DRAFT FINAL

4825 GLENBROOK ROAD
POST-REMOVAL ACTION RISK REDUCTION SUMMARY

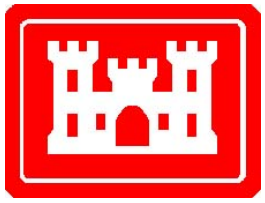
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3
WASHINGTON, D.C.

Prepared For:

U.S. ARMY ENGINEERING AND SUPPORT CENTER, HUNTSVILLE

and

U.S. ARMY CORPS OF ENGINEERS, BALTIMORE DISTRICT



December 12, 2019

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LIST OF ACRONYMS AND ABBREVIATIONS

ABP	Agent Breakdown Products
AU	American University
AUES	American University Experiment Station
bgs	Below Ground Surface
CCDC	Combat Capabilities Development Command – Chemical Biological Center
CDI	Chronic Daily Intake
CENAB	United States Army Corps of Engineers, Baltimore District
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CWM	Chemical Warfare Materiel
DERP	Defense Environmental Restoration Program
ECBC	Edgewood Chemical and Biological Center
ECS	Engineering Control Structure
EMS	Environmental Management Systems
EPC	Exposure Point Concentration
ft	Feet
FUDS	Formerly Used Defense Site
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HTRW	Hazardous, Toxic and Radioactive Waste
HTW	Hazardous Toxic Waste
IC	Intact Container
IDLH	Immediately Dangerous to Life or Health
kg	Kilogram
LOAEL	Lowest-Observed-Adverse-Effect Level
m	Meter
MD	Munitions Debris
MEC	Munitions and Explosives of Concern
mg	Milligram
MINICAMS	Miniature Continuous Air Monitoring System
NOAEL	No-Observed-Adverse-Effect Level
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PDT	Project Delivery Team
PEF	Particulate Emission Factor
PEL	Permissible Exposure Limit
PID	Photoionization Detector
QC	Quality Control
RAD	Remedial Action Design
RAGS	Risk Assessment Guidance for Superfund

REL	Recommended Exposure Limits
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SF	Slope Factor
SSFR	Site-Specific Final Report
SSWP	Site-Specific Work Plan
SVFUDS	Spring Valley Formerly Used Defense Site
SVOC	Semi-Volatile Organic Compounds
TEU	Technical Escort Unit
UCL	Upper Confidence Limit
URF	Unit Risk Factor
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
XRF	X-Ray Fluorescence

EXECUTIVE SUMMARY

ES.1 A human health risk assessment (HHRA) was performed to estimate the potential risks/hazards to current and future receptors from site-related contamination in the soil at the 4825 Glenbrook Road property located in Spring Valley, Washington, D.C. The remedial objectives for all factors other than risk have been achieved; therefore, if there is no unacceptable risk associated with Chemicals of Potential Concern (COPCs) based on this HHRA, then no further excavation is warranted and all the remedial action objectives and remedial goal have been met. The type and magnitude of exposures to COPCs at the site were estimated, potential exposure pathways, receptors, and exposure scenarios were identified, and potential exposure was quantified. This HHRA was performed under contract W912DY-09-D-0062, Delivery Order 0006, FUDS project no. C03DC091809, for the U.S. Army Engineering and Support Center, Huntsville (CEHNC) and the U.S. Army Corps of Engineers, Baltimore District (CENAB).

ES.2 4825 Glenbrook Road is part of the Spring Valley Formerly Used Defense Site (SVFUDS), an area of northwest Washington, D.C., formerly occupied by the American University Experiment Station (AUES). During World War I, the U.S. Government established the AUES to investigate the testing, production, and effects of noxious gases, antidotes, and protective masks and to conduct research and development on chemical warfare materiel, including mustard and lewisite agents, as well as adamsite, irritants, and smokes.

ES.3 During the remedial action activities conducted from 2012 through 2019, 20 ft by 20 ft grids were excavated at 4825 Glenbrook Road during high and low probability soil removal activities. Grids were excavated down to competent saprolite or when a site boundary wall was reached and confirmation samples were collected. Over excavation was conducted in specific locations until the arsenic concentrations in subsequent confirmation samples were below the Spring Valley remediation goal of 20 mg/kg, except for two small areas: the north wall of grid -10, -90 and area 4 (grid -10, -30).

ES.4 149 soil samples were collected that are representative of the soil remaining at the site. Eighty-nine (89) samples were analyzed for the Spring Valley comprehensive list of confirmation and/or grab sample parameters, including the chemical agents mustard and lewisite, agent breakdown products (ABPs), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, explosives, pesticides and PCBs, total cyanide, fluoride, iodine, and perchlorate. Sixty (60) Hazardous Toxic Waste (HTW) confirmation samples were collected that are representative of the soil remaining at the site after the over excavation of HTW-contaminated soil. These samples were analyzed for only the analyte(s) that exceeded the comparison values in the original corresponding confirmation sample results or preceding HTW confirmation samples if certain analytes continued to exceed the comparison values after each iteration of over excavation. These analytes included aluminum, antimony, arsenic, cobalt, cyanide, manganese, nickel, thallium, and vanadium which were evaluated as COPCs in this HHRA.

ES.5 The primary objective of this HHRA was to quantitatively characterize the human health risk associated with current and reasonably expected future exposure to contaminated soils at

4825 Glenbrook Road. The HHRA evaluated potential future residents (adult and child). The exposure pathways evaluated here include incidental soil ingestion, ingestion of homegrown vegetables, dermal contact with soils, and the inhalation of particulates.

ES.6 The cumulative cancer risk estimates for adult and child residents exposed to surface soil (i.e. 0-2 feet below ground surface (ft bgs)); and combined surface and subsurface soil (0-12 ft bgs) are within the United States Environmental Protection Agency (USEPA) target risk range of 1×10^{-6} to 1×10^{-4}. Thus, unacceptable cancer risks to the receptors at the site are not expected from assumed exposures to COPCs in soil.

ES.7 The hazard indices (HI) estimated for adult and child residents exposed to surface soil (0-2 ft bgs) and combined surface and subsurface soil (0-12 ft bgs) are below the benchmark of 1 following consideration of target organs. Thus, unacceptable hazards to residential receptors at the site are not expected from assumed exposures to COPCs in soil.

ES.8 The human health risk associated with current and reasonably expected future exposure to contaminated soils at 4825 Glenbrook Road was quantitatively characterized. The metals concentrations in the remaining soil are near or below background concentrations and residential exposure to the COPCs in soil do not pose an unacceptable risk. All other remaining compounds were below the Spring Valley comparison values as prescribed in the Site-Specific Work Plan for the Remedial Design/Remedial Action at 4825 Glenbrook Road Revision 6 (USACE 2017).

SECTION 1
INTRODUCTION

1.1 PROJECT OVERVIEW

1.1.0.1 The purpose of this report is to present the results of a human health risk assessment (HHRA) that estimated the potential risks/hazards to current and future receptors from site-related contamination remaining in the soil following remedial actions conducted at 4825 Glenbrook Road, located in Spring Valley, Washington, D.C. The 4825 Glenbrook Road property is owned by American University (AU). The remedial objectives for all factors other than risk have been achieved; therefore, if there is no unacceptable risk associated with COPCs based on this HHRA, then no further excavation is warranted and of all the remedial action objectives and the remediation goal have been met. The HHRA is based on analytical data collected during the remedial action activities conducted from 2012 through 2019.

1.1.0.2 As described in detail in Appendix A, an HHRA evaluating the risk associated with soil contamination was previously performed for 4825 Glenbrook Road as part of a Remedial Investigation (U.S. Army Corps of Engineers [USACE] 2011). The HHRA concluded that further action was warranted to mitigate unacceptable risk and hazards. The risk estimates exceed United States Environmental Protection Agency's (USEPA's) target risk range and acceptable hazard index (HI) of 1 for residents due to exposure to arsenic in soil. Therefore, excavation of all soils down to competent saprolite was conducted from 2012 through 2019. This HHRA is based on the data from soil samples collected during the remedial action that are representative of the soil remaining in place following excavation activities.

1.1.0.3 This HHRA report was prepared under contract W912DY-09-D-0062, Delivery Order 0006, FUDS project no. C03DC091809, for the U.S. Army Engineering and Support Center, Huntsville and the U.S. Army Corps of Engineers, Baltimore District (CENAB).

1.2 SVFUDS BACKGROUND

1.2.0.1 4825 Glenbrook Road is a private residential parcel of approximately 0.4 acres located within Operable Unit 3 (OU-3) of the Spring Valley Formerly Used Defense Site (SVFUDS). The SVFUDS is an area of northwest Washington, D.C., that was formerly occupied by the American University Experiment Station (AUES). During World War I, the U.S. Government established the AUES to investigate the testing, production, and effects of noxious gases, antidotes, and protective masks. The AUES was located on the grounds of the current AU and used additional property in the vicinity to conduct research and development on chemical warfare materiel (CWM), including mustard agent and lewisite agent, as well as adamsite, irritants, and smokes. After the war, these activities were transferred to other locations and the site was returned to the owners. The SVFUDS location map is presented as Figure 1-1.

1.3 PREVIOUS INVESTIGATIONS AT 4825 GLENBROOK ROAD

1.3.0.1 Over the years, numerous investigations have been performed at 4825 Glenbrook Road. Previous investigations were conducted at different times, by different parties, and with different sampling objectives and analytical parameters. The previous investigations include:

- Environmental Management Systems (Environmental Management Systems [EMS] 1992) – soil sampling when workers encountered buried glassware
- USACE (1995) – Remedial Investigation (RI) soil sampling
- USEPA (1999c) – Surface soil sampling
- USACE (1999) – Geophysical investigation
- USEPA (1999a) – X-ray fluorescence (XRF) sampling
- USEPA (1999b) – Surface and subsurface soil sampling
- USACE (2009) – Soil gas and driveway agent breakdown product (ABP) soil sampling
- USACE (2011) – RI activities conducted at 4825 Glenbrook Road from 2000-2010. Final RI report including HHRA was published in 2011.
- USACE (2019) – Remedial action activities conducted at 4825 Glenbrook Road from 2012-2019 to remove soil with arsenic concentrations greater than 20 mg/kg. The residence including the house, foundation, slabs, driveway, sidewalk, and landscaping adjacent to the property were also removed and disposed of in support of this remedial action.

1.3.0.2 Detailed results of the previous investigations listed above (excluding the current remedial action activities) are included in Appendix A – 4825 Glenbrook Road Human Health Risk Assessment (USACE 2011).

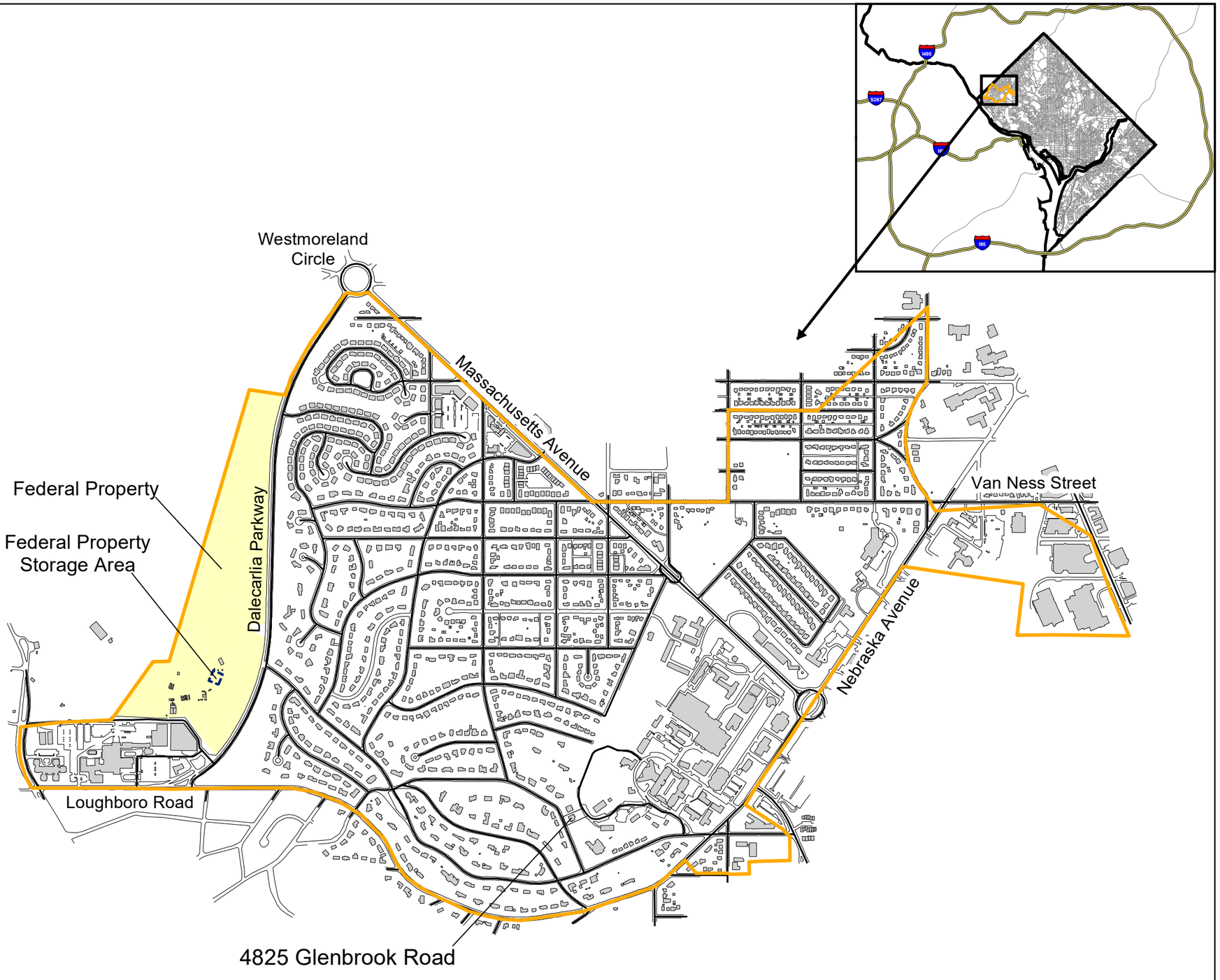

Figure 1-1
Spring Valley FUDS Location

4825 Glenbrook Road
Spring Valley, Washington, D.C.

Legend

- Buildings
- Spring Valley FUDS Boundary
- Federal Property
- Federal Property Storage Area
- Road

1,200 600 0 1,200 Feet

1 inch = 1,000 feet

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1.4 SUMMARY OF CURRENT REMEDIAL ACTIVITIES

1.4.0.1 USACE performed remedial action activities at 4825 Glenbrook Road from 2012 through 2019.

1.4.0.2 Remedial action activities consisted of the following:

- Residence demolition to remove the house while keeping the basement slab and exterior masonry walls below grade intact. (Completed December 2012)
- Re-route sewer and water lines and perform investigation of eleven test pits, one J-shaped sewer trench and the front curb area. (Completed June 2013)
- Removal of high probability area soils including the basement slab and exterior walls below grade. (Completed July 2016)
- Removal of low probability area soils and any remaining Hazardous Toxic Waste (HTW)-contaminated areas. (Completed July 2019)

1.4.0.3 Over 3,000 cubic yards of soil have been removed from 4825 Glenbrook Road since remedial activities began in 2012. The complete results are documented in the Site-Specific Final Report (SSFR).

1.4.0.4 Based on the Decision Document, the remediation goal for the 4825 Glenbrook Road RA is the removal of all soil with a concentration greater than 20 mg/kg for arsenic. The additional remedial action objectives for the site are:

1. Prevent direct contact with soil having a non-carcinogenic Hazard Index (HI) exceeding 1
2. Prevent direct contact with soil having a cancer risk in excess of 1 x 10-4
3. Remove military munitions from the site allowing for Unrestricted Use/Unlimited Exposure (UU/UE)

Relative to the third remedial goal associated with military munitions, it assumes that all munitions were either buried or otherwise discarded. All high and low probability areas were excavated down to competent saprolite (evidence of undisturbed material) ensuring that all potential burial areas were removed down to undisturbed material. Therefore, relative to military munitions, the site now allows for Unrestricted Use/Unlimited Exposure (UU/UE). Arsenic concentrations above 20 mg/kg were detected and left in place in area 4 and the north wall of grid -10, -90; therefore, arsenic was evaluated in this HHRA. Achievement of the first two remedial objectives regarding contact with soil are the subject of this HHRA.

1.5 OBJECTIVES AND SCOPE

1.5.0.1 The objective is to conduct a site-specific quantitative HHRA for human receptors at 4825 Glenbrook Road to determine if any further excavation is warranted based on the existing concentrations of chemicals of potential concern (COPCs) (including arsenic) remaining at the site. All data was evaluated following guidance from the United States Environmental Protection Agency (USEPA 1992a) to determine whether it was acceptable for use in an HHRA. Sample locations that have been subsequently excavated were excluded from the risk assessment data set. Data considered acceptable were used to identify and screen COPCs. For the receptors

present at the site, the HHRA identified potential exposure pathways and estimated the magnitude of assumed exposure to COPCs. This information, in conjunction with toxicity information for the COPCs, provides a quantitative post remedial action risk assessment and determines if potential risks to human health associated with exposure to chemicals in the soil remaining at 4825 Glenbrook Road are acceptable.

1.5.0.2 The HHRA was conducted following techniques and methods prescribed by the USACE and USEPA, including the following:

- Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual (Part A), interim final (USEPA 1989);
- Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors (USEPA 1991a);
- Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (USEPA 1991b).
- Guidance for Data Usability in Risk Assessment (Part A) (USEPA 1992a);
- Human Health Toxicity Values in Superfund Risk Assessments (USEPA 2003);
- Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA 2004a);
- On the computation of a 95 percent upper confidence limit of the unknown population mean based upon data sets with below detection limit observations (USEPA 2006);
- Risk Assessment Guidance for Superfund (RAGS). Volume I: Human health evaluation manual. Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA 2009);
- Exposure Factors Handbook (USEPA 2011);
- Technical and user guides to ProUCL v5.1 (USEPA 2015); and
- Regional Screening Levels – User's Guide (USEPA 2019a).

