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JUL 0 1 2019

Mr. Brian Begley
Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
300 Sower Boulevard, 2nd Floor
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PPPO-02-5571469-19

Ms. Julie Corkran
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Begley and Ms. Corkran:

TRANSMITTAL OF THE UPDATED METHODS FOR CONDUCTING RISK ASSESSMENTS AND RISK EVALUATIONS AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, VOLUME 1. HUMAN HEALTH (DOE/LX/07-0107&D2/R10/V1)

Enclosed please find the revised *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 1. Human Health,* DOE/LX/07-0107&D2/R10/V1. This revision updates the previously issued document. Updates have been coordinated through the Risk Assessment Working Group. With these revisions, the Risk Methods Document has been updated to promote development of human health risk assessments in accordance with the most current state and federal guidance.

The U.S. Department of Energy requests acknowledgement of receipt of the subject document no later than August 15, 2019.

If you have any questions or require additional information, please contact Rich Bonczek at (859) 219-4051.

Sincerely,

Tracey Duncan
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosures:
1. Human Health Risk Methods Document, DOE/LX/07-0107&D2/R10/V1—Clean
2. Human Health Risk Methods Document, DOE/LX/07-0107&D2/R10/V1—Redline

General Reference Compendium

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DOE/LX/07-0107&D2/R10/V1

Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1. Human Health

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Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1. Human Health

Date Issued—June 2019

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Task Order DE-EM0004895

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PREFACE

This *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah Kentucky, Volume 1. Human Health,* DOE/LX/07-0107&D2/R10/V1 (previous versions issued as DOE/LX/07-0107&D2/R9/V1, DOE/LX/07-0107&D2/R8/V1, DOE/LX/07-0107&D2/R7/V1, DOE/LX/07-0107&D2/R6/V1, DOE/LX/07-0107&D2/R5/V1, DOE/LX/07-0107&D2/R4/V1, DOE/LX/07-0107&D2/R2/V1, DOE/LX/07-0107&D2/R1/V1, and DOE/OR/07-1506&D1/V1/R1), was prepared in accordance with the requirements under both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). This document is not meant to be prescriptive, rather it is meant to provide guidance for the completion of risk analyses beyond the guidance found in the most recent revision of *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2015a). Specifically, this document integrates results of comment resolution meetings and technical meetings between the regulatory agencies and the U.S. Department of Energy and provisions in the Federal Facility Agreement (FFA) for the Paducah Gaseous Diffusion Plant (PGDP) (EPA 1998a) and provides methods that should be followed when completing risk analyses to ensure consistency in risk analyses. Risk analyses considered in this document are human health risk assessments and risk evaluations prepared for both informal and formal reports. This document and its appendices, including preliminary remediation goal values, are for use at PGDP and are not applicable to other sites within the Commonwealth of Kentucky.

In accordance with Section IV of the FFA for PGDP, this integrated technical document was developed to satisfy both CERCLA and RCRA corrective action requirements. The phases of the investigation process are referenced by CERCLA terminology within this document to reduce the potential for confusion.

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FIGURES

TABLES

EXHIBITS

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ACRONYMS

AF	adherence factor
ALM	Adult Lead Model
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
AT123D	Analytical Transient 1-, 2-, 3-Dimensional Simulation of Waste Transport in the Aquifer System
bgs	below ground surface
CAS	Chemical Abstracts Service
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COPC	chemical or radionuclide of potential concern
DAF	dilution attenuation factor
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
ED	exposure duration
EE/CA	Engineering Evaluation/Cost Analysis
EF	exposure frequency
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FA	fraction absorbed
FFA	Federal Facility Agreement
FS	feasibility study
GI	gastrointestinal
HEAST	Health Effects Assessment Summary Tables
HHRAWG	Human Health Risk Assessment Working Group
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake and Biokinetic
IRIS	Integrated Risk Information System
IUR	inhalation unit risk
KAR	*Kentucky Administrative Regulations*
K_d	distribution coefficient
K_p	permeability coefficient
KDEP	Kentucky Department for Environmental Protection
KYRHTAB	Kentucky Radiation Health and Toxic Agents Branch
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MCL	maximum contaminant level
MDC	minimum detectable concentration
MOC	medium of concern
MQC	minimum quantification concentration
MQO	measurement quality objective
MUSLE	Modified Universal Soil Loss Equation
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl

POC	pathway of concern
PGDP	Paducah Gaseous Diffusion Plant
PRA	probabilistic risk assessment
PRG	preliminary remediation goal
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RAWG	Risk Assessment Working Group
RCRA	Resource Conservation and Recovery Act
RESRAD	RESidual RADioactivity (model)
RfC	reference concentration
RfD	reference dose
RG	remedial goal
RGA	Regional Gravel Aquifer
RGO	remedial goal option
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SADA	Spatial Analysis and Decision Assistance
SESOIL	Seasonal Soil Model
SF	slope factor
SI	site investigation
SMP	Site Management Plan
SQL	sample quantitation limit
SSL	soil screening level
SWMU	solid waste management unit
SWMM	Storm Water Management Model
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCE	trichloroethene
TEF	toxicity equivalence factor
UCL	upper confidence limit
UCRS	Upper Continental Recharge System
UTL	upper tolerance limit
VISL	vapor intrusion screening level
VOC	volatile organic compound
XRF	X-ray fluorescence

EXECUTIVE SUMMARY

This document describes the methods used to prepare the human health risk assessments and risk evaluations needed to complete remedial activities at the Paducah Gaseous Diffusion Plant (PGDP). This document is not meant to be prescriptive, rather it is meant to provide the framework to complete appropriate risk analyses for projects listed in the Paducah Site Management Plan (DOE 2015a) taking into account site-specific conditions at PGDP. The materials and methods presented in this document were developed following agreements reached between the U.S. Department of Energy (DOE) and the regulatory agencies during comment resolution meetings, in the Federal Facility Agreement (FFA), and at technical meetings. In this document, the human health risk analyses that will occur during each phase of remedial activities are discussed, analytical techniques are described, and several analytical tools are presented. By providing this material in a single document, consistency of human health risk assessments and evaluations performed for PGDP is ensured, thereby speeding the completion and review of risk assessments and risk evaluations. This document and its appendices, including preliminary remediation goal values, are for use at PGDP and are not applicable to other sites within the Commonwealth of Kentucky. Any endorsement of this document by Commonwealth agencies is limited to its use at PGDP.

PGDP was placed on the National Priorities List on May 31, 1994. In accordance with Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), DOE entered into an FFA with the U.S. Environmental Protection Agency (EPA) and Kentucky on February 13, 1998 (EPA 1998a). The FFA established one set of consistent requirements for achieving comprehensive site remediation in accordance with the Resource Conservation and Recovery Act and CERCLA, including stakeholder involvement. The FFA requires that an evaluation of alternative remedies to address any release be conducted when a baseline risk assessment shows that the cumulative carcinogenic risk for an individual exposed to a given release, based on a reasonable maximum exposure for both current and future land use, is greater than 10^{-6}, or a baseline risk assessment shows that the noncarcinogenic hazard quotient for an individual exposed to a given release, based on a reasonable maximum exposure for both current and future land use, is greater than 1.[1]

This document also discusses some of the methods used to complete radiological dose assessments at PGDP. Radiological dose assessments are conducted to provide information for risk managers and are separate from the risk assessment conducted per the FFA for decision making. The methods for radiological dose assessment are presented generally, and additional discussion should be held with regulatory agencies prior to initiating any radiological dose assessment project that is part of an FFA project.

This document was prepared by the PGDP Risk Assessment Working Group (RAWG). The RAWG is a multiagency, multidisciplinary group tasked with meeting the following goals:

- Produce tools that can be used to prioritize remedial activities at the PGDP.
- Develop methods to complete risk evaluations for the PGDP.
- Make the results of the risk assessments and evaluations at the PGDP more useful to risk managers.

[1] The FFA requires evaluation of alternative remedies if a baseline risk assessment shows noncarcinogenic hazard quotient greater than 1; however, the practice, according to this document and EPA guidance, is based on cumulative hazard index, not hazard from individual chemicals or radionuclides of potential concern.

- Enhance risk communication between the producers of risk assessments and risk evaluations and the users of this information (e.g., risk managers).

Organizations participating in the production of this document and their affiliations are DOE, EPA, Commonwealth of Kentucky Energy and Environment Cabinet, and Commonwealth of Kentucky Radiation Health Branch.

1. INTRODUCTION

The purpose of this document is to present the methods and approaches used for screening level, baseline human health, and residual risk assessments and risk evaluations at the Paducah Gaseous Diffusion Plant (PGDP) and provide resources [such as preliminary remediation goals (PRGs) and radiological dose-based concentrations] for completing those assessments. This document is not meant to be prescriptive, rather it is meant to provide the framework to complete appropriate risk analyses for projects listed in the Paducah Site Management Plan (SMP) (DOE 2015a) taking into account site-specific conditions at PGDP. This document is not intended to replace or modify guidance from the U.S. Environmental Protection Agency (EPA), guidance from the Commonwealth of Kentucky, or any of the tripartite agreements. Analyses of risks and hazards presented by environmental contamination at PGDP are integral to the Federal Facility Agreement's (FFA) primary objective of implementing remedies that minimize, control, or eliminate risks to human health and the environment. These analyses begin during the scoping phase (e.g., during scoping meetings and during, for example, the preliminary assessment/site investigation) when available environmental media and historical information are interpreted and compared with site-specific PRGs and other screening criteria to determine if action may be required at release sites and to plan the timing of that action. These analyses continue during investigation (e.g., the remedial investigation) when historical information, site-specific PRGs, and other screening criteria are used to focus the work plan on the risk-related problems that must be investigated and may need to be addressed during data collection. Subsequently, the results of the risk analyses are used in decision documents to justify why an action is or is not needed at a site.[2] A more streamlined approach for risk assessments is sometimes used for removal action decision documents. During the production of the decision documents, the risk analyses also are used to develop the risk-based cleanup levels used in subsequent design activities.

Several major decision points occur during the aforementioned process. These decision points often limit the scope of risk analyses performed during investigation and remedy selection, but allow for interim actions to address important environmental concerns and occur several times during the process.

Risk assessors provide information at the decision points and risk managers use that information to make decisions. Risk assessors and managers and their roles are defined as follows (EPA 1989a).

- **Risk Assessor.** An individual, team, or organization that generates site- or media-specific risk assessments for use in site-specific decision making. The assessor relies on existing databases and information [e.g., EPA Integrated Risk Information System (IRIS), health assessment documents, and program-specific toxicity information] and media- or site-specific exposure information in characterizing risk. This group also relies, in part, on regulatory agency risk assessment guidelines and program-specific guidance to address scientific policy issues and scientific uncertainties.

- **Risk Manager.** An individual, team, or organization with responsibility for or authority to take action in response to an identified risk. Risk managers *integrate* the risk characterization information provided by the risk assessor with other considerations specified in applicable statutes to make and justify regulatory decisions. Generally, risk managers include lead and regulatory agency managers and decision makers. Risk managers also play a role in determining the scope of risk assessments.

[2] There may be scenarios presented pursuant to this document that might not be commensurate with the reasonable foreseeable land use, but may serve as a reference point to decision makers.

This document presents the methods to be used to complete the analyses described herein. In addition, this document discusses many of the analytical tools that can be used to complete this process and discusses the sources of the tools. Materials and methods used to complete scoping activities, including the derivation of risk and radiological dose-based PRGs, the background concentrations of chemicals and radionuclides, and other screening criteria are in Section 2; materials and methods specific to the human health risk assessments, including work plan preparation and baseline human health risk assessment, are in Section 3, "Risk Analyses during the Remedial Investigation"; materials and methods applicable to the feasibility study (FS) risk evaluation, including cleanup level development and consideration of residual risks, are in Section 4.

Radiological dose assessments sometimes are provided to risk managers, as well, and also are discussed within these sections. The approach to radiological dose assessments discussed here is based on EPA guidance (EPA 2000a) and is specific to PGDP. The radiological dose-based concentrations are based on Federal Guidance Report 13 (EPA 1999a) and are not appropriate for other activities such as establishment of authorized limits. The exposure parameters used to derive the radiological dose-based concentrations presented are useful inputs when deriving authorized limits.

This Risk Methods Document discusses determination of cumulative risk for environmental media that are divided into separate operable units. According to the SMP, a final comprehensive site operable unit evaluation will occur following completion of each of the specific operable units at PGDP. The final comprehensive site operable unit will maximize use of the relevant data from previous cleanup activities and document the residual contamination and risk. The comprehensive site operable unit remedial investigation will include a sitewide baseline human health and ecological risk assessment to evaluate residual risks and ensure all actions taken to date, when considered collectively, are protective of human health and the environment from a sitewide perspective (DOE 2015a).

2. RISK ANALYSES DURING SCOPING ACTIVITIES

Risk analyses during site scoping activities will be performed to do the following:

- Determine if site risks are so great as to require immediate action prior to Remedial Investigation (RI)/FS (i.e., interim action);[3]
- Determine if site risks are so low as to support a no-further-action decision;
- Prioritize the further investigation of those sites not requiring an interim action or potentially requiring no further action;
- Divide exposure setting into exposure units;[4] and
- Provide information to be used in subsequent work plan development.

General depictions of the methods that will be followed to complete these analyses are shown in Figure 2.1. Figures 2.2, 2.3, 2.4, and 2.5 present specific issues related to the risk screening process (including issues related to radiological dose).

Generally, analyses completed as part of risk-based site scoping will rely on simple comparisons between site contamination data to PGDP-specific PRGs, including risk-based action and no-action concentrations,[5] radiological dose-based concentrations (if a radiological dose assessment is conducted), background concentrations, and potentially applicable or relevant and appropriate requirements (ARARs). Table 2.1 shows the significant chemicals or radionuclides of potential concern (COPCs) at PGDP with the chemical abstract services (CAS) number. Significant COPCs are chemicals that have been retained as contaminants of concern (COCs) (sometimes listed as constituents of concern) in prior risk assessments at PGDP. For the purposes of this document, these terms are essentially equivalent. These COPCs therefore are likely to be COPCs for other risk assessments, but the absence of a chemical from the list does not imply that it would not be a COPC at a PGDP site. Risk-based action and no-action concentrations and radiological dose-based concentrations for significant COPCs are presented in Tables A.1 through A.11 in Appendix A. Action and no-action soil concentrations based on radiological dose limits are derived by following EPA guidance (EPA 2000a) and are used for radiological dose assessments at PGDP.

> **COPCs**
> Use of the terms "COPCs" and "chemicals" within this document is intended to include radionuclides, as applicable.

Table A.1 presents risk-based action concentrations for contaminants in soil and sediment; Table A.2 presents risk-based action levels for contaminants in groundwater; Table A.3 presents risk-based action levels for contaminants in surface water; Table A.4 presents risk-based no-action levels for contaminants in soil and sediment; Table A.5 presents risk-based no-action levels for contaminants in groundwater;

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[3] The report from this point forward will use references to remedial action documents instead of removal action documents for simplicity. If the approach for removal actions differs in the subsequent discussions, these differences will be noted, as appropriate.

[4] A default exposure unit of 0.5 acres will be used for sites inside the PGDP industrialized area. For a site outside the industrialized area, the size of the exposure unit will be decided during scoping by agreement among the three parties.

[5] Risk-based action concentrations are the lesser of the cancer-based values for excess lifetime cancer risk (ELCR) of 1×10^{-4} and hazard-based values for hazard index (HI) of 3. Risk-based no-action concentrations are the lesser of the cancer-based values for ELCR of 1×10^{-6} and hazard-based values for HI of 0.1. Cancer-based values are based on lifetime scenario for residential and recreational use.

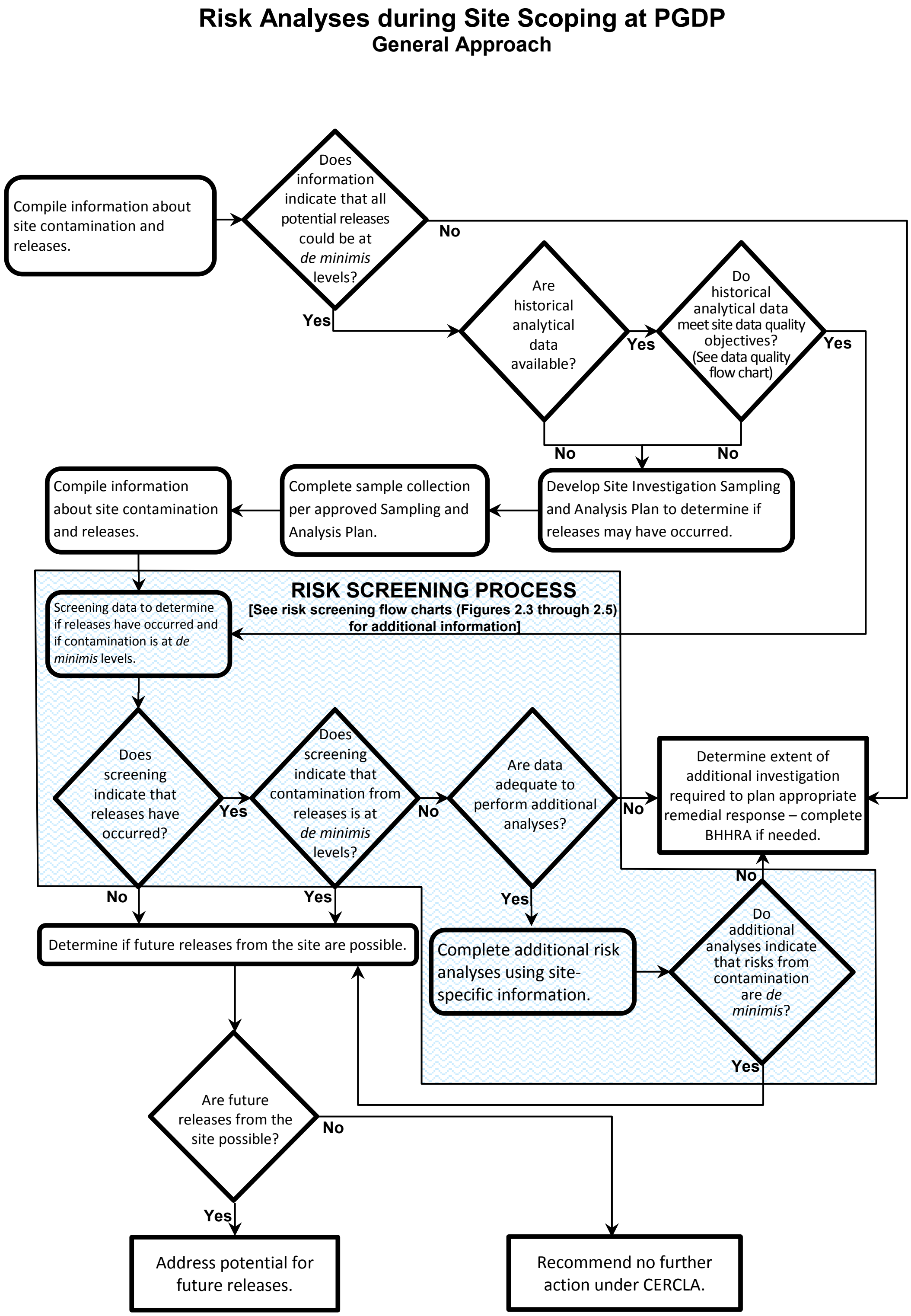


Figure 2.1. General Approach to Risk-Based Site Scoping

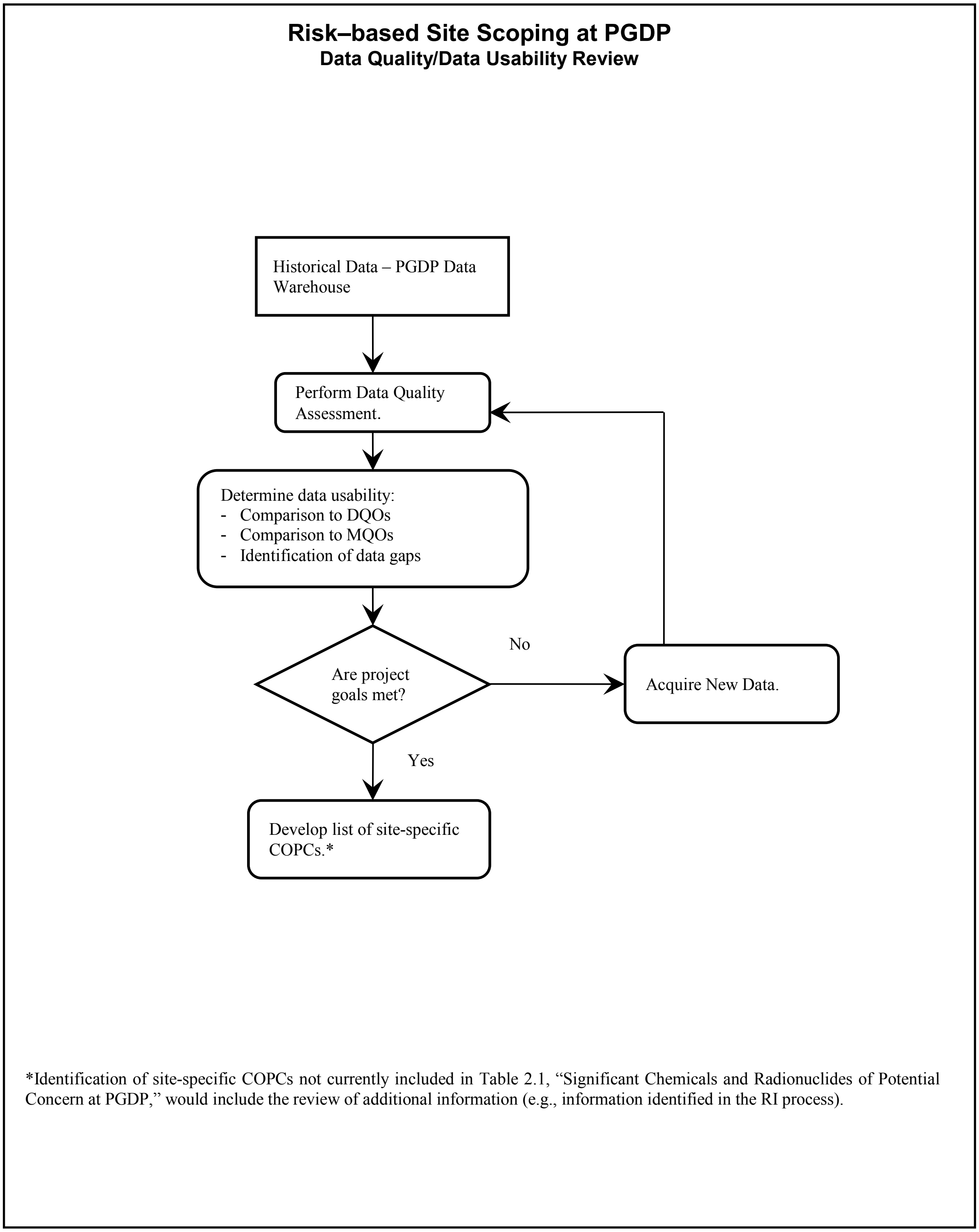
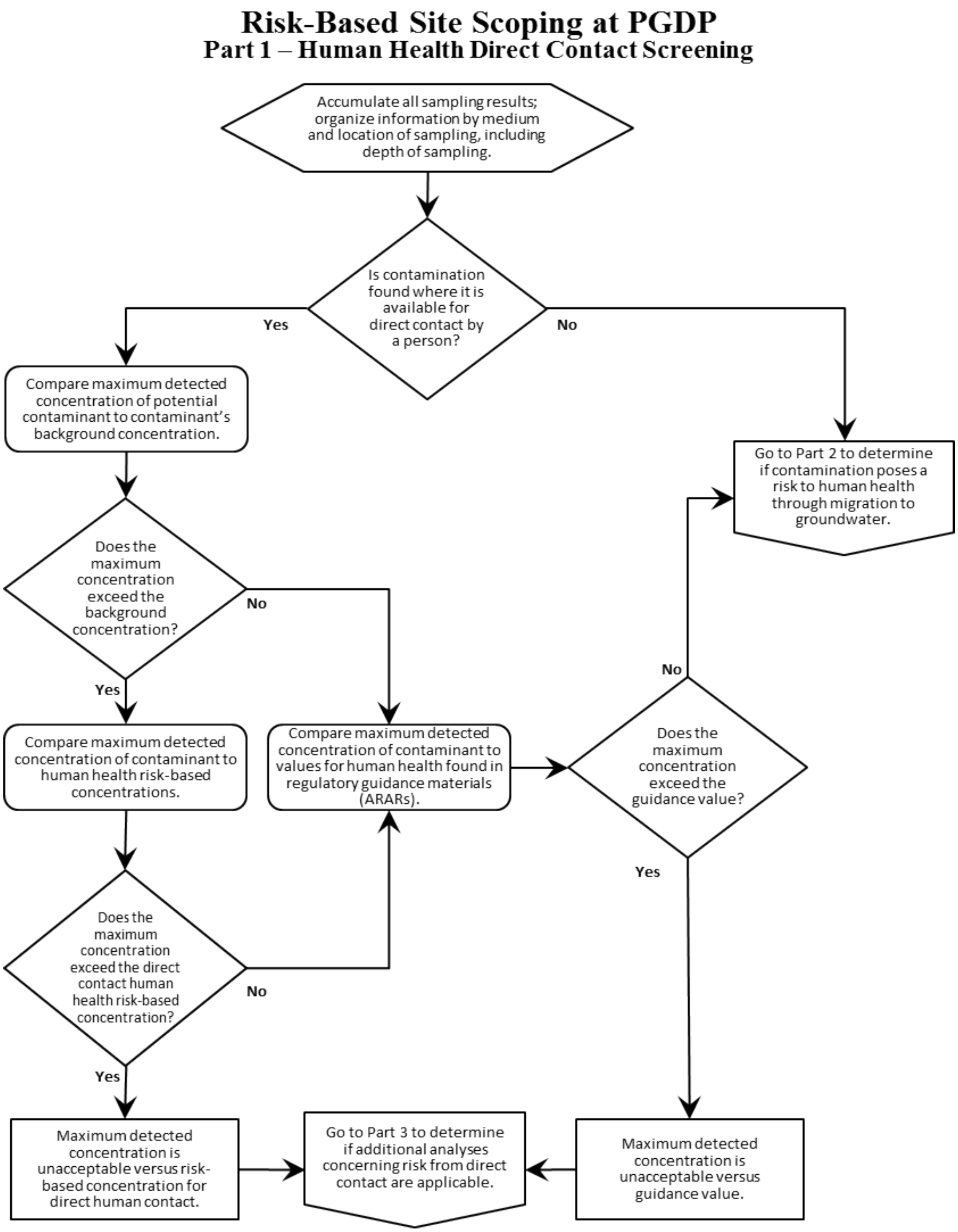
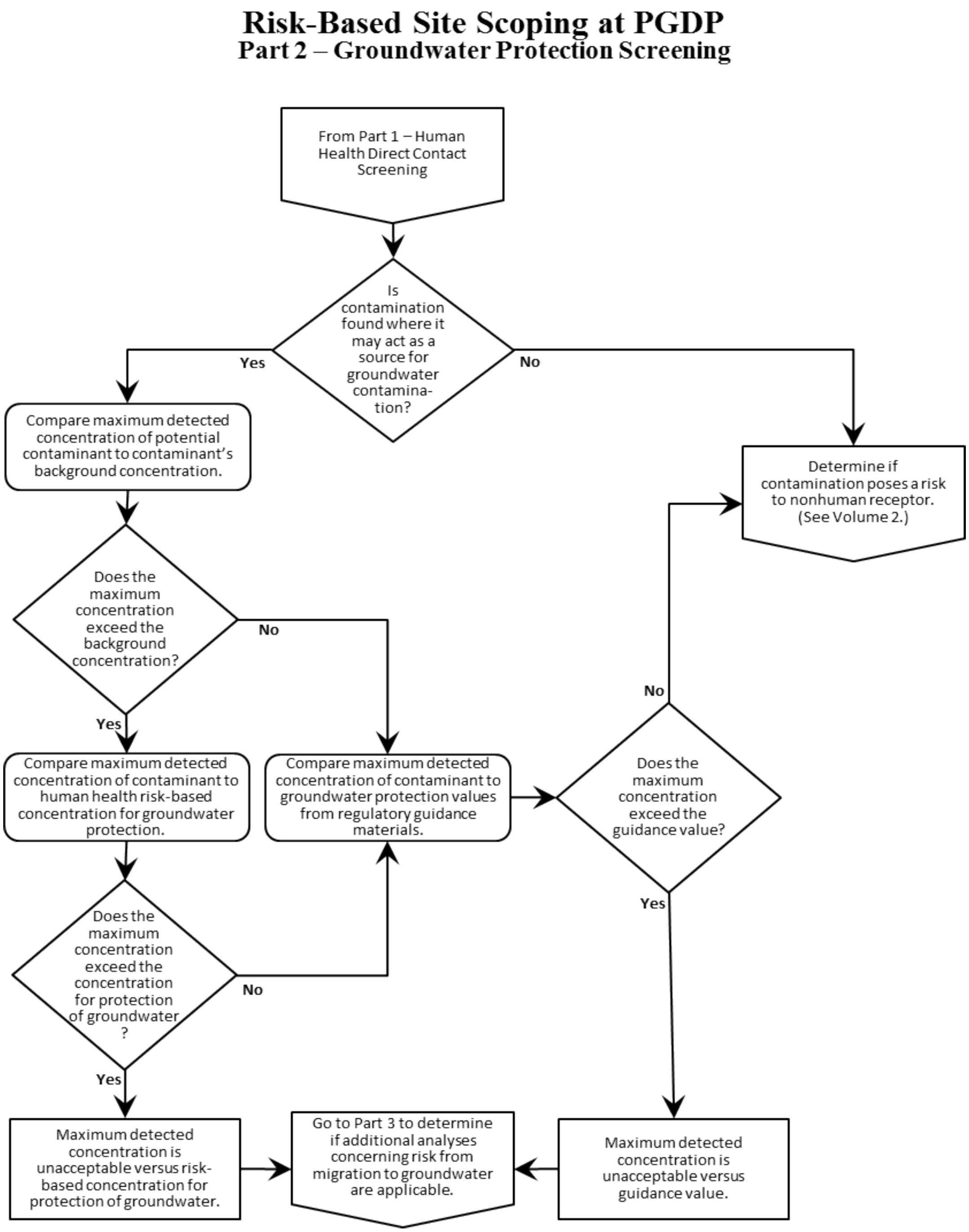


Figure 2.2. Data Quality Review to Support Risk-Based Site Scoping



NOTE: Guidance values are presented in Appendix A.

Figure 2.3. Human Health Direct Contact Screening during Risk-Based Site Scoping



NOTE: Guidance values are presented in Appendix A.

Figure 2.4. Groundwater Protection Screening during Risk-Based Site Scoping

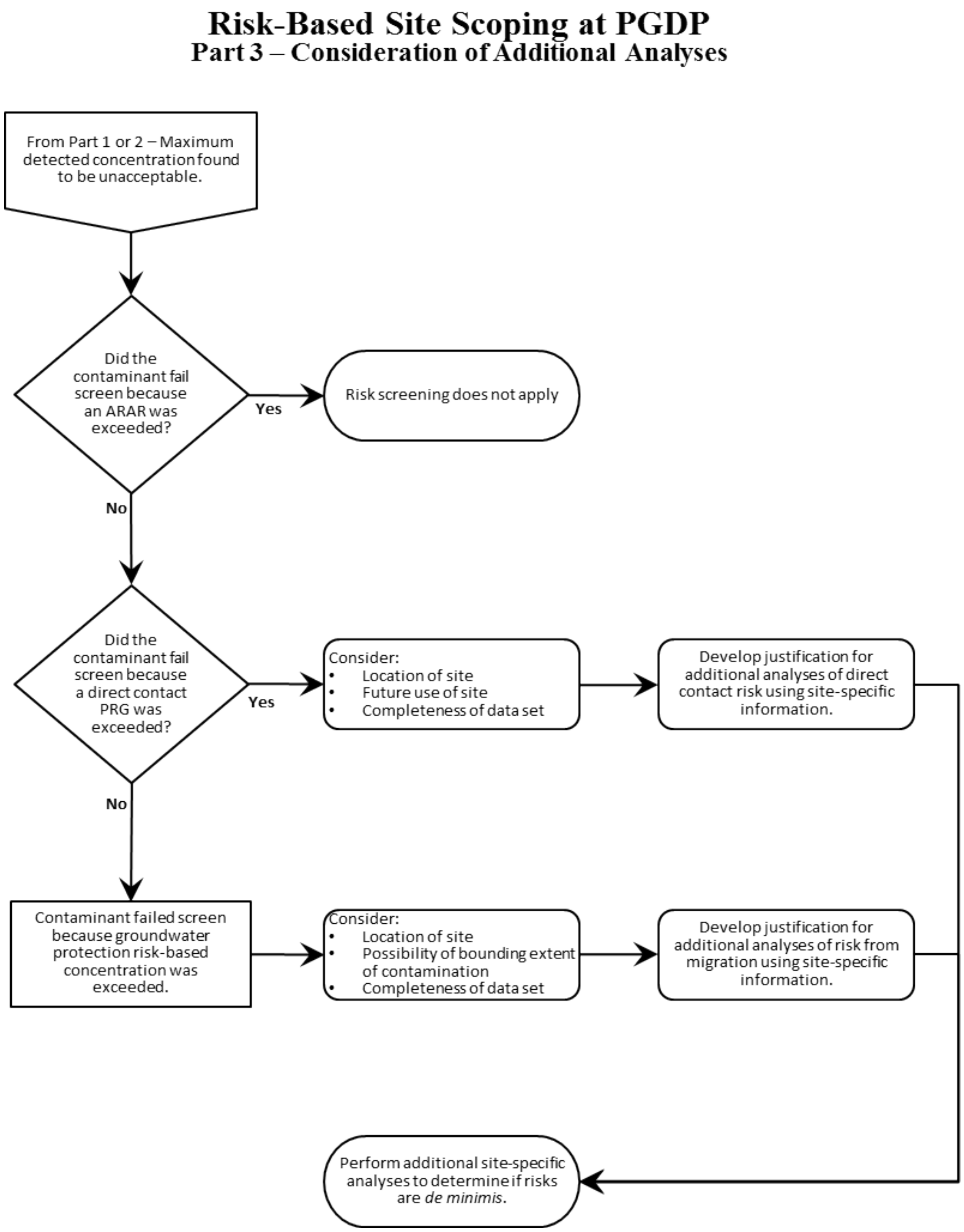


Figure 2.5. Consideration of Additional Analyses during Risk-Based Site Scoping

Table 2.1. Significant Chemicals and Radionuclides of Potential Concern at PGDP[1,2]

Inorganic Chemicals		Organic Compounds		Radionuclides	
Analyte	CAS Number	Analyte	CAS Number	Analyte	CAS Number
Aluminum	7429-90-5	Acenaphthene	83-32-9	Americium-241	14596-10-2
Antimony	7440-36-0	Acenaphthylene	208-96-8	Cesium-137+D	10045-97-3
Arsenic	7440-38-2	Acrylonitrile	107-13-1	Neptunium-237+D	13994-20-2
Barium	7440-39-3	Anthracene	120-12-7	Plutonium-238	13981-16-3
Beryllium	7440-41-7	Benzene	71-43-2	Plutonium-239	15117-48-3
Boron	7440-42-8	Bromodichloromethane	75-27-4	Plutonium-240	14119-33-6
Cadmium	7440-43-9	Carbazole	86-74-8	Technetium-99	14133-76-7
Chromium III	16065-83-1	Carbon tetrachloride	56-23-5	Thorium-230	14269-63-7
Chromium VI[3]	18540-29-9	Chloroform	67-66-3	Uranium-234	13966-29-5
Cobalt	7440-48-4	1,1-Dichloroethene	75-35-4	Uranium-235+D	15117-96-1
Copper	7440-50-8	1,2-Dichloroethane	107-06-2	Uranium-238+D	7440-61-1
Fluoride	16984-48-8	1,2-Dichloroethene (mixed)	540-59-0		
Iron	7439-89-6	*trans*-1,2-Dichloroethene	156-60-5		
Lead	7439-92-1	*cis*-1,2-Dichloroethene	156-59-2		
Manganese	7439-96-5	Dieldrin	60-57-1		
Mercury	7439-97-6	Ethylbenzene	100-41-4		
Molybdenum	7439-98-7	Fluoranthene	206-44-0		
Nickel	7440-02-0	Fluorene	86-73-7		
Selenium	7782-49-2	Hexachlorobenzene	118-74-1		
Silver	7440-22-4	Naphthalene	91-20-3		
Thallium	7440-28-0	2-Nitroaniline	88-74-4		
Uranium	NA	N-Nitroso-di-n-propylamine	621-64-7		
Vanadium	7440-62-2	Pentachlorophenol	87-86-5		
Zinc	7440-66-6	Phenanthrene	85-01-8		
		Pyrene	129-00-0		
		Tetrachloroethene	127-18-4		
		1,1,1-Trichloroethane	71-55-6		
		1,1,2-Trichloroethane	79-00-5		
		Trichloroethene[3]	79-01-6		
		Total Dioxins/Furans	1746-01-6		
		2,3,7,8-HpCDD	37871-00-4		
		2,3,7,8-HpCDF	38998-75-3		
		2,3,7,8-HxCDD	34465-46-8		
		2,3,7,8-HxCDF	55684-94-1		
		OCDD	3268-87-9		
		OCDF	39001-02-0		
		2,3,7,8-PeCDD	36088-22-9		
		1,2,3,7,8-PeCDF	57117-41-6		
		2,3,4,7,8-PeCDF	57117-31-4		
		2,3,7,8-TCDD	1746-01-6		
		2,3,7,8-TCDF	5127-31-9		
		Total Carcinogenic PAHs[3]	50-32-8		
		Benz(a)anthracene[3]	56-55-3		
		Benzo(a)pyrene[3]	50-32-8		
		Benzo(b)fluoranthene[3]	205-99-2		
		Benzo(k)fluoranthene[3]	207-08-9		
		Chrysene[3]	218-01-9		
		Dibenz(a,h)anthracene[3]	53-70-3		
		Indeno(1,2,3-cd)pyrene[3]	193-39-5		
		Total PCBs	1336-36-3		
		Aroclor 1016	12674-11-2		
		Aroclor 1221	11104-28-2		
		Aroclor 1232	11141-16-5		
		Aroclor 1242	53469-21-9		
		Aroclor 1248	12672-29-6		
		Aroclor 1254	11097-69-1		
		Aroclor 1260	11096-82-5		
		Vinyl chloride[3]	75-01-4		
		Xylenes (Mixture)	1330-20-7		
		p-Xylene	106-42-3		
		m-Xylene	108-38-3		
		o-Xylene	95-47-6		

[1] This list of chemicals, compounds, and radionuclides was compiled from COPCs retained as COCs in baseline risk assessments performed at PGDP between 1990 and 2013 (i.e., DOE 1996a; DOE 1996b; DOE 1999a; DOE 1999b; DOE 2000a; DOE 2001; DOE 2005; DOE 2008; DOE 2010; DOE 2013).
[2] List may be added to during project scoping based on additional information.
[3] Chemical is considered a mutagen (see Table B.5).

Table A.6 presents risk-based no-action levels for contaminants in surface water; Table A.7 presents risk-based no-action levels for contaminants in soil that are protective of groundwater drawn from the Regional Gravel Aquifer (RGA) immediately adjacent to a contaminated area; Table A.8 presents radiological dose-based levels for radionuclide contaminants in soil and sediment; Table A.9 presents radiological dose-based levels for radionuclide contaminants in groundwater; Table A.10 presents radiological dose-based levels for radionuclide contaminants in surface water; and Table A.11 presents radiological dose-based levels for radionuclide contaminants in soil that are protective of groundwater drawn from the RGA immediately adjacent to a contaminated area. Methods used to develop the risk-based and radiological dose-based screening values are presented in Appendix B of this document.

Screening values for the residential scenario are used in data screening to develop the list of COPCs in a baseline human health risk assessment (see Section 3.3.3.2 for additional information). Additional scenarios/receptors are used to determine early action screening.

All groundwater screening is performed using the resident. Of the two receptors (i.e., child and adult), use of the smaller child screening value is more protective of human health. Note that values for soil deemed protective of groundwater also are available and are based on the resident only.

The surface water screening values selected are a location-specific decision. For all areas along effluent ditches or along creeks carrying effluent, the industrial worker screening values are appropriate. Additionally, at areas outside the industrialized areas, use of the recreator values is appropriate. Of the three recreator values available, the child recreator values are the smallest and most protective of human health. Note that two different sets of recreator values are available; these are a set for screening shallow water courses under a wading scenario and a set for screening deeper water courses under a swimming scenario. While which of these two recreator screening values to use is a location-specific decision, general guidance should be to use the wading values for most areas. If exposure by a resident to surface water is of concern, use of the recreator values is appropriate, because rates of contact for the recreator were selected assuming that the individual would be a local resident.

Determining which soil or sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker risk-based screening values is appropriate. [Surface soil is defined as 0–1 ft below ground surface (bgs) (EPA 2018a).] However, if the scenario involves outdoor maintenance type activities, the outdoor worker risk-based screening values also should be considered. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (i.e., soil from the surface down to 10 or 16 ft bgs, as appropriate), use of the excavation worker risk-based screening values is appropriate. For locations, outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident risk-based screening values is appropriate. As with the surface water values, the child resident risk-based screening values are the most conservative (in terms of protecting human health). Generally, the recreator risk-based screening values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident risk-based screening values are more appropriate for grassy fields. Finally, the outdoor worker risk-based screening values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. If screening needs to consider shorter-term exposures to both surface and subsurface soil in locations outside the industrialized area, excavation worker screening values can be used.

A comparison of analyte concentrations detected in soil and groundwater samples to analyte concentrations detected in background samples will be performed as part of the development of the list of COPCs as shown in Figures 2.3 and 2.4. The values used to represent background are presented in Appendix A. Appendix E also contains a discussion of the derivation of the background values. Only surface soil (0–1 ft bgs), subsurface soil (1–16 ft bgs), and groundwater drawn from the RGA and McNairy Formation will be included in comparison with background concentrations because background values are available only for these media at PGDP (DOE 2000b). The RGA is the lateral flow system that constitutes the shallow Class II groundwater aquifer beneath PGDP and contiguous lands to the north. The McNairy formation flow system is below the RGA.

> **PEGASIS**
> The Portsmouth/Paducah Project Office (PPPO) Environmental Geographic Analytical Spatial Information System (PEGASIS) originally was pioneered by the Kentucky Research Consortium for Energy and the Environment (KRCEE), PEGASIS provides dynamic mapping and environmental monitoring data display for PGDP.
>
> PEGASIS is available online at the following link: https://pegasis.pad.pppo.gov/

Background concentrations for chemicals and radionuclides in soil and RGA and McNairy Formation groundwater to be used during site-scoping activities are presented in Tables A.12 and A.13, respectively. In the background screen for soil and groundwater, the maximum detected concentration of the COPCs will be compared to the values presented in Tables A.12 and A.13. Analytes for which the maximum detected concentrations [or maximum activity concentrations for radionuclides with reported values greater than their minimum detectable concentration (MDC)] is less than background will be removed from the data set used in the risk assessment. The background values for soil presented in Table A.12 represent upper tolerance limits (UTLs) of background except as noted in the table footnotes. Additional comparisons of the maximum detected analyte concentration or maximum activity concentration for radionuclides with the range of background values also may be conducted in the uncertainty section of the risk assessment (discussed in Section 3.3.7) to further evaluate if a COPC represents a site contaminant. Because surface water and sediment are transient media in which concentrations and activities can change rapidly, PGDP does not plan to develop surface water and sediment background. Currently, a comparison of the full range of concentrations and activities in upstream versus downstream samples is to be used to determine if a unit or area is releasing contaminants to the environment. Additionally, as part of the analysis, the data adequacy at both the upgradient location and potentially contaminated site must be considered.

To perform the screening analyses during site scoping, available data must be deemed sufficient to determine the potential contamination at a site. Data used during site scoping will be evaluated using the systematic approach presented in Figure 2.2 to ensure that risk analyses employ data of known quality and that the appropriate quantities and types of data are acquired. This systematic approach also is used to evaluate data during remedial investigation, as discussed in Section 3. Detailed discussions related to data quality/data usability review are provided in Section 3.3.3.1.

In presenting the results of risk-based site scoping analyses, several tables should be prepared using a format that allows for easy identification of those chemicals, compounds, and radioisotopes with the potential to contribute to unacceptable levels of risk. If a radiological dose analysis is conducted, similar tables should be prepared to present the results of the radiological dose-based site scoping analysis. To complete the risk-based screening analyses for site scoping, tables will be prepared for soil and sediment, groundwater, and surface water screening. For soil and sediment, up to four tables will be prepared using the risk-based screening levels. These tables offer comparisons among the following:

- Maximum detected concentrations and action levels,
- Maximum detected concentrations and no-action levels,
- Maximum detected concentrations and levels deemed protective of groundwater, and

- Maximum detected concentrations and established background values for naturally occurring inorganics and radionuclides.

For both groundwater and surface water, two tables will be prepared using the risk-based screening levels. These tables offer comparisons between the following:

- Maximum detected concentrations and action levels and
- Maximum detected concentration and no-action levels.

In addition, summary tables providing the following information will be prepared for each medium:

- Lists of chemicals and radionuclides analyzed for but never detected;
- A presentation of summary statistics, including a comparison of detected analytes with background;
- Lists of sampling stations that contain a contaminant at a concentration greater than the action screening level; and
- Lists of sampling stations that contain a contaminant at a concentration greater than the no-action screening level.

2.1 ANALYSES SUPPORTING ACTION PRIOR TO RI/FS

As discussed in the FFA, interim actions are required at those sites that pose an imminent risk or hazard to human health and the environment. Generally, sites requiring an interim remedial or removal action are those at which contamination with a single or small number of analytes presents a total carcinogenic risk greater than 1×10^{-4} or a systemic toxicity value (i.e., hazard index or HI) greater than one and for which the risk analyses indicate that exposure is occurring under current use patterns. For these sites, the screening risk analyses will be limited to that described here because additional analyses will slow response time; however, to complete later decision documents, estimates of cumulative risk will be developed. [Note: The exact decision point for interim action is a project-specific decision. The values included here are for illustration only. For example, it is possible that a site is a yard that contains source material that might present a principal threat. At such sites, the scoping analyses may not include a risk-based screen. Additionally, note that risks posed to nonhuman receptors (e.g., ecological risk) may call for an interim remedial or removal action even when risks to humans are negligible.] To derive these estimates of cumulative risk, the methods in Equations 1, 2, 3, and 4 will be used. Methods to derive radiological dose estimates are similar and are not presented in the equations. For example, when deriving radiological dose estimates, the dose-based PRG derived using a target dose of 1 mrem/yr would replace the "Cancer PRG," and "Target Risk" would be replaced with a target dose of 1 mrem/yr.[6]

$$\text{Analyte-specific Risk} = \frac{\text{MAX}}{\text{Cancer PRG}} \times \text{Target Risk} \qquad \textbf{[Eq. 1]}$$

where: MAX = Maximum detected concentration in a medium.
Cancer PRG = The medium-specific risk-based no-action screening value for the analyte.
Target Risk = The target risk upon which the risk-based PRG calculation was based (1×10^{-6}).

NOTE: This relationship is not applicable to non-linear based PRGs [e.g., some vapor intrusion screening levels (VISLs)]

[6] The radiation target dose 1 mrem/year is not a DOE, EPA, or Kentucky standard. Also, as with risk-based PRGs for chemicals and radionuclides, dose-based PRGs are used in project screening only and should not be considered clean-up values.

$$\text{Total Risk} = \sum \text{Analyte-specific Risks} \quad \textbf{[Eq. 2]}$$

where: Analyte-specific risk is the result from Eq. 1.

$$\text{Analyte-specific Hazard} = \frac{\text{MAX}}{\text{Hazard PRG}} \times \text{Target Hazard} \quad \textbf{[Eq. 3]}$$

where: MAX = Maximum detected concentration in a medium.
Hazard PRG = The medium-specific risk-based no-action screening value for the analyte.
Target Hazard = The target hazard upon which the risk-based PRG calculation was based (0.1).

$$\text{Total Hazard} = \sum \text{Analyte-specific Hazards} \quad \textbf{[Eq. 4]}$$

where: Analyte-specific Hazard is the result from Eq. 3.

[Note: When performing these calculations, total risk and hazard estimates will be developed within medium for only the scenario appropriate to the unit's or area's location and use because the reasonably anticipated future land use at a site is significant in defining source material as a principal or low-level threat waste (EPA 1991a). A total risk (or hazard) over all media may be estimated if exposure to contaminants in multiple media may occur. Also, when summarizing this information, the analytes driving the medium-specific total risk and hazard and the major uncertainties in the estimate will be reported, and a total risk or hazard estimate over all media may be reported if this is deemed appropriate.]

The results provided by these analyses may not be sufficient for documentation of final actions, and additional risk assessment and risk evaluation may be needed to meet reporting requirements. Items not provided by these analyses include the following:

- The identification of use scenarios of concern, including consideration of sensitive subpopulations;
- The identification of pathways of concern (POCs);
- Consideration of risks due to the transformation, degradation, or migration of contamination (although a comparison of analyte concentrations in soil to screening values protective of groundwater provides this in part); and
- An analysis of uncertainties, including the effect of uncertainties on the resulting risk estimates.

2.2 ANALYSES SUPPORTING NO FURTHER ACTION DECISIONS

No further action can be selected for those sites where it can be demonstrated that no contamination is present that exceeds no-action levels [i.e., risks are *de minimis* (see Figures 2.1–2.5)] or ARARs. (Note: Non-risk issues also must be considered in making this decision. At some sites without unacceptable risk, a no further action decision may not be appropriate because of non-risk concerns.)

In calculating the risk estimate for this decision, the tables discussed earlier and the equations presented earlier will be used. In summarizing this information, the estimated total risk and hazard from all contaminants under the appropriate use will be reported, and the future risk or hazard posed by contaminant transformation, degradation, and migration will be considered qualitatively. In addition, the uncertainties associated with the screening comparison will be discussed, and the effect of these uncertainties on the total risk and hazard estimates for each scenario will be described. Note: As part of this screening analysis, the total risk or hazard over all media will be presented and discussed to ensure that a no further action decision is appropriate.

2.3 ANALYSES USED TO PRIORITIZE FURTHER INVESTIGATIONS

Remedial activities at PGDP are prioritized to ensure that funds allocated to PGDP for remedial actions are directed toward those units or areas that pose the greatest risk to human health and the environment. This prioritization will ensure that these actions provide the maximum benefits in risk reduction. When necessary, risk and hazard estimates for prioritization will be calculated using the tables and equations presented earlier. When summarizing this information, the estimated total risk and hazard from all contaminants under both industrial and residential use will be reported, and the potential future radiological doses and risks posed by contaminant transformation, degradation, and migration will be considered qualitatively. In addition, the uncertainties associated with the screening comparison will be discussed, and the effect of these uncertainties on the total risk and hazard estimates for each receptor group will be estimated qualitatively.

3. RISK ANALYSES DURING THE REMEDIAL INVESTIGATION

At PGDP, risk analyses occur at three points during the RI of sites: during the preparation of the RI work plan (and some sampling and analysis plans); following implementation of the initial round of work described in the RI work plan (if needed to plan contingency sampling); and during the preparation of the RI report. Analyses occurring at each of these points are discussed in the following sections. (Note that radiological dose assessments are not specifically described in the following. Generally, if a radiological dose assessment is provided, it will be presented in the same format as the risk assessment.)

3.1 ANALYSES DURING WORK PLAN DEVELOPMENT AND IMPLEMENTATION (SCREENING RISK ASSESSMENTS)

As noted in Section 2.4, the screening analyses performed during the site scoping can be used directly in work plan development to reduce the cost of subsequent RI/FS activities. This section discusses the screening analyses that will be performed as part of work plan development and describes the material that will appear in work plans and sampling and analysis plans. (Note: In the following material, "work plan" is used generically for work plans and for those sampling and analysis plans in which risk screening is of use.)

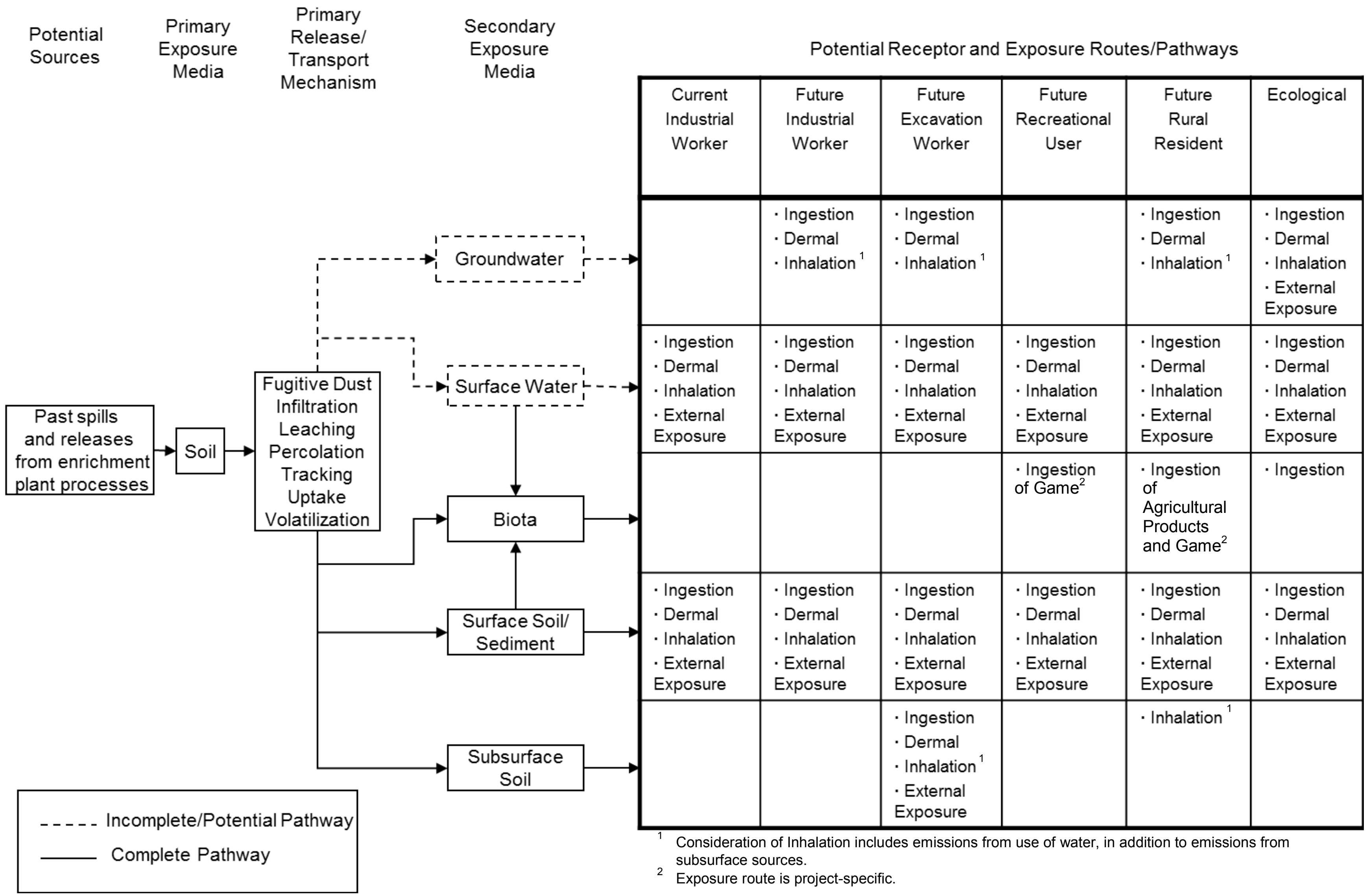
Generally, in work plans, the majority of the risk-related information will appear as part of the initial evaluation. In the work plan's initial evaluation, the scope, objectives, and methods for the baseline risk assessment will be related; preliminary conceptual site models will be presented; laboratory analytical (or quantitation) limits will be discussed relative to no-action screening levels developed specifically for PGDP (i.e., risk-based PRGs in Appendix A); and a preliminary list of COPCs (preliminary COPCs) will be identified. Risk-related information also will appear in the introduction, site characterization summary, and alternatives development description contained in most work plans.

3.1.1 Analyses Appearing in the Introduction of the Integrated RI/FS Work Plan

In the introductory chapter of work plans, the requirements for risk assessments and analyses will be used to help develop the DQOs for the RI. DQOs are qualitative and quantitative criteria used to establish requirements for sample collection and analysis and are based on the needs and intended uses of the data. As a primary user of RI data, the consideration of risk analyses is integral to this process.

Development of DQOs follows a series of steps. The seven steps in the process are shown in a flowchart found in EPA QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006a). Similar steps are found in DOE guidance, *Institutionalizing the Data Quality Objectives Process for EM's Environmental Data Collection Activities* (DOE 1994). The purpose and goal of each step are described in the text in EPA QA/G-4, accompanying the flowchart. EPA QA/G-4 also includes a summary of key elements that also may be of use in developing DQOs for specific investigations. The role of risk assessment within each of these steps is briefly discussed in the remainder of this section.

During Step 1, State the Problem, of the DQO process, risk analyses will be used to identify qualitatively the preliminary COPCs, receptors that may be exposed to contaminants, locations at which exposure may occur, and pathways by which contaminants may reach these locations. This information will be used to develop the conceptual site model against which new data collected as part of the RI can be compared. An example conceptual site model is presented in Figure 3.1.



[1] Consideration of Inhalation includes emissions from use of water, in addition to emissions from subsurface sources.
[2] Exposure route is project-specific.

Figure 3.1. Example Risk-Based Conceptual Site Model

Risk analyses also will be used during Step 1 of the DQO process to ensure that the risk management issues are addressed during the investigation. For example, in the approved sampling and analysis plan for SWMU 2 of Waste Area Grouping 22 (DOE 1996a), the problem is stated:

> In the past, uranium and multiple COCs were disposed of at SWMU 2. These contaminants have been shown by previous work to be migrating (vertically and horizontally) from the waste cells and show the potential for subsurface migration from the SWMU to the RGA at concentrations or activities that may pose risk to human health and the environment....

Risk analyses will be used during Step 2, Identify the Goals of the Study, of the DQO process to clearly pose questions that must be addressed during the RI. Generally, questions developed during Step 2 of the process will be related to the contamination concentrations that may remain at or migrate from a site and not pose unacceptable risk. Inputs to these questions include contaminant fate and transport and activity patterns of current and future receptors. For example, in the SWMU 2 sampling and analysis plan (DOE 1996a), primary questions related to risk assessment and risk management included the following:

- Will the contaminants migrate (and how) to the RGA at unacceptable concentrations?
- Is there lateral/vertical contaminant movement in the Upper Continental Recharge System (UCRS)?
- What are the chemical characteristics of the waste?

Risk analyses will be used during Step 3, Identify Information Inputs, of the DQO process to establish the preliminary remedial action objectives (RAOs) that must be achieved to mitigate risk to human health and the environment and to provide information useful in determining which alternatives may achieve these objectives. RAOs are criteria used in the FS to aid in the alternative development and selection process. They are site-specific goals that establish the primary objectives and extent of cleanup required by a CERCLA remediation (EPA 1988) and consider COCs, media of concern (MOCs), and potential exposure pathways. The screening levels presented in Section 2 are concentration goals that will make up a portion of the preliminary RAOs for each project. For all investigations at PGDP, the basis of this portion of the human health RAO is to prevent exposure to contaminated media that results in a cumulative (or total) excess lifetime cancer risk (ELCR) greater than 1×10^{-6} or a cumulative (or total) HI greater than or equal to one. This generalized RAO will be enhanced on a project-specific basis as needed (e.g., to include radiological dose concerns).

Risk analyses will be used during Step 4, Define the Boundaries of the Study, of the DQO process to aid in the determination of the spatial and temporal boundaries within which samples must be collected or to which contaminant concentrations must be modeled. Risk analyses will be used to identify spatial boundaries by delimiting the locations both at a SWMU and away from the SWMU at which exposure to contaminants may occur (i.e., exposure points). Risk analyses will be used to identify temporal boundaries by delineating the present and future receptors that may be exposed to contamination and the periods during which these receptors potentially may be present at the exposure points. This information will be used, in turn, to determine the modeling needs for the RI.

Risk analyses will be used during both Steps 3 and 5, Develop the Analytic Approach to the Decision, to set the risk-based limits inherent in these rules and to identify the data required to determine if these limits may be exceeded, consistent with Section XII of the Paducah FFA (EPA 1998a). A primary decision rule that will be included in all work plans for PGDP will note that action must be considered if the risk or hazard posed by contamination at or migrating from a site exceeds allowable limits of an ELCR greater than 1×10^{-6} or HI greater than or equal to one. For example, in the SWMU 2 sampling and analysis plan (DOE 1996a), the leading decision rule (D1) is as follows:

> If any of the constituents shown in Table 5.2 are migrating or could migrate (based on RESRAD for uranium and technetium-99 (^{99}Tc) and best available 2- or 3-D model for other constituents) from the burial pits, soil matrix, and/or UCRS to the RGA in the future and are found to pose a risk greater than 1×10^{-6} (excess lifetime cancer) or an HI = 1 (noncancer), then an action to control the migration will be evaluated.

Similarly, the following inputs necessary to make this decision are common to all investigations:

- Chemical-specific exposure point concentrations (EPCs) in environmental media, including contaminant concentrations in waste;
- Land-use assumptions (i.e., which scenarios need to be considered);
- Exposure pathways and exposure routes for all current and potential future receptors;
- Exposure units for the investigated area;
- Modeling parameters;
- Risk estimates for each receptor, including sensitive subpopulations, if applicable.

Risk analyses will be used in Step 6, Specify Performance or Acceptance Criteria, by providing the risk-based goals and contaminant concentrations and activities related to these goals that can be used either quantitatively or qualitatively to set decision error limits. As noted previously, consistent with the PGDP FFA, the risk-based goals to be used in all investigations are 1×10^{-6} for ELCR and 1 for HI. For a radiological dose assessment done to provide information for risk managers, the radiological dose-based goal is 1 mrem/year. The concentrations and activities related to these goals are the PRGs presented as the no-action levels in Section 2.

Risk analyses will be used in Step 7, Develop the Plan for Obtaining Data, to ensure that the sampling strategy proposed for all investigations meets the minimum requirements needed to achieve answers to the risk-related decision rules. To ensure that this is achieved, all sampling proposed as part of all investigations will be critically reviewed against the needs established under the decision rules for the investigation. Sampling that does not provide information useful to answering risk-related decisions will be justified on another basis.

3.1.2 Analyses Appearing in Prior Characterization Chapter of the Integrated RI/FS Work Plan

In the prior characterization chapter of work plans, results of previous risk evaluations performed for the site under investigation or related to the site will be summarized. Generally, these summaries will consist of results from evaluations performed during the Phases I and II Site Investigations (CH2M HILL 1991 and 1992) or baseline risk assessments and screening analyses performed to support earlier decisions at or near the site, such as prioritization activities.

