present in all ERAs because of the limitations of available data and the need to make certain assumptions and extrapolations based on incomplete information. In addition, the use of various models (for example, uptake and food web exposures) each carries with it some associated uncertainty as to how well the model reflects actual conditions. The uncertainties in this ERA are mainly attributable to the following factors:

- <u>Undetected Constituents</u>: Some PAHs were not detected in the sediment samples. Because these compounds were not detected, it is assumed that these PAHs are not present in sediment. There is some uncertainty associated with this assumption because reporting limits represent a concentration under which these compounds could theoretically be present. However, to lessen the uncertainty of the assumption, one-half the reporting limits were used as surrogate detected concentrations when total PAHs concentrations were calculated. Therefore, this uncertainty is considered low especially since there was a uniform low level of PAH detections in the shotfall zone.

- <u>Duplicate Analyses</u>: When evaluating samples with field duplicates, the value used in the ERA was always the detected concentration when one result was a detection and the constituent was not detected in the duplicate, regardless of whether the non-detected value was higher. In these cases, the use of the detected concentration has less uncertainty because it represents an actual measured value (versus an upper limit bound) and the two samples will have similar if not identical reporting limits. Additionally, when there was a detection in both the parent and field duplicate sample, the higher of the two results was always used so as to bias the result higher. Therefore, this uncertainty is considered low.

- <u>Food Web Exposure Modeling</u>: Lead and PAH compound concentrations in aquatic food items (plants, invertebrates, and fish) were estimated from sediment concentrations and were not directly measured. The use of generic, literature-derived exposure models and bioaccumulation factors introduces some uncertainty into the resulting estimates. The values selected, and methodology employed were intended to provide a conservative SERA or more reasonable (Step 3A) estimate of potential food web exposure concentrations.

  AUFs were assumed to equal 1.0. This is also a conservative assumption because a significant percentage of time for each upper trophic-level receptor species could be spent foraging offsite in unaffected areas or in areas where chemical concentrations are expected to be significantly less.

B2.8 Conclusions

No further action is warranted for the aquatic habitat associated with the theoretical shotfall zone of the Former Skeet Ranges.

B2.9 References

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Tables

Table B2-1. Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints

Former Skeet Range, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor
Survival, growth, and reproduction of benthic macroinvertebrate communities	Are site-related constituent concentrations in sediment sufficient to adversely affect benthic macroinvertebrate communities?	Comparison of constituent concentrations in surface soils with sediment screening values	Benthic macroinvertebrates (worms, bivalves, crustaceans)
Survival, growth, and reproduction of benthic macroinvertebrate communities	Are site-related constituent concentrations in sediment sufficient to adversely affect benthic macroinvertebrate communities?	Comparison of constituent concentrations in surface soils with sediment screening values	Fish (various forage fish, Flounder, Striped bass, rockfish)
Survival, growth, and reproduction of submerged aquatic plant communities	Are site-related constituent concentrations in sediment sufficient to adversely affect aquatic plant communities?	Comparison of constituent concentrations in sediment with sediment screening values	Aquatic plants (Bay grasses)
Survival, growth, and reproduction of reptile populations	Are site-related constituent concentrations in sediment sufficient to adversely affect reptile populations?	Comparison of constituent concentrations in sediment with sediment screening values	Reptiles (turtles, snakes)
	Are site-related constituent concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to reptile populations?	Evidence of potential risk to other upper trophic level terrestrial receptors evaluated in the ERA	
Survival, growth, and reproduction of avian aquatic piscivore populations	Are site-related constituent concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume fish from the shotfall zone of the Patuxcent River?	Comparison of modeled dietary intakes using surface soil concentrations with literature-based ingestion screening values; ratios >1 based upon the NOAEL-LOAEL range indicate an effect.	Great blue heron, Osprey
Survival, growth, and reproduction of avian semi-aquatic invertivore populations	Are site-related constituent concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume benthic macroinvertebrates from the shotfall zone of the Patuxcent River?		Marsh wren, Spotted sandpiper
Survival, growth, and reproduction of avian semi-aqiatic omnivore populations	Are site-related constituent concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian receptor populations that may consume aquatic plants and benthic macroinvertebrates from the shotfall zone of the Patuxcent River?		Raccoon
Survival, growth, and reproduction of mammalian semi-aquatic herbivore populations	Are site-related constituent concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian receptor populations that may consume aquatic plants from the shotfall zone of the Patuxcent River?		Muskrat

Table B2-2.Surface Sediment Chemical Analytical Results (Phase 1) - Habitat Descriptions
Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)
NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Sample Time	Water Depth (feet)	Habitat	Live Organisms
Shotfall Zone Samples	1	PX-FSR-SD01-000H	6/13/19	1355	0.2	Sand with gravel and cobbles, brown, loose, no signs of organisms.	None
		PX-FSR-SD02-000H	6/15/19	1225	0.4	Sand with gravel and cobbles, brown, loose, no signs of organisms.	None
		PX-FSR-SD03-000H	6/13/19	1345	0.6	Sand with gravel and cobbles, brown, loose, no signs of organisms.	None
	2	PX-FSR-SD04-000H	6/15/19	1215	0.2	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD05-000H	6/13/19	1335	0.4	Sand with gravel and cobbles, light brown, loose, no signs of organisms.	None
		PX-FSR-SD06-000H	6/15/19	1200	0.7	Sand and cobbles, gray brown, loose, no signs of organisms.	None
		PX-FSR-SD07-000H	6/13/19	1315	1.4	Sand with some gravel, gray brown, loose, broken shells.	None
		PX-FSR-SD08-000H	6/15/19	1130	1.5	Soft silt with sand, dark gray brown, trace broken shells, sticks, few small bivalves	Bivalves
		PX-FSR-SD09-000H	6/13/19	1305	1.6	Soft silt with sand, dark gray brown, no signs of organisms.	None
	3	PX-FSR-SD10-000H	6/13/19	1245	0.2	Sand with gravel and cobbles, light brown, loose, few small crustaceans.	Crustaceans
		PX-FSR-SD11-000H	6/15/19	1120	0.4	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD12-000H	6/13/19	1235	1.4	Sand with gravel, light gray brown, loose, broken shells, few small bivalves, trace seaweed/grass.	Bivalves
		PX-FSR-SD13-000H	6/15/19	1110	1.7	Soft silt with sand, dark gray brown, sticks, no signs of organisms.	None
		PX-FSR-SD14-000H	6/13/19	1225	1.8	Soft silt with sand, dark gray brown, many small broken bivalve shells.	None
		PX-FSR-SD15-000H	6/15/19	1105	1.8	Soft silt with sand, dark gray brown, trace shells.	None
		PX-FSR-SD16-000H	6/13/19	1210	2.0	Soft silt with sand, very dark brown, broken shells.	None
	4	PX-FSR-SD17-000H	6/15/19	1055	0.2	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD18-000H	6/13/19	1155	0.5	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD19-000H	6/15/19	1045	1.5	Sand with silt, brown and gray, loose, broken shells throughout, few small bivalves.	Bivalves
		PX-FSR-SD20-000H	6/13/19	1150	1.8	Soft silt with some sand, dark gray brown, worm.	Worm
		PX-FSR-SD21-000H	6/15/19	1035	1.7	Soft silt with sand, brown and gray, oyster shells, broken shells.	None
		PX-FSR-SD22-000H	6/15/19	1025	1.8	Soft silt with sand, dark gray brown, some oyster shells, trace broken shells, sticks.	None
		PX-FSR-SD23-000H	6/13/19	1135	2.1	Soft silt some sand, dark gray brown, shell fragments, oyster shells.	None
		PX-FSR-SD24-000H	6/15/19	0920	2.1	Soft silt with sand, dark gray brown, large oyster shells, broken shells.	None
	5	PX-FSR-SD25-000H	6/13/19	1120	0.3	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD26-000H	6/15/19	0910	0.4	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD27-000H	6/13/19	1105	1.7	Soft silt with sand, dark brown, loose, broken shells throughout.	None
		PX-FSR-SD28-000H	6/15/19	0900	1.6	Soft silt with sand, dark gray brown, trace broken shells.	None
		PX-FSR-SD29-000H	6/13/19	1050	1.9	Soft silt with some sand, dark brown, loose, broken shells, large oyster shells, small bivalves.	Bivalves
		PX-FSR-SD30-000H	6/15/19	0850	1.8	Soft silt and sand, dark gray brown, trace broken shells.	None
		PX-FSR-SD31-000H	*Refusal at multiple attempts, therefore not sampled*				
		PX-FSR-SD32-000H	6/12/19	1435	2.2	Silt and sand, dark brown and black, loose, large oyster shells.	None
	6	PX-FSR-SD33-000H	6/15/19	0835	0.1	Sand and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD34-000H	6/12/19	1425	0.5	Sand, brown, loose, no signs of organisms.	None
		PX-FSR-SD35-000H	6/15/19	0825	1.4	Sand, brown, loose, broken shells, small bivalves.	Bivalves
		PX-FSR-SD36-000H	6/12/19	1415	1.8	Silt and sand and cobbles, dark gray to brown, some shells.	None
		PX-FSR-SD37-000H	6/15/19	0820	1.8	Soft silt and sand, dark gray brown, broken shells, oyster shells.	None
		PX-FSR-SD38-000H	6/12/19	1045	2.1	Silt and sand, dark brown, abundant oyster shells.	None
		PX-FSR-SD39-000H	6/15/19	0810	2.0	Soft silt and sand, dark gray brown, abundant oyster shells.	None
	7	PX-FSR-SD40-000H	6/12/19	1025	0.3	Sand and gravel and cobbles, light brown, loose, no signs of organisms.	None
		PX-FSR-SD41-000H	6/15/19	0800	0.3	Sand, light brown gray, loose, trace broken shells.	None
		PX-FSR-SD42-000H	6/12/19	1010	1.6	Sand some silt, dark brown gray, loose, broken shells, small bivalves.	Bivalves
		PX-FSR-SD43-000H	6/15/19	0755	1.6	Soft silt with sand, dark gray brown, sticks and broken shells.	None
		PX-FSR-SD44-000H	6/12/19	1000	1.9	Silt and sand, dark brown, broken shells, oyster shells.	None
		PX-FSR-SD45-000H	*Refusal at multiple attempts, therefore not sampled*				
		PX-FSR-SD46-000H	6/12/19	0950	2.1	Silt and sand, dark brown, loose, broken shells.	None

Table B2-2.Surface Sediment Chemical Analytical Results (Phase 1) - Habitat Descriptions

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Sample Time	Water Depth (feet)	Habitat	Live Organisms
Shotfall Zone Samples	8	PX-FSR-SD47-000H	6/15/19	1330	0.1	Cobbles and sand, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD48-000H	6/12/19	0930	0.4	Sand, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD49-000H	6/15/19	0735	0.5	Sand, light gray brown, loose, trace broken shells.	None
		PX-FSR-SD50-000H	6/12/19	0920	1.7	Silt and sand, dark brown, loose, no signs of organisms.	None
		PX-FSR-SD51-000H	6/15/19	0730	1.7	Soft silt with sand, dark brown, sticks and broken shells, oyster shells.	None
		PX-FSR-SD52-000H	6/12/19	0910	1.9	Silt and sand, dark brown, loose, small bivalves and shells.	Bivalves
		PX-FSR-SD53-000H				*Refusal at multiple attempts, therefore not sampled*	
	9	PX-FSR-SD54-000H	6/15/19	1320	0.1	Cobbles with sand, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD55-000H	6/12/19	0855	0.4	Sand and gravel and cobbles, light brown, loose, no signs of organisms.	None
		PX-FSR-SD56-000H	6/15/19	0700	0.3	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD57-000H	6/12/19	0840	1.4	Sand, brown, loose, no signs of organisms.	None
		PX-FSR-SD58-000H	6/15/19	0655	1.6	Soft silt with sand, dark gray brown, trace broken shells.	None
		PX-FSR-SD59-000H	6/12/19	0830	1.8	Soft silt and sand, brown, shell fragments.	None
	10	PX-FSR-SD60-000H	6/15/19	1245	0.2	Sand with gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PX-FSR-SD61-000H	6/15/19	0645	0.2	Sand with gravel and cobbles, light gray brown, loose, trace broken shells.	None
		PX-FSR-SD62-000H	6/12/19	0810	0.4	Sand with gravel and cobbles, brown, loose, no signs of organisms.	None
Background Samples	A	PAX-BG-SD01-000H				*Refusal at multiple attempts, therefore not sampled*	
		PAX-BG-SD02-000H	6/15/19	1515	1.3	Soft silt with sand, brown, no signs of organisms.	None
		PAX-BG-SD03-000H	6/13/19	1500	1.1	Sand, brown, loose, small crustaceans, many live bivalves.	Crustaceans, Bivalves
		PAX-BG-SD04-000H	6/15/19	1505	1.1	Sand, brown, loose, no signs of organisms.	None
	B	PAX-BG-SD05-000H	6/15/19	1450	1.5	Soft silt with sand, dark gray, trace broken shells.	None
		PAX-BG-SD06-000H	6/13/19	1450	1.6	Soft silt with sand, dark gray and brown, trace broken shells.	None
		PAX-BG-SD07-000H	6/15/19	1440	1.6	Dense silt with sand and clay, gray/blue, some shells.	None
		PAX-BG-SD08-000H	6/13/19	1435	1.6	Sand and silt, brown, loose, broken shells throughout.	None
	C	PAX-BG-SD09-000H	6/15/19	1420	0.5	Sand with cobbles and gravel, brown, loose, no signs of organisms.	None
		PAX-BG-SD10-000H	6/15/19	1405	1.1	Sand, brown, loose, trace shell fragments.	None
		PAX-BG-SD11-000H	6/13/19	1410	1.2	Sand with gravel, brown, loose, small bivalves, broken shells.	Bivalves
		PAX-BG-SD12-000H	6/14/19	0835	1.3	Sand with silt, brown, loose, broken shells throughout.	None
	D	PAX-BG-SD13-000H	6/12/19	1355	0.4	Sand and gravel and cobbles, light gray brown, loose, no signs of organisms.	None
		PAX-BG-SD14-000H	6/12/19	1345	0.6	Sand and gravel and cobbles, light brown, loose, oyster and bivalve shell fragments, bivalve.	Bivalves
		PAX-BG-SD15-000H	6/12/19	1335	0.6	Sand, brown, loose, small shells, none live organisms.	None
		PAX-BG-SD16-000H	6/12/19	1325	0.6	Sand, light brown, loose, shell fragments, bivalves.	Bivalves
	E	PAX-BG-SD17-000H	6/12/19	1315	0.4	Sand and gravel and cobbles, light gray brown, loose, shell fragments, small crustacean.	Crustacean
		PAX-BG-SD18-000H	6/12/19	1305	0.5	Sand, brown, loose, broken shells, crustacean.	Crustacean
		PAX-BG-SD19-000H	6/12/19	1255	0.6	Sand, brown, loose, abundant small bivalves.	Bivalves
		PAX-BG-SD20-000H	6/12/19	1240	0.6	Sand with silt, brown, loose, abundant small bivalves, crustacean.	Crustacean, Bivalves

Table B2-3. Summary of Available Surface Sediment Chemical Analytical Data (Phase 1)

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Lead	PAHs	Pellet Count	Acid Volatile Sulfide (AVS)/ Simultaneously Extracted Metals (SEM)	% Solids	pH	Total Organic Carbon (TOC)	Grain Size
Shotfall Zone Samples	1	PX-FSR-SD01-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD02-000H	6/15/19	x		x					
		PX-FSR-SD03-000H	6/13/19	x		x	x	x	x	x	x
	2	PX-FSR-SD04-000H	6/15/19	x		x					
		PX-FSR-SD05-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD06-000H	6/15/19	x		x					
		PX-FSR-SD07-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD08-000H	6/15/19	x		x					
		PX-FSR-SD08P-000H	*field duplicate*	x		x					
		PX-FSR-SD09-000H	6/13/19	x		x	x	x	x	x	x
	3	PX-FSR-SD10-000H	6/13/19	x	x	x	x	x	x	x	x
		PX-FSR-SD11-000H	6/15/19	x		x					
		PX-FSR-SD12-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD13-000H	6/15/19	x		x					
		PX-FSR-SD14-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD15-000H	6/15/19	x		x					
		PX-FSR-SD16-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD16P-000H	*field duplicate*	x		x			x	x	
	4	PX-FSR-SD17-000H	6/15/19	x	x	x					
		PX-FSR-SD18-000H	6/13/19	x	x	x	x	x	x	x	x
		PX-FSR-SD19-000H	6/15/19	x		x					
		PX-FSR-SD20-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD21-000H	6/15/19	x		x					
		PX-FSR-SD21P-000H	*field duplicate*	x		x					
		PX-FSR-SD22-000H	6/15/19	x		x					
		PX-FSR-SD23-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD24-000H	6/15/19	x		x					