1.5.0.3 The scope of this HHRA evaluates the risks associated with assumed human exposure to soil contamination and the potential for contaminants detected in soil.

1.6 TECHNICAL APPROACH OVERVIEW

1.6.0.1 The four-step risk assessment procedure recommended by USEPA (1989) was used for this evaluation. The four steps are as follows:

1. data evaluation;
2. exposure assessment;
3. toxicity assessment; and
4. risk characterization.

1.6.0.2 The first step of the HHRA process involves an evaluation of available data. Section 2.1 describes the data used in this evaluation. Data were also screened to identify the COPCs that will be evaluated in the subsequent steps.

1.6.0.3 The second step in the HHRA process is the exposure assessment. The purpose of the exposure assessment is to identify and evaluate the nature of past chemical releases, potential exposure pathways, potential receptors, and exposure scenarios. This involves the preparation of a Conceptual Site Model (CSM) to determine which potential exposure pathways will be

evaluated. The CSM is site specific and was used to identify all potentially complete exposure pathways for both current and future human receptors.

1.6.0.4 Steps 3 and 4 (toxicity assessment and risk characterization) are performed for those chemicals identified as COPCs in step 1. The toxicity assessment involves researching available toxicity data and is conducted concurrently with step 2, the exposure assessment. If toxicity data are available, step 4 is conducted and cancer risk estimates and noncancer estimates (also referred to as hazard estimates) are determined for each COPC for each complete exposure pathway. Risk/hazard estimates for each chemical are summed for each receptor to determine the cumulative potential health threat to a potential receptor exposed to site-related contamination (i.e., risk characterization). The risk characterization step also includes an evaluation of the uncertainties associated with steps 1 through 4, including a qualitative description of the inherent and site-specific uncertainties in the HHRA. The uncertainty evaluation also discusses the potential effects on the risk estimates; i.e., the risks may be over- or under-estimated, depending on the uncertainties in the HHRA.

1.7 ORGANIZATION OF THE RISK ASSESSMENT

1.7.0.1 This report consists of seven sections, including this introduction, and three appendices.

- Section 2 presents the data evaluation, summarizes the analytical results, summarizes the results of the statistical calculations (including the derivation of exposure-point concentrations), and presents the results of the risk-based concentration screening.
- Section 3 presents the human health exposure assessment.
- Section 4 presents the toxicity assessment.
- Section 5 provides the method to characterize potential human health risks, including a qualitative analysis of the uncertainties in the HHRA process.
- Section 6 presents the conclusions of the HHRA.
- Section 7 lists references cited in this report.
- Appendix A presents the 2011 HHRA
- Appendix B presents data summary tables.
- Appendix C presents the ProUCL input and output.
- Appendix D presents the risk characterization tables.
- Appendix E presents the validated data of soil remaining at the site in area 4 and the surrounding grids.

SECTION 2
DATA EVALUATION AND IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

2.0.0.1 The first step of the HHRA process involves a review of the available site data that can be used in the HHRA. This step includes:

- Data gathering;
- Development of data sets for potentially complete exposure pathways (performed in conjunction with the human health exposure assessment – discussed in Section 3 of this report); and
- Identification of COPCs to be included in the HHRA.

2.0.0.2 The section below describes the process for evaluating site data, developing the data set used in the HHRA, and presents the specific COPCs evaluated in the HHRA.

2.1 SUMMARY OF CURRENT HHRA DATA

2.1.0.1 4825 Glenbrook Road is a private residential parcel of approximately 0.4 acres located within OU-3 of the SVFUDS. Over the years, numerous investigations have been performed at the 4825 Glenbrook Road property, at different times, by different parties, and with different sampling objectives and analytical parameters. These efforts include:

- 1992, EMS (contracted by AU)
- 1995, USACE
- 1994, USEPA
- 1999, USEPA
- 2000-2019, USACE

2.1.0.2 All sample data from previous reports and investigations conducted at 4825 Glenbrook Road prior to the current remedial action are not included in this risk assessment data set. The soil sample data collected during the remedial action activities used in this HHRA is included in Appendix B.

2.1.0.3 The locations of the samples included in the current HHRA data set are shown in Figures 2-1, 2-2 and 2-3. Figure 2-4 depicts the three Engineering Control Structure (ECS) locations for reference.

2.1.0.4 A total of 149 confirmation soil samples were collected during the remedial activities, including field duplicate quality control (QC) samples, that are representative of the soil still in place at 4825 Glenbrook Road. (Table 2-1)

- Seventy-nine (79) original confirmation soil samples were collected from the former high and low probability areas after the areas were excavated down to competent saprolite or a site boundary wall was reached. Combat Capabilities Development Command – Chemical Biological Center (CCDC) analyzed the samples for chemical agents (i.e., mustard agent and lewisite) and agent

breakdown products (ABPs) (e.g., 1,4-dithiane and 1,4-oxathiane). Once CCDC determined the samples were clear

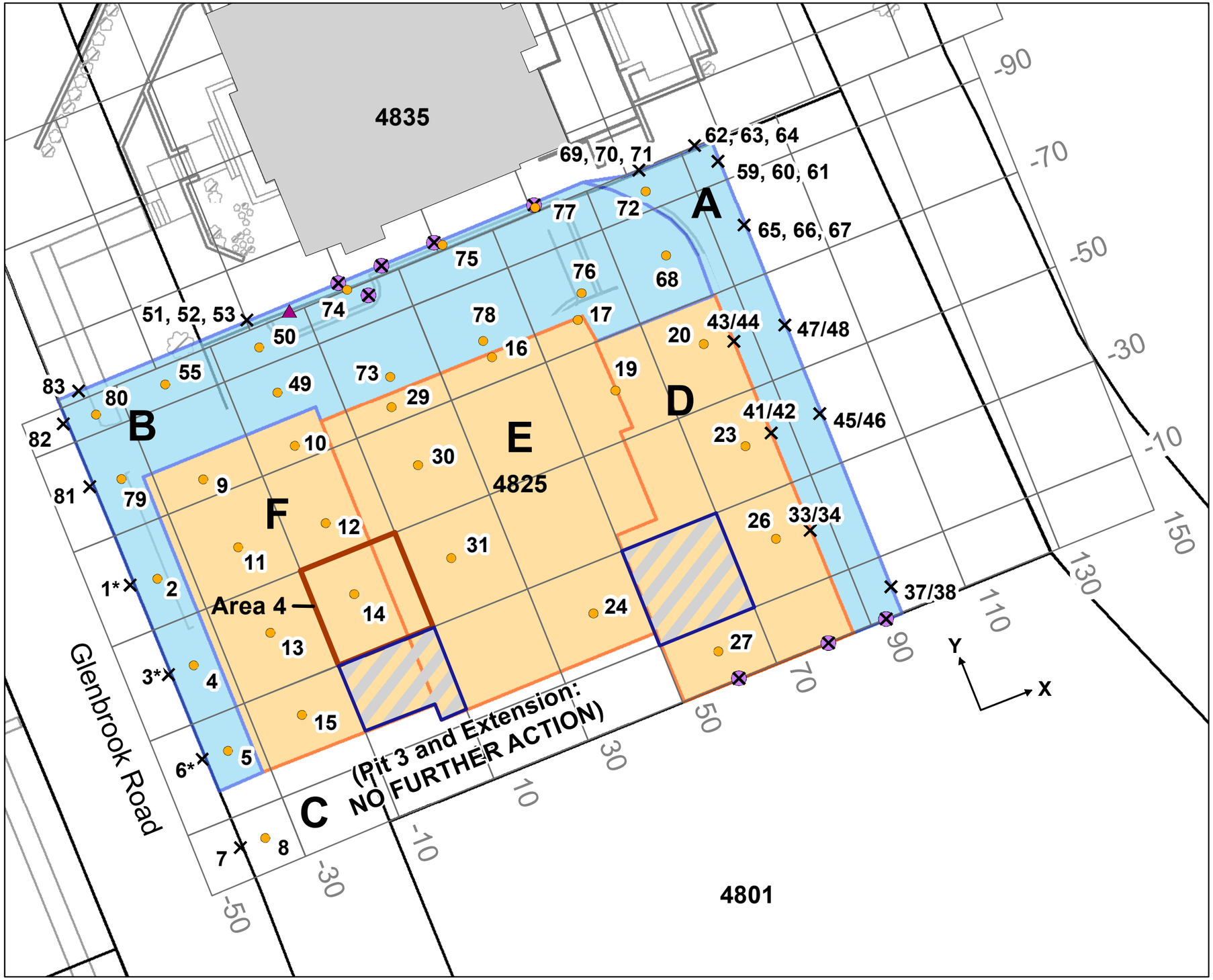

Figure 2-1
Original Confirmation/Grab Samples
Still in Place

4825 Glenbrook Road
Spring Valley, Washington, D.C.

Legend

- Floor Sample
- Sidewall Confirmation Sample
- Grab 1 and 2
- No Sidewall to Sample
- Bedrock Refusal
- Buildings
- Property Boundaries
- 20' Grid
- Grid -10,-30 – Area 4

Excavated Areas

- High-Probability
- Low-Probability

0 10 20 40 Feet

1 inch = 20 feet

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Date:	7/29/2019
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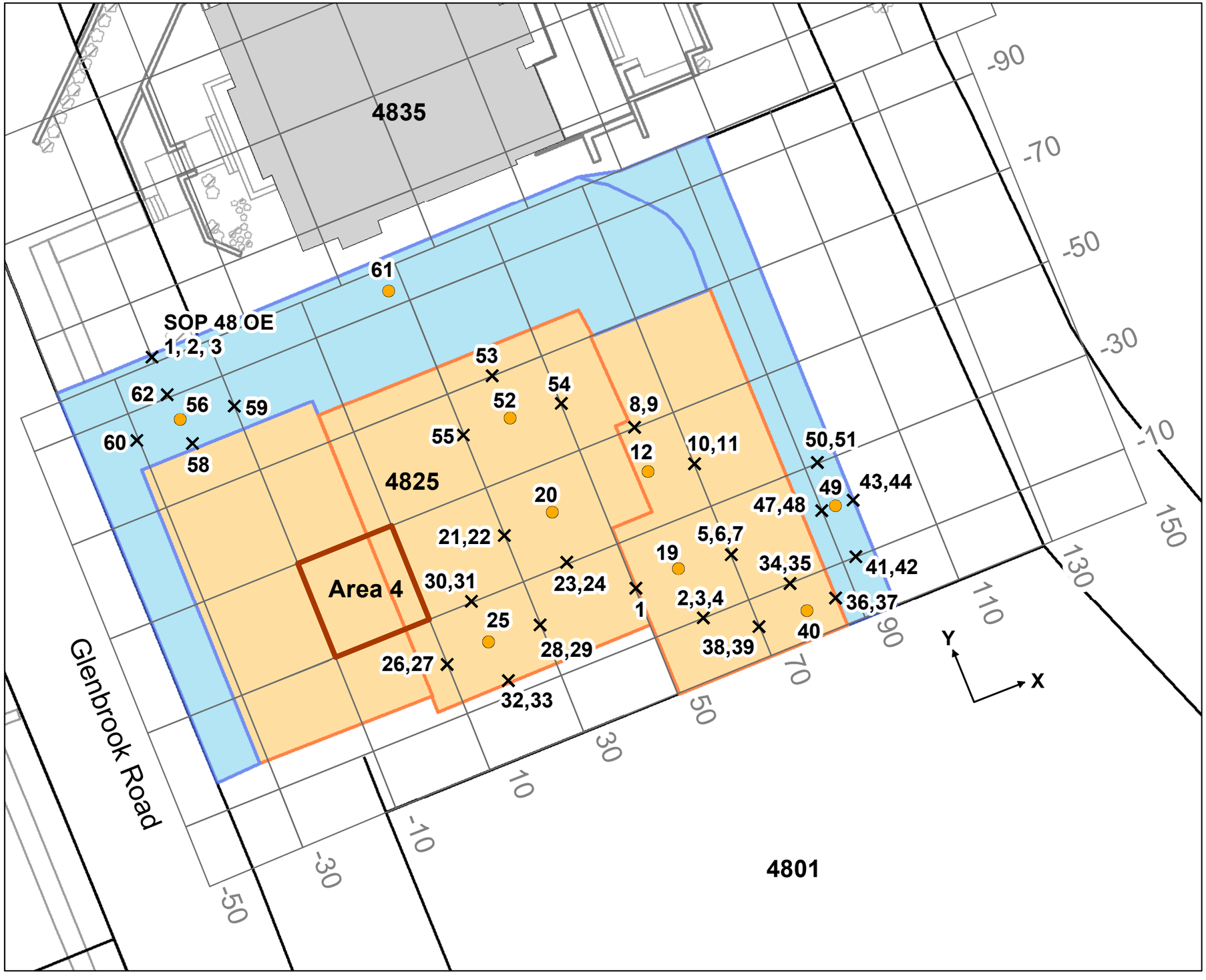

Figure 2-2
HTW Confirmation Samples
Still in Place

4825 Glenbrook Road
Spring Valley, Washington, D.C.

Legend

- Floor Sample Location
- Sidewall Confirmation Sample Location
- Buildings-Structures
- Property Boundaries
- 20' Grid
- Grid -10,-30 – Area 4

Excavated Areas

- Low-Probability
- High-Probability

0 10 20 40 Feet

1 inch = 20 feet

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Date:	7/24/2019
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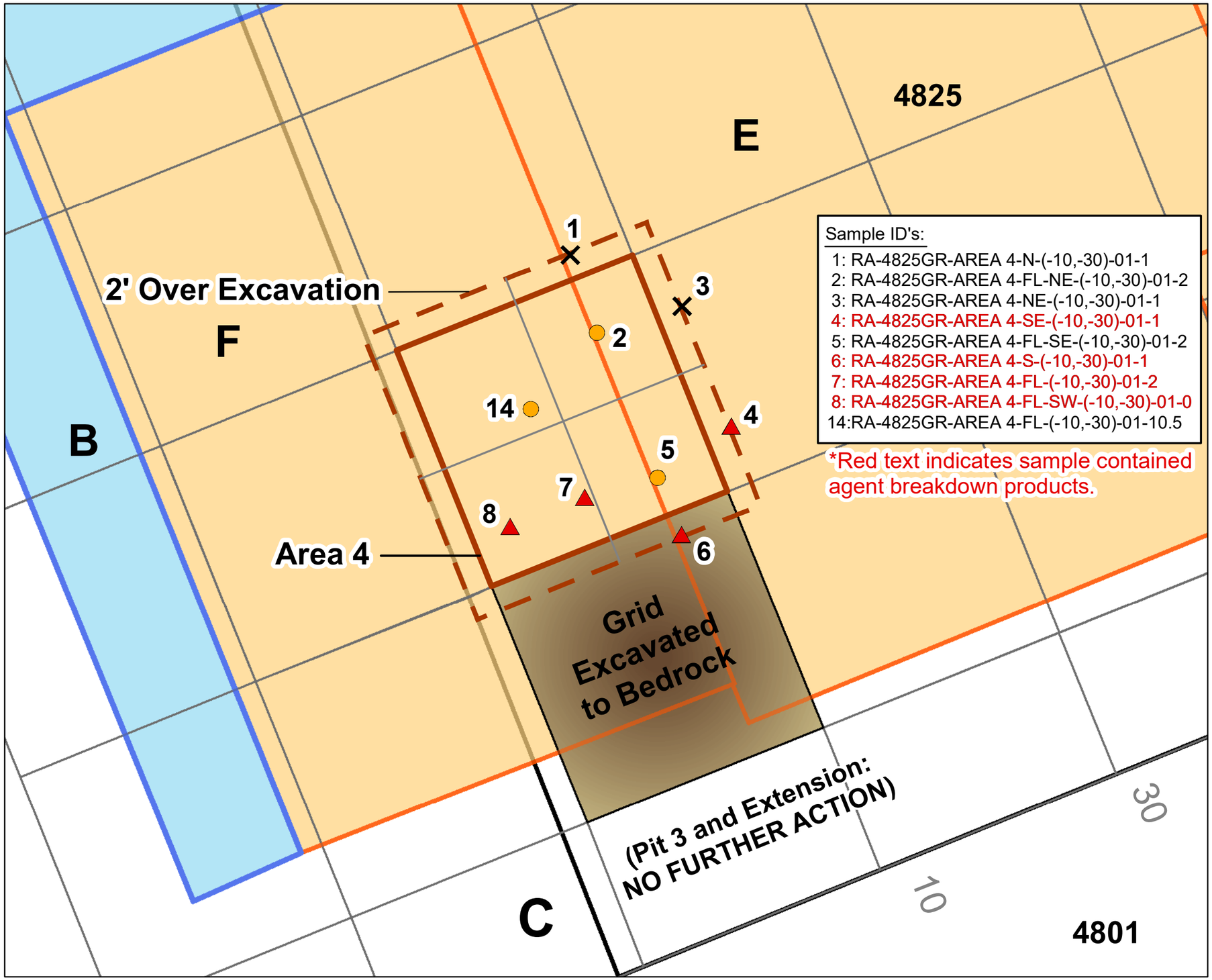

Figure 2-3
Confirmation/Grab Samples
Still in Place in Area 4 (Grid-10,-30)

4825 Glenbrook Road
Spring Valley, Washington, D.C.

Legend

- Floor Sample Location
- Wall Sample Location
- Sample Contained Agent Breakdown Product(s)
- Property Boundaries
- 20' Grid
- Grid -10,-30 – Area 4