In presenting the information from previous evaluations, **no attempt will be made to correct any errors or update any values contained in the earlier reports**. All information contained in the earlier report will be presented without change; however, any errors or uncertainties affecting the results will be identified. Additionally, because in earlier baseline risk assessments, results were not summarized in a consistent format, an attempt will be made to present the results taken from these earlier reports in two-way tables. [Note: The format for the two-way table is patterned after the format in Exhibits 8-2 and 8-3 of Risk Assessment Guidance for Superfund (RAGS), Part A, (EPA 1989a) and is consistent with the risk characterization tables found in RAGS, Part D (EPA 1998b).] The exact format for tables presented in RAGS, Part D, is not used for the PGDP risk characterization tables because the Risk Assessment Working Group (RAWG) determined that the tables presented in this Risk Methods Document are adequate to meet the intent of RAGS, Part D. In addition, when summarizing the results of previous assessments, the scenarios, pathways, contaminants, and MOC for each unit or area under investigation will be listed, and major uncertainties affecting the risk assessment results will be noted.

An example of the format for the "two-way table," adapted from Table 5.78 of Appendix L.1 of the approved *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Grouping 1 and 7 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996b), is shown in Exhibit 3.1. The example table shown in the exhibit will be used to summarize risk assessment results because it allows easy identification of scenarios of concern (i.e., value in column entitled "Total Risk," COCs (i.e., values in the column entitled "Chemical-Specific Risk"), and POCs (i.e., values in the row entitled "Pathway Risk"). In addition, the chemicals and pathways driving total risk can be easily identified, and the risk related to exposure to each environmental medium can be easily derived (i.e., by summing the appropriate pathway totals). Finally, the blank cells in the table and the associated explanation for these blanks show where information was insufficient to allow risks to be characterized.

Exhibit 3.1. Example Two-Way Table for Presentation of Historical Risk Assessment Results

SWMU 136 Excess Lifetime Cancer Risks for Future Rural Resident							
Analyte	**Ingestion of Groundwater**	**Dermal Contact with Groundwater**	**. . . .**	**Ingestion of Soil**	**. . . .**	**Chemical-specific Risk**	**Total Risk**
Trichloroethene	2.30E-05	4.17E-06	. . . .		. . . .	8.35E-05	
Benzo(a)anthracene			. . . .	8.78E-09	. . . .	1.35E-06	
Benzo(a)pyrene			. . . .	1.20E-07	. . . .	1.83E-05	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Uranium-238			. . . .	1.53E-09	. . . .	3.05E-07	
Pathway Risk	2.32E-05	4.23E-06	. . . .	1.72E-07	. . . .		
Total Risk							1.10E-04

Note: The reasons for blank cells are discussed as part of the risk assessment/evaluation. Generally, blank cells will result from unavailable or inadequate data.

3.1.3 Analyses Appearing in Initial Evaluation Chapter of the Integrated RI/FS Work Plan

In the initial evaluation chapter of work plans, the methods to be used to complete the baseline risk assessment for the units or areas under investigation will be discussed, and a preliminary evaluation of historical information, including a comparison of concentrations and activities of analytes in environmental samples with risk-based screening values (e.g., NALs and ALs, chemical-specific ARARs, etc.) and a comparison of analytical limits with background concentrations, will be presented. This information will be used, in turn, to develop the field sampling plan contained in the work plan.

The description of the methods to be used to complete the baseline risk assessments for the units or areas under investigation will follow that presented in Section 3.3 of this document. Generally, this material will delineate clearly the scope and objectives of the baseline risk assessment and briefly describe the activities that will occur during the data evaluation (i.e., identification of COPCs); exposure assessment; toxicity assessment; risk characterization; and remedial goal option (RGO) development stages of the baseline human health risk assessment. This material also will summarize the results that will be obtained from each stage of the baseline risk assessment. As part of this discussion, conceptual site models for each unit or area under investigation will be presented.

The preliminary evaluation of historical information presented in this chapter of the work plan will summarize the information presented in earlier chapters of the work plan and evaluate this information against the characterization and inventory of wastes, information status of key assessment factors, and release potential from contaminant sources. As part of the characterization and inventory of wastes, comparison tables similar to those discussed in Section 2 will be prepared. Because additional screening criteria may need to be considered, the comparison tables prepared as part of site scoping activities may not be able to be transferred directly to the work plan. An example of the comparison table that will be used in work plans to compare the PGDP screening PRGs to analytical results from soil (and sediment) and groundwater (and surface water) is shown in Exhibit 3.2.

Exhibit 3.2. Presentation of Screening Assessment Results in the RI Work Plan

Analyte	Soil (mg/kg or pCi/g)			Groundwater (μg/L or pCi/L)			
	Maximum[1]	PRG[2]	Method Detection Limit[3]	Maximum	PRG	MCL[4]	Method Detection Limit
# 1							
# 2							
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
# N							

[1] This value will be the maximum detected value for the medium reported in previous investigations. The qualifier codes attached to the value, if any, will be included with the value.
[2] The risk-based PGDP screening preliminary remediation goal (i.e., PRG) that appears in this table will be the no-action child residential use PRGs taken from Appendix A.
[3] This value will be the project-specific value reported in the Quality Assurance Project Plan of the work plan (or the appropriate chapter of sampling and analysis plans). For radionuclides, this column should have the heading "MDC" or "MDQ" and present MDCs from Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) guidance.
[4] The maximum contaminant levels (i.e., MCLs) are drinking water standards and will be taken from the most recent information.

After completing the comparison table for each site, the analytes that previously were detected or are expected to be present and that have detection limits (MDCs for radionuclides) that exceed the PRGs will be reported. The analytes with detection limits exceeding PRGs will be reported because the quantitation limit (or method detection limit for chemicals or MDC for radionuclides) used for samples providing data for risk assessment should be less than those concentrations that may have an impact on human health or the environment. It is important to note that, although this evaluation may show that some quantitation limits exceed their respective screening criteria, this evaluation alone will not be used to establish the analytical quantitation limits for a project. The analytical limits will be established considering this information and factors such as site history and potential actions.

Material in the comparison tables also will be used to compile a list of preliminary COPCs for each unit or area under investigation. An analyte will be placed on this preliminary list if the concentration or activity concentration of the analyte at a unit or area exceeds one or more of the screening criteria. Note: Unless it can be shown that cross-media contamination is not present, the list of preliminary COPCs will be compiled over all media. If it can be demonstrated that cross-media contamination is not likely, then a list of preliminary COPCs will be compiled for each medium to be investigated during the project. These lists will provide risk managers with information that can be used in the initial selection and screening of alternatives. In addition, this list can be used to target the analyte list for the project to ensure that analytical costs are appropriate for the project.

An example of the comparison table that will be used in work plans to compare background values to analytical results for inorganic chemicals and radionuclides in soil and groundwater is shown in Exhibit 3.3. (Note: as discussed earlier, background values are not available for sediment and surface water; therefore, a table comparing analytical results from sediment and surface water to background will not be presented.) This table will be used to justify the analyte list for the project. As with the list of preliminary COPCs, justification of the analyte list is important to ensure that analytical costs are appropriate for the project.

Exhibit 3.3. Presentation of Background Comparison in the RI Work Plan

	Soil Data for SWMU (mg/kg or pCi/g)[1]			**Soil Background Concentration (mg/kg or pCi/g)[2]**	**Groundwater Data for SWMU (µg/L or pCi/L)[3]**			**Groundwater Background Concentration (µg/L or pCi/L)[4]**
Analyte	**SWMU 1**	**. . .**	**SWMU N**		**SWMU 1**	**. . .**	**SWMU N**	
# 1		. . .				. . .		
# 2		. . .				. . .		
. . .		. . .				. . .		
# N		. . .				. . .		

[1] This will be the maximum detected value for soil reported in previous investigations. The qualifier codes attached to the value, if any, will be included with the value.
[2] The soil background concentration (or activity concentration) will be that presented in Appendix A or updated values.
[3] This will be the maximum detected value for groundwater reported in previous investigations. The qualifier codes attached to the value, if any, will be included with the value.
[4] The groundwater background concentration (or activity concentration) will be that presented in Appendix A or updated values.

3.1.4 Analyses Appearing in Remedial Alternatives Development Chapter of the Integrated RI/FS Work Plan

In the remedial alternatives development chapter of work plans, attention will be paid to the importance of risk reduction in remedial alternatives development and to the method to be used to measure risk reduction during the detailed analysis of remedial alternatives. For example, this chapter will note that remedial alternatives are developed to be protective of human health and the environment and that RAOs will consider COCs, POCs, and MOCs. In addition, this chapter will present the nine criteria used in the detailed analysis of alternatives under CERCLA. Most importantly, this chapter will discuss if a qualitative or quantitative detailed risk analysis of alternatives is anticipated and delineate the data that are required to support this risk analysis. (Determining whether a qualitative or quantitative risk analysis of alternatives is needed is important because additional data may need to be collected during the RI to support a quantitative analysis. Additional discussion concerning qualitative and quantitative risk analysis of alternatives is presented in Section 4.)

3.2 ANALYSES FOLLOWING COMPLETION OF THE INITIAL ROUND OF INVESTIGATION

Many RI work plans will contain a description of contingency sampling that may be used to address the uncertainties in environmental contaminant distribution expected to be encountered during the investigation. If this contingency sampling is to be collected as part of a phased investigation, then analyses may be used to allow the three FFA parties to discuss and agree if contingency soil (or sediment) sampling is necessary. In this case, a formal or informal report may be prepared after the completion of the initial round of sampling. In this report, results from the initial sampling and relevant historical sampling may be compared to human health screening criteria (i.e., PRGs) for the expected future use of the area and background concentrations of chemicals and radionuclides. To keep this presentation consistent with that used in work plan development, this presentation will use comparison tables similar to those presented earlier. Because the extent of soil (or sediment) contamination needs to be considered, as well as the nature of contamination, tables considering the location of samples (horizontal and vertical), in addition to the tables considering the maximum detected analyte concentrations, will be prepared. A spatial plane view presentation of the data also should be provided.

The format of the comparison table to be used to determine if the nature of contamination in soil may pose an unacceptable risk or hazard is in Exhibit 3.4. In this table, the maximum detected concentration or activity concentration in all soil samples collected at a site is compared to the no-action PRG for soil exposure for the expected future land use, the groundwater protection PRG, and the background concentration. This table will be used to refine the list of preliminary COPCs and the analytical list for contingency sampling. In this evaluation, an analyte will become a preliminary COPC if its concentration exceeds any PRG and the background concentration or activity concentration.

Exhibit 3.4. Presentation of Screening Assessment Results to Evaluate Nature of Contamination in Soil after the Initial Round of Sampling

	Soil (mg/kg or pCi/g)			
Analyte	**Maximum[1]**	**PRG[2]**	**Groundwater Protection PRG[3]**	**Background[4]**
# 1				
# 2				
. . .	. . .	. . .	. . .	. . .
# N				

[1] This value will be the maximum detected value for soil reported in the current and relevant previous investigations. The qualifier codes attached to the value, if any, will be included with the value.
[2] The PRG will be the no-action PRGs for exposure to soil for the appropriate future use taken from Appendix A. If residential use PRGs are used, then the child no-action level should be used.
[3] The groundwater protection PRG will be the no-action PRGs taken from Appendix A. Note: This PRG is protective of groundwater that may be used in the home. A PRG for protection of groundwater used industrially is not relevant to this screening assessment.
[4] The soil background concentration (or activity concentration) will be that presented in Appendix A or the most recent updated study/report.

The format of the comparison table to be used to determine if the nature of contamination in sediment may pose an unacceptable cancer risk or hazard will be similar to that in Exhibit 3.4; however, for the sediment table, neither the groundwater protection PRG nor the background concentration will appear. The groundwater protection PRG will not be included because migration of contaminants from sediment to groundwater is not expected to be a significant migratory pathway. Background concentrations of chemicals and radionuclides will not be included because these data do not exist for sediment. As with the soil table, the sediment table will be used to refine the list of preliminary COPCs and the analytical list for contingency sampling. In this evaluation, an analyte will become a preliminary COPC if its concentration or activity concentration exceeds any risk-based screening criterion.

The format of the comparison table to be used to evaluate the adequacy of initial sampling in delimiting the extent of contamination in surface soil is in Exhibit 3.5. In this table, the analyte concentrations or activities in surface soil samples collected along migration routes or at the periphery of a site are compared to the no-action PRG for soil for the expected future land use and the background concentration or activity concentration. Note that the groundwater protection soil PRG is not used in this comparison because that evaluation is performed as part of the subsurface soil evaluation. Generally, surface sampling will be deemed adequate if analyte concentrations and activities in samples collected along migration routes do not exceed both the no-action PRGs for soil and background concentrations. In deciding if sampling has adequately determined the extent of contamination, additional factors such as historical information will be considered.

Exhibit 3.5. Presentation of Screening Assessment Results to Evaluate Extent of Contamination in Surface Soil after the Initial Round of Sampling

Analyte	Soil (mg/kg or pCi/g)		
	Maximum[1]	PRG[2]	Background[3]
# 1			
# 2			
. . .	. . .	. . .	. . .
# N			

[1] This value will be the maximum detected value for soil reported in a sample collected along migration routes or at the periphery of the unit or area in the current investigation. The qualifier codes attached to the value, if any, will be included with the value.
[2] The PRG will be the no-action PRGs for the appropriate future use taken from Appendix A.
[3] The soil background concentration (or activity concentration) will be that presented in Appendix A or the most recent updated study/report.

The format of the comparison table to be used to evaluate the adequacy of initial sampling in delimiting the extent of contamination in sediment will be similar to that used for soil (Exhibit 3.5); however, the background concentration or activity concentration will not appear in the sediment table because background values for sediment do not exist. The evaluation of this table will be the same as for soil.

The format of the comparison table to be used to evaluate the adequacy of initial sampling in delimiting the extent of contamination in subsurface soil is in Exhibit 3.6. In this table, the analyte concentrations or activities in subsurface soil samples collected at the periphery of the area under investigation will be compared to the groundwater protection PRGs and background concentrations of chemicals and radionuclides. Note: The no-action PRGs for soil are not in this table because these criteria are for contact with contaminated soil, and contact with subsurface soil is not expected. Generally, subsurface sampling will be deemed adequate if analyte concentrations and activities in samples collected at the periphery of the unit or area under investigation do not exceed both the groundwater protection PRGs and background concentrations. In deciding if sampling has adequately determined the extent of contamination, additional factors such as historical information will be considered.

Analyses to evaluate groundwater and surface water sampling in determining the nature and extent of contamination in groundwater and surface water will be similar to those for soil. The format of the comparison table to be used to determine if the nature of contamination in groundwater may pose an unacceptable excess cancer risk or systemic toxicity is in Exhibit 3.7. In this table, the maximum detected concentration or activity concentration in all groundwater samples collected at the site will be compared to the no-action PRG for residential use of groundwater, the maximum contaminant level (MCL), and the background concentration or activity concentration. This table will be used to refine the list of preliminary COPCs and the analytical list for contingency sampling. In this evaluation, an analyte will become a preliminary COPC if its concentration exceeds any screening criterion and the background concentration or activity concentration. Comparisons to MCLs will not be used to identify COPCs, but will be provided for information only.

Exhibit 3.6. Presentation of Screening Assessment Results to Evaluate Extent of Contamination in Subsurface Soil after the Initial Round of Sampling

Analyte	Soil (mg/kg or pCi/g)		
	Maximum[1]	Groundwater Protection PRG[2]	Background[3]
# 1			
# 2			
. . .	. . .	. . .	. . .
# N			

[1] This value will be the maximum detected value or maximum activity concentration for radionuclides for subsurface soil reported in a sample collected at the periphery of the unit or area in the current investigation. The qualifier codes attached to the value, if any, will be included with the value.
[2] These values are taken from Appendix A.
[3] The soil background concentration (or activity concentration) will be that presented in Appendix A or the most recent updated study/report.

Exhibit 3.7. Presentation of Screening Assessment Results to Evaluate Nature of Contamination in Groundwater after the Initial Round of Sampling

Analyte	Groundwater (μg/L or pCi/L)			
	Maximum[1]	PRG[2]	Maximum Contaminant Level[3]	Background[4]
# 1				
# 2				
. . .	. . .	. . .	. . .	. . .
# N				

[1] This value will be the maximum detected value for groundwater reported in all samples collected around the unit or area during the current and relevant previous investigations. The qualifier codes attached to the value, if any, will be included with the value.
[2] The PRG will be the no-action PRGs in Appendix A for the child.
[3] The MCL will be taken from Appendix A or the most recent update.
[4] The groundwater background concentration (or activity concentration) will be that presented in Appendix A or the most recent update.

The table used to determine if contamination in surface water may pose an unacceptable cancer risk or hazard will be similar to that in Exhibit 3.7; however, background concentrations of chemicals and radionuclides will not appear in the surface water table because background data do not exist for surface water. The evaluation of this table will match that for groundwater.

For all investigations except the final RI of the Groundwater Operable Unit, there will be limited evaluation of the extent of existing groundwater contamination during the evaluation of the initial round of sampling. Currently, only the extent of dense nonaqueous-phase liquid contamination (i.e., secondary sources) is addressed during the investigation of the individual units and areas. The method used for the detection of these secondary sources does not rely on risk analysis and will not be discussed here. For the Groundwater Operable Unit investigation, the comparison table used to examine the adequacy of sampling in determining the extent of groundwater contamination will be similar to that in Exhibit 3.7; however, in this evaluation, a table will be prepared for each groundwater sampling location along the suspected periphery of the contaminant plumes. In each of these tables, the maximum detected analyte concentrations and activities will be compared to the no-action residential use PRGs, MCLs, and background concentrations. Generally, groundwater sampling will be deemed adequate to determine the extent of contamination if analyte concentrations and activities in samples collected along periphery of the suspected groundwater contaminant plumes do not exceed screening criteria and background concentrations. In deciding if sampling has adequately determined the extent of contamination, additional factors such as historical information will be considered.

The table to be used to determine the adequacy of sampling in determining the extent of surface water contamination also will be similar to that in Exhibit 3.7. As noted earlier, this table will not contain background concentrations of chemicals and radionuclides because background values are not available for surface water. Generally, surface water sampling will be deemed adequate to determine the extent of contamination if analyte concentrations and activities in samples collected downstream of a unit or area do not exceed screening criteria. In deciding if sampling has adequately determined the extent of contamination, additional factors such as historical information will be considered.

3.3 ANALYSES FOR THE RI REPORT (BASELINE RISK ASSESSMENTS)

Baseline risk assessments will be prepared to support final actions at PGDP. To ensure consistency among assessments and conformity with agreements reached between the U.S. Department of Energy (DOE) and regulatory agencies, all assessments will contain either the material described in succeeding sections or an explanation stating why the material is not presented. Material described herein but not relevant to a particular assessment will be noted in the assessment. The following are specific objectives of the remedial action process to be addressed in this section:

- Delineate the methods PGDP will use in the evaluation, determination, and documentation of baseline risks to human health and the environment at a site; and

- Describe the methods PGDP will use to determine the concentrations and activities of analytes that can remain on-site and still be adequately protective of human health and the environment both on-site and off-site.

In the following sections, the presentation follows the outline to be used in baseline human health risk assessments. Data evaluation methods are discussed in Section 3.3.3, exposure assessment methods are presented in Section 3.3.4, toxicity assessment methods are described in Section 3.3.5, risk characterization methods are delineated in Section 3.3.6, uncertainty in the risk assessment is discussed in Section 3.3.7, and RGO derivation methods are discussed in Section 3.3.8. In addition, the sources used to prepare this material are listed in Section 3.3.1, and general issues are considered in Section 3.3.2.

[Note: The methods for the baseline ecological risk assessment are not considered here. They are described in the companion Ecological Risk Methods Document. Additionally, methods to be used for radiological dose assessment are not presented in detail. The methods for radiological dose assessment generally should follow those used for baseline risk assessments.]

3.3.1 Guidance Documents

The methods discussed in the following sections are consistent with current EPA Region 4 and headquarters risk assessment guidance documents, the Commonwealth of Kentucky Department for Environmental Protection (KDEP) risk assessment guidance, and applicable DOE Orders. In addition, these methods are consistent with agreements reached during meetings among DOE, EPA Region 4, and KDEP risk assessment personnel (DOE 1996c; EPA 1996a; KDEP 1996; and RAWG 2000b, 2000c, 2000d, 2000e, 2000f, 2000g, 2007a, 2007b, 2007c, 2012a, and 2012b, and Appendix E of DOE 2017 and DOE 2018) and strategies and methods developed for human health risk assessments for use at other DOE sites located in EPA Region 4 (e.g., K-25, X-10, and Y-12 in Oak Ridge, Tennessee). Some of these methods are different from those used in earlier risk assessments. References for methods and approach should refer to this methods document and/or the original guidance documents instead of other site-specific project documents to avoid inappropriate references. Many of the documents and other materials used in developing the methods are listed chronologically in the following sections. If newer versions of the listed reference are available, the newer version should be used in place of the specific version listed in the following sections.

3.3.1.1 EPA guidance documents and materials

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Parts A, B, C, D, E, and F* (EPA 1989a, 1991b, 1991c, 1998b, 2004a, and 2009, respectively) (RAGS, Parts A, B, C, D, E, and F, respectively)

- *Exposure Assessment Methods Handbook* (EPA 1989b)

- *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (EPA 1990a)

- *Guidance for Data Usability in Risk Assessment* (EPA 1990b)

- *Dermal Exposure Assessment: Principles and Applications* (EPA 1992a)

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment* (EPA 1992b)

- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992c)

- *Guidelines for Exposure Assessment* (EPA 1992d)

- *Revisions to Sections 3.3.1 and 3.3.2 of the RAGS, Part B* (EPA 1993a)

- *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure* (EPA 1993b)

- *Guidance Manual for the Integrated Exposure Uptake and Biokinetic (IEUBK) Model for Lead in Children,* EPA/540/R-93/081 (EPA 1994a)

- *OSWER Directive: Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, OSWER Dir #9355.4-12* (EPA 1994b)

- *Soil Screening Guidance: Technical Background Document,* EPA/540/R-95/128, Office of Solid Waste and Emergency Response, Washington, DC, July 1996 (EPA 1996b)

- *Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites,* OSWER Directive 9200.4-26 (EPA 1998c)

- *Soil Screening Guidance for Radionuclides: User's Guide* and *Technical Background Document Final Guidance,* OSWER Directive 9355.4-16A and OSWER Directive 9355.4-16 (EPA 2000b)

- *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Third Edition,* EPA 823-B-00-007 (EPA 2000c)

- *Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water* (Schaum et al. 1994)

- Risk Assessment Guidance for Superfund: Volume III-Part A, Process for Conducting Probabilistic Risk Assessment (EPA 2001a)

- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites,* Superfund, Office of Solid Waste and Emergency Response, OSWER 9355.4-24 (EPA 2002)

- *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil* (EPA 2003a)

- *Human Health Toxicity Values in Superfund Risk Assessments* (EPA 2003b)

- *Integrated Exposure Uptake Biokinetic Model for Lead in Children,* Windows® version (IEUBKwin v1.1 build 9) (available at https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals) (EPA 2004a)

- *Guidelines for Carcinogen Risk Assessment* (EPA 2005a)

- *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA 2005b)

- *Guidance on Systematic Planning Using the Data Quality Objective Process,* EPA QA/G-4 (EPA 2006a)

- *Systematic Planning: A Case Study for Hazardous Waste Site Investigations,* EPA QA/CS-1 (EPA 2006b)

- *National Recommended Water Quality Criteria:* 2006 (EPA 2006c)

- 2006 Edition of the Drinking Water Standards and Health Advisories (EPA 2006d)

- Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S (EPA 2006e)

- *EPA provisional toxicity values support document* available on request from Technical Support Section, EPA Region 4 (EPA-PROV)

- *The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds* (Van den Berg et al. 2006)

- *Exposure Factors Handbook 2011 Edition (Final Report)* (EPA 2011)

- *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors,* OSWER 9200.1-120 (EPA 2014a)

- *Determining Groundwater Exposure Point Concentrations,* OSWER 9283.1-42 (EPA 2014b)

- *Risk Assessment Forum White Paper: Probabilistic Risk Assessment Methods and Case Studies.* (EPA/100/R-14/004) (EPA 2014c)

- *Probabilistic Risk Assessment to Inform Decision Making: Frequently Asked Questions* (EPA/100/R-14/003) (EPA 2014d)

- "Radiation Risk Assessment at CERCLA Sites: Q&A," (OSWER 9285.6-20) (EPA 2014e)

- *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*, OSWER 9200.2-154, Office of Solid Waste and Emergency Response, Washington, DC, June 2015 (EPA 2015a)

- *ProUCL Version 5.1 Technical Guide, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations.* Office of Research and Development Site Characterization and Monitoring Technical Support Center, Atlanta, GA (EPA/600/R-07/041) (EPA 2015b)

- *Recommendations for Sieving Soil and Dust Samples at Lead Sites for Assessment of Incidental Ingestion*, (EPA 2016a)

- *Region 4 Human Health Risk Assessment Supplemental Guidance,* EPA Region 4, March 2018 Update (EPA 2018a)

- EPA Regional Screening Level Tables (EPA 2018b) at https://www.epa.gov/risk/regional-screening-levels-rsls

3.3.1.2 Commonwealth of Kentucky guidance documents and materials

- *Kentucky Risk Assessment Guidance,* Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky (KDEP 2002)

- *Kentucky Guidance for Ambient Background Assessment,* Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 8 (KDEP 2004a)

- *Kentucky Guidance for Groundwater Assessment Screening,* Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 15 (KDEP 2004b)

- *Trichloroethylene Environmental Levels of Concern,* Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, April (KDEP 2004c)

3.3.1.3 DOE guidance documents and materials

- *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (DOE 2000c)

- *Optimizing Radiation Protection of the Public and the Environment for Use with DOE O 458.1, ALARA Requirements*, DOE-HDBK-1215-2014 (DOE 2014)

- *Environmental Radiological Effluent Monitoring and Environmental Surveillance*, DOE-HDBK-1216-2015 (DOE 2015b)

3.3.1.4 Other materials

- Meeting Summary for the Risk Assessment/Risk Evaluation Meeting, February 7, 1996, in Atlanta, February 13, 1996, Conference Call (DOE 1996c)

- *Guidance for Conducting Risk Assessments and Related Risk Activities for the DOE-ORO Environmental Management Program* (Bechtel Jacobs Company LLC 1999)

- Minutes and notes from meetings of the PGDP Human Health Risk Assessment Working Group (RAWG 2000b, 2000c, 2000d, 2000e, 2000f, 2000g, 2007a, 2007b, 2007c, 2012a, 2012b, and Appendix E of DOE 2017 and DOE 2018)

- *Geochemical and Mineralogical Data for Soils of the Conterminous United States* (USGS 2013)

- Programmatic Quality Assurance Project Plan (DOE 2018)

- *Biota Modeling in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators for Use in EPA Superfund Risk Assessment: Explanation of Intake Rate Derivation, Transfer Factor Compilation, and Mass Loading Factor Sources* (ORNL 2016)

3.3.2 General Methods

The risk methods document generally follows guidance in EPA's RAGS (EPA 1989a) and Kentucky's *Risk Assessment Guidance* (KDEP 2002); however, there are issues for which the two guidance documents differ. In those cases, the Risk Methods Document reconciles these two different approaches. The document also serves to address site-specific issues where guidance may be lacking and/or to document site-specific agreements among representatives of the RAWG from DOE, EPA, and Kentucky.

3.3.2.1 Format for the baseline human health risk assessment

The outline that will be followed when preparing baseline human health risk assessments for PGDP is provided in Appendix C of this document. This outline is consistent with that in RAGS, Part A (EPA 1989a), and in *Kentucky Risk Assessment Guidance* (KDEP 2002) and includes all sections that must be included in a complete baseline human health risk assessment. As such, some portions of the outline may not be applicable to some baseline human health risk assessments of limited scope; however, any baseline human health risk assessment prepared for PGDP will include the major and second level headings in the order presented. Major headings that will appear in all baseline risk assessments are "Results of Previous Studies," "Identification of Chemicals of Potential Concern," "Exposure Assessment," "Toxicity Assessment," "Risk Characterization," "Uncertainty in the Risk Assessment," "Conclusions and Summary," and "Remedial Goal Options Development." In addition, each baseline human health risk assessment will contain introductory material that delineates the scope and objectives of the assessment.

Examples of the format for tables that will be used in the risk assessment are presented in Exhibit 3.8. *List of Chemicals of Potential Concern*; Exhibit 3.9. *Summary of Pathway Analysis in the Exposure Assessment*; Exhibit 3.10. *Presentation of Exposure Point Concentrations*; Exhibit 3.11. *Chemical-Specific Parameters*; Exhibit 3.12. *Daily Intakes (Chronic Dose) for Receptor 1*; Exhibit 3.13. *Exposure Route Summary for the Current Use Scenario—Systemic Toxicity;* Exhibit 3.14. *Driving Contaminants' Summary for Current Use Scenario—Systemic Toxicity*; Exhibit 3.15. *Summary of Risk Characterization*; Exhibit 3.16. *Summary of Uncertainty Analysis*; and Exhibit 3.17. *Presentation of Remedial Goal Options*. Shorter summary tables for the body of the report will summarize the following information:

- Land use scenarios and media assessed for each source area;

- Scenarios for which human health risk exceeds *de minimis* levels; and

- A table for each source summarizing the COCs and POCs, as well as the contribution of each COC and POC to the total risk and hazard.

3.3.2.2 Presentation of results from previous studies

In all baseline risk assessments prepared for PGDP, the results will be presented from previous risk assessments and other risk evaluations that are relevant to the unit or area being assessed. These results will be included to allow for a comparison between results of earlier work and the results of the current baseline risk assessment. Differences seen will be discussed in the observations section of the current baseline risk assessment.

The format for presenting the results of the earlier risk assessments will follow that which will be used for reporting previous studies in the RI work plan. This is discussed in detail in Section 3.1.2. For risk evaluations, if any, that are not risk assessments, results will be presented verbatim and without interpretation. Relevant results from these studies also may be used in the uncertainty discussion of the current baseline human health risk assessment.

3.3.3 Data Evaluation Methods

The primary purpose of this section of the baseline human health risk assessment will be to develop the list of COPCs used in the assessment. In this section, the data quality/data usability review, procedures to screen data, a summary of the results of the screening, and a final list of COPCs will be presented. Additionally, this section will provide site-specific characterization data used in the exposure assessment. Methods to complete each of these activities are presented in the following.

3.3.3.1 Data quality/data usability review

The overall goal of the data quality/data usability review is to develop a data set of known quality that is representative of the site and is reproducible. Use of this systematic approach is consistent with EPA guidance (EPA 2006f; EPA 2006e). The data quality/data usability review process (Figure 2.2) incorporates the aspects of data quality/data usability [measurement quality objectives (MQOs)] with an evaluation of planned data uses for each project DQOs to make a determination concerning the suitability of historical/current project data for use in risk assessment. The initial steps of data assessment and data validation generally are completed by a subject matter expert before the results are provided to the risk assessor. The data quality assessment (DQA) examines the data set to ensure that the MQOs have been met and that the data are sufficient and representative of the site or source investigated. Figure 3.2 [from the EPA DQA guidance (EPA 2006f)] is provided to illustrate how DQA fits into the data evaluation process.

3.3.3.2 Procedures to screen or evaluate data to determine COPCs

Data screening to develop the list of COPCs will be performed in the following eight steps.

- **Step 1: Evaluation of sample design and locations.** Data will be examined to ensure that the samples from which data were derived were collected using sampling methods that are adequate to determine the nature and extent of contamination for the particular unit or area being assessed. Data not from the unit or area under investigation or not useful in determining contaminant migration from the unit or area will not be used quantitatively in the assessment because these data are not representative of the unit or area for which remedial actions are being considered. In particular, when considering groundwater sampling results, only data from samples collected from wells located in contaminant plumes will be used.

For radionuclides, the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) is the guidance used for surface soil sampling for characterization, remedial support surveys, and final status surveys (EPA 2018a).

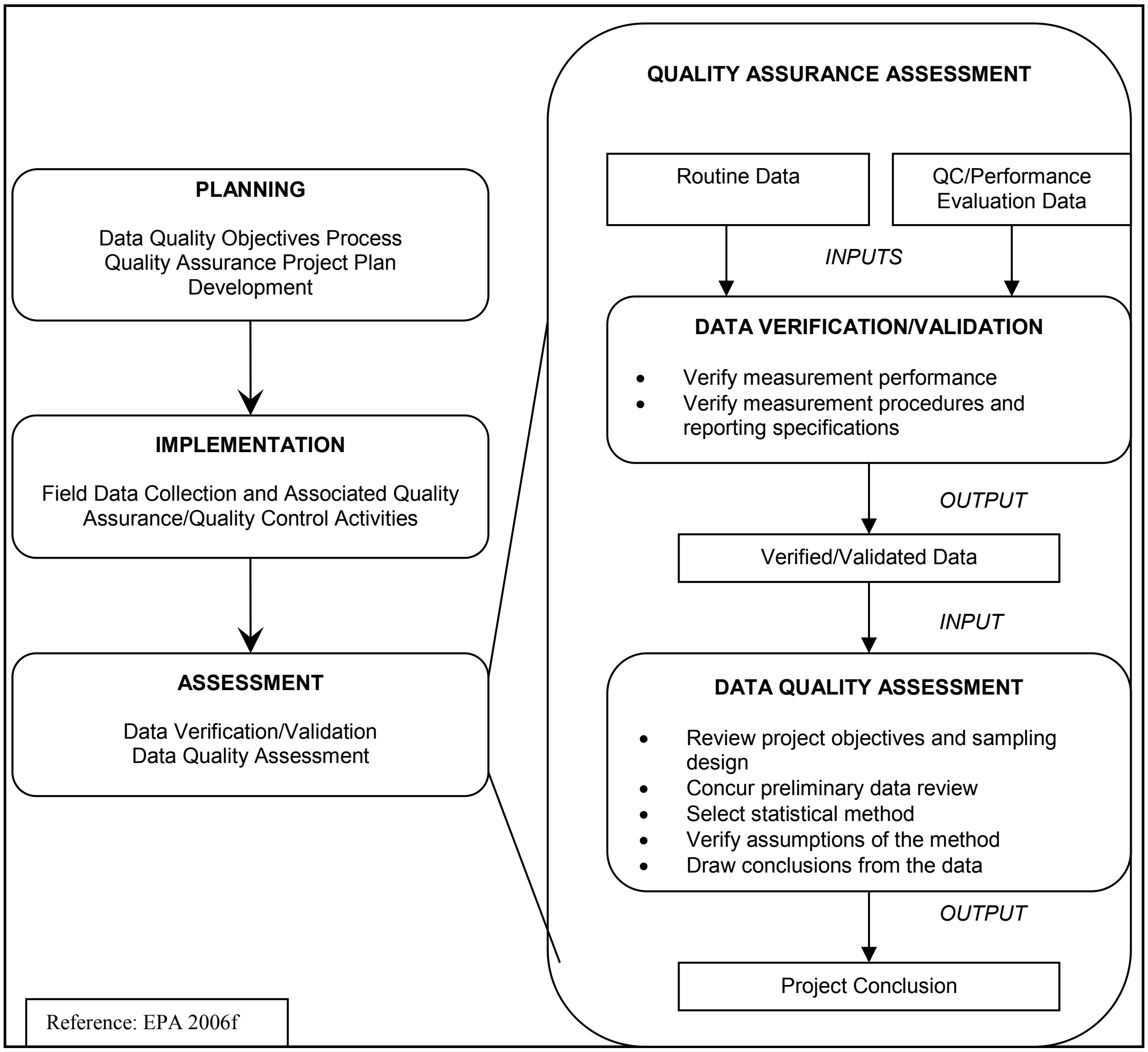


Figure 3.2. Data Life Cycle

- **Step 2: Evaluation of sampling and analytical methods.** Data will be examined to ensure that the sampling methods and analytical methods used in the laboratory are consistent with EPA-approved methods for nonradionuclides. Data for nonradionuclides not from EPA-approved methods will not be used quantitatively in the risk assessment, but may be used qualitatively. Methods for radionuclides will be evaluated during the DQO process to ensure that data quality requirements can be achieved. Also in this step, groundwater and surface water data will be examined, and data from the analyses of filtered water will be deleted from the data set. Only results from unfiltered samples will be used quantitatively in baseline human risk assessments performed at PGDP. Note: Filtered groundwater and surface water data may be used in the uncertainty section of the assessment when discussing data sources and their effects on risk estimates.

  For many sites, survey-type data such as X-ray fluorescence (XRF) data and results from polychlorinated biphenyl (PCB) field test kits are available in addition to the laboratory analytical data. The primary use of such data is for site characterization, but these survey-type data also can play a role in risk-based decision making. Survey-type data assist in determining the distribution of COPCs and can be used to identify which sets of laboratory data should be combined to develop site average contaminant concentrations. Potentially, survey-type data also could be combined with lab data in a risk assessment to determine the average concentrations for contaminants, but this would require demonstrating that the lab and survey-type data possess similar detection limits and analytical uncertainty. Collection of survey-type data should follow methods consistent with those developed by EPA (EPA 2018a). Project teams will need to address the uncertainty if detection limits from XRF and PCB field test kits cause EPCs to be inconsistent with maximum detected results. Addressing this uncertainty may include obtaining additional sampling/analytical data. Detection limits for the XRF and PCB test kits optimally should be below levels consistent with expected cleanup levels. In addition, a DQA would need to be completed to show that both types of data sets are comparable and representative of the site conditions. This DQA either could be in the risk assessment or in a report completed prior to or in concert with the risk assessment.

Finally, whenever survey-type data are used for guiding how lab data are handled or are combined with lab data, then the risk assessment would need to have an uncertainty discussion that appropriately identifies (a) how the results of the risk assessment could vary if the survey type data were not used and (b) how the use of the survey data increases or decreases the risk of making an incorrect risk-based decision for a location.

- **Step 3: Evaluation of sample quantitation limits.**

  Chemicals. The sample quantitation limits for each analyte and sample will be examined to determine if these limits were below the concentration at which the analyte may pose an unacceptable risk or hazard to human health. If the maximum sample quantitation limit for an analyte (over all samples within a medium) is greater than the concentration that may pose an unacceptable risk or hazard to human health, and the analyte is not detected in any sample, then the data for that analyte will be deemed suspect. Data from these analytes will not be used quantitatively in the risk assessment, but the potential risk or hazard from exposure to media potentially containing these analytes will be examined qualitatively. In developing the qualitative assessment for these data, the maximum quantitation limit for the analyte (in all samples from a medium) will be compared to the appropriate no-action residential PRG if historical or process information indicates that the analyte potentially could be present. One-half the maximum quantitation limit for the analyte (in all samples from a medium) will be used in this comparison if historical or process information indicates that the analyte is not expected to be present.

  Radionuclides. The analysis for radionuclides will be performed in two steps. In the first step, the MDC/minimum detectable concentration/minimum quantification concentration (MQC) for each analyte and sample will be examined to determine if these limits were below the concentration or activity concentration at which the analyte may pose an unacceptable risk (or radiological dose). If the maximum MDC/MQC for an analyte over all samples within a medium is greater than the concentration or activity concentration that may pose an unacceptable risk (or radiological dose) to human health and the analyte is less than the minimum detectable activity concentration MDC/MQC in any samples, then the data for that analyte will be deemed suspect.[7] The MDCs used for radionuclides should be the MDCs established in the MARLAP Manual (EPA 2004b), which provides

[7] Radionuclide results reported with an uncertainty that indicates the result could fall below the MDC will be reported as detections or nondetects or otherwise flagged in the data verification/validation and assessment process indicating the detected result is tentative.

guidance for evaluating SQLs for radionuclide data. For radionuclides, all reported values, including negative values,[8] will be used to derive the EPCs under current conditions.

Survey-type data. When XRF data are used in the derivation of EPCs, all XRF values, including negative values, will be used as reported. Other survey-type data (such as PCB field test kits) should be used in accordance with project-specific review of the data and performance of the method.

See Figure 3.3 for an example of Step 3.

Evaluation of Sample Quantitation Limits

Chemicals:

Consider the following results for Chemicals W, X, Y, and Z. Assume that Chemicals W and Y are site-related contaminants and that Chemicals X and Z are not site-related. Also, let the data qualifier (U) be defined as not detected at the sample quantitation limit (SQL).

Chemical	Sample 1	Sample 2	Sample 3	Sample 4	Screening Value
W	10U	10U	10U	10U	5
X	10U	10U	10U	10U	5
Y	10U	6	10U	10U	5
Z	1U	1U	1U	1U	5

Then, following the rules in Step 3 of the data evaluation process:

- Results for Chemical W are suspect because the maximum SQL overall results (10) is greater than the screening value (5), and Chemical W was not detected in any sample. Because Chemical W is site-related, the qualitative risk analysis of this chemical's potential effect would use the full SQL.
- Results for Chemical X are suspect because the maximum SQL overall results (10) is greater than the screening value (5), and Chemical X was not detected in any sample. Because Chemical X is not site related, the qualitative risk analysis of this chemical's potential effect would use one-half the SQL.
- Results for Chemical Y are not suspect even though the maximum SQL exceeds the screening value because Chemical Y was detected in one sample.
- Results for Chemical Z are not suspect because the maximum SQL is less than the screening value.

For radionuclides, SQLs should be evaluated in accordance with the guidance in the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (EPA 2004b).

Note: Other data qualifiers associated with the data must also be considered during data evaluation. Please see Step 4 of the data evaluation process.

Figure 3.3. Example of Step 3–Evaluation of Sample Quantitation Limits Laboratory Analytical Data

- **Step 4: Evaluation of data qualifiers and codes.** Generally, the rules presented in RAGS, Part A, Exhibits 5.4 and 5.5 (EPA 1989a) will be used to evaluate all data qualifiers and codes attached to analytical results for chemicals; however, data with a "B" qualifier (i.e., analyte also found in associated blank) will be examined by analyte to ensure that site-related analytes are not eliminated. For other analytes, the "5 and 10X's Rule" described in RAGS, Part A, (EPA 1989a) will be considered. In addition, the method used in data validation to examine blank contamination will be

[8] Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count.

evaluated. If data validation qualified sample results as "U" (i.e., analyte not detected) instead of "B" when blank contamination was present and the analyte passed the "5 and 10X's Rule," then the data will be reevaluated. Specifically, if chemical data are qualified "B," and the value is less than that defined by the "5 and 10X's Rule," then the data will be assumed to be a nondetect and the reported value will be used to derive the EPC.

— Evaluation of radionuclide data will follow rules agreed upon by the Commonwealth of Kentucky Radiation Health Branch [formerly the Kentucky Radiation Health and Toxic Agents Branch (KYRHTAB)] and DOE (RAWG 2000a through 2000f). The data assessment qualifiers that will appear and their description are as follows:

  – **KYRHTAB-LT:** KYRHTAB has performed an independent data assessment and the results are less than the MDC or detection limit and should not be plotted.

  – **KYRHTAB-50:** KYRHTAB has performed an independent data assessment and the radiation counting uncertainty is greater than 50% of the analytical results.

  – **KYRHTAB-ER:** KYRHTAB has performed an independent data assessment and the data present error problems (i.e., no counting uncertainty or zero counting uncertainty).

  – **KYRHTAB-OK:** KYRHTAB has performed an independent data assessment and the data are acceptable for use.

- **Step 5: Elimination of analytes not detected.** Generally, any chemical not detected in at least one sample from a medium will be deleted from the data set. Any radionuclide for which no analytical results exceed its MARLAP MDC also will be deleted from the project dataset, provided the MDC is an acceptable level for the project.[9] If a chemical analyte is suspected of being present at very low concentrations (i.e., below the quantitation limit) due to cross-media contamination or is suspected of being present based on historical or process information, the analyte may remain in the data set even though the analyte was not detected. In this case, the concentrations used to determine the representative or EPC for the analyte will be the sample quantitation limits for the analyte in the medium. For classes of analytes such as polycyclic aromatic hydrocarbons (PAHs), PCBs, and dioxins/furans, if one compound is detected at a concentration greater than a screening value and is identified as a COPC, then others in that class will be assumed to be present as well. The method used to analyze these classes of compounds is presented later in this section.

- **Step 6: Examination of toxicity of detected analytes.** The maximum concentrations and activities of analytes remaining in the data set will be compared to no-action residential use risk-based PRGs by medium. The PRGs used in this comparison will be the no-action values for the child found in Appendix A. Those analytes with a maximum detected concentration less than each respective no-action risk-based PRG will be eliminated from the data set unless the analyte has a bioaccumulation factor for fish equal to or greater than 100 (DOE 1996d). Note: The uncertainty introduced through the application of this screening procedure will be examined quantitatively in the uncertainty analysis portion of the baseline risk assessment. The derivation of the risk-based PRGs used in this comparison is described in Appendix B of this document.

- **Step 7: Examination of analyte concentrations of essential nutrients detected in site samples.** Analytes not removed from the data set in previous steps will be examined to determine if any are

[9] These types of decisions (acceptable MDCs) would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development.

essential nutrients. Seven analytes known to be essential nutrients and known to be toxic only at extremely high concentrations will be removed from the data set on the basis of regulatory guidance (EPA 2018a). These analytes are calcium, chloride, iodine, magnesium, potassium, sodium, and phosphorus. No other analytes known to be essential nutrients will be deleted from the data set on the basis of this screen. Any uncertainty regarding retention of essential nutrient in the list of COPCs will be discussed in the uncertainty section of the risk assessment.

- **Step 8: Comparison of analyte concentrations detected in soil and groundwater samples to analyte concentrations detected in background.** This comparison is performed as part of the development of the list of COPCs. As a first step, maximum detected concentrations of analytes will be compared to the background concentrations presented in Appendix A. Analytes not detected at a concentration greater than the background concentration will not be retained as COPCs. Analytes detected at concentrations greater than their background concentration may be retained as COPCs, depending upon the outcome of other screening steps. Analytes retained as COPCs, however, may be considered with the full range of background as part of the uncertainty analysis. This analysis, if completed, will be done to determine if the analyte is generally present at concentrations above its background concentration or if the detected concentrations of the analyte above the selected background concentration is consistent with natural enrichment. The impacts on risk characterization of not retaining an analyte on the basis of the background screen will also be considered in the uncertainty analysis.

During the development of the list of COPCs, concentrations of total carcinogenic PAHs, PCBs, and dioxins/furans (dioxins) will be derived. Total carcinogenic PAHs, total PCBs, and total dioxins will be derived to allow for the correct use of the toxicity screen described in Step 6 and to allow for correct calculation of ELCR from exposure to these organic compounds.

When deriving total carcinogenic PAHs, the toxicity equivalence factors (TEFs) presented in Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2005c) will be used. These TEFs are presented in Table 3.1. Note that these TEFs will be applied to the concentrations of detected PAHs in each sample and that the total carcinogenic PAH concentration in a sample will be the sum of the products of each carcinogenic PAH and its TEF. For samples in which PAHs are not detected, the value for the minimum detection limit of the PAHs with TEFs will be used in the calculation of the EPC.

When deriving total PCBs [if this analyte (i.e., Total PCBs) is not reported in the data set], the detected concentrations of each PCB within a sample will be summed. For samples in which no PCBs are detected, the value for the minimum detection limit of the PCBs will be used in the calculation of the EPC. If there are detection limits for PCBs exceeding risk-based concentrations, this issue should be discussed in the uncertainty section. Note that there are no TEFs to use when deriving total PCBs from individual Aroclors. If dioxin-like PCBs are detected at a site, they should be added to the total PCBs after weighting with the TEFs for those compounds in Van Den Berg, et al. 2006.

When deriving total dioxin, the TEFs presented in *Federal Register*: May 10, 2007 (Volume 72, Number 90*), Dioxin and Dioxin-like Compounds; Toxic Equivalency Information* will be used. These TEFs are presented in Table 3.1. Note that these TEFs will be applied to both the concentrations of detected dioxins and furans and to one-half the sample quantitation limit of undetected dioxins and furans, when one or more dioxin or furan is detected. The total dioxin concentration in a sample will be the sum of the products of each dioxin/furan and its TEF. For samples in which no dioxin or furan was detected, the minimum detection limit for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) will be used as the value for the total dioxin concentration. If there are detection limits for dioxins and furans exceeding risk-based concentrations, this issue should be discussed in the uncertainty section.

Table 3.1. Toxicity Equivalency Factors for Carcinogenic PAH Compounds and Dioxins/Furans

Carcinogenic PAH Compound[1]	Toxicity Equivalence Factor	Dioxin/Furan Compound[2]	Toxicity Equivalence Factor
Benzo(a)pyrene	1.0	2,3,7,8-TCDD	1.0
Benzo(a)anthracene	0.1	1,2,3,7,8-PeCDD	1.0
Benzo(b)fluoranthene	0.1	1,2,3,4,7,8-HxCDD	0.1
Benzo(k)fluoranthene	0.01	1,2,3,6,7,8-HxCDD	0.1
Chrysene	0.001	1,2,3,7,8,9-HxCDD	0.1
Dibenzo(a,h)anthracene	1.0	1,2,3,4,6,7,8-HpCDD	0.01
Indeno(1,2,3-c,d)pyrene	0.1	OCDD	0.0003
All other PAHs	0	2,3,7,8-TCDF	0.1
		1,2,3,7,8-PeCDF	0.03
		2,3,4,7,8-PeCDF	0.3
		1,2,3,4,7,8-HxCDF	0.1
		1,2,3,6.7,8-HxCDF	0.1
		1,2,3,7,8,9-HxCDF	0.1
		2,3,4,6,7,8-HxCDF	0.1
		1,2,3,4,6,7,8-HpCDF	0.01
		1,2,3,4,7,8,9-HpCDF	0.01
		OCDF	0.0003

[1] TEFs from EPA 2005c
[2] TEFs from Van Den Berg, et al. 2006

3.3.3.3 Presentation of data evaluation

A summary of the data evaluation will be provided in both narrative and tables. Tables from each step of the data evaluation process may be presented. The detailed data tables, if voluminous, should appear in an appendix to the risk assessment; however, the summary tables described earlier (see Section 3.3.2.1) should appear in the main text of the assessment. At minimum, a table listing the COPCs for the assessment should appear in the main text. An example of the information that should appear in this summary table is in Exhibit 3.8.

Exhibit 3.8. List of Chemicals or Radionuclides of Potential Concern

Analyte	Frequency of Detection[1]
Site and Medium[2]	
Analyte # 1	
Analyte # 2	
. . .	. . .
Analyte # N	

[1] This value will be the number of samples in which the analyte was detected over the number of samples in which an analysis for the analyte was performed.
[2] A list of COPCs will be presented for each site and medium combination.

3.3.3.4 Site-specific characterization information

Several pieces of site-specific characterization information are relevant to virtually all baseline human health risk assessments performed for PGDP because they explain resource use around PGDP. Because this information is in the form of interviews and letters, it generally is not readily available; therefore, this information is included in Appendix E of this document to provide a ready source of these materials. Appendix E, presents the following documentation.

- Reference to the Phase I Site Investigation results of surface water and groundwater users survey to determine groundwater use near PGDP (CH2M HILL 1991);[10]

- Summary of agricultural practices in Ballard County, Kentucky;

- Summary of the agricultural practices in McCracken County, Kentucky;

- Area of crop land in Ballard and McCracken County, Kentucky;

- Recreational use of Bayou and Little Bayou Creeks near PGDP;

- Annual harvests of turkeys and deer, in McCracken and Ballard Counties, Kentucky, and waterfowl in Ballard County, Kentucky;

- Reports entitled "Planning Issues for Superfund Site Remediation" and "Quantitative Decision Making in Superfund: A Data Quality Objectives Case Study" from *Hazardous Materials Control* regarding use of exposure units in risk calculations and remedial decisions;

- A link to Kentucky Risk Assessment Guidance;

- Environmental Indicators flowchart submitted to the Hazardous Waste Branch of the Kentucky Division for Waste Management;

- The table of parameters for probabilistic risk assessment (PRA) from the Southwest Plume Investigation report. This table provides the parameter values used for the PRA in that report, which should be considered for use in other PRAs. The values in the table do not represent specified default values for use in all PRAs.

- Lead-210 and PAHs at PGDP;

- Guidance on development of site-specific soil screening levels and site-specific dilution attenuation factors to be implemented when scoping projects;

- Human health information for the Paducah vapor intrusion evaluation; and

- Minutes from the previous year's RAWG meetings.

3.3.4 Exposure Assessment Methods

The primary purpose of this section of the baseline human health risk assessment will be to report the results of the exposure assessment for each unit or area investigated. In this section, the exposure setting for each unit or area will be characterized, exposure pathways will be identified, exposure will be quantified (i.e., chronic dose or intake calculated), and chronic doses (or intake) will be presented. Methods to complete each of these steps are discussed in the following sections.

[10] Although completed in 1989, these surveys are relevant to current use of surface water and groundwater because these survey results were collected before the current Water Policy was in place; therefore, these survey results represent likely surface water and groundwater use within the Water Policy Box and in adjacent areas in the absence of PGDP-derived contamination.

3.3.4.1 Characterize the exposure setting

This section of the exposure assessment or other portions of the document will describe the physical setting of each unit, including meteorology, climate, vegetation, soil type, surface hydrology, groundwater hydrology, and geology. In addition, the surrounding populations will be characterized as needed. Specific note will be given to determining if sensitive subpopulations may be present. In risk assessments in RI reports, the information presented concerning climate, vegetation, soil type, surface hydrology, groundwater hydrology, and geology will be brief, and references will be to material presented in earlier sections of the RI report. (Note: A brief presentation of this material must be included in the baseline risk assessment because the FFA states that the baseline risk assessment is to be written as a stand-alone report.) In baseline risk assessments not in RI reports, the information presented concerning climate, vegetation, soil type, surface hydrology, groundwater hydrology, and geology will be more extensive.

Current and potential future land use and the time frame for future use also will be discussed in this section of the exposure assessment. The most likely future land use will be determined using information in the most recent PGDP SMP; however, because future land use over time is uncertain, the use scenarios considered in the baseline risk assessment will not be governed by that information alone. Use scenarios that will be considered in all baseline risk assessments under future conditions are rural residential, recreational, industrial, outdoor worker, and excavation. Appropriate use scenarios may be evaluated during project scoping.

Finally, this section of the baseline human health risk assessment will integrate the preceding information and declare the unit or area under investigation either as a source or integrator unit and identify exposure points. Definitions used to determine whether the area or unit is a source or integrator are as follows:

- **Source unit.** Those units or areas that may release contaminants to other units or areas.
- **Integrator unit.** Those units or areas that accumulate contaminants from source units or areas.

Generally, application of these definitions to units and areas to be investigated at PGDP shows that all areas on-site where contamination exists (e.g., the soil and other material at burial grounds, spill areas, and landfills) are source areas. Integrator units identified using these definitions are air, groundwater (e.g., RGA), and surface water (e.g., Bayou and Little Bayou Creek watersheds and the Ohio River).

Also in this section of the exposure assessment, exposure points will be evaluated. For source units, the exposure points that will be evaluated under current conditions are at the unit or area ("hot spots" may be evaluated separately) and at points downgradient to which contamination may migrate. Downgradient points that will be evaluated for risk communication purposes include at the PGDP industrialized area boundary [i.e., the boundary of the area corresponding to the industrial land use delineated in the SMP (DOE 2015a)]; at the DOE property boundary; and at Little Bayou Creek. Note that for some source units, one or more of these exposure points may not be relevant. The exposure assessment will provide an explanation for exposure points not selected for risk characterization.

For integrator units, exposure points that will be considered are those within the contaminated area (e.g., above the contaminated groundwater plume or along the contaminated ditch) and at areas downgradient. Generally, exposure points that consider migration from a source will consider the time of exposure. For example, for exposure to groundwater both at a source and at the facility boundary, risk or hazard from exposure to measured concentrations under current conditions and future conditions will be determined. In addition, risk or hazard from exposure to expected future concentrations or activities will be modeled to determine the risk or hazard that may occur under potential future conditions as contaminants migrate from the source to the underlying

Industrialized Area
Area corresponding to the industrial land use delineated in the Site Management Plan.

aquifer. Exposure to contaminants in or migrating to the surface water integrator unit will be handled similarly. The mechanism that will be used to determine the extent of modeling that will be used in a baseline human health risk assessment is discussed later.

3.3.4.2 Identification of exposure pathways

This section of the exposure assessment will delineate the pathways through which the receptors may be exposed under both current and future conditions. For current receptors, these pathways and their parameters should be based on realistic exposures; for future receptors, these pathways and their parameters should be based on reasonable maximum exposure (RME) values. The goal of this material will be to provide a complete depiction of all exposure pathways for current and future uses. To achieve this goal, this section will present conceptual site models and supporting text. Also, in this section, each pathway will be described in terms of source, exposure route, exposure point, and receptor. This format will be followed because all four must be present for a complete pathway to exist. Note: Potential pathways not containing all four items will be described as being incomplete, and text justifying their omission from the assessment will be provided. Potential pathways that will be considered in all assessments are described herein.

Exposure assessments in baseline human health risk assessments completed in the past indicate that at least 24 exposure pathways should be considered as potential pathways in all assessments. These pathways are listed. (Note: Additional pathways, such as contact with buried waste and modeled vapor intrusion, may be reasonable for some units or areas; these pathways are not included.)

- Ingestion of groundwater as a drinking water source
- Inhalation of volatile constituents emitted from groundwater during household use (including showering)
- Dermal contact with groundwater while showering
- External exposure to ionizing radiation emitted by constituents in groundwater while showering
- Inhalation of volatile constituents emitted from groundwater during irrigation
- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of particulates emitted from soil
- Inhalation of volatile constituents emitted from soil
- External exposure to ionizing radiation emitted by constituents in soil
- Incidental ingestion of surface water while swimming or wading in creeks or natural or man-made ponds
- Dermal contact with surface water while swimming or wading in creeks or natural or man-made ponds
- External exposure to ionizing radiation emitted by constituents in surface water while swimming or wading in creeks or natural or man-made ponds

- Incidental ingestion of sediment while swimming or wading in creeks or natural or man-made ponds
- Dermal contact with sediment while swimming or wading in creeks or natural or man-made ponds
- External exposure to ionizing radiation emitted by constituents in sediment while swimming or wading in creeks or natural or man-made ponds
- Consumption of fish taken from creeks or natural or man-made ponds
- Consumption of vegetables and produce raised in contaminated soil
- Consumption of irrigated vegetables
- Consumption of beef from animals contaminated by consuming vegetation (pasture and concentrates) irrigated with contaminated water or grown on contaminated soil, by drinking contaminated water, or ingesting contaminated soil
- Consumption of dairy products (i.e., milk) from animals contaminated by consuming vegetation (pasture and concentrates) irrigated with contaminated water or grown on contaminated soil, by drinking contaminated water, or ingesting contaminated soil
- Consumption of pork from animals contaminated by consuming vegetation (concentrates) irrigated with contaminated water or grown on contaminated soil or by drinking contaminated water
- Consumption of poultry products from animals drinking contaminated water
- Consumption of game (i.e., deer, rabbits, and quail) contaminated by consuming contaminated vegetation or soil and ingesting water

While these pathways have been found to be reasonable in past assessments, not all may be reasonable, or complete, for future assessments; therefore, the decision as to which pathways to quantify will be made on a project-specific basis. In any case, the rationale for the inclusion or exclusion of any of the pathways listed herein will be included in the exposure assessment.

It is important to note that the pathways relating to livestock consumption are not reasonable for most source units. This is because most source units are too small to support livestock in addition to a homestead and garden. Generally, a source unit will be required to be larger than two acres to be considered for livestock production. (This requirement assumes that a minimum of two acres is required for a home and associated garden.) Note: Under this definition, all integrator unit assessments will contain an assessment of risk from consumption of livestock because the area they cover is greater than two acres. In assessments where livestock consumption is included, the range size for each beef or cow will be two acres per head (Morrison 1959).

For baseline human health and ecological risk assessments that incorporate larger areas (such as the final sitewide baseline human health and ecological risk assessment), scenarios will be evaluated on a project-specific basis including evaluation of exposure due to unit size (e.g., recreational/hunter scenarios where wild game have a range much larger than 0.5 acres).

Using the characterization information and pathway analysis, a conceptual site model will be developed for each unit or area. The format that will be used for the conceptual site models is that in Figure 3.1. Note: When presenting the conceptual site models for multiple units or areas in a single baseline human health risk assessment, the units or areas may be grouped to reduce the number of figures that need to be presented.

3.3.4.3 Quantification of exposure

To quantify exposure or dose, both the EPC and the exposure factors are required. Here, the EPC can be defined as the concentration or activity concentration of the COPC in the environmental medium ingested, inhaled, contacted, or consumed, and the exposure factor can be defined as the product of the exposure parameters describing the degree of exposure to the environmental medium in terms of duration or frequency of exposure and mass of the receptor.

EPCs under current conditions of all COPCs for which environmental samples were taken will be determined using the following procedure.

(1) If results from fewer than ten samples are available, then the EPC will be the maximum detected concentration.

(2) If results from ten or more samples are available, then the most recent version of EPA's ProUCL software will be used to determine the EPC. The value selected as the EPC will be the value recommended by ProUCL, noted as the "Potential UCL to Use." EPA's ProUCL software[11] incorporates a number of different distributional tests that may be used to calculate the most appropriate EPC (EPA 2015c). In the current version of ProUCL, the software has computation methods for handling data sets with nondetect values. Unless other determinations are made during project scoping, nondetect values should be handled according to the recommendations in the ProUCL User Guide (EPA 2015c). Additional information regarding the statistics and computation methods used in ProUCL can be found in the User Guide and in the ProUCL Technical Guide (EPA 2015b). Additionally, it is unlikely that the UCLs based upon those methods will exceed the maximum detected value, unless some outliers are present in the data set. The RAWG has concluded that the 95% UCL should be used as the EPC and if the 95% UCL exceeds the maximum detected concentration, then the uncertainty needs to be discussed in the uncertainty section of the risk assessment.

Options to determine the ten or more samples may include use of grid values. It is recommended that a geostatistical approach utilizing Spatial Analysis and Decision Assistance (SADA) or similar software be used to estimate values for empty grids. SADA is available at http://www.sadaproject.net/. Alternately, an average value may be used. An

> From Soils Operable Unit RI Report (DOE 2012):
>
> The representative sampling design for the SWMUs was gridding. In some instances (such as SWMUs/AOCs not grid sampled in summer 2010), when a grid was applied to the SWMUs/AOCs, a grid lacking a sample result resulted. In order to fill a grid lacking a sample result, the average of the grids within the exposure unit with sampling results was used. Attachment D2 [of the Soils Operable Unit RI Report] presents an uncertainty evaluation in determining EPC values using these averages against EPC values calculated without using the averages or the maximum value, as applicable. An example for determining the EPC through averaging is illustrated below.
>
> If the SWMU/exposure unit combination had less than 10 grids, the maximum grid result was used as the EPC. If the SWMU/exposure unit combination had 10 or more grids, the grid values were used to determine the EPC. Grid values were determined following guidance in the work plan. Basically, the maximum detected result from within the grid applies to the grid. If not detected, the minimum detection limit applies to the grid.
>
> If a grid had no result (detect or nondetect) for the COPC, an average of the results for the grids with results was used.

[11] Software is available at www.epa.gov/land-research/proucl-software.

example is shown in the text box [from Soils Operable Unit RI Report (DOE 2012)]. These options should be discussed and agreed to in the planning phases of projects.