Table B2-3. Summary of Available Surface Sediment Chemical Analytical Data (Phase 1)
Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)
NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Lead	PAHs	Pellet Count	Acid Volatile Sulfide (AVS)/ Simultaneously Extracted Metals (SEM)	% Solids	pH	Total Organic Carbon (TOC)	Grain Size
Shotfall Zone Samples	5	PX-FSR-SD25-000H	6/13/19	x	x	x	x	x	x	x	x
		PX-FSR-SD26-000H	6/15/19	x	x	x					
		PX-FSR-SD27-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD28-000H	6/15/19	x		x					
		PX-FSR-SD28P-000H	*field duplicate*	x		x					
		PX-FSR-SD29-000H	6/13/19	x		x	x	x	x	x	x
		PX-FSR-SD30-000H	6/15/19	x		x					
		PX-FSR-SD31-000H	*not collected*	NA		NA					
		PX-FSR-SD32-000H	6/12/19	x		x	x	x	x	x	x
	6	PX-FSR-SD33-000H	6/15/19	x	x	x					
		PX-FSR-SD34-000H	6/12/19	x	x	x	x	x	x	x	x
		PX-FSR-SD35-000H	6/15/19	x		x					
		PX-FSR-SD36-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD37-000H	6/15/19	x		x					
		PX-FSR-SD38-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD39-000H	6/15/19	x		x					
	7	PX-FSR-SD40-000H	6/12/19	x	x	x	x	x	x	x	x
		PX-FSR-SD41-000H	6/15/19	x	x	x					
		PX-FSR-SD41P-000H	*field duplicate*	x	x	x					
		PX-FSR-SD42-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD43-000H	6/15/19	x		x					
		PX-FSR-SD44-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD45-000H	*not collected*	NA	NA	NA					
		PX-FSR-SD46-000H	6/12/19	x		x	x	x	x	x	x
	8	PX-FSR-SD47-000H	6/15/19	x	x	x					
		PX-FSR-SD48-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD49-000H	6/15/19	x		x					
		PX-FSR-SD50-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD51-000H	6/15/19	x		x					
		PX-FSR-SD52-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD53-000H	*not collected*	NA	NA	NA					

Table B2-3. Summary of Available Surface Sediment Chemical Analytical Data (Phase 1)

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Lead	PAHs	Pellet Count	Acid Volatile Sulfide (AVS)/ Simultaneously Extracted Metals (SEM)	% Solids	pH	Total Organic Carbon (TOC)	Grain Size
Shotfall Zone Samples	9	PX-FSR-SD54-000H	6/15/19	x		x					
		PX-FSR-SD55-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD56-000H	6/15/19	x		x					
		PX-FSR-SD56P-000H	*field duplicate*	x		x					
		PX-FSR-SD57-000H	6/12/19	x		x	x	x	x	x	x
		PX-FSR-SD58-000H	6/15/19	x		x					
		PX-FSR-SD59-000H	6/12/19	x		x	x	x	x	x	x
	10	PX-FSR-SD60-000H	6/15/19	x		x					
		PX-FSR-SD61-000H	6/15/19	x		x					
		PX-FSR-SD62-000H	6/12/19	x		x	x	x	x	x	x
Background Samples	A	PX-BG-SD01-000H	*not collected*	NA	NA						
		PX-BG-SD02-000H	6/15/19	x	x						
		PX-BG-SD03-000H	6/13/19	x	x		x	x	x	x	x
		PX-BG-SD04-000H	6/15/19	x	x						
	B	PX-BG-SD05-000H	6/15/19	x	x						
		PX-BG-SD06-000H	6/13/19	x	x		x	x	x	x	x
		PX-BG-SD07-000H	6/15/19	x	x						
		PX-BG-SD08-000H	6/13/19	x	x		x	x	x	x	x
	C	PX-BG-SD09-000H	6/15/19	x	x		x	x	x	x	x
		PX-BG-SD10-000H	6/15/19	x	x						
		PX-BG-SD11-000H	6/13/19	x	x		x	x	x	x	x
		PX-BG-SD11P-000H	*field duplicate*	x	x				x	x	
		PX-BG-SD12-000H	6/14/19	x	x						
	D	PX-BG-SD13-000H	6/12/19	x	x				x	x	
		PX-BG-SD14-000H	6/12/19	x	x		x	x	x	x	x
		PX-BG-SD15-000H	6/12/19	x	x				x	x	
		PX-BG-SD16-000H	6/12/19	x	x		x	x	x	x	x
	E	PX-BG-SD17-000H	6/12/19	x	x		x	x	x	x	x
		PX-BG-SD18-000H	6/12/19	x	x				x	x	
		PX-BG-SD18P-000H	*field duplicate*	x	x				x	x	
		PX-BG-SD19-000H	6/12/19	x	x		x	x	x	x	x
		PX-BG-SD20-000H	6/12/19	x	x				x	x	

Notes:

An "x" indicates if that sample was analyzed for that parameter

NA indicates samples that were not analyzed due to the proposed sample not being collected

Blank cells indicate parameter was not proposed for that sample

Table B2-4. Surface Sediment Chemical Analytical Results (Phase 1) - Other Parameters

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	% Solids	pH	TOC (MG/KG)	Grain Size Fines (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
Shotfall Zone Samples	1	PX-FSR-SD01-000H	6/13/19	85.6	7.41	386	0.11	7.94	67.55	23.08	1.32
		PX-FSR-SD03-000H	6/13/19	84.6	7.48	2190	0.37	3.7	70.69	23.84	1.4
	2	PX-FSR-SD05-000H	6/13/19	84.3	7.46	2140	0.39	16.28	49.46	33.88	0.0
		PX-FSR-SD07-000H	6/13/19	78.1	8.01	4450	0.72	71.04	26.31	0.84	1.09
		PX-FSR-SD09-000H	6/13/19	68.3	7.62	6320	16.82	79.2	2.02	0.19	1.77
	3	PX-FSR-SD10-000H	6/13/19	89.9	7.53	526	0.08	21.29	30.31	46.63	1.69
		PX-FSR-SD12-000H	6/13/19	80.7	7.64	635	0.5	34.04	58.64	4.1	2.72
		PX-FSR-SD14-000H	6/13/19	61.7	7.7	9650	27.33	68.28	2.9	0.04	1.45
		PX-FSR-SD16-000H	6/13/19	55.8	7.87	9760	28.01	63.65	4.53	1.59	2.22
	4	PX-FSR-SD18-000H	6/13/19	89.3	7.51	904	0.36	13.99	28.49	56.47	0.69
		PX-FSR-SD20-000H	6/13/19	64.8	7.69	7710	22.23	72.65	3.44	0.32	1.36
		PX-FSR-SD23-000H	6/13/19	61.6	7.97	10400	28.51	62.7	4.25	0.83	3.71
	5	PX-FSR-SD25-000H	6/13/19	88.6	7.54	382	0.12	16.31	35.27	47.7	0.6
		PX-FSR-SD27-000H	6/13/19	70.1	7.77	4360	9.52	83.27	3.16	1.2	2.85
		PX-FSR-SD29-000H	6/13/19	64	8.01	6630	24.75	67.69	4.52	0.84	2.2
		PX-FSR-SD32-000H	6/12/19	67.9	7.9	5870	13.52	75.49	5.5	2.74	2.75
	6	PX-FSR-SD34-000H	6/12/19	80.6	7	716	0.6	65.5	31.54	0.58	1.78
		PX-FSR-SD36-000H	6/12/19	66.4	7.9	7620	20.42	70.06	4.83	2.01	2.68
		PX-FSR-SD38-000H	6/12/19	68.5	7.96	5790	11.31	57.69	9.18	12.04	9.78
	7	PX-FSR-SD40-000H	6/12/19	86.6	7.04	457	0.12	13.33	50.28	37.62	0.0
		PX-FSR-SD42-000H	6/12/19	80.6	7.84	705	0.88	78.74	17.88	0.08	2.42
		PX-FSR-SD44-000H	6/12/19	70.1	7.84	5880	19.14	73.77	3.43	0.24	3.42
		PX-FSR-SD46-000H	6/12/19	70.9	8.03	4570	10.01	81.66	4.65	1.29	2.39
	8	PX-FSR-SD48-000H	6/12/19	82.5	7.24	556	0.46	57.54	39.01	2.75	0.24
		PX-FSR-SD50-000H	6/12/19	71.9	7.83	4250	9.39	83.8	3.76	0.5	2.55
		PX-FSR-SD52-000H	6/12/19	73	8.05	3450	8.44	82.55	5.45	1.81	1.75
	9	PX-FSR-SD55-000H	6/12/19	87.4	7.13	722	0.37	42.11	25.06	29.16	3.3
		PX-FSR-SD57-000H	6/12/19	80.7	7.39	741	0.89	77.16	19.28	0.62	2.05
		PX-FSR-SD59-000H	6/12/19	67.1	7.79	5490	20.03	73.72	3.28	0.21	2.76
	10	PX-FSR-SD62-000H	6/12/19	91	7.71	832	0.42	24.08	32.26	40.1	3.14

Table B2-4. Surface Sediment Chemical Analytical Results (Phase 1) - Other Parameters

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	% Solids	pH	TOC (MG/KG)	Grain Size				
							Fines (%)	**Fine Sand (%)**	**Medium Sand (%)**	**Coarse Sand (%)**	**Gravel (%)**
Background Samples	A	PX-BG-SD03-000H	6/13/19	82.6	7.43	898	1.15	41.56	54.81	0.41	2.07
	B	PX-BG-SD06-000H	6/13/19	70.6	7.78	5890	10.42	72.08	11.99	2.72	2.79
		PX-BG-SD08-000H	6/13/19	79.7	7.95	2750	5.48	74.97	16.56	1.72	1.27
	C	PX-BG-SD09-000H	6/15/19	86.9	7.3	1200	0.2	28.72	26.72	46.01	0.0
		PX-BG-SD11-000H	6/13/19	80.4	7.63	753	0.89	68.58	26.03	1.83	2.67
		PX-BG-SD11P-000H	*field duplicate*	--	7.92	878	--	--	--	--	--
	D	PX-BG-SD13-000H	6/12/19	--	7.43	1000	--	--	--	--	--
		PX-BG-SD14-000H	6/12/19	89	7.63	1680	0.39	18.95	31.26	47.54	1.86
		PX-BG-SD15-000H	6/12/19	--	7.77	1060	--	--	--	--	--
		PX-BG-SD16-000H	6/12/19	80.2	7.63	1100	0.46	74.92	22.81	0.44	1.37
	E	PX-BG-SD17-000H	6/12/19	83	7.37	687	0.41	17.18	52.19	30.17	0.05
		PX-BG-SD18-000H	6/12/19	--	7.5	1570	--	--	--	--	--
		PX-BG-SD18P-000H	*field duplicate*	--	7.45	1590	--	--	--	--	--
		PX-BG-SD19-000H	6/12/19	78.7	7.8	1820	1.14	33.9	57.04	5.67	2.25
		PX-BG-SD20-000H	6/12/19	--	7.85	1500	--	--	--	--	--

Table B2-5. Ingestion Screening Values - Birds

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Inorganics								
Lead[1]	Japanese quail	0.15	12 weeks	oral in diet	reproduction	11.3	1.13	Sample et al. 1996
Lead[2]	American kestrel	0.13	7 months	oral in diet	reproduction	19.3	3.85	Sample et al. 1996
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Acenaphthylene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(a)anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(a)pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(b)fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(g,h,i)perylene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Benzo(k)fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Chrysene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Dibenz(a,h)anthracene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Fluoranthene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Fluorene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Indeno(1,2,3-cd)pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Phenanthrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963
Pyrene	chicken	1.50	35 days	oral in diet	reproduction	35.5	7.10	Rigdon and Neal 1963

Notes:

1 - TRV used for spotted sandpiper

2 - TRV used for great blue heron, marsh wren, osprey

Table B2-6. Ingestion Screening Values - Mammals

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Inorganics								
Lead	rat	0.35	3 generations	oral in diet	reproduction	80.0	8.00	Sample et al. 1996
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	mouse	0.03	13 weeks	oral (gavage)	reproduction	700	350	ATSDR 1995
Acenaphthylene	mouse	0.03	13 weeks	oral (gavage)	reproduction	700	350	ATSDR 1995
Anthracene	mouse	0.03	13 weeks	oral (gavage)	reproduction	5,000	1,000	ATSDR 1995
Benzo(a)anthracene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Benzo(a)pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Benzo(b)fluoranthene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Benzo(g,h,i)perylene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Benzo(k)fluoranthene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Chrysene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Dibenz(a,h)anthracene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Fluoranthene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995
Fluorene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995
Indeno(1,2,3-cd)pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996
Phenanthrene	mouse	0.03	13 weeks	oral (gavage)	reproduction	2,500	500	ATSDR 1995
Pyrene	mouse	0.03	GD 7-16	oral (gavage)	reproduction	10.0	2.00	Sample et al. 1996

Table B2-7. Soil Bioconcentration Factors For Plants and Soil Invertebrates - Step 2

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Sediment-Plant BCF (dry weight)		Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	**Reference**	**Value**	**Reference**	**Value**	**Reference**
Inorganics						
Lead	0.468	Bechtel Jacobs 1998b	1.522	Sample et al. 1998b	0.070	Krantzberg and Boyd 1992
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	1.3367	USEPA 2005b	0.30	Beyer and Stafford 1993	1.00	--
Acenaphthylene	1.2156	USEPA 2005b	0.22	Beyer and Stafford 1993	1.00	--
Anthracene	0.9588	USEPA 2005b	0.32	Beyer and Stafford 1993	1.00	--
Benzo(a)anthracene	0.5229	USEPA 2005b	0.27	Beyer and Stafford 1993	1.00	--
Benzo(a)pyrene	0.4212	USEPA 2005b	0.34	Beyer and Stafford 1993	1.00	--
Benzo(b)fluoranthene	0.4017	USEPA 2005b	0.21	Beyer and Stafford 1993	1.00	--
Benzo(g,h,i)perylene	0.3086	USEPA 2005b	0.15	Beyer and Stafford 1993	1.00	--
Benzo(k)fluoranthene	0.4017	USEPA 2005b	0.21	Beyer and Stafford 1993	1.00	--
Chrysene	0.5229	USEPA 2005b	0.44	Beyer and Stafford 1993	1.00	--
Dibenz(a,h)anthracene	0.3102	USEPA 2005b	0.49	Beyer and Stafford 1993	1.00	--
Fluoranthene	0.7099	USEPA 2005b	0.37	Beyer and Stafford 1993	1.00	--
Fluorene	1.1471	USEPA 2005b	0.20	Beyer and Stafford 1993	1.00	--
Indeno(1,2,3-cd)pyrene	0.3168	USEPA 2005b	0.41	Beyer and Stafford 1993	1.00	--
Phenanthrene	0.9588	USEPA 2005b	0.28	Beyer and Stafford 1993	1.00	--
Pyrene	0.7137	USEPA 2005b	0.39	Beyer and Stafford 1993	1.00	--

Notes:

Soil-plant CBFs were used to extrapolate to sediment

Table B2-8. Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 2

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Dietary Composition (percent)				Sediment Ingestion (percent)	
Receptor	**Value**	**Reference**	**Value**	**Reference**	**Fish**	**Aquatic Plants**	**Benthic Invert.**	**Reference**	**Value**	**Reference**
Birds										
Great blue heron	2.10	Butler 1992	0.1356	allometric equation	100	0	0	USEPA 1993; Quinney and Smith 1980	0	Sample and Suter 1994
Marsh wren	0.010	Dunning 1993	0.0030	USEPA 1993	0	0	95.0	USEPA 1993	5.0	Assumed based on diet
Osprey	1.24	Dunning 1993	0.0919	USEPA 1993	100	0	0	USEPA 1993	0	Assumed based on diet
Spotted sandpiper	0.029	Dunning 1993	0.0105	allometric equation	0	0	82.0	USEPA 1993	18.0	Beyer et al. 1994
Mammals										
Muskrat	0.750	USEPA 1993	0.0765	USEPA 1993	0	90.6	0	USEPA 1993	9.4	Beyer et al. 1994 (raccoon)
Raccoon	4.23	Silva and Downing 1995	0.1307	Conover 1989	7.0	40.0	43.6	USEPA 1993	9.4	Beyer et al. 1994