Excavated Areas

- High-Probability
- Low-Probability

0 4 8 16 Feet

1 inch = 8 feet

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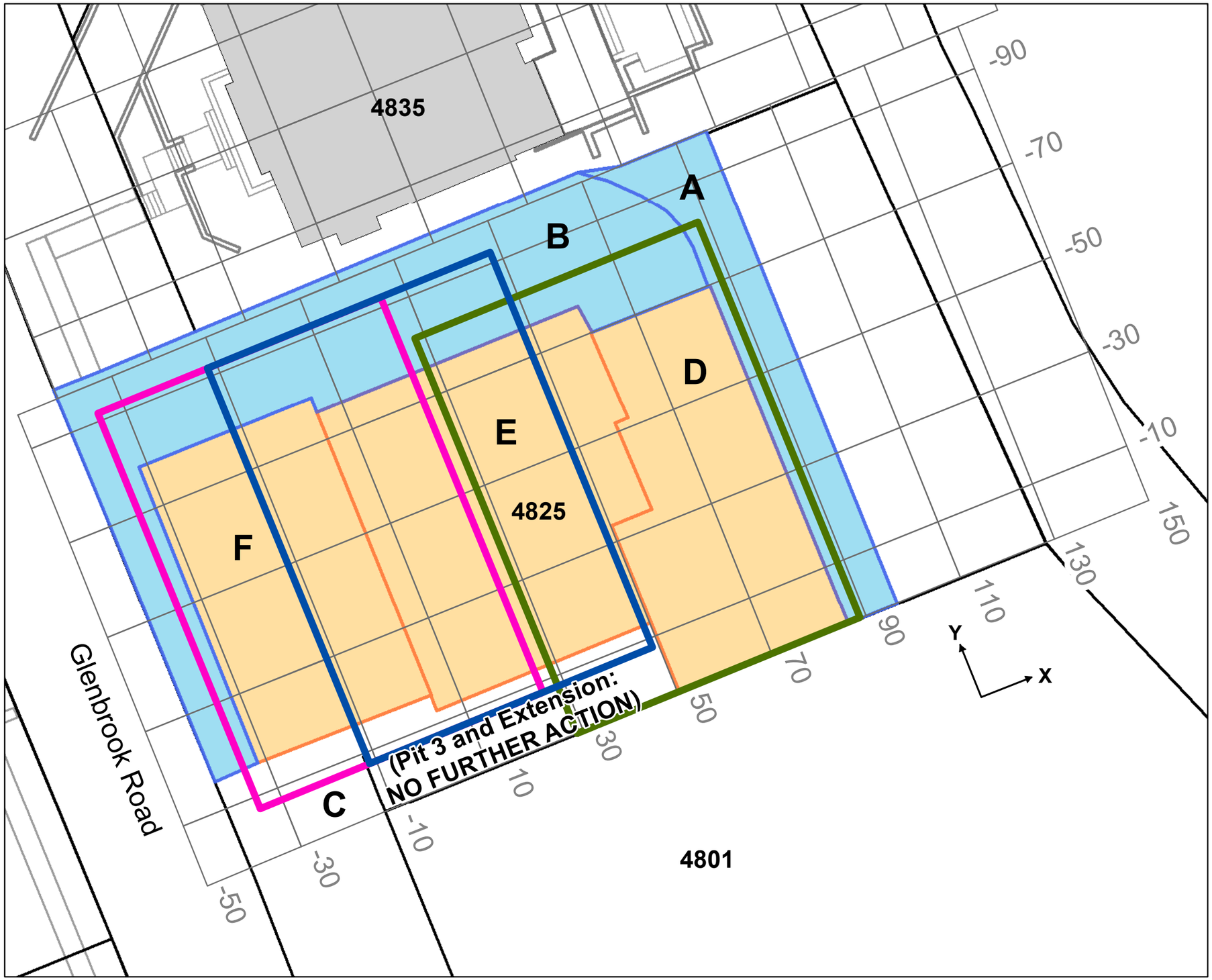

Figure 2-4
Former ECS Locations

4825 Glenbrook Road
Spring Valley, Washington, D.C.

Legend

- Buildings-Structures
- Property Boundaries
- 20' Grid

ECS Tent Locations

- 1st Tent Location
- 2nd Tent Location
- 3rd Tent Location

Excavated Areas

- Low-Probability
- High-Probability

0 10 20 40 Feet

1 inch = 20 feet

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Date:	11/6/2019
Figure Number:	2-4
Page Number:	2-6

Table 2-1: 4825 Glenbrook Road Risk Evaluation - Confirmation Samples Still In Place

Figure ID	General Location	Sample ID	Date Collected	Shallow/Mid/Deep
1	Front Yard	RA-4825GR-WW-(-50,-50)-01-0.25	02/11/2013	S
1	Front Yard	RA-4825GR-WW-(-50,-50)-02-1.75	02/11/2013	S
2	Front Yard	RA-4825GR-FL-(-50,-50)-01-2.25	02/11/2013	M
3	Front Yard	RA-4825GR-WW-(-50,-30)-01-0.25	02/11/2013	S
3	Front Yard	RA-4825GR-WW-(-50,-30)-02-0.75	02/11/2013	S
4	Front Yard	RA-4825GR-FL-(-50,-30)-01-1.25	02/11/2013	S
5	Front Yard	RA-4825GR-FL-(-50,-10)-01-1.5	02/11/2013	S
6	Front Yard	RA-4825GR-WW-(-50,-10)-01-0.25	02/11/2013	S
6	Front Yard	RA-4825GR-WW-(-50,-10)-02-1.0	02/11/2013	S
7	Front Yard	RA-4825GR-WW-(-50,10)-01-0.25	02/11/2013	S
8	Front Yard	RA-4825GR-FL-(-50,10)-01-0.50	02/11/2013	S
9	Tent 1	RA-4825GR-FL-(-30,-70)-01-7.3	07/31/2014	M
10	Tent 1	RA-4825GR-FL-(-10,-70)-01-13.9	07/31/2014	D
11	Tent 1	RA-4825GR-FL-(-30,-50)-01-6.11	07/31/2014	M
12	Tent 1	RA-4825GR-FL-(-10,-50)-01-11.5	07/31/2014	M
13	Tent 1	RA-4825GR-FL-(-30,-30)-01-4.75	07/31/2014	M
14	Tent 1/Area 4	RA-4825GR-FL-(-10,-30)-01-10.5	07/31/2014	M
15	Tent 1	RA-4825GR-FL-(-30,-10)-01-6.1	07/31/2014	M
16	Tent 2	RA-4825GR-FL-(30,-70)-01-4.0	09/16/2015	M
16 FD	Tent 2	RA-4825GR-FL-(32,-72)-01-2.0	09/16/2015	M
17	Tent 2	RA-4825GR-FL-(50,-70)-01-4.0	09/16/2015	M
19	Tent 2	RA-4825GR-FL-(50,-50)-01-8.0	10/19/2015	M
20	Tent 2	RA-4825GR-FL-(70,-50)-01-2.0	10/19/2015	M
23	Tent 2	RA-4825GR-FL-(70,-30)-01-5.0	10/19/2015	M
24	Tent 2	RA-4825GR-FL-(30,-10)-01-6.0	10/19/2015	M
26	Tent 2	RA-4825GR-FL-(70,-10)-01-11.0	10/19/2015	M
27	Tent 2	RA-4825GR-FL-(50,10)-01-21.0	10/19/2015	D
29	Tent 3	RA-4825GR-FL-(10,-70)-01-4.9	05/18/2016	M
30	Tent 3	RA-4825GR-FL-(10,-50)-01-4.8	05/18/2016	M
30 FD	Tent 3	RA-4825GR-FL-(10,-50)-02-4.8	05/18/2016	M
31	Tent 3	RA-4825GR-FL-(10,-30)-01-5.1	05/18/2016	M
33	Area A (70,-10)	RA-4825GR-AREA A-E-(70,-10)-01-0.5	10/17/2016	M
34	Area A (70,-10)	RA-4825GR-AREA A-E-(70,-10)-02-0.5	10/17/2016	M
37	Area A (90,10)	RA-4825GR-AREA A-E-(90,10)-01-0.5	10/17/2016	M
38	Area A (90,10)	RA-4825GR-AREA A-E-(90,10)-02-0.5	10/17/2016	S
38 FD	Area A (90,10)	RA-4825GR-AREA A-E-(90,10)-03-06	10/17/2016	S
41	Area A (70,-30)	RA-4825GR-AREA A-E-(70,-30)-01-0.5	10/24/2016	M
42	Area A (70,-30)	RA-4825GR-AREA A-E-(70,-30)-02-0.5	10/24/2016	S
43	Area A (70,-50)	RA-4825GR-AREA A-E-(70,-50)-01-0.5	10/24/2016	M
44	Area A (70,-50)	RA-4825GR-AREA A-E-(70,-50)-02-0.5	10/24/2016	S
45	Area A (90,-30)	RA-4825GR-AREA A-E-(90,-30)-01-0.5	10/24/2016	M
46	Area A (90,-30)	RA-4825GR-AREA A-E-(90,-30)-02-0.5	10/24/2016	S
47	Area A (90,-50)	RA-4825GR-AREA A-E-(90,-50)-01-0.5	10/24/2016	M
48	Area A (90,-50)	RA-4825GR-AREA A-E-(90,-50)-02-0.5	10/24/2016	S
48 FD	Area A (90,-50)	RA-4825GR-AREA A-E-(90,-50)-03-0.6	10/24/2016	S
49	Area B (-10,-70)	RA-4825GR-FL-(-10,-70)-01-6.8	03/02/2017	M
50	Area B (-10,-90)	RA-4825GR-FL-(-10,-90)-01-9.1	03/02/2017	M
51	Area B (-10,-90)	RA-4825GR-AREA B-N-(-10,-90)-01-8.3	03/02/2017	M
52	Area B (-10,-90)	RA-4825GR-AREA B-N-(-10,-90)-02-4.1	03/02/2017	M
53	Area B (-10,-90)	RA-4825GR-AREA B-N-(-10,-90)-03-0.6	03/02/2017	S
55	Area B (-30,-90)	RA-4825GR-FL-(-30,-90)-01-6.1	03/02/2017	M
59	Area A/E (90,-90)	RA-4825GR-AREA A-E-(90,-90)-01-0.5	02/26/2019	S
60	Area A/E (90,-90)	RA-4825GR-AREA A-E-(90,-90)-02-6.5	02/26/2019	M

Table 2-1: 4825 Glenbrook Road Risk Evaluation - Confirmation Samples Still In Place

Figure ID	General Location	Sample ID	Date Collected	Shallow/Mid/Deep
61	Area A/E (90,-90)	RA-4825GR-AREA A-E-(90,-90)-03-12.5	02/26/2019	D
62	Area A/E (90,-90)	RA-4825GR-AREA A-N-(90,-90)-01-0.5	02/26/2019	S
63	Area A/E (90,-90)	RA-4825GR-AREA A-N-(90,-90)-02-6	02/26/2019	M
64	Area A/E (90,-90)	RA-4825GR-AREA A-N-(90,-90)-03-11.5	02/26/2019	M
65	Area A/E (90,-70)	RA-4825GR-AREA A-E-(90,-70)-01-0.5	02/26/2019	S
66	Area A/E (90,-70)	RA-4825GR-AREA A-E-(90,-70)-02-3	02/26/2019	M
67	Area A/E (90,-70)	RA-4825GR-AREA A-E-(90,-70)-03-5.5	02/26/2019	M
68	Area B (70,-70)	RA-4825GR-AREA B-FL-(70,-70)-01-9	02/26/2019	M
68 FD	Area B (70,-70)	RA-4825GR-AREA B-FL-(70,-70)-02-9	02/26/2019	M
69	Area A (70,-90)	RA-4825GR-AREA A-N-(70,-90)-01-0.5	02/26/2019	S
70	Area A (70,-90)	RA-4825GR-AREA A-N-(70,-90)-02-4.5	02/26/2019	M
71	Area A (70,-90)	RA-4825GR-AREA A-N-(70,-90)-03-8.5	02/26/2019	M
72	Area A (70,-90)	RA-4825GR-AREA B-FL-(70,-90)-01-9	02/26/2019	M
73	Area B (10,-70)	RA-4825GR-AREA B-FL-(10,-70)-01-3	05/09/2019	M
74	Area B (10,-90)	RA-4825GR-AREA B-FL-(10,-90)-01-3	05/09/2019	M
75	Area B (30,-90)	RA-4825GR-AREA B-FL-(30,-90)-01-3	05/09/2019	M
76	Area B (50,-70)	RA-4825GR-AREA B-FL-(50,-70)-01-2.7	05/09/2019	M
77	Area B (50,-90)	RA-4825GR-AREA B-FL-(50,-90)-01-2.5	05/09/2019	M
78	Area B (30,-70)	RA-4825GR-AREA B-FL-(30,-70)-01-2	05/15/2019	S
79	Area B (-50,-70)	RA-4825GR-AREA B-FL-(-50,-70)-01-1	05/15/2019	S
80	Area B (-50,-90)	RA-4825GR-AREA B-FL-(-50,-90)-01-1.5	05/15/2019	S
80 FD	Area B (-50,-90)	RA-4825GR-AREA B-FL-(-50,-90)-02-1.5	05/15/2019	S
81	Area B (-50,-70)	RA-4825GR-AREA B-W-(-50,-70)-01-0.5	05/15/2019	S
82	Area B (-50,-90)	RA-4825GR-AREA B-W-(-50,-90)-01-0.5	05/15/2019	S
83	Area B (-50,-90)	RA-4825GR-AREA B-N-(-50,-90)-01-0.5	05/15/2019	S
83 FD	Area B (-50,-90)	RA-4825GR-AREA B-N-(-50,-90)-02-0.5	05/15/2019	S
AREA 4 GRAB 7	Area 4 (-10,-30)	RA-4825GR-AREA 4-FL-(-10,-30)-01-2	04/29/2019	M
AREA 4 GRAB 2	Area 4 (-10,-30)	RA-4825GR-AREA 4-FL-NE-(-10,-30)-01-2	04/29/2019	M
AREA 4 GRAB 5	Area 4 (-10,-30)	RA-4825GR-AREA 4-FL-SE-(-10,-30)-01-2	04/29/2019	M
AREA 4 GRAB 8	Area 4 (-10,-30)	RA-4825GR-AREA 4-FL-SW-(-10,-30)-01-0	04/29/2019	M
AREA 4 GRAB 1	Area 4 (-10,-30)	RA-4825GR-AREA 4-N-(-10,-30)-01-1	04/29/2019	M
AREA 4 GRAB 3	Area 4 (-10,-30)	RA-4825GR-AREA 4-NE-(-10,-30)-01-1	04/29/2019	M
AREA 4 GRAB 6	Area 4 (-10,-30)	RA-4825GR-AREA 4-S-(-10,-30)-01-1	04/29/2019	M
AREA 4 GRAB 4	Area 4 (-10,-30)	RA-4825GR-AREA 4-SE-(-10,-30)-01-1	04/29/2019	M
HTW 1 (W)	50,-10	RA-4825GR-AREA D-W-(50,-10)-01-0.6	04/23/2018	D
HTW 2	50,-10	RA-4825GR-AREA D-S-(50,-10)-01-0.6	04/23/2018	D
HTW 3	50,-10	RA-4825GR-AREA D-S-(50,-10)-02-4	04/23/2018	D
HTW 4	50,-10	RA-4825GR-AREA D-S-(50,-10)-03-0.6	04/23/2018	D
HTW 5	50,-10	RA-4825GR-AREA D-E-(50,-10)-01-0.6	04/23/2018	D
HTW 6	50,-10	RA-4825GR-AREA D-E-(50,-10)-02-2.8	04/23/2018	D
HTW 7	50,-10	RA-4825GR-AREA D-E-(50,-10)-03-0.6	04/23/2018	D
HTW 8	50,-30	RA-4825GR-AREA D-E-N-(50,-30)-01	04/26/2018	M
HTW 9	50,-30	RA-4825GR-AREA D-E-N-(50,-30)-02	04/26/2018	M
HTW 10	50,-30	RA-4825GR-AREA D-E-E-(50,-30)-01	04/26/2018	M
HTW 11	50,-30	RA-4825GR-AREA D-E-E-(50,-30)-02	04/26/2018	M
HTW 12	50,-30	RA-4825GR-FL-(50,-30)-01	04/26/2018	M
HTW 19	50,-10	RA-4825GR-FL-(50, -10)-01-10	05/16/2018	D
HTW 20	30,-30	RA-4825GR-FL-(30,-30)-03-1	05/24/2018	M
HTW 20 FD	30,-30	RA-4825GR-FL-(30,-30)-04-1	05/24/2018	M
HTW 21	30,-30	RA-4825GR-AREA E-W-(30,-30)-01-1	05/24/2018	M
HTW 22	30,-30	RA-4825GR-AREA E-W-(30,-30)-02-1	05/24/2018	M
HTW 23	30,-30	RA-4825GR-AREA E-S-(30,-30)-01-1	05/24/2018	M
HTW 24	30,-30	RA-4825GR-AREA E-S-(30,-30)-02-1	05/24/2018	M

Table 2-1: 4825 Glenbrook Road Risk Evaluation - Confirmation Samples Still In Place