In determining the UCL when the medium is soil, data will be segregated into depth intervals relevant to receptors.

- For scenarios in locations inside the industrialized area, the following will be used to estimate the EPC:

  - Excavation worker: data from samples collected from 0 to 10 ft bgs,[12]
  - Outdoor worker: data from samples collected from 0 to 1 ft bgs, and
  - All other scenarios: data from samples collected from 0 to 1 ft bgs.

- For scenarios in locations outside the industrialized area, the following will be used to estimate the EPC:

  - Excavation worker: data from samples collected from 0 to 10 ft bgs,[12]
  - Outdoor worker performing maintenance-type activities: data from samples collected from 0 to 10 ft bgs,[8] and
  - All other scenarios: data from samples collected from 0 to 1 ft bgs.

In determining the UCL when the medium is groundwater, data from samples from each potable aquifer (i.e., RGA and McNairy Formation) will be used; however, data will be summarized within and not over aquifers, consistent with EPA guidance (EPA 2014b). Note: For the groundwater integrator investigations (e.g., that for the Groundwater Operable Unit), the representative concentration for groundwater may be the average concentration of the samples taken from wells within the contaminant plume if data are sufficient. EPA guidance recommends calculating the 95% UCL of the arithmetic mean as the EPC for risk assessments (EPA 2014b). It is generally desirable to use at least 10 data points for each contaminant (e.g., 5 wells and 2 rounds of data representative of current conditions equate to 10 data points) to compute a 95% UCL. If the 95% UCL is greater than the maximum detected concentration, EPA guidance recommends that the EPC default to the maximum detected concentration for that contaminant. The RAWG has concluded that the 95% UCL should be used as the EPC and if the 95% UCL exceeds the maximum detected concentration, then the uncertainty needs to be discussed. If less than 3 wells are within the core of the plume, maximum detections may be used as the EPC for that contaminant (EPA 2014b). In addition, as with soil, the wells used in each calculation may be grouped so that risk or hazard at differing contaminant concentrations and in various areas may be estimated. Decisions concerning the method that will be used to estimate the concentration of COPCs for the groundwater integrator unit will be made on a case-by-case basis and will be justified in the baseline risk assessment.

Risks from water drawn from the UCRS will not be presented in the main body of the risk assessment because this water source is not considered to be an aquifer due to low yield. However, risks from ingestion of water from this source will be considered at least qualitatively in the uncertainty section of the risk assessment.

Finally, for some samples, duplicate or split-sample analyses may be available. When calculating the representative concentration, the maximum value reported in the duplicate or split-sample analysis will be

[12] Unless information indicates that results from samples collected at deeper depths (i.e., 0–16 ft bgs in areas where infrastructure is found) should be included in the derivation of the EPC.

used. Duplicate and split-sample results will not be averaged when calculating the representative concentration in baseline risk assessments performed for PGDP.

The EPCs and activities used for future conditions will depend on the time frame for which risk or hazard is being quantified. At minimum, for all assessments for PGDP, risk and hazard to potential future users, will be quantified using the current EPCs and activities. In addition, for those sites and areas where future concentrations or activities may increase, modeled concentrations will be used. To determine if modeling is needed, the maximum soil concentrations and activities at the source (over all depths) for each analyte will be compared to the appropriate groundwater protection PRG (PRGs appear in Appendix A). If the maximum soil concentration exceeds the groundwater protection PRG, then future concentrations in groundwater and surface water (if appropriate) will be modeled. Models to be used to determine future concentrations and activities at the source and in groundwater will be based on the modeling matrix presented in Table 3.2. Tier 1 values are existing sets of screening levels used for the initial screening of a site. Tier 2 values also are used for scoping, but account for more specific estimates of model parameters than the default Tier 1 values. Tiers 3 and 4 are models used with primarily site–specific values for site decision making.

Because all models contain significant uncertainty, the baseline risk assessment's analysis of off-site migration also will include risks calculated using current contaminant concentrations [i.e., data collected within the year preceding the model so that the data is representative of modeled conditions, if possible (e.g., if the model is created in 2015, then data collected in 2014 will be used)] at source units in addition to modeled values. This analysis will be included in the uncertainty section of all baseline risk assessments that contain modeling.

In baseline risk assessments for the integrator units, analyte degradation, attenuation, and transformation will be considered in addition to migration when calculating future concentrations, if possible. The analysis of these factors will rely upon the analysis presented in earlier sections of the remedial investigation report.

The equations to be used to combine the EPCs and exposure factors to estimate dose will follow the general format presented in RAGS, Part A (EPA 1989a). This general equation is shown in Equation 5. Specific equations are presented in Appendix D of this document. In this appendix, references are presented for each exposure parameter (e.g., CR, BW) included in the equation. Generally, these parameters were taken from guidance documents (e.g., EPA 1989a; KDEP 2002) unless site-specific values are available. (Equations used to derive radionuclide dose are similar to those presented in Appendix D.)

$$\text{Intake} = C \times \frac{CR \times EFD}{BW} \times \frac{1}{AT} \qquad \textbf{Eq. 5}$$

where: Intake = The chemical dose [mg/(kg × day)]
C = The average concentration contacted over the exposure period. See Eqs. 6 and 7 and associated discussion.
CR = The contact rate or amount of contaminated medium contacted per unit time or event.
EFD = The exposure frequency and duration describing how long and how often exposure occurs.
BW = The average body weight of the receptor over the term of exposure.
AT = The averaging time or period over which exposure is averaged.

In the material in Appendix D, equations that can be used to calculate the concentrations of COPCs in selected biota (e.g., vegetables, fish, game, and livestock) also are presented. Generally, for baseline human health risk assessments for source units inside the industrialized area at PGDP, concentrations of COPCs in biota will be estimated using these equations because biota sampling cannot be performed. (These biota are not present.)

Table 3.2. Modeling Matrix for Groundwater, Surface Water, and Biota

	Values for Soil to Protect Groundwater	Model	Point of Exposure	Notes
INVESTIGATION DOCUMENTS	Tier 1 (Used for scoping)	Soil Screening Levels (SSLs) and/or RESidual RADioactivity (RESRAD) Vapor intrusion model	At source unit At source unit	Value to be used for initial scoping, use dilution attenuation factor (DAF) of 1 for SSLs unless site-specific values are available. Groundwater protection value based on residential use and targets of 1E-6, 0.1, and 1 for risk, hazard, and radiological dose, respectively. If site-specific DAF values are used, then need to justify these values. The depth of water needs to be considered in the calculation. Initial vapor intrusion model will use default values.
	Tier 2 (Used for scoping)	Seasonal Soil Model (SESOIL) and/or RESRAD	At source unit	Includes source delimitation. Recognize SESOIL limitations when modeling inorganic COPCs-refine distribution coefficients (K_ds).
DECISION DOCUMENTS	Tier 3 (Enhanced modeling used in decision documents if needed)	SESOIL and RESRAD suite of codes (including RESRAD-OFFSITE) with Analytical Transient 1-, 2-, 3-Dimensional Simulation of Waste Transport in the Aquifer System (AT123D)	At source unit and at downgradient points (Industrialized area, DOE property boundary, creek, river)	Uses source delimitation and refined K_ds from above. Use values from this effort to set initial cleanup levels. On the Terrace (southern portion of PGDP), different points of exposure will apply.
	Tier 4 (Enhanced modeling used in decision and design documents if needed)	Source modeling and three-dimensional finite-difference groundwater model (MODFLOW/MT3D/ RT3D)	At source unit and at downgradient points appropriate to the selected remedy	To be used to refine cleanup levels (if needed). May be especially important to set monitoring goals. On the Terrace (southern portion of PGDP), different points of exposure will apply.

Table 3.2. Modeling Matrix for Groundwater, Surface Water, and Biota (Continued)

	Values for Soil and Sediment to Protect Surface Water	Model	Point of Exposure	Notes
INVESTIGATION DOCUMENTS	Tier 1 (Used for scoping)	SSLs and/or RESRAD	At source unit	Value to be used for initial scoping by Project Team. Use DAF of 1 for SSLs. Groundwater protection value based on recreational use and targets of 1E-6, 0.1, and 1 for risk, hazard, and radiological dose, respectively. If site-specific DAF values are used, then need to justify these values.
	Tier 2 (Used for scoping)	Modified Universal Soil Loss Equation (MUSLE)	At source unit	Includes source delimitation. Value to be used during follow-up meetings by Project Team.
DECISION DOCUMENTS	Tier 3 (Enhanced modeling used in decision documents if needed)	Storm Water Management Model (SWMM)	At source unit and at downgradient points (Industrialized area, creek)	Uses source delimitation from above. Initial cleanup level calculations.
	Tier 4 (Enhanced modeling used in decision and design documents if needed)	Enhanced SWMM	At source unit and at downgradient points appropriate to the selected remedy (Industrialized area, creek)	To be used to refine cleanup levels (if needed). May be especially important to set monitoring goals.

Table 3.2. Modeling Matrix for Groundwater, Surface Water, and Biota (Continued)

	Values for Soil and Sediment to Protect Biota	Model	Point of Exposure	Notes
INVESTIGATION DOCUMENTS	Tier 1	NONE	NONE	The RAWG determined that development of screening values based on biota modeling would not be appropriate; therefore, these values do not exist.
	Tier 2 (Used in Baseline Risk Assessments)	Those contained in current Methods Document, Appendix D	At source unit	Includes source delimitation.
DECISION DOCUMENTS	Tier 3 (Enhanced modeling used in Decision Documents if needed)	Those contained in current Methods Document, Appendix D for biota and transport models presented earlier for receiving media.	At source unit and at downgradient points (Industrialized area, creek)	Uses source delimitation from above. Initial cleanup level calculations.
	Tier 4 (Enhanced modeling used in Decision and Design Documents if needed)	Those contained in current Methods Document, Appendix D for biota and transport models presented earlier for receiving media.	At source unit and at downgradient points (Industrialized area, creek)	To be used to refine cleanup levels (if needed). May be especially important to set monitoring goals.

For assessments for source units outside the industrialized area and for integrator unit baseline risk assessments, results from biota sampling may be available. In cases where this information is available, the EPC will be calculated using the methods presented earlier in this section. In cases where this information is not available, the equations presented in Appendix D will be used to estimate the concentrations in biota. (Note: Because concentrations in biota can differ markedly with time of sampling, tissue sampled, species sampled, age of animal, and other factors, the use of analytical results from biota sampling in the risk assessment also may give results that are very uncertain; therefore, the uncertainty in the results calculated using biota analytical results also will be considered completely.)

3.3.4.4 Consideration of vapor intrusion

Analysis of the exposure pathway for vapor intrusion due to volatile organic compound (VOC)-contaminated soils and groundwater will be evaluated on a project-specific basis, as needed. This potential exposure pathway often is considered in order to support possible future industrial missions within the PGDP industrialized area. Redevelopment with the potential for inhabited structures to be located in areas where VOC-contaminated groundwater and soil exist or have existed is considered a reasonable future use. Additionally, areas outside the industrialized area where volatile contaminants may be present (e.g., the Water Policy Area) may be considered.

OSWER Technical Guide for Assessing and Mitigating the VI Pathway from Subsurface Vapor Sources to Indoor Air (EPA 2015a) provides technical and policy recommendations on determining if the VI pathway poses an unacceptable risk to human health. VISLs can be used to evaluate site analytical data. VISLs are risk-based screening levels used to identify sites or buildings that may pose a health concern through the vapor intrusion pathway. The EPA VISL calculator is located on the Web site https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls. Please refer to Table E.10 in Appendix E for vapor intrusion risk information. At sites where subsurface concentrations of vapor-forming chemicals fall below VISLs, no further action or study is warranted as long as the site fulfills the conditions and assumptions of the generic conceptual model underlying the development of the VISLs. Evaluating these conditions and assumptions requires "basic knowledge of the subsurface source of vapors (e.g., location, form, and extent of site-specific vapor-forming chemicals) and subsurface conditions (e.g., soil type in the vadose zone, depth to groundwater for groundwater sources), which are important elements of the CSM."

Exceeding a VISL generally suggests that unacceptable exposures might occur and that further evaluation of the vapor intrusion pathway is appropriate. Further evaluation could be a human health risk assessment conducted to determine whether the potential human health risk posed to building occupants by a complete vapor intrusion pathway are within or exceed acceptable levels of risk (i.e., EPA CERCLA risk range and Kentucky's target risk[13]), consistent with EPA guidance. The primary purpose of this risk assessment is to provide risk managers with an understanding of the risks to human health posed by vapor intrusion under current and reasonably expected future conditions. Depending on building- and site-specific circumstances, an early action also could be considered. See Sections 3.3 and 7.8 of OSWER Publication 9200.2-154 for additional information on when it may be appropriate to implement mitigation of the vapor intrusion pathway as an early action even though all pertinent lines of evidence have not yet been completely developed.

[13] EPA's generally acceptable risk range is 10^{-4} to 10^{-6} for carcinogenic risk and below the HI of 1 for noncarcinogens (EPA 1999b). Kentucky's target risk is defined as 10^{-6} (401 *KAR* 100:030).

3.3.4.5 Presentation of the results of the exposure assessment

Several figures and tables will be used to report the results of the exposure assessment in baseline human health risk assessments performed for PGDP. As noted earlier, conceptual site models for each unit, group of units, or area under investigation will be presented, and tables presenting exposure and risk information will be prepared. In addition, this section also will present a summary of the decisions made concerning the selection of pathways to be quantified for each unit or area under investigation; the representative (i.e., exposure point) concentration of COPCs in each medium, including biota; any chemical-specific values used in the calculations; and the daily intakes resulting from the application of the exposure equations.

The material appearing in this summary will be taken from the larger tables presented in the appendix to the risk assessment. Formats to present this summary information are in Exhibits 3.9–3.12.

Exhibit 3.9. Summary of Pathway Analysis in the Exposure Assessment

Potentially Exposed Population	Exposure route, medium, and exposure point[1]	Pathway selected? (yes/no)	Reason for pathway selection or dismissal[2]
Time period[3]			
Population 1[4]			
	Pathway 1		
	Pathway 2		
	. . .	. . .	. . .
	Pathway N		

[1] Each of the pathways presented in this section will be included.
[2] A short statement drawn from the discussion in the text will be provided for the decision.
[3] Summary tables will be prepared for both the current or future time period. If multiple future time periods are assessed, a summary table will be included for each.
[4] The populations include residential, recreational, industrial, and excavator. Only populations relevant to the time period will be included.

Exhibit 3.10. Presentation of Exposure Point Concentrations[1]

COPC[2]	Medium 1[3]	Medium 2	. . .	Medium N
Unit or Area 1[4]				
Analyte 1			. . .	
Analyte 2			. . .	
. . .	. . .	. . .	. . .	. . .
Analyte N			. . .	

[1] A table will be made for each time period if models are used to estimate future representative concentrations.
[2] All COPCs across all media will be presented for each unit or area.
[3] All media will be listed. The order will be groundwater, soil, sediment, surface water, and biota if possible. More than one EPC may be derived for a media if different depths are used for exposures under different scenarios.
[4] Each unit or area will be presented separately, but only one table will be used if possible.

Exhibit 3.11. Chemical-Specific Parameters

COPC[1]	Parameter 1[2]	Parameter 2	. . .	Parameter N
Analyte 1			. . .	
Analyte 2			. . .	
. . .	. . .	. . .	. . .	. . .
Analyte N			. . .	

[1] All COPCs over all units or areas investigated will be presented. A separate list will not be presented for each unit unless unit-specific, chemical-specific parameters are used in the assessment.
[2] All chemical-specific parameters will be listed so that the calculations in the assessment can be duplicated by reviewers or users.

Exhibit 3.12. Daily Intakes (Chronic Dose) for Receptor 1[1]

COPC[2]	Pathway 1[3]	Pathway 2	. . .	Pathway N
Unit or Area 1[4]				
Analyte 1			. . .	
Analyte 2			. . .	
. . .	. . .	. . .	. . .	. . .
Analyte N			. . .	

[1] A separate table will be made for each receptor. If use patterns are assumed to differ between time periods, separate tables for each time period will also be provided.
[2] COPCs across all media will be listed for each unit or area.
[3] Each pathway included in the assessment will be listed. The order followed will be groundwater pathways, soil pathways, surface water pathways, sediment pathways, and biota pathways, if possible.
[4] A separate presentation will be made for each unit or area; however, only one table will be used if possible.

3.3.4.6 Probabilistic risk assessment

Initially, all baseline risk assessments will be conducted as deterministic (point estimate) risk assessments. COPCs with high variability and uncertainty in exposure concentrations or for which individual exposure parameters greatly influence the risk or hazard estimate may be considered for PRAs. These assessments evaluate the variability and uncertainty in risk estimates, and are used to determine the likelihood of exceeding a risk level of concern. PRAs will be conducted following the guidance in *RAGS Volume III-Part A* (EPA 2001a). Scoping is an extremely important component of a PRA to determine which parameters should vary and to develop appropriate ranges of values for those parameters. Ranges of values for variables in the risk equations that were used in a previous PRA for the Southwest Plume are provided in Appendix E of this document. The values for variables listed in Appendix E are appropriate as a starting point for other PRAs, but should be reviewed to ensure they are applicable to a specific project and modified if necessary. Documents using PRA also will need to include additional sections providing explanation of how the PRA was conducted, the interpretation of the results, and the appropriate application of the results to decision making to ensure that the PRA and its results are understandable to both the regulatory agencies and the public. Additional information regarding probabilistic risk assessment can be found in the references listed in Section 3.3.1.1.

3.3.5 Toxicity Assessment Methods

The primary purpose of this section of the baseline human health risk assessment will be to report the toxic effects of the COPCs on exposed populations. In addition, this section will briefly describe the methods used by EPA and in the toxicity assessment, to develop toxicity parameters, delineate the sources used to acquire the toxicity parameters, and present tables summarizing the toxicity information used in the risk assessment. In closing, this section will summarize the amount of toxicity information available on the COPCs in the risk assessment and discuss general toxicity assessment uncertainties. Requirements for each of these activities are discussed below.

3.3.5.1 Toxicity summaries

A toxicity summary for each COPC will be presented in the toxicity assessment. Each summary will contain a short description of the toxic effects of the chemical and the source of the toxicity values. Included in each description will be information on the effects associated with exposure to the chemical; the concentrations at which adverse effects are expected to occur in humans; a brief description of the database used to derive each toxicity value, including the particular study from which the toxicity value used in risk characterization was derived; and the approval status of any toxicity values. Each toxicity summary will conclude with a listing of the toxicity values used in the risk assessment for administered and absorbed dose routes of exposure.

3.3.5.2 Sources of toxicity information

The sources that will be used in developing toxicity information for risk assessments performed for PGDP are listed below. These will be examined in the order presented.

- Tier 1 sources: *IRIS* (EPA 2016b)
- Tier 2 sources: EPA Provisional Peer Reviewed Toxicity Values
- Tier 3 sources:
    - Health Effects Assessment Summary Tables (HEAST) (EPA 1997b, 2001b)
    - Other sources identified in OSWER Directive 9285.7-53
    - Agency for Toxic Substances and Disease Registry toxicological profiles

When compiling toxicity information, provisional and withdrawn values and toxicity values withdrawn from IRIS or HEAST will be included, and provisional values will be clearly identified. If toxicity information is not available from the sources listed above, surrogate chemicals with toxicity values may be identified through consideration of chemical structure and characteristics. Selection of surrogate chemicals requires consultation with and approval from EPA and KDEP.

Note: Toxicity values will not be developed for PGDP risk assessments without consultation with the regulatory agencies.

Three additional issues will be addressed when reporting the sources of toxicity information. These are the use of toxicity values for chronic versus subchronic effects, the calculation of toxicity values for absorbed versus administered dose, and the use of oral administered dose toxicity values for the inhalation exposure route. Each of these is discussed herein.

Generally, all risk assessments performed for PGDP will only use toxicity values for chronic exposure when characterizing risk. Although RAGS, Part A, (EPA 1989a) states that toxicity values for subchronic exposure should be used for exposure durations less than seven years in length, these will not be used because they are not available for many chemicals (in which case the chronic value should be used). The receptor groups that are affected by this decision are the child rural resident, the recreational user, and the outdoor worker. In no case will toxicity values based on subchronic exposure be used for child or teen receptors. For outdoor workers, toxicity values based in subchronic exposure may be used if the information provided by their use is beneficial in remedial action decision making.

To properly characterize risk from absorbed dose (e.g., dose from dermal absorption across the skin), it is necessary to have toxicity values that are based on absorbed dose. Generally, all toxicity values in IRIS and HEAST are based on administered dose and cannot be used directly with the chronic daily absorbed doses calculated using the exposure equations in Appendix D. To convert administered dose toxicity values to absorbed dose toxicity values, the guidance provided in *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual. Supplemental Guidance, Dermal Risk Assessment, Interim Guidance* (EPA 1992b) will be used. The method delineated in this guidance is depicted in Eqs. 6 and 7. Equation 6 shows that the administered dose toxicity value for cancer effects (administered dose slope factor) is converted to an absorbed dose toxicity value (absorbed dose slope factor) by dividing by the chemical-specific gastrointestinal absorption efficiency of the respective chemical or compound. Equation 7 shows that the administered dose toxicity value for systemic toxicity [administered reference dose (RfD)] are converted to an absorbed dose toxicity value (absorbed RfD) by multiplying by the chemical-specific gastrointestinal absorption efficiency of the respective chemical or compound.

As stated in RAGS Part E (EPA 2004):

> For those organic chemicals that do not appear on the table, the recommendation is to assume a 100% ABS_{GI} value, based on review of literature, indicating that organic chemicals are generally well absorbed (>50%) across the GI tract. Absorption data for inorganics are also provided in Exhibit 4-1 [see text box], indicating a wide range of absorption values for inorganics. Despite the wide range of absorption values for inorganics, the recommendation is to assume a 100% ABS_{GI} value for inorganics that do not appear in this table. This assumption may contribute to an underestimation of risk for those inorganics that are actually poorly absorbed. The extent of this underestimation is inversely proportional to the actual GI absorption.

$$Absorbed\ SF = \frac{Administered\ SF}{GI\ Efficiency} \qquad \textbf{Eq. 6}$$

where: Absorbed SF = The absorbed dose slope factor for cancer effects
Administered SF = The administered dose slope factor for cancer effects
GI Efficiency = The chemical-specific gastrointestinal absorption efficiency

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$$Absorbed\ RfD = Administered\ RfD \times GI\ Efficiency \qquad \textbf{Eq. 7}$$

where: Absorbed RfD = The absorbed reference dose for systemic toxicity
Administered RfD = The administered reference dose for systemic toxicity
GI Efficiency = The chemical-specific gastrointestinal absorption efficiency

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The dermal dose derived with this methodology provides an estimate of the contribution of the dermal pathway to the systemic dose. Dermal exposure for baseline risk assessments will follow the *Risk Assessment Guidance for Superfund Volume I : Human Health Evaluation Manual* (Part E, Supplemental Guidance for Dermal Risk Assessment) (EPA 2004c). The EPA guidance provides specific values for eleven compounds or groups of compounds in Exhibit 3-4 of the dermal guidance. For an alternative evaluation, providing more restrictive values for the dermal-soil pathway, the default values of 25% dermal absorption for VOCs, 10% dermal absorption from soil for all semivolatile organic compounds without specific absorption values specified in RAGS, Part E: and 5% dermal absorption from soil for all inorganic compounds without specific absorption specified in RAGS, Part E, may (based on project-specific goals) be applied to a quantitative risk assessment. This approach is consistent with guidance from KDEP. KDEP-specific values for dermal absorption are provided in Appendix B. See text box for additional information. For the dermal-water pathway, absorption should be calculated using the methods described in RAGS, Part E. For inorganic chemicals, the K_p (permeability coefficient) parameter has been identified as one of the major parameters contributing to uncertainty in the assessment of dermal exposures to contaminants in aqueous media. The EPA guidance recommends the use of predicted K_p values. For chemicals that fall outside the Effective Prediction Domain for determining K_p, a fraction-absorbed (FA) term should be applied. This Risk Methods Document recommends the EPA default exposure values for all variables for the dermal-water and dermal-soil pathways. These include the residential scenario for water exposure and residential and industrial for soil exposure. For dermal-water exposures, the entire skin surface area is assumed to be available for exposure when bathing and swimming occurs, but the surface area available for a wading scenario includes the portions of the body specified in Appendix D for the dermal equations. Default values for the soil adherence factor (AF) also are provided with the equations in Appendix D. The guidance does not include a method for assessing dermal absorption of chemicals in the vapor phase, with the assumption that inhalation will be the major exposure route for vapors.

In RAGS Part E 2004, Exhibit 4-1, the following GI absorption efficiencies are listed that are below the 5% dermal absorption KDEP has recommended as a default value for inorganics. For these constituents, the dermal absorption value should be modified from 5% to mimic the GI absorption efficiencies, as follows:

Beryllium	0.007	= 0.7%
Chromium III	0.013	= 1.3%
Chromium VI	0.025	= 2.5%
Manganese	0.04	= 4%
Nickel	0.04	= 4%
Silver	0.04	= 4%
Vanadium	0.026	= 2.6%

This is in addition to the chemical-specific dermal absorption fractions listed in RAGS Part E Exhibit 3-4, including:

Arsenic	0.03	= 3%
Cadmium	0.001	= 0.1%

3.3.5.3 Tables summarizing the toxicity information

To facilitate review of the toxicity assessment, summary tables of toxicity information will be prepared following the examples in the previous sections of this guidance document. Additional tables may be prepared for the main body of the risk assessment, if needed to clarify the toxicity assessment process.

3.3.5.4 Summary of toxicity information available on the COPCs

This section of the toxicity assessment will provide a listing of the chemical classes and the number of chemicals within each class that have toxicity information ordered by medium within the unit or area under investigation. This summary will be presented to illustrate the total amount of toxicity information available to characterize risk in the following section.

3.3.6 Risk Characterization Methods

The primary purpose of this section of the baseline human health risk assessment will be to integrate the dose information developed in the exposure assessment with the effects information presented in the toxicity assessment to characterize the risk and hazard posed by environmental contamination at PGDP. In this section, the methods used to integrate the information to characterize risk and hazard and the tables and narrative summarizing the risk characterization for each exposure unit under each current and potential future use scenario will be presented. This section will conclude with a listing of use scenarios of concern for each location and a listing of COCs, POCs, and MOCs for each use scenario of concern.

3.3.6.1 Methods used to integrate dose and toxicity

In all baseline human health risk assessments performed for PGDP, the methods outlined in RAGS, Part A, will be used to integrate dose and toxicity information and characterize risk. To characterize risk from inhaled contaminants, the methods outlined in RAGS, Part F will be followed (EPA 2009). The following presents the equations that will be used for these calculations and describes the result of each equation. Note: In this presentation, the calculations for systemic toxicity (i.e., hazard) and cancer risk are presented separately because they differ slightly. Also, note that the values for systemic toxicity are estimates of whether the daily doses from each COPC, from each exposure pathway, and over all pathways and COPCs exceed that which may result in toxic effects in the receptor. However, the values for cancer risk are estimates of the excess cancer incidence that may result from exposure to each COPC, from each exposure pathway, and over all pathways.

Equations 8, 9, and 10 will be used to characterize the potential for systemic toxicity in all baseline human health risk assessments performed for PGDP. The result of Eq. 8 (Eq. 8a for inhalation) is a numeric estimate of the potential for systemic toxicity posed by a single chemical within a single pathway of exposure. The result of Eq. 9 is a numeric estimate of the potential for systemic toxicity posed by all chemicals reaching a receptor through a single pathway. The result of Eq. 10 is a numeric estimate of the potential for systemic toxicity posed to a receptor by exposure to all chemicals over all pathways. (This last value is often called an estimate of "total noncarcinogenic risk.")

$$\mathrm{HQ}_i = \frac{\mathrm{CDI}_i}{\mathrm{RfD}_i} \qquad \textbf{Eq. 8}$$

where: HQ_i = The hazard quotient, an estimate of the systemic toxicity posed by a single chemical
CDI_i = The estimate of chronic daily intake (or absorbed dose for some exposure routes) from the exposure assessment (calculated from the chemical intake equations in Appendix D)
RfD_i = The chronic reference dose for administered or absorbed dose, as appropriate

$$\mathrm{HQ} = \frac{\mathrm{EC}\ (\mu\mathrm{g/m3})}{[\mathrm{RfC}\ (\mathrm{mg/m3}) \times 1000\ (\mu\mathrm{g/mg})]} \qquad \textbf{Eq. 8a}$$

where: HQ_i = The hazard quotient, an estimate of the systemic toxicity posed by a single chemical for inhalation
EC_i = The exposure concentration for chronic exposure (calculated from the equations in Appendix D)
RfC_i = The reference concentration for chronic inhalation exposure

$$HI_p = \sum_{i=1}^{n} HQ_i \qquad \textbf{Eq. 9}$$

where: HI_p = The pathway hazard index, an estimate of the systemic toxicity posed by all chemicals within a single pathway

HQ_i = The individual chemical hazard quotients for chemicals reaching the receptor through a single pathway (from Eq. 8 or Eq. 8a)

$$HI_{total} = \sum_{p=1}^{n} HI_p \qquad \textbf{Eq. 10}$$

where: HI_{total} = The total hazard index, an estimate of the systemic toxicity posed by all chemicals over all pathways
HI_p = The pathway hazard indices from Eq. 9

Equations 11, 12, and 13 will be used to characterize the potential excess lifetime cancer incidence (i.e., ELCR) in all baseline human health risk assessments performed for PGDP. The result of Eq. 11 (Eq. 11a for inhalation) is an estimate of the increased cancer incidence (i.e., a probability) to a receptor that results from exposure to a single chemical (or radionuclide) within a single pathway for chemicals without identified mutagenic effects. For chemicals with mutagenic effects, the equation may be modified through use of age-dependent adjustment factors combined with age-specific exposure estimates to assess cancer risks, consistent with EPA guidance (EPA 2005b). The result of Eq. 12 is an estimate of the increased cancer incidence (i.e., probability) that results from exposure to all chemicals (or radionuclides) reaching a receptor through a single pathway. The result of Eq. 13 is an estimate of the increased cancer incidence (i.e., probability) that results from exposure to all chemicals (or radionuclides) reaching a receptor over all pathways. (This last value is often called an estimate of “total carcinogenic risk.”)

$$\mathrm{ELCR}_i = \mathrm{CDI}_i \times \mathrm{SF}_i \qquad \textbf{Eq. 11}$$

where: $ELCR_i$ = The chemical-specific excess cancer incidence
CDI_i = The estimate of chronic daily intake (or absorbed dose) from the exposure assessment (calculated from the chemical intake equations in Appendix D)
SF_i = The slope factor for administered or absorbed dose, as appropriate

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$$\mathrm{ELCR} = \mathrm{EC}\ (\mu\mathrm{g/m3}) \times \mathrm{IUR}\ (\mu\mathrm{g/m3})^{-1} \qquad \textbf{Eq. 11a}$$

where: $ELCR_i$ = The chemical-specific excess cancer incidence
EC_i = The exposure concentration for chronic exposure (calculated from the equations in Appendix D)
IUR_i = The unit risk for chronic inhalation exposure

$$ELCR_p = \sum_{i=1}^{n} ELCR_i \qquad \textbf{Eq. 12}$$

where: $ELCR_p$ = The pathway-specific excess cancer incidence
ELCRi = The chemical-specific excess cancer incidence from Eq. 11 or Eq. 11a

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$$ELCR_{total} = \sum_{p=1}^{n} ELCR_p \qquad \textbf{Eq. 13}$$

where: $ELCR_{total}$ = The total excess cancer incidence posed by all chemicals over all pathways
$ELCR_p$ = The pathway-specific excess cancer incidence from Eq. 12

3.3.6.2 Presentation of risk characterization

In the baseline human health risk assessment, risk will be characterized for each exposure unit under each current and potential future use scenario. The results of the characterization will be presented in both tables and as narrative. The tables that will be used for each time, exposure unit, and receptor combination will be consistent with the two-way table presented in RAGS, Part D (EPA 1998b). At this time, scenarios are evaluated independently. Scenarios may be combined if it is determined that it is appropriate to do so to represent cumulative risk on a site-specific basis. The exact format presented in RAGS Part D is not used for the PGDP risk characterization tables because the FFA team discussed table presentation and agreed that the tables presented in this guidance document are adequate to meet the intent of RAGS, Part D. The narrative that explains this table, which may include summary tables, will present the exposure unit; the receptor, HI_{total} (from Equation 10) or $ELCR_{total}$ (from Equation 13); the primary pathways contributing to HI_{total} or $ELCR_{total}$ (i.e., "driving pathways"); and the primary chemicals contributing to HI_{total} or $ELCR_{total}$ (i.e., "driving chemicals"). An example of a narrative description of risk taken from DOE 1996e is presented below.

Exhibit 3.13 summarizes the HIs for exposure routes for the current industrial worker over all locations. As shown in this exhibit, the total scenario HI (i.e., Location Total in Exhibit 3.13) is greater than 1 for Sectors 5, 6, and 9. For each location, the driving exposure route is dermal contact with soil, which accounts for more than 95% of the total HI. Also, for each location, the inhalation exposure route contributes insignificantly to the location total HI.

Exhibit 3.13. Exposure Route Summary for the Current Use Scenario—Systemic Toxicity[a]

Scenario and Location	Exposure Routes for Soil			Location Total
	Incidental Ingestion	Dermal Contact	Inhalation of Vapors/Particles	
Current industrial worker				
Sector 1 % of Total	N/A NV	N/A NV	N/A NV	**NV**
Sector 2 % of Total	< 0.1 1%	0.4 99%	NV NV	**0.4**
Sector 3 % of Total	< 0.1 2%	0.3 98%	< 0.1 < 1%	**0.3**
Sector 4 % of Total	< 0.1 1%	1.0 99%	< 0.1 < 1%	**1.0**
Sector 5 % of Total	< 0.1 2%	1.7 98%	< 0.1 < 1%	**1.8**
Sector 6 % of Total	< 0.1 5%	1.2 95%	< 0.1 < 1%	**1.2**
Sector 8 % of Total	< 0.1 < 1%	1.0 99%	< 0.1 < 1%	**1.0**
Sector 9 % of Total	< 0.1 1%	1.3 99%	NV NV	**1.3**

N/A indicates that the scenario is not applicable for this location.
NV indicates that a value is not available.
[a] Current convention is to use one significant digit for presentation of hazard indices. Two significant digits are used here when the hazard index is greater than 1 to enable the reader to match the numbers reported in the exhibit with those in its associated risk characterization table. Additionally, use of two significant digits, when the exposure route's value is greater than 1, allows the reader to sum the route values and check the location total.

Exhibit 3.14 summarizes the contaminants contributing more than 1% of the total systemic toxicity for the current industrial worker over all locations for those locations where the total systemic toxicity for the location exceeds 1. As shown in this exhibit, in each case, metals are the primary driving contaminants; however, PCBs and PAHs are minor contributors for Sector 6.

Exhibit 3.14. Driving Contaminants Summary for Current Use Scenario—Systemic Toxicity

Scenario and Location	Driving Contaminants Over All Exposure Routes	Location Total
	Current industrial worker	
Sector 1	HI < 1	**NV**
Sector 2	HI < 1	**0.4**
Sector 3	HI < 1	**0.3**
Sector 4	HI < 1	**1.0**
Sector 5	iron (47%); chromium (26%); antimony (22%); uranium (3%)	**1.8**
Sector 6	chromium (22%); antimony (22%); arsenic (20%); PCB (13%); aluminum (13%); pyrene (2%); fluoranthene (1%)	**1.2**
Sector 8	HI < 1	**1.0**
Sector 9	antimony (58%); aluminum (23%); chromium (17%); uranium (2%)	**1.3**

N/A indicates that the scenario is not applicable for this location.
NV indicates that a value is not available.
HI < 1 indicates that total scenario hazard index is less than 1; therefore, analytes are not listed.

In the tables prepared for risk characterization, all COPCs will be listed, even those that do not have a value. Also, these tables will present the total chemical-specific hazard (or total chemical-specific risk) over all pathways, the total pathway-specific hazard (or risk) over all chemicals, the total hazard or risk over all pathways and chemicals, and the total risk and hazard over all media within the exposure unit (consistent with the Conceptual Site Model).

3.3.6.3 Risk characterization for lead

Risk characterization for lead is a special case. Although it is known that exposure to lead can result in systemic toxic effects and possibly cancer, the approved toxicity values required to estimate potential for systemic toxicity and carcinogenesis are not available. The risk characterization for lead will consist of a comparison of the maximum detected concentration from the site/source to the no-action screening levels from EPA and the Commonwealth of Kentucky. The no-action screening levels are 400 mg/kg in soil and sediment for the residential and recreational scenarios, 800 mg/kg in soil and sediment for the industrial, and outdoor worker scenarios) and 15 μg/L in groundwater and surface water for all scenarios (residential, recreational, industrial, and outdoor worker). Sites with lead concentrations exceeding these levels will undergo additional analysis for risk using the results of EPA's IEUBK (EPA 2004a) for evaluating residential and recreational exposures of children and the results of the EPA Adult Lead Model (ALM) (EPA 2003a) for evaluating industrial and outdoor worker exposures. The parameters for use in each of these models are presented in Appendix B. Screening values for lead appear in the tables presented in Appendix A.

3.3.6.4 Selection of use scenarios, POCs, COCs, and MOCs

Use scenarios, pathways, contaminants, and MOC will be identified for each unit or area under investigation. If any unit or area is divided into exposure units during the exposure assessment, use scenarios, pathways, contaminants, and MOC will be identified for each exposure unit.

In identifying use scenarios, pathways, contaminants, and MOC, specific rules will be followed as discussed below.

- **Identification of use scenarios of concern.** To determine use scenarios of concern or the basis of risk, risk characterization results for total systemic toxicity (HI_{total}) and total risk ($ELCR_{total}$) will be compared to benchmarks of HI = 1.0 and ELCR = 1×10^{-6}. Use scenarios with HI_{total} or $ELCR_{total}$ exceeding either of these benchmarks will be deemed use scenarios of concern. Note: The results in the example narrative provided in Section 3.3.6.2 indicate the teen recreational use scenario is a use scenario of concern for SWMU 8a (HI_{total} = 71.5). This value would be found in the lower right hand corner of a two-way table consistent with RAGS, Part D (EPA 1998b).

- **Identification of POCs.** To determine POCs, risk characterization results for pathway hazard (HI_p) and risk ($ELCR_p$) over all chemicals *within a use scenario of concern* will be compared to benchmarks of HI = 0.1 and ELCR = 1 × 10^{-6}. Pathways within a use scenario of concern exceeding either of these benchmarks will be deemed POCs for the use scenario of concern. Note: The results in the example narrative provided in Section 3.3.6.2 indicate that the POCs for the teen recreational user are dermal contact with surface water (HI_p = 2.0), dermal contact with leachate (HI_p = 0.6), ingestion of fish (HI_p = 60.5), ingestion of sediment (HI_p = 0.1), dermal contact with sediment (HI_p = 8.2), and ingestion of venison (HI_p = 0.2). These values would be found along the bottom margin of a two-way table consistent with RAGS, Part D (EPA 1998b).

- **Identification of COCs.** To determine COCs, risk characterization results for chemical hazard (HQ_i) and risk ($ELCR_i$) over all pathways *within a use scenario of concern* will be compared to benchmarks of HQ = 0.1 and ELCR = 1 × 10^{-6}. Chemicals of potential concern within a use scenario of concern exceeding either of these benchmarks will be deemed COCs for the use scenario of concern. [Note: For dioxins and furans, carcinogenic PAHs, and PCBs, the total risk over all congeners (for dioxins and furans) or compounds (for carcinogenic PAHs and PCBs) will be used when determining if these are COCs.] The results in the example narrative provided in Section 3.3.6.2 indicates that the COCs for the teen recreational user are aluminum (HQ_i = 0.2), antimony (HQ_i = 6.1), arsenic (HQ_i = 0.2), cadmium (HQ_i = 0.6), iron (HQ_i = 9.4), manganese ((HQ_i = 48.4), strontium (HQ_i = 0.1), vanadium (HQ_i = 4.7), and zinc (HQ_i = 1.7). These values would be found along the right margin of a two-way table.

- **Identification of Priority COCs.** To determine priority COCs (i.e., those COCs contributing most to cumulative HI and ELCR), risk characterization results for chemical hazard (HQ_i) and risk ($ELCR_i$) over all pathways *within a use scenario of concern* will be compared to benchmarks of HQ = 1 and ELCR = 1 × 10^{-4}. COCs exceeding either of these benchmarks will be deemed priority COCs for the use scenario of concern. [Note: For dioxins and furans, carcinogenic PAHs, and PCBs, the total risk over all congeners (for dioxins and furans) or compounds (for carcinogenic PAHs and PCBs) will be used when determining if these chemicals are priority COCs.]

- **Identification of MOCs.** To determine MOCs, the POCs are reviewed, and those media in these pathways are deemed to be MOC. This is equivalent to screening the total risk and hazard posed by COPCs in the various media against benchmarks of HI = 0.1 and ELCR = 1 × 10^{-6}. For the results presented in the example narrative in Section 3.3.6.2, the MOCs are surface water, leachate, fish, sediment, and venison.

- **Identification of scenarios of concern, POCs, COCs, and MOCs in Radiological Dose Assessment.** If a radiological dose assessment is conducted to provide additional information to risk managers, a scenario of concern will be one that has a total radiological dose exceeding the PGDP *de minimis* radiological dose of 1 mrem/year. A COC will be one that has a contaminant-specific radiological dose exceeding 1 mrem/year. A POC will be an exposure route that has a route-specific radiological dose exceeding 1 mrem/year. An MOC will be those media appearing in any POC.

3.3.6.5 Consideration of COPCs for which risk cannot be estimated

For some COPCs, information is insufficient for risk characterization. Generally, risk cannot be characterized for these chemicals because toxicity values are not available. When this occurs in risk assessments performed for PGDP, these COPCs will be deemed COCs during risk characterization, and they will be reported along with the COCs chosen by the rules outlined above.

3.3.6.6 Summary of risk characterization

To provide a summary of risk characterization for each unit or area under investigation, a table will be prepared and included as a summary of risk characterization in all baseline human health risk assessments. This table will follow the format shown in Exhibit 3.15 and list the risk and hazard posed within each use scenario of concern, the percent contribution of each POC to HI_{total} and $ELCR_{total}$, and the percent contribution of each COC to HI_{total} and $ELCR_{total}$. A similar table will be prepared to summarize the results of the radiological dose assessment if a radiological dose assessment is conducted for the site.

Exhibit 3.15. Summary of Risk Characterization

Use Scenario[1]	Total ELCR[2]	COCs[3]	% Total ELCR[4]	POCs[5]	% Total ELCR[6]	Total HI[7]	COCs	% Total HI[8]	POCs	% Total HI[9]
# 1										
# 2										
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
# N										

1 All use scenarios will be listed.
2 These values will be those found at the lower right of each unit's two-way table for the scenario of interest.
3 These constituents will be the COCs selected applying the rules listed earlier.
4 This value will be calculated by dividing the chemical-specific ELCR ($ELCR_i$) by the total ELCR ($ELCR_{total}$).
5 These pathways will be the POCs selected applying the rules listed earlier.
6 This value will be calculated by dividing the pathway-specific ELCR ($ELCR_p$) by the total ELCR ($ELCR_{total}$).
7 These values will be those found at the lower right of each unit's two-way table for the scenario of interest.
8 This value will be calculated by dividing the chemical-specific hazard quotient (HQ_i) by the total HI (HI_{total}).
9 This value will be calculated by dividing the pathway-specific HI (HI_p) by the total HI (HI_{total}).

3.3.7 Consideration of Uncertainty in the Risk Assessment

Uncertainties are associated with each of the steps of the baseline risk assessment. Following a general discussion of uncertainties in risk assessment, this section presents the uncertainties that will be addressed in baseline human health risk assessments prepared for PGDP and provides a format for summarizing this information (when a qualitative uncertainty analysis or sensitivity analysis is performed).

The potential effect of the uncertainties on the final risk characterization must be considered when interpreting the results of the risk characterization because the uncertainties directly affect the final risk estimates. Types of uncertainties that must be considered can be divided into four broad categories. These are uncertainties associated with data and data evaluation (i.e., identification of COPCs); exposure assessment; toxicity assessment; and risk characterization. Specific uncertainties under each of these broad categories that will be addressed in baseline human health risk assessments completed for PGDP are listed in the following material.

The exact method that will be used to present the uncertainty analysis in all baseline risk assessments cannot be included here. This is due, in large part, to the fact that the rigor of the uncertainty analysis will depend on the unit or area under investigation, the decisions that must be made for the unit or area, and the uncertainties affecting the risk estimates. At minimum, all baseline risk assessments will contain a qualitative uncertainty analysis that will include a quantitative sensitivity analysis of salient uncertainties. In the qualitative uncertainty analysis, the magnitude of the uncertainty on the risk characterization will be categorized as small, moderate, or large. Uncertainties categorized as small will be those that should not cause the risk estimates to vary by more than one order of magnitude; uncertainties categorized as moderate will be those that may cause the risk estimates to vary by between one and two orders of magnitude; and, uncertainties categorized as large will be those that may cause the risk estimates to vary by more than two orders of magnitude.

In the qualitative uncertainty analysis, a note will be made that the uncertainties listed and evaluated are neither independent nor mutually exclusive. It also will be noted that the total effect of all uncertainties upon the risk estimates is not the sum of the estimated effects of each uncertainty evaluated.

3.3.7.1 Uncertainties in data, data evaluation, and identification of COPCs

- Retention of common laboratory contaminants in the list of COPC
- Retention of infrequently detected analytes (i.e., detected in less than 10% of the samples analyzed) in the list of COPCs
- Lack of consideration in temporal patterns when selecting COPCs
- Spatial distribution and number of sampling locations (representativeness)
- Quantitation limits for some analytes exceeding their respective human health risk-based screening criteria (i.e., PRGs)
- Use of historical data[14] in addition to data collected as part of the RI field investigation
- Removal of analytes from the list of COPCs on the basis of a comparison to background concentrations
- Removal of analytes from the list of COPCs on the basis of comparison to concentrations found in associated blanks
- Removal of analytes from the list of COPCs on the basis of a toxicity screen
- Characterization of EPCs for environmental media under current conditions, including EPCs that are greater than maximum detected values
- Consideration of temporal changes in analyte concentrations and activities
- Use of results from analyses of unfiltered groundwater samples versus filtered groundwater samples
- Use of results from analyses of unfiltered surface water samples versus filtered surface water samples
- Uncertainties in exposure assessment
- Incorporation of biota fate and transport modeling into risk and hazard estimates (if this type of modeling were performed)
- Uncertainties in modeled concentrations, including the consideration of solubility as defined by differences between contaminant concentrations in filtered and unfiltered water samples

[14] This uncertainty includes use of historical data with qualifiers, as described in Step 4 of Section 3.3.3.2.

- Use of reasonable maximum exposure parameters versus average parameters for all exposure routes and associated pathways

- General issues in the development of conceptual site models

- Consideration of livestock scenarios

- Summation of risk and hazard across units or areas under investigation

- Use of default values from KDEP 2002 when estimating dermal absorbed dose (especially from soil and sediment)

- Difference in gamma walkover survey results and associated laboratory analyses

- Difference in calculation due to use of significant figures

3.3.7.2 Uncertainties in toxicity assessment

- Use of provisional or withdrawn toxicity values

- Difference in risk estimates for TCE based on use of KDEP oral slope factor and EPA TCE oral slope factor

- Extrapolation of oral administered dose toxicity values to inhalation dose toxicity values

- Derivation of absorbed dose toxicity values from oral administered dose toxicity values

- Lack of toxicity information, toxicity values, or both for some COPCs

- Use of chronic exposure toxicity values for exposures that are subchronic

3.3.7.3 Uncertainties in risk characterization

- Combination of chemical-specific risk and hazard estimates ($ELCR_i$ and HQ_i, respectively) to derive pathway-specific and use scenario risk and hazard estimates ($ELCR_p$ and $ELCR_{total}$ and HI_p and HI_{total}, respectively) (i.e., effect of chemical mixtures)

- Using mutagenic effects for risk characterization

- Combination of risk estimates from chemical and radioisotope exposure

- Summing cancer risks across pathways and across target organs

- Evaluating presence or absence of Chromium VI when analyte-specific analyses are not available.

(Note: Uncertainties regarding the risk characterization are discussed in the accompanying text box.)

3.3.7.4 Summary of qualitative uncertainty analysis

Because uncertainties in the baseline risk assessment must be addressed when screening potential remedial actions, developing revised preliminary remedial goals from RGOs and selecting the final action, the effect of all uncertainties on the risk and hazard estimates will be summarized in a single table. Note: Exhibit 3.16, is most useful when summarizing a qualitative uncertainty analysis; other formats may be used for a quantitative uncertainty analysis.

In addition to the summary table, a narrative (i.e., an Observations section) discussing the joint effects of the various uncertainties on the risk characterization results will be prepared. The overall goal of the narrative will be to focus the list of COCs to those COCs that contribute significantly to the risk and for which the risk estimate or the revised risk estimate in the uncertainty analysis is believed to reasonably reflect the risks posed to receptors under the most likely future use. This narrative in the Observations section will discuss how uncertainties affect the identification of COCs and evaluate scenarios that reflect the most likely future exposure. It also will describe how the inclusion of certain pathways (dermal, food ingestion, etc.) may lead to an overestimate of risks and summarizes which contaminants and/or pathways exceed *de minimis* levels. The narrative will address each of the COCs individually.

Uncertainty in Combining Chemical-Specific Risk and Hazard Estimates and Pathway-Specific Risk and Hazard Estimates

One uncertainty in the risk characterization guidance contained in this document is the method used to combine HQs and chemical-specific ELCRs across pathways and to combine pathway HIs and ELCRs to calculate total HI and ELCR. The method to be used to calculate pathway HIs and ELCRs follows EPA protocols (EPA 1989a). This method calls for the simple addition of HQs and chemical-specific ELCRs to calculate pathway HIs and ELCRs, respectively, and assumes that all effects between chemicals are additive. As explained in EPA 1989a, this assumption is made because information concerning the effects of chemical mixtures is lacking.

The following limitations of this approach for systemic toxicity effects are reported by EPA:

- Little is known about the effects of chemical mixtures; although additivity is assumed, the interaction of multiple chemicals could possibly be synergistic or antagonistic.
- The RfDs and RfCs do not have equal accuracy or precision and are not based on the same severity of effects.
- Dose additivity is most properly applied to compounds that induce the same effect by the same mechanism of action. While the approach recommended by EPA is a useful screening-level approach, the cumulative systemic toxicity could be overestimated for chemicals that act by different mechanisms and/or on different target organs.

The following limitations of this approach for chemical carcinogenesis are reported by EPA:

- Cancer risks (i.e., ELCRs) are based on slope factors that represent an upper 95th percentile estimate of potency; the upper 95th percentiles of probability distributions are not strictly additive. Summing these risks can result in an overly conservative estimate of lifetime ELCR.
- Cancer risks may not be additive. By analogy to systemic toxicity effects, the endpoints may differ, and mechanisms of effect may vary.
- Not all slope factors contain the same weight-of-evidence for human carcinogenicity. EPA recognizes this by placing weight-of-evidence classifications on all slope factors. Those contaminants with a weight-of-evidence classification of A should probably receive more attention in the selection of a remedial design than contaminants with a B or C classification. Similarly, a contaminant with a B classification should probably receive greater attention than one with a C classification. The simple combination of ELCRs does not take this hierarchy into account.

Uncertainty in Combining Risk Estimated for Chemical Exposure to Those for Risk Estimated for Radioisotope Exposure

Uncertainty associated with adding risks from chemical exposure to those from exposure to radionuclides arises from two sources. First, the slope factors used to characterize the risk from chemicals are derived differently from the slope factors used to characterize risk from radionuclides. This difference results in estimates of chemical exposure risks that may be considered to be upper-bound risk estimates and estimates of radionuclide exposure risks that may be considered to be central tendency (i.e., "best") estimates; therefore, combining chemical exposure and radionuclide exposure risk estimates to estimate total risk for a land use scenario may place too much emphasis on chemical exposure risk. Second, the mechanism by which chemicals may cause cancer varies from the mechanism by which radionuclides may cause cancer. This difference in mechanism of action inflates the uncertainties that assume cancer risks are additive.

Exhibit 3.16. Summary of Uncertainty Analysis

Description of Uncertainty	Estimated Effect[1]		
	Small	Moderate	Large
Uncertainties related to data, data evaluation, and identification of chemicals of potential concern[2]			
Data uncertainty 1			
Data uncertainty 2			
. . .	. . .	. . .	. . .
Data uncertainty n			

[1] Definitions of effects are as follows:

- Small—Uncertainty should not cause the risk or hazard estimate to vary by more than one order of magnitude;
- Moderate—Uncertainty may cause the risk or hazard estimate to vary by between one and two orders of magnitude; and
- Large—Uncertainty may cause the risk or hazard estimate to vary by more than two orders of magnitude.

[2] A similar heading will appear for each of the major portions of the baseline human health risk assessment. The other headings are "Uncertainties related to exposure assessment," "Uncertainties related to toxicity assessment," and "Uncertainties related to risk characterization."

3.3.8 Remedial Goal Option Derivation Methods

This section of the baseline human health risk assessment will delineate the methods used to derive and present RGOs. It is important to note that RGOs are not cleanup levels, but are site-specific, risk- or radiological dose-based criteria that may be used to guide the development of revised PRGs in the FS and cleanup levels in the Record of Decision (ROD) by risk managers. Cleanup levels are developed as part of the risk analysis in the ROD (EPA 2018a).

3.3.8.1 Calculation of remedial goal options

Guidance in EPA (2018) directs that multiple RGOs must be calculated for each COC identified in a baseline human health risk assessment. To do this, the goals are calculated by rearranging the exposure equations quantified in the risk assessment so that they solve for a concentration or activity concentration in a medium that results in a specific "target risk," "target hazard," or "target radiological dose." Target risks that will be used to derive RGOs at PGDP are 1×10^{-4}, 1×10^{-5}, and 1×10^{-6}. Target hazards that will be used to derive RGOs are 3, 1, and 0.1. Target radiological doses for all media except groundwater are 1, 12, 25, and 100 mrem/year. For groundwater, the radiological dose targets are 1, 4 (for beta and photon emitters), 12, 25, and 100 mrem/year. As noted above, an RGO must be developed for each COC. Because the selection of a COC is medium- and use scenario-specific, RGOs will be developed for each COC identified for each use scenario of concern at a unit or area. Also, because RGOs must be medium-specific, exposure routes that integrate contaminant contributions from more than one medium (e.g., consumption of vegetables) will be segregated so that each medium contributing to the exposure route is evaluated separately. This segregation will be done by assuming that the concentration or activity concentration of contaminants in the medium not under evaluation is zero.

Two methods may be used to develop RGOs. The first involves rearranging and combining all the exposure equations utilized to determine risk or hazard and using the rearranged equation to calculate the RGO. The second simply uses ratios of concentrations or activities and level of risk, hazard, or radiological dose to derive the RGO. Although the first method is of greater utility because the rearranged equation can be used to directly solve for RGOs, its use involves rearranging a large complex equation in which the chance for error abounds, especially if the estimated contaminant concentrations at the exposure point rely on fate and transport modeling. Similarly, although the second method is simpler mathematically, it can result in an incorrect solution if risk, hazard, or radiological dose determined for

COCs at the source in the baseline human health risk assessment is not linearly and directly related to the concentration or activity concentration of the COCs at the exposure point. Fortunately, the concentration or activity concentration in each of the exposure equations that will be used in baseline human health risk assessments at PGDP (see Appendix D) is linearly and directly related to the resulting risk, hazard, or radiological dose; therefore, the second method will be used in risk assessments at PGDP and is presented in Eqs. 14 and 15. Note: If additional exposure equations beyond those in Appendix D are used in an assessment performed for PGDP, these equations will be checked to ensure that the concentration or activity concentration of COCs is directly and linearly related to risk or hazard.

$$\frac{\text{Conc}_{observed}}{\text{ELCR}_{derived}} = \frac{\text{RGO}}{\text{Target ELCR}} \quad \textbf{Eq. 14}$$

where: $\text{Conc}_{observed}$ = The representative EPC for the COC
$\text{ELCR}_{derived}$ = The chemical-specific ELCR of a COC due to exposure to a single medium across all exposure routes
RGO = The remedial goal option
Target ELCR = Either 1×10^{-4}, 1×10^{-5}, or 1×10^{-6}

$$\frac{\text{Conc}_{observed}}{\text{HI}_{derived}} = \frac{\text{RGO}}{\text{Target HI}} \quad \textbf{Eq. 15}$$

where: $\text{Conc}_{observed}$ = The representative EPC for the COC
$\text{HI}_{derived}$ = The chemical-specific HI of a COC from exposure to a single medium across all exposure routes
RGO = The remedial goal option
Target HI = Either 3, 1, or 0.1

As noted, radiological dose-based RGOs will be calculated using similar methods. The targets to be used for all media except groundwater are 1, 12, 25, and 100 mrem/year. For groundwater, the radiological dose targets are 1, 4, 12, 25, and 100 mrem/year.

3.3.8.2 Presentation of remedial goal options

As noted, RGOs must be calculated for each COC within each MOC for each use scenario of concern identified in the baseline human health risk assessment; therefore, many RGOs will be developed in most risk assessments considering multiple units or areas. To simplify the consideration of the RGOs by users of the risk assessment, the format in Exhibit 3.17 will be used to present the RGOs in all baseline human health risk assessments prepared for PGDP. Note: Using this format will result in the preparation of a single table containing all COCs within each MOC for each use scenario of concern; therefore, this table or relevant potions of it can be used directly in the FS.

Exhibit 3.17. Presentation of Remedial Goal Options[1]

COC	Rep. Conc.[2]	Regulatory Value[3]	ELCR at Conc.[4]	HI at Conc.[5]	RGO at HI=0.1	RGO at HI=1	RGO at HI=3	RGO at ELCR= 1×10^{-6}	RGO at ELCR= 1×10^{-5}	RGO at ELCR= 1×10^{-4}	Units
Scenario and medium[6]											
# 1[7]											
# 2											
. . .	. . .		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
# N											

[1] A separate table will be made for each unit or area under investigation.
[2] This value will be the representative concentration used in the calculation of risk or hazard in the baseline human health risk assessment.
[3] Regulatory values (taken from ARARs) may not be available for some media.
[4] This value will be the chemical-specific, medium-specific ELCR presented in the baseline human health risk assessment for the scenario of concern.
[5] This value will be the chemical-specific, medium-specific HI presented in the baseline human health risk assessment for the scenario of concern.
[6] Each MOC within a scenario of concern will be presented. The current use scenario RGOs will be presented first followed by the options for the most likely future use. The options for the least likely future use will appear last. Also, for the ground and surface water RGO tables, the appropriate MCLs will be listed.
[7] All COCs should be listed, including those that could not be evaluated quantitatively.
A separate table following a similar format will be prepared for radiological dose-based RGOs.

3.3.8.3 Revising exposure parameters and calculations in the uncertainty section

As part of the uncertainty analysis for the risk assessment, risk may be recalculated with default exposure factors replaced using exposure parameters consistent with site-specific values. The decision to recalculate risks using these alternative exposure parameters would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development. For example, the exposure duration of 25 years for the outdoor worker may be replaced with a shorter duration of 1 to 5 years that is more likely to reflect the potential exposures at the site. The shorter exposure duration and possibly a revised exposure frequency combined with the other default parameters for the outdoor worker scenario also may be used to produce an excavation worker scenario. Also, risk from dermal exposure to soil/sediment could be evaluated quantitatively to determine the impact of the use of default dermal absorption (ABS) values on the risk characterization. These revised calculations may be considered in the development of revised PRGs and cleanup levels to be used in the preparation of remedy selection documents.

4. RISK ANALYSES IN THE PREPARATION OF REMEDY SELECTION DOCUMENTS

As noted in RAGS, Part C, (EPA 1991c) and in *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Documents* (EPA 1999b), risk analyses are an integral part of the remedy selection documents (e.g., FS, Proposed Plan, and ROD). The role of risk evaluations in these documents is discussed in this section. Risk evaluations that appear in other documents, including site investigation (SI) documents and Engineering Evaluations/Cost Analyses (EE/CAs), should be equivalent in data quality and content to risk assessments in the documents described in this section. Risk assessments in SI and EE/CA documents may vary from those described in the following section depending on how that risk assessment is used in decision-making for the specific project. A more streamlined approach for risk assessments is sometimes used for removal action decision documents.

Risk evaluations begin in the development and screening stage of the FS, extend through the detailed analysis of alternatives in the FS, and are reported in varying level of detail in the Proposed Plan and ROD. The primary goal of risk analyses here is to provide risk managers with the information needed to choose among specific remedial alternatives and to verify that a cleanup level was achieved. Generally, if a piece of risk information is not needed to choose among alternatives or to verify cleanup, it does not need to be generated; however, it should be noted that it is not uncommon for additional risk analyses to occur after the completion and signing of a ROD (e.g., during the design and implementation of the chosen remedy and after the implementation is complete). Generally, additional analyses occur because additional information relevant to the chosen remedy is acquired. Because the need for and form of these analyses is determined on a project-specific basis, the analyses that may occur after the completion of the FS are not discussed in detail here. The information provided in Sections 2 and 3 should be used to guide any additional work to ensure technical adequacy.

4.1 RISK ANALYSES DURING THE FEASIBILITY STUDY

Risk analyses impact four significant portions of the FS. These are the reporting of baseline or screening risk assessment results (including any radiological dose assessment); the evaluation of the risk analyses to determine the need for remedial action; the identification, development, and screening of technologies and alternatives; and support of the detailed analysis of alternatives. These areas are discussed in Sections 4.1.1, 4.1.2, 4.1.3, and 4.1.4, respectively.

4.1.1 Presentation of Risk Assessment Results in the Feasibility Study

Section 7, Summary and Conclusions, of the baseline human health risk assessment often may be copied directly to the FS report to summarize the identified risks that the feasibility study will need to address. Additionally, following guidance in EPA 1999b, the tables consistent with RAGS, Part D, or relevant parts of them can be inserted directly into the FS. The material placed in the FS will contain a summary of the methods used to identify the COPCs and to complete the exposure assessment, toxicity assessment, and risk characterization, including the identification of significant uncertainties affecting the risk results. In addition, the risk characterization summary tables (Exhibit 3.15) and the relevant portions of the RGO summary tables (Exhibit 3.17) can be transported directly to the FS report. Electronic copies of this material will be made available to the authors of the FS report to simplify the reporting of this information and ensure consistency between the RI and FS reports.

As noted in RAGS Part C (EPA 1991c), the primary use of the baseline risk assessment from the RI is to identify the need for remedial action in the absence of any action. A risk evaluation of remedial alternatives will follow the same general steps as a baseline risk assessment. For some FS reports, recalculation of risk or radiological dose estimates may be required to differentiate between remedial alternatives; these additional risk evaluation activities should be conducted within the scope of Chapter 2 of RAGS Part C (EPA 1991c).