Table B2-9. Surface Sediment Chemical Analytical Results (Step 2/Phase 1) - Lead

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Lead (MG/KG)		Pellet Count[1]
Shotfall Zone Samples	1	PX-FSR-SD01-000H	6/13/19	1.75		0
		PX-FSR-SD02-000H	6/15/19	1.39	J	--
		PX-FSR-SD03-000H	6/13/19	3.08		0
	2	PX-FSR-SD04-000H	6/15/19	3.06	J	--
		PX-FSR-SD05-000H	6/13/19	2.00		0
		PX-FSR-SD06-000H	6/15/19	2.13	J	--
		PX-FSR-SD07-000H	6/13/19	1.86		0
		PX-FSR-SD08-000H	6/15/19	5.28	J	--
		PX-FSR-SD08P-000H	*field duplicate*	5.79	J	--
		PX-FSR-SD09-000H	6/13/19	5.61		0
	3	PX-FSR-SD10-000H	6/13/19	2.95		0
		PX-FSR-SD11-000H	6/15/19	2.14	J	--
		PX-FSR-SD12-000H	6/13/19	1.02		0
		PX-FSR-SD13-000H	6/15/19	7.93	J	--
		PX-FSR-SD14-000H	6/13/19	7.68		0
		PX-FSR-SD15-000H	6/15/19	7.20	J	--
		PX-FSR-SD16-000H	6/13/19	7.23		0
		PX-FSR-SD16P-000H	*field duplicate*	8.37		not analyzed
	4	PX-FSR-SD17-000H	6/15/19	2.83	J	--
		PX-FSR-SD18-000H	6/13/19	1.16		0
		PX-FSR-SD19-000H	6/15/19	2.82	J	--
		PX-FSR-SD20-000H	6/13/19	11.5		0
		PX-FSR-SD21-000H	6/15/19	7.84	J	2
		PX-FSR-SD21P-000H	*field duplicate*	7.41	J	not analyzed
		PX-FSR-SD22-000H	6/15/19	7.14	J	--
		PX-FSR-SD23-000H	6/13/19	7.45		0
		PX-FSR-SD24-000H	6/15/19	7.13	J	--
	5	PX-FSR-SD25-000H	6/13/19	2.01		0
		PX-FSR-SD26-000H	6/15/19	1.54	J	--
		PX-FSR-SD27-000H	6/13/19	5.67		0
		PX-FSR-SD28-000H	6/15/19	9.28	J	10
		PX-FSR-SD28P-000H	*field duplicate*	9.45	J	not analyzed
		PX-FSR-SD29-000H	6/13/19	9.76		0
		PX-FSR-SD30-000H	6/15/19	8.98	J	1
		PX-FSR-SD31-000H	*not collected*	--		not analyzed
		PX-FSR-SD32-000H	6/12/19	12.5		0
	6	PX-FSR-SD33-000H	6/15/19	2.55	J	--
		PX-FSR-SD34-000H	6/12/19	27.9		0
		PX-FSR-SD35-000H	6/15/19	2.38	J	--
		PX-FSR-SD36-000H[2]	6/12/19	85,600		0
		PX-FSR-SD37-000H	6/15/19	6.46	J	2
		PX-FSR-SD38-000H	6/12/19	4.18	J	0
		PX-FSR-SD39-000H	6/15/19	4.55	J	--

Table B2-9. Surface Sediment Chemical Analytical Results (Step 2/Phase 1) - Lead

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Lead (MG/KG)		Pellet Count[1]
Shotfall Zone Samples	7	PX-FSR-SD40-000H	6/12/19	2.25	J	0
		PX-FSR-SD41-000H	6/15/19	1.55	J	--
		PX-FSR-SD41P-000H	*field duplicate*	1.92	J	not analyzed
		PX-FSR-SD42-000H	6/12/19	12.4	J	0
		PX-FSR-SD43-000H	6/15/19	7.50	J	--
		PX-FSR-SD44-000H	6/12/19	4.91	J	0
		PX-FSR-SD45-000H	*not collected*	--		not analyzed
		PX-FSR-SD46-000H	6/12/19	4.14	J	0
	8	PX-FSR-SD47-000H	6/15/19	3.33	J	--
		PX-FSR-SD48-000H	6/12/19	2.48	J	0
		PX-FSR-SD49-000H	6/15/19	3.04	J	--
		PX-FSR-SD50-000H	6/12/19	8.13	J	0
		PX-FSR-SD51-000H	6/15/19	4.67	J	--
		PX-FSR-SD52-000H	6/12/19	4.27	J	0
		PX-FSR-SD53-000H	*not collected*	--		not analyzed
	9	PX-FSR-SD54-000H	6/15/19	3.19	J	--
		PX-FSR-SD55-000H	6/12/19	3.73	J	0
		PX-FSR-SD56-000H	6/15/19	2.25	J	--
		PX-FSR-SD56P-000H	*field duplicate*	2.68	J	not analyzed
		PX-FSR-SD57-000H	6/12/19	1.65	J	0
		PX-FSR-SD58-000H	6/15/19	5.77	J	--
		PX-FSR-SD59-000H	6/12/19	6.23	J	0
	10	PX-FSR-SD60-000H	6/15/19	2.67	J	--
		PX-FSR-SD61-000H	6/15/19	1.34	J	--
		PX-FSR-SD62-000H	6/12/19	1.96	J	0
Background Samples	A	PX-BG-SD01-000H	*not collected*	--		not analyzed
		PX-BG-SD02-000H	6/15/19	2.38	J	not analyzed
		PX-BG-SD03-000H	6/13/19	12.9		not analyzed
		PX-BG-SD04-000H	6/15/19	0.56	J	not analyzed
	B	PX-BG-SD05-000H	6/15/19	2.68	J	not analyzed
		PX-BG-SD06-000H	6/13/19	11.5		not analyzed
		PX-BG-SD07-000H	6/15/19	3.94	J	not analyzed
		PX-BG-SD08-000H	6/13/19	4.21		not analyzed
	C	PX-BG-SD09-000H	6/15/19	1.07	J	not analyzed
		PX-BG-SD10-000H	6/15/19	0.76	J	not analyzed
		PX-BG-SD11-000H	6/13/19	1.02		not analyzed
		PX-BG-SD11P-000H	*field duplicate*	1.05		not analyzed
		PX-BG-SD12-000H	6/14/19	1.02	J	not analyzed
	D	PX-BG-SD13-000H	6/12/19	8.81		not analyzed
		PX-BG-SD14-000H	6/12/19	0.88		not analyzed
		PX-BG-SD15-000H	6/12/19	0.80		not analyzed
		PX-BG-SD16-000H	6/12/19	0.71	J	not analyzed
	E	PX-BG-SD17-000H	6/12/19	0.38	J	not analyzed
		PX-BG-SD18-000H	6/12/19	0.47	J	not analyzed
		PX-BG-SD18P-000H	*field duplicate*	0.45	J	not analyzed
		PX-BG-SD19-000H	6/12/19	0.63	J	not analyzed
		PX-BG-SD20-000H	6/12/19	0.85	J	not analyzed

Notes:

Shaded concentrations exceed the lead ecological screening level (ESL) of 35.8 mg/kg (Threshold Effect Concentration [TEC]; MacDonald et al. 2000)

1 - Pellets were retained in a #35 sieve (0.5 millimeters)

2 - To test validity of 85,600 mg/kg, archived digestate was re-analyzed (result 85,100 mg/kg) and additional stock sediment (orginal sample) was re-digested/re-analyzed (result 11.9 mg/kg)

Table B2-10. Surface Sediment Chemical Analytical Results (Step 2/Phase 1) - SEM/AVS

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Transect	Sample ID	Sample Date	Acid Volatile Sulfides (UMOL/G)		Simultaneously Extractable Metals (UMOL/G) Cadmium		Copper		Lead		Nickel		Zinc		Total SEM[1]	SEM/AVS[2]
Shotfall Zone Samples	1	PX-FSR-SD01-000H	6/13/19	0.01	U	0.00034	U	0.002	J	0.0091		0.0012	U	0.0056	U	0.01467	2.9
	1	PX-FSR-SD03-000H	6/13/19	0.086		0.00043	U	0.0035		0.0062		0.0013	J	0.012		0.023215	0.3
	2	PX-FSR-SD05-000H	6/13/19	0.123		0.00029	J	0.0079		0.0176		0.0025	J	0.0267		0.05499	0.4
	2	PX-FSR-SD07-000H	6/13/19	0.036	J	0.00045	J	0.0093		0.006		0.0025	J	0.054		0.07225	2.0
	2	PX-FSR-SD09-000H	6/13/19	0.021	J	0.00155		0.07		0.0137		0.0159		0.196		0.29715	14.2
	3	PX-FSR-SD10-000H	6/13/19	0.014	U	0.00048	U	0.0049		0.0129		0.0013	J	0.0169		0.03624	5.2
	3	PX-FSR-SD12-000H	6/13/19	0.287		0.00079		0.005		0.0055		0.0012	J	0.0187		0.03119	0.1
	3	PX-FSR-SD14-000H	6/13/19	0.019	U	0.00166		0.0319		0.0131		0.0146		0.211		0.27309	28.7
	3	PX-FSR-SD16-000H	6/13/19	0.207		0.00195		0.0371		0.0143		0.0178		0.275		0.34615	1.7
	4	PX-FSR-SD18-000H	6/13/19	0.011	U	0.00037	U	0.0039		0.0054		0.0017	J	0.0165		0.027685	5.0
	4	PX-FSR-SD20-000H	6/13/19	0.458		0.00205		0.0321		0.0437		0.0143		0.262		0.35415	0.8
	4	PX-FSR-SD23-000H	6/13/19	2.81		0.00199		0.0321		0.015		0.0163		0.284		0.34939	0.1
	5	PX-FSR-SD25-000H	6/13/19	0.022	J	0.00013	J	0.0014	J	0.0052		0.0012	U	0.0043	U	0.00948	0.4
	5	PX-FSR-SD27-000H	6/13/19	4.54		0.00191		0.0364		0.0258		0.0139		0.254		0.33201	0.1
	5	PX-FSR-SD29-000H	6/13/19	3.15		0.00199		0.0292		0.0191		0.0141		0.277		0.34139	0.1
	5	PX-FSR-SD32-000H	6/12/19	4.6		0.00138		0.0211		0.0095		0.0122		0.238		0.28218	0.1
	6	PX-FSR-SD34-000H	6/12/19	0.012	U	0.0004	U	0.0043		0.0059		0.0018	J	0.0162		0.0284	4.7
	6	PX-FSR-SD36-000H	6/12/19	0.123		0.00138		0.0274		0.0191		0.0137		0.18		0.24158	2.0
	6	PX-FSR-SD38-000H	6/12/19	2.51		0.00212		0.0358		0.0143		0.0169		0.23		0.29912	0.1
	7	PX-FSR-SD40-000H	6/12/19	0.013	U	0.00042	U	0.0039		0.0064		0.0015	U	0.007		0.02176	3.3
	7	PX-FSR-SD42-000H	6/12/19	0.012	J	0.00025	J	0.0104		0.0061		0.002	J	0.0277		0.04645	3.9
	7	PX-FSR-SD44-000H	6/12/19	0.24		0.00173		0.0287		0.0126		0.014		0.223		0.28003	1.2
	7	PX-FSR-SD46-000H	6/12/19	1.77		0.00157		0.0226		0.0103		0.0109		0.185		0.23037	0.1
	8	PX-FSR-SD48-000H	6/12/19	0.012	U	0.0004	U	0.0046		0.0089		0.0017	J	0.015		0.0304	5.1
	8	PX-FSR-SD50-000H	6/12/19	2.7		0.00116		0.0143		0.0126		0.008		0.159		0.19506	0.1
	8	PX-FSR-SD52-000H	6/12/19	0.279		0.00142		0.0232		0.0094		0.0102		0.15		0.19422	0.7
	9	PX-FSR-SD55-000H	6/12/19	0.011	U	0.00035	U	0.0041		0.0122		0.0014	J	0.0149		0.032775	6.0
	9	PX-FSR-SD57-000H	6/12/19	0.147		0.00043	U	0.0091		0.0058		0.0016	J	0.0227		0.039415	0.3
	9	PX-FSR-SD59-000H	6/12/19	0.167		0.0015		0.024		0.0119		0.0127		0.209		0.2591	1.6
	10	PX-FSR-SD62-000H	6/12/19	0.016	U	0.00027	J	0.0052		0.0059		0.0021	J	0.02		0.03347	4.2
Background Samples	A	PX-BG-SD03-000H	6/13/19	0.011	U	0.00025	J	0.0062		0.0022		0.0027		0.0259		0.03725	6.8
	B	PX-BG-SD06-000H	6/13/19	1.17		0.0012		0.024		0.0082		0.0103		0.144		0.1877	0.2
	B	PX-BG-SD08-000H	6/13/19	0.345		0.00126		0.017		0.0059		0.0088		0.11		0.14296	0.4
	C	PX-BG-SD09-000H	6/15/19	0.066		0.00045	U	0.0035		0.0023	U	0.0022	J	0.0142		0.021275	0.3
	C	PX-BG-SD11-000H	6/13/19	0.031	J	0.00038	J	0.0077		0.0032		0.0047		0.0614		0.07738	2.5
	D	PX-BG-SD14-000H	6/12/19	0.013	U	0.00044	U	0.0065		0.0017	J	0.005		0.0195		0.03292	5.1
	D	PX-BG-SD16-000H	6/12/19	0.014	U	0.00046	U	0.0081		0.0016	J	0.0032		0.0479		0.06103	8.7
	E	PX-BG-SD17-000H	6/12/19	0.032		0.00036	U	0.0044		0.0018	U	0.0014	J	0.0181		0.02718	0.8
	E	PX-BG-SD19-000H	6/12/19	0.069		0.00048	U	0.0082		0.0024	U	0.0048		0.0231		0.04164	0.6

Notes:

1 - Sum or detected SEM with 1/2 reporting values for non-detects

2 - Toxicity is predicted as most likely for ∑SEM:AVS ratios greater than 8.0 (Burton et al. 2005); ∑SEM:AVS ratios greater than 8.0 are shaded

Table B2-11. Surface Sediment Chemical Analytical Results (Step 2/Phase 1) - PAHs