Figure ID	General Location	Sample ID	Date Collected	Shallow/Mid/Deep
HTW 25	10,-10	RA-4825GR-FL-(10,-10)-01	06/20/2018	M
HTW 26	10,-10	RA-4825GR-AREA E-W-(10,-10)-01	06/20/2018	M
HTW 27	10,-10	RA-4825GR-AREA E-W-(10,-10)-02	06/20/2018	M
HTW 28	10,-10	RA-4825GR-AREA E-E-(10,-10)-01	06/20/2018	M
HTW 29	10,-10	RA-4825GR-AREA E-E-(10,-10)-02	06/20/2018	M
HTW 30	10,-10	RA-4825GR-AREA E-N-(10,-10)-01	06/20/2018	M
HTW 31	10,-10	RA-4825GR-AREA E-N-(10,-10)-02	06/20/2018	M
HTW 32	10,-10	RA-4825GR-AREA E-S-(10,-10)-01	06/20/2018	M
HTW 33	10,-10	RA-4825GR-AREA E-S-(10,-10)-02	06/20/2018	M
HTW 34	Area D and A (70,10)	RA-4825GR-AREA D-N -(70,10)-01	07/12/2018	M
HTW 35	Area D and A (70,10)	RA-4825GR-AREA D-N -(70,10)-02	07/12/2018	M
HTW 36	Area D and A (70,10)	RA-4825GR-AREA D-E-(70,10)-01	07/12/2018	M
HTW 37	Area D and A (70,10)	RA-4825GR-AREA D-E-(70,10)-02	07/12/2018	M
HTW 38	Area D and A (70,10)	RA-4825GR-AREA D-W-(70,10)-01	07/12/2018	M
HTW 39	Area D and A (70,10)	RA-4825GR-AREA D-W-(70,10)-02	07/12/2018	M
HTW 40	Area D and A (70,10)	RA-4825GR-FL-(70,10)-01	07/12/2018	M
HTW 40 FD	Area D and A (70,10)	RA-4825GR-FL-(70,10)-05	07/12/2018	M
HTW 41	Area A (90,-10)	RA-4825GR-AREA A-S-(90,-10)-01	07/17/2018	M
HTW 42	Area A (90,-10)	RA-4825GR-AREA A-S-(90,-10)-02	07/17/2018	M
HTW 43	Area A (90,-10)	RA-4825GR-AREA A-E-(90,-10)-01	07/17/2018	M
HTW 44	Area A (90,-10)	RA-4825GR-AREA A-E-(90,-10)-02	07/17/2018	M
HTW 47	Area A (90,-10)	RA-4825GR-AREA A-W-(90,-10)-01	07/17/2018	M
HTW 48	Area A (90,-10)	RA-4825GR-AREA A-W-(90,-10)-02	07/17/2018	M
HTW 49	Area A (90,-10)	RA-4825GR-FL-(90,-10)-01	07/17/2018	M
HTW 49 FD	Area A (90,-10)	RA-4825GR-FL-(90,-10)-06	07/17/2018	M
HTW 50	Area A (90,-10)	RA-4825GR-AREA A-N-(90,-10)-01-1	07/25/2018	M
HTW 51	Area A (90,-10)	RA-4825GR-AREA A-N-(90,-10)-02-1	07/25/2018	M
HTW 52	Tent 2	RA-4825GR-FL-(30,-50)-02-8.0	06/04/2019	M
HTW 53	Tent 2	RA-4825GR-AREA E-N-(30,-50)-01-7.0	06/04/2019	M
HTW 54	Tent 2	RA-4825GR-AREA E-E-(30,-50)-01-7.0	06/04/2019	M
HTW 55	Tent 2	RA-4825GR-AREA E-W-(30,-50)-01-7.0	06/04/2019	M
HTW 56	Area B (-30,-70)	RA-4825GR-FL-(-30,-70)-02-8.4	06/10/2019	M
HTW 58	Area B (-30,-70)	RA-4825GR-AREA B-S-(-30,-70)-01-6.9	06/10/2019	M
HTW 59	Area B (-30,-70)	RA-4825GR-AREA B-E-(-30,-70)-01-6.9	06/10/2019	M
HTW 60	Area B (-30,-70)	RA-4825GR-AREA B-W-(-30,-70)-01-6.9	06/10/2019	M
HTW 61	Area B (10,-90)	RA-4825GR-FL-(10,-90)-02-8.0	06/12/2019	M
HTW 62	Area B (-30,-70)	RA-4825GR-AREA B-N-(-30,-70)-02-6.9	06/25/2019	M
SOP 48 OE 1	Area B (-30,-90)	RA-4825GR-AREA B-N-(-30,-90)-04-5.4	03/06/2019	M
SOP 48 OE 2	Area B (-30,-90)	RA-4825GR-AREA B-N-(-30,-90)-05-2.7	03/06/2019	M
SOP 48 OE 3	Area B (-30,-90)	RA-4825GR-AREA B-N-(-30,-90)-06-0.6	03/06/2019	S
SOP 48 OE 3 FD	Area B (-30,-90)	RA-4825GR-AREA B-N-(-30,-90)-07-0.6	03/06/2019	S
GRAB 1	Area B (-10,-90)	RA-4825GR-AREA B-N-(-10,-90)-GRAB 1	7/26/2019	M
GRAB 2	Area B (-10,-90)	RA-4825GR-AREA B-N-(-10,-90)-GRAB 2	7/26/2019	M

of chemical agent and ABPs, these samples were sent to a commercial lab and analyzed for the confirmation sample parameters listed in the Site-Specific Work Plan (SSWP) (USACE 2017). Confirmation sample parameters include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), explosives, metals, pesticides, polychlorinated biphenyls (PCBs), cyanide, fluoride, iodine, and perchlorate.

- Sixty (60) HTW confirmation soil samples were collected after the over excavation of HTW-contaminated soil. These samples were analyzed for only the analyte(s) that exceeded the comparison values in the original corresponding confirmation sample results or preceding HTW confirmation samples if certain analytes continued to exceed the comparison values after each iteration of over excavation. These analytes included aluminum, antimony, arsenic, cobalt, cyanide, manganese, nickel, thallium, and vanadium.
- Eight (8) grab samples were collected on April 29, 2019 from area 4 (grid -10, -30) to identify the cause of several Miniature Continuous Air Monitoring System (MINICAMS) alarms for lewisite that occurred the week of March 25, 2019. CCDC analyzed the samples for chemical agents (i.e., mustard agent and lewisite) and ABPs (e.g., 1,4-dithiane and 1,4-oxathiane). Four samples contained mustard ABPs as depicted in Figure 2-3. The concentrations of the mustard ABPs in all four of the samples were below the residential comparison values in the SSWP. One commercial lab agreed to accept these four samples and analyzed them for the grab sample parameters listed in the SSWP. Grab sample parameters are the same as confirmation sample parameters and include VOCs, SVOCs, explosives, metals, pesticides, PCBs, cyanide, fluoride, iodine and perchlorate. The remaining four samples that were clear of chemical agent and ABPs were sent to a commercial lab and analyzed for the grab sample parameters listed above and in the SSWP.
- Two (2) grab samples were collected from the north wall of grid -10, -90 on July 26, 2019 after an intact container fell from a ledge of soil while the area was being over excavated for arsenic exceeding 20 mg/kg on July 22, 2019. CCDC analyzed the samples for chemical agents (i.e., mustard agent and lewisite) and ABPs (e.g., 1,4-dithiane and 1,4-oxathiane). Once CCDC determined the samples were clear of chemical agent and ABPs, these samples were sent to a commercial lab and were analyzed for the grab sample parameters listed above and in the SSWP. The results from these two samples were included in the HHRA. Additionally, the results of the three original confirmation samples collected from the north wall of grid -10, -90 were also included in this HHRA since over excavation was not completed due to the intact container being discovered.

2.1.0.5 Each of the 149 soil samples included in this HHRA data set were sorted into one of three different depth ranges corresponding to different exposure scenarios. These depths represent the depth below the original ground surface (before any excavation activities occurred) that the sample was collected from:

- Shallow: 0-2 ft bgs, defined as surface soil, represents non-intrusive activities (i.e. routine landscaping);
- Mid: 2-12 ft bgs, defined as subsurface soil, represents excavation activities such as construction and utility work; and
- Deep: >12 ft bgs, defined as deep soil, represents depths at which direct contact is not expected. Three original confirmation samples and eight HTW confirmation samples were identified as deeper than 12 feet bgs.

2.1.0.6 15 original confirmation samples (samples collected after high and low probability areas were excavated down to competent saprolite or a site boundary wall was reached) and 11 HTW confirmation samples (samples collected after over excavation was conducted) were considered obsolete after over excavation was conducted in the corresponding sample locations. These samples were not included in the current HHRA data set because they are not representative of the remaining soil still in place at 4825 Glenbrook Road.

2.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

2.2.0.1 Data from the 149 samples representative of soils remaining in place at the site (Table 2-1) were screened to identify COPCs in soils:

- The maximum detected concentration of each chemical was compared to the comparison criteria established in the SSWP (USACE 2017). Only chemicals detected at concentrations that exceeded the comparison criteria were retained as COPCs.
- Additionally, the 95 percent Upper Confidence Limit (UCL) of the mean (95% UCL) of thallium (1.7 mg/kg for surface soil and 1.5 mg/kg for combined surface and subsurface soil) is less than the background Upper Tolerance Limit (UTL) (2.2 mg/kg), which was not statistically derived, but rather was set at the reporting limit of the background data set, due to the high percentage of non-detects in the background data set for thallium. Therefore, thallium was not retained as a COPC.

2.2.0.2 The following eight (8) COPCs were identified in soil for quantitative evaluation:

- Aluminum;
- Antimony;
- Arsenic;
- Cobalt;
- Cyanide;
- Manganese;
- Nickel; and
- Vanadium.

2.3 STATISTICAL EVALUATION OF DATA

2.3.0.1 The 95% UCL of each COPC was used to estimate the concentration of a contaminant that a receptor could be exposed to over a length of time, the exposure point concentration (EPC). This EPC was then used to estimate risk. All UCLs were calculated using the latest version of ProUCL from USEPA (2015); i.e., ProUCL v5.1. Refer to the ProUCL User's and Technical Guides (USEPA 2015) for a detailed discussion of the statistical methods

used. Criteria for the selection of the computational method, as well as the formulae for the computational methods, are provided in USEPA (2002b, 2006, 2015) and are not repeated here. ProUCL uses the Kaplan-Meier method to account for non-detects in the calculation of UCLs (USEPA 2006, 2015).

2.3.0.2 The UCLs recommended by ProUCL were used as the EPCs for the Reasonable Maximum Exposure (RME) exposure scenario. The EPCs calculated using ProUCL are summarized in Tables 2-2 and 2-3. In the case where the 95% UCL was greater than the maximum detected concentration, the maximum detected concentration was used as the RME in accordance with USEPA guidance (USEPA 1989). The summary statistics and the detailed output from ProUCL are presented in Appendix C.

TABLE 2-2
SURFACE SOIL (0-2') EXPOSURE POINT CONCENTRATIONS
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

CAS Number	COPC	Maximum Detected Concentration (mg/kg)		UCL	Selected Exposure Point Concentration (mg/kg)		Source (Max or UCL)
Inorganics							
7429-90-5	Aluminum	60400		28820	28820		UCL
7440-36-0	Antimony	7.2		3.1	3.1		UCL
7440-38-2	Arsenic	42.8		9.3	9.3		UCL
7440-48-4	Cobalt	64.0	K	35.1	35.1		UCL
57-12-5	Cyanide	0.41	U	NC	0.41	U	Max
7439-96-5	Manganese	3720		1421	1421		UCL
7440-02-0	Nickel	152	L	93	93		UCL
7440-62-2	Vanadium	212	J	90	90		UCL

NOTES:
CAS = Chemical Abstracts Service number.
COPC = Chemical of potential concern.
J = estimated value
K = Matrix Spike High
L = Matrix Spike Low
Max = Maximum detected concentration, or maximum LOD if there were no detections.
NC = Not calculated because there were no detections.
U = not detected
UCL = Upper confidence limit.

TABLE 2-3
COMBINED SURFACE SOIL AND SUBSURFACE SOIL (0-12') EXPOSURE POINT CONCENTRATIONS
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

CAS Number	COPC	Maximum Detected Concentration (mg/kg)	UCL	Selected Exposure Point Concentration (mg/kg)	Source (Max or UCL)
Inorganics					
7429-90-5	Aluminum	75800	32269	32269	UCL
7440-36-0	Antimony	12.5	1.9	1.9	UCL
7440-38-2	Arsenic	130.0	19	19	UCL
7440-48-4	Cobalt	87.6	33.1	33.1	UCL
57-12-5	Cyanide	0.19	0.16	0.16	UCL
7439-96-5	Manganese	3720	1001	1001	UCL
7440-02-0	Nickel	212	85	85	UCL
7440-62-2	Vanadium	323	118	118	UCL

NOTES:
CAS = Chemical Abstracts Service number.
COPC = Chemical of potential concern.
Max = Maximum detected concentration, or maximum LOD if there were no detections.
UCL = Upper confidence limit.

SECTION 3
EXPOSURE ASSESSMENT

3.0.0.1 The objective of the exposure assessment is to estimate the type and magnitude of potential exposures to COPCs at the site. The exposure assessment includes identification of potential exposure pathways, receptors, and exposure scenarios, as well as quantification of exposure. Following USEPA (1989) guidance, exposure assessment is a three-step process involving characterization of the exposure setting, identification of exposure pathways, and quantification of exposure. To complete these three steps, it is important to 1) develop a CSM; 2) estimate the EPC; 3) determine exposure assumptions; and 4) quantitatively estimate exposure.

3.0.0.2 The following sections present the human health exposure assessment conducted for 4825 Glenbrook Road. It should be noted that this HHRA evaluates only assumed exposures to soil as indicated in the CSM (Figure 3-1).

3.1 CONCEPTUAL SITE MODEL

3.1.0.1 A CSM is an effective tool to define site dynamics, streamline the risk evaluation, and develop appropriate response actions. The CSM is the mechanism to identify complete exposure pathways between environmental media affected by site-related contamination and potential receptors.

3.1.0.2 The CSM (Figure 3-1) is intended to present and clarify assumptions regarding:

- Suspected sources and types of contaminants present;
- Contaminant release and transport mechanisms;
- Affected media (e.g., soil);
- Exposure or contact points with contaminated media at the site (e.g., direct contact with soil);
- Exposure routes for chemical intake by receptors at the site (e.g., dermal uptake); and
- Potential receptors that could contact site-related contaminants in affected media under current or future land use scenarios.

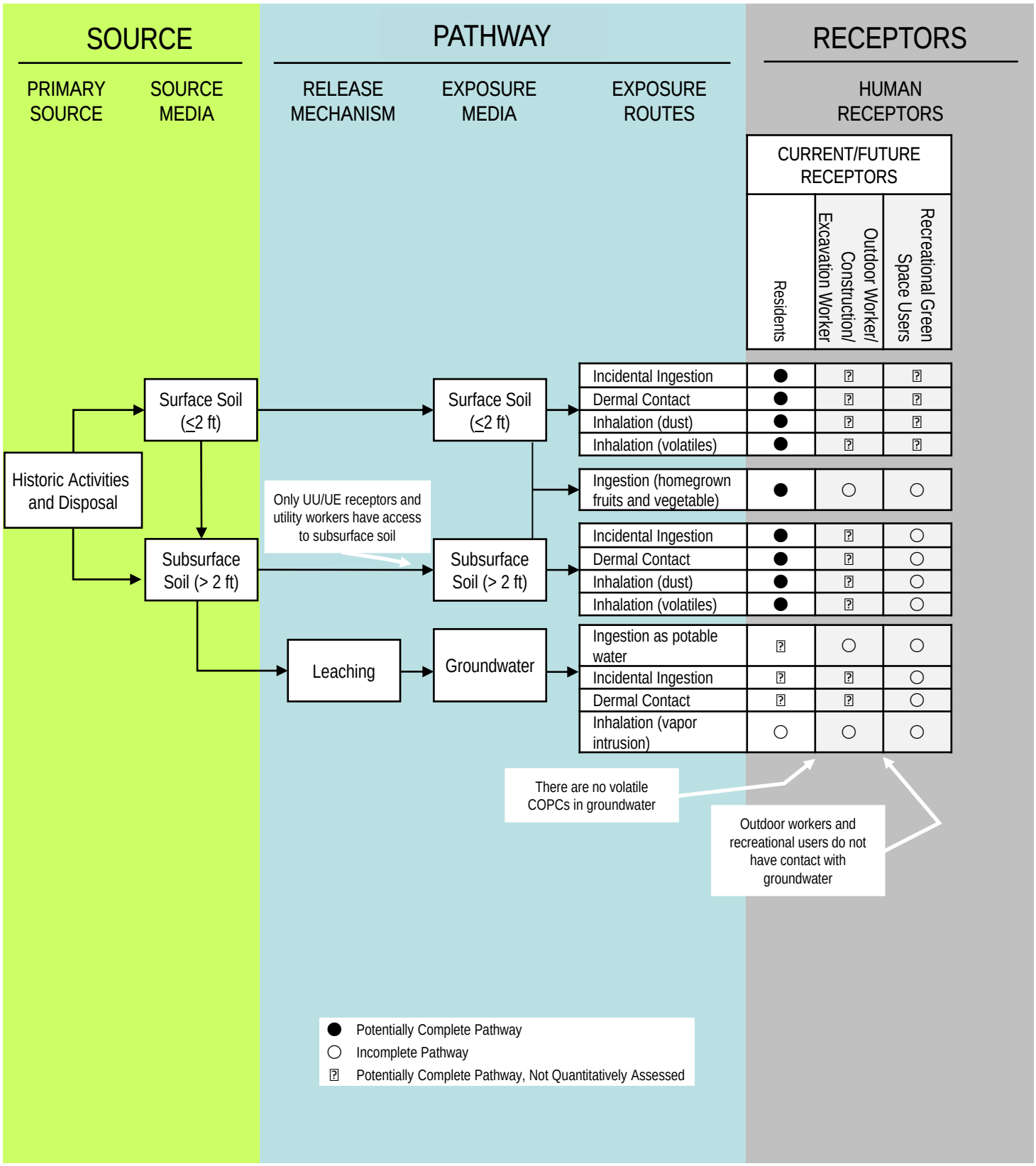
3.1.0.3 Designation of an exposure pathway as complete indicates that human exposure is possible but does not necessarily mean that exposure will occur, nor that exposure will occur at the levels estimated here. When any one of the factors listed above is missing in a pathway, it is considered to be incomplete. Incomplete exposure pathways do not pose a potential risk and were not evaluated in this risk assessment.