The overall objective of the detailed analysis of alternatives is to obtain and present information that is needed for decision makers to select a remedial alternative for a site. The risk evaluations conducted to support the FS are, in effect, residual risk evaluations that determine whether a technology is capable of achieving PRGs. To support alternative analysis, these residual risk evaluations may consider non-default exposure scenarios and impacts of engineering and institutional controls and may use performance-based criteria (i.e., remove all affected media with concentrations greater than a target level).

Most of the time, it will be sufficient for an FS detailed analysis to indicate whether an alternative has the potential to achieve the PRGs, rather than to quantify the risk that will remain after implementation of the alternative. If more detailed information concerning long-term risk is needed to select an alternative (e.g., to determine the more favorable of two otherwise similar alternatives), then it may be useful to determine whether one alternative is more certain to achieve the PRGs than the other, whether (or to what extent) one may be able to surpass (i.e., achieve lower concentrations than) the PRGs, or whether one may be able to achieve the goals in a shorter time.

Thus, an FS risk evaluation that identifies the post-remedy residual risk may need to be coupled with an implementability, certainty, or permanence evaluation to identify the factors that may be needed to be described further in the remedial design to ensure the achievement of remedial goals. As noted in RAGS Part C, Chapter 2, the presence of the five-year review process focuses the degree of these evaluations. For example, if a remedy includes capping of contaminated soils, then the potential future exposures due to cap failure may include direct contact with soils and leaching of contaminants to groundwater. However, the worst-case situation of complete containment system failure does not necessarily need to be evaluated because it is unlikely to occur, because five-year reviews are conducted at all sites where wastes are managed on-site above concentration levels that allow for unrestricted use and unlimited exposure.

The level of risk evaluation to be conducted in the FS should be determined and agreed to by the three FFA parties during scoping for the FS. Situations where risk estimates may need to be updated for the FS report include the following:

- The time between the completion of the RI report and the preparation of the FS report is such that additional information not considered in the RI report becomes available (e.g., additional samples and/or updated toxicity information/values).

- It is determined that the remedial technologies will produce new contaminants that were not present at the site under baseline conditions.

- The decision to include in the FS more advanced modeling from the matrix in Table 3.2 (including probabilistic risk assessment) in the FS than was used in the RI in order to provide refined estimates of risk necessary for determining the long-term or short-term effectiveness of remedial options or the differences in residual risk between remedial options.

Revised PRGs consistent with the alternatives will be derived in the FS. These revised PRGs will utilize the site-specific information in the RI report and the risk assessment in their calculation.

If additional risk evaluations are required in the FS, then these computations will follow the methods outlined in Section 3. Most importantly, the exposure equations presented in Appendix D will be used for all risk computations that appear in the FS report, and the methods presented in Section 3.3.8 for RGO development will be followed.

In FS reports, the summary of the risk evaluation results will be followed by an evaluation of these results. This evaluation will consider the risk estimates, their basis, and the uncertainties deemed relevant to selection of a remedy. This evaluation will provide the focus for RAO development later in the FS report. The information that follows identifies typical decisions made when determining the need for remedial action in the FS report.

4.1.2 Modifications to Risk Assessment Parameters that May Appear in the Feasibility Study

The baseline human health risk assessment identifies whether remedial action is necessary and provides a basis for evaluating the proposed remedial alternatives; therefore, the baseline human health risk assessment typically will not change in the FS.

The uncertainty section of the baseline human health risk assessment will identify whether an uncertainty is small, moderate, or large (i.e., uncertainties categorized as small do not affect the risk estimates by more than one order of magnitude; those categorized as moderate may affect the risk estimates by between one and two orders of magnitude; uncertainties categorized as large may affect the risk estimate by more than two orders of magnitude; see Section 3.3.7). The FS should evaluate the uncertainty in more detail and may recalculate risk values as determined by agreement of the three parties to support the alternative evaluation better.

Calculation of short-term risks during the detailed analysis of remedial alternatives (see Section 4.1.3) may require significant recalculation of risks and hazards from the baseline risk assessment to account for differences between the exposures to current workers and off-site residents and the default values used for the baseline risk assessment in the RI. For example, current industrial workers and current off-site residents do not consume groundwater from the facility for drinking. In addition, current industrial workers have lower dermal exposure and shorter duration of exposure than is assumed for future industrial workers under a default exposure scenario. Outdoor workers also will have lower exposures than the default parameters due to the use of personal protective equipment and engineering controls. These differences need to be accounted for in the evaluation of risk in the FS, and these evaluations shall be incorporated in the discussion of the detailed analysis of remedial alternatives.

4.1.2.1 Land use considerations for determining appropriate response actions to protect future potential receptors

Land use is an important consideration when determining appropriate response actions based on potential future receptors. Uncertainties associated with future land use are due to the inability to predict if existing controls will be in place in the future and the reliability of implementing additional controls. There may be scenarios developed pursuant to this document that may not be commensurate with the reasonable foreseeable land use, but may serve as a reference point to decision makers. Consequently, the results of the baseline human health risk assessment will not be modified when determining potential risks to future receptors. However, additional risk evaluation (beyond the baseline risk assessment) of scenarios may be used to support development of alternatives developed in the FS report. The ability of these alternatives to ensure protection of potential future receptors will be evaluated in the FS, using risk evaluation as appropriate. Protection may be accomplished through continuation of existing controls in some instances or through the application of new controls. Consequently, potential future scenarios will be evaluated in the FS alternative evaluation to supply decision makers with the information needed to choose appropriate remedial actions. The information that follows provides examples of scenarios that may be evaluated for future receptors in the FS report.

Site-specific exposures for current industrial workers and the inability to predict potential future exposures have been discussed earlier. For a future industrial worker, the risks to a default industrial worker as determined in the baseline human health risk assessment ***will be used when estimating risks to determine the need for action.*** This evaluation includes potential risks as a result of contact with contaminated RGA groundwater, which also is a possibility in the future. Additional evaluations may be developed, however, for the future industrial worker to include an evaluation of the impacts of continuation of the existing institutional controls (i.e., controls and procedures that limit access to affected soil and groundwater and provide an alternative water source); continuation of or application of new controls and procedures (i.e., continuation of current industrial scenario); assuming contact with contaminated RGA groundwater (i.e., no separate water source); and default exposure (i.e., no controls or procedures) without contact with contaminated RGA groundwater (i.e., assuming a separate water supply). Any set of exposure parameters agreed to during scoping may be used to develop a scenario. That scenario may be subjected to additional risk evaluation in the FS to identify the remedial action drivers, irrespective of whether or not that scenario is itself realistic.

Future recreational users and residential users inside the DOE property boundary (including area within the restricted access area, but not the surrounding West Kentucky Wildlife Management Area) may be further assessed in the FS report. The risk managers first will review the results of the baseline risk assessment that assumes that no controls would be in place to restrict a future on-site recreational user or resident from contact with surface contamination. As with the industrial worker, however, the risk managers can identify scenarios to be subjected to additional risk analysis that do place restrictions on exposure to be used in considering alternative FS scenarios to best identify the remedial action drivers.

Modeling during the baseline human health risk assessment typically involves a large degree of uncertainty. For this reason, modeling parameters may be reevaluated during the preparation of the FS report, as discussed in the modeling matrix presented in Table 3.2, if needed to reduce uncertainty and aid in choosing between the proposed remedial alternatives. For the same reason, the FS may consider use of probabilistic models for risk assessment in place of the deterministic models used during the RI if these additional analyses are deemed necessary through scoping agreements by the three parties.

4.1.2.2 Identification of use scenarios, pathways, contaminants, and MOC for decision making purposes

Following evaluation of the results and uncertainties in the baseline human health risk assessment, additional risk evaluation performed to support the FS, and finalization of risk management decisions, a list of use scenarios, pathways, contaminants, and MOC for decision making purposes will be developed.

In the FS report, each item of concern will be identified based on the guidance presented in Section 3.3.6.4.

4.1.3 Risk Analyses during the Identification and Screening of Technologies and Alternatives

During the identification and screening stage of the FS, a range of remedial alternatives is identified, and each alternative is evaluated with respect to effectiveness, implementability, and cost (EPA 1991c). As part of the evaluation of effectiveness, human health risks to the community (e.g., short- and long-term health risks from releases during remediation and after remediation, respectively) and remediation workers (i.e., short-term health risks during remedial activities) will be considered. At PGDP, this evaluation will be performed qualitatively to be consistent with guidance in RAGS, Part C.

4.1.4 Risk Analyses during the Detailed Analysis of Alternatives

The overall objective of the detailed analysis of alternatives is to obtain and present the information needed by risk managers to select a remedial alternative for a site (EPA 1991c). Risk analysis affects three of the selection criteria against which alternatives are evaluated: long-term effectiveness, short-term effectiveness, and overall protection of human health and the environment.

Generally, the human health risk analyses performed during the FS will follow the same procedures as the baseline human health risk assessment. Unlike the baseline human health risk assessment, where the purpose is to estimate the risk posed by environmental contamination in the absence of any action, the purpose of the FS risk analyses is to determine by how much the various remedial alternatives reduce risk or to evaluate short-term risks brought about through remedy implementation (e.g., air stripper emissions).

Consistent with RAGS, Part C, (EPA 1991c), at PGDP the risk analyses performed during the detailed analysis of alternatives may be either qualitative or quantitative. In most cases, a qualitative analysis will be sufficient as indicated in RAGS, Part C; however, a quantitative analysis may be required in some cases. The decision about whether a qualitative or quantitative analysis of alternatives is needed will be made using guidance in RAGS, Part C. In this guidance, EPA notes that the type of analysis that is required depends on (1) whether the relative short-term or long-term effectiveness is an important consideration in selecting the alternative and (2) the "perceived risk" associated with the alternative. Where perceived risk is high, a quantitative risk evaluation would be more appropriate. In RAGS, Part C, EPA defines "perceived risk" as that leading to the belief by site engineers, risk assessors, and neighboring communities, including workers, that an alternative either may not be adequately protective or lead to increased risk. Specific parameters that will be taken into account at PGDP when examining "perceived risk" and determining if a quantitative analysis is required include the following (adapted from RAGS, Part C):

- Proximity of populations to the unit or area;
- Presence of highly or acutely toxic chemicals;
- Technologies with high release potential, either planned or unplanned;
- High uncertainties in the nature of releases;
- Multiple contaminants or exposure routes or both affecting the same receptor;
- Releases from neighboring units or areas, including uncontrolled releases from units or areas not yet addressed;
- Releases that occur over a long period; and
- Level of community concern.

4.1.4.1 Qualitative risk evaluations

As noted herein, a qualitative analysis will be sufficient for most units or areas. In this type of analysis, the risk evaluation will qualitatively evaluate each alternative against the RAOs defined during the FS. In all cases, the qualitative analysis will evaluate whether the alternative can reduce exposure to probable and potential receptor populations to acceptable levels. In many evaluations, this will involve qualitatively determining if an alternative is effective in reducing contaminant concentrations at a unit or area to the cleanup level (i.e., the RGO or revised PRG consistent with the alternative being evaluated).[15]

In other cases, this will involve determining if an alternative is effective in changing activity patterns of receptors so that the rate of contact by receptors to the contaminated materials is reduced, resulting in a lowered exposure. Finally, the qualitative risk evaluation in the detailed analysis of alternatives for PGDP will examine the potential for an alternative to produce new contaminants that were not at a unit or area during the RI.

In developing the risk evaluation portion of the qualitative detailed analysis of alternatives, several sources of information will be used. These sources are listed below [adapted from RAGS, Part C, (EPA 1991c)] and include information from the baseline or screening risk assessment (as modified during the risk management to determine the need for action), treatability studies, and results at other sites. Material from the risk assessment includes the following:

- The exposure setting, including exposed populations and future land use;
- The exposure pathways, including sources of contamination, COCs, fate and transport of chemicals (i.e., migration, degradation, and transformation), and exposure points;
- General exposure considerations, including rate of contact, exposure frequency, and exposure duration;
- Exposure concentrations, including temporal effects;
- Estimates of chemical intake and uptake;
- Toxicity information, including uncertainty in toxicity values; and
- Methods used to quantify risks from exposure to media containing multiple chemicals and radionuclides.

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[15] "Preliminary remediation goals...may be revised...based on the consideration of appropriate factors including, but not limited to: exposure factors, uncertainty factors, and technical factors. Included under exposure factors are: cumulative effect of multiple contaminants, the potential for human exposure from other pathways at the site, population sensitivities, potential impacts on environmental receptors, and cross-media impacts of alternatives. Factors related to uncertainty may include: the reliability of alternatives, the weight of scientific evidence concerning exposures and individual and cumulative health effects, and the reliability of exposure data. Technical factors may include: detection/quantification limits for contaminants, technical limitations to remediation, the ability to monitor and control movement of contaminants, and background levels of contaminants. The final selection of the appropriate risk level is made when the remedy is selected based on the balancing of criteria...." [taken from the National Contingency Plan Preamble: Exposure, Technical, and Uncertainty Factors (55 Fed. Reg. 8717, March 8, 1990)]. Also, see RAGS Volume 1, Part B, Section 2.3 and 2.8 (EPA 1993a) and OSWER Directive 9355.0-30, "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (EPA 1990a).

Material found in treatability studies that will be used in the qualitative risk evaluation includes the following:

- Effectiveness at reducing potential for exposure, either through reduction in contaminant concentrations and activities or through making the medium containing the contaminant unavailable for contact;

- Potential for short-term emissions; and

- Potential for production of new contaminants.

Materials found when examining results from other sites that will be used in the qualitative risk evaluation include the following:

- Actual contaminant reductions achieved;

- Conditions in which the technology was not effective; and

- Actual release rates of current or new contaminants.

4.1.4.2 Quantitative risk evaluations

Methods for quantitative risk evaluations during the detailed analysis of alternatives will follow the same procedures as the baseline human health risk assessment. Unlike the baseline human health risk assessment, where the goal is to estimate the potential risk posed by environmental contamination in the absence of any action, the goal of the FS risk analyses is to determine to what extent the various remedial alternatives reduce risk such that unacceptable levels of risk are not posed by residual environmental contamination.

4.2 RISK ANALYSES AFTER THE FEASIBILITY STUDY

After the FS is completed, a remedy is proposed in the Proposed Plan and documented in the ROD. Following this, the remedy is designed and implemented and, depending on the remedy, the site either is deleted or is placed within the group for which five-year reviews are required. This section discusses the risk evaluation activities that will occur during and after preparation of the Proposed Plan. These risk evaluation activities should be consistent with EPA guidance in the *Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents* (EPA 1999b). Some of the material presented here was taken from RAGS, Part C (EPA 1991c).

4.2.1 Risk Evaluation for the Proposed Remedial Action Plan

Typically, no new risk evaluations will take place during the preparation of the Proposed Plan. The material presented in the Proposed Plan should be taken from the supporting FS. This includes a summary of site risks, the site COCs, and, if applicable, the revised PRGs for the selected alternative or a description of the basis for them (i.e., risk or radiological dose target). Consistent with EPA 1999b, the material presented in the "Summary of Site Risks" section of the Proposed Plan primarily will be presented as narrative and limited to approximately three paragraphs. Key information from the baseline risk assessment (or other FS risk evaluations) that will be presented includes all the following:

- Major COCs in each medium
- Land- and groundwater-use assumptions

- Potentially exposed populations under current and future use scenarios
- Major pathways and routes of exposure
- Summary of risk characterization

The risk section of the Proposed Plan also will contain a text box of standard language from the Proposed Plan/ROD guidance (EPA 1999b). This standard language will contain a definition of risk assessment and the meaning of the results from a risk assessment. The risk section of the Proposed Plan will conclude with language similar to the following text taken from EPA 1999b.

> It is the lead agency's current judgment that the Preferred Alternative identified in this Proposed Plan, or one of the other active measures considered in the Proposed Plan, is necessary to protect public health or welfare or the environment from actual or threatened releases of pollutants or contaminants from this site. These pollutants or contaminants may present an imminent and substantial endangerment to public health or welfare.

If new information becomes available during the public comment period, then additional analysis of the alternatives, or possibly the site risks, may be needed. (Note: These analyses will encompass all alternatives and be performed qualitatively to the extent possible.)

4.2.2 Risk Evaluation for the ROD

The primary risk evaluation-related activities that will occur during the ROD will be to document the results of the risk assessment and the risk evaluation portions of the comparison of alternatives performed in the FS and to document the derivation of the chemical-specific cleanup levels. Consistent with EPA guidance in both *Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents* (EPA 1999b) and RAGS, Part C (EPA 1991c), the appropriate risk evaluation materials will be discussed in relation to three of the nine CERCLA alternative analysis criteria: long-term effectiveness, short-term effectiveness, and overall protection of human health and the environment. The discussion of overall protection of human health and the environment will consider, to the extent possible, any residual risks that may remain after the alternative is implemented. Specific information to be presented includes the following:

- Chemical-specific cleanup levels to be attained at the conclusion of the response action;
- Corresponding chemical-specific risk levels;
- Areas of attainment for cleanup levels for groundwater being addressed; and
- Lead agency's basis for the cleanup levels (e.g., risk calculation, ARARs, background, etc.).

To the extent possible, the "Summary of Site Risks" section of the ROD will be presented following the outline contained in EPA 1999b; therefore, this material will include the following:

- A statement of basis for taking action and
- A brief summary of the relevant portions of the risk assessment.

Additionally, this section will focus on the risk drivers as defined in the FS and the exposure scenarios and pathways driving the need for action. The conceptual site model (which should be presented in the *Summary of Site Characteristics* section of the ROD) will be used to support the presentation of site risks.

The standard language to be used for the statement of basis for action will be similar to that which also appears in the Proposed Plan. For the ROD, this statement will appear at the beginning of the site risk summary instead of at the end.

In most cases, the tabular format in EPA 1999b will be used to present risk assessment/evaluation results in the ROD; however, additional tables or tables of a slightly different format may be used to explain the risk assessment/evaluation results, as needed. Note that the primary purpose for including the detailed risk characterization tables in an appendix of the baseline risk assessment is to streamline the preparation of these tables for the FS and ROD.

4.2.3 Risk Analyses for Residual Risks

As noted in RAGS, Part C, (EPA 1991c) analyses to examine residual risks may be required for some locations after implementation of a remedy. Additionally, as discussed in the SMP (DOE 2015a), after completion of all investigations and remedial actions at PGDP, the FFA requires that PGDP determine the residual risks remaining at the facility. Finally, the five-year review of some sites may require additional residual risk analyses. These residual risk analyses should be conducted consistent with guidance on the five-year review process from both EPA (EPA 2001c; EPA 2003c) and DOE (DOE 2002).

The methods to be used to complete the analyses of residual risks at most units will be qualitative. If quantitative, these analyses will be consistent with the methods in either Section 2 or that in Section 3 of this document. Additionally, any quantitative analyses will be consistent with Section 3.3.4 of RAGS, Part C (EPA 1991c). Generally, these analyses will determine the risks remaining after remediation due to contamination remaining at or migrating from sources (or multiple sources). In these analyses, the measured concentrations and activities of contaminants remaining at the various sources units and in the integrator unit will be used. The cleanup levels in the ROD for the various source units and areas in the integrator units should not be used in these analyses.

Other issues that will be considered when evaluating residual risk will be the following:

- Concentrations and activities of new analytes formed as a result of remedial activities or because of natural processes;
- Changes in land use or proposed future use since the completion of the baseline risk assessment;
- Updated toxicity values; and
- Reduction of migration because of engineered controls and expected future performance of these controls.

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APPENDIX A

SCREENING LEVELS

(Current as of October 2018)

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SCREENING LEVELS

This appendix presents lists of values that can be used during screening and baseline human health risk assessments at the Paducah Gaseous Diffusion Plant (PGDP). These values include risk- and dose-based values for soil, sediment, groundwater, and surface water; background values for soil and groundwater; and regulatory values. All information is current as of the production dates listed in this document, and all values were calculated using the best available information. Methods used to derive the risk- and dose-based values are presented in Appendix B. The screening values presented in this appendix were developed specifically for PGDP and may not be applicable to sites outside that facility. Values are provided in these tables for significant chemicals or radionuclides of potential concern (COPCs) for PGDP. Values for other COPCs can be obtained using the Risk Assessment Information System (RAIS) online calculator, as modified using PGDP-specific inputs.

Please consider the following notes before using the values presented in this appendix.

(1) Action values are the lesser of a hazard-based value calculated using a target hazard index (HI) of 3 and a cancer-based value calculated using a target excess lifetime cancer risk (ELCR) of 1E-04.

(2) HI values are calculated separately for each receptor. Cancer risks for receptors within a scenario are combined to give one ELCR. For the residential scenario, the cancer risk reflects the adult and child combined. For the recreational scenario, the cancer risk reflects the combined risk to adult, child, and teen.

(3) Action values and no action values are calculated using only direct exposure pathways. Please see Appendix B for a listing of exposure parameters included in the preliminary remediation goal (PRG) calculations. Because not all of the action values are calculated using PGDP default exposure parameters (e.g., see note 9a), these values should be used as benchmarks only. Cumulative risk calculations should not be based upon these values.

(4) No action values are the lesser of a hazard-based value calculated using a target HI of 0.1 and a cancer-based value calculated using a target ELCR of 1E-06. If more than five COPCs are identified for the site, it also may be appropriate to generate no action levels based on 1E-07 risk to account for additivity of risk. These values were calculated using the exposure parameters listed with the exposure equations in Appendix D. These parameters also are listed in Appendix B. Because the no action values are consistent with the PGDP default exposure parameters, these values can be used to derive cumulative risk estimates in addition to their use as benchmarks.

(5) Background values for soil and groundwater presented in this appendix are provisional. Soil background values, except as noted, were derived as detailed in DOE 1996 and DOE 1997. Groundwater background values were derived from a study presented in the Groundwater Operable Unit Feasibility Study Report (DOE 2000). These values have not been agreed to for all uses by the PGDP Risk Assessment Working Group; therefore, these background values are subject to change should other values be more appropriate.

(6) Soil screening levels for chemicals for protection of groundwater were derived using RAIS. The Soil Screening Level (SSL) values based upon a dilution attenuation factor (DAF) of 1 should be considered to be “no action values.” “Action” SSLs have not been selected to date for the PGDP. In addition to the SSLs at a DAF of 1, SSLs at a DAF of 20 also are included.

(7) Regulatory values are for planning purposes only and may not be applicable to conditions at PGDP. Maximum contaminant level (MCL) values are included with the Risk Methods Document's groundwater action levels and no action levels. A qualified regulatory specialist should be consulted before using these values for other purposes.

(8) The outdoor worker scenario is defined as the person exposed to surface soil (i.e., 0–1 ft) inside the industrialized area and surface and subsurface soil (i.e., 0–10 ft or 0–16 ft, as appropriate) outside the industrialized area, for an exposure duration of 25 years for 185 days/year. The excavation worker scenario is defined as the person exposed to surface and subsurface soil (i.e., 0–10 ft or 0–16 ft, as appropriate) for an exposure duration of 5 years for 185 days/year.

(9) COPC-specific notes for risk-based and dose-based screening values:

a) General—Several soil/sediment screening values (especially those on the action level tables) are listed with a value of 100,000. This value was assigned to the COPC because the screening value derived for the contaminant exceeded the upper limit value deemed reasonable by the PGDP Risk Assessment Working Group; therefore, the screening value was reduced to an upper limit value (100,000 mg/kg or pCi/g). If the COPC's environmental concentration exceeds the upper limit value, then additional risk evaluations for the COPC should be performed before accepting the results of a simple comparison. Surface water and groundwater screening values (especially those on the action level tables) may exceed the saturation limit for the analyte; a comparison has not been performed.

b) Chromium—The screening value for Chromium VI presented in these tables should only be used if the comparison is to a Chromium VI result. For a 'Total Chromium' result, the screening value listed for Chromium VI should be used, unless it is determined on a project-specific basis that chromium VI is not present. The presence or absence of Chromium VI when analyte-specific analyses are not available should be discussed as an uncertainty.

c) Lead—The screening values for lead were selected by the PGDP Risk Assessment Working Group. These values were not derived using the methods presented in Appendix B. No action levels are 400 mg/kg for soil/sediment for the resident and the recreator scenarios and 800 mg/kg for the industrial worker and outdoor worker scenarios. These values represent the current screening values provided by the Kentucky Department for Environmental Protection. Action levels for soil/sediment are set preliminarily equivalent to the no action levels. Sites at which the 400 mg/kg concentration in soil is exceeded should be evaluated using site specific Integrated Exposure Uptake Biokinetic (IEUBK) modeling for a level resulting in a child exceeding a target blood level of 2.5 µg/dL [the Commonwealth of Kentucky's recommended blood lead level (Section B.3)] and a target blood level of 10 µg/dl and Adult Lead Model (ALM) modeling for an adult exceeding the same target blood lead levels. Parameters for use in the IEUBK model are provided in Table B.6 of Appendix B. Parameters for the ALM model should be developed for each site. No action and action levels for groundwater and for surface water are unchanged from those agreed to by the PGDP Risk Assessment Working Group in the 2001 version of this document.

d) Carcinogenic polycyclic aromatic hydrocarbons (cPAHs)—[These organic compounds include benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.] The PGDP Risk Assessment Working Group has determined that these compounds should be evaluated as a group using the PAH (Total) screening values. Please see Section 3.3.3.2, Step 8, of the main text of the methods document for guidance on deriving total PAH concentration from results for individual compounds.

e) Polychlorinated biphenyls (PCB)—These organic compounds include those listed as Aroclors in the screening tables.) The PGDP Risk Assessment Working Group has determined that the cancer effects of these organic compound mixtures should be evaluated as a group using the PCB (Total) screening values. (The screening value associated with the highest risk value is to be used.) Please see Section 3.3.3.2, Step 8, of the main text of the methods document for guidance on deriving total PCB concentration from results for individual mixtures.

f) Dioxins/Furans—(These organic compounds include the following chlorinated dioxins and furans: 2,3,7,8-TCDD; 1,2,3,7,8-PeCDD; 2,3,4,7,8-PeCDD; 2,3,5,7,8-PeCDD; 2,3,6,7,8-PeCDD; 1,2,3,4,7,8-HxCDD; 1,2,3,5,7,8-HxCDD, 1,2,3,6,7,8-HxCDD; 2,3,4,5,7,8-HxCDD; 2,3,4,6,7,8-HxCDD; 2,3,5,6,7,8-HxCDD; 1,2,3,4,5,7,8-HpCDD; 1,2,3,4,6,7,8-HpCDD; 2,3,4,5,6,7,8-HpCDD; OCDD; 2,3,7,8-TCDF; 1,2,3,7,8-PeCDF; 2,3,4,7,8-PeCDF; 1,2,3,4,7,8-HxCDF; 1,2,3,5,7,8-HxCDF, 1,2,3,6,7,8-HxCDF; 2,3,4,5,7,8-HxCDF; 2,3,4,6,7,8-HxCDF; 2,3,5,6,7,8-HxCDF; 1,2,3,4,5,7,8-HpCDF; 1,2,3,4,6,7,8-HpCDF; 2,3,4,5,6,7,8-HpCDF; and OCDF.) The PGDP Risk Assessment Working Group has determined that these organic compounds should be evaluated as a group using the Dioxins/Furans (Total) screening values. Please see Section 3.3.3.2, Step 8, of the main text of the methods document for guidance on deriving the total dioxin/furan concentration from results for individual compounds.

g) Radionuclides—For cesium-137, neptunium-237, uranium-235, and uranium-238, screening values derived considering the contribution from short-lived decay products should be used. These screening values are listed with a "+D" in the following tables.

   Radionuclides—Dose targets are (1) 1 mrem/year (from NRCRP Report No. 116, Section 17, Negligible Individual Dose and ANSI/HPS standard N13.12); (2) 12 mrem/year (from "Radiation Risk Assessment at CERCLA Sites: Q & A" OSWER No. 9200.4-40, June 13, 2014); (3) 25 mrem/year (derived from the public dose limit of 100 mrem/year limit in DOE Order 458.1 and considering ALARA principles); and (4) 100 mrem/year. A value of 4 mrem/year is used for groundwater (from http://www.epa.gov/safewater/contaminants/index.html). As with risk-based PRGs for COPCs, dose-based PRGs are used in project screening only and should not be considered clean-up values.

Due to the nature of Appendix A, not all acronyms are defined within the text. An acronym list is provided on page A-9.

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TABLES

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ACRONYMS

ALARA	as low as reasonably achievable
AL	action level
ALM	Adult Lead Model
ANSI	American National Standards Institute
ATSDR	Agency for Toxic Substances and Disease Registry
BaP	benzo(a)pyrene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
COPC	chemical or radionuclide of potential concern
cPAHs	carcinogenic polycyclic aromatic hydrocarbons
DAF	dilution attenuation factor
DOE	U.S. Department of Energy
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
GW	groundwater
HI	hazard index
HPS	Health Physics Society
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
K_d	chemical-specific distribution coefficient
MCL	maximum contaminant level
N/A	not available
NAL	no action level
NRCRP	Nuclear Regulatory Commission Report
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
PRG	Preliminary Remediation Goal
RAIS	Risk Assessment Information System
RCRA	Resource Conservation and Recovery Act
RfD	oral reference dose
RGA	Regional Gravel Aquifer
RGO	remedial goal option
SSL	Soil Screening Level
UTL	upper tolerance limit

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Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP

(Values calculated in October 2018 and are based on best available information.)

			Outdoor Worker			Excavation Worker			Industrial Worker		
CAS	**Analyte**	**Units**	**Cancer**	**Hazard**	**Action**	**Cancer**	**Hazard**	**Action**	**Cancer**	**Hazard**	**Action**
7429-90-5	Aluminum	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
7440-36-0	Antimony (metallic)	mg/kg	-	3.96E+02	3.96E+02	-	3.96E+02	3.96E+02	-	2.80E+03	2.80E+03
7440-38-2	Arsenic, Inorganic	mg/kg	7.48E+01	3.60E+02	7.48E+01	3.74E+02	3.60E+02	3.60E+02	1.60E+02	7.71E+02	1.60E+02
7440-39-3	Barium	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
7440-41-7	Beryllium and compounds	mg/kg	1.00E+05	1.97E+03	1.97E+03	1.00E+05	1.97E+03	1.97E+03	1.00E+05	1.35E+04	1.35E+04
7440-42-8	Boron And Borates Only	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
7440-43-9	Cadmium (Diet)	mg/kg	1.00E+05	7.59E+02	7.59E+02	1.00E+05	7.59E+02	7.59E+02	1.00E+05	1.82E+03	1.82E+03
16065-83-1	Chromium(III), Insoluble Salts	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
18540-29-9	Chromium(VI)	mg/kg	1.83E+02	2.96E+03	1.83E+02	9.14E+02	2.96E+03	9.14E+02	1.23E+03	2.08E+04	1.23E+03
7440-47-3	Chromium (Total)[a]	-	-	-	-	-	-	-	-	-	-
7440-48-4	Cobalt	mg/kg	1.00E+05	2.95E+02	2.95E+02	1.00E+05	2.95E+02	2.95E+02	1.00E+05	2.06E+03	2.06E+03
7440-50-8	Copper	mg/kg	-	3.96E+04	3.96E+04	-	3.96E+04	3.96E+04	-	1.00E+05	1.00E+05
16984-48-8	Fluoride	mg/kg	-	3.96E+04	3.96E+04	-	3.96E+04	3.96E+04	-	1.00E+05	1.00E+05
7439-89-6	Iron	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
7439-92-1	Lead[b]	mg/kg	-	-	8.00E+02	-	-	8.00E+02	-	-	8.00E+02
7439-96-5	Manganese	mg/kg	-	2.32E+04	2.32E+04	-	2.32E+04	2.32E+04	-	1.00E+05	1.00E+05
7439-97-6	Mercury, Inorganic Salts	mg/kg	-	2.96E+02	2.96E+02	-	2.96E+02	2.96E+02	-	2.10E+03	2.10E+03
7439-98-7	Molybdenum	mg/kg	-	4.92E+03	4.92E+03	-	4.92E+03	4.92E+03	-	3.48E+04	3.48E+04
7440-02-0	Nickel Soluble Salts	mg/kg	1.00E+05	1.96E+04	1.96E+04	1.00E+05	1.96E+04	1.96E+04	1.00E+05	1.00E+05	1.00E+05
7782-49-2	Selenium	mg/kg	-	4.92E+03	4.92E+03	-	4.92E+03	4.92E+03	-	3.51E+04	3.51E+04
7440-22-4	Silver	mg/kg	-	4.92E+03	4.92E+03	-	4.92E+03	4.92E+03	-	3.51E+04	3.51E+04
7791-12-0	Thallium (Soluble Salts)	mg/kg	-	9.87E+00	9.87E+00	-	9.87E+00	9.87E+00	-	7.02E+01	7.02E+01
N/A	Uranium (Insoluble Compounds) [c]	mg/kg	-	2.95E+03	2.95E+03	-	2.95E+03	2.95E+03	-	2.04E+04	2.04E+04
N/A	Uranium (Soluble Salts) [c]	mg/kg	-	1.97E+02	1.97E+02	-	1.97E+02	1.97E+02	-	1.40E+03	1.40E+03
7440-62-2	Vanadium and Compounds	mg/kg	-	4.95E+03	4.95E+03	-	4.95E+03	4.95E+03	-	3.45E+04	3.45E+04
7440-66-6	Zinc and Compounds	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
83-32-9	Acenaphthene	mg/kg	-	3.03E+04	3.03E+04	-	3.03E+04	3.03E+04	-	4.14E+04	4.14E+04
208-96-8	Acenaphthylene[d]	mg/kg	-	3.03E+04	3.03E+04	-	3.03E+04	3.03E+04	-	4.14E+04	4.14E+04
107-13-1	Acrylonitrile	mg/kg	8.93E+01	2.71E+02	8.93E+01	4.46E+02	2.71E+02	2.71E+02	1.24E+02	2.02E+02	1.24E+02
120-12-7	Anthracene	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
71-43-2	Benzene	mg/kg	5.19E+02	1.28E+03	5.19E+02	2.59E+03	1.28E+03	1.28E+03	5.31E+02	1.33E+03	5.31E+02
117-81-7	Bis(2-ethylhexyl)phthalate[e]	mg/kg	3.79E+03	1.14E+04	3.79E+03	1.90E+04	1.14E+04	1.14E+04	5.80E+03	1.74E+04	5.80E+03
75-27-4	Bromodichloromethane	mg/kg	1.59E+02	1.97E+04	1.59E+02	7.93E+02	1.97E+04	7.93E+02	1.30E+02	1.00E+05	1.30E+02
86-74-8	Carbazole	mg/kg	2.65E+03	-	2.65E+03	1.33E+04	-	1.33E+04	4.06E+03	-	4.06E+03
56-23-5	Carbon Tetrachloride	mg/kg	3.14E+02	1.59E+03	3.14E+02	1.57E+03	1.59E+03	1.57E+03	2.96E+02	1.84E+03	2.96E+02
67-66-3	Chloroform	mg/kg	1.78E+02	3.12E+03	1.78E+02	8.90E+02	3.12E+03	8.90E+02	1.39E+02	3.21E+03	1.39E+02
75-71-8	Dichlorodifluoromethane (Freon-12)[e]	mg/kg	-	1.48E+03	1.48E+03	-	1.48E+03	1.48E+03	-	1.10E+03	1.10E+03

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

			Outdoor Worker			Excavation Worker			Industrial Worker		
CAS	Analyte	Units	Cancer	Hazard	Action	Cancer	Hazard	Action	Cancer	Hazard	Action
75-34-3	Dichloroethane, 1,1-[e]	mg/kg	1.90E+03	1.69E+04	1.90E+03	9.52E+03	1.69E+04	9.52E+03	1.58E+03	1.36E+04	1.58E+03
107-06-2	Dichloroethane, 1,2-	mg/kg	2.26E+02	5.19E+02	2.26E+02	1.13E+03	5.19E+02	5.19E+02	2.09E+02	4.17E+02	2.09E+02
75-35-4	Dichloroethylene, 1,1-	mg/kg	-	3.78E+03	3.78E+03	-	3.78E+03	3.78E+03	-	3.00E+03	3.00E+03
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	-	8.88E+03	8.88E+03	-	8.88E+03	8.88E+03	-	6.30E+04	6.30E+04
156-59-2	Dichloroethylene, 1,2-cis-	mg/kg	-	1.97E+03	1.97E+03	-	1.97E+03	1.97E+03	-	1.40E+04	1.40E+04
156-60-5	Dichloroethylene, 1,2-trans-	mg/kg	-	1.70E+03	1.70E+03	-	1.70E+03	1.70E+03	-	1.36E+03	1.36E+03
60-57-1	Dieldrin	mg/kg	3.32E+00	2.84E+01	3.32E+00	1.66E+01	2.84E+01	1.66E+01	5.08E+00	4.35E+01	5.08E+00
1746-01-6	Dioxins/Furans, Total (as TCDD)[f]	mg/kg	5.76E-04	5.67E-04	5.67E-04	2.88E-03	5.67E-04	5.67E-04	1.57E-03	1.57E-03	1.57E-03
37871-00-4	~HpCDD	mg/kg	5.77E-02	5.67E-02	5.67E-02	2.89E-01	5.67E-02	5.67E-02	1.58E-01	1.57E-01	1.57E-01
38998-75-3	~HpCDF, 2,3,7,8-	mg/kg	5.79E-02	5.67E-02	5.67E-02	2.90E-01	5.67E-02	5.67E-02	1.60E-01	1.57E-01	1.57E-01
34465-46-8	~HxCDD, 2,3,7,8-	mg/kg	5.80E-03	5.67E-03	5.67E-03	2.90E-02	5.67E-03	5.67E-03	1.61E-02	1.58E-02	1.58E-02
55684-94-1	~HxCDF, 2,3,7,8-	mg/kg	5.80E-03	5.67E-03	5.67E-03	2.90E-02	5.67E-03	5.67E-03	1.61E-02	1.58E-02	1.58E-02
3268-87-9	~OCDD	mg/kg	1.93E+00	1.89E+00	1.89E+00	9.67E+00	1.89E+00	1.89E+00	5.38E+00	5.25E+00	5.25E+00
39001-02-0	~OCDF	mg/kg	1.93E+00	1.89E+00	1.89E+00	9.67E+00	1.89E+00	1.89E+00	5.38E+00	5.25E+00	5.25E+00
36088-22-9	~PeCDD, 2,3,7,8-	mg/kg	5.80E-04	5.67E-04	5.67E-04	2.90E-03	5.67E-04	5.67E-04	1.61E-03	1.58E-03	1.58E-03
57117-41-6	~PeCDF, 1,2,3,7,8-	mg/kg	1.93E-02	1.89E-02	1.89E-02	9.67E-02	1.89E-02	1.89E-02	5.38E-02	5.25E-02	5.25E-02
57117-31-4	~PeCDF, 2,3,4,7,8-	mg/kg	1.93E-03	1.89E-03	1.89E-03	9.67E-03	1.89E-03	1.89E-03	5.38E-03	5.25E-03	5.25E-03
1746-01-6	~TCDD, 2,3,7,8-	mg/kg	5.76E-04	5.67E-04	5.67E-04	2.88E-03	5.67E-04	5.67E-04	1.57E-03	1.57E-03	1.57E-03
51207-31-9	~TCDF, 2,3,7,8-	mg/kg	5.77E-03	5.67E-03	5.67E-03	2.89E-02	5.67E-03	5.67E-03	1.58E-02	1.57E-02	1.57E-02
100-41-4	Ethylbenzene	mg/kg	2.59E+03	4.98E+04	2.59E+03	1.30E+04	4.98E+04	1.30E+04	2.66E+03	6.72E+04	2.66E+03
206-44-0	Fluoranthene	mg/kg	-	2.02E+04	2.02E+04	-	2.02E+04	2.02E+04	-	2.76E+04	2.76E+04
86-73-7	Fluorene	mg/kg	-	2.02E+04	2.02E+04	-	2.02E+04	2.02E+04	-	2.76E+04	2.76E+04
118-74-1	Hexachlorobenzene	mg/kg	4.66E+01	7.89E+02	4.66E+01	2.33E+02	7.89E+02	2.33E+02	1.26E+02	5.61E+03	1.26E+02
91-20-3	Naphthalene	mg/kg	2.26E+03	1.98E+03	1.98E+03	1.13E+04	1.98E+03	1.98E+03	1.67E+03	1.61E+03	1.61E+03
88-74-4	Nitroaniline, 2-	mg/kg	-	5.67E+03	5.67E+03	-	5.67E+03	5.67E+03	-	8.61E+03	8.61E+03
621-64-7	Nitroso-di-N-propylamine, N-	mg/kg	7.58E+00	-	7.58E+00	3.79E+01	-	3.79E+01	1.16E+01	-	1.16E+01
87-86-5	Pentachlorophenol	mg/kg	8.11E+01	1.74E+03	8.11E+01	4.06E+02	1.74E+03	4.06E+02	8.77E+01	1.88E+03	8.77E+01
85-01-8	Phenanthrene[d]	mg/kg	-	3.03E+04	3.03E+04	-	3.03E+04	3.03E+04	-	4.14E+04	4.14E+04
1336-36-3	Polychlorinated Biphenyls, Total	mg/kg	2.24E+01	-	2.24E+01	1.12E+02	-	1.12E+02	2.93E+01	-	2.93E+01
12674-11-2	~Aroclor 1016	mg/kg	6.41E+02	3.39E+01	3.39E+01	3.21E+03	3.39E+01	3.39E+01	8.43E+02	4.50E+01	4.50E+01
11104-28-2	~Aroclor 1221	mg/kg	2.19E+01	-	2.19E+01	1.09E+02	-	1.09E+02	2.81E+01	-	2.81E+01
11141-16-5	~Aroclor 1232	mg/kg	2.12E+01	-	2.12E+01	1.06E+02	-	1.06E+02	2.67E+01	-	2.67E+01
53469-21-9	~Aroclor 1242	mg/kg	2.24E+01	-	2.24E+01	1.12E+02	-	1.12E+02	2.94E+01	-	2.94E+01
12672-29-6	~Aroclor 1248	mg/kg	2.24E+01	-	2.24E+01	1.12E+02	-	1.12E+02	2.94E+01	-	2.94E+01
11097-69-1	~Aroclor 1254	mg/kg	2.25E+01	9.72E+00	9.72E+00	1.12E+02	9.72E+00	9.72E+00	2.96E+01	1.29E+01	1.29E+01
11096-82-5	~Aroclor 1260	mg/kg	2.26E+01	-	2.26E+01	1.13E+02	-	1.13E+02	2.98E+01	-	2.98E+01

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Outdoor Worker			Excavation Worker			Industrial Worker		
			Cancer	Hazard	Action	Cancer	Hazard	Action	Cancer	Hazard	Action
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[g]	mg/kg	4.71E+01	1.51E+02	4.71E+01	2.35E+02	1.51E+02	1.51E+02	6.43E+01	2.06E+02	6.43E+01
56-55-3	~Benz[a]anthracene	mg/kg	4.69E+02	-	4.69E+02	2.35E+03	-	2.35E+03	6.39E+02	-	6.39E+02
50-32-8	~Benzo[a]pyrene	mg/kg	4.71E+01	1.51E+02	4.71E+01	2.35E+02	1.51E+02	1.51E+02	6.43E+01	2.06E+02	6.43E+01
205-99-2	~Benzo[b]fluoranthene	mg/kg	4.71E+02	-	4.71E+02	2.35E+03	-	2.35E+03	6.43E+02	-	6.43E+02
207-08-9	~Benzo[k]fluoranthene	mg/kg	4.71E+03	-	4.71E+03	2.35E+04	-	2.35E+04	6.43E+03	-	6.43E+03
218-01-9	~Chrysene	mg/kg	4.71E+04	-	4.71E+04	1.00E+05	-	1.00E+05	6.43E+04	-	6.43E+04
53-70-3	~Dibenz[a,h]anthracene	mg/kg	4.71E+01	-	4.71E+01	2.35E+02	-	2.35E+02	6.43E+01	-	6.43E+01
193-39-5	~Indeno[1,2,3-cd]pyrene	mg/kg	4.71E+02	-	4.71E+02	2.35E+03	-	2.35E+03	6.43E+02	-	6.43E+02
129-00-0	Pyrene	mg/kg	-	1.52E+04	1.52E+04	-	1.52E+04	1.52E+04	-	2.07E+04	2.07E+04
127-18-4	Tetrachloroethylene	mg/kg	1.12E+04	1.30E+03	1.30E+03	5.58E+04	1.30E+03	1.30E+03	1.07E+04	1.20E+03	1.20E+03
108-88-3	Toluene[e]	mg/kg	-	6.54E+04	6.54E+04	-	6.54E+04	6.54E+04	-	1.00E+05	1.00E+05
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[e]	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	8.43E+04	8.43E+04
71-55-6	Trichloroethane, 1,1,1-	mg/kg	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05	1.00E+05
79-00-5	Trichloroethane, 1,1,2-	mg/kg	5.11E+02	2.55E+01	2.55E+01	2.56E+03	2.55E+01	2.55E+01	5.28E+02	1.90E+01	1.90E+01
79-01-6	Trichloroethylene	mg/kg	6.17E+02	6.78E+01	6.78E+01	3.09E+03	6.78E+01	6.78E+01	6.31E+02	5.70E+01	5.70E+01
75-01-4	Vinyl Chloride	mg/kg	9.44E+01	1.08E+03	9.44E+01	4.72E+02	1.08E+03	4.72E+02	2.06E+02	1.19E+03	2.06E+02
108-38-3	Xylene, m-	mg/kg	-	9.27E+03	9.27E+03	-	9.27E+03	9.27E+03	-	7.14E+03	7.14E+03
95-47-6	Xylene, o-	mg/kg	-	1.08E+04	1.08E+04	-	1.08E+04	1.08E+04	-	8.43E+03	8.43E+03
106-42-3	Xylene, p-	mg/kg	-	9.45E+03	9.45E+03	-	9.45E+03	9.45E+03	-	7.29E+03	7.29E+03
1330-20-7	Xylene, Mixture	mg/kg	-	9.69E+03	9.69E+03	-	9.69E+03	9.69E+03	-	7.50E+03	7.50E+03
14596-10-2	Am-241	pCi/g	3.33E+02	-	3.33E+02	1.64E+03	-	1.64E+03	6.01E+02	-	6.01E+02
10045-97-3	Cs-137+D	pCi/g	1.45E+01	-	1.45E+01	5.82E+01	-	5.82E+01	1.08E+01	-	1.08E+01
13994-20-2	Np-237+D	pCi/g	3.26E+01	-	3.26E+01	1.63E+02	-	1.63E+02	2.49E+01	-	2.49E+01
13981-16-3	Pu-238	pCi/g	4.20E+02	-	4.20E+02	1.94E+03	-	1.94E+03	2.65E+03	-	2.65E+03
15117-48-3	Pu-239	pCi/g	3.66E+02	-	3.66E+02	1.83E+03	-	1.83E+03	2.27E+03	-	2.27E+03
14119-33-6	Pu-240	pCi/g	3.67E+02	-	3.67E+02	1.83E+03	-	1.83E+03	2.31E+03	-	2.31E+03
14133-76-7	Tc-99	pCi/g	3.11E+04	-	3.11E+04	1.00E+05	-	1.00E+05	1.00E+05	-	1.00E+05
14269-63-7	Th-230	pCi/g	5.64E+02	-	5.64E+02	2.82E+03	-	2.82E+03	3.13E+03	-	3.13E+03
13966-29-5	U-234	pCi/g	8.60E+02	-	8.60E+02	4.30E+03	-	4.30E+03	5.01E+03	-	5.01E+03
15117-96-1	U-235+D	pCi/g	5.23E+01	-	5.23E+01	2.62E+02	-	2.62E+02	4.08E+01	-	4.08E+01
7440-61-1	U-238+D	pCi/g	1.80E+02	-	1.80E+02	8.98E+02	-	8.98E+02	1.66E+02	-	1.66E+02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Recreational User	Adult Recreational User		Child Recreational User		Teen Recreational User	
			Cancer[h]	Hazard	Action	Hazard	Action	Hazard	Action
7429-90-5	Aluminum	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
7440-36-0	Antimony (metallic)	mg/kg	-	3.36E+03	3.36E+03	2.35E+02	2.35E+02	1.38E+03	1.38E+03
7440-38-2	Arsenic, Inorganic	mg/kg	8.09E+01	9.54E+02	8.09E+01	1.84E+02	8.09E+01	3.63E+02	8.09E+01
7440-39-3	Barium	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
7440-41-7	Beryllium and compounds	mg/kg	1.00E+05	1.67E+04	1.67E+04	1.17E+03	1.17E+03	6.84E+03	6.84E+03
7440-42-8	Boron And Borates Only	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
7440-43-9	Cadmium (Diet)	mg/kg	1.00E+05	2.25E+03	2.25E+03	3.96E+02	3.96E+02	8.58E+02	8.58E+02
16065-83-1	Chromium(III), Insoluble Salts	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
18540-29-9	Chromium(VI)	mg/kg	7.47E+01	2.52E+04	7.47E+01	1.76E+03	7.47E+01	1.03E+04	7.47E+01
7440-47-3	Chromium (Total)[a]	-	-	-	-	-	-	-	-
7440-48-4	Cobalt	mg/kg	1.00E+05	2.51E+03	2.51E+03	1.76E+02	1.76E+02	1.03E+03	1.03E+03
7440-50-8	Copper	mg/kg	-	1.00E+05	1.00E+05	2.35E+04	2.35E+04	1.00E+05	1.00E+05
16984-48-8	Fluoride	mg/kg	-	1.00E+05	1.00E+05	2.35E+04	2.35E+04	1.00E+05	1.00E+05
7439-89-6	Iron	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
7439-92-1	Lead[b]	mg/kg	-	-	4.00E+02	-	4.00E+02	-	4.00E+02
7439-96-5	Manganese	mg/kg	-	1.00E+05	1.00E+05	1.40E+04	1.40E+04	8.01E+04	8.01E+04
7439-97-6	Mercury, Inorganic Salts	mg/kg	-	2.53E+03	2.53E+03	1.76E+02	1.76E+02	1.03E+03	1.03E+03
7439-98-7	Molybdenum	mg/kg	-	4.20E+04	4.20E+04	2.93E+03	2.93E+03	1.72E+04	1.72E+04
7440-02-0	Nickel Soluble Salts	mg/kg	1.00E+05	1.00E+05	1.00E+05	1.17E+04	1.17E+04	6.78E+04	6.78E+04
7782-49-2	Selenium	mg/kg	-	4.20E+04	4.20E+04	2.93E+03	2.93E+03	1.72E+04	1.72E+04
7440-22-4	Silver	mg/kg	-	4.20E+04	4.20E+04	2.93E+03	2.93E+03	1.72E+04	1.72E+04
7791-12-0	Thallium (Soluble Salts)	mg/kg	-	8.43E+01	8.43E+01	5.88E+00	5.88E+00	3.45E+01	3.45E+01
N/A	Uranium (Insoluble Compounds)[c]	mg/kg	-	2.51E+04	2.51E+04	1.76E+03	1.76E+03	1.03E+04	1.03E+04
N/A	Uranium (Soluble Salts) [c]	mg/kg	-	1.68E+03	1.68E+03	1.17E+02	1.17E+02	6.87E+02	6.87E+02
7440-62-2	Vanadium and Compounds	mg/kg	-	4.23E+04	4.23E+04	2.96E+03	2.96E+03	1.73E+04	1.73E+04
7440-66-6	Zinc and Compounds	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
83-32-9	Acenaphthene	mg/kg	-	5.13E+04	5.13E+04	1.38E+04	1.38E+04	1.92E+04	1.92E+04
208-96-8	Acenaphthylene[d]	mg/kg	-	5.13E+04	5.13E+04	1.38E+04	1.38E+04	1.92E+04	1.92E+04
107-13-1	Acrylonitrile	mg/kg	1.80E+02	7.74E+02	1.80E+02	5.64E+02	1.80E+02	5.76E+02	1.80E+02
120-12-7	Anthracene	mg/kg	-	1.00E+05	1.00E+05	6.93E+04	6.93E+04	9.60E+04	9.60E+04
71-43-2	Benzene	mg/kg	1.09E+03	4.62E+03	1.09E+03	1.48E+03	1.09E+03	3.09E+03	1.09E+03
117-81-7	Bis(2-ethylhexyl)phthalate[e]	mg/kg	3.32E+03	2.16E+04	3.32E+03	5.37E+03	3.32E+03	8.10E+03	3.32E+03
75-27-4	Bromodichloromethane	mg/kg	3.49E+02	1.00E+05	3.49E+02	1.17E+04	3.49E+02	6.87E+04	3.49E+02
86-74-8	Carbazole	mg/kg	2.32E+03	-	2.32E+03	-	2.32E+03	-	2.32E+03
56-23-5	Carbon Tetrachloride	mg/kg	6.72E+02	6.18E+03	6.72E+02	1.65E+03	6.72E+02	3.99E+03	6.72E+02
67-66-3	Chloroform	mg/kg	3.96E+02	1.13E+04	3.96E+02	3.66E+03	3.96E+02	7.53E+03	3.96E+02
75-71-8	Dichlorodifluoromethane (Freon-12)[e]	mg/kg	-	4.23E+03	4.23E+03	3.06E+03	3.06E+03	3.15E+03	3.15E+03

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

			Recreational User	Adult Recreational User		Child Recreational User		Teen Recreational User	
CAS	Analyte	Units	Cancer[h]	Hazard	Action	Hazard	Action	Hazard	Action
75-34-3	Dichloroethane, 1,1-[e]	mg/kg	4.18E+03	5.10E+04	4.18E+03	2.93E+04	4.18E+03	3.69E+04	4.18E+03
107-06-2	Dichloroethane, 1,2-	mg/kg	4.86E+02	1.57E+03	4.86E+02	8.97E+02	4.86E+02	1.14E+03	4.86E+02
75-35-4	Dichloroethylene, 1,1-	mg/kg	-	1.14E+04	1.14E+04	6.69E+03	6.69E+03	8.25E+03	8.25E+03
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	-	7.59E+04	7.59E+04	5.28E+03	5.28E+03	3.09E+04	3.09E+04
156-59-2	Dichloroethylene, 1,2-cis-	mg/kg	-	1.69E+04	1.69E+04	1.17E+03	1.17E+03	6.87E+03	6.87E+03
156-60-5	Dichloroethylene, 1,2-trans-	mg/kg	-	5.13E+03	5.13E+03	2.95E+03	2.95E+03	3.72E+03	3.72E+03
60-57-1	Dieldrin	mg/kg	2.90E+00	5.40E+01	2.90E+00	1.34E+01	2.90E+00	2.03E+01	2.90E+00
1746-01-6	Dioxins/Furans, Total (as TCDD)[f]	mg/kg	7.22E-04	1.94E-03	7.22E-04	3.03E-04	3.03E-04	7.41E-04	7.22E-04
37871-00-4	~HpCDD	mg/kg	7.23E-02	1.94E-01	7.23E-02	3.03E-02	3.03E-02	7.41E-02	7.23E-02
38998-75-3	~HpCDF, 2,3,7,8-	mg/kg	7.24E-02	1.94E-01	7.24E-02	3.03E-02	3.03E-02	7.41E-02	7.24E-02
34465-46-8	~HxCDD, 2,3,7,8-	mg/kg	7.25E-03	1.94E-02	7.25E-03	3.03E-03	3.03E-03	7.41E-03	7.25E-03
55684-94-1	~HxCDF, 2,3,7,8-	mg/kg	7.25E-03	1.94E-02	7.25E-03	3.03E-03	3.03E-03	7.41E-03	7.25E-03
3268-87-9	~OCDD	mg/kg	2.42E+00	6.45E+00	2.42E+00	1.01E+00	1.01E+00	2.47E+00	2.42E+00
39001-02-0	~OCDF	mg/kg	2.42E+00	6.45E+00	2.42E+00	1.01E+00	1.01E+00	2.47E+00	2.42E+00
36088-22-9	~PeCDD, 2,3,7,8-	mg/kg	7.25E-04	1.94E-03	7.25E-04	3.03E-04	3.03E-04	7.41E-04	7.25E-04
57117-41-6	~PeCDF, 1,2,3,7,8-	mg/kg	2.42E-02	6.45E-02	2.42E-02	1.01E-02	1.01E-02	2.47E-02	2.42E-02
57117-31-4	~PeCDF, 2,3,4,7,8-	mg/kg	2.42E-03	6.45E-03	2.42E-03	1.01E-03	1.01E-03	2.47E-03	2.42E-03
1746-01-6	~TCDD, 2,3,7,8-	mg/kg	7.22E-04	1.94E-03	7.22E-04	3.03E-04	3.03E-04	7.41E-04	7.22E-04
51207-31-9	~TCDF, 2,3,7,8-	mg/kg	7.23E-03	1.94E-02	7.23E-03	3.03E-03	3.03E-03	7.41E-03	7.23E-03
100-41-4	Ethylbenzene	mg/kg	5.46E+03	1.00E+05	5.46E+03	4.59E+04	5.46E+03	1.00E+05	5.46E+03
206-44-0	Fluoranthene	mg/kg	-	3.42E+04	3.42E+04	9.24E+03	9.24E+03	1.28E+04	1.28E+04
86-73-7	Fluorene	mg/kg	-	3.42E+04	3.42E+04	9.24E+03	9.24E+03	1.28E+04	1.28E+04
118-74-1	Hexachlorobenzene	mg/kg	8.86E+01	6.75E+03	8.86E+01	4.68E+02	8.86E+01	2.75E+03	8.86E+01
91-20-3	Naphthalene	mg/kg	5.09E+03	4.98E+03	4.98E+03	2.45E+03	2.45E+03	2.87E+03	2.87E+03
88-74-4	Nitroaniline, 2-	mg/kg	-	1.07E+04	1.07E+04	2.68E+03	2.68E+03	4.05E+03	4.05E+03
621-64-7	Nitroso-di-N-propylamine, N-	mg/kg	6.63E+00	-	6.63E+00	-	6.63E+00	-	6.63E+00
87-86-5	Pentachlorophenol	mg/kg	5.56E+01	2.33E+03	5.56E+01	7.38E+02	5.56E+01	8.70E+02	5.56E+01
85-01-8	Phenanthrene[d]	mg/kg	-	5.13E+04	5.13E+04	1.38E+04	1.38E+04	1.92E+04	1.92E+04
1336-36-3	Polychlorinated Biphenyls, Total	mg/kg	1.79E+01	-	1.79E+01	-	1.79E+01	-	1.79E+01
12674-11-2	~Aroclor 1016	mg/kg	5.12E+02	5.58E+01	5.58E+01	1.54E+01	1.54E+01	2.09E+01	2.09E+01
11104-28-2	~Aroclor 1221	mg/kg	1.77E+01	-	1.77E+01	-	1.77E+01	-	1.77E+01
11141-16-5	~Aroclor 1232	mg/kg	1.76E+01	-	1.76E+01	-	1.76E+01	-	1.76E+01
53469-21-9	~Aroclor 1242	mg/kg	1.79E+01	-	1.79E+01	-	1.79E+01	-	1.79E+01
12672-29-6	~Aroclor 1248	mg/kg	1.79E+01	-	1.79E+01	-	1.79E+01	-	1.79E+01
11097-69-1	~Aroclor 1254	mg/kg	1.79E+01	1.60E+01	1.60E+01	4.41E+00	4.41E+00	6.00E+00	6.00E+00
11096-82-5	~Aroclor 1260	mg/kg	1.80E+01	-	1.80E+01	-	1.80E+01	-	1.80E+01