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Sample Area	Sample ID	Sample Date	1-Methylnaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene	Total PAHs
Shotfall Zone Samples	PX-FSR-SD10-000H	6/13/19	1.98 U	1.98 U	1.98 U	1.98 U	1.98 U	5.94	8.14	8.05	13.3	8.31	7.34	13.7	3.67 J	1.98 U	13.9	1.98 U	1.98 U	3.11 J	93.4
	PX-FSR-SD17-000H	6/15/19	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	2.05 U	18.5
	PX-FSR-SD18-000H	6/13/19	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	2.91 J	2.61 J	4.14	1.95 J	1.47 J	2.58 J	1.97 U	4.2	1.97 U	2.06 J	1.97 U	2.04 J	3.93	35.8
	PX-FSR-SD25-000H	6/13/19	1.99 U	1.99 U	1.99 U	1.99 U	1.99 U	5.29	6.81	6.68	8.72	7.71	6.59	9.77	1.99 U	1.99 U	9.08	1.99 U	1.99 U	1.99 U	70.6
	PX-FSR-SD26-000H	6/15/19	2.04 U	2.04 U	2.04 U	2.04 U	1.36 J	2.38 J	2.04 J	2.62 J	2.12 J	1.55 J	2.29 J	2.04 U	3.95 J	2.04 U	1.97 J	2.04 U	2.69 J	3.38 J	33.5
	PX-FSR-SD33-000H	6/15/19	2 U	2 U	2 U	2 U	4.49	9.39	7.97	9.01	5.14	5.26	9.45	2 U	20.5	2 U	4.55	2 U	12.2	15.3	110.3
	PX-FSR-SD34-000H	6/12/19	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.19 U	2.32 J	2.19 U	2.19 U	2.19 U	2.19 U	1.93 J	21.8
	PX-FSR-SD40-000H	6/12/19	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	1.94 U	17.5
	PX-FSR-SD41-000H	6/15/19	2.15 U	2.15 U	2.15 U	2.15 U	2.14 J	3.9 J	3.03 J	4.38	2.71 J	1.92 J	4.03 J	2.15 U	8.39	2.15 U	2.56 J	2.15 U	6.62	6.31	53.5
	PX-FSR-SD41P-000H	*Field duplicate*	2.17 U	2.17 U	2.17 U	2.17 U	1.12 J	5.03	5.03	8.04	4.2 J	3.26 J	5.7	2.17 U	5.98	2.17 U	4.29	2.17 U	3.14 J	5.35	58.7
	PX-FSR-SD47-000H	6/15/19	2.02 U	2.02 U	2.02 U	2.02 U	3.95 J	10.8	11.7	11.3	9.75	8.68	11.7	6.8	16.7	1.79 J	9.41	2.02 U	11.6	12.8	132.0
		Maximum	*2.19*	*2.19*	*2.19*	*2.19*	*4.49*	*10.8*	*11.7*	*11.3*	*13.3*	*8.68*	*11.7*	*13.7*	*20.5*	*1.79*	*13.9*	*2.19*	*12.2*	*15.3*	*132.0*
Background Samples	PX-BG-SD02-000H	6/15/19	2.25 U	2.25 U	2.25 U	2.25 U	2.24 J	7.09	9.02	8.82	8.75	8.13	9.44	7.78	11.5	2.25 U	7.74	2.25 U	4 J	8.59	99.9
	PX-BG-SD03-000H	6/13/19	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	7.08	2.06 U	2.06 U	24.6
	PX-BG-SD04-000H	6/15/19	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.58 J	3.35 J	2.54 J	4.63	4.25	3.74 J	6.37	2.15 U	2.15 U	4.07 J	2.15 U	2.15 U	2.15 U	42.3
	PX-BG-SD05-000H	6/15/19	2.21 U	2.21 U	2.21 U	2.21 U	2.21 U	4.56	5.95	6.12	7.66	6.77	5.8	8.53	3.41 J	2.21 U	7.34	2.21 U	2.21 U	2.48 J	67.5
	PX-BG-SD06-000H	6/13/19	8.34	9.61	6.51	4.95	24.8	132	116	189	72.4	60.2	148	17.3	404	7.73	81.4	12.2	65.1	325	1,684.5
	PX-BG-SD07-000H	6/15/19	3.59 J	4.5	7.18	4.68	15.5	25.6	23.9	51.2	16.8	18.7	47.5	4.64	205	10.7	18	5.34	57	144	663.8
	PX-BG-SD08-000H	6/13/19	2.46 J	3.05 J	2.14 U	2.14 U	2.44 J	5.09	2.98 J	5.02	3.13 J	1.98 J	4.2 J	2.14 U	10.8	1.7 J	3.43 J	5.16	5.28	7.8	67.7
	PX-BG-SD09-000H	6/15/19	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	1.81 J	2.06 U	2.06 U	2.06 U	2.06 U	2.06 J	20.4
	PX-BG-SD10-000H	6/15/19	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	2.25 U	20.3
	PX-BG-SD11-000H	6/13/19	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.16 U	2.28 J	2.16 U	2.16 U	2.16 U	2.16 U	1.76 J	21.3
	PX-BG-SD11P-000H	*Field duplicate*	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.06 U	2.55 J	2.06 U	2.06 U	2.06 U	2.06 U	2.59 J	21.6
	PX-BG-SD12-000H	6/14/19	2.12 J	3.38 J	2.05 U	5.19	4.52	16.9	20.3	21.8	16.4	9.09	19.3	2.51 J	50.4	1.8 J	15.4	4.31	24.9	54.3	273.6
	PX-BG-SD13-000H	6/12/19	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	1.97 U	17.7
	PX-BG-SD14-000H	6/12/19	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	2.07 U	18.6
	PX-BG-SD15-000H	6/12/19	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	18.7
	PX-BG-SD16-000H	6/12/19	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	2.15 U	19.4
	PX-BG-SD17-000H	6/12/19	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	2.04 U	18.4
	PX-BG-SD18-000H	6/12/19	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	2.17 U	19.5
	PX-BG-SD18P-000H	*Field duplicate*	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	20.0
	PX-BG-SD19-000H	6/12/19	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	2.18 U	19.6
	PX-BG-SD20-000H	6/12/19	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	2.11 U	19.0
		Maximum	*8.34*	*9.61*	*7.18*	*5.19*	*24.8*	*132*	*116*	*189*	*72.4*	*60.2*	*148*	*17.3*	*404*	*10.7*	*81.4*	*12.2*	*65.1*	*325*	*1,684.5*

Notes:

All concentrations are in ug/kg

Grey shaded concentrations indicate detections

Pink shaded concentrations exceed the total PAH ecological screening level (ESL) of 1,610 ug/kg (Threshold Effect Concentration [TEC]; MacDonald et al. 2000)

Table B2-12. Food Web Model Results (Step 2/Phase 1)

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Chemical	Raccoon		Muskrat		Marsh wren		Spotted sandpiper		Great blue heron		Osprey	
	NOAEL	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Inorganics												
Lead	0.05	<0.01	0.18	0.02	0.80	0.16	3.95	0.40	0.03	<0.01	0.04	<0.01
Polycyclic Aromatic Hydrocarbons												
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

Shaded values represent a NOAEL-based HQ greater than 1.0

Table B2-13. Surface and Subsurface Sediment Chemical Analytical Results (Phase 2)

Former Skeet Ranges, Ecological Risk Assessment (Aquatic Habitat)

NAS Patuxent River, St. Mary's County, Maryland

Shotfall Zone Transect	Sample ID		Sample Date	Lead (MG/KG)		Pellet Count	Water Depth (feet)	Habitat	Live Organisms
6	PX-FSR-SD36-000H	Phase 1 sample	6/12/19	85,600		0	1.8	Silt and sand and cobbles, dark gray to brown, some shells.	None
			Re-analysis (same digestate)	85,100		--			
			Re-digested/Re-analyzed	11.9		--			
	PX-FSR-SD36A-000H	Re-sample (surface)	8/21/19	29.1	J	21	1.7	Soft silty sand, dark gray, loose, little broken oyster shells.	None
	PX-FSR-SD36AP-000H		*Field duplicate*	10.6	J	--			
	PX-FSR-SD36A-0624	Re-sample (subsurface)	8/21/19	2.59		0			
	PX-FSR-SD63-000H	Ring of step out samples; 10-foot from SD36A	8/22/19	10.5		11	1.6	Soft silty sand, dark brown to dark grey, no signs of organisms.	None
	PX-FSR-SD64-000H		8/21/19	23.8		7	1.7	Soft silty sand, dark brown, few broken oyster shells and small bivalve shells.	None
	PX-FSR-SD65-000H		8/21/19	12.3		21	1.7	Soft silty sand, dark gray, loose, few broken oyster shells.	None
	PX-FSR-SD66-000H		8/22/19	13.6		8	1.7	Soft silty sand, dark brown, no signs of organisms.	None
	PX-FSR-SD66P-000H		*Field duplicate*	12.6		--			

Notes:

Shaded concentrations exceed ecological screening level (ESL) of 35.8 mg/kg

Also collected during Phase 2, but held and never analyzed:

Hold	SD63	8/22/19	Core
Hold	SD64	8/21/19	Core
Hold	SD65	8/21/19	Core
Hold	SD66	8/22/19	Core
Hold	SD67	8/21/19	Grab
Hold	SD68	8/21/19	Grab
Hold	SD69	8/21/19	Grab
Hold	SD70	8/21/19	Grab

Appendix C
Applicable or Relevant and Appropriate Requirements

Appendix C-1
Federal Chemical-Specific ARARs
UXO 002, OU-2 Engineering Evaluation/Cost Analysis
Naval Air Station Patuxent River, St. Mary's County, Maryland

Media	Requirement	Prerequisite	Citation	Alternative	ARAR/TBC Determination	Comment
No Federal Chemical-Specific ARARs apply.						

Appendix C-2
Maryland Chemical-Specific ARARs
UXO 002, OU-2 Engineering Evaluation/Cost Analysis
Naval Air Station Patuxent River, St. Mary's County, Maryland

Media	**Requirement**	**Prerequisite**	**Citation**	**Alternative**	**ARAR Determination**	**Comment**
No Maryland Chemical-Specific ARARs apply.						

Appendix C-3
Federal Location-Specific ARARs
UXO 002, OU-2 Engineering Evaluation/Cost Analysis
Naval Air Station Patuxent River, St. Mary's County, Maryland

Location	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Coastal zone						
Coastal zone or area that will affect the coastal zone	Federal activities must be consistent with, to the maximum extent practicable, State coastal zone management programs. Federal agencies must comply with the consistency requirements of 15 CFR § 930.	Actions that may affect identified coastal zone resources or uses.	15 CFR 930.33(a)(1), (c); .36(a); .39(b), (c)	2 and 3	Applicable	Activities at UXO 002 that will affect Maryland’s coastal zone will be consistent to the maximum extent practicable with Maryland’s enforceable policies. Activities performed on-site and in compliance with CERCLA are not subject to adminsitrative review; however, the substantive requirements of making a consistency determination will be met.
Migratory Flyway						
Migratory bird area	Protects almost all species of native birds in the United States from unregulated taking.	Presence of migratory birds.	16 USC 703	2 and 3	Applicable	The site is located in the Atlantic Migratory Flyway. If migratory birds, or their nests or eggs, are identified at the site, operations will not destroy the birds, nests, or eggs.
Fish and Wildlife Coordination Act						
Floodplain	Action to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values.	Action that will occur in a floodplain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood prone areas.	Fish and Wildlife Coordination Act, 16 USC 661 et. seq.; Executive Order 11988; 40 CFR 6, Appendix A; 40 CFR 6.302	2 and 3	Applicable	As UXO-02 is located in a relatively flat area adjoining surface waters, construction activities may require compliance with this order. Erosion control measures will be implemented.

Location	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
No Maryland Location-Specific ARARs apply.						

Appendix C-5
Federal Action-Specific ARARs
UXO 002, OU-2 Engineering Evaluation/Cost Analysis
Naval Air Station Patuxent River, St. Mary's County, Maryland

Action	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Spill Prevention, Containment, and Control						
Storage of fuels and oils (petroleum and non-petroleum) onsite	If storage capacity limits are exceeded a Spill, Prevention, Control, and Countermeasures Plan must be prepared and implemented with procedures, methods, equipment, and other requirements to prevent the discharge of oil into or upon the navigable waters of the United States.	Total onsite storage capacity exceeding 1,320 gallons in containers that are 55 gallons or larger in size. The capacity of the containers (regardless of empty or full) triggers this requirement.	40 CFR 112.3(a)(1); 112.5 through 7; and 112.8(b),(c)(1), (c)(2), (c)(3), (c)(6), (c)(8)(iii), (c) (10), (d)(3), (d)(4), and (d)(5)	2 and 3	Applicable	It is anticipated that fuels will be stored onsite.This ARAR is applicable if 1,320 gallons of storage capacity for all oils in containers of 55-gallons or greater is present onsite at any time. If this occurs a Spill Prevention, Control, and Countermeasure (SPCC) Plan, or equivalent, will be prepared and implemented.
Onsite treatment in a Corrective Action Management Unit (CAMU)						
Onsite treatment	CAMU allows consolidation of waste on-site without triggering RCRA LDRs or minimum technology requirements	Minimum requirements for designating, designing, and operating a CAMU	40 CFR Part 264 Subpart S, Sections 264.550 through 264.555	2	Relevant and appropriate	These requirements would be relevant and appropriate if excavated material is disposed in an onsite cell.

Action	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Waste Management						
Onsite management of non-hazardous waste	Solid waste may not be managed in a manner that will likely create a nuisance; be conducive to pest infestation; pollute the air or water; impair the qualityof the environment; or create other hazards to public health, safety or comfort.	Management of solid wastes	COMAR 26.04.07.03(A)	2 and 3	Applicable	Remdiation wastes meeting the definition of solid waste will be managed onsite in accordance with these requiremetns.
Onsite treatment of waste military munitions	Provides requriements that must be met regarding the design and operation of a Miscellaneous Unit for the treatment of hazardous waste	Treatment of hazardous waste in a miscellaneous unit	COMAR 26.13.05.16-1(B)	3	Applicable	Military munitions that are disposed of rather than fired or expended are not exempt from the definition of solid waste and exhibit the hazardous waste characteristic of reactivity. If these items are treated onsite to deactivate the explosive hazard the substantive requirements of permitting will be met through the development and implementation of the Explosive Safety Submission for this project. Onsite CERCLA actions are exempt from adminsitrative requirements including permitting and administrative reviews; therefore, no permit will be obtained for this activity.
Onsite storage of waste military munitions	The DDESB storage standards applicable to waste military munitions in are DOD 6055.9-STD, "DOD Ammunition and Explosives Safety Standards" as adopted by the DDESB effective October 5, 2004 must be met or waste munitions must be stored as a reactive hazardous waste.	Accumulation of hazardous wastes in containers	COMAR 26.13.10.30(E)(1)	3	Applicable	Waste military munitions are not exempt from the definition of solid waste and exihibt the hazardous waste characteristic of reactivity. Munitonns that are being stored subject to the jurisdiction of the Department of Defense Explosives Safety Board (DDESB) or its successor agency are not subject to the management standards for hazardous waste. Compliance with the Explosives Safety Submission for this project will meet the substantive requirements of this ARAR.

Appendix C-6
Maryland Action-Specific ARARs
UXO 002, OU-2 Engineering Evaluation/Cost Analysis
Naval Air Station Patuxent River, St. Mary's County, Maryland

Action	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Erosion and Sediment Control						
Land clearing, grading, and earth disturbances	Regulations require the preparation and implementation of a plan to control erosion and sediment for activities involving land clearing, and grading and earth disturbances. Erosion and sediment control criteria are also established.	Land clearing, grading, and earth disturbances are exempt from preparing a plan if they disturb less than 5,000 square feet of land and less than 100 cubic yards of soil or over 100 cubic yards of earth	COMAR 26.17.01.07B(6)(a)-(g and COMAR 26.17.02.09 (E)(5)(a)-(e), (6)(a)-(p)	2 and 3	Applicable	It is expected that remedial activities will cover more than 5,000 square feet and remove more than 100 cubic yards of earth. The substantive requirements of these regulations will be met and erosion control measures will be implemented to prevent the migration of contaminated soil during earth disturbing work.
Noise Control						
Construction activities generating noise and vibrations	The maximum permitted levels for construction activities may not exceed 90 dBA during the day and 75 dBA during the night. Vibration beyond the property line will not be permitted to occur.	Conducting any construction activities that generate noise or vibrations	COMAR 26.02.03.02B(2)	2 and 3	Applicable	During removal action activities, the maximum allowable noise levels will not be exceeded. Vibrations will not be detectable beyond the property line.
Fugitive Dust Control						
Construction activities generating dust	Reasonable precautions must be taken to prevent particulate matter from becoming airborne during construction activities. These include the application of water or appropriate chemicals to roads, materials, and stockpiles; covering open-bodied vehicles that are transporting materials or soil likely to create dust, maintenance of roadways including the removal of soil that has been tracked out by equipment.	Conducting any construction activity which could cause particulate matter to become airborne.	COMAR 26.11.06.03(D)(1), (2), (4), (6)	2 and 3	Applicable	Dust control measures will be implemented as needed during remedial activities.

Appendix C-7

Acronyms, Abbreviations, and References

UXO 002, OU-2 Engineering Evaluation/Cost Analysis

Naval Air Station Patuxent River, St. Mary's County, Maryland

Acronyms and Abbreviations

ARAR	Applicable or relevant and appropriate requirement
BTAG	Biological Technical Assistance Group
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
COMAR	Code of Maryland Regulations
DOT	Department of Transportation
DNH	Division of Natural Heritage
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
μg/L	micrograms per liter
NAAQS	National Ambient Air Quality Standards
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NSDWRs	National Secondary Drinking Water Regulations
NSPS	New Source Performance Standards
PCB	Polychlorinated biphenyls
PMCL	Primary Maximum Contaminant Level
POTW	Publicly Owned Treatment Works
ppm	Parts per Million
RBC	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SPCC	Spill, Prevention, Control, and Countermeasures
SWMU	Solid Waste Management Unit
TBC	To Be considered
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substance Control Act
USACE	US Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency

References

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Interim Final* . Office of Emergency and Remedial Response. EPA/540/G-89/006.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes.* Office of Emergency and Remedial Response.

USEPA, 1998. RCRA, Superfund & EPCRA Hotline Training Manual. Introduction to Applicable or Relevant and Appropriate Requirements. EPA540-R-98-020.