3.1.0.4 CSMs are dynamic tools that can be updated as necessary. For example, if changes in site conditions occur, or additional site characterization information is collected, the CSM can be revised to more accurately reflect the most current information. Understanding site conditions and land uses helps to accurately identify potential receptors under current and likely future scenarios, as well as the most appropriate corrective action(s), if necessary.

Figure 3-1
HUMAN HEALTH CONCEPTUAL SITE MODEL

Site Name: 4825 Glenbrook Road, Spring Valley, Washington D.C.

Completed By: RA Contractor ***Date Completed:*** October 7, 2019



3.1.0.5 In addition, a potential receptor evaluation considers criteria such as:

- Current and future land use on and near the site;
- Zoning status and/or deed restrictions of the site and adjacent properties;
- Current and future access to the site and to the affected media;
- Existing and/or planned exposure controls (e.g., engineered containment structures);
- Present and planned site activities;
- Extent that the site is developed and vegetated; and
- Potential for soils to be disturbed (e.g., excavation such as tree planting at the site, installation of a swimming pool, digging trenches for utility lines, etc.).

3.1.0.6 Potential human receptors are defined as individuals who may be exposed to site-related contaminants in environmental media at a site. Consistent with USEPA (1989, 1995a) guidance, current and reasonably anticipated land uses were considered in the receptor selection process.

3.1.0.7 Based on previous investigations (EMS 1992; USEPA 1994, 1999a, b, c; and USACE 1999, 2009) the potential human receptors that may reasonably be anticipated to be present at 4825 Glenbrook Road are as follows:

- **Current Receptors** – The 4825 Glenbrook Road property is a vacant residential property located between the former AU President's house and the Republic of South Korea Ambassador's residence. The site is currently fenced to restrict access. Only personnel under contract to USACE or their subcontractors visit the site to perform weekly inspections, including routine landscaping (outdoor worker).
- **Future Receptors –** 4825 Glenbrook Road is not currently used for residential purposes. However, a residential dwelling was located on the lot and the lot may be returned to residential use in the future. Therefore, the residential exposure scenario was evaluated here. Additionally, future receptors could include outdoor (landscaping) workers, as well as construction workers. A recreational green space (i.e., park) user is also possible because green space is a potential future use (the property could be converted to a community park area).

3.1.0.8 For purposes of this post-remedy risk assessment, only residents are further evaluated. As the most sensitive receptor, because of the length of exposure and the inclusion of children in the exposure assessment, the calculated risks would be greatest for a resident. Therefore, evaluation of residential risk is most appropriate for evaluation of the protectiveness of the excavation that has been accomplished at 4825 Glenbrook Road. While outdoor workers and green space users are also potential receptors at the site, the risk estimates for these receptors would be less than those for residents.

3.2 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS

3.2.0.1 EPCs are the concentrations of chemicals in a given medium to which a receptor may be exposed at a specific location known as the "exposure point." EPCs are estimated using a combination of available analytical data and fate and transport modeling data to represent the RME that is expected to occur at the site. EPCs are estimated using the 95% UCL on the mean as calculated by USEPA ProUCL. If there was an insufficient sample size to calculate a 95% UCL, the maximum detected concentration was kept as the EPC.

3.2.0.2 Table 2-1 presents results for all samples, including primary and duplicate samples. The "best value" sample result of all primary and duplicate results were used to determine the EPC. If both values represent detected concentrations, then the highest detected concentration (i.e., the most conservative) was considered the "best value" for use in the risk assessment. If one value represents a detected concentration and one value is qualified as not detected, then the detected value was considered the best value and was retained in the risk assessment. If both values are qualified as not detected, the lowest reported U flagged value was retained.

3.2.0.3 Surface soil EPCs were estimated from the analytical data collected from the exposure area for surface soil (0-≤2 feet bgs). Soil EPCs for the combined surface and subsurface soil were calculated by aggregating analytical data collected from the exposure area for combined surface and subsurface soil (0-≤12 feet bgs). Data points were included in the appropriate soil profile based on the depth that the sample was collected below the original soil surface. When the depth of the sample below original ground surface was uncertain, the assumptions erred on the side of shallower to be more conservative. Soil EPCs are shown in Tables 2-2 and 2-3. The anticipated exposures for each receptor are discussed in Section 3.3.0.4.

3.3 EXPOSURE PATHWAYS

3.3.0.1 USEPA (1989) defines an exposure pathway as: "The course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (*e.g.*, air) or media (in cases of intermedia transfer) is also included."

3.3.0.2 The potential soil exposure routes that are evaluated here are limited to those exposure pathways necessary for determining the effectiveness of the remedy (i.e., excavation). The exposure pathways evaluated include the following:

- Soils - direct contact pathways
    - Inhalation of volatiles
    - Incidental soil ingestion
    - Dermal contact with soil
    - Inhalation of particulates
    - Ingestion of home grown vegetables

3.3.0.3 Soils - direct contact pathways. For direct contact with soils, none of the identified COPCs (aluminum, antimony, arsenic, cobalt, cyanide, manganese, nickel, and vanadium) are classified by USEPA (1991c, 2019a) as volatiles; i.e., have a molecular weight of less than 200 g/mole and a Henry's law constant greater than 1 x 10^{-5} atm-m^3/mole. Therefore, inhalation of volatiles in ambient air at the site is an incomplete pathway and was not evaluated further.

3.3.0.4 Assumed exposures to two different soil depth intervals were evaluated for the receptors at the site. The future resident was evaluated using an exposure interval of 0 to 2 ft bgs, to represent routine landscaping and gardening activities. Additionally, future residents were evaluated for assumed exposures to mixed soil, 0 to 12 ft bgs. This depth interval takes into account soil mixing that may occur due to excavation activities (e.g., slope regrading, swimming pool installation, utility work).

3.3.0.5 Each of these exposure pathways is discussed in detail below.

3.4 QUANTIFICATION OF EXPOSURE

3.4.0.1 Human intake over a long-term exposure period, called the chronic daily intake (CDI), was calculated for each COPC. Intake is defined as "a measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time (e.g., mg chemical/kg body weight-day)" (USEPA 1989). The CDI also takes into account exposure variables (i.e., assumptions about patterns of exposure to contaminated media), and whether the chemical is a carcinogen or a noncarcinogen. The total exposure is divided by the time period of interest to obtain an average exposure over time. The averaging time is a function of the toxic endpoint; i.e., for carcinogenic effects, it is the lifetime of an individual but for noncarcinogenic effects, it is the exposure duration.

3.4.0.2 The following subsections provide the exposure equations for each of the exposure pathways evaluated in this HHRA. Appendix D provides the detailed calculations using these equations for each receptor.

3.4.1 Incidental Ingestion of Contaminants in Soil

3.4.1.1 To estimate an oral CDI for the incidental ingestion of COPCs in soil, the following equation (USEPA 1989) was used:

$$CDI = \frac{EPC \times IR \times FI \times EF \times ED \times CF}{BW \times AT}$$

Where:

CDI	=	Chronic daily intake (mg/kg-d)
EPC	=	Exposure point concentration in soil (mg/kg)
IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction ingested from contaminated source (unitless)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (yrs)
CF	=	Conversion factor, 1E-06 (kg/mg)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

3.4.2 Ingestion of Homegrown Vegetables

3.4.2.1 USEPA Region III (2008) guidance states "All bioaccumulative compounds need to be assessed in the food chain exposure evaluation." According to bioaccumulative studies performed for soil (Battelle 2003), arsenic is the only COPC identified in soils at the site that is bioaccumulative. Therefore, exposures from the ingestion homegrown vegetables were assessed only for arsenic. The other COPCs were not evaluated for exposures via the ingestion of homegrown vegetables.

3.4.2.2 To estimate an oral CDI for the ingestion of COPCs in home-grown vegetables by residential receptors, the following equation (USEPA, 2004b) was used:

$$CDI = \frac{EPC \times IR_{veg} \times DW \times (1 - PL) \times EF \times ED \times CF}{AT}$$

Where:

CDI	=	Chronic daily intake (absorbed dose) (mg/kg-day)
EPC	=	Exposure point concentration in vegetables (mg/kg)
IR_{veg}	=	Home-grown vegetable ingestion rate (mg/kg-day)
DW	=	Dry weight percentage (%)
PL	=	Preparation and cooking loss (%)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (yrs)
CF	=	Conversion factor, 1E-06 (kg/mg)
AT	=	Averaging time (days)

3.4.2.3 Note that home-grown vegetable intake rates are available on a per capita basis on a "consumer only" basis. The "consumer only" intake rates exclude individuals that do not consume home-grown vegetables. To provide a health-protective risk assessment, the home-grown vegetable intake rates used here are the consumer only home-grown vegetable ingestion rates for the south from USEPA (2011; Table 13-13). Following USEPA (2004b) guidance, the intake rates are multiplied by the average percent of individuals "consuming homegrown vegetables during the survey period." The vegetable intake rates were calculated as follows:

- RME
  - 95^{th} percentile consumption rate for central cities in the south = 3.7 g/kg-day
  - Percent consuming: 6.63%
  - Consumption rate = 3.7 g/kg-day x 6.63% = 0.245 g/kg-day or 245 mg/kg-day

3.4.2.4 Since vegetable intake rates have been provided by USEPA (2011) in terms of wet weight, the intake rates must be converted to dry weight, as the soil and vegetable EPCs are in terms of dry weight. This is accomplished in the equation above by multiplying the vegetable ingestion rate by the average dry weight percentage of vegetables (14.68%; see Appendix D, Table D.9). Additionally, the vegetable intake rates from USEPA (2011) are for raw vegetables. To account for the weight of the food item lost in preparation, the vegetable intake rate is multiplied by the percentage lost during preparation/cooking. For homegrown vegetables, USEPA (2004b) provides a preparation loss of 12 percent.

3.4.3 Dermal Contact with Contaminants in Soil

3.4.3.1 To estimate a dermal CDI for COPCs in soil, the following equation was used (USEPA, 2004a):

$$CDI = \frac{EPC \times AF \times DAF \times CF \times EV \times EF \times ED \times SA}{BW \times AT}$$

Where:

CDI	=	Chronic daily intake (absorbed dose) (mg/kg-day)
EPC	=	Exposure point concentration in soil (mg/kg)
AF	=	Soil-to-skin adherence factor (mg/cm^2-day)
DAF	=	Dermal absorption fraction (unitless)
CF	=	Conversion factor (1E-06 kg/mg)
EV	=	Event frequency (events/day)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (yrs)
SA	=	Skin surface area available for contact (cm^2)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

3.4.4 Inhalation

3.4.4.1 Although body weight normalized CDIs (i.e., mg/kg-day) are used to estimate intakes for ingestion and dermal absorption, current USEPA (1996, 2002a, 2009, 2019a) guidance does not recommend this approach for estimating inhalation exposures. Instead, current guidance (USEPA 1996, 2002a, 2009, 2019a) recommends that risks and hazards be estimated from exposure frequency and duration normalized air concentrations. This is presented in detail in Sections 5.1 and 5.2.

3.5 EXPOSURE PARAMETERS AND ASSUMPTIONS

3.5.0.1 This risk assessment evaluates the RME for residential receptors. The RME is defined as the maximum level of exposure reasonably expected to occur (USEPA, 1989). In accordance with USEPA (1992b) recommendations, exposure parameters were chosen with the understanding that the combination of variables for a given pathway would result in an estimate of the RME for that pathway. Under this approach, some variables may not be at their individual maximum values, but when combined with other variables they will result in estimates of the RME. Studies of the compounding of conservatism in probabilistic risk assessments show that setting as few as two factors at RME levels or high end (e.g., near the 90th percentile), while the remaining variables are set at less conservative, typical values, results in a product of all input variables at an approximate RME level (e.g., 99th percentile value) (Cullen, 1994).

3.5.0.2 Generally, contact rate, exposure frequency, and exposure duration are the most sensitive parameters (i.e., most likely to drive exposure estimates). When statistical data were available, 90th or 95th percentile values were used for exposure duration. If distributions were not available (e.g., for workers), high-end estimates were made using best professional judgment. Typically, distributional data are not available for exposure frequency; therefore, high-end estimates have been made using available site-specific information and best professional judgment. The following subsections discuss the justification for each parameter.

3.5.0.3 Table 3-1 summarizes the RME exposure parameters used to evaluate receptors at the site.

TABLE 3-1
HUMAN HEALTH RISK ASSESSMENT SOIL EXPOSURE PARAMETERS
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

Abbreviation	Parameter	Units	Residential Receptor	Reference
AT_{nc} - child	Averaging Time – noncarcinogens, child	days	2,190	365 x ED_{child}
AT_{nc} - adult	Averaging Time – noncarcinogens, adult	days	7,300	365 x ED_{adult}
$AT_{nc - inh}$	Averaging Time - noncarcinogens, inhalation	days	9,490	365 x ED_{inh}
AT_c	Averaging Time – carcinogens	days	25,550	365 x 70
ED_{child}	Exposure Duration - child	years	6	USEPA, 2014
ED_{adult}	Exposure Duration - adult	years	20	USEPA, 2014
ED_{inh}	Exposure Duration - inhalation	years	26	ED_{child} + ED_{adult}
BW_{child}	Body Weight - child	kg	15	USEPA, 2014
BW_{adult}	Body Weight - adult	kg	80	USEPA, 2014
EF	Exposure Frequency	days/year	350	USEPA, 2014
IRS_{child}	Soil Ingestion Rate - child	mg/day	200	USEPA, 2014
IRS_{adult}	Soil Ingestion Rate - adult	mg/day	100	USEPA, 2014
EV	Event Frequency	events/day	1	
FI	Fraction Ingested	unitless	1	
CF_s	Conversion Factor-soil	kg/mg	1.00E-06	
SA_{child}	Exposed Skin Surface Area - child	cm^2	2,373	USEPA, 2014
SA_{adult}	Exposed Skin Surface Area - adult	cm^2	6,032	USEPA, 2014
AF_{child}	Adherence Factor - child	mg/cm^2	0.2	USEPA, 2014
AF_{adult}	Adherence Factor - adult	mg/cm^2	0.07	USEPA, 2014
ET	Exposure Time	hour/day	24	USEPA, 2014
IR_{veg}	Home-grown vegetable ingestion rate	mg/kd-day	245	USEPA, 2011 Table 13-13
DW	Dry Weight Percentage	%	14.68	USEPA, 2018 Table 9-53
PL	Preparation and cooking loss	%	12	USEPA, 2011 Table 13-69

3.5.1 Exposure-Point Concentrations

EPCs are intended to be representative of the concentrations of chemicals in a given medium to which a receptor may be exposed at the site (i.e., the exposure point). EPCs were calculated using ProUCL Version 5.1 (see Section 2.3). For incidental ingestion and dermal contact with soils, soil data collected at the site were used to calculate the EPCs, as described below. For the inhalation of COPCs in dusts and the ingestion of COPCs in homegrown vegetables, fate and transport models were used to estimate the EPCs, as described below.

3.5.1.1 Exposure-Point Concentrations for Airborne Fugitive Dust

3.5.1.1.1 Following USEPA (1996, 2002a) guidance, EPCs for COPCs in airborne fugitive dust should be based on soil EPCs and estimated using the following equation:

$$C_{air} = \frac{EPC}{PEF}$$

Where:

C_{air} = COPC concentration in air at the exposure point (mg/m^3);

EPC = Exposure point concentration in soil (mg/kg)

PEF = Particulate emission factor (m^3/kg).

3.5.1.1.2 The PEF relates the concentration of soil COPCs to the concentration in airborne dust particles air. This calculation addresses dust generated from open sources, which is termed "fugitive" because it is not discharged into the atmosphere in a confined flow. PEF calculations include the Q/C term (i.e., dispersion) specific to the site's size and meteorological conditions. The PEF is calculated using the following equation (USEPA 1996, 2002a):

$$PEF = Q/C_{wind} \times \frac{3{,}600 s/h}{0.036 \times (1 - V) \times \left(\frac{U_m}{U_t}\right)^3 \times F(x)}$$

Where:

Q/C_{wind} = 87.37 g/m^2-s per kg/m^3, based on a 0.5 acre source in Philadelphia, PA (USEPA 2002a) (the closest city with published data)

V = 0.5, fraction of vegetative cover (USEPA, 1996, 2002a)

U_m = 4.69 m/s, mean annual wind speed in Philadelphia, PA (USEPA, 1996, 2002a)

U_t = 11.32 m/s, equivalent threshold value of windspeed at 7 m (USEPA, 1996, 2002a)

F(x) = 0.194, windspeed distribution function for Philadelphia, PA (USEPA, 1996, 2002a).

3.5.1.1.3 Using this equation results in a PEF of 1.27 x 10^9 m^3/kg (see Appendix D).

3.5.1.2 Exposure-Point Concentrations for Homegrown Vegetables

3.5.1.2.1 To predict the concentrations of chemicals in homegrown produce at the site, screening-level bioaccumulation models were used. These models were selected from the following hierarchy of sources:

- USEPA's (2007) ecological soil screening levels (Eco-SSLs)
- Bechtel Jacobs (1998)
- USEPA's (1999d) screening level ecological risk assessment protocol for hazardous waste combustion facilities
- Baes et al. (1984)

3.5.1.2.2 The selected bioaccumulation models are shown in Appendix D.

SECTION 4
TOXICITY ASSESSMENT

4.0.0.1 The third step of the HHRA is the toxicity assessment. The objective of the toxicity assessment is to weigh available evidence regarding the potential for particular chemicals to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a chemical and the increased likelihood and/or severity of adverse effects. The types of toxicity values used in risk assessment include oral reference doses (RfDs), inhalation reference concentrations (RfCs), oral slope factors (SFs), and inhalation unit risk factors (URFs). SFs and URFs are used to evaluate carcinogenic effects. RfDs and RfCs are used to evaluate noncarcinogenic effects.