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Recreational User	Adult Recreational User		Child Recreational User		Teen Recreational User	
			Cancer[h]	Hazard	Action	Hazard	Action	Hazard	Action
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[g]	mg/kg	1.09E+01	2.56E+02	1.09E+01	6.93E+01	1.09E+01	9.60E+01	1.09E+01
56-55-3	~Benz[a]anthracene	mg/kg	1.09E+02	-	1.09E+02	-	1.09E+02	-	1.09E+02
50-32-8	~Benzo[a]pyrene	mg/kg	1.09E+01	2.56E+02	1.09E+01	6.93E+01	1.09E+01	9.60E+01	1.09E+01
205-99-2	~Benzo[b]fluoranthene	mg/kg	1.09E+02	-	1.09E+02	-	1.09E+02	-	1.09E+02
207-08-9	~Benzo[k]fluoranthene	mg/kg	1.09E+03	-	1.09E+03	-	1.09E+03	-	1.09E+03
218-01-9	~Chrysene	mg/kg	1.09E+04	-	1.09E+04	-	1.09E+04	-	1.09E+04
53-70-3	~Dibenz[a,h]anthracene	mg/kg	1.09E+01	-	1.09E+01	-	1.09E+01	-	1.09E+01
193-39-5	~Indeno[1,2,3-cd]pyrene	mg/kg	1.09E+02	-	1.09E+02	-	1.09E+02	-	1.09E+02
129-00-0	Pyrene	mg/kg	-	2.56E+04	2.56E+04	6.93E+03	6.93E+03	9.60E+03	9.60E+03
127-18-4	Tetrachloroethylene	mg/kg	2.38E+04	4.35E+03	4.35E+03	1.76E+03	1.76E+03	3.00E+03	3.00E+03
108-88-3	Toluene[e]	mg/kg	-	1.00E+05	1.00E+05	4.44E+04	4.44E+04	1.00E+05	1.00E+05
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[e]	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
71-55-6	Trichloroethane, 1,1,1-	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
79-00-5	Trichloroethane, 1,1,2-	mg/kg	1.07E+03	7.29E+01	7.29E+01	5.31E+01	5.31E+01	5.40E+01	5.40E+01
79-01-6	Trichloroethylene	mg/kg	8.32E+02	2.12E+02	2.12E+02	1.06E+02	1.06E+02	1.51E+02	1.51E+02
75-01-4	Vinyl Chloride	mg/kg	6.78E+00	4.05E+03	6.78E+00	1.18E+03	6.78E+00	2.66E+03	6.78E+00
108-38-3	Xylene, m-	mg/kg	-	2.72E+04	2.72E+04	1.75E+04	1.75E+04	2.00E+04	2.00E+04
95-47-6	Xylene, o-	mg/kg	-	3.21E+04	3.21E+04	2.01E+04	2.01E+04	2.34E+04	2.34E+04
106-42-3	Xylene, p-	mg/kg	-	2.78E+04	2.78E+04	1.78E+04	1.78E+04	2.03E+04	2.03E+04
1330-20-7	Xylene, Mixture	mg/kg	-	2.85E+04	2.85E+04	1.82E+04	1.82E+04	2.09E+04	2.09E+04
14596-10-2	Am-241	pCi/g	8.41E+02	-	8.41E+02	-	8.41E+02	-	8.41E+02
10045-97-3	Cs-137+D	pCi/g	3.31E+01	-	3.31E+01	-	3.31E+01	-	3.31E+01
13994-20-2	Np-237+D	pCi/g	7.31E+01	-	7.31E+01	-	7.31E+01	-	7.31E+01
13981-16-3	Pu-238	pCi/g	1.19E+03	-	1.19E+03	-	1.19E+03	-	1.19E+03
15117-48-3	Pu-239	pCi/g	1.06E+03	-	1.06E+03	-	1.06E+03	-	1.06E+03
14119-33-6	Pu-240	pCi/g	1.06E+03	-	1.06E+03	-	1.06E+03	-	1.06E+03
14133-76-7	Tc-99	pCi/g	3.22E+04	-	3.22E+04	-	3.22E+04	-	3.22E+04
14269-63-7	Th-230	pCi/g	1.42E+03	-	1.42E+03	-	1.42E+03	-	1.42E+03
13966-29-5	U-234	pCi/g	1.62E+03	-	1.62E+03	-	1.62E+03	-	1.62E+03
15117-96-1	U-235+D	pCi/g	1.16E+02	-	1.16E+02	-	1.16E+02	-	1.16E+02
7440-61-1	U-238+D	pCi/g	3.67E+02	-	3.67E+02	-	3.67E+02	-	3.67E+02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Resident	Adult Resident		Child Resident	
			Cancer[h]	Hazard	Action	Hazard	Action
7429-90-5	Aluminum	mg/kg	-	1.00E+05	1.00E+05	1.00E+05	1.00E+05
7440-36-0	Antimony (metallic)	mg/kg	-	9.99E+02	9.99E+02	9.39E+01	9.39E+01
7440-38-2	Arsenic, Inorganic	mg/kg	3.56E+01	3.09E+02	3.56E+01	7.35E+01	3.56E+01
7440-39-3	Barium	mg/kg	-	1.00E+05	1.00E+05	4.59E+04	4.59E+04
7440-41-7	Beryllium and compounds	mg/kg	1.00E+05	4.74E+03	4.74E+03	4.68E+02	4.68E+02
7440-42-8	Boron And Borates Only	mg/kg	-	1.00E+05	4.98E+05	4.68E+04	4.68E+04
7440-43-9	Cadmium (Diet)	mg/kg	1.00E+05	7.20E+02	7.20E+02	1.58E+02	1.58E+02
16065-83-1	Chromium(III), Insoluble Salts	mg/kg	-	1.00E+05	1.00E+05	3.51E+05	3.51E+05
18540-29-9	Chromium(VI)	mg/kg	3.01E+01	7.38E+03	3.01E+01	7.02E+02	3.01E+01
7440-47-3	Chromium (Total)[a]	-	-	-	-	-	-
7440-48-4	Cobalt	mg/kg	4.24E+04	7.29E+02	7.29E+02	7.02E+01	7.02E+01
7440-50-8	Copper	mg/kg	-	1.00E+05	1.00E+05	9.39E+03	9.39E+03
16984-48-8	Fluoride	mg/kg	-	9.99E+04	9.99E+04	9.39E+03	9.39E+03
7439-89-6	Iron	mg/kg	-	1.75E+06	1.75E+06	1.64E+05	1.64E+05
7439-92-1	Lead[b]	mg/kg	-	-	4.00E+02	-	4.00E+02
7439-96-5	Manganese	mg/kg	-	4.68E+04	4.68E+04	5.49E+03	5.49E+03
7439-97-6	Mercury, Inorganic Salts	mg/kg	-	7.50E+02	7.50E+02	7.05E+01	7.05E+01
7439-98-7	Molybdenum	mg/kg	-	1.24E+04	1.24E+04	1.17E+03	1.17E+03
7440-02-0	Nickel Soluble Salts	mg/kg	1.00E+05	4.44E+04	4.44E+04	4.65E+03	4.65E+03
7782-49-2	Selenium	mg/kg	-	1.25E+04	1.25E+04	1.17E+03	1.17E+03
7440-22-4	Silver	mg/kg	-	1.25E+04	1.25E+04	1.17E+03	1.17E+03
7791-12-0	Thallium (Soluble Salts)	mg/kg	-	2.50E+01	2.50E+01	2.35E+00	2.35E+00
N/A	Uranium (Insoluble Compounds)[c]	mg/kg	-	7.20E+03	7.20E+03	7.02E+02	7.02E+02
N/A	Uranium (Soluble Salts)[c]	mg/kg	-	4.98E+02	4.98E+02	4.68E+01	4.68E+01
7440-62-2	Vanadium and Compounds	mg/kg	-	1.22E+04	1.22E+04	1.18E+03	1.18E+03
7440-66-6	Zinc and Compounds	mg/kg	-	7.50E+05	7.50E+05	7.05E+04	7.05E+04
83-32-9	Acenaphthene	mg/kg	-	1.70E+04	1.70E+04	5.55E+03	5.55E+03
208-96-8	Acenaphthylene[d]	mg/kg	-	1.70E+04	1.70E+04	5.55E+03	5.55E+03
107-13-1	Acrylonitrile	mg/kg	2.55E+01	4.80E+01	2.55E+01	4.77E+01	2.55E+01
120-12-7	Anthracene	mg/kg	-	8.49E+04	8.49E+04	2.77E+04	2.77E+04
71-43-2	Benzene	mg/kg	1.16E+02	3.21E+02	1.16E+02	2.45E+02	1.16E+02
117-81-7	Bis(2-ethylhexyl)phthalate[e]	mg/kg	1.49E+03	7.11E+03	1.49E+03	2.15E+03	1.49E+03
75-27-4	Bromodichloromethane	mg/kg	2.93E+01	5.01E+04	2.93E+01	4.68E+03	2.93E+01
86-74-8	Carbazole	mg/kg	1.04E+03	-	1.04E+03	-	1.04E+03
56-23-5	Carbon Tetrachloride	mg/kg	6.53E+01	4.47E+02	6.53E+01	3.12E+02	6.53E+01
67-66-3	Chloroform	mg/kg	3.16E+01	7.77E+02	3.16E+01	5.97E+02	3.16E+01
75-71-8	Dichlorodifluoromethane (Freon-12)[e]	mg/kg	-	2.63E+02	2.63E+02	2.62E+02	2.62E+02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Resident Cancer[h]	Adult Resident Hazard	Adult Resident Action	Child Resident Hazard	Child Resident Action
75-34-3	Dichloroethane, 1,1-[e]	mg/kg	3.55E+02	3.24E+03	3.55E+02	3.06E+03	3.55E+02
107-06-2	Dichloroethane, 1,2-	mg/kg	4.64E+01	9.96E+01	4.64E+01	9.36E+01	4.64E+01
75-35-4	Dichloroethylene, 1,1-	mg/kg	-	7.20E+02	7.20E+02	6.81E+02	6.81E+02
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	-	2.25E+04	2.25E+04	2.11E+03	2.11E+03
156-59-2	Dichloroethylene, 1,2-cis-	mg/kg	-	5.01E+03	5.01E+03	4.68E+02	4.68E+02
156-60-5	Dichloroethylene, 1,2-trans-	mg/kg	-	3.27E+02	3.27E+02	3.06E+02	3.06E+02
60-57-1	Dieldrin	mg/kg	1.30E+00	1.78E+01	1.30E+00	5.37E+00	1.30E+00
1746-01-6	Dioxins/Furans, Total (as TCDD)[f]	mg/kg	3.08E-04	6.21E-04	3.08E-04	1.21E-04	1.21E-04
37871-00-4	~HpCDD	mg/kg	3.09E-02	6.21E-02	3.09E-02	1.21E-02	1.21E-02
38998-75-3	~HpCDF, 2,3,7,8-	mg/kg	3.12E-02	6.24E-02	3.12E-02	1.21E-02	1.21E-02
34465-46-8	~HxCDD, 2,3,7,8-	mg/kg	3.14E-03	6.24E-03	3.14E-03	1.21E-03	1.21E-03
55684-94-1	~HxCDF, 2,3,7,8-	mg/kg	3.14E-03	6.24E-03	3.14E-03	1.21E-03	1.21E-03
3268-87-9	~OCDD	mg/kg	1.05E+00	2.08E+00	1.05E+00	4.05E-01	4.05E-01
39001-02-0	~OCDF	mg/kg	1.05E+00	2.08E+00	1.05E+00	4.05E-01	4.05E-01
36088-22-9	~PeCDD, 2,3,7,8-	mg/kg	3.14E-04	6.24E-04	3.14E-04	1.21E-04	1.21E-04
57117-41-6	~PeCDF, 1,2,3,7,8-	mg/kg	1.05E-02	2.08E-02	1.05E-02	4.05E-03	4.05E-03
57117-31-4	~PeCDF, 2,3,4,7,8-	mg/kg	1.05E-03	2.08E-03	1.05E-03	4.05E-04	4.05E-04
1746-01-6	~TCDD, 2,3,7,8-	mg/kg	3.08E-04	6.21E-04	3.08E-04	1.21E-04	1.21E-04
51207-31-9	~TCDF, 2,3,7,8-	mg/kg	3.09E-03	6.21E-03	3.09E-03	1.21E-03	1.21E-03
100-41-4	Ethylbenzene	mg/kg	5.78E+02	1.66E+04	5.78E+02	1.01E+04	5.78E+02
206-44-0	Fluoranthene	mg/kg	-	1.13E+04	1.13E+04	3.69E+03	3.69E+03
86-73-7	Fluorene	mg/kg	-	1.13E+04	1.13E+04	3.69E+03	3.69E+03
118-74-1	Hexachlorobenzene	mg/kg	2.12E+01	2.00E+03	2.12E+01	1.88E+02	2.12E+01
91-20-3	Naphthalene	mg/kg	3.83E+02	4.05E+02	3.83E+02	3.51E+02	3.51E+02
88-74-4	Nitroaniline, 2-	mg/kg	-	3.51E+03	3.51E+03	1.07E+03	1.07E+03
621-64-7	Nitroso-di-N-propylamine, N-	mg/kg	2.97E+00	-	2.97E+00	-	2.97E+00
87-86-5	Pentachlorophenol	mg/kg	2.54E+01	7.77E+02	2.54E+01	2.96E+02	2.54E+01
85-01-8	Phenanthrene[d]	mg/kg	-	1.70E+04	1.70E+04	5.55E+03	5.55E+03
1336-36-3	Polychlorinated Biphenyls, Total	mg/kg	7.88E+00	-	7.88E+00	-	7.88E+00
12674-11-2	~Aroclor 1016	mg/kg	2.27E+02	1.85E+01	1.85E+01	6.18E+00	6.18E+00
11104-28-2	~Aroclor 1221	mg/kg	7.52E+00	-	7.52E+00	-	7.52E+00
11141-16-5	~Aroclor 1232	mg/kg	7.08E+00	-	7.08E+00	-	7.08E+00
53469-21-9	~Aroclor 1242	mg/kg	7.91E+00	-	7.91E+00	-	7.91E+00
12672-29-6	~Aroclor 1248	mg/kg	7.92E+00	-	7.92E+00	-	7.92E+00
11097-69-1	~Aroclor 1254	mg/kg	7.97E+00	5.31E+00	5.31E+00	1.76E+00	1.76E+00
11096-82-5	~Aroclor 1260	mg/kg	8.03E+00	-	8.03E+00	-	8.03E+00

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.1. Soil/Sediment Action Levels for Significant COPCs at PGDP (Continued)

			Resident	Adult Resident		Child Resident	
CAS	Analyte	Units	Cancer[h]	Hazard	Action	Hazard	Action
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[g]	mg/kg	4.78E+00	8.40E+01	4.78E+00	2.76E+01	4.78E+00
56-55-3	~Benz[a]anthracene	mg/kg	4.75E+01	-	4.75E+01	-	4.75E+01
50-32-8	~Benzo[a]pyrene	mg/kg	4.78E+00	8.40E+01	4.78E+00	2.76E+01	4.78E+00
205-99-2	~Benzo[b]fluoranthene	mg/kg	4.78E+01	-	4.78E+01	-	4.78E+01
207-08-9	~Benzo[k]fluoranthene	mg/kg	4.78E+02	-	4.78E+02	-	4.78E+02
218-01-9	~Chrysene	mg/kg	4.78E+03	-	4.78E+03	-	4.78E+03
53-70-3	~Dibenz[a,h]anthracene	mg/kg	4.78E+00	-	4.78E+00	-	4.78E+00
193-39-5	~Indeno[1,2,3-cd]pyrene	mg/kg	4.78E+01	-	4.78E+01	-	4.78E+01
129-00-0	Pyrene	mg/kg	-	8.49E+03	8.49E+03	2.77E+03	2.77E+03
127-18-4	Tetrachloroethylene	mg/kg	2.36E+03	2.88E+02	2.88E+02	2.43E+02	2.43E+02
108-88-3	Toluene[e]	mg/kg	-	5.01E+04	5.01E+04	1.47E+04	1.47E+04
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[e]	mg/kg	-	2.01E+04	2.01E+04	2.01E+04	2.01E+04
71-55-6	Trichloroethane, 1,1,1-	mg/kg	-	2.57E+04	2.57E+04	2.45E+04	2.45E+04
79-00-5	Trichloroethane, 1,1,2-	mg/kg	1.15E+02	4.50E+00	4.50E+00	4.50E+00	4.50E+00
79-01-6	Trichloroethylene	mg/kg	9.43E+01	1.37E+01	1.37E+01	1.24E+01	1.24E+01
75-01-4	Vinyl Chloride	mg/kg	5.92E+00	2.88E+02	5.92E+00	2.10E+02	5.92E+00
108-38-3	Xylene, m-	mg/kg	-	1.71E+03	1.71E+03	1.65E+03	1.65E+03
95-47-6	Xylene, o-	mg/kg	-	2.01E+03	2.01E+03	1.94E+03	1.94E+03
106-42-3	Xylene, p-	mg/kg	-	1.74E+03	1.74E+03	1.68E+03	1.68E+03
1330-20-7	Xylene, Mixture	mg/kg	-	1.79E+03	1.79E+03	1.73E+03	1.73E+03
14596-10-2	Am-241	pCi/g	1.75E+02	-	1.75E+02	-	1.75E+02
10045-97-3	Cs-137+D	pCi/g	4.02E+00	-	4.02E+00	-	4.02E+00
13994-20-2	Np-237+D	pCi/g	9.11E+00	-	9.11E+00	-	9.11E+00
13981-16-3	Pu-238	pCi/g	4.27E+02	-	4.27E+02	-	4.27E+02
15117-48-3	Pu-239	pCi/g	3.77E+02	-	3.77E+02	-	3.77E+02
14119-33-6	Pu-240	pCi/g	3.80E+02	-	3.80E+02	-	3.80E+02
14133-76-7	Tc-99	pCi/g	1.10E+04	-	1.10E+04	-	1.10E+04
14269-63-7	Th-230	pCi/g	4.93E+02	-	4.93E+02	-	4.93E+02
13966-29-5	U-234	pCi/g	5.77E+02	-	5.77E+02	-	5.77E+02
15117-96-1	U-235+D	pCi/g	1.48E+01	-	1.48E+01	-	1.48E+01
7440-61-1	U-238+D	pCi/g	5.56E+01	-	5.56E+01	-	5.56E+01

NOTES: The action level for HI is 3 because the range of values for HI (based on RGO tables) are 0.1, 1, and 3. Please see Figure 1.1 of the Risk Methods Document.

Values are provided in these tables for significant COPCs for PGDP. Values for other COPCs can be obtained using the RAIS online calculator, as modified using PGDP-specific inputs.

[a] Chromium (Total) AL should utilize Chromium III or Chromium VI, as appropriate.

[b] Lead values should be checked prior to use to ensure they are still current.

[c] Based on recommendation from EPA 2016, ALs for uranium (soluble salts) now use the RfD for uranium derived from ATSDR. The RfD for uranium available in IRIS has been added as uranium (insoluble compounds).

[d] Acenaphthylene and phenanthrene use values for acenaphthene.

[e] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.

[f] Total dioxins/furans uses values for 2,3,7,8-TCDD, see screening note 9f in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.

[g] Total carcinogenic PAHs uses values for BaP, see screening note 9d in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.

[h] For the recreational user and the resident, ELCRs (i.e. cancer ALs) were calculated using the child/teen/adult or child/adult age-adjusted lifetime scenario, respectively.

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.2. Groundwater Action Levels and Primary MCLs for Significant COPCs at PGDP

(Values calculated in October 2018 and are based on best available information.)

			Resident	Adult Resident		Child Resident		Primary
CAS	**Analyte**	**Units**	**Cancer[a]**	**Hazard**	**Action**	**Hazard**	**Action**	**MCLs[j]**
7429-90-5	Aluminum	µg/L	-	9.96E+04	9.96E+04	6.00E+04	6.00E+04	-
7440-36-0	Antimony (metallic)	µg/L	-	3.87E+01	3.87E+01	2.34E+01	2.34E+01	6.00E+00
7440-38-2	Arsenic, Inorganic	µg/L	5.17E+00	2.99E+01	5.17E+00	1.80E+01	5.17E+00	1.00E+01
7440-39-3	Barium	µg/L	-	1.85E+04	1.85E+04	1.13E+04	1.13E+04	2.00E+03
7440-41-7	Beryllium and compounds	µg/L	-	1.11E+02	1.11E+02	7.38E+01	7.38E+01	4.00E+00
7440-42-8	Boron And Borates Only	µg/L	-	1.99E+04	1.99E+04	1.20E+04	1.20E+04	-
7440-43-9	Cadmium (Water)	µg/L	-	4.50E+01	4.50E+01	2.77E+01	2.77E+01	5.00E+00
16065-83-1	Chromium(III), Insoluble Salts	µg/L	-	1.05E+05	1.05E+05	6.75E+04	6.75E+04	-
18540-29-9	Chromium(VI)	µg/L	3.50E+00	2.08E+02	3.50E+00	1.34E+02	3.50E+00	-
7440-47-3	Chromium (Total)[b]	µg/L	-	-	-	-	-	1.00E+02
7440-48-4	Cobalt	µg/L	-	3.00E+01	3.00E+01	1.80E+01	1.80E+01	-
7440-50-8	Copper	µg/L	-	3.99E+03	3.99E+03	2.40E+03	2.40E+03	1.30E+03
16984-48-8	Fluoride	µg/L	-	3.99E+03	3.99E+03	2.40E+03	2.40E+03	4.00E+03
7439-89-6	Iron	µg/L	-	6.96E+04	6.96E+04	4.20E+04	4.20E+04	-
7439-92-1	Lead[c]	µg/L	-	-	3.00E+01	-	3.00E+01	1.50E+01
7439-96-5	Manganese	µg/L	-	2.11E+03	2.11E+03	1.30E+03	1.30E+03	-
7439-97-6	Mercury, Inorganic Salts	µg/L	-	2.78E+01	2.78E+01	1.70E+01	1.70E+01	2.00E+00
7439-98-7	Molybdenum	µg/L	-	4.98E+02	4.98E+02	2.99E+02	2.99E+02	-
7440-02-0	Nickel Soluble Salts	µg/L	-	1.95E+03	1.95E+03	1.18E+03	1.18E+03	-
7782-49-2	Selenium	µg/L	-	4.98E+02	4.98E+02	2.99E+02	2.99E+02	5.00E+01
7440-22-4	Silver	µg/L	-	4.62E+02	4.62E+02	2.82E+02	2.82E+02	-
7791-12-0	Thallium (Soluble Salts)	µg/L	-	9.96E-01	9.96E-01	6.00E-01	6.00E-01	2.00E+00
N/A	Uranium (Insoluble Compounds) [d]	µg/L	-	2.99E+02	2.99E+02	1.80E+02	1.80E+02	3.00E+01
N/A	Uranium (Soluble Salts) [d]	µg/L	-	1.99E+01	1.99E+01	1.20E+01	1.20E+01	3.00E+01
7440-62-2	Vanadium and Compounds	µg/L	-	4.14E+02	4.14E+02	2.59E+02	2.59E+02	-
7440-66-6	Zinc and Compounds	µg/L	-	2.99E+04	2.99E+04	1.80E+04	1.80E+04	-
83-32-9	Acenaphthene	µg/L	-	2.52E+03	2.52E+03	1.61E+03	1.61E+03	-
208-96-8	Acenaphthylene[e]	µg/L	-	2.52E+03	2.52E+03	1.61E+03	1.61E+03	-
107-13-1	Acrylonitrile	µg/L	5.23E+00	1.25E+01	5.23E+00	1.25E+01	5.23E+00	-
120-12-7	Anthracene	µg/L	-	8.22E+03	8.22E+03	5.31E+03	5.31E+03	-
71-43-2	Benzene	µg/L	4.55E+01	1.22E+02	4.55E+01	9.96E+01	4.55E+01	5.00E+00
117-81-7	Bis(2-ethylhexyl)phthalate[f]	µg/L	5.56E+02	2.00E+03	5.56E+02	1.20E+03	5.56E+02	6.00E+00
75-27-4	Bromodichloromethane	µg/L	1.34E+01	1.88E+03	1.34E+01	1.13E+03	1.34E+01	8.00E+01[k]
86-74-8	Carbazole	µg/L	2.03E+02	-	2.03E+02	-	2.03E+02	-
56-23-5	Carbon Tetrachloride	µg/L	4.55E+01	2.11E+02	4.55E+01	1.49E+02	4.55E+01	5.00E+00
67-66-3	Chloroform	µg/L	2.21E+01	3.66E+02	2.21E+01	2.92E+02	2.21E+01	8.00E+01[k]
75-71-8	Dichlorodifluoromethane (Freon-12)[f]	µg/L	-	6.06E+02	6.06E+02	5.91E+02	5.91E+02	-

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.2. Groundwater Action Levels and Primary MCLs for Significant COPCs at PGDP (Continued)

			Resident	Adult Resident		Child Resident		Primary
CAS	Analyte	Units	Cancer[a]	Hazard	Action	Hazard	Action	MCLs[j]
75-34-3	Dichloroethane, 1,1-[f]	µg/L	2.75E+02	2.68E+03	2.75E+02	2.45E+03	2.75E+02	-
107-06-2	Dichloroethane, 1,2-	µg/L	1.71E+01	4.08E+01	1.71E+01	3.90E+01	1.71E+01	5.00E+00
75-35-4	Dichloroethylene, 1,1-	µg/L	-	9.75E+02	9.75E+02	8.55E+02	8.55E+02	7.00E+00
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	8.04E+02	8.04E+02	4.89E+02	4.89E+02	-
156-59-2	Dichloroethylene, 1,2-cis-	µg/L	-	1.79E+02	1.79E+02	1.08E+02	1.08E+02	7.00E+01
156-60-5	Dichloroethylene, 1,2-trans-	µg/L	-	3.09E+02	3.09E+02	2.79E+02	2.79E+02	1.00E+02
60-57-1	Dieldrin	µg/L	1.75E-01	1.79E+00	1.75E-01	1.14E+00	1.75E-01	-
1746-01-6	Dioxins/Furans, Total (as TCDD)[g]	µg/L	1.19E-05	5.49E-05	1.19E-05	3.60E-05	1.19E-05	3.00E-05
37871-00-4	~HpCDD, 2,3,7,8-	µg/L	1.19E-03	5.49E-03	1.19E-03	3.60E-03	1.19E-03	-
38998-75-3	~HpCDF, 2,3,7,8-	µg/L	1.19E-03	5.49E-03	1.19E-03	3.60E-03	1.19E-03	-
34465-46-8	~HxCDD	µg/L	5.99E-04	7.02E-04	5.99E-04	4.20E-04	4.20E-04	-
55684-94-1	~HxCDF, 2,3,7,8-	µg/L	5.99E-04	7.02E-04	5.99E-04	4.20E-04	4.20E-04	-
3268-87-9	~OCDD	µg/L	2.00E-01	2.34E-01	2.00E-01	1.40E-01	1.40E-01	-
39001-02-0	~OCDF	µg/L	2.00E-01	2.34E-01	2.00E-01	1.40E-01	1.40E-01	-
36088-22-9	~PeCDD, 2,3,7,8-	µg/L	5.99E-05	7.02E-05	5.99E-05	4.20E-05	4.20E-05	-
57117-41-6	~PeCDF, 1,2,3,7,8-	µg/L	2.00E-03	2.34E-03	2.00E-03	1.40E-03	1.40E-03	-
57117-31-4	~PeCDF, 2,3,4,7,8-	µg/L	2.00E-04	2.34E-04	2.00E-04	1.40E-04	1.40E-04	-
1746-01-6	~TCDD, 2,3,7,8-	µg/L	1.19E-05	5.49E-05	1.19E-05	3.60E-05	1.19E-05	3.00E-05
51207-31-9	~TCDF, 2,3,7,8-	µg/L	1.19E-04	5.49E-04	1.19E-04	3.60E-04	1.19E-04	-
100-41-4	Ethylbenzene	µg/L	1.50E+02	3.15E+03	1.50E+02	2.42E+03	1.50E+02	7.00E+02
206-44-0	Fluoranthene	µg/L	-	3.99E+03	3.99E+03	2.41E+03	2.41E+03	-
86-73-7	Fluorene	µg/L	-	1.38E+03	1.38E+03	8.82E+02	8.82E+02	-
118-74-1	Hexachlorobenzene	µg/L	9.76E-01	8.01E+01	9.76E-01	4.80E+01	9.76E-01	1.00E+00
91-20-3	Naphthalene	µg/L	1.65E+01	1.85E+01	1.65E+01	1.83E+01	1.65E+01	-
88-74-4	Nitroaniline, 2-	µg/L	-	9.39E+02	9.39E+02	5.67E+02	5.67E+02	-
621-64-7	Nitroso-di-N-propylamine, N-	µg/L	1.08E+00	-	1.08E+00	-	1.08E+00	-
87-86-5	Pentachlorophenol	µg/L	4.13E+00	1.05E+02	4.13E+00	6.81E+01	4.13E+00	1.00E+00
85-01-8	Phenanthrene[e]	µg/L	-	2.52E+03	2.52E+03	1.61E+03	1.61E+03	-
1336-36-3	Polychlorinated Biphenyls, Total	µg/L	4.36E+00	-	4.36E+00	-	4.36E+00	5.00E-01
12674-11-2	~Aroclor 1016	µg/L	2.24E+01	7.02E+00	7.02E+00	4.20E+00	4.20E+00	-
11104-28-2	~Aroclor 1221	µg/L	4.71E-01	-	4.71E-01	-	4.71E-01	-
11141-16-5	~Aroclor 1232	µg/L	4.71E-01	-	4.71E-01	-	4.71E-01	-
53469-21-9	~Aroclor 1242	µg/L	7.85E-01	-	7.85E-01	-	7.85E-01	-
12672-29-6	~Aroclor 1248	µg/L	7.85E-01	-	7.85E-01	-	7.85E-01	-
11097-69-1	~Aroclor 1254	µg/L	7.85E-01	2.00E+00	7.85E-01	1.20E+00	7.85E-01	-
11096-82-5	~Aroclor 1260	µg/L	7.85E-01	-	7.85E-01	-	7.85E-01	-

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.2. Groundwater Action Levels and Primary MCLs for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Resident	Adult Resident		Child Resident		Primary
			Cancer[a]	Hazard	Action	Hazard	Action	MCLs[j]
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	2.51E+00	3.00E+01	2.51E+00	1.81E+01	2.51E+00	2.00E-01
56-55-3	~Benz[a]anthracene	µg/L	2.98E+00	-	2.98E+00	-	2.98E+00	-
50-32-8	~Benzo[a]pyrene	µg/L	2.51E+00	3.00E+01	2.51E+00	1.81E+01	2.51E+00	2.00E-01
205-99-2	~Benzo[b]fluoranthene	µg/L	2.51E+01	-	2.51E+01	-	2.51E+01	-
207-08-9	~Benzo[k]fluoranthene	µg/L	2.51E+02	-	2.51E+02	-	2.51E+02	-
218-01-9	~Chrysene	µg/L	2.51E+03	-	2.51E+03	-	2.51E+03	-
53-70-3	~Dibenz[a,h]anthracene	µg/L	2.51E+00	-	2.51E+00	-	2.51E+00	-
193-39-5	~Indeno[1,2,3-cd]pyrene	µg/L	2.51E+01	-	2.51E+01	-	2.51E+01	-
129-00-0	Pyrene	µg/L	-	5.58E+02	5.58E+02	3.63E+02	3.63E+02	-
127-18-4	Tetrachloroethylene	µg/L	1.13E+03	1.51E+02	1.51E+02	1.22E+02	1.22E+02	5.00E+00
108-88-3	Toluene[f]	µg/L	-	5.04E+03	5.04E+03	3.30E+03	3.30E+03	1.00E+03
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	3.09E+04	3.09E+04	3.06E+04	3.06E+04	-
71-55-6	Trichloroethane, 1,1,1-	µg/L	-	2.64E+04	2.64E+04	2.40E+04	2.40E+04	2.00E+02
79-00-5	Trichloroethane, 1,1,2-	µg/L	2.75E+01	1.25E+00	1.25E+00	1.25E+00	1.25E+00	5.00E+00
79-01-6	Trichloroethylene	µg/L	4.94E+01	9.69E+00	9.69E+00	8.49E+00	8.49E+00	5.00E+00
75-01-4	Vinyl Chloride	µg/L	1.88E+00	1.93E+02	1.88E+00	1.33E+02	1.88E+00	2.00E+00
108-38-3	Xylene, m-	µg/L	-	5.94E+02	5.94E+02	5.79E+02	5.79E+02	-
95-47-6	Xylene, o-	µg/L	-	5.97E+02	5.97E+02	5.79E+02	5.79E+02	-
106-42-3	Xylene, p-	µg/L	-	5.97E+02	5.97E+02	5.79E+02	5.79E+02	-
1330-20-7	Xylene, Mixture	µg/L	-	5.97E+02	5.97E+02	5.79E+02	5.79E+02	1.00E+04
14596-10-2	Am-241[i]	pCi/L	5.04E+01	-	5.04E+01	-	5.04E+01	1.50E+01[l]
10045-97-3	Cs-137+D[i]	pCi/L	1.71E+02	-	1.71E+02	-	1.71E+02	[m]
13994-20-2	Np-237+D[i]	pCi/L	7.63E+01	-	7.63E+01	-	7.63E+01	1.50E+01[n]
13981-16-3	Pu-238[i]	pCi/L	3.98E+01	-	3.98E+01	-	3.98E+01	1.50E+01[o]
15117-48-3	Pu-239[i]	pCi/L	3.87E+01	-	3.87E+01	-	3.87E+01	1.50E+01[o]
14119-33-6	Pu-240[i]	pCi/L	3.87E+01	-	3.87E+01	-	3.87E+01	1.50E+01[o]
14133-76-7	Tc-99[i]	pCi/L	1.90E+03	-	1.90E+03	-	1.90E+03	[p]
14269-63-7	Th-230[i]	pCi/L	5.72E+01	-	5.72E+01	-	5.72E+01	1.50E+01[q]
13966-29-5	U-234[i]	pCi/L	7.39E+01	-	7.39E+01	-	7.39E+01	[r]
15117-96-1	U-235+D[i]	pCi/L	7.28E+01	-	7.28E+01	-	7.28E+01	[r]
7440-61-1	U-238+D[i]	pCi/L	6.01E+01	-	6.01E+01	-	6.01E+01	[r]

NOTES: The action level for HI is 3 because the range of values for HI (based on RGO tables) are 0.1, 1, and 3. Please see Figure 1.1 of the Risk Methods Document.
Values are provided in these tables for significant COPCs for PGDP. Values for other COPCs can be obtained using the RAIS online calculator, as modified using PGDP-specific inputs.
Action levels are not adjusted for saturation limits.
[a] For the resident, ELCRs (i.e. cancer ALs) were calculated using the child/adult age-adjusted lifetime scenario (i.e., lifetime exposure).
[b] Chromium (Total) AL should utilize Chromium III or Chromium VI, as appropriate.
[c] Lead values should be checked prior to use to ensure they are still current.
[d] Based on recommendation from EPA 2016, ALs for uranium (soluble salts) now uses the RfD for uranium derived from ATSDR. The RfD for uranium available in IRIS has been added as uranium (insoluble compounds).
[e] Acenaphthylene and phenanthrene use values for acenaphthene.
[f] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.
[g] Total dioxins/furans uses values for 2,3,7,8-TCDD, see screening note 9f in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.2. Groundwater Action Levels and Primary MCLs for Significant COPCs at PGDP (Continued)

[h] Total carcinogenic PAHs uses values for BaP, see screening note 9d in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.
[i] Radionuclides use only the ingestion risk values.
[j] Accessed at "https://www.epa.gov/dwstandardsregulations"; last updated May 22, 2017; accessed October 29, 2018.
[k] MCL is for the sum of the concentrations for trihalomethanes.
[l] Additional information regarding Am-241 can be found in "EPA Facts about Americium-241," dated July 2002, at the following link: https://semspub.epa.gov/work/HQ/176296.pdf; accessed October 29, 2018.
[m] The EPA MCL for Cs-137 is 4 mrem/yr. The value derived by the EPA from the 4 mrem/yr MCL for Cs-137 is 200 pCi/L (see "Limits for Beta Particles and Photon Emitters at 4 millrems/year" found on https://www.epa.gov/sites/production/files/2015-09/documents/guide_radionuclides_table-betaphotonemitters.pdf; accessed October 29, 2018).
[n] "Maximum Contaminant Level's in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators," revised September 2015, found on https://epa-prgs.ornl.gov/radionuclides/MCLs_2015.pdf ; accessed October 29, 2018.
[o] Additional information regarding plutonium can be found at the following link: http://www2.epa.gov/radiation/radionuclides.
[p] The value derived by the EPA from the 4 mrem/yr MCL for Tc-99 is 900 pCi/L, (see https://www.epa.gov/sites/production/files/2015-09/documents/guide_radionuclides_table-betaphotonemitters.pdf). An alternate value derived by EPA from the 4 mrem/yr MCL is 3,790 pCi/L and was proposed in the July 18, 1991, *Federal Register*. See Table A.9 for Tc-99 dose-based groundwater screening levels resulting in a 4 mrem/yr dose based upon more recent dosimetry.
[q] Additional information regarding thorium can be found at the following link: http://www2.epa.gov/radiation/radionuclides.
[r] The uranium MCL is 30 µg/L and can be assumed to be at a 1:1 ratio for pCi/L (or 30 pCi/L). The MCL also can be converted to 20 pCi/L for total uranium using a uranium activity expected at PGDP. Isotopic uranium values derived from this conversion are 10.24 pCi/L for U-234, 0.466 pCi/L for U-235, and 9.99 pCi/L for U-238, assuming natural occurring uranium at 0.725% U-235 and the following ratios:

- U-234/U-235 ranges 21-22 obtained from conversion approximately 21.9
- U-235/U-238 ranges 0.04-0.05 obtained from conversion approximately 0.045

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP

(Values calculated in October 2018 and are based on best available information.)

			Outdoor Worker[a]			Excavation Worker[a]			Industrial Worker[a]		
CAS	**Analyte**	**Units**	**Cancer**	**Hazard**	**Action**	**Cancer**	**Hazard**	**Action**	**Cancer**	**Hazard**	**Action**
7429-90-5	Aluminum	µg/L	-	1.55E+08	1.55E+08	-	1.55E+08	1.55E+08	-	3.81E+07	3.81E+07
7440-36-0	Antimony (metallic)	µg/L	-	9.30E+03	9.30E+03	-	9.30E+03	9.30E+03	-	2.29E+03	2.29E+03
7440-38-2	Arsenic, Inorganic	µg/L	9.66E+03	4.65E+04	9.66E+03	4.83E+04	4.65E+04	4.65E+04	2.38E+03	1.15E+04	2.38E+03
7440-39-3	Barium	µg/L	-	2.17E+06	2.17E+06	-	2.17E+06	2.17E+06	-	5.34E+05	5.34E+05
7440-41-7	Beryllium and compounds	µg/L	-	2.17E+03	2.17E+03	-	2.17E+03	2.17E+03	-	5.34E+02	5.34E+02
7440-42-8	Boron And Borates Only	µg/L	-	3.09E+07	3.09E+07	-	3.09E+07	3.09E+07	-	7.65E+06	7.65E+06
7440-43-9	Cadmium (Water)	µg/L	-	3.87E+03	3.87E+03	-	3.87E+03	3.87E+03	-	9.54E+02	9.54E+02
16065-83-1	Chromium(III), Insoluble Salts	µg/L	-	3.03E+06	3.03E+06	-	3.03E+06	3.03E+06	-	7.44E+05	7.44E+05
18540-29-9	Chromium(VI)	µg/L	3.62E+02	5.82E+03	3.62E+02	1.81E+03	5.82E+03	1.81E+03	8.92E+01	1.43E+03	8.92E+01
7440-47-3	Chromium (Total)[b]	-	-	-	-	-	-	-	-	-	-
7440-48-4	Cobalt	µg/L	-	1.16E+05	1.16E+05	-	1.16E+05	1.16E+05	-	2.87E+04	2.87E+04
7440-50-8	Copper	µg/L	-	6.21E+06	6.21E+06	-	6.21E+06	6.21E+06	-	1.53E+06	1.53E+06
16984-48-8	Fluoride	µg/L	-	6.21E+06	6.21E+06	-	6.21E+06	6.21E+06	-	1.53E+06	1.53E+06
7439-89-6	Iron	µg/L	-	1.09E+08	1.09E+08	-	1.09E+08	1.09E+08	-	2.68E+07	2.68E+07
7439-92-1	Lead[c]	µg/L	-	-	3.00E+01	-	-	3.00E+01	-	-	3.00E+01
7439-96-5	Manganese	µg/L	-	1.49E+05	1.49E+05	-	1.49E+05	1.49E+05	-	3.66E+04	3.66E+04
7439-97-6	Mercury, Inorganic Salts	µg/L	-	3.27E+03	3.27E+03	-	3.27E+03	3.27E+03	-	8.01E+02	8.01E+02
7439-98-7	Molybdenum	µg/L	-	7.77E+05	7.77E+05	-	7.77E+05	7.77E+05	-	1.91E+05	1.91E+05
7440-02-0	Nickel Soluble Salts	µg/L	-	6.21E+05	6.21E+05	-	6.21E+05	6.21E+05	-	1.53E+05	1.53E+05
7782-49-2	Selenium	µg/L	-	7.77E+05	7.77E+05	-	7.77E+05	7.77E+05	-	1.91E+05	1.91E+05
7440-22-4	Silver	µg/L	-	5.16E+04	5.16E+04	-	5.16E+04	5.16E+04	-	1.28E+04	1.28E+04
7791-12-0	Thallium (Soluble Salts)	µg/L	-	1.55E+03	1.55E+03	-	1.55E+03	1.55E+03	-	3.81E+02	3.81E+02
N/A	Uranium (Insoluble Compounds) [d]	µg/L	-	4.65E+05	4.65E+05	-	4.65E+05	4.65E+05	-	1.15E+05	1.15E+05
N/A	Uranium (Soluble Salts) [d]	µg/L	-	3.09E+04	3.09E+04	-	3.09E+04	3.09E+04	-	7.65E+03	7.65E+03
7440-62-2	Vanadium and Compounds	µg/L	-	2.03E+04	2.03E+04	-	2.03E+04	2.03E+04	-	5.01E+03	5.01E+03
7440-66-6	Zinc and Compounds	µg/L	-	7.77E+07	7.77E+07	-	7.77E+07	7.77E+07	-	1.91E+07	1.91E+07
83-32-9	Acenaphthene	µg/L	-	1.11E+05	1.11E+05	-	1.11E+05	1.11E+05	-	1.75E+04	1.75E+04
208-96-8	Acenaphthylene[e]	µg/L	-	1.11E+05	1.11E+05	-	1.11E+05	1.11E+05	-	1.75E+04	1.75E+04
107-13-1	Acrylonitrile	µg/L	2.20E+04	5.10E+06	2.20E+04	1.10E+05	5.10E+06	1.10E+05	4.92E+03	1.14E+06	4.92E+03
120-12-7	Anthracene	µg/L	-	3.30E+05	3.30E+05	-	3.30E+05	3.30E+05	-	4.59E+04	4.59E+04
71-43-2	Benzene	µg/L	1.72E+04	4.05E+04	1.72E+04	8.60E+04	4.05E+04	4.05E+04	3.67E+03	8.67E+03	3.67E+03
117-81-7	Bis(2-ethylhexyl)phthalate[f]	µg/L	-	-	-	-	-	-	-	-	-
75-27-4	Bromodichloromethane	µg/L	4.83E+04	6.42E+05	4.83E+04	2.42E+05	6.42E+05	2.42E+05	8.61E+03	1.14E+05	8.61E+03
86-74-8	Carbazole	µg/L	1.26E+04	-	1.26E+04	6.29E+04	-	6.29E+04	2.00E+03	-	2.00E+03
56-23-5	Carbon Tetrachloride	µg/L	1.12E+04	3.36E+04	1.12E+04	5.60E+04	3.36E+04	3.36E+04	2.00E+03	6.00E+03	2.00E+03
67-66-3	Chloroform	µg/L	6.23E+04	2.07E+05	6.23E+04	3.12E+05	2.07E+05	2.07E+05	1.24E+04	4.11E+04	1.24E+04
75-71-8	Dichlorodifluoromethane (Freon-12)[f]	µg/L	-	3.18E+06	3.18E+06	-	3.18E+06	3.18E+06	-	6.27E+05	6.27E+05

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Outdoor Worker[a]			Excavation Worker[a]			Industrial Worker[a]		
			Cancer	Hazard	Action	Cancer	Hazard	Action	Cancer	Hazard	Action
75-34-3	Dichloroethane, 1,1-[f]	µg/L	3.51E+05	4.29E+06	3.51E+05	1.76E+06	4.29E+06	1.76E+06	7.29E+04	8.91E+05	7.29E+04
107-06-2	Dichloroethane, 1,2-	µg/L	3.51E+04	2.06E+05	3.51E+04	1.76E+05	2.06E+05	1.76E+05	7.30E+03	4.26E+04	7.30E+03
75-35-4	Dichloroethylene, 1,1-	µg/L	-	6.30E+05	6.30E+05	-	6.30E+05	6.30E+05	-	1.31E+05	1.31E+05
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	1.20E+05	1.20E+05	-	1.20E+05	1.20E+05	-	2.49E+04	2.49E+04
156-59-2	Dichloroethylene, 1,2-cis-	µg/L	-	2.67E+04	2.67E+04	-	2.67E+04	2.67E+04	-	5.55E+03	5.55E+03
156-60-5	Dichloroethylene, 1,2-trans-	µg/L	-	2.67E+05	2.67E+05	-	2.67E+05	2.67E+05	-	5.55E+04	5.55E+04
60-57-1	Dieldrin	µg/L	9.40E+00	8.07E+01	9.40E+00	4.70E+01	8.07E+01	4.70E+01	1.32E+00	1.13E+01	1.32E+00
1746-01-6	Dioxins/Furans, Total (as TCDD)[g]	µg/L	-	-	-	-	-	-	-	-	-
37871-00-4	~HpCDD	µg/L	-	-	-	-	-	-	-	-	-
38998-75-3	~HpCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
34465-46-8	~HxCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
55684-94-1	~HxCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
3268-87-9	~OCDD	µg/L	-	-	-	-	-	-	-	-	-
39001-02-0	~OCDF	µg/L	-	-	-	-	-	-	-	-	-
36088-22-9	~PeCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
57117-41-6	~PeCDF, 1,2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
57117-31-4	~PeCDF, 2,3,4,7,8-	µg/L	-	-	-	-	-	-	-	-	-
1746-01-6	~TCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
51207-31-9	~TCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
100-41-4	Ethylbenzene	µg/L	2.78E+04	3.27E+05	2.78E+04	1.39E+05	3.27E+05	1.39E+05	5.41E+03	6.39E+04	5.41E+03
206-44-0	Fluoranthene	µg/L	-	-	-	-	-	-	-	-	-
86-73-7	Fluorene	µg/L	-	5.76E+04	5.76E+04	-	5.76E+04	5.76E+04	-	8.34E+03	8.34E+03
118-74-1	Hexachlorobenzene	µg/L	-	-	-	-	-	-	-	-	-
91-20-3	Naphthalene	µg/L	-	6.69E+04	6.69E+04	-	6.69E+04	6.69E+04	-	1.23E+04	1.23E+04
88-74-4	Nitroaniline, 2-	µg/L	-	3.06E+05	3.06E+05	-	3.06E+05	3.06E+05	-	5.82E+04	5.82E+04
621-64-7	Nitroso-di-N-propylamine, N-	µg/L	7.85E+02	-	7.85E+02	3.92E+03	-	3.92E+03	1.53E+02	-	1.53E+02
87-86-5	Pentachlorophenol	µg/L	1.80E+02	3.84E+03	1.80E+02	8.98E+02	3.84E+03	8.98E+02	2.52E+01	5.40E+02	2.52E+01
85-01-8	Phenanthrene[e]	µg/L	-	1.11E+05	1.11E+05	-	1.11E+05	1.11E+05	-	1.75E+04	1.75E+04
1336-36-3	Polychlorinated Biphenyls, Total	µg/L	-	-	-	-	-	-	-	-	-
12674-11-2	~Aroclor 1016	µg/L	-	-	-	-	-	-	-	-	-
11104-28-2	~Aroclor 1221	µg/L	4.16E+01	-	4.16E+01	2.08E+02	-	2.08E+02	5.66E+00	-	5.66E+00
11141-16-5	~Aroclor 1232	µg/L	4.16E+01	-	4.16E+01	2.08E+02	-	2.08E+02	5.66E+00	-	5.66E+00
53469-21-9	~Aroclor 1242	µg/L	-	-	-	-	-	-	-	-	-
12672-29-6	~Aroclor 1248	µg/L	-	-	-	-	-	-	-	-	-
11097-69-1	~Aroclor 1254	µg/L	-	-	-	-	-	-	-	-	-
11096-82-5	~Aroclor 1260	µg/L	-	-	-	-	-	-	-	-	-

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Outdoor Worker[a]			Excavation Worker[a]			Industrial Worker[a]		
			Cancer	Hazard	Action	Cancer	Hazard	Action	Cancer	Hazard	Action
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	-	-	-	-	-	-	-	-	-
56-55-3	~Benz[a]anthracene	µg/L	-	-	-	-	-	-	-	-	-
50-32-8	~Benzo[a]pyrene	µg/L	-	-	-	-	-	-	-	-	-
205-99-2	~Benzo[b]fluoranthene	µg/L	-	-	-	-	-	-	-	-	-
207-08-9	~Benzo[k]fluoranthene	µg/L	-	-	-	-	-	-	-	-	-
218-01-9	~Chrysene	µg/L	-	-	-	-	-	-	-	-	-
53-70-3	~Dibenz[a,h]anthracene	µg/L	-	-	-	-	-	-	-	-	-
193-39-5	~Indeno[1,2,3-cd]pyrene	µg/L	-	-	-	-	-	-	-	-	-
129-00-0	Pyrene	µg/L	-	2.07E+04	2.07E+04	-	2.07E+04	2.07E+04	-	2.78E+03	2.78E+03
127-18-4	Tetrachloroethylene	µg/L	1.85E+05	2.50E+04	2.50E+04	9.24E+05	2.50E+04	2.50E+04	3.07E+04	4.14E+03	4.14E+03
108-88-3	Toluene[f]	µg/L	-	4.02E+05	4.02E+05	-	4.02E+05	4.02E+05	-	8.25E+04	8.25E+04
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	2.15E+08	2.15E+08	-	2.15E+08	2.15E+08	-	3.51E+07	3.51E+07
71-55-6	Trichloroethane, 1,1,1-	µg/L	-	2.24E+07	2.24E+07	-	2.24E+07	2.24E+07	-	4.26E+06	4.26E+06
79-00-5	Trichloroethane, 1,1,2-	µg/L	4.47E+04	1.09E+05	4.47E+04	2.24E+05	1.09E+05	1.09E+05	8.62E+03	2.11E+04	8.62E+03
79-01-6	Trichloroethylene	µg/L	2.45E+04	6.06E+03	6.06E+03	1.22E+05	6.06E+03	6.06E+03	4.70E+03	1.16E+03	1.16E+03
75-01-4	Vinyl Chloride	µg/L	2.32E+03	5.37E+04	2.32E+03	1.16E+04	5.37E+04	1.16E+04	5.09E+02	1.18E+04	5.09E+02
108-38-3	Xylene, m-	µg/L	-	6.15E+05	6.15E+05	-	6.15E+05	6.15E+05	-	1.19E+05	1.19E+05
95-47-6	Xylene, o-	µg/L	-	6.84E+05	6.84E+05	-	6.84E+05	6.84E+05	-	1.33E+05	1.33E+05
106-42-3	Xylene, p-	µg/L	-	6.57E+05	6.57E+05	-	6.57E+05	6.57E+05	-	1.28E+05	1.28E+05
1330-20-7	Xylene, Mixture	µg/L	-	6.48E+05	6.48E+05	-	6.48E+05	6.48E+05	-	1.26E+05	1.26E+05
14596-10-2	Am-241	pCi/L	-	-	-	-	-	-	-	-	-
10045-97-3	Cs-137+D	pCi/L	-	-	-	-	-	-	-	-	-
13994-20-2	Np-237+D	pCi/L	-	-	-	-	-	-	-	-	-
13981-16-3	Pu-238	pCi/L	-	-	-	-	-	-	-	-	-
15117-48-3	Pu-239	pCi/L	-	-	-	-	-	-	-	-	-
14119-33-6	Pu-240	pCi/L	-	-	-	-	-	-	-	-	-
14133-76-7	Tc-99	pCi/L	-	-	-	-	-	-	-	-	-
14269-63-7	Th-230	pCi/L	-	-	-	-	-	-	-	-	-
13966-29-5	U-234	pCi/L	-	-	-	-	-	-	-	-	-
15117-96-1	U-235+D	pCi/L	-	-	-	-	-	-	-	-	-
7440-61-1	U-238+D	pCi/L	-	-	-	-	-	-	-	-	-

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

		Recreational User Swimming	Adult Recreational User Swimming		Child Recreational User Swimming		Teen Recreational User Swimming	
Analyte	**Units**	**Cancer[i]**	**Hazard**	**Action**	**Hazard**	**Action**	**Hazard**	**Action**
Aluminum	µg/L	-	1.07E+07	1.07E+07	2.49E+06	2.49E+06	6.54E+06	6.54E+06
Antimony (metallic)	µg/L	-	1.66E+03	1.66E+03	6.09E+02	6.09E+02	1.20E+03	1.20E+03
Arsenic, Inorganic	µg/L	3.31E+02	3.21E+03	3.31E+02	7.47E+02	3.31E+02	1.96E+03	3.31E+02
Barium	µg/L	-	4.53E+05	4.53E+05	1.99E+05	1.99E+05	3.48E+05	3.48E+05
Beryllium and compounds	µg/L	-	5.25E+02	5.25E+02	2.93E+02	2.93E+02	4.29E+02	4.29E+02
Boron And Borates Only	µg/L	-	2.15E+06	2.15E+06	4.98E+05	4.98E+05	1.31E+06	1.31E+06
Cadmium (Water)	µg/L	-	8.46E+02	8.46E+02	3.96E+02	3.96E+02	6.60E+02	6.60E+02
Chromium(III), Insoluble Salts	µg/L	-	7.02E+05	7.02E+05	3.90E+05	3.90E+05	5.85E+05	5.85E+05
Chromium(VI)	µg/L	2.04E+01	1.39E+03	2.04E+01	7.53E+02	2.04E+01	1.13E+03	2.04E+01
Chromium (Total)[b]	-	-	-	-	-	-	-	-
Cobalt	µg/L	-	3.87E+03	3.87E+03	8.01E+02	8.01E+02	2.24E+03	2.24E+03
Copper	µg/L	-	4.29E+05	4.29E+05	9.96E+04	9.96E+04	2.61E+05	2.61E+05
Fluoride	µg/L	-	4.29E+05	4.29E+05	9.96E+04	9.96E+04	2.61E+05	2.61E+05
Iron	µg/L	-	7.53E+06	7.53E+06	1.74E+06	1.74E+06	4.56E+06	4.56E+06
Lead[c]	µg/L	-	-	3.00E+01	-	3.00E+01	-	3.00E+01
Manganese	µg/L	-	3.33E+04	3.33E+04	1.61E+04	1.61E+04	2.62E+04	2.62E+04
Mercury, Inorganic Salts	µg/L	-	6.78E+02	6.78E+02	2.99E+02	2.99E+02	5.22E+02	5.22E+02
Molybdenum	µg/L	-	5.37E+04	5.37E+04	1.25E+04	1.25E+04	3.27E+04	3.27E+04
Nickel Soluble Salts	µg/L	-	1.01E+05	1.01E+05	3.42E+04	3.42E+04	7.14E+04	7.14E+04
Selenium	µg/L	-	5.37E+04	5.37E+04	1.25E+04	1.25E+04	3.27E+04	3.27E+04
Silver	µg/L	-	1.09E+04	1.09E+04	4.83E+03	4.83E+03	8.34E+03	8.34E+03
Thallium (Soluble Salts)	µg/L	-	1.07E+02	1.07E+02	2.49E+01	2.49E+01	6.54E+01	6.54E+01
Uranium (Insoluble Compounds) [d]	µg/L	-	3.21E+04	3.21E+04	7.47E+03	7.47E+03	1.96E+04	1.96E+04
Uranium (Soluble Salts) [d]	µg/L	-	2.15E+03	2.15E+03	4.98E+02	4.98E+02	1.31E+03	1.31E+03
Vanadium and Compounds	µg/L	-	4.68E+03	4.68E+03	2.40E+03	2.40E+03	3.75E+03	3.75E+03
Zinc and Compounds	µg/L	-	3.63E+06	3.63E+06	7.83E+05	7.83E+05	2.14E+06	2.14E+06
Acenaphthene	µg/L	-	1.71E+04	1.71E+04	9.54E+03	9.54E+03	1.40E+04	1.40E+04
Acenaphthylene[e]	µg/L	-	1.71E+04	1.71E+04	9.54E+03	9.54E+03	1.40E+04	1.40E+04
Acrylonitrile	µg/L	8.67E+02	3.93E+05	8.67E+02	9.60E+04	8.67E+02	2.44E+05	8.67E+02
Anthracene	µg/L	-	4.53E+04	4.53E+04	2.57E+04	2.57E+04	3.72E+04	3.72E+04
Benzene	µg/L	2.28E+03	7.56E+03	2.28E+03	3.45E+03	2.28E+03	5.85E+03	2.28E+03
Bis(2-ethylhexyl)phthalate[f]	µg/L	4.32E+04	2.99E+05	4.32E+04	5.61E+04	4.32E+04	1.65E+05	4.32E+04
Bromodichloromethane	µg/L	3.98E+03	8.25E+04	3.98E+03	3.03E+04	3.98E+03	6.00E+04	3.98E+03
Carbazole	µg/L	1.48E+03	-	1.48E+03	-	1.48E+03	-	1.48E+03
Carbon Tetrachloride	µg/L	1.33E+03	5.43E+03	1.33E+03	2.65E+03	1.33E+03	4.29E+03	1.33E+03
Chloroform	µg/L	6.47E+03	3.21E+04	6.47E+03	1.29E+04	6.47E+03	2.40E+04	6.47E+03
Dichlorodifluoromethane (Freon-12)[f]	µg/L	-	5.16E+05	5.16E+05	2.20E+05	2.20E+05	3.93E+05	3.93E+05

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Swimming	Adult Recreational User Swimming		Child Recreational User Swimming		Teen Recreational User Swimming	
		Cancer[i]	Hazard	Action	Hazard	Action	Hazard	Action
Dichloroethane, 1,1-[f]	µg/L	3.71E+04	6.84E+05	3.71E+04	2.68E+05	3.71E+04	5.07E+05	3.71E+04
Dichloroethane, 1,2-	µg/L	3.07E+03	2.89E+04	3.07E+03	1.00E+04	3.07E+03	2.05E+04	3.07E+03
Dichloroethylene, 1,1-	µg/L	-	1.11E+05	1.11E+05	4.89E+04	4.89E+04	8.52E+04	8.52E+04
Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	2.10E+04	2.10E+04	9.18E+03	9.18E+03	1.61E+04	1.61E+04
Dichloroethylene, 1,2-cis-	µg/L	-	4.65E+03	4.65E+03	2.04E+03	2.04E+03	3.57E+03	3.57E+03
Dichloroethylene, 1,2-trans-	µg/L	-	4.65E+04	4.65E+04	2.04E+04	2.04E+04	3.57E+04	3.57E+04
Dieldrin	µg/L	1.00E+00	1.11E+01	1.00E+00	6.24E+00	1.00E+00	9.09E+00	1.00E+00
Dioxins/Furans, Total (as TCDD)[g]	µg/L	4.65E-03	1.05E-02	4.65E-03	1.97E-03	1.97E-03	5.76E-03	4.65E-03
~HpCDD	µg/L	4.65E-01	1.05E+00	4.65E-01	1.97E-01	1.97E-01	5.76E-01	4.65E-01
~HpCDF, 2,3,7,8-	µg/L	4.65E-01	1.05E+00	4.65E-01	1.97E-01	1.97E-01	5.76E-01	4.65E-01
~HxCDD, 2,3,7,8-	µg/L	4.65E-02	1.05E-01	4.65E-02	1.97E-02	1.97E-02	5.76E-02	4.65E-02
~HxCDF, 2,3,7,8-	µg/L	4.65E-02	1.05E-01	4.65E-02	1.97E-02	1.97E-02	5.76E-02	4.65E-02
~OCDD	µg/L	1.55E+01	3.48E+01	1.55E+01	6.54E+00	6.54E+00	1.92E+01	1.55E+01
~OCDF	µg/L	1.55E+01	3.48E+01	1.55E+01	6.54E+00	6.54E+00	1.92E+01	1.55E+01
~PeCDD, 2,3,7,8-	µg/L	4.65E-03	1.05E-02	4.65E-03	1.97E-03	1.97E-03	5.76E-03	4.65E-03
~PeCDF, 1,2,3,7,8-	µg/L	1.55E-01	3.48E-01	1.55E-01	6.54E-02	6.54E-02	1.92E-01	1.55E-01
~PeCDF, 2,3,4,7,8-	µg/L	1.55E-02	3.48E-02	1.55E-02	6.54E-03	6.54E-03	1.92E-02	1.55E-02
~TCDD, 2,3,7,8-	µg/L	4.65E-03	1.05E-02	4.65E-03	1.97E-03	1.97E-03	5.76E-03	4.65E-03
~TCDF, 2,3,7,8-	µg/L	4.65E-02	1.05E-01	4.65E-02	1.97E-02	1.97E-02	5.76E-02	4.65E-02
Ethylbenzene	µg/L	3.93E+03	6.09E+04	3.93E+03	3.27E+04	3.93E+03	4.92E+04	3.93E+03
Fluoranthene	µg/L	-	6.00E+05	6.00E+05	1.12E+05	1.12E+05	3.30E+05	3.30E+05
Fluorene	µg/L	-	8.19E+03	8.19E+03	4.62E+03	4.62E+03	6.72E+03	6.72E+03
Hexachlorobenzene	µg/L	3.78E+02	1.20E+04	3.78E+02	2.25E+03	3.78E+02	6.60E+03	3.78E+02
Naphthalene	µg/L	-	1.18E+04	1.18E+04	6.30E+03	6.30E+03	9.51E+03	9.51E+03
Nitroaniline, 2-	µg/L	-	4.20E+04	4.20E+04	1.53E+04	1.53E+04	3.03E+04	3.03E+04
Nitroso-di-N-propylamine, N-	µg/L	5.02E+01	-	5.02E+01	-	5.02E+01	-	5.02E+01
Pentachlorophenol	µg/L	1.95E+01	5.34E+02	1.95E+01	3.06E+02	1.95E+01	4.38E+02	1.95E+01
Phenanthrene[e]	µg/L	-	1.71E+04	1.71E+04	9.54E+03	9.54E+03	1.40E+04	1.40E+04
Polychlorinated Biphenyls, Total	µg/L	1.51E+03	-	1.51E+03	-	1.51E+03	-	1.51E+03
~Aroclor 1016	µg/L	8.63E+03	1.05E+03	1.05E+03	1.97E+02	1.97E+02	5.76E+02	5.76E+02
~Aroclor 1221	µg/L	4.36E+00	-	4.36E+00	-	4.36E+00	-	4.36E+00
~Aroclor 1232	µg/L	4.36E+00	-	4.36E+00	-	4.36E+00	-	4.36E+00
~Aroclor 1242	µg/L	3.02E+02	-	3.02E+02	-	3.02E+02	-	3.02E+02
~Aroclor 1248	µg/L	3.02E+02	-	3.02E+02	-	3.02E+02	-	3.02E+02
~Aroclor 1254	µg/L	3.02E+02	2.99E+02	2.99E+02	5.61E+01	5.61E+01	1.65E+02	1.65E+02
~Aroclor 1260	µg/L	3.02E+02	-	3.02E+02	-	3.02E+02	-	3.02E+02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Swimming	Adult Recreational User Swimming		Child Recreational User Swimming		Teen Recreational User Swimming	
		Cancer[i]	Hazard	Action	Hazard	Action	Hazard	Action
Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	1.49E+02	4.50E+03	1.49E+02	8.43E+02	1.49E+02	2.47E+03	1.49E+02
~Benz[a]anthracene	µg/L	1.49E+03	-	1.49E+03	-	1.49E+03	-	1.49E+03
~Benzo[a]pyrene	µg/L	1.49E+02	4.50E+03	1.49E+02	8.43E+02	1.49E+02	2.47E+03	1.49E+02
~Benzo[b]fluoranthene	µg/L	1.49E+03	-	1.49E+03	-	1.49E+03	-	1.49E+03
~Benzo[k]fluoranthene	µg/L	1.49E+04	-	1.49E+04	-	1.49E+04	-	1.49E+04
~Chrysene	µg/L	1.49E+05	-	1.49E+05	-	1.49E+05	-	1.49E+05
~Dibenz[a,h]anthracene	µg/L	1.49E+02	-	1.49E+02	-	1.49E+02	-	1.49E+02
~Indeno[1,2,3-cd]pyrene	µg/L	1.49E+03	-	1.49E+03	-	1.49E+03	-	1.49E+03
Pyrene	µg/L	-	2.76E+03	2.76E+03	1.58E+03	1.58E+03	2.27E+03	2.27E+03
Tetrachloroethylene	µg/L	2.22E+04	3.96E+03	3.96E+03	2.09E+03	2.09E+03	3.18E+03	3.18E+03
Toluene[f]	µg/L	-	7.68E+04	7.68E+04	3.93E+04	3.93E+04	6.15E+04	6.15E+04
Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	3.27E+07	3.27E+07	1.64E+07	1.64E+07	2.59E+07	2.59E+07
Trichloroethane, 1,1,1-	µg/L	-	3.72E+06	3.72E+06	1.71E+06	1.71E+06	2.89E+06	2.89E+06
Trichloroethane, 1,1,2-	µg/L	4.12E+03	1.55E+04	4.12E+03	5.85E+03	4.12E+03	1.13E+04	4.12E+03
Trichloroethylene	µg/L	1.94E+03	1.01E+03	1.01E+03	4.56E+02	4.56E+02	7.77E+02	7.77E+02
Vinyl Chloride	µg/L	6.97E+00	9.30E+03	6.97E+00	3.75E+03	6.97E+00	6.96E+03	6.97E+00
Xylene, m-	µg/L	-	1.14E+05	1.14E+05	6.12E+04	6.12E+04	9.24E+04	9.24E+04
Xylene, o-	µg/L	-	1.27E+05	1.27E+05	6.75E+04	6.75E+04	1.03E+05	1.03E+05
Xylene, p-	µg/L	-	1.22E+05	1.22E+05	6.51E+04	6.51E+04	9.87E+04	9.87E+04
Xylene, Mixture	µg/L	-	1.21E+05	1.21E+05	6.42E+04	6.42E+04	9.75E+04	9.75E+04
Am-241	pCi/L	6.35E+03	-	6.35E+03	-	6.35E+03	-	6.35E+03
Cs-137+D	pCi/L	2.16E+04	-	2.16E+04	-	2.16E+04	-	2.16E+04
Np-237+D	pCi/L	9.60E+03	-	9.60E+03	-	9.60E+03	-	9.60E+03
Pu-238	pCi/L	5.01E+03	-	5.01E+03	-	5.01E+03	-	5.01E+03
Pu-239	pCi/L	4.87E+03	-	4.87E+03	-	4.87E+03	-	4.87E+03
Pu-240	pCi/L	4.87E+03	-	4.87E+03	-	4.87E+03	-	4.87E+03
Tc-99	pCi/L	2.39E+05	-	2.39E+05	-	2.39E+05	-	2.39E+05
Th-230	pCi/L	7.19E+03	-	7.19E+03	-	7.19E+03	-	7.19E+03
U-234	pCi/L	9.30E+03	-	9.30E+03	-	9.30E+03	-	9.30E+03
U-235+D	pCi/L	9.16E+03	-	9.16E+03	-	9.16E+03	-	9.16E+03
U-238+D	pCi/L	7.56E+03	-	7.56E+03	-	7.56E+03	-	7.56E+03