Appendix D
Engineer’s Cost Estimates

Appendix D. Engineer's Cost Estimates

Cost Type	Alternative 1	Alternative 2	Alternative 3
	No Action	**Stabilization and Engineering Cover with LUCs**	**Removal, Stabilization, and Off-site Disposal**
Total Estimated Present Worth Costs			
Capital Cost	$0	$1,177,000	$1,168,000
O&M Cost	$0	$854,658	$3,777
Periodic Cost	$0	$90,000	$5,000
Total Estimated Costs	$0	$2,121,658	$1,176,777
Net Present Value	$0	$1,184,127	$1,331,000
Estimated Range of Costs	From	From	From
-30%	$0	$1,485,161	$823,744
	To	To	To
+50%	$0	$3,182,487	$1,765,166

Site:		Naval Air Station Patuxent River			**Description:**	Alternative 2 – Capping in Place
Area:		Former Skeet Range				
Location:		St. Mary's County, Maryland				
Base Year:		2024				
Alternative:		2				

Description		Units	Quantity	Unit Price	Balanced Total	Cost Notes
Work Planning Documents						
Construction Work Plan and Design		LS	1	$ 75,000.00	$ 75,000	
Treatability Study		LS	1	$ 15,000.00	$ 15,000	
EM 385 H&S Plan		LS	1	$ 12,000.00	$ 12,000	
Construction Completion Report		LS	1	$ 20,000.00	$ 20,000	
Work Planning Documents Total					**$ 122,000**	
Mobilization, Demobilization and Site Set-up						
Mobilization		LS	1	$ 10,235.02	$ 10,235	
Equipment Rental During Mob		LS	1	$ 8,565.05	$ 8,565	
Demobilization		LS	1	$ 5,240.72	$ 5,241	
Site Setup		LS	1	$ 30,205.19	$ 30,205	1) Clear and Uncover old road from previous cleanup project, 2) Repair old road as needed, 3) Extend road and build new turaround and loading area at OU-2 Total of 21,900 ft2 road and turaround. Assume 6" of 3 in minus stone (57 stone) at 50% usage = 405 cy = 608 tons = 304 tons needed
Mobilization, Demobilization and Site Set-up Total					**$ 54,246**	
Site Clearing						
Tree Clearing		DAY	5	$ 20,774.91	$ 103,875	Equipment crew, rentals and labor expenses during clearing. 1) Fell large trees and de-branch, 2) Cut trees for shipment by logger for reclaim, 3) Assume logger takes trees for free, 4) Chip branches and small trees, 5) General Cleanup of area, 6) Provide 1 - 40 cy roll-off for unusable debris
Ground Cover Removal		DAY	3	$ 17,186.88	$ 51,561	See Alt 2 Notes for Takeoff info. To ensure that the first lift of common backfill will compact to 95% proctor all groundcover should be removed from the Capping Area. Raking of pine needles, leaves and other cover could be required before cap installation. This process will likely collect lead shot and clay pigeon particles also which could be screend out before the ground cover is shipped to the disposal site. Collected clay and lead shot should be properly dosposed offsite.
Stump Removal and Loadout		DAY	2	$ 8,084.47	$ 16,169	
Site Clearing Total					**$ 171,604**	
Silt Fence and Safety Fence Installation						
Install Silt Fence and Orange Safety Fence		LS	1	$ 8,007.82	$ 8,008	Approximately 1200 lf od Super Silt Fence ans Orange Saferty Fence
Remove Silt and Safety Fencing		LS	1	$ 2,938.67	$ 2,939	
Silt Fence and Safety Fence Installation Total					**$ 10,946**	
Transport and Disposal						
T&D Ground Cover & Debris - Cap Area		CY	300	$ 143.40	$ 43,020	See Alt 2 Note for Takeoff information
T&D Stumps		TON	40	$ 182.34	$ 7,294	See Alt 2 Note for Takeoff information
T&D Lead Shot, Clay & Debris		Drum	10	$ 1,232.00	$ 12,320	See Alt 2 Note for Takeoff information
Transport and Disposal Total					**$ 62,634**	
Surveyiing		LS	1	$ 12,320.0	**$ 12,320**	
Cap Installation						
Cap Material Sampling Labor and Supplies		TON	3,640	$ 0.71	$ 2,584	Field personnel to obtain samples and for Atterberg Tests for cap material
Cap Material Confirmation Sample Analysis		TON	3,640	$ 0.58	$ 2,111	Lab analysis of samples of cap material
Place and Compact Cap Soils (incl Testing)		TON	3,640	$ 31.09	$ 113,168	Place,compact, test and grade import cap material (common backfill) . Cost also includes 3rd pary Nuclear Density testing in the field
Import Cap Soils (Common Backfill)		TON	3,640	$ 60.02	$ 218,473	Find and procure, Load and Transport clean cap soil to the Naval base from a borrow are located within a 50 mile radius of the Base. In place compacted density of material is assumed to be 1.5 tons/cy after compaction to 95% Standard Proctor.
Backfill Of Excavation Total					**$ 336,336**	

Site:		Naval Air Station Patuxent River			**Description:**	Alternative 2 – Capping in Place
Area:		Former Skeet Range				
Location:		St. Mary's County, Maryland				
Base Year:		2024				
Alternative:		2				
Description		**Units**	**Quantity**	**Unit Price**	**Balanced Total**	**Cost Notes**
Site Restoration						
Revegetation		AC	1.5	$ 6,776.00	$ 10,164	Hydroseed Subcontractor
Watering and Establishment Period		MO	6	$ 4,078.17	$ 24,469	Apply water to are as necessary to establish vegetation
Site Restoration Total					**$ 34,633**	
Land Use Controls						
Deed Restriction		LS	1	$ 10,000.00	$ 10,000	
Warning Signage		LS	1	$ 5,000.00	$ 5,000	
Land Use Control Implementation Plan		LS	1	$ 15,000.00	$ 15,000	
Land Use Controls					**$ 30,000**	
Subtotal					**$ 834,719**	
Contingency (25%)				25.0%	$ 208,680	
Project Management				*6.0%*	$ 50,083	EPA 2000, p. 5-13, $500K - $2M
Construction Management				*8.0%*	$ 66,778	EPA 2000, p. 5-13, $500K - $2M
Subtotal					**$ 1,160,260**	
Performance Bond (2%)				2.0%	$ 16,694	Industry Average
TOTAL CAPITAL COST					**$ 1,177,000**	
Operation and Maintenance						
LTM and LUCs						
Operation and Maintenance						
Description		**Unit**	**Quantity**	**Unit Price**	**Total**	**Assumptions**
Land Use Controls						
Cap Maintenance		Each	1	$ 10,000	$ 10,000	Repair erosion, replant vegegation, repair borrows
Warning Sign Maintenance		Each	1	$ 500	$ 500	Maintenance of warning signs
LUC Administrative Reviews/Report		Each	1	$ 3,000	$ 3,000	Review Administrative LUCs
Public Awareness Education		Each	1	$ 2,000	$ 2,000	
Annual LUC Site Inspections/Report						Annual site inspection with LUC Report
Labor		Hour	8	$ 100	$ 800	
Rental Vehicle		Day	1	$ 120	$ 120	
Annual LUC Report		Each	1	$ 5,000	$ 5,000	
Subtotal					$ 21,420	Annual total
Contingency (25%)			25.0%	$ 21,420	$ 5,355	
Project Management			*8.0%*	$ 21,420	$ 1,714	
Subtotal					$ 28,489	Annual total
Number of Events		Each	30	$ 28,489	**$ 854,658**	
TOTAL O&M COST - LTM AND LUC					**$ 854,658**	
Periodic Costs						
Description	**YEAR**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL**	**Assumptions**
5 Year Review	5	1	EA	$15,000	$ 15,000	
5 Year Review	10	1	EA	$15,000	$ 15,000	5 year reviews not applicable for this alternative after year 5
5 Year Review	15	1	EA	$15,000	$ 15,000	
5 Year Review	20	1	EA	$15,000	$ 15,000	
5 Year Review	25	1	EA	$15,000	$ 15,000	
5 Year Review	30	1	EA	$15,000	$ 15,000	
TOTAL PERIODIC COSTS					**$ 90,000**	

Site:		Naval Air Station Patuxent River			**Description:**	Alternative 2 – Capping in Place
Area:		Former Skeet Range				
Location:		St. Mary's County, Maryland				
Base Year:		2024				
Alternative:		2				
Description		**Units**	**Quantity**	**Unit Price**	**Balanced Total**	**Cost Notes**
Present Value Analysis						
Discount Rate =	2.0%	Source: White House OMB, 2022. This rate represents a				
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR**	**PRESENT VALUE**	
CAPITAL COST	0	$ 1,177,000		1.00	$ 1,177,000	
ANNUAL O&M COST	1 to 30			0.25	$ -	
PERIODIC COST	1	$ 28,489		0.20	$ 5,698	
PERIODIC COST	2	$ 28,489		0.04	$ 1,140	
PERIODIC COST	3	$ 28,489		0.01	$ 228	
PERIODIC COST	4	$ 28,489		0.00	$ 46	
PERIODIC COST + 5 YR REVIEW	5	$ 43,489		0.00	$ 14	
PERIODIC COST	6	$ 28,489		0.00	$ 2	
PERIODIC COST	7	$ 28,489		0.00	$ 0	
PERIODIC COST	8	$ 28,489		0.00	$ 0	
PERIODIC COST	9	$ 28,489		0.00	$ 0	
PERIODIC COST + 5 YR REVIEW	10	$ 43,489		0.00	$ 0	
PERIODIC COST	11	$ 28,489		0.00	$ 0	
PERIODIC COST	12	$ 28,489		0.00	$ 0	
PERIODIC COST	13	$ 28,489		0.00	$ 0	
PERIODIC COST	14	$ 28,489		0.00	$ 0	
PERIODIC COST + 5 YR REVIEW	15	$ 43,489		0.00	$ 0	
PERIODIC COST	16	$ 28,489		0.00	$ 0	
PERIODIC COST	17	$ 28,489		0.00	$ 0	
PERIODIC COST	18	$ 28,489		0.00	$ 0	
PERIODIC COST	19	$ 28,489		0.00	$ 0	
PERIODIC COST + 5 YR REVIEW	20	$ 43,489		0.00	$ 0	
PERIODIC COST	21	$ 28,489		0.00	$ 0	
PERIODIC COST	22	$ 28,489		0.00	$ 0	
PERIODIC COST	23	$ 28,489		0.00	$ 0	
PERIODIC COST	24	$ 28,489		0.00	$ 0	
PERIODIC COST + 5 YR REVIEW	25	$ 43,489		0.00	$ 0	
PERIODIC COST	26	$ 28,489		0.00	$ 0	
PERIODIC COST	27	$ 28,489		0.00	$ 0	
PERIODIC COST	28	$ 28,489		0.00	$ 0	
PERIODIC COST	29	$ 28,489		0.00	$ 0	
PERIODIC COST + 5 YR REVIEW	30	$ 43,489		0.00	$ 0	
Subtotal					**$ 1,184,127**	
Total Present Value					**$ 1,184,127**	

Assumptions and Exclusions

1. This AACE Class 4 Engineer's Estimate is only an estimate of possible construction costs for budgeting purposes. It is not an offer to perform the work. This estimate is limited to the conditions existing at the time of its issuance and is not a guarantee of actual price or cost. Uncertain market conditions such as, but not limited to: local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions etc may affect the accuracy of this estimate. Jacobs is not responsible for any variance from this estimate or actual prices and conditions obtained. This is an order-of-magnitude cost estimate that is expected to be within +50 to -30 percent of the anticipated costs in the EE/CA.

Site:		Naval Air Station Patuxent River			**Description:**	Alternative 3 – Removal, Stabilization, and Off-site Disposal
Area:		Former Skeet Range				
Location:		St. Mary's County, Maryland				
Base Year:		2024				
Alternative:		3				
Description		**Units**	**Quantity**	**Unit Price**	**Balanced Total**	**Cost Notes**
Work Planning Documents						
Construction Work Plan and Design		LS	1	$ 75,000.00	$ 75,000	
Treatability Study		LS	1	$ 15,000.00	$ 15,000	
EM 385 H&S Plan		LS	1	$ 12,000.00	$ 12,000	
Construction Completion Report		LS	1	$ 20,000.00	$ 20,000	
Work Planning Documents Total					**$ 122,000**	
Mobilization, Demobilization and Site Set-up						
Mobilization		LS	1	$ 10,235.02	$ 10,235	
Equipment Rental During Mob		LS	1	$ 8,565.05	$ 8,565	
Demobilization		LS	1	$ 5,240.72	$ 5,241	
Site Setup		LS	1	$ 30,205.19	$ 30,205	1) Clear and Uncover old road from previous cleanup project, 2) Repair old road as needed, 3) Extend road and build new turaround and loading area at OU-2 Total of 21,900 ft2 road and turaround. Assume 6" of 3 in minus stone (57 stone) at 50% usage = 405 cy = 608 tons = 304 tons needed
Mobilization, Demobilization and Site Set-up Total					**$ 54,246**	
Site Clearing		DAY	5	$ 20,774.91	**$ 103,875**	Equipment crew, rentals and labor expenses during clearing. 1) Fell large trees and de-branch, 2) Cut trees for shipment by logger for reclaim, 3) Assume logger takes trees for free, 4) Chip branches and small trees, 5) General Cleanup of area, 6) Provide 1 - 40 cy roll-off for unusable debris, 6) Dispose of pine needles and ground cover with ecvavated soils.
Silt Fence and Safety Fence Installation						
Install Silt Fence and Orange Safety Fence		LS	1	$ 8,007.82	$ 8,008	Approximately 1200 lf od Super Silt Fence ans Orange Saferty Fence
Remove Silt and Safety Fencing		LS	1	$ 2,938.67	$ 2,939	
Silt Fence and Safety Fence Installation Total					**$ 10,946**	
Excavation, Mixing and Loading						
Excavate and Move Soil to Loading Area		BCY	1,008	$ 22.24	$ 22,418	Excavate to intermediate pile so that 2nd excavator can pick up and mix with Portland Cement. 235 tons/day
Purchase,Deliver, Mix Portland (Stabilize Soils)		TON	152	$ 875.12	$ 133,018	Utilize 2nd 336 Excavator to turn and mix soils with 155 Supersacks of Type IL Portland Cement as the Materials are moved to the loadout area. Soils Should be turned 2 or 3 times as they are moved.
Load Trucks for Offsite Disposal		TON	1,664	$ 9.52	$ 15,841	Laborers for lining trucks and cleaning roads. Includes Truck Liner Cost
Excavation, Mixing and Loading Total					**$ 171,277**	
Excavation Confirmation Sampling						Based on 25,500 ft2 total area in main area and 30' x 30' grid on the floor + 1 sidewall sample every 40 ft. Small areas area assumed to require 1 floor sample and 4 sidewall samples per area. Prices are current
Excavation Confirmation Sampling Labor and Supply		TON	1,664	$ 19.54	$ 32,515	
Excavation Confirmation Sampling		TON	1,664	$ 11.79	$ 19,619	
Excavation Confirmation Sampling Total					**$ 52,133**	
Transport and Disposal		TON	1,664	$ 72.97	**$ 121,422**	Soil - 1705 Tons including Portland Cement - 10 Loads/Day, 22 Tons/Load - 220 tons/day - 8 Days to complete Stumps - 3 Loads - 30 Tons for 30 to 40 Stumps - 1 Day Transpot 112 mi to King and Queen LF

Site:		Naval Air Station Patuxent River			**Description:**	Alternative 3 – Removal, Stabilization, and Off-site Disposal
Area:		Former Skeet Range				
Location:		St. Mary's County, Maryland				
Base Year:		2024				
Alternative:		3				