4.1 TOXICITY VALUES FOR CARCINOGENIC EFFECTS

4.1.0.1 The SF is the toxicity value used to estimate the lifetime excess cancer risk associated with oral (i.e., ingestion) and dermal exposure to a known or suspected carcinogen (assuming a 70-year average life span). SFs are derived for those chemicals shown to cause an increased incidence of tumors in either human or animal studies. A dose-response relationship between tumor incidence and exposure using human epidemiologic or animal studies is used to derive the SF. This dose-response curve is then assumed to be linear at low doses (e.g., those found in situations of environmental contamination) and is used to predict tumor incidence at low exposure levels.

4.1.0.2 In this HHRA, chemical-specific SFs for COPCs were used to evaluate potential carcinogenic risk due to incidental ingestion of soil and dermal exposure to individual COPCs in soil. The SF is reported in terms of risk per milligrams (of chemical) per kilogram (unit body weight) per day $(mg/kg\text{-}d)^{-1}$. In addition, chemical specific URFs were used to evaluate the potential carcinogenic risk due to inhalation of COPCs. The URF is reported in terms of risk per milligrams (of chemical) in a cubic meter of air $(mg/m^3)^{-1}$.

4.1.0.3 Following USEPA (2003, 2019a) guidance and DoD Instruction 4715.18 (DoD 2019), SFs and URFs were obtained from the following hierarchy of primary sources:

- Tier 1: USEPA's IRIS (USEPA 2019b)
- Tier 2:USEPA's Provisional Peer Reviewed Toxicity Values
- Tier 3: Other Toxicity Values, including:
  - Office of Environmental Health Hazard Assessment (OEHHA) (2019) Toxicity Criteria Database
  - ORNL's (2007) Health-based environmental screening levels (HBESLs) for chemical warfare agents
  - USEPA's Health Effects Summary Tables (USEPA 1997)

4.1.0.4 The SFs and URFs used in this evaluation are shown in Table 4-1.

TABLE 4-1
HUMAN HEALTH RISK ASSESSMENT TOXICITY VALUES
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

					Ingestion			Dermal Contact		Inhalation		
CAS Number	Analyte	Volatile Organic Compound? (Yes/No)	Mutagenic Compound? (Yes/No)	ABS_d [1] (unitless)	RfD_o [2] (mg/kg-day)	SF_o [2] $((mg/kg\text{-}day)^{-1})$	GIABS [2] (unitless)	RfD_d [3] (mg/kg-day)	SF_d [4] $((mg/kg\text{-}day)^{-1})$	RfC_i (mg/m^3)	IUR $((\mu g/m^3)^{-1})$	C_{sat} (mg/kg)
	Inorganics											
7429-90-5	Aluminum	No	No	--	1.0E+00 P	--	1	1.0E+00	--	5.0E-03 P	--	--
7440-36-0	Antimony	No	No	--	4.0E-04 I	--	0.15	6.0E-05	--	--	--	--
7440-38-2	Arsenic	No	No	0.03	3.0E-04 I	1.5E+00 I	1	3.0E-04	1.5E+00	1.5E-05 C	4.3E-03 I	--
7440-48-4	Cobalt	No	No	--	3.0E-04 P	--	1	3.0E-04	--	6.0E-06 P	9.0E-03 P	--
57-12-5	Cyanide	Yes	No	--	6.0E-04 I	--	1	6.0E-04	--	8.0E-04 G	--	9.5E+05
7439-96-5	Manganese	No	No	--	2.4E-02 G	--	0.04	9.6E-04	--	5.0E-05 I	--	--
7440-02-0	Nickel	No	No	--	2.0E-02 I	--	0.04	8.0E-04	--	9.0E-05 A	2.6E-04 C	--
7440-62-2	Vanadium	No	No	--	5.0E-03 G	--	0.026	1.3E-04	--	1.0E-04 A	--	--

NOTES:

(1) ABS_d is the recommended dermal absorption fraction of contaminants in soil. ABS_d values are obtained from USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites, updated May 2019. Available at: https://semspub.epa.gov/work/HQ/199434.pdf.

(2) SF_o and RfD_o values are consistent with the USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites, updated May 2019, using the hierarchy of sources as listed in the text and the RSL users guide. Available at: https://semspub.epa.gov/work/HQ/199434.pdf.

(2) GIABS is the oral absorption factor of analytes that are absorbed in the intestinal tract. If the GIABS is greater than 0.5, use 1.0 as the value. GIABS values obtained from USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites, updated May 2019. Available at: https://semspub.epa.gov/work/HQ/199434.pdf.

(3) RfD_d is the dermal reference dose and is based on the absorbed dose. The RFD_d is calculated as RfD_o*GIABS.

(4) SF_d is the dermal slope factor and is based on absorbed dose. The SF_d is calculated as SF_o / GIABS.

-- = data not available.

Sources:

H = HEAST
I = IRIS
P= PPRTV
G = USEPA Regional Screening Levels - User's Guide Section 5
X= PPRTV Appendix
C = Cal EPA
A = ATSDR

4.2 TOXICITY VALUES FOR NONCARCINOGENIC EFFECTS

4.2.0.1 For chemicals that exhibit noncarcinogenic effects, the USEPA assumes that organisms have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the health effect is manifested. This threshold theory assumes the receptor can tolerate a range of exposures from zero to some finite value with no appreciable risk of adverse effects.

4.2.0.2 Toxicity values for chemicals exhibiting noncarcinogenic effects are developed using RfDs. The RfD provides an estimate of an average daily exposure to an individual (including sensitive individuals) below which there will not be an appreciable risk of adverse health effects. The RfD is derived using uncertainty factors (e.g., to adjust from animals to humans and to protect sensitive populations) to ensure it is unlikely to underestimate the potential for adverse noncarcinogenic effects. The purpose of the RfD is to provide a value against which the sum of other doses (i.e., those projected from human exposure to various environmental conditions) is compared. Doses significantly higher than the RfD may indicate that an inadequate margin of safety exists for exposure to that substance and that an adverse health effect could occur. The RfD is expressed in terms of mg/kg-d. In addition, chemical specific RfCs (inhalation reference concentration) were used to evaluate the potential noncarcinogenic effects due to inhalation of COPCs. The RfC is reported in terms mg/m^3.

4.2.0.3 Following USEPA (2003, 2019a) guidance and DoD Instruction 4715.18 (DoD 2019), RfDs and RfCs were obtained from the following hierarchy of primary sources:

- Tier 1: USEPA's IRIS (USEPA 2019b)
- Tier 2:USEPA's Provisional Peer Reviewed Toxicity Values
- Tier 3: Other Toxicity Values, including:
  - Office of Environmental Health Hazard Assessment (OEHHA) (2019) Toxicity Criteria Database
  - ORNL's (2007) Health-based environmental screening levels (HBESLs) for chemical warfare agents
  - USEPA's Health Effects Summary Tables (USEPA 1997)

4.2.0.4 The RfDs and RfCs used in this evaluation are shown in Table 4-1.

4.3 DERMAL TOXICITY VALUES

4.3.0.1 Oral toxicity values were also used to assess risks and/or hazards associated with the dermal contact exposure pathway (USEPA 2004a). Oral toxicity values reflect administered-dose values, which represent concentrations protective of ingestion. The dermal exposure route, however, evaluates the toxicity of concentrations of chemicals in the blood (absorbed dose). Therefore, the absorbed-dose concentrations identified for dermal exposure must be compared to toxicity values adjusted for gastrointestinal absorption (USEPA 2004a). Oral toxicity values were adjusted for gastrointestinal absorption by applying oral absorption factors to administered-dose toxicity values.

4.3.0.2 Oral slope factors (SF) and/or reference doses (RfD) were adjusted to estimate dermal toxicity values when the following conditions were met (USEPA 2004a):

- The critical study upon which the toxicity value is based employed an administered dose (e.g., delivery in diet or by gavage) in its study design;
- A scientifically defensible database exists and demonstrates that the gastrointestinal absorption of the chemical from a medium (e.g., water and feed) similar to the one employed in the critical study is less than 100 percent; and
- Oral absorption factors are available from either USEPA (2019) or the scientific literature.

4.3.0.3 The oral absorption factors (GIABS) used in this risk assessment are shown in Table 4-1, as are the dermal SFs (SF_d) and RfDs (RfD_d).

SECTION 5
RISK CHARACTERIZATION

5.0.0.1 The final step in the HHRA process is risk characterization. The purpose of the risk characterization step is to 1) review the results from the exposure and toxicity assessments; 2) quantitatively estimate the potential for cancer (i.e., risk) and noncancer (i.e., hazard) effects; and 3) assess and discuss uncertainties associated with each of the aforementioned steps. To characterize potential noncarcinogenic effects, estimated exposure levels were compared with their respective toxicity values. To characterize potential carcinogenic effects, the incremental probability of an individual developing cancer over a lifetime was calculated from the estimated exposure levels and chemical-specific dose/response information (i.e., carcinogenic toxicity factors). Cancer risk (for carcinogens) and hazard quotient (HQ; for noncarcinogens) estimates were calculated as described below for each COPC.

5.1 CARCINOGENIC EFFECTS

5.1.0.1 For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime (assumed to be 70 years) as a result of exposure to the potential carcinogen (i.e., incremental or excess individual lifetime cancer risk). For example, an excess lifetime cancer risk of 1 x 10^{-6} indicates an individual has a one-in-one-million probability of developing cancer over a lifetime as a result of site-related exposures to a specific COPC. Carcinogenic risk probabilities were estimated by multiplying the exposure level calculated for each exposure route by the corresponding cancer toxicity value (i.e., SF or URF) (USEPA 1989, 1996, 2004a, 2009) as follows:

$$Risk_{oral} = CDI_{oral} \times SF_o$$

$$Risk_{dermal} = CDI_{dermal} \times SF_d$$

$$Risk_{inhalation} = \frac{C_{air} \times EF \times ED \times ET \times URF \times CF}{AT \times 365\ days/year}$$

where:

AT	= Averaging time (years)
C_{air}	= COPC concentration in airborne dust or outdoor air (mg/m^3)
$CDI_{oral,dermal}$	= Chronic daily intake for each COPC via pathway indicated (mg/kg-day)
CF	= Conversion factor (1,000 µg/mg)
ED	= Exposure duration (years)
EF	= Exposure frequency (days/year)
ET	= Exposure time; i.e., the fraction of the day spent at the site (unitless)
OAF	= Oral absorption factor (unitless) – an adjustment factor for dermal toxicity values
Risk	= Incremental or excess individual lifetime cancer risk for each COPC (unitless)
SF_o	= Chemical specific oral slope factor ($(mg/kg\text{-}day)^{-1}$)
SF_d	= SF_o/OAF

URF = Chemical specific inhalation unit risk factor ($(\mu g/m^3)^{-1}$)

5.1.0.2 Risk probabilities are assumed to be additive for all COPCs across all exposure pathways to estimate a total excess cancer risk. After summing all of the risks, the total excess cancer risk estimates are then compared to the point of departure of 1×10^{-6} (USEPA 1990). In general, total risks greater than 1×10^{-4} require action; risks between 1×10^{-6} and 1×10^{-4} are in the risk management range and require the stakeholders to discuss and decide whether the risk estimates are acceptable; and risks less than 1×10^{-6} are generally considered acceptable.

5.2 NONCARCINOGENIC EFFECTS

5.2.0.1 For exposure to noncarcinogens, adverse effects are not assumed to occur below a certain threshold (i.e., the RfD or RfC). The potential for adverse noncarcinogenic effects (i.e., the hazard quotient or HQ) was estimated by dividing the exposure level calculated for each exposure route by the corresponding noncancer toxicity value (i.e., RfD or RfC) (USEPA 1989, 1996, 2004a, 2009) as follows:

$$HQ_{oral} = \frac{Intake_{oral}}{RfD_o}$$

$$HQ_{dermal} = \frac{Intake_{dermal}}{RfD_d}$$

$$HQ_{inhalation} = \frac{C_{air} \times EF \times ED \times ET \times CF}{RfC \times AT \times 365\ days/year}$$

where:

AT = Averaging time (years)
C_{air} = COPC concentration in airborne dust or outdoor air (mg/m^3)
ED = Exposure duration (years)
EF = Exposure frequency (days/year)
ET = Exposure time; i.e., the fraction of the day spent at the site (unitless)
CF = Conversion factor (1,000 µg/mg)
HQ = Hazard quotient for each COPC (unitless)
$Intake_{oral,dermal}$ = Oral and dermal exposure for each COPC (mg/kg-day)
OAF = Oral absorption factor (unitless)
RfD_o = Chemical specific oral reference dose (mg/kg-day)
RfD_d = RfD_o x OAF
RfC = inhalation reference concentration ($\mu g/m^3$)

5.2.0.2 After summing all the HQs for all COPCs across all exposure pathways, the sum (called a hazard index or HI) is then compared to the USEPA acceptable hazard level of 1. An HQ or HI less than 1 indicates a very low threat of adverse health effects, whereas an HQ or HI in excess of 1 indicates the potential for noncancer effects (USEPA 1989). It is important to consider that a HQ or HI above 1 only indicates a potential for noncarcinogenic adverse health effects for the receptor. It does not predict the incidence, or severity, of effects (USEPA 1989). Also, in cases where the total cumulative HI exceeds 1, target organs will be considered, since noncarcinogens that affect different target organs are not expected to have cumulative effects.

5.3 RISK CHARACTERIZATION RESULTS

5.3.0.1 Tables 5-1 through 5-2 summarize the human health risk/hazard results for assumed exposures to soil at 0-2 ft bgs for residents, while Tables 5-3 and 5-4 summarize the human health risk/hazard results for assumed exposure to soil at 0-12 ft bgs for residents. Appendix D provides the supporting calculations for the results presented in these tables.

5.3.1 Residents – Excess Cancer Risks

5.3.1.1 The total excess cancer risk for a resident (age-adjusted to account for both child and adult exposures) with 26 years exposure to surface soil (0-2 ft bgs) was estimated to be 3×10^{-5}, which is within the USEPA (1990) acceptable target risk range of 1×10^{-6} to 1×10^{-4} (Table 5-1).

5.3.1.2 The total excess cancer risk for a resident (age-adjusted) with 26 years exposure to combined surface and subsurface soil (0-12 ft bgs) was estimated to be 6×10^{-5}, which is within the USEPA (1990) acceptable target risk range of 1×10^{-6} to 1×10^{-4} (Table 5-3).

5.3.2 Residents – Non-Cancer Risks

5.3.2.1 Assumed adult residential exposures to COPCs in surface soil (0-2 ft bgs) resulted in a total HI of 1 (Table 5-1), which is equal to the benchmark level of concern for noncarcinogenic effects. This indicates that assumed exposures will not result in adverse health effects.

5.3.2.2 Assumed child residential exposures to COPCs in surface soil (0-2 ft bgs) resulted in a total HI of 4 (Table 5-1). Since the total HI was greater than 1, the hazards were further through consideration of target organ effects. As shown in Table 5-2, following consideration of target organs, no single target organ had an organ-specific HI greater than 1. This indicates that assumed exposures will not result in adverse health effects.

5.3.2.3 Assumed adult residential exposures to COPCs in combined surface and subsurface soil (0-12 ft bgs) resulted in a total HI of 1 (Table 5-3), which is equal to the benchmark level of concern for noncarcinogenic effects. This indicates that assumed exposures will not result in adverse health effects.

5.3.2.4 Assumed child residential exposures to COPCs in combined surface and subsurface soil (0-12 ft bgs) resulted in a total HI of 4 (Table 5-3). Since the total HI was greater than 1, the hazards were evaluated further through consideration of target organ effects. As shown in Table 5-4, following consideration of target organs, no single target organ had an organ-specific HI greater than 1. This indicates that assumed exposures will not result in adverse health effects.

TABLE 5-1
HUMAN HEALTH RISK EVALUATION SUMMARY SURFACE SOIL (0-2')
RESIDENTIAL RECEPTOR
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

Analyte	CAS Number	C_s [(1)] (mg/kg)	UCL or Max	Age-adjusted Ingestion Carcinogenic Risk	Home-grown Vegetable Ingestion Carcinogenic Risk	Age-adjusted Dermal Carcinogenic Risk	Age-adjusted Inhalation Carcinogenic Risk	Total Carcinogenic Risk	Child Ingestion Hazard Quotient	Child Dermal Hazard Quotient	Adult Ingestion Hazard Quotient	Adult Dermal Hazard Quotient	Home-Grown Vegetable Ingestion Hazard Quotient	Inhalation Hazard Quotient	Total Hazard Quotient - Child	Total Hazard Quotient - Adult
Inorganic Compounds																
Aluminum	7429-90-5	28820	UCL	--	--	--	--	--	0.37	--	0.035	--	--	0.10	0.47	0.14
Antimony	7440-36-0	3.1	UCL	--	--	--	--	--	0.10	--	0.0094	--	--	--	0.10	0.0094
Arsenic	7440-38-2	9.3	UCL	2.0E-05	5.9E-06	2E-06	2.7E-07	2.8E-05	0.40	0.028	0.037	0.0047	0.013	0.011	0.45	0.067
Cobalt	7440-48-4	35	UCL	--	--	--	2.1E-06	2.1E-06	1.5	--	0.14	--	--	0.11	1.6	0.25
Cyanide	57-12-5	0.41 U	Max	--	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	7439-96-5	1421	UCL	--	--	--	--	--	0.76	--	0.071	--	--	0.52	1.3	0.59
Nickel	7440-02-0	93	UCL	--	--	--	1.6E-07	1.6E-07	0.059	--	0.0056	--	--	0.019	0.078	0.024
Vanadium	7440-62-2	90	UCL	--	--	--	--	--	0.23	--	0.022	--	--	0.016	0.25	0.038
			Pathway Risk	**2E-05**	**6E-06**	**2E-06**	**3E-06**	**--**	**3**	**0.03**	**0.3**	**0.005**	**0.01**	**0.8**	**--**	**--**
							Total Risk	**3E-05**						**Hazard Index**	**4**	**1**

NOTES:

(1) COPC concentration in soil (Cs) is the exposure point concentration (i.e., 95% UCL or the maximum detected concentration). EPCs shown in Table 2-2.