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Wading[a]	Adult Recreational User Wading[a]		Child Recreational User Wading[a]		Teen Recreational User Wading[a]	
		Cancer[i]	Hazard	Action	Hazard	Action	Hazard	Action
Aluminum	µg/L	-	6.12E+07	6.12E+07	1.37E+07	1.37E+07	1.76E+07	1.76E+07
Antimony (metallic)	µg/L	-	3.66E+03	3.66E+03	8.19E+02	8.19E+02	1.06E+03	1.06E+03
Arsenic, Inorganic	µg/L	1.41E+03	1.83E+04	1.41E+03	4.11E+03	1.41E+03	5.28E+03	1.41E+03
Barium	µg/L	-	8.55E+05	8.55E+05	1.91E+05	1.91E+05	2.47E+05	2.47E+05
Beryllium and compounds	µg/L	-	8.55E+02	8.55E+02	1.91E+02	1.91E+02	2.47E+02	2.47E+02
Boron And Borates Only	µg/L	-	1.22E+07	1.22E+07	2.74E+06	2.74E+06	3.54E+06	3.54E+06
Cadmium (Water)	µg/L	-	1.53E+03	1.53E+03	3.42E+02	3.42E+02	4.41E+02	4.41E+02
Chromium(III), Insoluble Salts	µg/L	-	1.19E+06	1.19E+06	2.67E+05	2.67E+05	3.45E+05	3.45E+05
Chromium(VI)	µg/L	1.39E+01	2.29E+03	1.39E+01	5.13E+02	1.39E+01	6.63E+02	1.39E+01
Chromium (Total)[b]	µg/L	-	-	-	-	-	-	-
Cobalt	µg/L	-	4.59E+04	4.59E+04	1.03E+04	1.03E+04	1.32E+04	1.32E+04
Copper	µg/L	-	2.45E+06	2.45E+06	5.46E+05	5.46E+05	7.05E+05	7.05E+05
Fluoride	µg/L	-	2.45E+06	2.45E+06	5.46E+05	5.46E+05	7.05E+05	7.05E+05
Iron	µg/L	-	4.29E+07	4.29E+07	9.57E+06	9.57E+06	1.24E+07	1.24E+07
Lead[c]	µg/L	-	-	3.00E+01	-	3.00E+01	-	3.00E+01
Manganese	µg/L	-	5.88E+04	5.88E+04	1.31E+04	1.31E+04	1.70E+04	1.70E+04
Mercury, Inorganic Salts	µg/L	-	1.28E+03	1.28E+03	2.87E+02	2.87E+02	3.72E+02	3.72E+02
Molybdenum	µg/L	-	3.06E+05	3.06E+05	6.84E+04	6.84E+04	8.82E+04	8.82E+04
Nickel Soluble Salts	µg/L	-	2.45E+05	2.45E+05	5.46E+04	5.46E+04	7.05E+04	7.05E+04
Selenium	µg/L	-	3.06E+05	3.06E+05	6.84E+04	6.84E+04	8.82E+04	8.82E+04
Silver	µg/L	-	2.04E+04	2.04E+04	4.56E+03	4.56E+03	5.88E+03	5.88E+03
Thallium (Soluble Salts)	µg/L	-	6.12E+02	6.12E+02	1.37E+02	1.37E+02	1.76E+02	1.76E+02
Uranium (Insoluble Compounds) [d]	µg/L	-	1.83E+05	1.83E+05	4.11E+04	4.11E+04	5.28E+04	5.28E+04
Uranium (Soluble Salts) [d]	µg/L	-	1.22E+04	1.22E+04	2.74E+03	2.74E+03	3.54E+03	3.54E+03
Vanadium and Compounds	µg/L	-	8.01E+03	8.01E+03	1.79E+03	1.79E+03	2.31E+03	2.31E+03
Zinc and Compounds	µg/L	-	3.06E+07	3.06E+07	6.84E+06	6.84E+06	8.82E+06	8.82E+06
Acenaphthene	µg/L	-	2.80E+04	2.80E+04	6.27E+03	6.27E+03	8.10E+03	8.10E+03
Acenaphthylene[e]	µg/L	-	2.80E+04	2.80E+04	6.27E+03	6.27E+03	8.10E+03	8.10E+03
Acrylonitrile	µg/L	2.91E+03	1.82E+06	2.91E+03	4.08E+05	2.91E+03	5.25E+05	2.91E+03
Anthracene	µg/L	-	7.35E+04	7.35E+04	1.65E+04	1.65E+04	2.13E+04	2.13E+04
Benzene	µg/L	2.18E+03	1.39E+04	2.18E+03	3.09E+03	2.18E+03	3.99E+03	2.18E+03
Bis(2-ethylhexyl)phthalate[f]	µg/L	-	-	-	-	-	-	-
Bromodichloromethane	µg/L	5.10E+03	1.83E+05	5.10E+03	4.08E+04	5.10E+03	5.28E+04	5.10E+03
Carbazole	µg/L	1.18E+03	-	1.18E+03	-	1.18E+03	-	1.18E+03
Carbon Tetrachloride	µg/L	1.19E+03	9.60E+03	1.19E+03	2.15E+03	1.19E+03	2.78E+03	1.19E+03
Chloroform	µg/L	7.34E+03	6.57E+04	7.34E+03	1.47E+04	7.34E+03	1.90E+04	7.34E+03
Dichlorodifluoromethane (Freon-12)[f]	µg/L	-	1.00E+06	1.00E+06	2.24E+05	2.24E+05	2.90E+05	2.90E+05

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Wading[a]	Adult Recreational User Wading[a]		Child Recreational User Wading[a]		Teen Recreational User Wading[a]	
		Cancer[i]	Hazard	Action	Hazard	Action	Hazard	Action
Dichloroethane, 1,1-[f]	µg/L	4.32E+04	1.43E+06	4.32E+04	3.18E+05	4.32E+04	4.11E+05	4.32E+04
Dichloroethane, 1,2-	µg/L	4.32E+03	6.84E+04	4.32E+03	1.53E+04	4.32E+03	1.97E+04	4.32E+03
Dichloroethylene, 1,1-	µg/L	-	2.09E+05	2.09E+05	4.68E+04	4.68E+04	6.03E+04	6.03E+04
Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	3.99E+04	3.99E+04	8.91E+03	8.91E+03	1.15E+04	1.15E+04
Dichloroethylene, 1,2-cis-	µg/L	-	8.85E+03	8.85E+03	1.98E+03	1.98E+03	2.56E+03	2.56E+03
Dichloroethylene, 1,2-trans-	µg/L	-	8.85E+04	8.85E+04	1.98E+04	1.98E+04	2.56E+04	2.56E+04
Dieldrin	µg/L	7.82E-01	1.81E+01	7.82E-01	4.05E+00	7.82E-01	5.22E+00	7.82E-01
Dioxins/Furans, Total (as TCDD)[g]	µg/L	-	-	-	-	-	-	-
~HpCDD	µg/L	-	-	-	-	-	-	-
~HpCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~HxCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~HxCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~OCDD	µg/L	-	-	-	-	-	-	-
~OCDF	µg/L	-	-	-	-	-	-	-
~PeCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~PeCDF, 1,2,3,7,8-	µg/L	-	-	-	-	-	-	-
~PeCDF, 2,3,4,7,8-	µg/L	-	-	-	-	-	-	-
~TCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~TCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
Ethylbenzene	µg/L	3.21E+03	1.02E+05	3.21E+03	2.28E+04	3.21E+03	2.95E+04	3.21E+03
Fluoranthene	µg/L	-	-	-	-	-	-	-
Fluorene	µg/L	-	1.34E+04	1.34E+04	2.99E+03	2.99E+03	3.84E+03	3.84E+03
Hexachlorobenzene	µg/L	-	-	-	-	-	-	-
Naphthalene	µg/L	-	1.96E+04	1.96E+04	4.38E+03	4.38E+03	5.67E+03	5.67E+03
Nitroaniline, 2-	µg/L	-	9.33E+04	9.33E+04	2.09E+04	2.09E+04	2.69E+04	2.69E+04
Nitroso-di-N-propylamine, N-	µg/L	9.07E+01	-	9.07E+01	-	9.07E+01	-	9.07E+01
Pentachlorophenol	µg/L	1.49E+01	8.64E+02	1.49E+01	1.93E+02	1.49E+01	2.49E+02	1.49E+01
Phenanthrene[e]	µg/L	-	2.80E+04	2.80E+04	6.27E+03	6.27E+03	8.10E+03	8.10E+03
Polychlorinated Biphenyls, Total	µg/L	-	-	-	-	-	-	-
~Aroclor 1016	µg/L	-	-	-	-	-	-	-
~Aroclor 1221	µg/L	3.35E+00	-	3.35E+00	-	3.35E+00	-	3.35E+00
~Aroclor 1232	µg/L	3.35E+00	-	3.35E+00	-	3.35E+00	-	3.35E+00
~Aroclor 1242	µg/L	-	-	-	-	-	-	-
~Aroclor 1248	µg/L	-	-	-	-	-	-	-
~Aroclor 1254	µg/L	-	-	-	-	-	-	-
~Aroclor 1260	µg/L	-	-	-	-	-	-	-

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.3. Surface Water Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Wading[a]	Adult Recreational User Wading[a]		Child Recreational User Wading[a]		Teen Recreational User Wading[a]	
		Cancer[i]	Hazard	Action	Hazard	Action	Hazard	Action
Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	-	-	-	-	-	-	-
~Benz[a]anthracene	µg/L	-	-	-	-	-	-	-
~Benzo[a]pyrene	µg/L	-	-	-	-	-	-	-
~Benzo[b]fluoranthene	µg/L	-	-	-	-	-	-	-
~Benzo[k]fluoranthene	µg/L	-	-	-	-	-	-	-
~Chrysene	µg/L	-	-	-	-	-	-	-
~Dibenz[a,h]anthracene	µg/L	-	-	-	-	-	-	-
~Indeno[1,2,3-cd]pyrene	µg/L	-	-	-	-	-	-	-
Pyrene	µg/L	-	4.47E+03	4.47E+03	9.96E+02	9.96E+02	1.29E+03	1.29E+03
Tetrachloroethylene	µg/L	1.82E+04	6.63E+03	6.63E+03	1.49E+03	1.49E+03	1.91E+03	1.91E+03
Toluene[f]	µg/L	-	1.32E+05	1.32E+05	2.95E+04	2.95E+04	3.81E+04	3.81E+04
Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	5.64E+07	5.64E+07	1.26E+07	1.26E+07	1.63E+07	1.63E+07
Trichloroethane, 1,1,1-	µg/L	-	6.81E+06	6.81E+06	1.52E+06	1.52E+06	1.97E+06	1.97E+06
Trichloroethane, 1,1,2-	µg/L	5.11E+03	3.36E+04	5.11E+03	7.53E+03	5.11E+03	9.72E+03	5.11E+03
Trichloroethylene	µg/L	1.78E+03	1.86E+03	1.78E+03	4.17E+02	4.17E+02	5.37E+02	5.37E+02
Vinyl Chloride	µg/L	2.31E+01	1.88E+04	2.31E+01	4.23E+03	2.31E+01	5.43E+03	2.31E+01
Xylene, m-	µg/L	-	1.90E+05	1.90E+05	4.26E+04	4.26E+04	5.49E+04	5.49E+04
Xylene, o-	µg/L	-	2.13E+05	2.13E+05	4.77E+04	4.77E+04	6.15E+04	6.15E+04
Xylene, p-	µg/L	-	2.04E+05	2.04E+05	4.56E+04	4.56E+04	5.88E+04	5.88E+04
Xylene, Mixture	µg/L	-	2.01E+05	2.01E+05	4.50E+04	4.50E+04	5.82E+04	5.82E+04
Am-241	pCi/L	-	-	-	-	-	-	-
Cs-137+D	pCi/L	-	-	-	-	-	-	-
Np-237+D	pCi/L	-	-	-	-	-	-	-
Pu-238	pCi/L	-	-	-	-	-	-	-
Pu-239	pCi/L	-	-	-	-	-	-	-
Pu-240	pCi/L	-	-	-	-	-	-	-
Tc-99	pCi/L	-	-	-	-	-	-	-
Th-230	pCi/L	-	-	-	-	-	-	-
U-234	pCi/L	-	-	-	-	-	-	-
U-235+D	pCi/L	-	-	-	-	-	-	-
U-238+D	pCi/L	-	-	-	-	-	-	-

NOTES: The action level for HI is 3 because the range of values for HI (based on RGO tables) are 0.1, 1, and 3. Please see Figure 1.1 of the Risk Methods Document. Values are provided in these tables for significant COPCs for PGDP. Values for other COPCs can be obtained using the RAIS online calculator, as modified using PGDP-specific inputs. Action levels are not adjusted for saturation limits.

[a] Recreational User Wading and all Worker scenarios consider dermal contact only.
[b] Chromium (Total) AL should utilize Chromium III or Chromium VI, as appropriate.
[c] Lead values should be checked prior to use to ensure they are still current.
[d] Based on recommendation from EPA 2016, ALs for uranium (soluble salts) now uses the RfD for uranium derived from ATSDR. The RfD for uranium available in IRIS has been added as uranium (insoluble compounds).
[e] Acenaphthylene and Phenanthrene use values for Acenaphthene.
[f] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.
[g] Total dioxins/furans uses values for 2,3,7,8-TCDD, see screening note 9f in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.
[h] Total carcinogenic PAHs uses values for BaP, see screening note 9d in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.
[i] For the recreational user, ELCRs (i.e. cancer ALs) were calculated using the child/teen/adult age-adjusted lifetime scenario.

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP

(Values calculated in October 2018 and are based on best available information.)

			Outdoor Worker			Excavation Worker			Industrial Worker		
CAS	Analyte	Units	Cancer	Hazard	No Action	Cancer	Hazard	No Action	Cancer	Hazard	No Action
7429-90-5	Aluminum	mg/kg	-	3.26E+04	3.26E+04	-	3.26E+04	3.26E+04	-	1.00E+05	1.00E+05
7440-36-0	Antimony (metallic)	mg/kg	-	1.32E+01	1.32E+01	-	1.32E+01	1.32E+01	-	9.34E+01	9.34E+01
7440-38-2	Arsenic, Inorganic	mg/kg	7.48E-01	1.20E+01	7.48E-01	3.74E+00	1.20E+01	3.74E+00	1.60E+00	2.57E+01	1.60E+00
7440-39-3	Barium	mg/kg	-	6.47E+03	6.47E+03	-	6.47E+03	6.47E+03	-	4.04E+04	4.04E+04
7440-41-7	Beryllium and compounds	mg/kg	9.39E+03	6.55E+01	6.55E+01	4.69E+04	6.55E+01	6.55E+01	6.95E+03	4.50E+02	4.50E+02
7440-42-8	Boron And Borates Only	mg/kg	-	6.57E+03	6.57E+03	-	6.57E+03	6.57E+03	-	4.65E+04	4.65E+04
7440-43-9	Cadmium (Diet)	mg/kg	1.25E+04	2.53E+01	2.53E+01	6.26E+04	2.53E+01	2.53E+01	9.26E+03	6.05E+01	6.05E+01
16065-83-1	Chromium(III), Insoluble Salts	mg/kg	-	4.93E+04	4.93E+04	-	4.93E+04	4.93E+04	-	1.00E+05	1.00E+05
18540-29-9	Chromium(VI)	mg/kg	1.83E+00	9.85E+01	1.83E+00	9.14E+00	9.85E+01	9.14E+00	1.23E+01	6.93E+02	1.23E+01
7440-47-3	Chromium (Total)[a]	mg/kg	-	-	-	-	-	-	-	-	-
7440-48-4	Cobalt	mg/kg	2.50E+03	9.84E+00	9.84E+00	1.25E+04	9.84E+00	9.84E+00	1.85E+03	6.87E+01	6.87E+01
7440-50-8	Copper	mg/kg	-	1.32E+03	1.32E+03	-	1.32E+03	1.32E+03	-	9.34E+03	9.34E+03
16984-48-8	Fluoride	mg/kg	-	1.32E+03	1.32E+03	-	1.32E+03	1.32E+03	-	9.33E+03	9.33E+03
7439-89-6	Iron	mg/kg	-	2.30E+04	2.30E+04	-	2.30E+04	2.30E+04	-	1.00E+05	1.00E+05
7439-92-1	Lead[b]	mg/kg	-	-	8.00E+02	-	-	8.00E+02	-	-	8.00E+02
7439-96-5	Manganese	mg/kg	-	7.74E+02	7.74E+02	-	7.74E+02	7.74E+02	-	4.72E+03	4.72E+03
7439-97-6	Mercury, Inorganic Salts	mg/kg	-	9.86E+00	9.86E+00	-	9.86E+00	9.86E+00	-	7.01E+01	7.01E+01
7439-98-7	Molybdenum	mg/kg	-	1.64E+02	1.64E+02	-	1.64E+02	1.64E+02	-	1.16E+03	1.16E+03
7440-02-0	Nickel Soluble Salts	mg/kg	8.66E+04	6.52E+02	6.52E+02	1.00E+05	6.52E+02	6.52E+02	6.41E+04	4.30E+03	4.30E+03
7782-49-2	Selenium	mg/kg	-	1.64E+02	1.64E+02	-	1.64E+02	1.64E+02	-	1.17E+03	1.17E+03
7440-22-4	Silver	mg/kg	-	1.64E+02	1.64E+02	-	1.64E+02	1.64E+02	-	1.17E+03	1.17E+03
7791-12-0	Thallium (Soluble Salts)	mg/kg	-	3.29E-01	3.29E-01	-	3.29E-01	3.29E-01	-	2.34E+00	2.34E+00
N/A	Uranium (Insoluble Compounds)[c]	mg/kg	-	9.83E+01	9.83E+01	-	9.83E+01	9.83E+01	-	6.81E+02	6.81E+02
N/A	Uranium (Soluble Salts)[c]	mg/kg	-	6.58E+00	6.58E+00	-	6.58E+00	6.58E+00	-	4.66E+01	4.66E+01
7440-62-2	Vanadium and Compounds	mg/kg	-	1.65E+02	1.65E+02	-	1.65E+02	1.65E+02	-	1.15E+03	1.15E+03
7440-66-6	Zinc and Compounds	mg/kg	-	9.86E+03	9.86E+03	-	9.86E+03	9.86E+03	-	7.01E+04	7.01E+04
83-32-9	Acenaphthene	mg/kg	-	1.01E+03	1.01E+03	-	1.01E+03	1.01E+03	-	1.38E+03	1.38E+03
208-96-8	Acenaphthylene[d]	mg/kg	-	1.01E+03	1.01E+03	-	1.01E+03	1.01E+03	-	1.38E+03	1.38E+03
107-13-1	Acrylonitrile	mg/kg	8.93E-01	9.04E+00	8.93E-01	4.46E+00	9.04E+00	4.46E+00	1.24E+00	6.73E+00	1.24E+00
120-12-7	Anthracene	mg/kg	-	5.05E+03	5.05E+03	-	5.05E+03	5.05E+03	-	6.89E+03	6.89E+03
71-43-2	Benzene	mg/kg	5.19E+00	4.25E+01	5.19E+00	2.59E+01	4.25E+01	2.59E+01	5.31E+00	4.43E+01	5.31E+00
117-81-7	Bis(2-ethylhexyl)phthalate[e]	mg/kg	3.79E+01	3.79E+02	3.79E+01	1.90E+02	3.79E+02	1.90E+02	5.80E+01	5.80E+02	5.80E+01
75-27-4	Bromodichloromethane	mg/kg	1.59E+00	6.58E+02	1.59E+00	7.93E+00	6.58E+02	7.93E+00	1.30E+00	4.67E+03	1.30E+00
86-74-8	Carbazole	mg/kg	2.65E+01	-	2.65E+01	1.33E+02	-	1.33E+02	4.06E+01	-	4.06E+01
56-23-5	Carbon Tetrachloride	mg/kg	3.14E+00	5.29E+01	3.14E+00	1.57E+01	5.29E+01	1.57E+01	2.96E+00	6.12E+01	2.96E+00
67-66-3	Chloroform	mg/kg	1.78E+00	1.04E+02	1.78E+00	8.90E+00	1.04E+02	8.90E+00	1.39E+00	1.07E+02	1.39E+00
75-71-8	Dichlorodifluoromethane (Freon-12)[e]	mg/kg	-	4.94E+01	4.94E+01	-	4.94E+01	4.94E+01	-	3.68E+01	3.68E+01

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

			Outdoor Worker			Excavation Worker			Industrial Worker		
CAS	**Analyte**	**Units**	**Cancer**	**Hazard**	**No Action**	**Cancer**	**Hazard**	**No Action**	**Cancer**	**Hazard**	**No Action**
75-34-3	Dichloroethane, 1,1-[e]	mg/kg	1.90E+01	5.64E+02	1.90E+01	9.52E+01	5.64E+02	9.52E+01	1.58E+01	4.52E+02	1.58E+01
107-06-2	Dichloroethane, 1,2-	mg/kg	2.26E+00	1.73E+01	2.26E+00	1.13E+01	1.73E+01	1.13E+01	2.09E+00	1.39E+01	2.09E+00
75-35-4	Dichloroethylene, 1,1-	mg/kg	-	1.26E+02	1.26E+02	-	1.26E+02	1.26E+02	-	1.00E+02	1.00E+02
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	-	2.96E+02	2.96E+02	-	2.96E+02	2.96E+02	-	2.10E+03	2.10E+03
156-59-2	Dichloroethylene, 1,2-cis-	mg/kg	-	6.58E+01	6.58E+01	-	6.58E+01	6.58E+01	-	4.67E+02	4.67E+02
156-60-5	Dichloroethylene, 1,2-trans-	mg/kg	-	5.67E+01	5.67E+01	-	5.67E+01	5.67E+01	-	4.54E+01	4.54E+01
60-57-1	Dieldrin	mg/kg	3.32E-02	9.48E-01	3.32E-02	1.66E-01	9.48E-01	1.66E-01	5.08E-02	1.45E+00	5.08E-02
1746-01-6	Dioxins/Furans, Total (as TCDD)[f]	mg/kg	5.76E-06	1.89E-05	5.76E-06	2.88E-05	1.89E-05	1.89E-05	1.57E-05	5.24E-05	1.57E-05
37871-00-4	~HpCDD, 2,3,7,8-	mg/kg	5.77E-04	1.89E-03	5.77E-04	2.89E-03	1.89E-03	1.89E-03	1.58E-03	5.24E-03	1.58E-03
38998-75-3	~HpCDF, 2,3,7,8-	mg/kg	5.79E-04	1.89E-03	5.79E-04	2.90E-03	1.89E-03	1.89E-03	1.60E-03	5.24E-03	1.60E-03
34465-46-8	~HxCDD	mg/kg	5.80E-05	1.89E-04	5.80E-05	2.90E-04	1.89E-04	1.89E-04	1.61E-04	5.25E-04	1.61E-04
55684-94-1	~HxCDF, 2,3,7,8-	mg/kg	5.80E-05	1.89E-04	5.80E-05	2.90E-04	1.89E-04	1.89E-04	1.61E-04	5.25E-04	1.61E-04
3268-87-9	~OCDD	mg/kg	1.93E-02	6.29E-02	1.93E-02	9.67E-02	6.29E-02	6.29E-02	5.38E-02	1.75E-01	5.38E-02
39001-02-0	~OCDF	mg/kg	1.93E-02	6.29E-02	1.93E-02	9.67E-02	6.29E-02	6.29E-02	5.38E-02	1.75E-01	5.38E-02
36088-22-9	~PeCDD, 2,3,7,8-	mg/kg	5.80E-06	1.89E-05	5.80E-06	2.90E-05	1.89E-05	1.89E-05	1.61E-05	5.25E-05	1.61E-05
57117-41-6	~PeCDF, 1,2,3,7,8-	mg/kg	1.93E-04	6.29E-04	1.93E-04	9.67E-04	6.29E-04	6.29E-04	5.38E-04	1.75E-03	5.38E-04
57117-31-4	~PeCDF, 2,3,4,7,8-	mg/kg	1.93E-05	6.29E-05	1.93E-05	9.67E-05	6.29E-05	6.29E-05	5.38E-05	1.75E-04	5.38E-05
1746-01-6	~TCDD, 2,3,7,8-	mg/kg	5.76E-06	1.89E-05	5.76E-06	2.88E-05	1.89E-05	1.89E-05	1.57E-05	5.24E-05	1.57E-05
51207-31-9	~TCDF, 2,3,7,8-	mg/kg	5.77E-05	1.89E-04	5.77E-05	2.89E-04	1.89E-04	1.89E-04	1.58E-04	5.24E-04	1.58E-04
100-41-4	Ethylbenzene	mg/kg	2.59E+01	1.66E+03	2.59E+01	1.30E+02	1.66E+03	1.30E+02	2.66E+01	2.24E+03	2.66E+01
206-44-0	Fluoranthene	mg/kg	-	6.73E+02	6.73E+02	-	6.73E+02	6.73E+02	-	9.19E+02	9.19E+02
86-73-7	Fluorene	mg/kg	-	6.73E+02	6.73E+02	-	6.73E+02	6.73E+02	-	9.19E+02	9.19E+02
118-74-1	Hexachlorobenzene	mg/kg	4.66E-01	2.63E+01	4.66E-01	2.33E+00	2.63E+01	2.33E+00	1.26E+00	1.87E+02	1.26E+00
91-20-3	Naphthalene	mg/kg	2.26E+01	6.61E+01	2.26E+01	1.13E+02	6.61E+01	6.61E+01	1.67E+01	5.38E+01	1.67E+01
88-74-4	Nitroaniline, 2-	mg/kg	-	1.89E+02	1.89E+02	-	1.89E+02	1.89E+02	-	2.87E+02	2.87E+02
621-64-7	Nitroso-di-N-propylamine, N-	mg/kg	7.58E-02	-	7.58E-02	3.79E-01	-	3.79E-01	1.16E-01	-	1.16E-01
87-86-5	Pentachlorophenol	mg/kg	8.11E-01	5.80E+01	8.11E-01	4.06E+00	5.80E+01	4.06E+00	8.77E-01	6.27E+01	8.77E-01
85-01-8	Phenanthrene[d]	mg/kg	-	1.01E+03	1.01E+03	-	1.01E+03	1.01E+03	-	1.38E+03	1.38E+03
1336-36-3	Polychlorinated Biphenyls, Total	mg/kg	2.24E-01	-	2.24E-01	1.12E+00	-	1.12E+00	2.93E-01	-	2.93E-01
12674-11-2	~Aroclor 1016	mg/kg	6.41E+00	1.13E+00	1.13E+00	3.21E+01	1.13E+00	1.13E+00	8.43E+00	1.50E+00	1.50E+00
11104-28-2	~Aroclor 1221	mg/kg	2.19E-01	-	2.19E-01	1.09E+00	-	1.09E+00	2.81E-01	-	2.81E-01
11141-16-5	~Aroclor 1232	mg/kg	2.12E-01	-	2.12E-01	1.06E+00	-	1.06E+00	2.67E-01	-	2.67E-01
53469-21-9	~Aroclor 1242	mg/kg	2.24E-01	-	2.24E-01	1.12E+00	-	1.12E+00	2.94E-01	-	2.94E-01
12672-29-6	~Aroclor 1248	mg/kg	2.24E-01	-	2.24E-01	1.12E+00	-	1.12E+00	2.94E-01	-	2.94E-01
11097-69-1	~Aroclor 1254	mg/kg	2.25E-01	3.24E-01	2.25E-01	1.12E+00	3.24E-01	3.24E-01	2.96E-01	4.30E-01	2.96E-01
11096-82-5	~Aroclor 1260	mg/kg	2.26E-01	-	2.26E-01	1.13E+00	-	1.13E+00	2.98E-01	-	2.98E-01

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Outdoor Worker			Excavation Worker			Industrial Worker		
			Cancer	Hazard	No Action	Cancer	Hazard	No Action	Cancer	Hazard	No Action
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[g]	mg/kg	4.71E-01	5.03E+00	4.71E-01	2.35E+00	5.03E+00	2.35E+00	6.43E-01	6.85E+00	6.43E-01
56-55-3	~Benz[a]anthracene	mg/kg	4.69E+00	-	4.69E+00	2.35E+01	-	2.35E+01	6.39E+00	-	6.39E+00
50-32-8	~Benzo[a]pyrene	mg/kg	4.71E-01	5.03E+00	4.71E-01	2.35E+00	5.03E+00	2.35E+00	6.43E-01	6.85E+00	6.43E-01
205-99-2	~Benzo[b]fluoranthene	mg/kg	4.71E+00	-	4.71E+00	2.35E+01	-	2.35E+01	6.43E+00	-	6.43E+00
207-08-9	~Benzo[k]fluoranthene	mg/kg	4.71E+01	-	4.71E+01	2.35E+02	-	2.35E+02	6.43E+01	-	6.43E+01
218-01-9	~Chrysene	mg/kg	4.71E+02	-	4.71E+02	2.35E+03	-	2.35E+03	6.43E+02	-	6.43E+02
53-70-3	~Dibenz[a,h]anthracene	mg/kg	4.71E-01	-	4.71E-01	2.35E+00	-	2.35E+00	6.43E-01	-	6.43E-01
193-39-5	~Indeno[1,2,3-cd]pyrene	mg/kg	4.71E+00	-	4.71E+00	2.35E+01	-	2.35E+01	6.43E+00	-	6.43E+00
129-00-0	Pyrene	mg/kg	-	5.05E+02	5.05E+02	-	5.05E+02	5.05E+02	-	6.89E+02	6.89E+02
127-18-4	Tetrachloroethylene	mg/kg	1.12E+02	4.34E+01	4.34E+01	5.58E+02	4.34E+01	4.34E+01	1.07E+02	4.00E+01	4.00E+01
108-88-3	Toluene[e]	mg/kg	-	2.18E+03	2.18E+03	-	2.18E+03	2.18E+03	-	6.25E+03	6.25E+03
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[e]	mg/kg	-	3.79E+03	3.79E+03	-	3.79E+03	3.79E+03	-	2.81E+03	2.81E+03
71-55-6	Trichloroethane, 1,1,1-	mg/kg	-	4.54E+03	4.54E+03	-	4.54E+03	4.54E+03	-	3.58E+03	3.58E+03
79-00-5	Trichloroethane, 1,1,2-	mg/kg	5.11E+00	8.49E-01	8.49E-01	2.56E+01	8.49E-01	8.49E-01	5.28E+00	6.32E-01	6.32E-01
79-01-6	Trichloroethylene	mg/kg	6.17E+00	2.26E+00	2.26E+00	3.09E+01	2.26E+00	2.26E+00	6.31E+00	1.90E+00	1.90E+00
75-01-4	Vinyl Chloride	mg/kg	9.44E-01	3.60E+01	9.44E-01	4.72E+00	3.60E+01	4.72E+00	2.06E+00	3.95E+01	2.06E+00
108-38-3	Xylene, m-	mg/kg	-	3.09E+02	3.09E+02	-	3.09E+02	3.09E+02	-	2.38E+02	2.38E+02
95-47-6	Xylene, o-	mg/kg	-	3.61E+02	3.61E+02	-	3.61E+02	3.61E+02	-	2.81E+02	2.81E+02
106-42-3	Xylene, p-	mg/kg	-	3.15E+02	3.15E+02	-	3.15E+02	3.15E+02	-	2.43E+02	2.43E+02
1330-20-7	Xylene, Mixture	mg/kg	-	3.23E+02	3.23E+02	-	3.23E+02	3.23E+02	-	2.50E+02	2.50E+02
14596-10-2	Am-241	pCi/g	3.33E+00	-	3.33E+00	1.64E+01	-	1.64E+01	6.01E+00	-	6.01E+00
10045-97-3	Cs-137+D	pCi/g	1.45E-01	-	1.45E-01	5.82E-01	-	5.82E-01	1.08E-01	-	1.08E-01
13994-20-2	Np-237+D	pCi/g	3.26E-01	-	3.26E-01	1.63E+00	-	1.63E+00	2.49E-01	-	2.49E-01
13981-16-3	Pu-238	pCi/g	4.20E+00	-	4.20E+00	1.94E+01	-	1.94E+01	2.65E+01	-	2.65E+01
15117-48-3	Pu-239	pCi/g	3.66E+00	-	3.66E+00	1.83E+01	-	1.83E+01	2.27E+01	-	2.27E+01
14119-33-6	Pu-240	pCi/g	3.67E+00	-	3.67E+00	1.83E+01	-	1.83E+01	2.31E+01	-	2.31E+01
14133-76-7	Tc-99	pCi/g	3.11E+02	-	3.11E+02	1.55E+03	-	1.55E+03	1.27E+03	-	1.27E+03
14269-63-7	Th-230	pCi/g	5.64E+00	-	5.64E+00	2.82E+01	-	2.82E+01	3.13E+01	-	3.13E+01
13966-29-5	U-234	pCi/g	8.60E+00	-	8.60E+00	4.30E+01	-	4.30E+01	5.01E+01	-	5.01E+01
15117-96-1	U-235+D	pCi/g	5.23E-01	-	5.23E-01	2.62E+00	-	2.62E+00	4.08E-01	-	4.08E-01
7440-61-1	U-238+D	pCi/g	1.80E+00	-	1.80E+00	8.98E+00	-	8.98E+00	1.66E+00	-	1.66E+00

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Recreational User	Adult Recreational User		Child Recreational User		Teen Recreational User	
			Cancer[h]	Hazard	No Action	Hazard	No Action	Hazard	No Action
7429-90-5	Aluminum	mg/kg	-	1.00E+05	1.00E+05	1.95E+04	1.95E+04	1.00E+05	1.00E+05
7440-36-0	Antimony (metallic)	mg/kg	-	1.12E+02	1.12E+02	7.82E+00	7.82E+00	4.59E+01	4.59E+01
7440-38-2	Arsenic, Inorganic	mg/kg	8.09E-01	3.18E+01	8.09E-01	6.13E+00	8.09E-01	1.21E+01	8.09E-01
7440-39-3	Barium	mg/kg	-	5.35E+04	5.35E+04	3.89E+03	3.89E+03	2.23E+04	2.23E+04
7440-41-7	Beryllium and compounds	mg/kg	2.12E+04	5.55E+02	5.55E+02	3.91E+01	3.91E+01	2.28E+02	2.28E+02
7440-42-8	Boron And Borates Only	mg/kg	-	5.61E+04	5.61E+04	3.91E+03	3.91E+03	2.29E+04	2.29E+04
7440-43-9	Cadmium (Diet)	mg/kg	2.82E+04	7.51E+01	7.51E+01	1.32E+01	1.32E+01	2.86E+01	2.86E+01
16065-83-1	Chromium(III), Insoluble Salts	mg/kg	-	1.00E+05	1.00E+05	2.93E+04	2.93E+04	1.00E+05	1.00E+05
18540-29-9	Chromium(VI)	mg/kg	7.47E-01	8.39E+02	7.47E-01	5.86E+01	7.47E-01	3.43E+02	7.47E-01
7440-47-3	Chromium (Total)[a]	mg/kg	-	-	-	-	-	-	-
7440-48-4	Cobalt	mg/kg	5.65E+03	8.37E+01	8.37E+01	5.86E+00	5.86E+00	3.43E+01	3.43E+01
7440-50-8	Copper	mg/kg	-	1.12E+04	1.12E+04	7.82E+02	7.82E+02	4.59E+03	4.59E+03
16984-48-8	Fluoride	mg/kg	-	1.12E+04	1.12E+04	7.82E+02	7.82E+02	4.59E+03	4.59E+03
7439-89-6	Iron	mg/kg	-	1.00E+05	1.00E+05	1.37E+04	1.37E+04	8.03E+04	8.03E+04
7439-92-1	Lead[b]	mg/kg	-	-	4.00E+02	-	4.00E+02	-	4.00E+02
7439-96-5	Manganese	mg/kg	-	6.36E+03	6.36E+03	4.67E+02	4.67E+02	2.67E+03	2.67E+03
7439-97-6	Mercury, Inorganic Salts	mg/kg	-	8.42E+01	8.42E+01	5.87E+00	5.87E+00	3.44E+01	3.44E+01
7439-98-7	Molybdenum	mg/kg	-	1.40E+03	1.40E+03	9.78E+01	9.78E+01	5.73E+02	5.73E+02
7440-02-0	Nickel Soluble Salts	mg/kg	1.00E+05	5.47E+03	5.47E+03	3.90E+02	3.90E+02	2.26E+03	2.26E+03
7782-49-2	Selenium	mg/kg	-	1.40E+03	1.40E+03	9.78E+01	9.78E+01	5.74E+02	5.74E+02
7440-22-4	Silver	mg/kg	-	1.40E+03	1.40E+03	9.78E+01	9.78E+01	5.74E+02	5.74E+02
7791-12-0	Thallium (Soluble Salts)	mg/kg	-	2.81E+00	2.81E+00	1.96E-01	1.96E-01	1.15E+00	1.15E+00
N/A	Uranium (Insoluble Compounds)[c]	mg/kg	-	8.35E+02	8.35E+02	5.86E+01	5.86E+01	3.42E+02	3.42E+02
N/A	Uranium (Soluble Salts)[c]	mg/kg	-	5.61E+01	5.61E+01	3.91E+00	3.91E+00	2.29E+01	2.29E+01
7440-62-2	Vanadium and Compounds	mg/kg	-	1.41E+03	1.41E+03	9.85E+01	9.85E+01	5.76E+02	5.76E+02
7440-66-6	Zinc and Compounds	mg/kg	-	8.42E+04	8.42E+04	5.87E+03	5.87E+03	3.44E+04	3.44E+04
83-32-9	Acenaphthene	mg/kg	-	1.71E+03	1.71E+03	4.61E+02	4.61E+02	6.40E+02	6.40E+02
208-96-8	Acenaphthylene[d]	mg/kg	-	1.71E+03	1.71E+03	4.61E+02	4.61E+02	6.40E+02	6.40E+02
107-13-1	Acrylonitrile	mg/kg	1.80E+00	2.58E+01	1.80E+00	1.88E+01	1.80E+00	1.92E+01	1.80E+00
120-12-7	Anthracene	mg/kg	-	8.54E+03	8.54E+03	2.31E+03	2.31E+03	3.20E+03	3.20E+03
71-43-2	Benzene	mg/kg	1.09E+01	1.54E+02	1.09E+01	4.92E+01	1.09E+01	1.03E+02	1.09E+01
117-81-7	Bis(2-ethylhexyl)phthalate[e]	mg/kg	3.32E+01	7.19E+02	3.32E+01	1.79E+02	3.32E+01	2.70E+02	3.32E+01
75-27-4	Bromodichloromethane	mg/kg	3.49E+00	5.62E+03	3.49E+00	3.91E+02	3.49E+00	2.29E+03	3.49E+00
86-74-8	Carbazole	mg/kg	2.32E+01	-	2.32E+01	-	2.32E+01	-	2.32E+01
56-23-5	Carbon Tetrachloride	mg/kg	6.72E+00	2.06E+02	6.72E+00	5.51E+01	6.72E+00	1.33E+02	6.72E+00
67-66-3	Chloroform	mg/kg	3.96E+00	3.75E+02	3.96E+00	1.22E+02	3.96E+00	2.51E+02	3.96E+00
75-71-8	Dichlorodifluoromethane (Freon-12)[e]	mg/kg	-	1.41E+02	1.41E+02	1.02E+02	1.02E+02	1.05E+02	1.05E+02

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

			Recreational User	Adult Recreational User		Child Recreational User		Teen Recreational User	
CAS	Analyte	Units	Cancer[g]	Hazard	No Action	Hazard	No Action	Hazard	No Action
75-34-3	Dichloroethane, 1,1-[e]	mg/kg	4.18E+01	1.70E+03	4.18E+01	9.78E+02	4.18E+01	1.23E+03	4.18E+01
107-06-2	Dichloroethane, 1,2-	mg/kg	4.86E+00	5.23E+01	4.86E+00	2.99E+01	4.86E+00	3.79E+01	4.86E+00
75-35-4	Dichloroethylene, 1,1-	mg/kg	-	3.79E+02	3.79E+02	2.23E+02	2.23E+02	2.75E+02	2.75E+02
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	-	2.53E+03	2.53E+03	1.76E+02	1.76E+02	1.03E+03	1.03E+03
156-59-2	Dichloroethylene, 1,2-cis-	mg/kg	-	5.62E+02	5.62E+02	3.91E+01	3.91E+01	2.29E+02	2.29E+02
156-60-5	Dichloroethylene, 1,2-trans-	mg/kg	-	1.71E+02	1.71E+02	9.82E+01	9.82E+01	1.24E+02	1.24E+02
60-57-1	Dieldrin	mg/kg	2.90E-02	1.80E+00	2.90E-02	4.47E-01	2.90E-02	6.75E-01	2.90E-02
1746-01-6	Dioxins/Furans, Total (as TCDD)[f]	mg/kg	7.22E-06	6.45E-05	7.22E-06	1.01E-05	7.22E-06	2.47E-05	7.22E-06
37871-00-4	~HpCDD, 2,3,7,8-	mg/kg	7.23E-04	6.45E-03	7.23E-04	1.01E-03	7.23E-04	2.47E-03	7.23E-04
38998-75-3	~HpCDF, 2,3,7,8-	mg/kg	7.24E-04	6.45E-03	7.24E-04	1.01E-03	7.24E-04	2.47E-03	7.24E-04
34465-46-8	~HxCDD	mg/kg	7.25E-05	6.46E-04	7.25E-05	1.01E-04	7.25E-05	2.47E-04	7.25E-05
55684-94-1	~HxCDF, 2,3,7,8-	mg/kg	7.25E-05	6.46E-04	7.25E-05	1.01E-04	7.25E-05	2.47E-04	7.25E-05
3268-87-9	~OCDD	mg/kg	2.42E-02	2.15E-01	2.42E-02	3.36E-02	2.42E-02	8.24E-02	2.42E-02
39001-02-0	~OCDF	mg/kg	2.42E-02	2.15E-01	2.42E-02	3.36E-02	2.42E-02	8.24E-02	2.42E-02
36088-22-9	~PeCDD, 2,3,7,8-	mg/kg	7.25E-06	6.46E-05	7.25E-06	1.01E-05	7.25E-06	2.47E-05	7.25E-06
57117-41-6	~PeCDF, 1,2,3,7,8-	mg/kg	2.42E-04	2.15E-03	2.42E-04	3.36E-04	2.42E-04	8.24E-04	2.42E-04
57117-31-4	~PeCDF, 2,3,4,7,8-	mg/kg	2.42E-05	2.15E-04	2.42E-05	3.36E-05	2.42E-05	8.24E-05	2.42E-05
1746-01-6	~TCDD, 2,3,7,8-	mg/kg	7.22E-06	6.45E-05	7.22E-06	1.01E-05	7.22E-06	2.47E-05	7.22E-06
51207-31-9	~TCDF, 2,3,7,8-	mg/kg	7.23E-05	6.45E-04	7.23E-05	1.01E-04	7.23E-05	2.47E-04	7.23E-05
100-41-4	Ethylbenzene	mg/kg	5.46E+01	7.12E+03	5.46E+01	1.53E+03	5.46E+01	4.38E+03	5.46E+01
206-44-0	Fluoranthene	mg/kg	-	1.14E+03	1.14E+03	3.08E+02	3.08E+02	4.27E+02	4.27E+02
86-73-7	Fluorene	mg/kg	-	1.14E+03	1.14E+03	3.08E+02	3.08E+02	4.27E+02	4.27E+02
118-74-1	Hexachlorobenzene	mg/kg	8.86E-01	2.25E+02	8.86E-01	1.56E+01	8.86E-01	9.18E+01	8.86E-01
91-20-3	Naphthalene	mg/kg	5.09E+01	1.66E+02	5.09E+01	8.16E+01	5.09E+01	9.58E+01	5.09E+01
88-74-4	Nitroaniline, 2-	mg/kg	-	3.58E+02	3.58E+02	8.93E+01	8.93E+01	1.35E+02	1.35E+02
621-64-7	Nitroso-di-N-propylamine, N-	mg/kg	6.63E-02	-	6.63E-02	-	6.63E-02	-	6.63E-02
87-86-5	Pentachlorophenol	mg/kg	5.56E-01	7.78E+01	5.56E-01	2.46E+01	5.56E-01	2.90E+01	5.56E-01
85-01-8	Phenanthrene[d]	mg/kg	-	1.71E+03	1.71E+03	4.61E+02	4.61E+02	6.40E+02	6.40E+02
1336-36-3	Polychlorinated Biphenyls, Total	mg/kg	1.79E-01	-	1.79E-01	-	1.79E-01	-	1.79E-01
12674-11-2	~Aroclor 1016	mg/kg	5.12E+00	1.86E+00	1.86E+00	5.14E-01	5.14E-01	6.98E-01	6.98E-01
11104-28-2	~Aroclor 1221	mg/kg	1.77E-01	-	1.77E-01	-	1.77E-01	-	1.77E-01
11141-16-5	~Aroclor 1232	mg/kg	1.76E-01	-	1.76E-01	-	1.76E-01	-	1.76E-01
53469-21-9	~Aroclor 1242	mg/kg	1.79E-01	-	1.79E-01	-	1.79E-01	-	1.79E-01
12672-29-6	~Aroclor 1248	mg/kg	1.79E-01	-	1.79E-01	-	1.79E-01	-	1.79E-01
11097-69-1	~Aroclor 1254	mg/kg	1.79E-01	5.33E-01	1.79E-01	1.47E-01	1.47E-01	2.00E-01	1.79E-01
11096-82-5	~Aroclor 1260	mg/kg	1.80E-01	-	1.80E-01	-	1.80E-01	-	1.80E-01

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

			Recreational User	Adult Recreational User		Child Recreational User		Teen Recreational User	
CAS	**Analyte**	**Units**	**Cancer[h]**	**Hazard**	**No Action**	**Hazard**	**No Action**	**Hazard**	**No Action**
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[g]	mg/kg	1.09E-01	8.53E+00	1.09E-01	2.31E+00	1.09E-01	3.20E+00	1.09E-01
56-55-3	~Benz[a]anthracene	mg/kg	1.09E+00	-	1.09E+00	-	1.09E+00	-	1.09E+00
50-32-8	~Benzo[a]pyrene	mg/kg	1.09E-01	8.53E+00	1.09E-01	2.31E+00	1.09E-01	3.20E+00	1.09E-01
205-99-2	~Benzo[b]fluoranthene	mg/kg	1.09E+00	-	1.09E+00	-	1.09E+00	-	1.09E+00
207-08-9	~Benzo[k]fluoranthene	mg/kg	1.09E+01	-	1.09E+01	-	1.09E+01	-	1.09E+01
218-01-9	~Chrysene	mg/kg	1.09E+02	-	1.09E+02	-	1.09E+02	-	1.09E+02
53-70-3	~Dibenz[a,h]anthracene	mg/kg	1.09E-01	-	1.09E-01	-	1.09E-01	-	1.09E-01
193-39-5	~Indeno[1,2,3-cd]pyrene	mg/kg	1.09E+00	-	1.09E+00	-	1.09E+00	-	1.09E+00
129-00-0	Pyrene	mg/kg	-	8.54E+02	8.54E+02	2.31E+02	2.31E+02	3.20E+02	3.20E+02
127-18-4	Tetrachloroethylene	mg/kg	2.38E+02	1.45E+02	1.45E+02	5.87E+01	5.87E+01	1.00E+02	1.00E+02
108-88-3	Toluene[e]	mg/kg	-	1.38E+04	1.38E+04	1.48E+03	1.48E+03	6.84E+03	6.84E+03
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[e]	mg/kg	-	1.08E+04	1.08E+04	7.94E+03	7.94E+03	8.03E+03	8.03E+03
71-55-6	Trichloroethane, 1,1,1-	mg/kg	-	1.36E+04	1.36E+04	8.16E+03	8.16E+03	9.87E+03	9.87E+03
79-00-5	Trichloroethane, 1,1,2-	mg/kg	1.07E+01	2.43E+00	2.43E+00	1.77E+00	1.77E+00	1.80E+00	1.80E+00
79-01-6	Trichloroethylene	mg/kg	8.32E+00	7.07E+00	7.07E+00	3.53E+00	3.53E+00	5.04E+00	5.04E+00
75-01-4	Vinyl Chloride	mg/kg	6.78E-02	1.35E+02	6.78E-02	3.94E+01	6.78E-02	8.88E+01	6.78E-02
108-38-3	Xylene, m-	mg/kg	-	9.07E+02	9.07E+02	5.83E+02	5.83E+02	6.65E+02	6.65E+02
95-47-6	Xylene, o-	mg/kg	-	1.07E+03	1.07E+03	6.70E+02	6.70E+02	7.80E+02	7.80E+02
106-42-3	Xylene, p-	mg/kg	-	9.25E+02	9.25E+02	5.93E+02	5.93E+02	6.78E+02	6.78E+02
1330-20-7	Xylene, Mixture	mg/kg	-	9.50E+02	9.50E+02	6.07E+02	6.07E+02	6.96E+02	6.96E+02
14596-10-2	Am-241	pCi/g	8.41E+00	-	8.41E+00	-	8.41E+00	-	8.41E+00
10045-97-3	Cs-137+D	pCi/g	3.31E-01	-	3.31E-01	-	3.31E-01	-	3.31E-01
13994-20-2	Np-237+D	pCi/g	7.31E-01	-	7.31E-01	-	7.31E-01	-	7.31E-01
13981-16-3	Pu-238	pCi/g	1.19E+01	-	1.19E+01	-	1.19E+01	-	1.19E+01
15117-48-3	Pu-239	pCi/g	1.06E+01	-	1.06E+01	-	1.06E+01	-	1.06E+01
14119-33-6	Pu-240	pCi/g	1.06E+01	-	1.06E+01	-	1.06E+01	-	1.06E+01
14133-76-7	Tc-99	pCi/g	3.22E+02	-	3.22E+02	-	3.22E+02	-	3.22E+02
14269-63-7	Th-230	pCi/g	1.42E+01	-	1.42E+01	-	1.42E+01	-	1.42E+01
13966-29-5	U-234	pCi/g	1.62E+01	-	1.62E+01	-	1.62E+01	-	1.62E+01
15117-96-1	U-235+D	pCi/g	1.16E+00	-	1.16E+00	-	1.16E+00	-	1.16E+00
7440-61-1	U-238+D	pCi/g	3.67E+00	-	3.67E+00	-	3.67E+00	-	3.67E+00

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Resident Cancer[h]	Adult Resident Hazard	Adult Resident No Action	Child Resident Hazard	Child Resident No Action
7429-90-5	Aluminum	mg/kg	-	7.46E+04	7.46E+04	7.74E+03	7.74E+03
7440-36-0	Antimony (metallic)	mg/kg	-	3.33E+01	3.33E+01	3.13E+00	3.13E+00
7440-38-2	Arsenic, Inorganic	mg/kg	3.56E-01	1.03E+01	3.56E-01	2.45E+00	3.56E-01
7440-39-3	Barium	mg/kg	-	1.35E+04	1.35E+04	1.53E+03	1.53E+03
7440-41-7	Beryllium and compounds	mg/kg	1.59E+03	1.58E+02	1.58E+02	1.56E+01	1.56E+01
7440-42-8	Boron And Borates Only	mg/kg	-	1.66E+04	1.66E+04	1.56E+03	1.56E+03
7440-43-9	Cadmium (Diet)	mg/kg	2.12E+03	2.40E+01	2.40E+01	5.28E+00	5.28E+00
16065-83-1	Chromium(III), Insoluble Salts	mg/kg	-	1.00E+05	1.00E+05	1.17E+04	1.17E+04
18540-29-9	Chromium(VI)	mg/kg	3.01E-01	2.46E+02	3.01E-01	2.34E+01	3.01E-01
7440-47-3	Chromium (Total)[a]	mg/kg	-	-	-	-	-
7440-48-4	Cobalt	mg/kg	4.24E+02	2.43E+01	2.43E+01	2.34E+00	2.34E+00
7440-50-8	Copper	mg/kg	-	3.34E+03	3.34E+03	3.13E+02	3.13E+02
16984-48-8	Fluoride	mg/kg	-	3.33E+03	3.33E+03	3.13E+02	3.13E+02
7439-89-6	Iron	mg/kg	-	5.84E+04	5.84E+04	5.48E+03	5.48E+03
7439-92-1	Lead[b]	mg/kg	-	-	4.00E+02	-	4.00E+02
7439-96-5	Manganese	mg/kg	-	1.56E+03	1.56E+03	1.83E+02	1.83E+02
7439-97-6	Mercury, Inorganic Salts	mg/kg	-	2.50E+01	2.50E+01	2.35E+00	2.35E+00
7439-98-7	Molybdenum	mg/kg	-	4.14E+02	4.14E+02	3.91E+01	3.91E+01
7440-02-0	Nickel Soluble Salts	mg/kg	1.47E+04	1.48E+03	1.48E+03	1.55E+02	1.55E+02
7782-49-2	Selenium	mg/kg	-	4.17E+02	4.17E+02	3.91E+01	3.91E+01
7440-22-4	Silver	mg/kg	-	4.17E+02	4.17E+02	3.91E+01	3.91E+01
7791-12-0	Thallium (Soluble Salts)	mg/kg	-	8.34E-01	8.34E-01	7.82E-02	7.82E-02
N/A	Uranium (Insoluble Compounds) [c]	mg/kg	-	2.40E+02	2.40E+02	2.34E+01	2.34E+01
N/A	Uranium (Soluble Salts) [c]	mg/kg	-	1.66E+01	1.66E+01	1.56E+00	1.56E+00
7440-62-2	Vanadium and Compounds	mg/kg	-	4.08E+02	4.08E+02	3.93E+01	3.93E+01
7440-66-6	Zinc and Compounds	mg/kg	-	2.50E+04	2.50E+04	2.35E+03	2.35E+03
83-32-9	Acenaphthene	mg/kg	-	5.66E+02	5.66E+02	1.85E+02	1.85E+02
208-96-8	Acenaphthylene[d]	mg/kg	-	5.66E+02	5.66E+02	1.85E+02	1.85E+02
107-13-1	Acrylonitrile	mg/kg	2.55E-01	1.60E+00	2.55E-01	1.59E+00	2.55E-01
120-12-7	Anthracene	mg/kg	-	2.83E+03	2.83E+03	9.23E+02	9.23E+02
71-43-2	Benzene	mg/kg	1.16E+00	1.07E+01	1.16E+00	8.17E+00	1.16E+00
117-81-7	Bis(2-ethylhexyl)phthalate[e]	mg/kg	1.49E+01	2.37E+02	1.49E+01	7.15E+01	1.49E+01
75-27-4	Bromodichloromethane	mg/kg	2.93E-01	1.67E+03	2.93E-01	1.56E+02	2.93E-01
86-74-8	Carbazole	mg/kg	1.04E+01	-	1.04E+01	-	1.04E+01
56-23-5	Carbon Tetrachloride	mg/kg	6.53E-01	1.49E+01	6.53E-01	1.04E+01	6.53E-01
67-66-3	Chloroform	mg/kg	3.16E-01	2.59E+01	3.16E-01	1.99E+01	3.16E-01
75-71-8	Dichlorodifluoromethane (Freon-12)[e]	mg/kg	-	8.76E+00	8.76E+00	8.72E+00	8.72E+00

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

			Resident	Adult Resident		Child Resident	
CAS	Analyte	Units	Cancer[h]	Hazard	No Action	Hazard	No Action
75-34-3	Dichloroethane, 1,1-[e]	mg/kg	3.55E+00	1.08E+02	3.55E+00	1.02E+02	3.55E+00
107-06-2	Dichloroethane, 1,2-	mg/kg	4.64E-01	3.32E+00	4.64E-01	3.12E+00	4.64E-01
75-35-4	Dichloroethylene, 1,1-	mg/kg	-	2.40E+01	2.40E+01	2.27E+01	2.27E+01
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	-	7.51E+02	7.51E+02	7.04E+01	7.04E+01
156-59-2	Dichloroethylene, 1,2-cis-	mg/kg	-	1.67E+02	1.67E+02	1.56E+01	1.56E+01
156-60-5	Dichloroethylene, 1,2-trans-	mg/kg	-	1.09E+01	1.09E+01	1.02E+01	1.02E+01
60-57-1	Dieldrin	mg/kg	1.30E-02	5.93E-01	1.30E-02	1.79E-01	1.30E-02
1746-01-6	Dioxins/Furans, Total (as TCDD)[f]	mg/kg	3.08E-06	2.07E-05	3.08E-06	4.04E-06	3.08E-06
37871-00-4	~HpCDD, 2,3,7,8-	mg/kg	3.09E-04	2.07E-03	3.09E-04	4.04E-04	3.09E-04
38998-75-3	~HpCDF, 2,3,7,8-	mg/kg	3.12E-04	2.08E-03	3.12E-04	4.04E-04	3.12E-04
34465-46-8	~HxCDD	mg/kg	3.14E-05	2.08E-04	3.14E-05	4.04E-05	3.14E-05
55684-94-1	~HxCDF, 2,3,7,8-	mg/kg	3.14E-05	2.08E-04	3.14E-05	4.04E-05	3.14E-05
3268-87-9	~OCDD	mg/kg	1.05E-02	6.93E-02	1.05E-02	1.35E-02	1.05E-02
39001-02-0	~OCDF	mg/kg	1.05E-02	6.93E-02	1.05E-02	1.35E-02	1.05E-02
36088-22-9	~PeCDD, 2,3,7,8-	mg/kg	3.14E-06	2.08E-05	3.14E-06	4.04E-06	3.14E-06
57117-41-6	~PeCDF, 1,2,3,7,8-	mg/kg	1.05E-04	6.93E-04	1.05E-04	1.35E-04	1.05E-04
57117-31-4	~PeCDF, 2,3,4,7,8-	mg/kg	1.05E-05	6.93E-05	1.05E-05	1.35E-05	1.05E-05
1746-01-6	~TCDD, 2,3,7,8-	mg/kg	3.08E-06	2.07E-05	3.08E-06	4.04E-06	3.08E-06
51207-31-9	~TCDF, 2,3,7,8-	mg/kg	3.09E-05	2.07E-04	3.09E-05	4.04E-05	3.09E-05
100-41-4	Ethylbenzene	mg/kg	5.78E+00	5.52E+02	5.78E+00	3.37E+02	5.78E+00
206-44-0	Fluoranthene	mg/kg	-	3.77E+02	3.77E+02	1.23E+02	1.23E+02
86-73-7	Fluorene	mg/kg	-	3.77E+02	3.77E+02	1.23E+02	1.23E+02
118-74-1	Hexachlorobenzene	mg/kg	2.12E-01	6.67E+01	2.12E-01	6.26E+00	2.12E-01
91-20-3	Naphthalene	mg/kg	3.83E+00	1.35E+01	3.83E+00	1.17E+01	3.83E+00
88-74-4	Nitroaniline, 2-	mg/kg	-	1.17E+02	1.17E+02	3.56E+01	3.56E+01
621-64-7	Nitroso-di-N-propylamine, N-	mg/kg	2.97E-02	-	2.97E-02	-	2.97E-02
87-86-5	Pentachlorophenol	mg/kg	2.54E-01	2.59E+01	2.54E-01	9.86E+00	2.54E-01
85-01-8	Phenanthrene[d]	mg/kg	-	5.66E+02	5.66E+02	1.85E+02	1.85E+02
1336-36-3	Polychlorinated Biphenyls, Total	mg/kg	7.88E-02	-	7.88E-02	-	7.88E-02
12674-11-2	~Aroclor 1016	mg/kg	2.27E+00	6.18E-01	6.18E-01	2.06E-01	2.06E-01
11104-28-2	~Aroclor 1221	mg/kg	7.52E-02	-	7.52E-02	-	7.52E-02
11141-16-5	~Aroclor 1232	mg/kg	7.08E-02	-	7.08E-02	-	7.08E-02
53469-21-9	~Aroclor 1242	mg/kg	7.91E-02	-	7.91E-02	-	7.91E-02
12672-29-6	~Aroclor 1248	mg/kg	7.92E-02	-	7.92E-02	-	7.92E-02
11097-69-1	~Aroclor 1254	mg/kg	7.97E-02	1.77E-01	7.97E-02	5.88E-02	5.88E-02
11096-82-5	~Aroclor 1260	mg/kg	8.03E-02	-	8.03E-02	-	8.03E-02

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.4. Soil/Sediment No Action Levels for Significant COPCs at PGDP (Continued)

			Resident	Adult Resident		Child Resident	
CAS	Analyte	Units	Cancer[h]	Hazard	No Action	Hazard	No Action
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[g]	mg/kg	4.78E-02	2.80E+00	4.78E-02	9.20E-01	4.78E-02
56-55-3	~Benz[a]anthracene	mg/kg	4.75E-01	-	4.75E-01	-	4.75E-01
50-32-8	~Benzo[a]pyrene	mg/kg	4.78E-02	2.80E+00	4.78E-02	9.20E-01	4.78E-02
205-99-2	~Benzo[b]fluoranthene	mg/kg	4.78E-01	-	4.78E-01	-	4.78E-01
207-08-9	~Benzo[k]fluoranthene	mg/kg	4.78E+00	-	4.78E+00	-	4.78E+00
218-01-9	~Chrysene	mg/kg	4.78E+01	-	4.78E+01	-	4.78E+01
53-70-3	~Dibenz[a,h]anthracene	mg/kg	4.78E-02	-	4.78E-02	-	4.78E-02
193-39-5	~Indeno[1,2,3-cd]pyrene	mg/kg	4.78E-01	-	4.78E-01	-	4.78E-01
129-00-0	Pyrene	mg/kg	-	2.83E+02	2.83E+02	9.23E+01	9.23E+01
127-18-4	Tetrachloroethylene	mg/kg	2.36E+01	9.61E+00	9.61E+00	8.10E+00	8.10E+00
108-88-3	Toluene[e]	mg/kg	-	1.67E+03	1.67E+03	4.89E+02	4.89E+02
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[e]	mg/kg	-	6.70E+02	6.70E+02	6.69E+02	6.69E+02
71-55-6	Trichloroethane, 1,1,1-	mg/kg	-	8.55E+02	8.55E+02	8.15E+02	8.15E+02
79-00-5	Trichloroethane, 1,1,2-	mg/kg	1.15E+00	1.50E-01	1.50E-01	1.50E-01	1.50E-01
79-01-6	Trichloroethylene	mg/kg	9.43E-01	4.56E-01	4.56E-01	4.12E-01	4.12E-01
75-01-4	Vinyl Chloride	mg/kg	5.92E-02	9.59E+00	5.92E-02	7.00E+00	5.92E-02
108-38-3	Xylene, m-	mg/kg	-	5.69E+01	5.69E+01	5.51E+01	5.51E+01
95-47-6	Xylene, o-	mg/kg	-	6.71E+01	6.71E+01	6.45E+01	6.45E+01
106-42-3	Xylene, p-	mg/kg	-	5.80E+01	5.80E+01	5.61E+01	5.61E+01
1330-20-7	Xylene, Mixture	mg/kg	-	5.96E+01	5.96E+01	5.76E+01	5.76E+01
14596-10-2	Am-241	pCi/g	1.75E+00	-	1.75E+00	-	1.75E+00
10045-97-3	Cs-137+D	pCi/g	4.02E-02	-	4.02E-02	-	4.02E-02
13994-20-2	Np-237+D	pCi/g	9.11E-02	-	9.11E-02	-	9.11E-02
13981-16-3	Pu-238	pCi/g	4.27E+00	-	4.27E+00	-	4.27E+00
15117-48-3	Pu-239	pCi/g	3.77E+00	-	3.77E+00	-	3.77E+00
14119-33-6	Pu-240	pCi/g	3.80E+00	-	3.80E+00	-	3.80E+00
14133-76-7	Tc-99	pCi/g	1.10E+02	-	1.10E+02	-	1.10E+02
14269-63-7	Th-230	pCi/g	4.93E+00	-	4.93E+00	-	4.93E+00
13966-29-5	U-234	pCi/g	5.77E+00	-	5.77E+00	-	5.77E+00
15117-96-1	U-235+D	pCi/g	1.48E-01	-	1.48E-01	-	1.48E-01
7440-61-1	U-238+D	pCi/g	5.56E-01	-	5.56E-01	-	5.56E-01

NOTES: Values are provided in these tables for significant COPCs for PGDP. Values for other COPCs can be obtained using the RAIS online calculator, as modified using PGDP-specific inputs.