Description		**Units**	**Quantity**	**Unit Price**	**Balanced Total**	**Cost Notes**
Surveyiing		LS	1	$ 12,320.0	**$ 12,320**	
Backfill Of Excavation						
Confirmation Sampling Labor and Supplies		TON	1,512	$ 2.53	$ 3,825	Field personnel to obtain samples for Atterberg Tests for backfill material
Confirmation Sample Analysis - Backfill Soils		TON	1,512	$ 1.39	$ 2,102	Based on 25,500 ft2 total area in main area and 30' x 30' grid on the floor + 1 sidewall sample every 40 ft. Small areas area assumed to require 1 floor sample and 4 sidewall samples per area. Prices are based on 2021 analytical prices escalated 30%.
Place and Compact Backfill Soils (incl Testing)		TON	1,512	$ 32.08	$ 48,505	Place,compact, test and grade import backfill. Time includes cost to spread chipped wood. Cost also includes cost for 3rd pary Nuclear Density testing in the field
Import Common Backfill		TON	1,512	$ 60.21	$ 91,038	Find and procure, Approve, load and Transport clean soil fill to the Naval base from a borrow are located within a 50 mile radius of the Base. In place compacted density of material is assumed to be 1.5 tons/cy after compaction to 95% Standard Proctor.
Backfill Of Excavation Total					**$ 145,470**	
Site Restoration						
Revegetation		AC	1.5	$ 6,776.00	$ 10,164	Hydroseed Subcontractor
Watering and Establishment Period		MO	6	$ 4,078.17	$ 24,469	Apply water to are as necessary to establish vegetation
Site Restoration Total					**$ 34,633**	
Land Use Controls						
Deed Restriction		LS	0	$ -	$ -	LTM and LUCs Not Applicable for this Alternative
Warning Signage		LS	0	$ -	$ -	
Land Use Control Implementation Plan		LS	0	$ -	$ -	
Land Use Controls					**$ -**	
Subtotal					**$ 828,322**	
Contingency (25%)				25.0%	$ 207,081	
Project Management				*6.0%*	$ 49,699	EPA 2000, p. 5-13, $500K - $2M
Construction Management				*8.0%*	$ 66,266	EPA 2000, p. 5-13, $500K - $2M
Subtotal					**$ 1,151,368**	
Performance Bond (2%)				2.0%	$ 16,566	Industry Average
TOTAL CAPITAL COST					**$ 1,168,000**	

Operation and Maintenance						
LTM and LUCs						
Operation and Maintenance						
Description		**Unit**	**Quantity**	**Unit Price**	**Total**	**Assumptions**
Land Use Controls						
Cap Maintenance		Each	1	$ -	$ -	Repair erosion, replant vegegation, repair borrows
Warning Sign Maintenance		Each	1	$ 500	$ 500	Maintenance of warning signs
LUC Administrative Reviews/Report		Each	1	$ -	$ -	Review Administrative LUCs
Public Awareness Education		Each	1	$ -	$ -	
Annual LUC Site Inspections/Report						Annual site inspection with LUC Report
Labor		Hour	8	$ 100	$ 800	
Rental Vehicle		Day	1	$ 120	$ 120	
Annual LUC Report		Each	1	$ -	$ -	
Subtotal					$ 1,420	Annual total
Contingency (25%)			25.0%	$ 1,420	$ 355	
Project Management			*8.0%*	$ 1,420	$ 114	
Number of Events		Each	2	$ 1,889	**$ 3,777**	
TOTAL O&M COST - LTM AND LUC					**$ 3,777**	

Site:		Naval Air Station Patuxent River			**Description:**	Alternative 3 – Removal, Stabilization, and Off-site Disposal
Area:		Former Skeet Range				
Location:		St. Mary's County, Maryland				
Base Year:		2024				
Alternative:		3				

Description		**Units**	**Quantity**	**Unit Price**	**Balanced Total**	**Cost Notes**
Periodic Costs						
Description	**YEAR**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL**	**Assumptions**
5 Year Review	5	1	EA	$5,000	$ 5,000	
5 Year Review	10	1	EA	$0	$ -	5 year reviews not applicable for this alternative after year 5
5 Year Review	15	1	EA	$0	$ -	
5 Year Review	20	1	EA	$0	$ -	
5 Year Review	25	1	EA	$0	$ -	
5 Year Review	30	1	EA	$0	$ -	
TOTAL PERIODIC COSTS					**$ 5,000**	

Present Value Analysis						
Discount Rate =	2.0%	Source: White House OMB, 2022. This rate represents a				
COST TYPE	**YEAR**	**TOTAL COST**	**TOTAL COST PER YEAR**	**DISCOUNT FACTOR**	**PRESENT VALUE**	
CAPITAL COST	0	$ 1,168,000		1.00	$ 1,168,000	
ANNUAL O&M COST	1 to 30			0.25	$ -	
PERIODIC COST	1	$ 755		0.20	$ 151	
PERIODIC COST	2	$ 755		0.04	$ 30	
PERIODIC COST	3	$ -		0.01	$ -	
PERIODIC COST	4	$ -		0.00	$ -	
PERIODIC COST	5	$ 5,000		0.00	$ 2	
PERIODIC COST	6			0.00	$ -	
PERIODIC COST	7			0.00	$ -	
PERIODIC COST	8			0.00	$ -	
PERIODIC COST	9			0.00	$ -	
PERIODIC COST	10			0.00	$ -	
PERIODIC COST	11			0.00	$ -	
PERIODIC COST	12			0.00	$ -	
PERIODIC COST	13			0.00	$ -	
PERIODIC COST	14			0.00	$ -	
PERIODIC COST	15			0.00	$ -	
PERIODIC COST	16			0.00	$ -	
PERIODIC COST	17			0.00	$ -	
PERIODIC COST	18			0.00	$ -	
PERIODIC COST	19			0.00	$ -	
PERIODIC COST	20			0.00	$ -	
PERIODIC COST	21			0.00	$ -	
PERIODIC COST	22			0.00	$ -	
PERIODIC COST	23			0.00	$ -	
PERIODIC COST	24			0.00	$ -	
PERIODIC COST	25			0.00	$ -	
PERIODIC COST	26			0.00	$ -	
PERIODIC COST	27			0.00	$ -	
PERIODIC COST	28			0.00	$ -	
PERIODIC COST	29			0.00	$ -	
PERIODIC COST	30			0.00	$ -	
Subtotal					**$ 1,168,183**	
Total Present Value					**$ 1,168,183**	

Assumptions and Exclusions

1. This AACE Class 4 Engineer's Estimate is only an estimate of possible construction costs for budgeting purposes. It is not an offer to perform the work. This estimate is limited to the conditions existing at the time of its issuance and is not a guarantee of actual price or cost. Uncertain market conditions such as, but not limited to: local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions etc may affect the accuracy of this estimate. Jacobs is not responsible for any variance from this estimate or actual prices and conditions obtained. This is an order-of-magnitude cost estimate that is expected to be within +50 to -30 percent of the anticipated costs in the EE/CA.

Appendix E
Sustainability Analysis

APPENDIX E

Sustainability Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges

E.1 Introduction

This appendix presents the approach taken and results obtained from a sustainability analysis performed for Operable Unit (OU) 2 (Former Skeet Ranges) of the Munitions Response Site Unexploded Ordnance (UXO) 002 (Former Small Arms Ranges) located at Naval Air Station Patuxent River, St. Mary's County, Maryland. A site description and history of UXO-002, OU-2 is provided within the Engineering Evaluation/Cost Analysis (EE/CA). The following alternatives were developed to address potential risks to human health and the environment from exposure to impacted surface soil and subsurface debris. A detailed summary of the alternatives is provided in the EE/CA.

- Alternative 1: No Action
- Alternative 2: Stabilization and Engineered Cover with Land Use Controls (LUCs) and Long-Term Monitoring (LTM)
- Alternative 3: Removal, Stabilization, and Offsite Disposal

The purpose of this analysis is to provide a quantitative assessment of the potential environmental and social impact of each alternative. The sustainability analysis was performed using SiteWise Version 3.2 (Battelle, 2018) for Alternatives 2 and 3. Although the No Action alternative (Alternative 1) has no actions that would impact sustainability, it is not considered a viable alternative and will not be further discussed in this analysis.

E.2 Method and Assumptions

The SiteWise tool consists of a series of Excel-based spreadsheets used to conduct a baseline assessment of sustainability metrics. The assessment is carried out using a spreadsheet-based building block approach, where every removal alternative can be broken down into components for discrete phases of work (such as construction, operation, LTM), or different systems for more complex removal actions.

SiteWise uses various emission factors from governmental or non-governmental research sources to determine the environmental impact of each activity. The quantitative metrics calculated by the tool include:

1) Greenhouse gases (GHGs) reported as metric tons of carbon dioxide equivalents (CO_2e), consisting of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)
2) Energy usage (expressed as millions of British Thermal Units [MMBTU])
3) Water usage (gallons of water)
4) Air emissions of criteria pollutants consisting of metric tons of nitrogen (NO_x), sulfur oxides (SO_x), and particulate matter (PM_{10})
5) Accident risk (risk of injury and risk of fatality)

For the purpose of this discussion, the term "footprint" will be used to describe the quantified emissions or quantities for each metric. To estimate the sustainability footprint for each alternative, only those elements possessing important sustainability impacts were included in the assessment. A lower footprint indicates lower deleterious impacts to environmental and social metrics, which collectively make up the SiteWise sustainability metrics. Conversely, a higher footprint indicates higher deleterious impacts associated with the SiteWise metrics.

The major conclusions of this sustainability analysis are incorporated into the effectiveness criteria evaluation of the EE/CA.

The following is a description of the major activities for each alternative:

- Alternative 2: Stabilization and Engineered Cover with LUCs and LTM
  - Production of fill for backfilling (industry averages for heavy equipment operation to dig soil from the ground or borrow area), gravel for road access, and cement for stabilization
  - Transportation of personnel and equipment for stabilization and cover installation activities
  - Equipment use for stabilization and cover installation activities
  - Onsite labor hours
  - Transportation and disposal of residuals to a non-hazardous landfill
  - Operations and maintenance (O&M) – includes annual inspections and 5-year review inspections for 30 years
- Alternative 3: Removal Action with Stabilization and Offsite Disposal
  - Production of fill for backfilling (industry averages for heavy equipment operation to dig soil from the ground or borrow area), gravel for road access, and cement for stabilization
  - Transportation of personnel, equipment, and materials for removal, stabilization, and disposal activities
  - Equipment use to excavate and stabilize soils
  - Onsite labor hours
  - Transportation and disposal of residuals to a non-hazardous landfill
  - Operations and maintenance (O&M)—includes annual inspections for 1 year

General Assumptions

The specific assumptions made for the individual remedies are presented in **Tables E-1** and **E-2**. The following general assumptions are used for the SiteWise tool evaluation:

- The complete environmental footprint for production of equipment used, or production of the vehicles used for transportation, is not considered in this analysis.
- Daily local transportation is assumed to consist of 50 miles of driving a light duty truck per day.
- The nonhazardous landfill is located 115 miles away from the site, and all waste is assumed to be nonhazardous.
- Environmental footprints from non-hazardous waste landfill operations are based on inert waste disposed of in a sanitary landfill.
- The following weights and distance for delivery are used for equipment:
  - Bulldozer, loader: 20 tons each, 50 miles round trip
  - Chipper:20 tons, 50 miles round trip
  - Sifter: 20 tons, 100 miles round trip
  - Excavator: 30 tons, 50 miles round trip

E.3 Results and Conclusions

A comparative analysis for Alternatives 2 and 3 is summarized in Figure E-1. Table E-3 presents a comparison of the quantitative environmental footprint metrics evaluated for each of the alternatives. Alternative 3 (Removal , Stabilization, and Offsite Disposal) had higher footprints in each of the sustainability metrics compared with Alternative 2 (Stabilization and Engineered Cover with LUCs and LTM) primarily due to the transportation and disposal of residual waste associated with Alternative 3.

A relative impact summary is also provided in Table E-3. It should be noted that while this analysis compares the environmental footprints of each of the alternatives, the alternatives may differ with respect to other evaluation criteria. Therefore, a comparison of the results of the alternatives needs to be made in the context of the benefits (e.g., ARAR compliance, contaminant reduction, site reuse, cost effectiveness, etc.) of each of the alternatives. In this case, Alternative 3 results in removal of the waste from the site, whereas Alternative 2 involves waste being managed onsite.

The following is a summary of the individual alternatives:

- **Alternative 2: Stabilization and Engineered Cover with LUCs and LTM**
  - GHG and Energy Use: The majority of the GHG and energy use footprints were associated with material production (clean soil for engineered cap and gravel for the access road). Material production, listed under consumables, during the remedial implementation phase contributed approximately 54 and 56 percent of the GHG and energy use footprints, respectively, while material production during the site preparation phase contributed 22 and 26, percent, respectively. During remedial implementation, equipment and material transportation contributed approximately 12 and 9 percent of the total potential GHG and energy use footprints, respectively. All other categories contributed 5 percent or less in each category.
  - Water Use: Water use from this alternative was attributed to hydraseeding for site restoration.
  - Criteria Air Pollutants (NO_X, SO_X, PM_{10}): Similar to GHG and energy use, the majority of the criteria air pollutant (NO_X, SO_X, PM_{10}) footprints was from material production during the remedial implementation phase (69, 75, and 83 percent, respectively), and during the site preparation phase (16, 24, and 14 percent, respectively). Equipment and material transportation during the site preparation phase contributed 11, 1, and 3 percent of the total NO_X, SO_X, and PM_{10} emissions, respectively.
  - Accident Risks: The majority of each accident risk footprint (risk of fatality and risk of injury) are associated with the onsite labor hours (listed under equipment use and miscellaneous) during the site preparation phase (17 and 30 percent, respectively), during the remedial implementation phase (10 and 17 percent, respectively) and during the operations and maintenance phase (10 and 18 percent, respectively). Transportation of equipment during the remedial implementation phase (34 and 19 percent, respectively) and during the site preparation phase (6 and 3 percent, respectively) contributed the second highest accident risk footprints. Transportation of personnel and residual handling also contributed 10 percent or less in each category.

    Results are provided in **Table E-4** and **Figure E-2**.

- **Alternative 3: Removal Action with Stabilization and Offsite Disposal**
  - GHG and Energy Use: The majority of the GHG and energy use footprints were associated with material production (clean soil for backfill and gravel for the access road). Material production, listed under consumables, during the remedial implementation phase contributed approximately 59 and 40 percent of the GHG and energy use footprints, respectively, while material production during the site preparation phase contributed 9 and 21, percent, respectively. Residual handling during the remedial implementation phase contributed approximately 20 and 26 percent of the total GHG and energy use footprints, respectively. Transportation of equipment and personnel contributed 4 percent or less in each category.
  - Water Use: Water use from this alternative was attributed to hydraseeding for site restoration.
  - Criteria Air Pollutants (NO_X, SO_X, PM_{10}): Similar to GHG and energy use, the majority of the criteria air pollutant (NO_X, SO_X, PM_{10}) footprints was from material production during the remedial implementation phase (58, 77, and 32 percent, respectively), and during the site preparation phase (9, 11, and 4 percent,

respectively). Equipment and material transportation during the remedial implementation phase contributed 9, 5, and 1 percent of the total NO_X, SO_X, and PM_{10} emissions, respectively.

– Accident Risks; The majority of each accident risk footprint (risk of fatality and risk of injury) are associated with residual handling and transportation during the remedial implementation phase (46 and 29 percent, respectively). Onsite labor hours (listed under equipment use and miscellaneous) during the remedial implementation phase (18 and 37 percent, respectively) and during the site preparation phase (7 and 14 percent, respectively) had the second highest accident risk footprints. Transportation of personnel and transportation of equipment also contributed 10 percent or less in each category.

Results are provided in Table E-5 and Figure E-3.

E.4 Uncertainty

The SiteWise tool calculates environmental and risk footprints based on industry averages, published emissions factors, and generalized data sources. The footprint results are not representative of actual emissions and should be used for comparative purposes only.

E.5 Recommendations

The inventory from the SiteWise tool were used to estimate the environmental footprint of the alternatives. Once the alternative is selected Navy Green and Sustainable Remediation Best Management Practices (NAVFAC EXWC, 2016) will be considered in the remedial action.

Specific best management practices for these alternatives are as follows:

- Minimize fill brought onsite through grading of the excavation, or by using soil from a “clean” area of the site rather than import soil from an offsite source .
- If some more of the debris can be recycled, additional environmental benefits may be realized.
- Include using equipment with emissions control devices or managing work such that engine idle time is minimized.
- Recycle downed trees for onsite landscaping boundaries and wildlife restoration habitats.
- Choose stabilization materials that are manufactured through processes involving a low environmental impact.

E.6 References

Battelle. 2018. *SiteWise Version 3.2*. NAVFAC Engineering Service Center. October.

Naval Facilities Engineering Command, Engineering and Expeditionary Warfare Center (NAVFAC EXWC). 2016. *Green and Sustainable Remediation Best Management Practices*. September.