-- = Not calculated because analyte not detected or toxicity data not available.

U = Analyte was analyzed for but not detected above the limit of detection (LOD).

TABLE 5-2
NONCANCER HAZARDS SEPARATED BY TARGET ORGAN FOR SURFACE SOIL (0-2')
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

Target Organ	Chemical Groupings for Ingestion + Dermal Exposure Pathways	Ingestion + Dermal Hazard Index [1]	Chemical Groupings for Inhalation Exposure Pathways	Inhalation Hazard Index [1]	Summed Segregated Hazard Index [2]
Body Weight	Nickel	0.06	N/A	N/A	0.06
Cardiovascular	N/A	N/A	Arsenic	0.01	0.01
Dermal	Arsenic	0.4	Arsenic	0.01	1
	Vanadium	0.2			
Nervous	Manganese	0.8	Arsenic	0.01	1
			Manganese	0.5	
Neurological	Aluminum	0.4	Aluminum	0.1	0.5
Reproductive	N/A	N/A	Arsenic	0.01	0.01
Respiratory system	N/A	N/A	Antimony	--	0.2
			Arsenic	0.01	
			Cobalt	0.1	
			Nickel	0.02	
			Vanadium	0.02	
Testes	Cyanide	N/A	N/A	0.1	0.1
Thyroid	Cobalt	1	Cyanide	--	1
Whole Body	Antimony	0.06	N/A	N/A	0.1

[1] See Table 5-1.

[2] Sum of the ingestion+dermal and inhalation hazard indices for the applicable target organ.

-- Hazard not calculated because analyte was not detected at the exposure area.

N/A - Not applicable. Does not have a toxicity value for the exposure pathway.

TABLE 5-3
HUMAN HEALTH RISK EVALUATION SUMMARY COMBINED SUFACE AND SUBSURFACE SOIL (0-12')
RESIDENTIAL RECEPTOR
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

Analyte	CAS Number	C_s [(1)] (mg/kg)	UCL or Max	Age-adjusted Ingestion Carcinogenic Risk	Home-grown Vegetable Ingestion Carcinogenic Risk	Age-adjusted Dermal Carcinogenic Risk	Age-adjusted Inhalation Carcinogenic Risk	Total Carcinogenic Risk	Child Ingestion Hazard Quotient	Child Dermal Hazard Quotient	Adult Ingestion Hazard Quotient	Adult Dermal Hazard Quotient	Home-Grown Vegetable Ingestion Hazard Quotient	Inhalation Hazard Quotient	Total Hazard Quotient - Child	Total Hazard Quotient - Adult
Inorganic Compounds																
Aluminum	7429-90-5	32269	UCL	--	--	--	--	--	0.41	--	0.039	--	--	0.12	0.53	0.16
Antimony	7440-36-0	1.863	UCL	--	--	--	--	--	0.060	--	0.0056	--	--	--	0.060	0.0056
Arsenic	7440-38-2	19.12	UCL	4.1E-05	1.2E-05	3E-06	5.5E-07	5.7E-05	0.81	0.058	0.076	0.0097	0.027	0.023	0.92	0.14
Cobalt	7440-48-4	33.05	UCL	--	--	--	2.0E-06	2.0E-06	1.4	--	0.13	--	--	0.10	1.5	0.23
Cyanide	57-12-5	0.157	UCL	--	--	--	--	--	0.0033	--	0.00031	--	--	0.061	0.064	0.061
Manganese	7439-96-5	1001	UCL	--	--	--	--	--	0.53	--	0.050	--	--	0.36	0.90	0.41
Nickel	7440-02-0	84.72	UCL	--	--	--	1.5E-07	1.5E-07	0.054	--	0.0051	--	--	0.017	0.071	0.022
Vanadium	7440-62-2	117.8	UCL	--	--	--	--	--	0.30	--	0.028	--	--	0.021	0.32	0.050
			Pathway Risk	**4E-05**	**1E-05**	**3E-06**	**3E-06**	**--**	**4**	**0.06**	**0.3**	**0.010**	**0.03**	**0.7**	**--**	**--**
							Total Risk	**6E-05**						**Hazard Index**	**4**	**1**

NOTES:
(1) COPC concentration in soil (Cs) is the exposure point concentration (i.e., 95% UCL or the maximum detected concentration). EPCs shown in Table 2-3.
-- = Not calculated because analyte not detected or toxicity data not available.

TABLE 5-4
NONCANCER HAZARDS SEPARATED BY TARGET ORGAN FOR COMBINED SURFACE AND SUBSURFACE SOIL (0-12')
4825 GLENBROOK ROAD
SPRING VALLEY FORMERLY USED DEFENSE SITE
OPERABLE UNIT 3, WASHINGTON, D.C.

Target Organ	Chemical Groupings for Ingestion + Dermal Exposure Pathways	Ingestion + Dermal Hazard Index [1]	Chemical Groupings for Inhalation Exposure Pathways	Inhalation Hazard Index [1]	Summed Segregated Hazard Index [2]
Body Weight	Nickel	0.05	N/A	N/A	0.05
Cardiovascular	N/A	N/A	Arsenic	0.02	0.02
Dermal	Arsenic	0.9	Arsenic	0.02	1
	Vanadium	0.3			
Nervous	Manganese	0.5	Arsenic	0.02	0.9
			Manganese	0.4	
Neurological	Aluminum	0.4	Aluminum	0.1	0.5
Reproductive	N/A	N/A	Arsenic	0.02	0.02
Respiratory system	N/A	N/A	Antimony	--	0.2
			Arsenic	0.02	
			Cobalt	0.1	
			Nickel	0.02	
			Vanadium	0.02	
Testes	Cyanide	N/A	N/A	0.1	0.1
Thyroid	Cobalt	1	Cyanide	0.06	1
Whole Body	Antimony	0.05	N/A	N/A	0.05

[1] See Table 5-3.

[2] Sum of the ingestion+dermal and inhalation hazard indices for the applicable target organ.

-- Hazard not calculated because analyte was not detected at the exposure area.

N/A - Not applicable. Does not have a toxicity value for the exposure pathway.

5.4 UNCERTAINTY ANALYSIS

5.4.0.1 All HHRAs involve the use of assumptions, judgments, and imperfect data to varying degrees resulting in uncertainties in the final estimates of risk. These uncertainties are generally associated with the multitude of conditions that characterize each step of the HHRA process (i.e., data evaluation and identification of COPCs, exposure assessment, toxicity assessment, and risk characterization). These conditions are characteristically conservative and tend to overestimate potential site-related risks. This discussion qualitatively describes the major uncertainties in the HHRA for 4825 Glenbrook Road.

5.4.1 Uncertainty in Data Collection and Evaluation

5.4.1.1 Analysis of uncertainties focuses on determining whether the available data are representative of contaminant concentrations and site conditions, and whether the sampling, analyses, and/or statistical treatment of the data result in an over- or under-estimation of potential risk. Although most of the assumptions used to calculate risk are designed to over predict the risk, there are a few occasions where the risk may be underestimated.

5.4.1.2 Where a chemical was not detected, USEPA's (2015) ProUCL uses the Kaplan-Meier method to account for the effect of the non-detects on the estimated UCLs. This assumption tends to overestimate the potential risk. Nonetheless, since the chemical was not detected, there is still some uncertainty in the true UCL.

5.4.1.3 Backfill soil data were not used in this risk assessment. Therefore, this risk assessment is likely to overestimate exposure, as the addition of clean fill was not accounted for in estimation of an EPC, likely resulting in an overemphasis on remaining contamination in the EPC. Additionally, determination of soil profiles did not account for proposed increases in grade of up to 12 ft in portions of the site. Increases in grade would be expected to reduce or even eliminate exposure to potentially contaminated soil left in place by effectively creating a barrier to exposure.

5.4.1.4 The samples used in this HHRA were collected over a period of approximately 7 years. The data was validated in accordance with USEPA procedures and are all sufficient to be used to perform a risk assessment. However, it should be noted that the analytical laboratories and analytical procedures have changed over the years, which are expected to have introduced some variation into the measurements.

5.4.1.5 Steady-state conditions were assumed for evaluation of potential future exposures, that may tend to overestimate long-term exposures and health risks since contaminant concentrations may decrease over time due to biodegradation, volatilization, and leaching, among other factors.

5.4.1.6 Cobalt is one of the COPCs, but it was not considered bioaccumulative because there are several conflicting bioaccumulative studies for cobalt. Cobalt is currently under review for whether it is bioaccumulative. Not considering cobalt as a bioaccumulative compound for the risk assessment may underestimate the risk if cobalt is bioaccumulative.

5.4.2 Uncertainty in Exposure Assessment

5.4.2.1 There is uncertainty associated with how well an exposure scenario approximates the precise conditions to which a receptor may be exposed at a given site. Potential human exposures could deviate from those estimated in this HHRA through differences in exposure frequency, contact rate, exposure duration, body weight, and life span. However, because the RME exposure parameter values generally consist of upper bound (i.e., 95th percentile) estimates, it is likely the RME exposure and risk estimates presented here are upper-bound estimates that overestimate exposures (and risks) for the average receptor.

5.4.2.2 Generic models were used to estimate the concentrations of COPCs in vegetables grown at the site. However, bioaccumulation from soil to plants is dependent on multiple factors, including soil pH, metal species present in the soil, plant species, part of the plant measured/consumed, etc. Thus, the predicted concentrations in vegetables presented here are subject to uncertainty.

5.4.2.3 The soil ingestion rates assumed in this HHRA are incidental soil ingestion rates; i.e., ingestion of soil or dust particles that adhere to food, cigarettes, objects that are mouthed, or hands. However, some children are known to exhibit a behavior called soil-pica, which "…is the recurrent ingestion of unusually high amounts of soil" (USEPA 2008). Children who exhibit soil-pica behavior have much higher soil ingestion rates than assumed here; i.e., 1,000 to 5,000 mg/day or more (USEPA 2008) vs. 100 mg/day. Thus, soil-pica children would be expected to have correspondingly higher (i.e., 10 to 50x) exposures, and risks, than were estimated here.

5.4.2.4 Due to the numerous test pits and sampling activities that have taken place at the site, some of the samples categorized as "surface" may no longer be near the soil surface and may currently be in deeper soil. Data points were included in the appropriate soil profile based on the depth that the sample was collected below the original soil surface. When the depth of the sample below original ground surface was uncertain, the assumption erred on the side of shallower to be more conservative. This may overestimate risk. However, assumed exposures to both 0-2 and 0-12 ft bgs were evaluated at the site. Therefore, the uncertainty associated with the current depth of the samples is expected to be small.

5.4.3 Uncertainty in Toxicity Assessment

5.4.3.1 Some uncertainty is also inherent in the toxicity values used in the HHRA. Carcinogenic SFs are route-specific values derived only for compounds shown to cause an increased incidence of tumors in either human or animal studies. Dose-response relationships between tumor incidence and exposure using human epidemiologic or animal studies are used to derive the SF. This dose-response curve is then assumed to be linear at low doses (e.g., those found in situations of environmental contamination) and is used to predict tumor incidence at low exposure levels. When an animal study is used, the final SF is adjusted to account for extrapolation of animal data to humans. If the studies used to derive the SF were conducted for less than the life span of the test organism, the final SF has also been adjusted to reflect risk associated with lifetime exposure.

5.4.3.2 The SF is generally an upper 95th percentile confidence limit of the probability of a response based on experimental animal data in the multistage model. This means that the site-specific chemical risk is not likely to exceed the risk estimate derived through the model and is likely to be less than the predicted risk.

5.4.3.3 The chronic RfD for a compound is based on studies where either human or animal populations were exposed to a given compound by a given route of exposure for the major portion of the life span (as a USEPA guideline, seven years to a lifetime) (USEPA 1989). RfDs are derived by determining dose-specific effect levels from all available quantitative studies and applying uncertainty factors to the most appropriate effect level to determine a RfD for humans. Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the data. Typically, an uncertainty factor of 100 to 1,000 is used in the adjustments. In addition, USEPA may use a modifying factor of up to 10 that applies to professional judgment of uncertainties. General uncertainties in the derivation of RfDs may be associated with factors such as: (1) variations in the general population (to protect sensitive receptors); (2) extrapolation of animal data to humans; (3) use of a subchronic study versus a chronic study to determine the no-observed-adverse-effect level (NOAEL); or (4) use of a lowest-observed-adverse-effect level (LOAEL) versus a NOAEL. Both the uncertainty and modifying factors are conservative in nature and tend to overestimate risk.

5.4.3.4 As indicated above, toxicity factors are generally route specific (i.e., they are either for inhalation or oral exposure to a given chemical). In this risk assessment, oral RfDs and CSFs were used to evaluate the risk associated with ingestion of a given chemical. RfCs and inhalation URFs were used to evaluate the risk associated with inhalation of chemicals. Due to differences in the exposure pathways, route-to-route extrapolation was not performed between oral and inhalation pathways (USEPA 2009). In other words, if an inhalation toxicity factor did not exist, the oral RfD or CSF was not used to calculate one. For analytes that are inhaled, absorbed through the lungs, and have systemic toxic effects, the absence of route-to-route extrapolation will tend to underestimate the risk associated with inhalation exposure to a given chemical. Conversely, for chemicals that have only portal of entry effects, and not systemic effects, the use of route-to-route extrapolation would tend to overestimate the risks.

5.4.4 Uncertainty in Estimating Chemical Risk

5.4.4.1 The expression of the potential risk associated with contaminants detected at the site is a result of the combined steps of data evaluation, exposure assessment, and toxicity assessment. This combination provides the potential to magnify the uncertainties present in these steps of the HHRA process.

5.4.4.2 The chemical risk calculations include the risk associated with exposure to all COPCs evaluated at the site. Whenever carcinogenic and non-carcinogenic toxicity factors are available for a given chemical, the risk and hazard are both calculated. Cumulative risk is calculated using all available analytes. However, the risks are not necessarily additive; e.g., the risks could be synergistic or even antagonistic. When the non-carcinogenic hazard quotient is greater than 1, potential target organ effects were considered. Only those chemicals that affected the same target organ, as indicated by the critical study for calculating the RfD, were considered to have a cumulative toxicity. This assumption may tend to underestimate the hazard, should a chemical affect multiple target organs not represented in the critical study or should there be synergistic effects among the COPCs.

5.4.5 Uncertainty Associated with MINICAMS Interferent for Lewisite

5.4.5.1 While conducting field work on March 28, 2019, MINICAMS alarms were triggered for lewisite (L) resulting in work stoppage. As confirmed by DAMMS tubes and confirmation

samples, it was subsequently determined that the lewisite detections were false positives. In a past L interference event in area 4 (March 2014), 1,4-dichloropthalene was determined to most likely be the cause of the interference. Dichloronapthalene does not appear on available lists of past chemicals used at Spring Valley, however, it can be associated with Halo Wax, which is a chemical listed as being used at Spring Valley. Additionally, the compound is noted in an old journal article discussing smoke and arsenicals research.

5.4.5.2 There are no means to quantify the detection of 1,4-dichloronaphthalene. There are no regional screening levels (RSLs), permissible exposure limits (PELs), or recommended exposure limits (RELs) for 1,4-dichloronaphthalene. Though there is a level of uncertainty relative to chlorinated naphthalenes, potential exposures will be mitigated by the placement of clean fill across the entire site. At no time during the Remedial Action were any VOCs or SVOCs detected above the comparison criteria established in the SSWP (USACE 2017), therefore it is unlikely that this one SVOC is present in any concentration that would result in an unacceptable risk.

5.4.6 Uncertainty Associated with Mustard ABPs

5.4.6.1 Grid -10, -30 and grid -10, -10 to the south of area 4 were areas where intact containers and numerous glass fragments were uncovered during high probability operations under ECS location 1. This potential source material along with the house foundation walls and floor (Figure 5-1) were removed. Grid -10, -30 was excavated down to competent saprolite and a confirmation sample was collected on July 31, 2014 from the floor of grid -10, -30 (RA-4825GR-FL-(-10,-30)-01-10.5). Grid -10, -10 was excavated to bedrock as a result of persistent detections of mustard ABPs 1,4-dithiane and 1,4-oxathiane in soil waste characterization samples. A confirmation sample was not collected from grid -10, -10 due to bedrock refusal.

5.4.6.2 Sample RA-4825GR-FL-(-10,-30)-01-10.5 depicted as Sample 14 on Figure 2-3 was clear of agent and agent breakdown products, but contained an arsenic concentration of 66.5 mg/kg; therefore, grid -10, -30 required over excavation to reduce the concentration of arsenic below 20 mg/kg.