[a] Chromium (Total) NAL should utilize Chromium III or Chromium VI Chromium VI, as appropriate.

[b] Lead values should be checked prior to use to ensure they are still current.

[c] Based on recommendation from EPA 2016, NALs for uranium (soluble salts) now use the RfD for uranium derived from ATSDR. The RfD for uranium available in IRIS has been added as uranium (insoluble compounds).

[d] Acenaphthylene and phenanthrene use values for Acenaphthene.

[e] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.

[f] Total dioxins/furans uses values for 2,3,7,8-TCDD, see screening note 9f in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.

[g] Total carcinogenic PAHs uses values for BaP, see screening note 9d in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.

[h] For the recreational user and the resident, ELCRs (i.e. cancer NALs) were calculated using the child/teen/adult or child/adult age-adjusted lifetime scenario, respectively.

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.5. Groundwater No Action Levels and Primary MCLs for Significant COPCs at PGDP

(Values calculated in October 2018 and are based on best available information.)

			Resident	Adult Resident		Child Resident		Primary
CAS	**Analyte**	**Units**	**Cancer[a]**	**Hazard**	**No Action**	**Hazard**	**No Action**	**MCLs[j]**
7429-90-5	Aluminum	µg/L	-	3.32E+03	3.32E+03	2.00E+03	2.00E+03	-
7440-36-0	Antimony (metallic)	µg/L	-	1.29E+00	1.29E+00	7.79E-01	7.79E-01	6.00E+00
7440-38-2	Arsenic, Inorganic	µg/L	5.17E-02	9.96E-01	5.17E-02	5.99E-01	5.17E-02	1.00E+01
7440-39-3	Barium	µg/L	-	6.18E+02	6.18E+02	3.77E+02	3.77E+02	2.00E+03
7440-41-7	Beryllium and compounds	µg/L	-	3.71E+00	3.71E+00	2.46E+00	2.46E+00	4.00E+00
7440-42-8	Boron And Borates Only	µg/L	-	6.64E+02	6.64E+02	3.99E+02	3.99E+02	-
7440-43-9	Cadmium (Water)	µg/L	-	1.50E+00	1.50E+00	9.22E-01	9.22E-01	5.00E+00
16065-83-1	Chromium(III), Insoluble Salts	µg/L	-	3.50E+03	3.50E+03	2.25E+03	2.25E+03	-
18540-29-9	Chromium(VI)	µg/L	3.50E-02	6.92E+00	3.50E-02	4.45E+00	3.50E-02	-
7440-47-3	Chromium (Total)[b]	µg/L	-	-	-	-	-	1.00E+02
7440-48-4	Cobalt	µg/L	-	9.99E-01	9.99E-01	6.01E-01	6.01E-01	-
7440-50-8	Copper	µg/L	-	1.33E+02	1.33E+02	7.99E+01	7.99E+01	1.30E+03
16984-48-8	Fluoride	µg/L	-	1.33E+02	1.33E+02	7.99E+01	7.99E+01	4.00E+03
7439-89-6	Iron	µg/L	-	2.32E+03	2.32E+03	1.40E+03	1.40E+03	-
7439-92-1	Lead[c]	µg/L	-	-	1.50E+01	-	1.50E+01	1.50E+01
7439-96-5	Manganese	µg/L	-	7.03E+01	7.03E+01	4.34E+01	4.34E+01	-
7439-97-6	Mercury, Inorganic Salts	µg/L	-	9.27E-01	9.27E-01	5.66E-01	5.66E-01	2.00E+00
7439-98-7	Molybdenum	µg/L	-	1.66E+01	1.66E+01	9.98E+00	9.98E+00	-
7440-02-0	Nickel Soluble Salts	µg/L	-	6.49E+01	6.49E+01	3.92E+01	3.92E+01	-
7782-49-2	Selenium	µg/L	-	1.66E+01	1.66E+01	9.98E+00	9.98E+00	5.00E+01
7440-22-4	Silver	µg/L	-	1.54E+01	1.54E+01	9.41E+00	9.41E+00	-
7791-12-0	Thallium (Soluble Salts)	µg/L	-	3.32E-02	3.32E-02	2.00E-02	2.00E-02	2.00E+00
N/A	Uranium (Insooluble Compounds) [d]	µg/L	-	9.96E+00	9.96E+00	5.99E+00	5.99E+00	3.00E+01
N/A	Uranium (Soluble Salts) [d]	µg/L	-	6.64E-01	6.64E-01	3.99E-01	3.99E-01	3.00E+01
7440-62-2	Vanadium and Compounds	µg/L	-	1.38E+01	1.38E+01	8.64E+00	8.64E+00	-
7440-66-6	Zinc and Compounds	µg/L	-	9.98E+02	9.98E+02	6.00E+02	6.00E+02	-
83-32-9	Acenaphthene	µg/L	-	8.41E+01	8.41E+01	5.35E+01	5.35E+01	-
208-96-8	Acenaphthylene[e]	µg/L	-	8.41E+01	8.41E+01	5.35E+01	5.35E+01	-
107-13-1	Acrylonitrile	µg/L	5.23E-02	4.16E-01	5.23E-02	4.15E-01	5.23E-02	-
120-12-7	Anthracene	µg/L	-	2.74E+02	2.74E+02	1.77E+02	1.77E+02	-
71-43-2	Benzene	µg/L	4.55E-01	4.07E+00	4.55E-01	3.32E+00	4.55E-01	5.00E+00
117-81-7	Bis(2-ethylhexyl)phthalate[f]	µg/L	5.56E+00	6.67E+01	5.56E+00	4.01E+01	5.56E+00	6.00E+00
75-27-4	Bromodichloromethane	µg/L	1.34E-01	6.25E+01	1.34E-01	3.78E+01	1.34E-01	8.00E+01[k]
86-74-8	Carbazole	µg/L	2.03E+00	-	2.03E+00	-	2.03E+00	-
56-23-5	Carbon Tetrachloride	µg/L	4.55E-01	7.02E+00	4.55E-01	4.95E+00	4.55E-01	5.00E+00
67-66-3	Chloroform	µg/L	2.21E-01	1.22E+01	2.21E-01	9.72E+00	2.21E-01	8.00E+01[k]
75-71-8	Dichlorodifluoromethane (Freon-12)[f]	µg/L	-	2.02E+01	2.02E+01	1.97E+01	1.97E+01	-

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.5. Groundwater No Action Levels and Primary MCLs for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Resident Cancer[a]	Adult Resident Hazard	Adult Resident No Action	Child Resident Hazard	Child Resident No Action	Primary MCLs[j]
75-34-3	Dichloroethane, 1,1-[f]	µg/L	2.75E+00	8.93E+01	2.75E+00	8.16E+01	2.75E+00	-
107-06-2	Dichloroethane, 1,2-	µg/L	1.71E-01	1.36E+00	1.71E-01	1.30E+00	1.71E-01	5.00E+00
75-35-4	Dichloroethylene, 1,1-	µg/L	-	3.25E+01	3.25E+01	2.85E+01	2.85E+01	7.00E+00
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	2.68E+01	2.68E+01	1.63E+01	1.63E+01	-
156-59-2	Dichloroethylene, 1,2-cis-	µg/L	-	5.95E+00	5.95E+00	3.61E+00	3.61E+00	7.00E+01
156-60-5	Dichloroethylene, 1,2-trans-	µg/L	-	1.03E+01	1.03E+01	9.29E+00	9.29E+00	1.00E+02
60-57-1	Dieldrin	µg/L	1.75E-03	5.95E-02	1.75E-03	3.81E-02	1.75E-03	-
1746-01-6	Dioxins/Furans, Total (as TCDD)[g]	µg/L	1.19E-07	1.83E-06	1.19E-07	1.20E-06	1.19E-07	3.00E-05
37871-00-4	~HpCDD, 2,3,7,8-	µg/L	1.19E-05	1.83E-04	1.19E-05	1.20E-04	1.19E-05	-
38998-75-3	~HpCDF, 2,3,7,8-	µg/L	1.19E-05	1.83E-04	1.19E-05	1.20E-04	1.19E-05	-
34465-46-8	~HxCDD	µg/L	5.99E-06	2.34E-05	5.99E-06	1.40E-05	5.99E-06	-
55684-94-1	~HxCDF, 2,3,7,8-	µg/L	5.99E-06	2.34E-05	5.99E-06	1.40E-05	5.99E-06	-
3268-87-9	~OCDD	µg/L	2.00E-03	7.79E-03	2.00E-03	4.68E-03	2.00E-03	-
39001-02-0	~OCDF	µg/L	2.00E-03	7.79E-03	2.00E-03	4.68E-03	2.00E-03	-
36088-22-9	~PeCDD, 2,3,7,8-	µg/L	5.99E-07	2.34E-06	5.99E-07	1.40E-06	5.99E-07	-
57117-41-6	~PeCDF, 1,2,3,7,8-	µg/L	2.00E-05	7.79E-05	2.00E-05	4.68E-05	2.00E-05	-
57117-31-4	~PeCDF, 2,3,4,7,8-	µg/L	2.00E-06	7.79E-06	2.00E-06	4.68E-06	2.00E-06	-
1746-01-6	~TCDD, 2,3,7,8-	µg/L	1.19E-07	1.83E-06	1.19E-07	1.20E-06	1.19E-07	3.00E-05
51207-31-9	~TCDF, 2,3,7,8-	µg/L	1.19E-06	1.83E-05	1.19E-06	1.20E-05	1.19E-06	-
100-41-4	Ethylbenzene	µg/L	1.50E+00	1.05E+02	1.50E+00	8.06E+01	1.50E+00	7.00E+02
206-44-0	Fluoranthene	µg/L	-	1.33E+02	1.33E+02	8.02E+01	8.02E+01	-
86-73-7	Fluorene	µg/L	-	4.59E+01	4.59E+01	2.94E+01	2.94E+01	-
118-74-1	Hexachlorobenzene	µg/L	9.76E-03	2.67E+00	9.76E-03	1.60E+00	9.76E-03	1.00E+00
91-20-3	Naphthalene	µg/L	1.65E-01	6.16E-01	1.65E-01	6.11E-01	1.65E-01	-
88-74-4	Nitroaniline, 2-	µg/L	-	3.13E+01	3.13E+01	1.89E+01	1.89E+01	-
621-64-7	Nitroso-di-N-propylamine, N-	µg/L	1.08E-02	-	1.08E-02	-	1.08E-02	-
87-86-5	Pentachlorophenol	µg/L	4.13E-02	3.49E+00	4.13E-02	2.27E+00	4.13E-02	1.00E+00
85-01-8	Phenanthrene[e]	µg/L	-	8.41E+01	8.41E+01	5.35E+01	5.35E+01	-
1336-36-3	Polychlorinated Biphenyls, Total	µg/L	4.36E-02	-	4.36E-02	-	4.36E-02	5.00E-01
12674-11-2	~Aroclor 1016	µg/L	2.24E-01	2.34E-01	2.24E-01	1.40E-01	1.40E-01	-
11104-28-2	~Aroclor 1221	µg/L	4.71E-03	-	4.71E-03	-	4.71E-03	-
11141-16-5	~Aroclor 1232	µg/L	4.71E-03	-	4.71E-03	-	4.71E-03	-
53469-21-9	~Aroclor 1242	µg/L	7.85E-03	-	7.85E-03	-	7.85E-03	-
12672-29-6	~Aroclor 1248	µg/L	7.85E-03	-	7.85E-03	-	7.85E-03	-
11097-69-1	~Aroclor 1254	µg/L	7.85E-03	6.67E-02	7.85E-03	4.01E-02	7.85E-03	-
11096-82-5	~Aroclor 1260	µg/L	7.85E-03	-	7.85E-03	-	7.85E-03	-

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.5. Groundwater No Action Levels and Primary MCLs for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Resident Cancer[a]	Adult Resident Hazard	Adult Resident No Action	Child Resident Hazard	Child Resident No Action	Primary MCLs[j]
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	2.51E-02	1.00E+00	2.51E-02	6.02E-01	2.51E-02	2.00E-01
56-55-3	~Benz[a]anthracene	µg/L	2.98E-02	-	2.98E-02	-	2.98E-02	-
50-32-8	~Benzo[a]pyrene	µg/L	2.51E-02	1.00E+00	2.51E-02	6.02E-01	2.51E-02	2.00E-01
205-99-2	~Benzo[b]fluoranthene	µg/L	2.51E-01	-	2.51E-01	-	2.51E-01	-
207-08-9	~Benzo[k]fluoranthene	µg/L	2.51E+00	-	2.51E+00	-	2.51E+00	-
218-01-9	~Chrysene	µg/L	2.51E+01	-	2.51E+01	-	2.51E+01	-
53-70-3	~Dibenz[a,h]anthracene	µg/L	2.51E-02	-	2.51E-02	-	2.51E-02	-
193-39-5	~Indeno[1,2,3-cd]pyrene	µg/L	2.51E-01	-	2.51E-01	-	2.51E-01	-
129-00-0	Pyrene	µg/L	-	1.86E+01	1.86E+01	1.21E+01	1.21E+01	-
127-18-4	Tetrachloroethylene	µg/L	1.13E+01	5.03E+00	5.03E+00	4.06E+00	4.06E+00	5.00E+00
108-88-3	Toluene[f]	µg/L	-	1.68E+02	1.68E+02	1.10E+02	1.10E+02	1.00E+03
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	1.03E+03	1.03E+03	1.02E+03	1.02E+03	-
71-55-6	Trichloroethane, 1,1,1-	µg/L	-	8.81E+02	8.81E+02	8.01E+02	8.01E+02	2.00E+02
79-00-5	Trichloroethane, 1,1,2-	µg/L	2.75E-01	4.16E-02	4.16E-02	4.15E-02	4.15E-02	5.00E+00
79-01-6	Trichloroethylene	µg/L	4.94E-01	3.23E-01	3.23E-01	2.83E-01	2.83E-01	5.00E+00
75-01-4	Vinyl Chloride	µg/L	1.88E-02	6.43E+00	1.88E-02	4.44E+00	1.88E-02	2.00E+00
108-38-3	Xylene, m-	µg/L	-	1.98E+01	1.98E+01	1.93E+01	1.93E+01	-
95-47-6	Xylene, o-	µg/L	-	1.99E+01	1.99E+01	1.93E+01	1.93E+01	-
106-42-3	Xylene, p-	µg/L	-	1.99E+01	1.99E+01	1.93E+01	1.93E+01	-
1330-20-7	Xylene, Mixture	µg/L	-	1.99E+01	1.99E+01	1.93E+01	1.93E+01	1.00E+04
14596-10-2	Am-241[i]	pCi/L	5.04E-01	-	5.04E-01	-	5.04E-01	1.50E+01[l]
10045-97-3	Cs-137+D[i]	pCi/L	1.71E+00	-	1.71E+00	-	1.71E+00	[m]
13994-20-2	Np-237+D[i]	pCi/L	7.63E-01	-	7.63E-01	-	7.63E-01	1.50E+01[n]
13981-16-3	Pu-238[i]	pCi/L	3.98E-01	-	3.98E-01	-	3.98E-01	1.50E+01[o]
15117-48-3	Pu-239[i]	pCi/L	3.87E-01	-	3.87E-01	-	3.87E-01	1.50E+01[o]
14119-33-6	Pu-240[i]	pCi/L	3.87E-01	-	3.87E-01	-	3.87E-01	1.50E+01[o]
14133-76-7	Tc-99[i]	pCi/L	1.90E+01	-	1.90E+01	-	1.90E+01	[p]
14269-63-7	Th-230[i]	pCi/L	5.72E-01	-	5.72E-01	-	5.72E-01	1.50E+01[q]
13966-29-5	U-234[i]	pCi/L	7.39E-01	-	7.39E-01	-	7.39E-01	[r]
15117-96-1	U-235+D[i]	pCi/L	7.28E-01	-	7.28E-01	-	7.28E-01	[r]
7440-61-1	U-238+D[i]	pCi/L	6.01E-01	-	6.01E-01	-	6.01E-01	[r]

NOTES:
Values are provided in these tables for significant COPCs for PGDP. Values for other COPCs can be obtained using the RAIS online calculator, as modified using PGDP-specific inputs.
No action levels are not adjusted for saturation limits.
[a] For the resident, ELCRs (i.e. cancer ALs) were calculated using the child/adult age-adjusted lifetime scenario (i.e., lifetime exposure).
[b] Chromium (Total) NAL should utilize Chromium III or Chromium VI, as appropriate.
[c] Lead values should be checked prior to use to ensure they are still current.
[d] Based on recommendation from EPA 2016, ALs for uranium (soluble salts) now uses the RfD for uranium derived from ATSDR. The RfD for uranium available in IRIS has been added as uranium (insoluble compounds).
[e] Acenaphthylene and phenanthrene use values for acenaphthene.
[f] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.
[g] Total dioxins/furans uses values for 2,3,7,8-TCDD, see screening note 9f in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.5. Groundwater No Action Levels and Primary MCLs for Significant COPCs at PGDP (Continued)

[h] Total carcinogenic PAHs uses values for BaP, see screening note 9d in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.
[i] Radionuclides use only the ingestion risk values.
[j] Accessed at "https://www.epa.gov/dwstandardsregulations"; last updated May 22, 2017; accessed October 29, 2018.
[k] MCL is for the sum of the concentrations for trihalomethanes.
[l] Additional information regarding Am-241 can be found in "EPA Facts about Americium-241," dated July 2002, at the following link: https://semspub.epa.gov/work/HQ/176296.pdf; accessed October 29, 2018.
[m] The EPA MCL for Cs-137 is 4 mrem/yr. The value derived by the EPA from the 4 mrem/yr MCL for Cs-137 is 200 pCi/L (see "Limits for Beta Particles and Photon Emitters at 4 millrems/year" found on https://www.epa.gov/sites/production/files/2015-09/documents/guide_radionuclides_table-betaphotonemitters.pdf; accessed October 31,2018).
[n] "Maximum Contaminant Level's in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators," revised September 2015, found on https://epa-prgs.ornl.gov/radionuclides/MCLs_2015.pdf; accessed October 29, 2018.
[o] Additional information regarding plutonium can be found at the following link: http://www2.epa.gov/radiation/radionuclides.
[p] The value derived by EPA from the 4 mrem/yr MCL for Tc-99 is 900 pCi/L, (see https://www.epa.gov/sites/production/files/2015-09/documents/guide_radionuclides_table-betaphotonemitters.pdf). An alternate value derived by EPA from the 4 mrem/yr MCL is 3,790 pCi/L and was proposed in the July 18, 1991, *Federal Register*. See Table A.9 for Tc-99 dose-based groundwater screening levels resulting in a 4 mrem/yr dose based upon more recent dosimetry.
[q] Additional information regarding thorium can be found at the following link: http://www2.epa.gov/radiation/radionuclides.
[r] The uranium MCL is 30 µg/L and can be assumed to be at a 1:1 ratio for pCi/L (or 30 pCi/L). The MCL also can be converted to 20 pCi/L for total uranium using a uranium activity expected at PGDP. Isotopic uranium values derived from this conversion are 10.24 pCi/L for U-234, 0.466 pCi/L for U-235, and 9.99 pCi/L for U-238, assuming natural occurring uranium at 0.725% U-235 and the following ratios:

- U-234/U-235 ranges 21-22 obtained from conversion approximately 21.9
- U-235/U-238 ranges 0.04-0.05 obtained from conversion approximately 0.045

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP

(Values calculated in October 2018 and are based on best available information.)

CAS	Analyte	Units	Outdoor Worker[a]			Excavation Worker[a]			Industrial Worker[a]		
			Cancer	Hazard	No Action	Cancer	Hazard	No Action	Cancer	Hazard	No Action
7429-90-5	Aluminum	µg/L	-	5.17E+06	5.17E+06	-	5.17E+06	5.17E+06	-	1.27E+06	1.27E+06
7440-36-0	Antimony (metallic)	µg/L	-	3.10E+02	3.10E+02	-	3.10E+02	3.10E+02	-	7.64E+01	7.64E+01
7440-38-2	Arsenic, Inorganic	µg/L	9.66E+01	1.55E+03	9.66E+01	4.83E+02	1.55E+03	4.83E+02	2.38E+01	3.82E+02	2.38E+01
7440-39-3	Barium	µg/L	-	7.24E+04	7.24E+04	-	7.24E+04	7.24E+04	-	1.78E+04	1.78E+04
7440-41-7	Beryllium and compounds	µg/L	-	7.24E+01	7.24E+01	-	7.24E+01	7.24E+01	-	1.78E+01	1.78E+01
7440-42-8	Boron And Borates Only	µg/L	-	1.03E+06	1.03E+06	-	1.03E+06	1.03E+06	-	2.55E+05	2.55E+05
7440-43-9	Cadmium (Water)	µg/L	-	1.29E+02	1.29E+02	-	1.29E+02	1.29E+02	-	3.18E+01	3.18E+01
16065-83-1	Chromium(III), Insoluble Salts	µg/L	-	1.01E+05	1.01E+05	-	1.01E+05	1.01E+05	-	2.48E+04	2.48E+04
18540-29-9	Chromium(VI)	µg/L	3.62E+00	1.94E+02	3.62E+00	1.81E+01	1.94E+02	1.81E+01	8.92E-01	4.78E+01	8.92E-01
7440-47-3	Chromium (Total)[b]	µg/L	-	-	-	-	-	-	-	-	-
7440-48-4	Cobalt	µg/L	-	3.88E+03	3.88E+03	-	3.88E+03	3.88E+03	-	9.55E+02	9.55E+02
7440-50-8	Copper	µg/L	-	2.07E+05	2.07E+05	-	2.07E+05	2.07E+05	-	5.09E+04	5.09E+04
16984-48-8	Fluoride	µg/L	-	2.07E+05	2.07E+05	-	2.07E+05	2.07E+05	-	5.09E+04	5.09E+04
7439-89-6	Iron	µg/L	-	3.62E+06	3.62E+06	-	3.62E+06	3.62E+06	-	8.92E+05	8.92E+05
7439-92-1	Lead[c]	µg/L	-	-	1.50E+01	-	-	1.50E+01	-	-	1.50E+01
7439-96-5	Manganese	µg/L	-	4.97E+03	4.97E+03	-	4.97E+03	4.97E+03	-	1.22E+03	1.22E+03
7439-97-6	Mercury, Inorganic Salts	µg/L	-	1.09E+02	1.09E+02	-	1.09E+02	1.09E+02	-	2.67E+01	2.67E+01
7439-98-7	Molybdenum	µg/L	-	2.59E+04	2.59E+04	-	2.59E+04	2.59E+04	-	6.37E+03	6.37E+03
7440-02-0	Nickel Soluble Salts	µg/L	-	2.07E+04	2.07E+04	-	2.07E+04	2.07E+04	-	5.09E+03	5.09E+03
7782-49-2	Selenium	µg/L	-	2.59E+04	2.59E+04	-	2.59E+04	2.59E+04	-	6.37E+03	6.37E+03
7440-22-4	Silver	µg/L	-	1.72E+03	1.72E+03	-	1.72E+03	1.72E+03	-	4.25E+02	4.25E+02
7791-12-0	Thallium (Soluble Salts)	µg/L	-	5.17E+01	5.17E+01	-	5.17E+01	5.17E+01	-	1.27E+01	1.27E+01
N/A	Uranium (Insoluble Compounds)[d]	µg/L	-	1.55E+04	1.55E+04	-	1.55E+04	1.55E+04	-	3.82E+03	3.82E+03
N/A	Uranium (Soluble Salts)[d]	µg/L	-	1.03E+03	1.03E+03	-	1.03E+03	1.03E+03	-	2.55E+02	2.55E+02
7440-62-2	Vanadium and Compounds	µg/L	-	6.78E+02	6.78E+02	-	6.78E+02	6.78E+02	-	1.67E+02	1.67E+02
7440-66-6	Zinc and Compounds	µg/L	-	2.59E+06	2.59E+06	-	2.59E+06	2.59E+06	-	6.37E+05	6.37E+05
83-32-9	Acenaphthene	µg/L	-	3.71E+03	3.71E+03	-	3.71E+03	3.71E+03	-	5.84E+02	5.84E+02
208-96-8	Acenaphthylene[e]	µg/L	-	3.71E+03	3.71E+03	-	3.71E+03	3.71E+03	-	5.84E+02	5.84E+02
107-13-1	Acrylonitrile	µg/L	2.20E+02	1.70E+05	2.20E+02	1.10E+03	1.70E+05	1.10E+03	4.92E+01	3.79E+04	4.92E+01
120-12-7	Anthracene	µg/L	-	1.10E+04	1.10E+04	-	1.10E+04	1.10E+04	-	1.53E+03	1.53E+03
71-43-2	Benzene	µg/L	1.72E+02	1.35E+03	1.72E+02	8.60E+02	1.35E+03	8.60E+02	3.67E+01	2.89E+02	3.67E+01
117-81-7	Bis(2-ethylhexyl)phthalate[f]	µg/L	-	-	-	-	-	-	-	-	-
75-27-4	Bromodichloromethane	µg/L	4.83E+02	2.14E+04	4.83E+02	2.42E+03	2.14E+04	2.42E+03	8.61E+01	3.81E+03	8.61E+01
86-74-8	Carbazole	µg/L	1.26E+02	-	1.26E+02	6.29E+02	-	6.29E+02	2.00E+01	-	2.00E+01
56-23-5	Carbon Tetrachloride	µg/L	1.12E+02	1.12E+03	1.12E+02	5.60E+02	1.12E+03	5.60E+02	2.00E+01	2.00E+02	2.00E+01
67-66-3	Chloroform	µg/L	6.23E+02	6.90E+03	6.23E+02	3.12E+03	6.90E+03	3.12E+03	1.24E+02	1.37E+03	1.24E+02
75-71-8	Dichlorodifluoromethane (Freon-12)[f]	µg/L	-	1.06E+05	1.06E+05	-	1.06E+05	1.06E+05	-	2.09E+04	2.09E+04

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

			Outdoor Worker[a]			Excavation Worker[a]			Industrial Worker[a]		
CAS	Analyte	Units	Cancer	Hazard	No Action	Cancer	Hazard	No Action	Cancer	Hazard	No Action
75-34-3	Dichloroethane, 1,1-[f]	µg/L	3.51E+03	1.43E+05	3.51E+03	1.76E+04	1.43E+05	1.76E+04	7.29E+02	2.97E+04	7.29E+02
107-06-2	Dichloroethane, 1,2-	µg/L	3.51E+02	6.85E+03	3.51E+02	1.76E+03	6.85E+03	1.76E+03	7.30E+01	1.42E+03	7.30E+01
75-35-4	Dichloroethylene, 1,1-	µg/L	-	2.10E+04	2.10E+04	-	2.10E+04	2.10E+04	-	4.35E+03	4.35E+03
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	4.01E+03	4.01E+03	-	4.01E+03	4.01E+03	-	8.31E+02	8.31E+02
156-59-2	Dichloroethylene, 1,2-cis-	µg/L	-	8.91E+02	8.91E+02	-	8.91E+02	8.91E+02	-	1.85E+02	1.85E+02
156-60-5	Dichloroethylene, 1,2-trans-	µg/L	-	8.91E+03	8.91E+03	-	8.91E+03	8.91E+03	-	1.85E+03	1.85E+03
60-57-1	Dieldrin	µg/L	9.40E-02	2.69E+00	9.40E-02	4.70E-01	2.69E+00	4.70E-01	1.32E-02	3.77E-01	1.32E-02
1746-01-6	Dioxins/Furans, Total (as TCDD)[g]	µg/L	-	-	-	-	-	-	-	-	-
37871-00-4	~HpCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
38998-75-3	~HpCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
34465-46-8	~HxCDD	µg/L	-	-	-	-	-	-	-	-	-
55684-94-1	~HxCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
3268-87-9	~OCDD	µg/L	-	-	-	-	-	-	-	-	-
39001-02-0	~OCDF	µg/L	-	-	-	-	-	-	-	-	-
36088-22-9	~PeCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
57117-41-6	~PeCDF, 1,2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
57117-31-4	~PeCDF, 2,3,4,7,8-	µg/L	-	-	-	-	-	-	-	-	-
1746-01-6	~TCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
51207-31-9	~TCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-	-	-
100-41-4	Ethylbenzene	µg/L	2.78E+02	1.09E+04	2.78E+02	1.39E+03	1.09E+04	1.39E+03	5.41E+01	2.13E+03	5.41E+01
206-44-0	Fluoranthene	µg/L	-	-	-	-	-	-	-	-	-
86-73-7	Fluorene	µg/L	-	1.92E+03	1.92E+03	-	1.92E+03	1.92E+03	-	2.78E+02	2.78E+02
118-74-1	Hexachlorobenzene	µg/L	-	-	-	-	-	-	-	-	-
91-20-3	Naphthalene	µg/L	-	2.23E+03	2.23E+03	-	2.23E+03	2.23E+03	-	4.09E+02	4.09E+02
88-74-4	Nitroaniline, 2-	µg/L	-	1.02E+04	1.02E+04	-	1.02E+04	1.02E+04	-	1.94E+03	1.94E+03
621-64-7	Nitroso-di-N-propylamine, N-	µg/L	7.85E+00	-	7.85E+00	3.92E+01	-	3.92E+01	1.53E+00	-	1.53E+00
87-86-5	Pentachlorophenol	µg/L	1.80E+00	1.28E+02	1.80E+00	8.98E+00	1.28E+02	8.98E+00	2.52E-01	1.80E+01	2.52E-01
85-01-8	Phenanthrene[e]	µg/L	-	3.71E+03	3.71E+03	-	3.71E+03	3.71E+03	-	5.84E+02	5.84E+02
1336-36-3	Polychlorinated Biphenyls, Total	µg/L	-	-	-	-	-	-	-	-	-
12674-11-2	~Aroclor 1016	µg/L	-	-	-	-	-	-	-	-	-
11104-28-2	~Aroclor 1221	µg/L	4.16E-01	-	4.16E-01	2.08E+00	-	2.08E+00	5.66E-02	-	5.66E-02
11141-16-5	~Aroclor 1232	µg/L	4.16E-01	-	4.16E-01	2.08E+00	-	2.08E+00	5.66E-02	-	5.66E-02
53469-21-9	~Aroclor 1242	µg/L	-	-	-	-	-	-	-	-	-
12672-29-6	~Aroclor 1248	µg/L	-	-	-	-	-	-	-	-	-
11097-69-1	~Aroclor 1254	µg/L	-	-	-	-	-	-	-	-	-
11096-82-5	~Aroclor 1260	µg/L	-	-	-	-	-	-	-	-	-

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

CAS	Analyte	Units	Outdoor Worker[a]			Excavation Worker[a]			Industrial Worker[a]		
			Cancer	Hazard	No Action	Cancer	Hazard	No Action	Cancer	Hazard	No Action
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	-	-	-	-	-	-	-	-	-
56-55-3	~Benz[a]anthracene	µg/L	-	-	-	-	-	-	-	-	-
50-32-8	~Benzo[a]pyrene	µg/L	-	-	-	-	-	-	-	-	-
205-99-2	~Benzo[b]fluoranthene	µg/L	-	-	-	-	-	-	-	-	-
207-08-9	~Benzo[k]fluoranthene	µg/L	-	-	-	-	-	-	-	-	-
218-01-9	~Chrysene	µg/L	-	-	-	-	-	-	-	-	-
53-70-3	~Dibenz[a,h]anthracene	µg/L	-	-	-	-	-	-	-	-	-
193-39-5	~Indeno[1,2,3-cd]pyrene	µg/L	-	-	-	-	-	-	-	-	-
129-00-0	Pyrene	µg/L	-	6.91E+02	6.91E+02	-	6.91E+02	6.91E+02	-	9.28E+01	9.28E+01
127-18-4	Tetrachloroethylene	µg/L	1.85E+03	8.32E+02	8.32E+02	9.24E+03	8.32E+02	8.32E+02	3.07E+02	1.38E+02	1.38E+02
108-88-3	Toluene[f]	µg/L	-	1.34E+04	1.34E+04	-	1.34E+04	1.34E+04	-	2.75E+03	2.75E+03
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	7.17E+06	7.17E+06	-	7.17E+06	7.17E+06	-	1.17E+06	1.17E+06
71-55-6	Trichloroethane, 1,1,1-	µg/L	-	7.45E+05	7.45E+05	-	7.45E+05	7.45E+05	-	1.42E+05	1.42E+05
79-00-5	Trichloroethane, 1,1,2-	µg/L	4.47E+02	3.64E+03	4.47E+02	2.24E+03	3.64E+03	2.24E+03	8.62E+01	7.02E+02	8.62E+01
79-01-6	Trichloroethylene	µg/L	2.45E+02	2.02E+02	2.02E+02	1.22E+03	2.02E+02	2.02E+02	4.70E+01	3.88E+01	3.88E+01
75-01-4	Vinyl Chloride	µg/L	2.32E+01	1.79E+03	2.32E+01	1.16E+02	1.79E+03	1.16E+02	5.09E+00	3.93E+02	5.09E+00
108-38-3	Xylene, m-	µg/L	-	2.05E+04	2.05E+04	-	2.05E+04	2.05E+04	-	3.96E+03	3.96E+03
95-47-6	Xylene, o-	µg/L	-	2.28E+04	2.28E+04	-	2.28E+04	2.28E+04	-	4.44E+03	4.44E+03
106-42-3	Xylene, p-	µg/L	-	2.19E+04	2.19E+04	-	2.19E+04	2.19E+04	-	4.25E+03	4.25E+03
1330-20-7	Xylene, Mixture	µg/L	-	2.16E+04	2.16E+04	-	2.16E+04	2.16E+04	-	4.20E+03	4.20E+03
14596-10-2	Am-241	pCi/L	-	-	-	-	-	-	-	-	-
10045-97-3	Cs-137+D	pCi/L	-	-	-	-	-	-	-	-	-
13994-20-2	Np-237+D	pCi/L	-	-	-	-	-	-	-	-	-
13981-16-3	Pu-238	pCi/L	-	-	-	-	-	-	-	-	-
15117-48-3	Pu-239	pCi/L	-	-	-	-	-	-	-	-	-
14119-33-6	Pu-240	pCi/L	-	-	-	-	-	-	-	-	-
14133-76-7	Tc-99	pCi/L	-	-	-	-	-	-	-	-	-
14269-63-7	Th-230	pCi/L	-	-	-	-	-	-	-	-	-
13966-29-5	U-234	pCi/L	-	-	-	-	-	-	-	-	-
15117-96-1	U-235+D	pCi/L	-	-	-	-	-	-	-	-	-
7440-61-1	U-238+D	pCi/L	-	-	-	-	-	-	-	-	-

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Swimming	Adult Recreational User Swimming		Child Recreational User Swimming		Teen Recreational User Swimming	
		Cancer[i]	Hazard	No Action	Hazard	No Action	Hazard	No Action
Aluminum	μg/L	-	3.58E+05	3.58E+05	8.30E+04	8.30E+04	2.18E+05	2.18E+05
Antimony (metallic)	μg/L	-	5.52E+01	5.52E+01	2.03E+01	2.03E+01	4.00E+01	4.00E+01
Arsenic, Inorganic	μg/L	3.31E+00	1.07E+02	3.31E+00	2.49E+01	3.31E+00	6.53E+01	3.31E+00
Barium	μg/L	-	1.51E+04	1.51E+04	6.64E+03	6.64E+03	1.16E+04	1.16E+04
Beryllium and compounds	μg/L	-	1.75E+01	1.75E+01	9.76E+00	9.76E+00	1.43E+01	1.43E+01
Boron And Borates Only	μg/L	-	7.17E+04	7.17E+04	1.66E+04	1.66E+04	4.35E+04	4.35E+04
Cadmium (Water)	μg/L	-	2.82E+01	2.82E+01	1.32E+01	1.32E+01	2.20E+01	2.20E+01
Chromium(III), Insoluble Salts	μg/L	-	2.40E+04	2.40E+04	1.30E+04	1.30E+04	1.95E+04	1.95E+04
Chromium(VI)	μg/L	2.04E-01	4.62E+01	2.04E-01	2.51E+01	2.04E-01	3.75E+01	2.04E-01
Chromium (Total)[b]	μg/L	-	-	-	-	-	-	-
Cobalt	μg/L	-	1.29E+02	1.29E+02	2.67E+01	2.67E+01	7.45E+01	7.45E+01
Copper	μg/L	-	1.43E+04	1.43E+04	3.32E+03	3.32E+03	8.70E+03	8.70E+03
Fluoride	μg/L	-	1.43E+04	1.43E+04	3.32E+03	3.32E+03	8.70E+03	8.70E+03
Iron	μg/L	-	2.51E+05	2.51E+05	5.81E+04	5.81E+04	1.52E+05	1.52E+05
Lead[c]	μg/L	-	-	1.50E+01	-	1.50E+01	-	1.50E+01
Manganese	μg/L	-	1.11E+03	1.11E+03	5.37E+02	5.37E+02	8.73E+02	8.73E+02
Mercury, Inorganic Salts	μg/L	-	2.26E+01	2.26E+01	9.96E+00	9.96E+00	1.74E+01	1.74E+01
Molybdenum	μg/L	-	1.79E+03	1.79E+03	4.15E+02	4.15E+02	1.09E+03	1.09E+03
Nickel Soluble Salts	μg/L	-	3.37E+03	3.37E+03	1.14E+03	1.14E+03	2.38E+03	2.38E+03
Selenium	μg/L	-	1.79E+03	1.79E+03	4.15E+02	4.15E+02	1.09E+03	1.09E+03
Silver	μg/L	-	3.62E+02	3.62E+02	1.61E+02	1.61E+02	2.78E+02	2.78E+02
Thallium (Soluble Salts)	μg/L	-	3.58E+00	3.58E+00	8.30E-01	8.30E-01	2.18E+00	2.18E+00
Uranium (Insoluble Compounds) [d]	μg/L	-	1.07E+03	1.07E+03	2.49E+02	2.49E+02	6.53E+02	6.53E+02
Uranium (Soluble Salts) [d]	μg/L	-	7.17E+01	7.17E+01	1.66E+01	1.66E+01	4.35E+01	4.35E+01
Vanadium and Compounds	μg/L	-	1.56E+02	1.56E+02	8.00E+01	8.00E+01	1.25E+02	1.25E+02
Zinc and Compounds	μg/L	-	1.21E+05	1.21E+05	2.61E+04	2.61E+04	7.12E+04	7.12E+04
Acenaphthene	μg/L	-	5.71E+02	5.71E+02	3.18E+02	3.18E+02	4.67E+02	4.67E+02
Acenaphthylene[e]	μg/L	-	5.71E+02	5.71E+02	3.18E+02	3.18E+02	4.67E+02	4.67E+02
Acrylonitrile	μg/L	8.67E+00	1.31E+04	8.67E+00	3.20E+03	8.67E+00	8.12E+03	8.67E+00
Anthracene	μg/L	-	1.51E+03	1.51E+03	8.58E+02	8.58E+02	1.24E+03	1.24E+03
Benzene	μg/L	2.28E+01	2.52E+02	2.28E+01	1.15E+02	2.28E+01	1.95E+02	2.28E+01
Bis(2-ethylhexyl)phthalate[f]	μg/L	4.32E+02	9.98E+03	4.32E+02	1.87E+03	4.32E+02	5.49E+03	4.32E+02
Bromodichloromethane	μg/L	3.98E+01	2.75E+03	3.98E+01	1.01E+03	3.98E+01	2.00E+03	3.98E+01
Carbazole	μg/L	1.48E+01	-	1.48E+01	-	1.48E+01	-	1.48E+01
Carbon Tetrachloride	μg/L	1.33E+01	1.81E+02	1.33E+01	8.83E+01	1.33E+01	1.43E+02	1.33E+01
Chloroform	μg/L	6.47E+01	1.07E+03	6.47E+01	4.29E+02	6.47E+01	8.00E+02	6.47E+01
Dichlorodifluoromethane (Freon-12)[f]	μg/L	-	1.72E+04	1.72E+04	7.33E+03	7.33E+03	1.31E+04	1.31E+04

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Swimming	Adult Recreational User Swimming		Child Recreational User Swimming		Teen Recreational User Swimming	
		Cancer[i]	Hazard	No Action	Hazard	No Action	Hazard	No Action
Dichloroethane, 1,1-[f]	µg/L	3.71E+02	2.28E+04	3.71E+02	8.94E+03	3.71E+02	1.69E+04	3.71E+02
Dichloroethane, 1,2-	µg/L	3.07E+01	9.63E+02	3.07E+01	3.34E+02	3.07E+01	6.84E+02	3.07E+01
Dichloroethylene, 1,1-	µg/L	-	3.69E+03	3.69E+03	1.63E+03	1.63E+03	2.84E+03	2.84E+03
Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	7.00E+02	7.00E+02	3.06E+02	3.06E+02	5.35E+02	5.35E+02
Dichloroethylene, 1,2-cis-	µg/L	-	1.55E+02	1.55E+02	6.79E+01	6.79E+01	1.19E+02	1.19E+02
Dichloroethylene, 1,2-trans-	µg/L	-	1.55E+03	1.55E+03	6.79E+02	6.79E+02	1.19E+03	1.19E+03
Dieldrin	µg/L	1.00E-02	3.70E-01	1.00E-02	2.08E-01	1.00E-02	3.03E-01	1.00E-02
Dioxins/Furans, Total (as TCDD)[g]	µg/L	4.65E-05	3.49E-04	4.65E-05	6.55E-05	4.65E-05	1.92E-04	4.65E-05
~HpCDD, 2,3,7,8-	µg/L	4.65E-03	3.49E-02	4.65E-03	6.55E-03	4.65E-03	1.92E-02	4.65E-03
~HpCDF, 2,3,7,8-	µg/L	4.65E-03	3.49E-02	4.65E-03	6.55E-03	4.65E-03	1.92E-02	4.65E-03
~HxCDD	µg/L	4.65E-04	3.49E-03	4.65E-04	6.55E-04	4.65E-04	1.92E-03	4.65E-04
~HxCDF, 2,3,7,8-	µg/L	4.65E-04	3.49E-03	4.65E-04	6.55E-04	4.65E-04	1.92E-03	4.65E-04
~OCDD	µg/L	1.55E-01	1.16E+00	1.55E-01	2.18E-01	1.55E-01	6.41E-01	1.55E-01
~OCDF	µg/L	1.55E-01	1.16E+00	1.55E-01	2.18E-01	1.55E-01	6.41E-01	1.55E-01
~PeCDD, 2,3,7,8-	µg/L	4.65E-05	3.49E-04	4.65E-05	6.55E-05	4.65E-05	1.92E-04	4.65E-05
~PeCDF, 1,2,3,7,8-	µg/L	1.55E-03	1.16E-02	1.55E-03	2.18E-03	1.55E-03	6.41E-03	1.55E-03
~PeCDF, 2,3,4,7,8-	µg/L	1.55E-04	1.16E-03	1.55E-04	2.18E-04	1.55E-04	6.41E-04	1.55E-04
~TCDD, 2,3,7,8-	µg/L	4.65E-05	3.49E-04	4.65E-05	6.55E-05	4.65E-05	1.92E-04	4.65E-05
~TCDF, 2,3,7,8-	µg/L	4.65E-04	3.49E-03	4.65E-04	6.55E-04	4.65E-04	1.92E-03	4.65E-04
Ethylbenzene	µg/L	3.93E+01	2.03E+03	3.93E+01	1.09E+03	3.93E+01	1.64E+03	3.93E+01
Fluoranthene	µg/L	-	2.00E+04	2.00E+04	3.74E+03	3.74E+03	1.10E+04	1.10E+04
Fluorene	µg/L	-	2.73E+02	2.73E+02	1.54E+02	1.54E+02	2.24E+02	2.24E+02
Hexachlorobenzene	µg/L	3.78E+00	3.99E+02	3.78E+00	7.49E+01	3.78E+00	2.20E+02	3.78E+00
Naphthalene	µg/L	-	3.92E+02	3.92E+02	2.10E+02	2.10E+02	3.17E+02	3.17E+02
Nitroaniline, 2-	µg/L	-	1.40E+03	1.40E+03	5.10E+02	5.10E+02	1.01E+03	1.01E+03
Nitroso-di-N-propylamine, N-	µg/L	5.02E-01	-	5.02E-01	-	5.02E-01	-	5.02E-01
Pentachlorophenol	µg/L	1.95E-01	1.78E+01	1.95E-01	1.02E+01	1.95E-01	1.46E+01	1.95E-01
Phenanthrene[e]	µg/L	-	5.71E+02	5.71E+02	3.18E+02	3.18E+02	4.67E+02	4.67E+02
Polychlorinated Biphenyls, Total	µg/L	1.51E+01	-	1.51E+01	-	1.51E+01	-	1.51E+01
~Aroclor 1016	µg/L	8.63E+01	3.49E+01	3.49E+01	6.55E+00	6.55E+00	1.92E+01	1.92E+01
~Aroclor 1221	µg/L	4.36E-02	-	4.36E-02	-	4.36E-02	-	4.36E-02
~Aroclor 1232	µg/L	4.36E-02	-	4.36E-02	-	4.36E-02	-	4.36E-02
~Aroclor 1242	µg/L	3.02E+00	-	3.02E+00	-	3.02E+00	-	3.02E+00
~Aroclor 1248	µg/L	3.02E+00	-	3.02E+00	-	3.02E+00	-	3.02E+00
~Aroclor 1254	µg/L	3.02E+00	9.98E+00	3.02E+00	1.87E+00	1.87E+00	5.49E+00	3.02E+00
~Aroclor 1260	µg/L	3.02E+00	-	3.02E+00	-	3.02E+00	-	3.02E+00

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Swimming	Adult Recreational User Swimming		Child Recreational User Swimming		Teen Recreational User Swimming	
		Cancer[i]	Hazard	No Action	Hazard	No Action	Hazard	No Action
Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	1.49E+00	1.50E+02	1.49E+00	2.81E+01	1.49E+00	8.24E+01	1.49E+00
~Benz[a]anthracene	µg/L	1.49E+01	-	1.49E+01	-	1.49E+01	-	1.49E+01
~Benzo[a]pyrene	µg/L	1.49E+00	1.50E+02	1.49E+00	2.81E+01	1.49E+00	8.24E+01	1.49E+00
~Benzo[b]fluoranthene	µg/L	1.49E+01	-	1.49E+01	-	1.49E+01	-	1.49E+01
~Benzo[k]fluoranthene	µg/L	1.49E+02	-	1.49E+02	-	1.49E+02	-	1.49E+02
~Chrysene	µg/L	1.49E+03	-	1.49E+03	-	1.49E+03	-	1.49E+03
~Dibenz[a,h]anthracene	µg/L	1.49E+00	-	1.49E+00	-	1.49E+00	-	1.49E+00
~Indeno[1,2,3-cd]pyrene	µg/L	1.49E+01	-	1.49E+01	-	1.49E+01	-	1.49E+01
Pyrene	µg/L	-	9.20E+01	9.20E+01	5.26E+01	5.26E+01	7.57E+01	7.57E+01
Tetrachloroethylene	µg/L	2.22E+02	1.32E+02	1.32E+02	6.98E+01	6.98E+01	1.06E+02	1.06E+02
Toluene[f]	µg/L	-	2.56E+03	2.56E+03	1.31E+03	1.31E+03	2.05E+03	2.05E+03
Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	1.09E+06	1.09E+06	5.46E+05	5.46E+05	8.64E+05	8.64E+05
Trichloroethane, 1,1,1-	µg/L	-	1.24E+05	1.24E+05	5.70E+04	5.70E+04	9.63E+04	9.63E+04
Trichloroethane, 1,1,2-	µg/L	4.12E+01	5.18E+02	4.12E+01	1.95E+02	4.12E+01	3.78E+02	4.12E+01
Trichloroethylene	µg/L	1.94E+01	3.35E+01	1.94E+01	1.52E+01	1.52E+01	2.59E+01	1.94E+01
Vinyl Chloride	µg/L	6.97E-02	3.10E+02	6.97E-02	1.25E+02	6.97E-02	2.32E+02	6.97E-02
Xylene, m-	µg/L	-	3.80E+03	3.80E+03	2.04E+03	2.04E+03	3.08E+03	3.08E+03
Xylene, o-	µg/L	-	4.24E+03	4.24E+03	2.25E+03	2.25E+03	3.42E+03	3.42E+03
Xylene, p-	µg/L	-	4.07E+03	4.07E+03	2.17E+03	2.17E+03	3.29E+03	3.29E+03
Xylene, Mixture	µg/L	-	4.02E+03	4.02E+03	2.14E+03	2.14E+03	3.25E+03	3.25E+03
Am-241	pCi/L	6.35E+01	-	6.35E+01	-	6.35E+01	-	6.35E+01
Cs-137+D	pCi/L	2.16E+02	-	2.16E+02	-	2.16E+02	-	2.16E+02
Np-237+D	pCi/L	9.60E+01	-	9.60E+01	-	9.60E+01	-	9.60E+01
Pu-238	pCi/L	5.01E+01	-	5.01E+01	-	5.01E+01	-	5.01E+01
Pu-239	pCi/L	4.87E+01	-	4.87E+01	-	4.87E+01	-	4.87E+01
Pu-240	pCi/L	4.87E+01	-	4.87E+01	-	4.87E+01	-	4.87E+01
Tc-99	pCi/L	2.39E+03	-	2.39E+03	-	2.39E+03	-	2.39E+03
Th-230	pCi/L	7.19E+01	-	7.19E+01	-	7.19E+01	-	7.19E+01
U-234	pCi/L	9.30E+01	-	9.30E+01	-	9.30E+01	-	9.30E+01
U-235+D	pCi/L	9.16E+01	-	9.16E+01	-	9.16E+01	-	9.16E+01
U-238+D	pCi/L	7.56E+01	-	7.56E+01	-	7.56E+01	-	7.56E+01

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Wading[a]	Adult Recreational User Wading[a]		Child Recreational User Wading[a]		Teen Recreational User Wading[a]	
		Cancer[i]	Hazard	No Action	Hazard	No Action	Hazard	No Action
Aluminum	µg/L	-	2.04E+06	2.04E+06	4.56E+05	4.56E+05	5.88E+05	5.88E+05
Antimony (metallic)	µg/L	-	1.22E+02	1.22E+02	2.73E+01	2.73E+01	3.53E+01	3.53E+01
Arsenic, Inorganic	µg/L	1.41E+01	6.11E+02	1.41E+01	1.37E+02	1.41E+01	1.76E+02	1.41E+01
Barium	µg/L	-	2.85E+04	2.85E+04	6.38E+03	6.38E+03	8.24E+03	8.24E+03
Beryllium and compounds	µg/L	-	2.85E+01	2.85E+01	6.38E+00	6.38E+00	8.24E+00	8.24E+00
Boron And Borates Only	µg/L	-	4.08E+05	4.08E+05	9.12E+04	9.12E+04	1.18E+05	1.18E+05
Cadmium (Water)	µg/L	-	5.09E+01	5.09E+01	1.14E+01	1.14E+01	1.47E+01	1.47E+01
Chromium(III), Insoluble Salts	µg/L	-	3.97E+04	3.97E+04	8.89E+03	8.89E+03	1.15E+04	1.15E+04
Chromium(VI)	µg/L	1.39E-01	7.64E+01	1.39E-01	1.71E+01	1.39E-01	2.21E+01	1.39E-01
Chromium (Total)[b]	µg/L	-	-	-	-	-	-	-
Cobalt	µg/L	-	1.53E+03	1.53E+03	3.42E+02	3.42E+02	4.41E+02	4.41E+02
Copper	µg/L	-	8.15E+04	8.15E+04	1.82E+04	1.82E+04	2.35E+04	2.35E+04
Fluoride	µg/L	-	8.15E+04	8.15E+04	1.82E+04	1.82E+04	2.35E+04	2.35E+04
Iron	µg/L	-	1.43E+06	1.43E+06	3.19E+05	3.19E+05	4.12E+05	4.12E+05
Lead[c]	µg/L	-	-	1.50E+01	-	1.50E+01	-	1.50E+01
Manganese	µg/L	-	1.96E+03	1.96E+03	4.38E+02	4.38E+02	5.65E+02	5.65E+02
Mercury, Inorganic Salts	µg/L	-	4.28E+01	4.28E+01	9.57E+00	9.57E+00	1.24E+01	1.24E+01
Molybdenum	µg/L	-	1.02E+04	1.02E+04	2.28E+03	2.28E+03	2.94E+03	2.94E+03
Nickel Soluble Salts	µg/L	-	8.15E+03	8.15E+03	1.82E+03	1.82E+03	2.35E+03	2.35E+03
Selenium	µg/L	-	1.02E+04	1.02E+04	2.28E+03	2.28E+03	2.94E+03	2.94E+03
Silver	µg/L	-	6.79E+02	6.79E+02	1.52E+02	1.52E+02	1.96E+02	1.96E+02
Thallium (Soluble Salts)	µg/L	-	2.04E+01	2.04E+01	4.56E+00	4.56E+00	5.88E+00	5.88E+00
Uranium (Insoluble Compounds)[d]	µg/L	-	6.11E+03	6.11E+03	1.37E+03	1.37E+03	1.76E+03	1.76E+03
Uranium (Soluble Salts)[d]	µg/L	-	4.08E+02	4.08E+02	9.12E+01	9.12E+01	1.18E+02	1.18E+02
Vanadium and Compounds	µg/L	-	2.67E+02	2.67E+02	5.97E+01	5.97E+01	7.71E+01	7.71E+01
Zinc and Compounds	µg/L	-	1.02E+06	1.02E+06	2.28E+05	2.28E+05	2.94E+05	2.94E+05
Acenaphthene	µg/L	-	9.34E+02	9.34E+02	2.09E+02	2.09E+02	2.70E+02	2.70E+02
Acenaphthylene[e]	µg/L	-	9.34E+02	9.34E+02	2.09E+02	2.09E+02	2.70E+02	2.70E+02
Acrylonitrile	µg/L	2.91E+01	6.07E+04	2.91E+01	1.36E+04	2.91E+01	1.75E+04	2.91E+01
Anthracene	µg/L	-	2.45E+03	2.45E+03	5.49E+02	5.49E+02	7.09E+02	7.09E+02
Benzene	µg/L	2.18E+01	4.62E+02	2.18E+01	1.03E+02	2.18E+01	1.33E+02	2.18E+01
Bis(2-ethylhexyl)phthalate[f]	µg/L	-	-	-	-	-	-	-
Bromodichloromethane	µg/L	5.10E+01	6.10E+03	5.10E+01	1.36E+03	5.10E+01	1.76E+03	5.10E+01
Carbazole	µg/L	1.18E+01	-	1.18E+01	-	1.18E+01	-	1.18E+01
Carbon Tetrachloride	µg/L	1.19E+01	3.20E+02	1.19E+01	7.16E+01	1.19E+01	9.25E+01	1.19E+01
Chloroform	µg/L	7.34E+01	2.19E+03	7.34E+01	4.91E+02	7.34E+01	6.33E+02	7.34E+01
Dichlorodifluoromethane (Freon-12)[f]	µg/L	-	3.34E+04	3.34E+04	7.47E+03	7.47E+03	9.65E+03	9.65E+03

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Wading[a]	Adult Recreational User Wading[a]		Child Recreational User Wading[a]		Teen Recreational User Wading[a]	
		Cancer[i]	Hazard	No Action	Hazard	No Action	Hazard	No Action
Dichloroethane, 1,1-[f]	µg/L	4.32E+02	4.75E+04	4.32E+02	1.06E+04	4.32E+02	1.37E+04	4.32E+02
Dichloroethane, 1,2-	µg/L	4.32E+01	2.28E+03	4.32E+01	5.09E+02	4.32E+01	6.57E+02	4.32E+01
Dichloroethylene, 1,1-	µg/L	-	6.95E+03	6.95E+03	1.56E+03	1.56E+03	2.01E+03	2.01E+03
Dichloroethylene, 1,2- (Mixed Isomers)	µg/L	-	1.33E+03	1.33E+03	2.97E+02	2.97E+02	3.84E+02	3.84E+02
Dichloroethylene, 1,2-cis-	µg/L	-	2.95E+02	2.95E+02	6.61E+01	6.61E+01	8.53E+01	8.53E+01
Dichloroethylene, 1,2-trans-	µg/L	-	2.95E+03	2.95E+03	6.61E+02	6.61E+02	8.53E+02	8.53E+02
Dieldrin	µg/L	7.82E-03	6.03E-01	7.82E-03	1.35E-01	7.82E-03	1.74E-01	7.82E-03
Dioxins/Furans, Total (as TCDD)[g]	µg/L	-	-	-	-	-	-	-
~HpCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~HpCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~HxCDD	µg/L	-	-	-	-	-	-	-
~HxCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~OCDD	µg/L	-	-	-	-	-	-	-
~OCDF	µg/L	-	-	-	-	-	-	-
~PeCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~PeCDF, 1,2,3,7,8-	µg/L	-	-	-	-	-	-	-
~PeCDF, 2,3,4,7,8-	µg/L	-	-	-	-	-	-	-
~TCDD, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
~TCDF, 2,3,7,8-	µg/L	-	-	-	-	-	-	-
Ethylbenzene	µg/L	3.21E+01	3.40E+03	3.21E+01	7.61E+02	3.21E+01	9.82E+02	3.21E+01
Fluoranthene	µg/L	-	-	-	-	-	-	-
Fluorene	µg/L	-	4.45E+02	4.45E+02	9.95E+01	9.95E+01	1.28E+02	1.28E+02
Hexachlorobenzene	µg/L	-	-	-	-	-	-	-
Naphthalene	µg/L	-	6.54E+02	6.54E+02	1.46E+02	1.46E+02	1.89E+02	1.89E+02
Nitroaniline, 2-	µg/L	-	3.11E+03	3.11E+03	6.95E+02	6.95E+02	8.97E+02	8.97E+02
Nitroso-di-N-propylamine, N-	µg/L	9.07E-01	-	9.07E-01	-	9.07E-01	-	9.07E-01
Pentachlorophenol	µg/L	1.49E-01	2.88E+01	1.49E-01	6.44E+00	1.49E-01	8.31E+00	1.49E-01
Phenanthrene[e]	µg/L	-	9.34E+02	9.34E+02	2.09E+02	2.09E+02	2.70E+02	2.70E+02
Polychlorinated Biphenyls, Total	µg/L	-	-	-	-	-	-	-
~Aroclor 1016	µg/L	-	-	-	-	-	-	-
~Aroclor 1221	µg/L	3.35E-02	-	3.35E-02	-	3.35E-02	-	3.35E-02
~Aroclor 1232	µg/L	3.35E-02	-	3.35E-02	-	3.35E-02	-	3.35E-02
~Aroclor 1242	µg/L	-	-	-	-	-	-	-
~Aroclor 1248	µg/L	-	-	-	-	-	-	-
~Aroclor 1254	µg/L	-	-	-	-	-	-	-
~Aroclor 1260	µg/L	-	-	-	-	-	-	-

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.6. Surface Water No Action Levels for Significant COPCs at PGDP (Continued)

Analyte	Units	Recreational User Wading[a]	Adult Recreational User Wading[a]		Child Recreational User Wading[a]		Teen Recreational User Wading[a]	
		Cancer[i]	Hazard	No Action	Hazard	No Action	Hazard	No Action
Polycyclic aromatic hydrocarbons, Total Carcinogenic[h]	µg/L	-	-	-	-	-	-	-
~Benz[a]anthracene	µg/L	-	-	-	-	-	-	-
~Benzo[a]pyrene	µg/L	-	-	-	-	-	-	-
~Benzo[b]fluoranthene	µg/L	-	-	-	-	-	-	-
~Benzo[k]fluoranthene	µg/L	-	-	-	-	-	-	-
~Chrysene	µg/L	-	-	-	-	-	-	-
~Dibenz[a,h]anthracene	µg/L	-	-	-	-	-	-	-
~Indeno[1,2,3-cd]pyrene	µg/L	-	-	-	-	-	-	-
Pyrene	µg/L	-	1.49E+02	1.49E+02	3.32E+01	3.32E+01	4.29E+01	4.29E+01
Tetrachloroethylene	µg/L	1.82E+02	2.21E+02	1.82E+02	4.95E+01	4.95E+01	6.38E+01	6.38E+01
Toluene[f]	µg/L	-	4.39E+03	4.39E+03	9.83E+02	9.83E+02	1.27E+03	1.27E+03
Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[f]	µg/L	-	1.88E+06	1.88E+06	4.20E+05	4.20E+05	5.42E+05	5.42E+05
Trichloroethane, 1,1,1-	µg/L	-	2.27E+05	2.27E+05	5.08E+04	5.08E+04	6.56E+04	6.56E+04
Trichloroethane, 1,1,2-	µg/L	5.11E+01	1.12E+03	5.11E+01	2.51E+02	5.11E+01	3.24E+02	5.11E+01
Trichloroethylene	µg/L	1.78E+01	6.21E+01	1.78E+01	1.39E+01	1.39E+01	1.79E+01	1.78E+01
Vinyl Chloride	µg/L	2.31E-01	6.28E+02	2.31E-01	1.41E+02	2.31E-01	1.81E+02	2.31E-01
Xylene, m-	µg/L	-	6.34E+03	6.34E+03	1.42E+03	1.42E+03	1.83E+03	1.83E+03
Xylene, o-	µg/L	-	7.10E+03	7.10E+03	1.59E+03	1.59E+03	2.05E+03	2.05E+03
Xylene, p-	µg/L	-	6.80E+03	6.80E+03	1.52E+03	1.52E+03	1.96E+03	1.96E+03
Xylene, Mixture	µg/L	-	6.71E+03	6.71E+03	1.50E+03	1.50E+03	1.94E+03	1.94E+03
Am-241	pCi/L	-	-	-	-	-	-	-
Cs-137+D	pCi/L	-	-	-	-	-	-	-
Np-237+D	pCi/L	-	-	-	-	-	-	-
Pu-238	pCi/L	-	-	-	-	-	-	-
Pu-239	pCi/L	-	-	-	-	-	-	-
Pu-240	pCi/L	-	-	-	-	-	-	-
Tc-99	pCi/L	-	-	-	-	-	-	-
Th-230	pCi/L	-	-	-	-	-	-	-
U-234	pCi/L	-	-	-	-	-	-	-
U-235+D	pCi/L	-	-	-	-	-	-	-
U-238+D	pCi/L	-	-	-	-	-	-	-

NOTES: Values are provided in these tables for significant COPCs for PGDP. Values for other COPCs can be obtained using the RAIS online calculator, as modified using PGDP-specific inputs. No action levels are not adjusted for saturation limits.