Tables

Table E-1. Alternative 2 – Stabilization and Engineered Cover with LUCs and LTM

Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges

Naval Air Station Patuxent River

St. Mary's County, Maryland

Site Preparation	SILT CURTAIN MATERIALS	Site Setup					
	Input length or perimeter of silt curtain (ft)	1,200					
	Input depth of silt curtain (ft)	3					
	BULK MATERIAL QUANTITIES	Site Setup Road Restoration	Site Setup Road Restoration	Cover Stabilization			
	Choose material from drop down menu	Gravel	HDPE Liner	Typical Cement			
	Choose units of material quantity from drop down menu	pounds	cubic feet	pounds			
	Input material quantity	608,000	189	22,000			
	PERSONNEL TRANSPORTATION - ROAD	Site Setup	Site Clearing				
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No				
	Choose vehicle type from drop down menu*	Light truck	Light truck				
	Choose fuel used from drop down menu	Gasoline	Gasoline				
	Input distance traveled per trip (miles)	50	50				
	Input number of trips taken	5	10				
	Input number of travelers	3	3				
	EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Dozer	Loader/Backhoe	Chipper	Sifter	Gravel	Portland Cement
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
	Choose fuel used from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
	Account for an empty return trip?	Yes	Yes	Yes	Yes	Yes	Yes
	Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).	50	50	50	100	1,302	127
	Input weight of equipment transported per truck load (tons)	20.00	20.00	20.00	20.00	23.00	11.00
	EARTHWORK	Dozer Road Restoration	Loader/Backhoe	Dozer Clearing			
	Choose earthwork equipment type from drop down menu	Dozer	Loader/Backhoe	Dozer			
	Choose fuel type from drop down menu	Diesel	Diesel	Diesel			
	Input volume of material to be removed (yd3)	203	303	303			
	Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No			
	MIXING EQUIPMENT	Pugmill Mixer					
	Choose fuel type from drop down menu	Diesel					
	Choose horsepower range from drop down menu	3 to 6					
	Input volume (yd3)	303					
	Input production rate (yd3/hr)	10					
	INTERNAL COMBUSTION ENGINES	Chipper	Sifter				
	Choose fuel type from drop down menu	Diesel	Diesel				
	Input fuel consumption rate (gal/hr or scf/hr)	10	10				
	Input operating hours (hr)	25	25				
	OPERATOR LABOR	Site Setup	Site Clearing				
	Choose occupation from drop-down menu	Construction laborers	Construction laborers				
	Input total time worked onsite (hours)	120	240				
Remedial Implementation	RESIDUE DISPOSAL/RECYCLING	Debris and Stumps	Return Trip	Lead Shot - 10 Drums			
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No			
	Input weight of the waste transported to landfill or recycling per trip (tons)	20	0	3			
	Choose fuel used from drop down menu	Diesel	Diesel	Diesel			
	Input total number of trips	7	6	1			
	Input number of miles per trip	50	115	115			
	LANDFILL OPERATIONS	Lead Shot - 10 Drums					
	Choose landfill type for waste disposal	Non-Hazardous					
	Input amount of waste disposed in landfill (tons)	3					
	BULK MATERIAL QUANTITIES	Cap Material					
	Choose material from drop down menu	Soil					
	Choose units of material quantity from drop down menu	cubic feet					
	Input material quantity	65,520					
	PERSONNEL TRANSPORTATION - ROAD	Surveying	Nuclear Density and Atterberg Testing	Cap Placement			
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No			
	Choose vehicle type from drop down menu*	Light truck	Light truck	Light truck			
	Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline			
	Input distance traveled per trip (miles)	50	50	50			
	Input number of trips taken	3	5	5			
	Input number of travelers	2	1	3			
	EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Cap Material					
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No					
	Choose fuel used from drop down menu	Diesel					
	Account for an empty return trip?	Yes					
	Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).	9,100					
	Input weight of equipment transported per truck load (tons)	20.00					
	EARTHWORK	Cap Placement					
	Choose earthwork equipment type from drop down menu	Dozer					
	Choose fuel type from drop down menu	Diesel					
	Input volume of material to be removed (yd3)	2,427					
	Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No					
	OPERATOR LABOR	Surveying	Nuclear Density and Atterberg Testing	Cap Placement			
	Choose occupation from drop-down menu	Construction laborers	Construction laborers	Construction laborers			
	Input total time worked onsite (hours)	48.0	40.0	120.0			
	LABORATORY ANALYSIS	Analysis 1					
	Input dollars spent on laboratory analysis ($)	$2,111.00					
	OTHER KNOWN ONSITE ACTIVITIES	Site Restoration					
	Water consumption (gallon)	40,000					
Operations and Maintenance	PERSONNEL TRANSPORTATION - ROAD	Annual Site Inspections					
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No					
	Choose vehicle type from drop down menu*	Light truck					
	Choose fuel used from drop down menu	Gasoline					
	Input distance traveled per trip (miles)	50					
	Input number of trips taken	30					
	Input number of travelers	1					
	OPERATOR LABOR	Annual Site Inspections					
	Choose occupation from drop-down menu	Construction laborers					
	Input total time worked onsite (hours)	240					

Table E-2. Alternative 3 - Removal Action with Stabilization and Offsite Disposal

Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges

Naval Air Station Patuxent River

St. Mary's County, Maryland

Site Preparation	SILT CURTAIN MATERIALS	Site Setup			
	Input length or perimeter of silt curtain (ft)	1,200			
	Input depth of silt curtain (ft)	3			
	BULK MATERIAL QUANTITIES	Site Setup Road Restoration	Site Setup Road Restoration		
	Choose material from drop down menu	Gravel	HDPE Liner		
	Choose units of material quantity from drop down menu	pounds	cubic feet		
	Input material quantity	608,000	189		
	PERSONNEL TRANSPORTATION - ROAD	Site Setup	Site Clearing		
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No		
	Choose vehicle type from drop down menu*	Light truck	Light truck		
	Choose fuel used from drop down menu	Gasoline	Gasoline		
	Input distance traveled per trip (miles)	50	50		
	Input number of trips taken	5	5		
	Input number of travelers	3	3		
	EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Dozer	Loader/Backhoe	Chipper	Gravel
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
	Choose fuel used from drop down menu	Diesel	Diesel	Diesel	Diesel
	Account for an empty return trip?	Yes	Yes	Yes	Yes
	Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).	50	50	50	1,302
	Input weight of equipment transported per truck load (tons)	20	20	20	23
	EARTHWORK	Dozer Road Restoration	Loader/Backhoe Clearing	Dozer Clearing	
	Choose earthwork equipment type from drop down menu	Dozer	Loader/Backhoe	Dozer	
	Choose fuel type from drop down menu	Diesel	Diesel	Diesel	
	Input volume of material to be removed (yd3)	203	303	303	
	Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	
	INTERNAL COMBUSTION ENGINES	Chipper			
	Choose fuel type from drop down menu	Diesel			
	Input fuel consumption rate (gal/hr or scf/hr)	10			
	Input operating hours (hr)	25			
	OPERATOR LABOR	Site Setup	Site Clearing		
	Choose occupation from drop-down menu	Construction laborers	Construction laborers		
	Input total time worked onsite (hours)	120	120		
	RESIDUE DISPOSAL/RECYCLING	Debris and Stumps	Return Trip		
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No		
	Input weight of the waste transported to landfill or recycling per trip (tons)	20	0		
	Choose fuel used from drop down menu	Diesel	Diesel		
	Input total number of trips	7	6		
	Input number of miles per trip	50	50		
Remedial Implementation	BULK MATERIAL QUANTITIES	Backfill	Portland Cement		
	Choose material from drop down menu	Soil	Typical Cement		
	Choose units of material quantity from drop down menu	cubic feet	pounds		
	Input material quantity	27,216	304,000		
	PERSONNEL TRANSPORTATION - ROAD	Surveying	Excavation and Mixing Crew	Sampling Team	Nuclear Density and Atterberg Testing
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
	Choose vehicle type from drop down menu*	Light truck	Light truck	Light truck	Light truck
	Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline
	Input distance traveled per trip (miles)	50	50	50	50
	Input number of trips taken	3	13	13	8
	Input number of travelers	2	4	1	1
	EQUIPMENT TRANSPORTATION - DEDICATED LOAD ROAD	Excavator 1	Excavator 2	Backfill	Portland Cement
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
	Choose fuel used from drop down menu	Diesel	Diesel	Diesel	Diesel
	Account for an empty return trip?	No	No	Yes	Yes
	Input one-way distance traveled (miles) with a given load. If applicable, impact for an empty return trip will be accounted for (no additional input is needed).	50	50	3,800	400
	Input weight of equipment transported per truck load (tons)	30.00	30.00	20.00	20.00
	EARTHWORK	Excavate	Mixing and Stabilization	Backfilling	
	Choose earthwork equipment type from drop down menu	Excavator	Excavator	Dozer	
	Choose fuel type from drop down menu	Diesel	Diesel	Diesel	
	Input volume of material to be removed (yd3)	1,008	1,109	1,512	
	Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	
	OPERATOR LABOR	Surveying	Excavation and Mixing Crew	Sampling Team	Nuclear Density and Atterberg Testing
	Choose occupation from drop-down menu	Construction laborers	Construction laborers	Construction laborers	Construction laborers
	Input total time worked onsite (hours)	48	416	104	64
	LABORATORY ANALYSIS	Analysis 1			
	Input dollars spent on laboratory analysis ($)	$21,721.00			
	OTHER KNOWN ONSITE ACTIVITIES	Site Restoration			
	Water consumption (gallon)	40,000			
	RESIDUE DISPOSAL/RECYCLING	Soil	Return Trip		
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No		
	Input weight of the waste transported to landfill or recycling per trip (tons)	20	0		
	Choose fuel used from drop down menu	Diesel	Diesel		
	Input total number of trips	84	83		
	Input number of miles per trip	115	115		
	LANDFILL OPERATIONS	Soil			
	Choose landfill type for waste disposal	Non-Hazardous			
	Input amount of waste disposed in landfill (tons)	1,664			
Operations and Maintenance	PERSONNEL TRANSPORTATION - ROAD	Annual Site Inspections			
	Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No			
	Choose vehicle type from drop down menu*	Light truck			
	Choose fuel used from drop down menu	Gasoline			
	Input distance traveled per trip (miles)	50			
	Input number of trips taken	2			
	Input number of travelers	1			
	OPERATOR LABOR	Annual Site Inspections			
	Choose occupation from drop-down menu	Construction laborers			
	Input total time worked onsite (hours)	16			

Table E-3. Relative Impact of Alternatives

Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges

Naval Air Station Patuxent River

St. Mary's County, Maryland

Remedial Alternatives	GHG Emissions	Total energy Used	Water Used	NO_x emissions	SO_x Emissions	PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Alternative 2 – Stabilization and Engineered Cover with LUCs and LTM	146	2,601	40,000	4.60E-01	5.28E-01	1.91E-01	2.11E-04	3.06E-02
Alternative 3 - Removal Action with Stabilization and Offsite Disposal	250	3,034	40,000	6.21E-01	8.10E-01	4.88E-01	3.28E-04	4.10E-02

Relative Impact

Remedial Alternatives	GHG Emissions	Total energy Used	Water Used	NO_x emissions	SO_x Emissions	PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
Alternative 2 – Stabilization and Engineered Cover with LUCs and LTM	Medium	High	High	High	Medium	Medium	Medium	High
Alternative 3 - Removal Action with Stabilization and Offsite Disposal	High	High	High	High	High	High	High	High

The relative impact is a qualitative assessment of the relative footprint of each alternative, a rating of High for an alternative is assigned if it is at least 70 percent of the maximum footprint, a rating of Medium is assigned if it is between 30 and 70 percent of the maximum footprint, and a rating of Low is assigned if it is less than 30 percent of the maximum footprint.

Notes:

MMBTU - million British Thermal Unit

NOx - Nitrogen Oxides

SOx - Sulfur Oxides

LUCs - land use controls

PM10 - Particulate Matter

GHG - Greenhouse Gases

NA - Not applicable

Table E-4. Alternative 2 - Stabilization and Engineered Cover with LUCs and LTM

Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges

Naval Air Station Patuxent River

St. Mary's County, Maryland

Phase	Activities	GHG Emissions		Total Energy Used		Water Used		NO_x Emissions		SO_x Emissions		PM_{10} Emissions		Accident Risk Fatality		Accident Risk Injury	
		metric ton	Percent of total	MMBTU	Percent of total	gallons	Percent of total	metric ton	Percent of total	metric ton	Percent of total	metric ton	Percent of total		Percent of total		Percent of total
Site Preparation	Consumables	31	22%	681	26%	NA	NA	7.5E-02	16%	1.2E-01	24%	2.6E-02	14%	NA	NA	NA	NA
	Transportation-Personnel	0	0%	5	0%	NA	NA	1.7E-04	0%	5.4E-06	0%	2.5E-05	0%	1.8E-05	8%	1.4E-03	5%
	Transportation-Equipment	6	4%	72	3%	NA	NA	1.7E-03	0%	3.1E-05	0%	1.5E-04	0%	1.3E-05	6%	1.1E-03	3%
	Equipment Use and Misc	7	5%	76	3%	0	0%	5.0E-02	11%	2.9E-03	1%	4.9E-03	3%	3.6E-05	17%	9.3E-03	30%
	Residual Handling	2	1%	25	1%	NA	NA	7.3E-04	0%	1.0E-04	0%	5.0E-04	0%	9.0E-06	4%	7.3E-04	2%
	Sub-Total	**46**	31%	**860**	33%	**0**	0%	**1.3E-01**	28%	**1.3E-01**	24%	**3.2E-02**	17%	**7.6E-05**	36%	**1.2E-02**	41%
Remedial Implementation	Consumables	79	54%	1,464	56%	NA	NA	3.2E-01	69%	3.9E-01	75%	1.6E-01	83%	NA	NA	NA	NA
	Transportation-Personnel	0	0%	5	0%	NA	NA	1.5E-04	0%	4.7E-06	0%	2.1E-05	0%	1.0E-05	5%	8.2E-04	3%
	Transportation-Equipment	18	12%	231	9%	NA	NA	5.6E-03	1%	9.8E-05	0%	4.9E-04	0%	7.1E-05	34%	5.7E-03	19%
	Equipment Use and Misc	2	1%	31	1%	40,000	100%	1.1E-02	2%	5.3E-03	1%	1.0E-03	1%	2.1E-05	10%	5.2E-03	17%
	Residual Handling	0	0%	0	0%	NA	NA	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%
	Sub-Total	**99**	68%	**1,731**	67%	**40,000**	100%	**3.3E-01**	72%	**4.0E-01**	76%	**1.6E-01**	83%	**1.0E-04**	48%	**1.2E-02**	38%
Operations and Maintenance	Consumables	0	0%	0	0%	NA	NA	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	NA	NA	NA	NA
	Transportation-Personnel	0.8	1%	10	0%	NA	NA	3.4E-04	0%	1.1E-05	0%	4.9E-05	0%	1.2E-05	6%	9.4E-04	3%
	Transportation-Equipment	0	0%	0	0%	NA	NA	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%
	Equipment Use and Misc	0	0%	0	0%	0	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	2.2E-05	10%	5.5E-03	18%
	Residual Handling	0	0%	0	0%	NA	NA	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%
	Sub-Total	**0.8**	1%	**10**	0%	**0**	0%	**3.4E-04**	0%	**1.1E-05**	0%	**4.9E-05**	0%	**3.4E-05**	16%	**6.5E-03**	21%
Total		**146**		**2,601**		**40,000**		**4.60E-01**		**5.28E-01**		**1.91E-01**		**2.11E-04**		**3.06E-02**	

Notes:

MMBTU - million British Thermal Unit

NOx - Nitrogen Oxides

SOx - Sulfur Oxides

PM10 - Particulate Matter

NA - Not Applicable

GHG - Greenhouse Gases

NA - not applicable

Table E-5. Alternative 3 - Removal, Stabilization, and Off-site Disposal

Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges

Naval Air Station Patuxent River

St. Mary's County, Maryland

Phase	Activities	GHG Emissions		Total Energy Used		Water Used		NO_x Emissions		SO_x Emissions		PM_{10} Emissions		Accident Risk Fatality		Accident Risk Injury	
		metric ton	Percent of total	MMBTU	Percent of total	gallons	Percent of total	metric ton	Percent of total	metric ton	Percent of total	metric ton	Percent of total		Percent of total		Percent of total
Site Preparation	Consumables	23	9%	638	21%	NA	NA	5.8E-02	9%	9.1E-02	11%	2.0E-02	4%	NA	NA	NA	NA
	Transportation-Personnel	0	0%	3	0%	NA	NA	1.1E-04	0%	3.6E-06	0%	1.6E-05	0%	1.2E-05	4%	9.4E-04	2%
	Transportation-Equipment	3	1%	39	1%	NA	NA	9.4E-04	0%	1.7E-05	0%	8.3E-05	0%	1.1E-05	3%	9.1E-04	2%
	Equipment Use and Misc	3	1%	42	1%	0	0%	2.6E-02	4%	1.7E-03	0%	2.6E-03	1%	2.3E-05	7%	5.8E-03	14%
	Residual Handling	1	0%	14	0%	NA	NA	3.5E-04	0%	6.1E-06	0%	3.1E-05	0%	5.1E-06	2%	4.1E-04	1%
	Sub-Total	**31**	12%	**736**	24%	**0**	0%	**8.5E-02**	14%	**9.3E-02**	12%	**2.2E-02**	5%	**5.1E-05**	16%	**8.1E-03**	20%
Remedial Implementation	Consumables	147	59%	1,209	40%	NA	NA	3.6E-01	58%	6.2E-01	77%	1.6E-01	32%	NA	NA	NA	NA
	Transportation-Personnel	1	0%	13	0%	NA	NA	4.2E-04	0%	1.3E-05	0%	6.0E-05	0%	3.1E-05	9%	2.5E-03	6%
	Transportation-Equipment	8	3%	110	4%	NA	NA	2.6E-03	0%	4.7E-05	0%	2.3E-04	0%	3.4E-05	10%	2.7E-03	7%
	Equipment Use and Misc	11	5%	165	5%	40,000	100%	5.7E-02	9%	3.8E-02	5%	5.2E-03	1%	6.1E-05	18%	1.5E-02	37%
	Residual Handling	51	20%	799	26%	NA	NA	1.2E-01	19%	5.7E-02	7%	3.0E-01	62%	1.5E-04	46%	1.2E-02	29%
	Sub-Total	**219**	88%	**2,297**	76%	**40,000**	100%	**5.4E-01**	86%	**7.2E-01**	88%	**4.7E-01**	95%	**2.7E-04**	84%	**3.3E-02**	79%
Operations and Maintenance	Consumables	0	0%	0	0%	NA	NA	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	NA	NA	NA	NA
	Transportation-Personnel	0.1	0%	0.7	0%	NA	NA	2.3E-05	0%	7.2E-07	0%	3.3E-06	0%	7.8E-07	0%	6.3E-05	0%
	Transportation-Equipment	0	0%	0	0%	NA	NA	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%
	Equipment Use and Misc	0	0%	0	0%	0	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	1.5E-06	0%	3.7E-04	1%
	Residual Handling	0	0%	0	0%	NA	NA	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%	0.0E+00	0%
	Sub-Total	**0.1**	0%	**0.7**	0%	**0**	0%	**2.3E-05**	0%	**7.2E-07**	0%	**3.3E-06**	0%	**2.2E-06**	1%	**4.3E-04**	1%
Total		**250**		**3,034**		**40,000**		**6.21E-01**		**8.10E-01**		**4.88E-01**		**3.28E-04**		**4.10E-02**	

Notes:

MMBTU - million British Thermal Unit

NOx - Nitrogen Oxides

SOx - Sulfur Oxides

PM10 - Particulate Matter

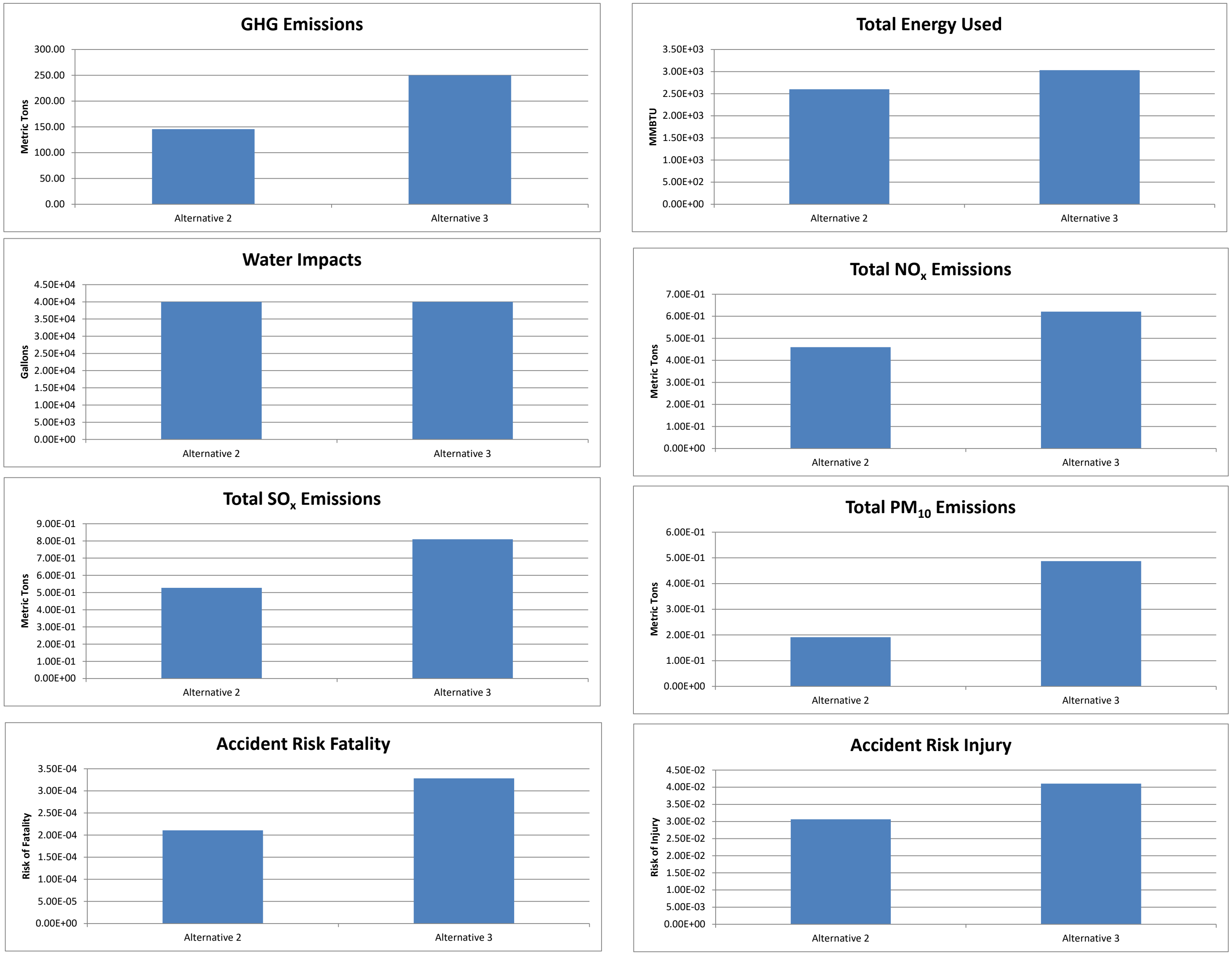
NA - Not Applicable

GHG - Greenhouse Gases

NA - not applicable

Figures

*Accident Risk is an estimate of how many accidents may occur. This risk is not the same as Cancer Risk, which is the probability (for a single person) of getting cancer. Accident risk is not comparable to Cancer Risk due to inherent fundamental differences.



Alternative 2 – Stabilization and Engineered Cover with LUCs and LTM
Alternative 3 – Removal Action with Stabilization and Offsite Disposal

FIGURE E-1
Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges
Naval Air Station Patuxent River
St. Mary's County, Maryland

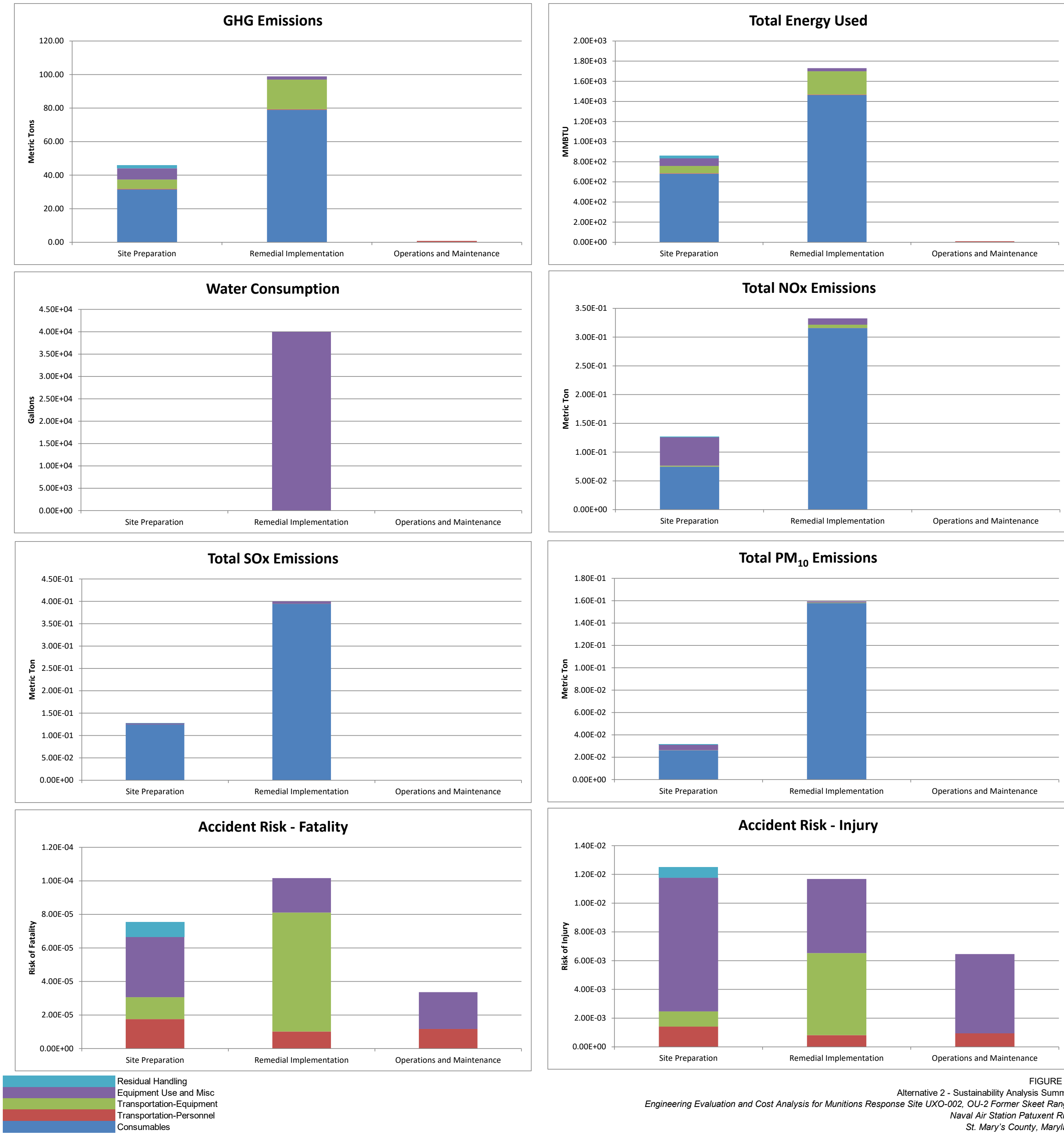


FIGURE E-2
Alternative 2 - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges
Naval Air Station Patuxent River
St. Mary's County, Maryland

FIGURE E-3
Alternative 3 - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis for Munitions Response Site UXO-002, OU-2 Former Skeet Ranges
Naval Air Station Patuxent River
St. Mary's County, Maryland

Appendix F
Regulatory Correspondence

REGION 3
PHILADELPHIA, PA 19103

Date: July 8, 2024

Mr. David Steckler, PG
NAVFAC Environmental Department Code EV2, Building 212
1314 Harwood Street, SE
Washington Navy Yard, DC 20374-5018

Ms. Krystal Ayotte
NAVFAC Environmental Department Naval Air Station, Code 8.7.1.4
22445 Perry Road, Bldg. 504
Patuxent River, MD 20670

Re: *Draft Engineering Evaluation/ Cost Analysis UXO-2 OU-2 Former Skeet Ranges, Naval Air Station Patuxent River, St. Mary's County, Maryland*

Dear Mr. Steckler and Ms. Ayotte:

The U.S. Environmental Protection Agency (EPA) has reviewed the referenced document and is pleased to provide you the following comment.

Toxicologist Review

Linda Watson, EPA toxicologist, has reviewed the *Draft Engineering Evaluation/ Cost Analysis UXO-2 OU-2 Former Skeet Ranges, Naval Air Station Patuxent River, St. Mary's County, Maryland.* If you have any questions regarding this comment, please contact Linda at 215-814-3116. Linda has the following comment:

1. **Section 3.3-Remediation Goals**. Please acknowledge EPA's updated guidance on lead. Perhaps the following language could be included. "*On January 17, 2024, EPA announced updated guidance for lead in residential soil at CERCLA sites. The new guidance recommends screening lead at 200 mg/kg*."

Sincerely,

Jenna O'Brien, U.S. EPA Remedial Project Manager

CC: Ms. Jenny E. Herman, MDE LMD/FF

CH2M HILL
2551 Dulles View Drive
Suite 700
Herndon, VA 20171
Tel (703) 376-5000
Fax (703) 376-5010

July 18, 2024

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Ms. Jenna O'Brien
US Environmental Protection Agency
Four Penn Center
1600 John F. Kennedy Boulevard (3SD11)
Philadelphia, PA 19103-2029

Subject: Response to USEPA comments on the *Draft Engineering Evaluation/Cost Analysis UXO-2 OU-2 Former Skeet Ranges, Naval Air Station Patuxent River, Maryland (May 2024)*
Navy CLEAN Contract N6247016D9000, CTO N4008020F5208

Dear Ms. O'Brien:

On behalf of Naval Facilities Engineering Command - Washington (NAVFAC Washington), this letter presents the Navy's response to comments provided by USEPA in correspondence dated July 8, 2024 on the above referenced document. USEPA comments are repeated below followed by NAVFAC Washington's response. The responses to the comments will be incorporated into the *Final Sixth Five-Year Review, Naval Air Station Patuxent River, St. Mary's County, Maryland.*

EPA Toxicologist Comments

Jenna O'Brien, EPA RPM, has reviewed the *Draft Engineering Evaluation/Cost Analysis UXO-2 OU-2 Former Skeet Ranges, Naval Air Station Patuxent River, St. Mary's County, Maryland* and provided comments. The Navy has prepared responses to Ms. Watson's comment as follows:

Comment 1, Section 3.3-Remediation Goals: Please acknowledge EPA's updated guidance on lead. Perhaps the following language could be included. "On January 17, 2024, EPA announced updated guidance for lead in residential soil at CERCLA sites. The new guidance recommends screening lead at 200 mg/kg.".

Response: The language in Section 3.3 will be updated to acknowledge EPA's updated guidance on lead. Thank you for your review.

If there are any questions or additional information is needed, please contact David Steckler with NAVFAC Washington (202-685-3275) or me at 540-454-9039 at your convenience.

Sincerely,

CH2M

John Ledbetter

John Ledbetter

Activity Manager

cc: David Steckler/ NAVFAC Washington
Jenny Herman/Maryland Department of the Environment
Krystal Ayotte/NAVFAC - NAS Patuxent River
Ian Zmudzin/CH2M

July 24, 2024

Electronic Delivery

Mr. David Steckler
NAVFAC WASHINGTON
1314 Harwood St, SE
Washington Navy Yard, 20374

Re: Draft Engineering Evaluation and Cost Analysis Report, Munitions Response Site, Former Skeet Ranges (UXO-002, OU-2), Naval Air Station Patuxent River, May 2024.

Dear Mr. Steckler:

The Federal Facilities Installation Restoration Program of the Maryland Department of the Environment has completed its review of the above-referenced document and has no comments. Please submit a final copy of this document for inclusion in the project file.

If you have any questions, please contact me at (410) 537-3319 or *jenny.herman@maryland.gov*.

Sincerely,

Jenny E. Herman

Jenny E. Herman
Geologist Program Consultant
Federal Facilities Installation Restoration Program

cc: Ms. Jenna O'Brien, Remedial Project Manager, Environmental Protection Agency
Mr. Curtis DeTore, Chief, Federal Assessment and Remediation Division