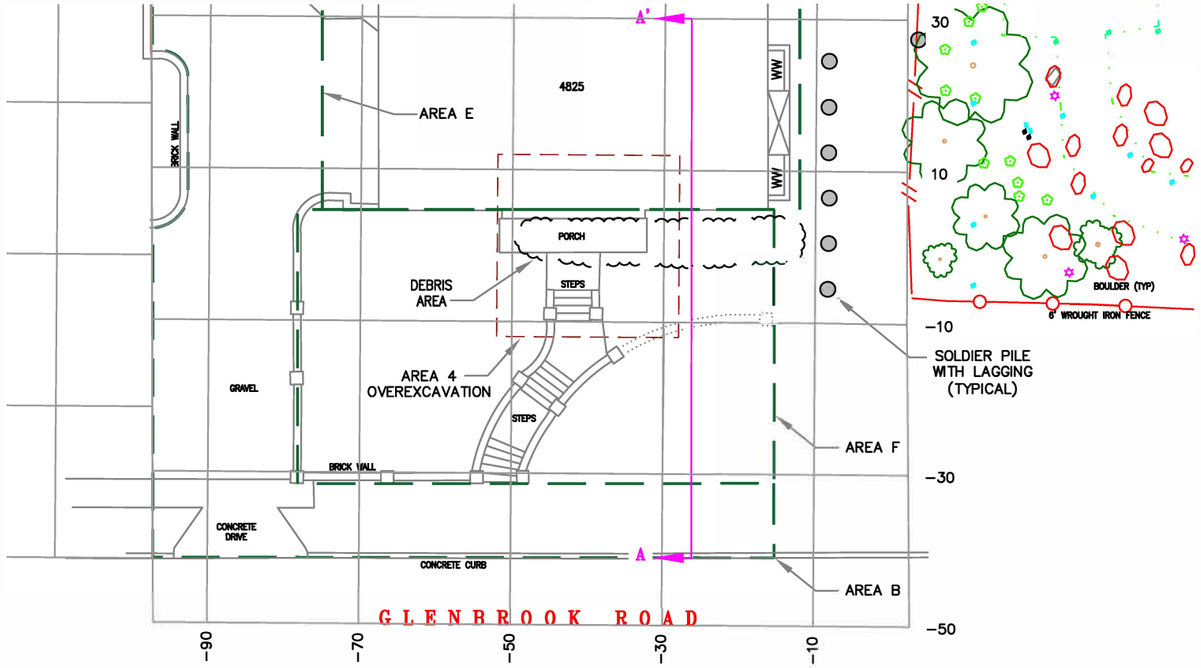
5.4.6.3 On July 2, 2018 an attempt was made to over excavate grid -10, -30 two feet down due to the elevated arsenic concentration discussed above. Over excavation of arsenic contaminated soil was conducted in accordance with SOP 47 – HTW Soil Excavation. After filling one roll-off container of soil, an odor indicative of mustard ABPs was detected by the workers. A grab sample (RA-4825GR-AREA F-E GRAB-01-070218) was collected from the soils the odor was emanating from. The grab sample had detections of mustard ABPs (210 µg/kg of 1,4-dithiane and 23 µg/kg of 1,4-oxathiane). It was decided by the PDT that grid -10, -30 would be excavated an additional two feet down and two feet out from each sidewall at a later date. Intrusive work was postponed, and the excavation area was temporarily backfilled. The plan to return to grid -10, -30 at a later date was developed in the interim.

5.4.6.4 In March 2019, intrusive work resumed in grid -10, -30, also referred to as “area 4” per SOP 48 – Low Probability Soil Excavation. An excavator was used to excavate the soils under low probability worker protection. Enhanced air monitoring protocols including air monitoring for chemical agent via MINICAMS were also conducted. The temporarily placed backfill was removed from the entire excavation and intrusive work began on the native material in the east side of the excavation area. On March 26, 2019, there were multiple MINICAMS alarms for L. It was determined that the MINICAMS alarms for L were false positives and were

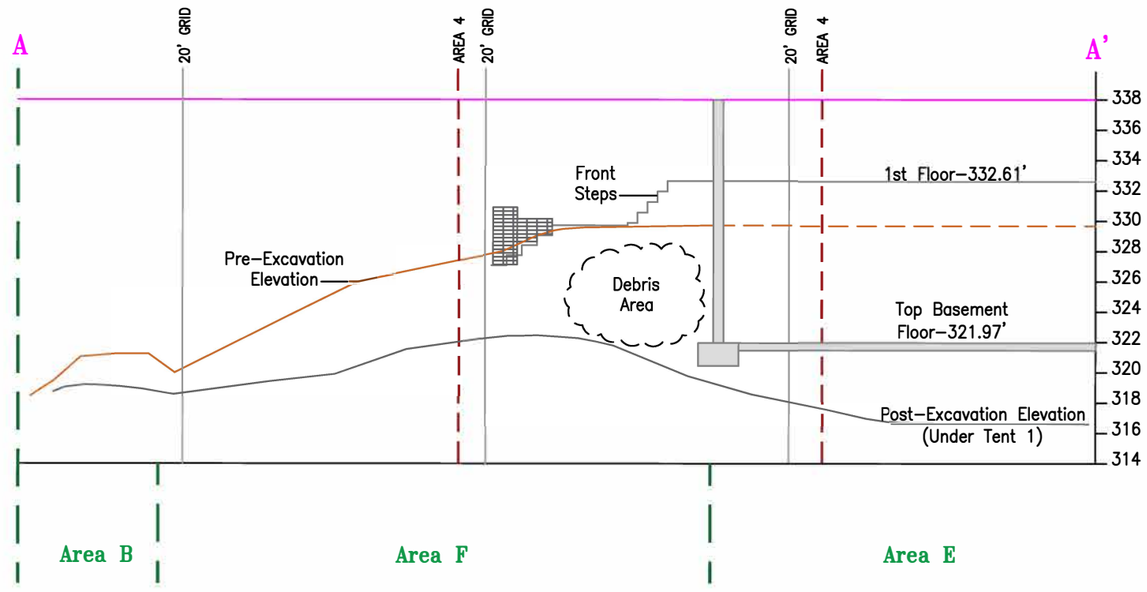
triggered by the same interferent discussed in section 5.4.5. Before work was stopped, eight grab samples were collected from the floor and the walls of the excavation as it stood. It should be noted that the grab sample collection procedure and parameters are the same as confirmation samples. Four wall and four floor samples were collected. Of the eight samples, four samples (two floor and two wall) had detections of the mustard breakdown product 1,4-dithiane. In addition to 1,4-dithiane, one floor sample RA-4825GR-AREA 4-FL-(-10,-30)-01-2 had a detection of 1,4-oxathiane. 1,4-oxathiane was detected at 0.059 mg/kg which is well below the residential based comparison value of 61 mg/kg. The highest concentration of 1,4-dithiane was 0.094 mg/kg detected in the same sample where 1,4-oxathiane was detected (RA-4825GR-AREA 4-FL-(-10,-30)-01-2). This concentration is also well below the residential based comparison value of 78 mg/kg.

5.4.6.5 Area 4 is bounded on all sides with grids whose confirmation samples were collected at relatively the same depth as the ABP positive grab samples collected from area 4 (Figure 5-2 and Table 5-5) (with the exception of grid -10, -10 where a confirmation sample was not collected due to bedrock refusal).

5.4.6.6 The confirmation samples above did not have any detectable quantities of ABPs. As the grab samples collected from area 4 represent the saprolite that was closest to the source material, it would follow that these concentrations would be the highest representative concentrations of ABPs in the remaining soil. As stated previously, these ABP detections were well below residential based comparison levels. Therefore, since (1) these concentrations are below the residential comparison criteria for mustard ABPs; (2) are the closest samples to the former source material; and (3) are bounded by samples at relatively the same depth with no detectable quantities of ABPs, it is highly unlikely that concentrations higher than the ABP comparison values exist in and around area 4. Therefore, no further excavation is warranted relative to ABPs.



PLAN VIEW
SCALE: 1"=20'



SECTION: A-A'
SCALE: 1"=10'

LEGEND

- 20' GRID
- AREA 4 OVEREXCAVATION
- HIGH PROBABILITY AREA

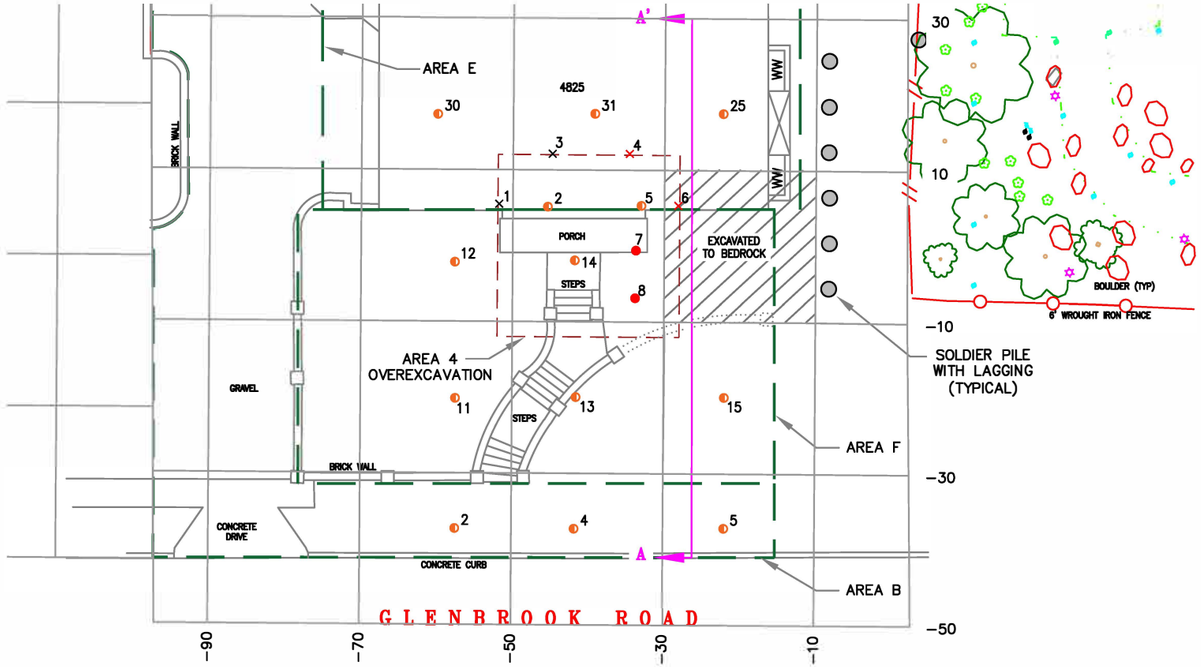
SCALE: 1" = 10'
Approximate Scale in Feet
10' 5' 0 10'

SCALE: 1" = 20'
Approximate Scale in Feet
20' 10' 0 20'

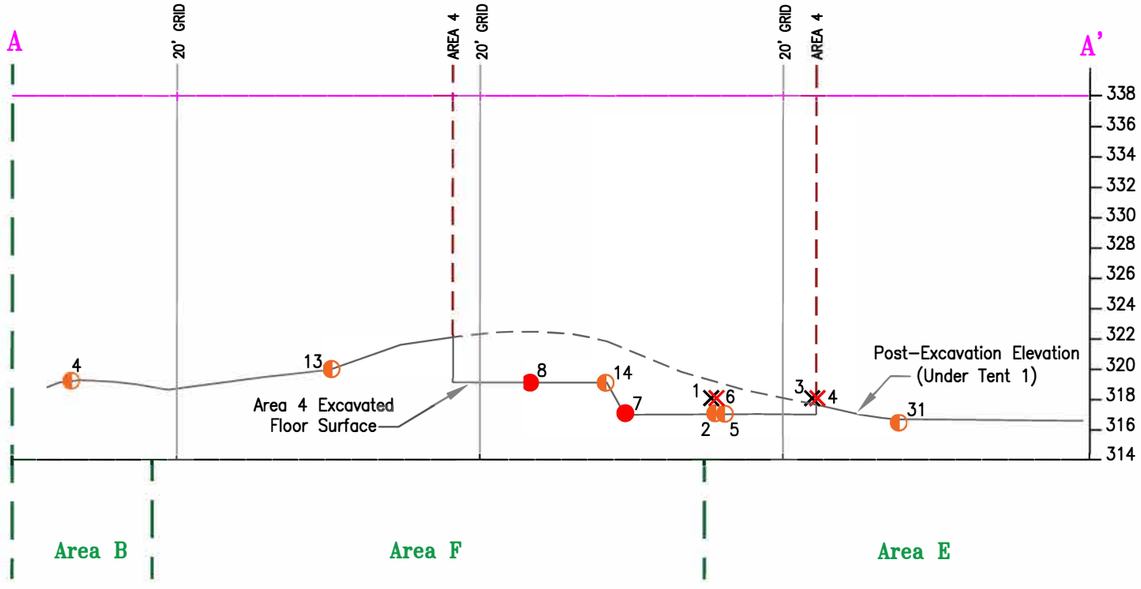
FIGURE 5-1
AREA 4
PRE-EXCAVATION
PLAN AND PROFILE
4825 GLENBROOK ROAD

SPRING VALLEY
WASHINGTON D.C.

FIGURE 1 AREA 4 PRE-EXCAVATION PLAN AND PROFILE.DWG 12/4/19



PLAN VIEW
SCALE: 1"=20'



SECTION: A-A'
SCALE: 1"=10'

LEGEND

- FLOOR SAMPLE LOCATION
- FLOOR SAMPLE CONTAINING AGENT BREAKDOWN PRODUCTS
- WALL SAMPLE LOCATION
- WALL SAMPLE CONTAINING AGENT BREAKDOWN PRODUCTS
- 20' GRID
- AREA 4 OVEREXCAVATION
- HIGH PROBABILITY AREA
- AREA EXCAVATED TO BEDROCK

SCALE: 1" = 10'
Approximate Scale in Feet
10' 5' 0 10'

SCALE: 1" = 20'
Approximate Scale in Feet
20' 10' 0 20'

FIGURE 5-2
AREA 4
POST-EXCAVATION SAMPLING
4825 GLENBROOK ROAD

SPRING VALLEY
WASHINGTON D.C.

FIGURE 2 AREA 4 POST-EXCAVATION SAMPLING.DWG 12/4/19

5.5 RISK SUMMARY

5.5.0.1 The carcinogenic risks estimated for the two receptor groups (adult residents and child residents) assumed to be exposed to COPCs in soil (via ingestion, dermal contact, the inhalation of dusts, and homegrown vegetable ingestion) at the site are summarized in Tables 5-1 through 5-4. The carcinogenic risks estimated for adult residents and child residents within the USEPA acceptable risk range of 1×10^{-6} and 1×10^{-4}, regardless of depth interval (i.e., 0-2 and 0-12 ft bgs) to which the receptors are assumed to be exposed. This indicates that assumed exposures to COPCs at the site are unlikely to result in unacceptable carcinogenic risks for the receptors evaluated.

5.5.0.2 Tables 5-1 and 5-3 show that the non-carcinogenic HIs estimated for adult residents do not exceed the benchmark of 1. Tables 5-1 and 5-3 show that the noncarcinogenic HI for child residents (0-2 feet bgs and 0-12 ft bgs) assumed to be exposed to COPCs in soils (via ingestion, dermal contact, the inhalation of dusts, and homegrown vegetable ingestion) at the site exceed USEPA's benchmark level of concern for noncarcinogenic effects of 1. Therefore, non-carcinogenic hazards were evaluated further through consideration of target organ effects. As shown in Tables 5-2 and 5-4, following consideration of target organs, no single target organ had an organ-specific HI greater than 1. This indicates that assumed exposures to COPCs at the site are unlikely to result in unacceptable non-carcinogenic hazards for the receptors evaluated.

SECTION 6
CONCLUSIONS

6.0.0.1 The primary objective of this HHRA was to quantitatively characterize the human health risk associated with post-remedy conditions for reasonably expected future residential exposure to contaminated soils at 4825 Glenbrook Road. The exposure pathways evaluated here include incidental soil ingestion, ingestion of homegrown vegetables, dermal contact with soil, and inhalation of particulates for child and adult residential receptors (Figure 3-1). Tables 5-1 through 5-4 provide a summary of the human health risk for each COPC for each receptor. The remedial objectives for all factors other than risk have been achieved; therefore, if there is no unacceptable risk associated with COPCs based on this HHRA, then no further excavation is warranted and all the remedial action objectives and remedial goal have been met.

6.0.0.2 The cumulative cancer risk estimates for adult and child residents exposed to surface soil (i.e. 0-2 ft below ground surface (bgs)) and to mixed soil (0-12 ft bgs) are within the USEPA target risk range of 1×10^{-6} to 1×10^{-4}. Thus, unacceptable cancer risks to the receptors at the site are not expected from assumed exposures to COPCs in soils.

6.0.0.3 The hazard indices (HI) estimated for adult and child residents exposed to surface soil (*i.e.*, 0-2 ft bgs) and to mixed soil (0-12 feet bgs) are below the benchmark of 1 following consideration of target organs. Thus, unacceptable hazard to the receptors at the site are not expected from assumed exposures to COPCs in soil.

6.0.0.4 The human health risk associated with current and reasonably expected future exposure to contaminated soils at 4825 Glenbrook Road was quantitatively characterized. The concentrations in the remaining soil are near or below background concentrations and residential exposure to the COPCs in soil do not pose an unacceptable risk.

6.0.0.5 Based on the above no further excavation is warranted at 4825 Glenbrook Road.

SECTION 7
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APPENDIX A
4825 GLENBROOK ROAD HUMAN HEALTH RISK ASSESSMENT (USACE 2011)

APPENDIX B
SUMMARY OF DATA INCLUDED IN THE HHRA

APPENDIX C
PROUCL INPUT AND OUTPUT

APPENDIX D
RISK CHARACTERIZATION TABLES

APPENDIX E
AREA 4 AND SURROUNDING GRIDS
VALIDATED DATA OF SOIL SAMPLES REMAINING IN PLACE
AT 4825 GLENBROOK ROAD