[a] Recreational User Wading and all Worker scenarios consider dermal contact only.
[b] Chromium (Total) should utilize Chromium III or Chromium VI NALs, as appropriate.
[c] Lead values should be checked prior to use to ensure they are still current.
[d] Based on recommendation from EPA 2016, NALs for uranium (soluble salts) now uses the RfD for uranium derived from ATSDR. The RfD for uranium available in IRIS has been added as uranium (insoluble compounds).
[e] Acenaphthylene and phenanthrene use values for acenaphthene.
[f] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.
[g] Total dioxins/furans uses values for 2,3,7,8-TCDD, see screening note 9f in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.
[h] Total carcinogenic PAHs uses values for BaP, see screening note 9d in the Appendix A introduction, 'Screening Levels' on pages A-3—A-5.
[i] For the recreational user, ELCRs (i.e. cancer NALs) were calculated using the child/teen/adult age-adjusted lifetime scenario.

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
No action level value is the lesser of the hazard- and cancer- based values when both are calculated.

Table A.7a. Risk-Based SSLs for Protection of RGA Groundwater for Significant COPCs at PGDP
(Values calculated in October 2018 and are based on best available information.)

		SSLs for EPA MCL[a]			SSLs PGDP NALs for the Resident (See Table A.5)[a]		
CAS Number	Chemical	SSL 1 (mg/kg)	SSL 20 (mg/kg)	GW Conc. (µg/L)	SSL 1 (mg/kg)	SSL 20 (mg/kg)	GW Conc. (µg/L)
7429-90-5	Aluminum	-	-	-	3.00E+03	5.99E+04	2.00E+03
7440-36-0	Antimony (metallic)	2.71E-01	5.42E+00	6.00E+00	3.52E-02	7.04E-01	7.79E-01
7440-38-2	Arsenic, Inorganic	2.92E-01	5.84E+00	1.00E+01	1.51E-03	3.02E-02	5.17E-02
7440-39-3	Barium	8.24E+01	1.65E+03	2.00E+03	1.55E+01	3.11E+02	3.77E+02
7440-41-7	Beryllium and compounds	3.16E+00	6.32E+01	4.00E+00	1.95E+00	3.89E+01	2.46E+00
7440-42-8	Boron And Borates Only	-	-	-	1.28E+00	2.56E+01	3.99E+02
7440-43-9	Cadmium	3.76E-01	7.52E+00	5.00E+00	6.93E-02	1.39E+00	9.22E-01
16065-83-1	Chromium (III), Insoluble Salts	-	-	-	4.04E+06	8.09E+07	2.25E+03
18540-29-9	Chromium (VI)	-	-	-	6.72E-04	1.34E-02	3.50E-02
7440-47-3	Chromium (Total)[b]	1.80E+05	3.60E+06	1.00E+02	-	-	-
7440-48-4	Cobalt	-	-	-	2.71E-02	5.43E-01	6.01E-01
7440-50-8	Copper	4.58E+01	9.15E+02	1.30E+03	2.81E+00	5.62E+01	7.99E+01
16984-48-8	Fluoride	6.01E+02	1.20E+04	4.00E+03	1.20E+01	2.40E+02	7.99E+01
7439-89-6	Iron	-	-	-	3.52E+01	7.04E+02	1.40E+03
7439-92-1	Lead	1.35E+01	2.70E+02	1.50E+01	-	-	-
7439-96-5	Manganese	-	-	-	2.83E+00	5.65E+01	4.34E+01
7439-97-6	Mercury, Inorganic Salts	-	-	-	2.95E-02	5.91E-01	5.66E-01
7439-98-7	Molybdenum	-	-	-	2.02E-01	4.03E+00	9.98E+00
7440-02-0	Nickel Soluble Salts	-	-	-	2.56E+00	5.12E+01	3.92E+01
7782-49-2	Selenium	2.60E-01	5.20E+00	5.00E+01	5.19E-02	1.04E+00	9.98E+00
7440-22-4	Silver	-	-	-	7.99E-02	1.60E+00	9.41E+00
7440-28-0	Thallium (Soluble Salts)	1.42E-01	2.85E+00	2.00E+00	1.42E-03	2.84E-02	2.00E-02
N/A	Uranium (Insoluble Compounds) [c]	1.35E+01	2.70E+02	3.00E+01	2.70E+00	5.39E+01	5.99E+00
N/A	Uranium (Soluble Salts) [c]	1.35E+01	2.70E+02	3.00E+01	1.80E-01	3.60E+00	3.99E-01
7440-62-2	Vanadium and Compounds	-	-	-	8.64E+00	1.73E+02	8.64E+00
7440-66-6	Zinc and Compounds	-	-	-	3.73E+01	7.46E+02	6.00E+02
83-32-9	Acenaphthene	-	-	-	5.49E-01	1.10E+01	5.35E+01
208-96-8	Acenaphthylene[d]	-	-	-	5.49E-01	1.10E+01	5.35E+01
107-13-1	Acrylonitrile	-	-	-	1.14E-05	2.28E-04	5.23E-02
120-12-7	Anthracene	-	-	-	5.81E+00	1.16E+02	1.77E+02
71-43-2	Benzene	2.56E-03	5.12E-02	5.00E+00	2.33E-04	4.66E-03	4.55E-01
117-81-7	Bis(2-ethylhexyl)phthalate[e]	1.44E+00	2.87E+01	6.00E+00	1.33E+00	2.66E+01	5.56E+00
75-27-4	Bromodichloromethane	2.17E-02	4.34E-01	8.00E+01	3.65E-05	7.30E-04	1.34E-01
86-74-8	Carbazole	-	-	-	3.76E-02	7.51E-01	2.03E+00
56-23-5	Carbon Tetrachloride	1.94E-03	3.89E-02	5.00E+00	1.77E-04	3.54E-03	4.55E-01
67-66-3	Chloroform	2.22E-02	4.43E-01	8.00E+01	6.12E-05	1.22E-03	2.21E-01
75-71-8	Dichlorodifluoromethane (Freon-12) [e]	-	-	-	3.04E-02	6.08E-01	1.97E+01

Table A.7a. Risk-Based SSLs for Protection of RGA Groundwater for Significant COPCs at PGDP (Continued)

		SSLs for EPA MCL[a]			SSLs PGDP NALs for the Resident (See Table A.5)[a]		
CAS Number	Chemical	SSL 1 (mg/kg)	SSL 20 (mg/kg)	GW Conc. (µg/L)	SSL 1 (mg/kg)	SSL 20 (mg/kg)	GW Conc. (µg/L)
75-34-3	Dichloroethane, 1,1- [e]	-	-	-	7.82E-04	1.56E-02	2.75E+00
107-06-2	Dichloroethane, 1,2-	1.42E-03	2.84E-02	5.00E+00	4.84E-05	9.69E-04	1.71E-01
75-35-4	Dichloroethylene, 1,1-	2.51E-03	5.03E-02	7.00E+00	1.02E-02	2.04E-01	2.85E+01
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	-	-	-	4.78E-03	9.56E-02	1.63E+01
156-59-2	Dichloroethylene, 1,2-*cis*-	2.06E-02	4.12E-01	7.00E+01	1.06E-03	2.12E-02	3.61E+00
156-60-5	Dichloroethylene, 1,2-*trans*-	3.13E-02	6.27E-01	1.00E+02	2.91E-03	5.83E-02	9.29E+00
60-57-1	Dieldrin	-	-	-	7.08E-05	1.42E-03	1.75E-03
1746-01-6	Dioxins/Furans, Total (as TCDD)[f]	1.50E-05	2.99E-04	3.00E-05	5.91E-08	1.18E-06	1.19E-07
37871-00-4	~HpCDD, 2,3,7,8-	-	-	-	2.75E-05	5.51E-04	1.19E-05
38998-75-3	~HpCDF, 2,3,7,8-	-	-	-	1.54E-05	3.08E-04	1.19E-05
34465-46-8	~HxCDD	-	-	-	8.33E-06	1.67E-04	5.99E-06
55684-94-1	~HxCDF, 2,3,7,8-	-	-	-	4.76E-06	9.52E-05	5.99E-06
3268-87-9	~OCDD	-	-	-	7.75E-03	1.55E-01	2.00E-03
39001-02-0	~OCDF	-	-	-	4.34E-03	8.68E-02	2.00E-03
36088-22-9	~PeCDD, 2,3,7,8-	-	-	-	5.19E-07	1.04E-05	5.99E-07
57117-41-6	~PeCDF, 1,2,3,7,8-	-	-	-	9.31E-06	1.86E-04	2.00E-05
57117-31-4	~PeCDF, 2,3,4,7,8-	-	-	-	9.31E-07	1.86E-05	2.00E-06
1746-01-6	~TCDD, 2,3,7,8-	1.50E-05	2.99E-04	3.00E-05	5.91E-08	1.18E-06	1.19E-07
51207-31-9	~TCDF, 2,3,7,8-	-	-	-	3.31E-07	6.62E-06	1.19E-06
100-41-4	Ethylbenzene	7.85E-01	1.57E+01	7.00E+02	1.68E-03	3.36E-02	1.50E+00
206-44-0	Fluoranthene	-	-	-	8.91E+00	1.78E+02	8.02E+01
86-73-7	Fluorene	-	-	-	5.45E-01	1.09E+01	2.94E+01
118-74-1	Hexachlorobenzene	1.26E-02	2.52E-01	1.00E+00	1.23E-04	2.46E-03	9.76E-03
91-20-3	Naphthalene	-	-	-	5.43E-04	1.09E-02	1.65E-01
88-74-4	Nitroaniline, 2-	-	-	-	8.01E-03	1.60E-01	1.89E+01
621-64-7	Nitroso-di-N-propylamine, N-	-	-	-	8.10E-06	1.62E-04	1.08E-02
87-86-5	Pentachlorophenol	1.38E-03	2.77E-02	1.00E+00	5.71E-05	1.14E-03	4.13E-02
85-01-8	Phenanthrene[d]	-	-	-	5.49E-01	1.10E+01	5.35E+01
1336-36-3	Polychlorinated Biphenyls, Total	7.82E-02	1.56E+00	5.00E-01	6.82E-03	1.36E-01	4.36E-02
12674-11-2	~Aroclor 1016	-	-	-	1.34E-02	2.68E-01	1.40E-01
11104-28-2	~Aroclor 1221	-	-	-	8.00E-05	1.60E-03	4.71E-03
11141-16-5	~Aroclor 1232	-	-	-	8.00E-05	1.60E-03	4.71E-03
53469-21-9	~Aroclor 1242	-	-	-	1.23E-03	2.45E-02	7.85E-03
12672-29-6	~Aroclor 1248	-	-	-	1.20E-03	2.41E-02	7.85E-03
11097-69-1	~Aroclor 1254	-	-	-	2.05E-03	4.10E-02	7.85E-03
11096-82-5	~Aroclor 1260	-	-	-	5.49E-03	1.10E-01	7.85E-03

Table A.7a. Risk-Based SSLs for Protection of RGA Groundwater for Significant COPCs at PGDP (Continued)

		SSLs for EPA MCL[a]			SSLs PGDP NALs for the Resident (See Table A.5)[a]		
CAS Number	Chemical	SSL 1 (mg/kg)	SSL 20 (mg/kg)	GW Conc. (µg/L)	SSL 1 (mg/kg)	SSL 20 (mg/kg)	GW Conc. (µg/L)
50-32-8	Polycyclic aromatic hydrocarbons, Total Carcinogenic[g]	2.35E-01	4.70E+00	2.00E-01	2.94E-02	5.89E-01	2.51E-02
56-55-3	~Benz[a]anthracene	-	-	-	1.05E-02	2.11E-01	2.98E-02
50-32-8	~Benzo[a]pyrene	2.35E-01	4.70E+00	2.00E-01	2.94E-02	5.89E-01	2.51E-02
205-99-2	~Benzo[b]fluoranthene	-	-	-	3.00E-01	6.01E+00	2.51E-01
207-08-9	~Benzo[k]fluoranthene	-	-	-	2.94E+00	5.89E+01	2.51E+00
218-01-9	~Chrysene	-	-	-	9.05E+00	1.81E+02	2.51E+01
53-70-3	~Dibenz[a,h]anthracene	-	-	-	9.58E-02	1.92E+00	2.51E-02
193-39-5	~Indeno[1,2,3-cd]pyrene	-	-	-	9.78E-01	1.96E+01	2.51E-01
129-00-0	Pyrene	-	-	-	1.32E+00	2.63E+01	1.21E+01
127-18-4	Tetrachloroethylene	2.27E-03	4.55E-02	5.00E+00	1.84E-03	3.69E-02	4.06E+00
108-88-3	Toluene [e]	6.92E-01	1.38E+01	1.00E+03	7.62E-02	1.52E+00	1.10E+02
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113) [e]	-	-	-	2.56E+00	5.13E+01	1.02E+03
71-55-6	Trichloroethane, 1,1,1-	7.01E-02	1.40E+00	2.00E+02	2.81E-01	5.62E+00	8.01E+02
79-00-5	Trichloroethane, 1,1,2-	1.62E-03	3.24E-02	5.00E+00	1.35E-05	2.69E-04	4.15E-02
79-01-6	Trichloroethylene	1.79E-03	3.57E-02	5.00E+00	1.01E-04	2.02E-03	2.83E-01
75-01-4	Vinyl Chloride	6.90E-04	1.38E-02	2.00E+00	6.47E-06	1.29E-04	1.88E-02
108-38-3	Xylene, m-	-	-	-	1.88E-02	3.77E-01	1.93E+01
95-47-6	Xylene, o-	-	-	-	1.91E-02	3.81E-01	1.93E+01
106-42-3	Xylene, p-	-	-	-	1.89E-02	3.77E-01	1.93E+01
1330-20-7	Xylene, Mixture	9.90E+00	1.98E+02	1.00E+04	1.91E-02	3.82E-01	1.93E+01

[a] Values in this table for SSLs of 1 and 20 were calculated using the Risk Assessment Information System (RAIS) in October 2018 located at the Web site http://rais.ornl.gov/cgi-bin/prg/PRG_search?select=chem. Prior to using the values in this table in a quantitative risk assessment, a risk assessor must be consulted to determine if any values need to be updated and to verify that the values are being used appropriately. SSL 1 indicates the soil screening level calculated for a DAF of 1. SSL 20 indicates the soil screening level calculated for a DAF of 20. The appropriate DAF is calculated on a project-specific basis, additional information is provided in Appendix E of this document.
[b] Chromium (Total) should utilizes chromium III or chromium VI, as appropriate. See list of screening levels note 9b (on page A-4).
[c] Based on recommendation from EPA 2016, SSLs for uranium (soluble salts) now use the RfD for uranium derived from ATSDR. The RfD for uranium available in IRIS has been added as uranium (insoluble compounds).
[d] Values for acenaphthylene and phenanthrene use values for acenaphthene, as a surrogate.
[e] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support. SSLs for other COPCs can be derived using similar methods as needed.
[f] Total dioxins/furans uses values for 2,3,7,8-TCDD, see list of screening levels note 9f (on page A-5).
[g] Total carcinogenic PAHs use values for BaP, see screening note 9d (page A-4).
Note: Default parameters from RAIS used are as follows:

Fraction organic carbon in soil (unitless)	0.002
Water-filled soil porosity (Lwater/Lsoil)	0.3
Dry soil bulk density (kg/L)	1.5
Soil particle density (kg/L)	2.65

Table A.7b. Risk-Based SSLs for Protection of RGA Groundwater for Radionuclide COPCs at PGDP

(Values calculated in October 2018 and are based on best available information.)

			Resident SSL 1		Resident SSL 20	
Parameter	**Radionuclide**	**Units**	**10^{-6}**	**10^{-4}**	**10^{-6}**	**10^{-4}**
14596-10-2	Americium-241	pCi/g	9.58E-01	9.58E+01	1.92E+01	1.92E+03
10045-97-3	Cesium-137+D	pCi/g	4.79E-01	4.79E+01	9.58E+00	9.58E+02
13994-20-2	Neptunium-237+D	pCi/g	5.36E-02	5.36E+00	1.07E+00	1.07E+02
13981-16-3	Plutonium-238	pCi/g	2.19E-01	2.19E+01	4.38E+00	4.38E+02
15117-48-3	Plutonium-239	pCi/g	2.13E-01	2.13E+01	4.26E+00	4.26E+02
14119-33-6	Plutonium-240	pCi/g	2.13E-01	2.13E+01	4.26E+00	4.26E+02
14133-76-7	Technetium-99	pCi/g	7.60E-03	7.60E-01	1.52E-01	1.52E+01
14269-63-7	Thorium-230	pCi/g	1.83E+00	1.83E+02	3.66E+01	3.66E+03
13966-29-5	Uranium-234	pCi/g	4.95E-02	4.95E+00	9.90E-01	9.90E+01
15117-96-1	Uranium-235+D	pCi/g	4.88E-02	4.88E+00	9.76E-01	9.76E+01
7440-61-1	Uranium-238+D	pCi/g	4.03E-02	4.03E+00	8.05E-01	8.05E+01

Values in this table for SSLs of 1 and 20 were calculated using the best available information in October 2018. Prior to using the values in this table (in a quantitative risk assessment), a risk assessor must be consulted to determine if any values need to be updated, and to verify that the values are being used appropriately.

SSLs calculated using the formula PRG*DAF*(K_d+(θ / ρ))/1,000 (EPA 2000).

Where

PRG is the no action limit (for the 10^{-6} column) or action level (for the 10^{-4} column) for the resident (see Tables A.5 and A.2, respectively)

DAF is the dilution attenuation factor set at 1 and 20

K_d is the chemical-specific distribution coefficient (see below).

θ is the porosity set at 0.3

ρ is the density set at 1.5

K_d values and their references are the following:

Radionuclide	**K_d**	**Reference**
Americium-241	1.90E+03	DOE 2012
Cesium-137+D	2.80E+02	DOE 2012
Neptunium-237+D	7.00E+01	DOE 2003
Plutonium-238	5.50E+02	DOE 2003
Plutonium-239	5.50E+02	DOE 2003
Plutonium-240	5.50E+02	DOE 2003
Technetium-99	2.00E-01	DOE 2003
Thorium-230	3.20E+03	DOE 2003
Uranium-234	6.68E+01	DOE 2003
Uranium-235+D	6.68E+01	DOE 2003
Uranium-238+D	6.68E+01	DOE 2003

Table A.8. Dose-Based Soil/Sediment Screening Levels for Site-Related Radionuclides at PGDP
(Values were calculated in November 2017 and are based on best available information.)

			Outdoor Worker			
Parameter	**Radionuclide**	**Units**	**1 mrem/yr**	**12 mrem/yr**	**25 mrem/yr**	**100 mrem/yr**
14596-10-2	Americium-241	pCi/g	1.37E+01	1.65E+02	3.43E+02	1.37E+03
10045-97-3	Cesium-137+D	pCi/g	2.17E+00	2.60E+01	5.42E+01	2.17E+02
13994-20-2	Neptunium-237+D	pCi/g	5.75E+00	6.90E+01	1.44E+02	5.75E+02
13981-16-3	Plutonium-238	pCi/g	1.28E+01	1.54E+02	3.20E+02	1.28E+03
15117-48-3	Plutonium-239	pCi/g	1.18E+01	1.41E+02	2.95E+02	1.18E+03
14119-33-6	Plutonium-240	pCi/g	1.18E+01	1.42E+02	2.95E+02	1.18E+03
14133-76-7	Technetium-99	pCi/g	4.44E+03	5.32E+04	1.11E+05	4.44E+05
14269-63-7	Thorium-230	pCi/g	1.40E+01	1.68E+02	3.50E+02	1.40E+03
13966-29-5	Uranium-234	pCi/g	6.12E+01	7.35E+02	1.53E+03	6.12E+03
15117-96-1	Uranium-235+D	pCi/g	9.15E+00	1.10E+02	2.29E+02	9.15E+02
7440-61-1	Uranium-238+D	pCi/g	3.10E+01	3.72E+02	7.74E+02	3.10E+03
			Excavation Worker			
Parameter	**Radionuclide**	**Units**	**1 mrem/yr**	**12 mrem/yr**	**25 mrem/yr**	**100 mrem/yr**
14596-10-2	Americium-241	pCi/g	1.37E+01	1.65E+02	3.43E+02	1.37E+03
10045-97-3	Cesium-137+D	pCi/g	2.17E+00	2.60E+01	5.42E+01	2.17E+02
13994-20-2	Neptunium-237+D	pCi/g	5.75E+00	6.90E+01	1.44E+02	5.75E+02
13981-16-3	Plutonium-238	pCi/g	1.28E+01	1.54E+02	3.20E+02	1.28E+03
15117-48-3	Plutonium-239	pCi/g	1.18E+01	1.41E+02	2.95E+02	1.18E+03
14119-33-6	Plutonium-240	pCi/g	1.18E+01	1.42E+02	2.95E+02	1.18E+03
14133-76-7	Technetium-99	pCi/g	4.44E+03	5.32E+04	1.11E+05	4.44E+05
14269-63-7	Thorium-230	pCi/g	1.40E+01	1.68E+02	3.50E+02	1.40E+03
13966-29-5	Uranium-234	pCi/g	6.12E+01	7.35E+02	1.53E+03	6.12E+03
15117-96-1	Uranium-235+D	pCi/g	9.15E+00	1.10E+02	2.29E+02	9.15E+02
7440-61-1	Uranium-238+D	pCi/g	3.10E+01	3.72E+02	7.74E+02	3.10E+03
			Industrial Worker			
Parameter	**Radionuclide**	**Units**	**1 mrem/yr**	**12 mrem/yr**	**25 mrem/yr**	**100 mrem/yr**
14596-10-2	Americium-241	pCi/g	5.29E+01	6.35E+02	1.32E+03	5.29E+03
10045-97-3	Cesium-137+D	pCi/g	1.62E+00	1.94E+01	4.05E+01	1.62E+02
13994-20-2	Neptunium-237+D	pCi/g	5.23E+00	6.28E+01	1.31E+02	5.23E+02
13981-16-3	Plutonium-238	pCi/g	7.17E+01	8.61E+02	1.79E+03	7.17E+03
15117-48-3	Plutonium-239	pCi/g	6.58E+01	7.90E+02	1.65E+03	6.58E+03
14119-33-6	Plutonium-240	pCi/g	6.59E+01	7.91E+02	1.65E+03	6.59E+03
14133-76-7	Technetium-99	pCi/g	2.00E+04	2.40E+05	5.01E+05	2.00E+06
14269-63-7	Thorium-230	pCi/g	7.76E+01	9.31E+02	1.94E+03	7.76E+03
13966-29-5	Uranium-234	pCi/g	3.84E+02	4.60E+03	9.59E+03	3.84E+04
15117-96-1	Uranium-235+D	pCi/g	7.76E+00	9.31E+01	1.94E+02	7.76E+02
7440-61-1	Uranium-238+D	pCi/g	4.10E+01	4.92E+02	1.02E+03	4.10E+03

Table A.8. Dose-Based Soil/Sediment Screening Levels for Site-Related Radionuclides at PGDP (Continued)

Parameter	Radionuclide	Units	Adult Recreator			
			1 mrem/yr	12 mrem/yr	25 mrem/yr	100 mrem/yr
14596-10-2	Americium-241	pCi/g	9.61E+01	1.15E+03	2.40E+03	9.61E+03
10045-97-3	Cesium-137+D	pCi/g	4.97E+00	5.97E+01	1.24E+02	4.97E+02
13994-20-2	Neptunium-237+D	pCi/g	1.55E+01	1.86E+02	3.88E+02	1.55E+03
13981-16-3	Plutonium-238	pCi/g	1.06E+02	1.27E+03	2.65E+03	1.06E+04
15117-48-3	Plutonium-239	pCi/g	9.75E+01	1.17E+03	2.44E+03	9.75E+03
14119-33-6	Plutonium-240	pCi/g	9.76E+01	1.17E+03	2.44E+03	9.76E+03
14133-76-7	Technetium-99	pCi/g	3.21E+04	3.85E+05	8.02E+05	3.21E+06
14269-63-7	Thorium-230	pCi/g	1.15E+02	1.39E+03	2.89E+03	1.15E+04
13966-29-5	Uranium-234	pCi/g	5.12E+02	6.15E+03	1.28E+04	5.12E+04
15117-96-1	Uranium-235+D	pCi/g	2.33E+01	2.79E+02	5.82E+02	2.33E+03
7440-61-1	Uranium-238+D	pCi/g	1.11E+02	1.33E+03	2.77E+03	1.11E+04

Parameter	Radionuclide	Units	Child Recreator			
			1 mrem/yr	12 mrem/yr	25 mrem/yr	100 mrem/yr
14596-10-2	Americium-241	pCi/g	3.15E+01	3.78E+02	7.87E+02	3.15E+03
10045-97-3	Cesium-137+D	pCi/g	3.69E+00	4.43E+01	9.22E+01	3.69E+02
13994-20-2	Neptunium-237+D	pCi/g	1.04E+01	1.25E+02	2.61E+02	1.04E+03
13981-16-3	Plutonium-238	pCi/g	3.01E+01	3.62E+02	7.53E+02	3.01E+03
15117-48-3	Plutonium-239	pCi/g	2.84E+01	3.41E+02	7.10E+02	2.84E+03
14119-33-6	Plutonium-240	pCi/g	2.84E+01	3.41E+02	7.10E+02	2.84E+03
14133-76-7	Technetium-99	pCi/g	4.05E+03	4.86E+04	1.01E+05	4.05E+05
14269-63-7	Thorium-230	pCi/g	3.01E+01	3.61E+02	7.52E+02	3.01E+03
13966-29-5	Uranium-234	pCi/g	1.08E+02	1.29E+03	2.69E+03	1.08E+04
15117-96-1	Uranium-235+D	pCi/g	1.55E+01	1.86E+02	3.89E+02	1.55E+03
7440-61-1	Uranium-238+D	pCi/g	5.17E+01	6.21E+02	1.29E+03	5.17E+03

Parameter	Radionuclide	Units	Teen Recreator			
			1 mrem/yr	12 mrem/yr	25 mrem/yr	100 mrem/yr
14596-10-2	Americium-241	pCi/g	7.16E+01	8.59E+02	1.79E+03	7.16E+03
10045-97-3	Cesium-137+D	pCi/g	3.69E+00	4.43E+01	9.23E+01	3.69E+02
13994-20-2	Neptunium-237+D	pCi/g	1.15E+01	1.38E+02	2.88E+02	1.15E+03
13981-16-3	Plutonium-238	pCi/g	8.26E+01	9.92E+02	2.07E+03	8.26E+03
15117-48-3	Plutonium-239	pCi/g	7.56E+01	9.08E+02	1.89E+03	7.56E+03
14119-33-6	Plutonium-240	pCi/g	7.57E+01	9.09E+02	1.89E+03	7.57E+03
14133-76-7	Technetium-99	pCi/g	1.95E+04	2.34E+05	4.88E+05	1.95E+06
14269-63-7	Thorium-230	pCi/g	8.22E+01	9.86E+02	2.05E+03	8.22E+03
13966-29-5	Uranium-234	pCi/g	2.54E+02	3.05E+03	6.36E+03	2.54E+04
15117-96-1	Uranium-235+D	pCi/g	1.69E+01	2.03E+02	4.24E+02	1.69E+03
7440-61-1	Uranium-238+D	pCi/g	7.50E+01	9.00E+02	1.88E+03	7.50E+03

Table A.8. Dose-Based Soil/Sediment Screening Levels for Site-Related Radionuclides at PGDP (Continued)

			Adult Resident			
Parameter	Radionuclide	Units	1 mrem/yr	12 mrem/yr	25 mrem/yr	100 mrem/yr
14596-10-2	Americium-241	pCi/g	2.00E+01	2.40E+02	5.00E+02	2.00E+03
10045-97-3	Cesium-137+D	pCi/g	5.14E-01	6.17E+00	1.28E+01	5.14E+01
13994-20-2	Neptunium-237+D	pCi/g	1.68E+00	2.01E+01	4.19E+01	1.68E+02
13981-16-3	Plutonium-238	pCi/g	3.04E+01	3.65E+02	7.60E+02	3.04E+03
15117-48-3	Plutonium-239	pCi/g	2.79E+01	3.35E+02	6.97E+02	2.79E+03
14119-33-6	Plutonium-240	pCi/g	2.79E+01	3.35E+02	6.99E+02	2.79E+03
14133-76-7	Technetium-99	pCi/g	6.85E+03	8.22E+04	1.71E+05	6.85E+05
14269-63-7	Thorium-230	pCi/g	3.27E+01	3.92E+02	8.17E+02	3.27E+03
13966-29-5	Uranium-234	pCi/g	1.47E+02	1.77E+03	3.68E+03	1.47E+04
15117-96-1	Uranium-235+D	pCi/g	2.47E+00	2.97E+01	6.18E+01	2.47E+02
7440-61-1	Uranium-238+D	pCi/g	1.32E+01	1.59E+02	3.31E+02	1.32E+03

			Child Resident			
Parameter	Radionuclide	Units	1 mrem/yr	12 mrem/yr	25 mrem/yr	100 mrem/yr
14596-10-2	Americium-241	pCi/g	1.06E+01	1.27E+02	2.64E+02	1.06E+03
10045-97-3	Cesium-137+D	pCi/g	5.14E-01	6.16E+00	1.28E+01	5.14E+01
13994-20-2	Neptunium-237+D	pCi/g	1.61E+00	1.94E+01	4.03E+01	1.61E+02
13981-16-3	Plutonium-238	pCi/g	1.18E+01	1.42E+02	2.96E+02	1.18E+03
15117-48-3	Plutonium-239	pCi/g	1.11E+01	1.34E+02	2.79E+02	1.11E+03
14119-33-6	Plutonium-240	pCi/g	1.12E+01	1.34E+02	2.79E+02	1.12E+03
14133-76-7	Technetium-99	pCi/g	1.52E+03	1.82E+04	3.79E+04	1.52E+05
14269-63-7	Thorium-230	pCi/g	1.18E+01	1.41E+02	2.94E+02	1.18E+03
13966-29-5	Uranium-234	pCi/g	4.25E+01	5.10E+02	1.06E+03	4.25E+03
15117-96-1	Uranium-235+D	pCi/g	2.38E+00	2.85E+01	5.94E+01	2.38E+02
7440-61-1	Uranium-238+D	pCi/g	1.07E+01	1.28E+02	2.67E+02	1.07E+03

Values in this table were calculated using the best available information in November 2017. Prior to using the values in this table (in a quantitative risk assessment), a risk assessor must be consulted to determine if any values need to be updated, and to verify that the values are being used appropriately. Screening levels are based on dose conversion factors from ICRP 72 and ICRP 60 (See Table B.3).

Screening Value = $[\Sigma 1/(\text{Pathway-Specific Action Levels})]^{-1}$

Pathways include ingestion, inhalation, and external gamma. (See Table B.4 for exposure parameters.)

Table A.9. Dose-Based Groundwater Screening Levels for Site-Related Radionuclides at PGDP
(Values were calculated in November 2017 and are based on best available information.)

			Adult Resident				
			1	4	12	25	100
Parameter	**Radionuclide**	**Units**	**mrem/yr**	**mrem/yr**	**mrem/yr**	**mrem/yr**	**mrem/yr**
14596-10-2	Americium-241	pCi/L	1.54E+00	6.18E+00	1.85E+01	3.86E+01	1.54E+02
10045-97-3	Cesium-137+D	pCi/L	2.38E+01	9.50E+01	2.85E+02	5.94E+02	2.38E+03
13994-20-2	Neptunium-237+D	pCi/L	2.79E+00	1.11E+01	3.34E+01	6.97E+01	2.79E+02
13981-16-3	Plutonium-238	pCi/L	1.34E+00	5.37E+00	1.61E+01	3.36E+01	1.34E+02
15117-48-3	Plutonium-239	pCi/L	1.24E+00	4.94E+00	1.48E+01	3.09E+01	1.24E+02
14119-33-6	Plutonium-240	pCi/L	1.24E+00	4.94E+00	1.48E+01	3.09E+01	1.24E+02
14133-76-7	Technetium-99	pCi/L	4.82E+02	1.93E+03	5.79E+03	1.21E+04	4.82E+04
14269-63-7	Thorium-230	pCi/L	1.47E+00	5.88E+00	1.77E+01	3.68E+01	1.47E+02
13966-29-5	Uranium-234	pCi/L	6.31E+00	2.53E+01	7.58E+01	1.58E+02	6.31E+02
15117-96-1	Uranium-235+D	pCi/L	6.53E+00	2.61E+01	7.84E+01	1.63E+02	6.53E+02
7440-61-1	Uranium-238+D	pCi/L	6.38E+00	2.55E+01	7.66E+01	1.60E+02	6.38E+02

			Child Resident				
			1	4	12	25	100
Parameter	**Radionuclide**	**Units**	**mrem/yr**	**mrem/yr**	**mrem/yr**	**mrem/yr**	**mrem/yr**
14596-10-2	Americium-241	pCi/L	3.67E+00	1.47E+01	4.40E+01	9.17E+01	3.67E+02
10045-97-3	Cesium-137+D	pCi/L	1.03E+02	4.13E+02	1.24E+03	2.58E+03	1.03E+04
13994-20-2	Neptunium-237+D	pCi/L	6.91E+00	2.76E+01	8.29E+01	1.73E+02	6.91E+02
13981-16-3	Plutonium-238	pCi/L	3.19E+00	1.27E+01	3.82E+01	7.96E+01	3.19E+02
15117-48-3	Plutonium-239	pCi/L	3.00E+00	1.20E+01	3.60E+01	7.51E+01	3.00E+02
14119-33-6	Plutonium-240	pCi/L	3.00E+00	1.20E+01	3.60E+01	7.51E+01	3.00E+02
14133-76-7	Technetium-99	pCi/L	4.30E+02	1.72E+03	5.17E+03	1.08E+04	4.30E+04
14269-63-7	Thorium-230	pCi/L	3.19E+00	1.27E+01	3.82E+01	7.96E+01	3.19E+02
13966-29-5	Uranium-234	pCi/L	1.12E+01	4.49E+01	1.35E+02	2.81E+02	1.12E+03
15117-96-1	Uranium-235+D	pCi/L	1.15E+01	4.59E+01	1.38E+02	2.87E+02	1.15E+03
7440-61-1	Uranium-238+D	pCi/L	1.06E+01	4.26E+01	1.28E+02	2.66E+02	1.06E+03

Values in this table were calculated using the best available information in November 2017. Prior to using the values in this table (in a quantitative risk assessment), a risk assessor must be consulted to determine if any values need to be updated and to verify that the values are being used appropriately.
Screening levels are based on dose conversion factors from ICRP 72 and ICRP 60 (See Table B.3).
Screening Value = $[\Sigma 1/(\text{Pathway-Specific Action Levels})]^{-1}$
Pathways include ingestion. (See Table B.4 for exposure parameters.)

Table A.10. Dose-Based Surface Water Screening Levels for Site-Related Radionuclides at PGDP

(Values calculated in November 2017 and are based on best available information.)

			Adult Recreator (swimming)				
			1	4	12	25	100
Parameter	Radionuclide	Units	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr
14596-10-2	Americium-241	pCi/L	2.31E+02	9.24E+02	2.77E+03	5.78E+03	2.31E+04
10045-97-3	Cesium-137+D	pCi/L	3.55E+03	1.42E+04	4.26E+04	8.88E+04	3.55E+05
13994-20-2	Neptunium-237+D	pCi/L	4.17E+02	1.67E+03	5.00E+03	1.04E+04	4.17E+04
13981-16-3	Plutonium-238	pCi/L	2.01E+02	8.03E+02	2.41E+03	5.02E+03	2.01E+04
15117-48-3	Plutonium-239	pCi/L	1.85E+02	7.39E+02	2.22E+03	4.62E+03	1.85E+04
14119-33-6	Plutonium-240	pCi/L	1.85E+02	7.39E+02	2.22E+03	4.62E+03	1.85E+04
14133-76-7	Technetium-99	pCi/L	7.21E+04	2.89E+05	8.66E+05	1.80E+06	7.21E+06
14269-63-7	Thorium-230	pCi/L	2.20E+02	8.80E+02	2.64E+03	5.50E+03	2.20E+04
13966-29-5	Uranium-234	pCi/L	9.44E+02	3.78E+03	1.13E+04	2.36E+04	9.44E+04
15117-96-1	Uranium-235+D	pCi/L	9.77E+02	3.91E+03	1.17E+04	2.44E+04	9.77E+04
7440-61-1	Uranium-238+D	pCi/L	9.55E+02	3.82E+03	1.15E+04	2.39E+04	9.55E+04
			Child Recreator (swimming)				
			1	4	12	25	100
Parameter	Radionuclide	Units	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr
14596-10-2	Americium-241	pCi/L	1.71E+02	6.84E+02	2.05E+03	4.28E+03	1.71E+04
10045-97-3	Cesium-137+D	pCi/L	4.82E+03	1.93E+04	5.78E+04	1.20E+05	4.82E+05
13994-20-2	Neptunium-237+D	pCi/L	3.23E+02	1.29E+03	3.87E+03	8.06E+03	3.23E+04
13981-16-3	Plutonium-238	pCi/L	1.49E+02	5.95E+02	1.78E+03	3.72E+03	1.49E+04
15117-48-3	Plutonium-239	pCi/L	1.40E+02	5.60E+02	1.68E+03	3.50E+03	1.40E+04
14119-33-6	Plutonium-240	pCi/L	1.40E+02	5.60E+02	1.68E+03	3.50E+03	1.40E+04
14133-76-7	Technetium-99	pCi/L	2.01E+04	8.03E+04	2.41E+05	5.02E+05	2.01E+06
14269-63-7	Thorium-230	pCi/L	1.49E+02	5.95E+02	1.78E+03	3.72E+03	1.49E+04
13966-29-5	Uranium-234	pCi/L	5.24E+02	2.10E+03	6.29E+03	1.31E+04	5.24E+04
15117-96-1	Uranium-235+D	pCi/L	5.36E+02	2.14E+03	6.43E+03	1.34E+04	5.36E+04
7440-61-1	Uranium-238+D	pCi/L	4.97E+02	1.99E+03	5.96E+03	1.24E+04	4.97E+04
			Teen Recreator (swimming)				
			1	4	12	25	100
Parameter	Radionuclide	Units	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr
14596-10-2	Americium-241	pCi/L	2.31E+02	9.24E+02	2.77E+03	5.78E+03	2.31E+04
10045-97-3	Cesium-137+D	pCi/L	3.55E+03	1.42E+04	4.26E+04	8.88E+04	3.55E+05
13994-20-2	Neptunium-237+D	pCi/L	4.16E+02	1.66E+03	4.99E+03	1.04E+04	4.16E+04
13981-16-3	Plutonium-238	pCi/L	2.10E+02	8.40E+02	2.52E+03	5.25E+03	2.10E+04
15117-48-3	Plutonium-239	pCi/L	1.93E+02	7.70E+02	2.31E+03	4.81E+03	1.93E+04
14119-33-6	Plutonium-240	pCi/L	1.93E+02	7.70E+02	2.31E+03	4.81E+03	1.93E+04
14133-76-7	Technetium-99	pCi/L	5.64E+04	2.26E+05	6.77E+05	1.41E+06	5.64E+06
14269-63-7	Thorium-230	pCi/L	2.10E+02	8.40E+02	2.52E+03	5.25E+03	2.10E+04
13966-29-5	Uranium-234	pCi/L	6.24E+02	2.50E+03	7.49E+03	1.56E+04	6.24E+04
15117-96-1	Uranium-235+D	pCi/L	6.55E+02	2.62E+03	7.86E+03	1.64E+04	6.55E+04
7440-61-1	Uranium-238+D	pCi/L	6.50E+02	2.60E+03	7.80E+03	1.62E+04	6.50E+04

Values in this table were calculated using the best available information in November 2017. Prior to using the values in this table (in a quantitative risk assessment), a risk assessor must be consulted to determine if any values need to be updated and to verify that the values are being used appropriately.

Screening levels are based on dose conversion factors from ICRP 72 and ICRP 60 (See Table B.3).

Screening Value = $[\Sigma 1/(\text{Pathway-Specific Action Levels})]^{-1}$

Pathways include ingestion. (See Table B.4 for exposure parameters.)

Table A.11. Dose-Based SSLs for Protection of RGA Groundwater for Site-Related Radionuclides at PGDP
(Values calculated in November 2017 and are based on best available information.)

			SSL 1				
Parameter	**Radionuclide**	**Units**	**1 mrem/yr**	**4 mrem/yr**	**12 mrem/yr**	**25 mrem/yr**	**100 mrem/yr**
14596-10-2	Americium-241	pCi/g	2.93E+00	1.17E+01	3.52E+01	7.33E+01	2.93E+02
10045-97-3	Cesium-137+D	pCi/g	6.67E+00	2.66E+01	7.99E+01	1.66E+02	6.67E+02
13994-20-2	Neptunium-237+D	pCi/g	1.96E-01	7.79E-01	2.34E+00	4.89E+00	1.96E+01
13981-16-3	Plutonium-238	pCi/g	7.37E-01	2.95E+00	8.86E+00	1.85E+01	7.37E+01
15117-48-3	Plutonium-239	pCi/g	6.82E-01	2.72E+00	8.14E+00	1.70E+01	6.82E+01
14119-33-6	Plutonium-240	pCi/g	6.82E-01	2.72E+00	8.14E+00	1.70E+01	6.82E+01
14133-76-7	Technetium-99	pCi/g	1.93E-01	7.72E-01	2.32E+00	4.84E+00	1.93E+01
14269-63-7	Thorium-230	pCi/g	4.70E+00	1.88E+01	5.66E+01	1.18E+02	4.70E+02
13966-29-5	Uranium-234	pCi/g	4.23E-01	1.70E+00	5.08E+00	1.06E+01	4.23E+01
15117-96-1	Uranium-235+D	pCi/g	4.38E-01	1.75E+00	5.25E+00	1.09E+01	4.38E+01
7440-61-1	Uranium-238+D	pCi/g	4.27E-01	1.71E+00	5.13E+00	1.07E+01	4.27E+01

			SSL 20				
Parameter	**Radionuclide**	**Units**	**1 mrem/yr**	**4 mrem/yr**	**12 mrem/yr**	**25 mrem/yr**	**100 mrem/yr**
14596-10-2	Americium-241	pCi/g	5.85E+01	2.35E+02	7.03E+02	1.47E+03	5.85E+03
10045-97-3	Cesium-137+D	pCi/g	1.33E+02	5.32E+02	1.60E+03	3.33E+03	1.33E+04
13994-20-2	Neptunium-237+D	pCi/g	3.92E+00	1.56E+01	4.69E+01	9.79E+01	3.92E+02
13981-16-3	Plutonium-238	pCi/g	1.47E+01	5.91E+01	1.77E+02	3.70E+02	1.47E+03
15117-48-3	Plutonium-239	pCi/g	1.36E+01	5.44E+01	1.63E+02	3.40E+02	1.36E+03
14119-33-6	Plutonium-240	pCi/g	1.36E+01	5.44E+01	1.63E+02	3.40E+02	1.36E+03
14133-76-7	Technetium-99	pCi/g	3.86E+00	1.54E+01	4.63E+01	9.68E+01	3.86E+02
14269-63-7	Thorium-230	pCi/g	9.41E+01	3.76E+02	1.13E+03	2.36E+03	9.41E+03
13966-29-5	Uranium-234	pCi/g	8.46E+00	3.39E+01	1.02E+02	2.12E+02	8.46E+02
15117-96-1	Uranium-235+D	pCi/g	8.75E+00	3.50E+01	1.05E+02	2.18E+02	8.75E+02
7440-61-1	Uranium-238+D	pCi/g	8.55E+00	3.42E+01	1.03E+02	2.14E+02	8.55E+02

Values in this table were calculated using the best available information in November 2017 following the methods shown in Table A.7b and the values presented in Table A.9 for the Adult Resident. SSL 1 indicates the soil screening level calculated for a DAF of 1. SSL 20 indicates the soil screening level calculated for a DAF of 20.

Table A.12. Background Concentrations for Surface and Subsurface Soil at PGDP

Background Levels of Selected Radionuclides and Metals in Soil and Geologic Media at the Paducah Gaseous Diffusion Plant **(DOE 1997)**

Analyte	Background Value[b]	
	Surface	Subsurface
Inorganic Chemicals (mg/kg)[a]		
Aluminum	13,000	12,000
Antimony	0.21	0.21
Arsenic	12	7.9
Barium	200	170
Beryllium	0.67	0.69
Cadmium	0.21	0.21
Calcium	200,000	6,100
Chromium (III)	16	43
Chromium (VI)[d]	---	---
Cobalt	14	13
Copper	19	25
Cyanide (CN-)[c]	---	---
Iron	28,000	28,000
Lead	36	23
Magnesium	7,700	2,100
Manganese	1,500	820
Mercury	0.2	0.13
Nickel	21	22
Potassium	1,300	950
Selenium	0.8	0.7
Silver	2.3	2.7
Sodium	320	340
Sulfide[d]	---	---
Thallium	0.21	0.34
Tin[d]	---	---
Uranium	4.9	4.6
Vanadium	38	37
Zinc	65	60
Radionuclide (pCi/g)		
Cesium-137	0.49	0.28
Neptunium-237[e]	0.1	---
Plutonium-238[e]	0.073	---
Plutonium-239[e]	0.025	---
Potassium-40	16	16
Radium-226	1.5	1.5
Strontium-90[e]	4.7	---
Technetium-99	2.5	2.8
Thorium-228	1.6	1.6
Thorium-230	1.5	1.4
Thorium-232	1.5	1.5
Uranium-234	1.2[f]	1.2[f]
Uranium-235	0.06[f]	0.06[f]
Uranium-238	1.2	1.2

Notes: Cells with "---" indicate data are not available or not applicable.

Values contained in this table have not been approved for all uses by the PGDP Risk Assessment Working Group; therefore, the values presented here are provisional values and subject to change.

[a] Includes inorganic chemicals found on Target Analyte List as defined by EPA in 1988 CLP Statement of Work and RCRA Appendix IX list of constituents.

[b] Value for use in screening to determine if inorganic chemical or radionuclide detected at naturally occurring concentration in surface or subsurface soil. Details on the derivation of the background concentrations for antimony, beryllium, cadmium, thallium, uranium, and all radionuclides are in DOE 1997. Details on the derivation of the background concentration for all other inorganic chemicals are in DOE 1996.

[c] Cyanide is not expected to be naturally occurring in soil at PGDP; background values were not derived.

[d] Data are not adequate to calculate a background concentration in soil for this analyte.

[e] Concentrations for these radionuclides in subsurface soil were not derived.

[f] The values listed for uranium-234 and uranium-235 are not from the 1996 background study, but are derived from the natural isotopic abundance ratio and the uranium-238 values. The values for these radionuclides that appeared in the 2001 version of the Risk Methods Document (DOE 2001) were the UTLs of measured values for the individual isotopes as reported in the PGDP background study (DOE 1997).

Table A.13. Background Concentrations for Groundwater Drawn from the RGA and McNairy Formation at PGDP

Background Concentrations of Naturally Occurring Inorganic Chemicals and Selected Radionuclides in the Regional Gravel Aquifer and McNairy Formation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky **in** ***Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Volume 5*** **(DOE 2000)**

Analyte	Over All Observations*		Over Wells*		Comparison Value	
	RGA	McNairy	RGA	McNairy		
Inorganic Chemicals (µg/L)						
Aluminum	2,189	687	1,640	750	2,000	NAL[b]
Aluminum, Dissolved	311	579	201	587	2,000	NAL[b]
Antimony	60[a]	60[a]	60[a]	60[a]	6	MCL[c]
Antimony, Dissolved	60[a]	60[a]	60[a]	60[a]	6	MCL[c]
Arsenic	5[a]	5[a]	5[a]	5[a]	10	MCL[c]
Arsenic, Dissolved	5[a]	5[a]	5[a]	5[a]	10	MCL[c]
Barium	235	296	202	265	2,000	MCL[c]
Barium, Dissolved	200	268	179	266	2,000	MCL[c]
Beryllium	4[a]	17[a]	4[a]	17[a]	4	MCL[c]
Beryllium, Dissolved	4[a]	4[a]	4[a]	4[a]	4	MCL[c]
Cadmium	10[a]	10[a]	10[a]	10[a]	5	MCL[c]
Cadmium, Dissolved	10[a]	10[a]	10[a]	10[a]	5	MCL[c]
Calcium	41,238	38,858	40,000	39,470		N/A
Calcium, Dissolved	38,166	38,829	35,800	40,270		N/A
Chloride	91,021	19,708	89,200	20,230		N/A
Chromium	144	60[a]	134	60[a]	100	MCL[c]
Chromium, Dissolved	50[a]	50[a]	50[a]	50[a]	100	MCL[c]
Cobalt	45[a]	96	45[a]	72	0.60	NAL[b]
Cobalt, Dissolved	45[a]	45[a]	45[a]	45[a]	0.60	NAL[b]
Copper	36	57	34	33	1,300	MCL[c]
Copper, Dissolved	20	13[a]	18	13[a]	1,300	MCL[c]
Fluoride	270	330	245	298	4,000	MCL[c]
Iron	5,030	18,360	3,720	15,830	1,400	NAL[b]
Iron, Dissolved	267	12,372	164	9,446	1,400	NAL[b]
Lead	129	50[a]	250	50[a]	15	MCL[c]
Lead, Dissolved	98	50[a]	250	50[a]	15	MCL[c]
Magnesium	16,262	13,418	15,700	16,457		N/A
Magnesium, Dissolved	16,215	14,171	15,400	16,533		N/A
Manganese	119	941	82	729	43	NAL[b]
Manganese, Dissolved	68	894	48	682	43	NAL[b]
Mercury	0.2[a]	0.2[a]	0.2[a]	0.2[a]	2	MCL[c]
Mercury, Dissolved	0.2[a]	0.2[a]	0.2[a]	0.2[a]	2	MCL[c]
Molybdenum	50[a]	50[a]	50[a]	50[a]	10	NAL[b]
Molybdenum, Dissolved	50[a]	50[a]	50[a]	50[a]	10	NAL[b]
Nickel	682	109[a]	530[g]	109[a]	39	NAL[b]
Nickel, Dissolved	305	50[a]	305	50[a]	39	NAL[b]
Nitrate as Nitrogen	15,561	1,474	13,500	1,430	10,000	MCL[c]
Potassium	5,195	55,752	4,470	64,080		N/A
Potassium, Dissolved	4,096	51,205	3,700	58,750		N/A
Selenium	5[a]	5[a]	5[a]	5[a]	50	MCL[c]
Selenium, Dissolved	5[a]	5[a]	5[a]	5[a]	50	MCL[c]
Silica	26,401	36,000	21,100	29,400		N/A

Table A.13. Background Concentrations for Groundwater Drawn from the RGA and McNairy Formation at PGDP (Continued)

Background Concentrations of Naturally Occurring Inorganic Chemicals and Selected Radionuclides in the Regional Gravel Aquifer and McNairy Formation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky **in** ***Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Volume 5*** **(DOE 2000)**

	Over All Observations*		Over Wells*		Comparison Value	
Analyte	**RGA**	**McNairy**	**RGA**	**McNairy**		
Silver	11[a]	50[a]	11[a]	50[a]	9.4	NAL[b]
Silver, Dissolved	60[a]	50[a]	60[a]	50[a]	9.4	NAL[b]
Sodium	59,450	29,200	63,500	24,920		N/A
Sodium, Dissolved	60,433	27,980	65,700	25,900		N/A
Sulfate	19,947	28,900	19,100	27,270		N/A
Thallium	56[a]	644	56[a]	255	2	MCL[c]
Thallium, Dissolved	56[a]	56[a]	56[a]	56[a]	2	MCL[c]
Uranium	2[a]	1[a]	2[a]	1[a]	30	MCL[c]
Uranium, Dissolved	2[a]	1	2[a]	1	30	MCL[c]
Vanadium	134	126	139	119	8.6	NAL[b]
Vanadium, Dissolved	134	126	131	107	8.6	NAL[b]
Zinc	54	142	25	104	600	NAL[b]
Zinc, Dissolved	49	116	26	80	600	NAL[b]
Radionuclides (pCi/L)						
Gross Alpha	5.8	11.9	2.36	5.3		N/A
Gross Beta	13.8	144.5	7.3	125.4		N/A
Neptunium-237	0.8	0.5	0.21	0.13	15	MCL[d]
Plutonium-239	0.1	0.2	0.03	0.04	15	MCL[d]
Radium-226	0.6	1.2	0.1	0.29	5	MCL[e]
Radon-222	626	295	555.3	228.3		N/A
Technetium-99	22.3	20.6	10.8	7.8	19	NAL[b]
Thorium-230	1.1	1.5	0.54	0.4	15	MCL[d]
Total Radium	1.3	0.7	0.46	0.36	5	MCL[e]
Uranium-234[f]	0.7	0.3	0.7	0.3	0.74	NAL[b]
Uranium-235[f]	0.3	0.2	0.3	0.2	0.73	NAL[b]
Uranium-238[f]	0.7	0.3	0.7	0.3	0.60	NAL[b]

Values contained in this table have not been approved for all uses by the PGDP Risk Assessment Working Group; therefore, the values presented here are provisional values and subject to change. The issues to be resolved are the data set from which these values were derived and the statistical methods used to analyze the data set.

*For inorganic chemicals, background concentrations were derived for both total and filtered samples over all observations within a group (i.e., both groundwater wells and soil boring data) and over only groundwater wells within a group (i.e., only groundwater wells data). For radionuclides, background concentrations were derived using total sample results only because there were too few results from filtered samples.

For all projects where averages within groundwater wells over time are considered, the values derived for these groundwater wells under the column heading "over wells" should be used. For all other projects, the values shown under the column heading "over all observations" should be used.

[a] Background value was derived qualitatively over all observations because analyte was never detected or was detected infrequently at a concentration near the analyte's detection limit.

[b] NAL is the no action level for the resident (i.e., the lesser of the child resident HI=0.1 and adult/child ELCR=1E-06, see Table A.5).

[c] MCL is the primary maximum contaminant level from "http://water.epa.gov/drink/contaminants/index.cfm"; see Tables A.2 and A.5.

[d] See Tables A.2 and A.5 for additional information.

[e] MCL is for radium-226 and radium-228 combined.

[f] Uranium isotopic concentrations were derived from the mass concentration of uranium.

[g] Nickel background value varies from Risk Methods Documents prior to 2013 due to an error in calculation in the source document. See Risk Assessment Working Group Meeting Minutes for December 5, 2012, February 6, 2013, and March 6, 2013 (DOE 2017, Appendix E).

N/A = an NAL or MCL comparison value is not available, as defined in footnotes b and c.

Gray shading. For those background values that were derived qualitatively over all observations, because the analyte never was detected or was detected infrequently at a concentration near the analyte's detection limit (see footnote a), the gray shading indicates that the background value is greater than the comparison value.

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APPENDIX B

DERIVATION OF PRELIMINARY REMEDIATION GOALS

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B.1 DERIVATION OF RISK-BASED PRELIMINARY REMEDIATION GOALS

This appendix presents the methods used to derive the direct contact risk-based action and no action screening levels [i.e., preliminary remediation goals (PRGs)]. The PRGs presented in Appendix A are taken from a U.S. Environmental Protection Agency (EPA)-sponsored site on the World Wide Web (https://rais.ornl.gov/) that maintains a calculator that was used for deriving PRGs using Paducah site-specific parameters. Groundwater protection soil screening levels (SSLs) are taken from an EPA-sponsored site on the World Wide Web (http://rais.ornl.gov/epa/ssl1.shtml); methods used to derive these SSLs are discussed on that Web site. Similarly, EPA maintains online calculators for determining PRGs for radionuclides and regional screening levels (RSLs) nonradionuclides. Links to those sites are as follows:

- https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search and
- https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search.

B.1.1 INTRODUCTION

No action and action direct contact risk-based PRGs may be derived using a modification of methods described in Risk Assessment Guidance for Superfund (RAGS), Part B (EPA 1991). In RAGS, Part B, risk-based PRGs are developed by rearranging the equations used to calculate risk or hazard in a risk assessment so that the equations solve for a concentration or activity concentration of an analyte that "yields" a target risk or hazard. To derive the direct contact PRGs, the linear, direct relationship between the concentration or activity concentration of an analyte in an environmental medium and the risk or hazard that exposure to this analyte can present were used. Although this method differs from that in RAGS, Part B, the ultimate results of the modified calculations match those that are received by rearranging the risk or hazard equations.

B.1.2 MATERIALS

In order to derive risk-based PRGs, several pieces of information are required. These are the receptors of interest, the routes through which the receptors may be exposed and equations describing these routes, carcinogenic (cancer) and noncarcinogenic (hazard) toxicity values, and target risk and hazard values. Each of these is discussed in the following subsections, and they are included on several tables within the appendix. Tables within the subsections that summarize information for deriving risk-based PRGs are as follows:

- Table B.1. Action and No Action Risk-Based Screening Levels for Chemicals Derived for PGDP by Medium;

- Table B.2. Action and No Action Risk-Based Screening Levels and SSLs for Radionuclides Derived for PGDP by Medium;

- Table B.3. Dose Conversion Factors for Radionuclides of Interest;

- Table B.4. Default Exposure Parameters Used in Calculation of RME;

- Table B.5. Toxicity Values and Information;
- Table B.6. Parameters for IEUBK Model;
- Table B.7. Soil Parameters for VF Calculations; and
- Table B.8. Volatilization Parameters.

B.1.2.1 Receptors

Table B.1 provides a matrix showing the medium-receptor combinations for which PRGs were derived. As shown there, over all media, the receptors for which no action and action direct contact risk-based PRGs were derived are the industrial worker; the resident (adult and child); the recreational user (adult, child, and teen); the excavation worker; and the outdoor worker. These receptors were chosen because they represent the most likely current and future receptors for most areas and units at the Paducah Gaseous Diffusion Plant (PGDP). Also, it is believed that the PRGs derived for these receptors yield a range of values that is most useful for determining the cleanup priority for the various areas and units at PGDP. Note: Outdoor worker PRGs (used for surface soil) can be used for a construction/excavation worker (used for surface and subsurface soil); however, because the duration and frequency of exposure for a construction/excavation worker would be markedly less than that for an outdoor worker, scenario-specific PRGs for the construction/excavation worker based on site-specific conditions should be derived, as appropriate. The teen recreational user is broken out separately from the adult recreational user, because the exposure parameters for teen recreational users are significantly different than for the adult.

Table B.1 also includes a series of notes that discusses how the PRGs are to be applied to data during site scoping. These notes should be considered before site scoping is attempted.

Table B.1. Action and No Action Risk-Based Screening Levels for Chemicals Derived for PGDP by Medium

Scenario/Receptor	Medium		
	Groundwater	Surface Water	Soil/Sediment
Outdoor Worker	No	Yes	Yes
Excavation Worker	No	Yes	Yes
Industrial Worker	No	Yes	Yes
Adult Recreator	No	Yes	Yes
Teen Recreator	No	Yes	Yes
Child Recreator	No	Yes	Yes
Adult Resident	Yes	No	Yes
Child Resident	Yes	No	Yes

Notes:
1. Screening values for the residential scenario are used in data screening to develop the list of chemicals or radionuclides of potential concern (COPCs) in a baseline human health risk assessment (see Section 3.3.3.2 "Procedures to screen or evaluate data to determine COPCs" of the main text for additional information). Additional scenarios/receptors should be used to determine early action screening.
2. All groundwater screening is to be performed using the resident. Of the two receptors (i.e., child and adult), use of the smaller child screening value is more protective of human health. Note that values for soil deemed protective of groundwater also are available and are based on the resident only.

Table B.1. Action and No Action Risk-Based Screening Levels for Chemicals Derived for PGDP by Medium (Continued)

3. The surface water screening values selected are a location-specific decision. For all areas along effluent ditches or along creeks carrying effluent, the industrial worker screening values are appropriate. Additionally, at areas outside the industrialized areas, use of the recreator values are appropriate. Of the three recreator values available, the child recreator values are the smallest and most protective of human health. Note that two different sets of recreator values are available; these are a set for screening shallow water courses under a wading scenario and a set for screening deeper water courses under a swimming scenario. While which of these two recreator screening values to use is a location-specific decision, general guidance should be to use the wading values for most areas. If exposure by a resident to surface water is of concern, use of the recreator values is appropriate, because rates of contact for the recreator were selected assuming that the individual would be a local resident.
4. Determining which soil or sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker risk-based screening values is appropriate. However, if the scenario involves outdoor maintenance type activities, the outdoor worker risk-based screening values also should be considered. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (i.e., soil from the surface down to 10 or 16 ft bgs, as appropriate), use of the excavation worker risk-based screening values is appropriate. For locations, outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident risk-based screening values is appropriate. As with the surface water values, the child resident risk-based screening values are the most "conservative" (in terms of protecting human health). Generally, the recreator risk-based screening values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident risk-based screening values are more appropriate for grassy fields. Finally, the outdoor worker risk-based screening values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. If screening needs to consider shorter-term exposures to both surface and subsurface soil in locations outside the industrialized area, excavation worker screening values can be used.
5. As mentioned above, values for soil for protection of groundwater also are available. These should be used in all areas.

B.1.2.2 Exposure Routes and Equations

The exposure routes considered for the various media-scenario combinations are provided below. Included in this list are the tables from Appendix D that display the equations used to derive chronic daily intake or absorbed dose. The sources for these exposure parameters are provided in the tables in Appendix D. These exposure parameters are summarized in a table at the back of this appendix (Table B.4). Since PRGs shown in Appendix A were derived using the Risk Assessment Information System (RAIS) online calculator, equations used for obtaining PGDP PRGs may or may not match the equations for calculating the reasonable maximum exposure (RME) intakes shown in Appendix D. Equations in Appendix D should be used to calculate RME intakes in a PGDP baseline human health risk assessment, as shown in Figure B.1.

It is important to note that PRGs are not derived for industrial use of groundwater. These are not derived because they would not be useful to remedial decision making, as indicated in the following material taken from RAGS, Part B, Section 3.2.1 (EPA 1991).

> Once ground water is determined to be suitable for drinking, risk-based concentrations should be based on residential exposures....Similarly, for surface water that is to be used for drinking, the risk-based PRGs should be calculated for residential populations, and not simply worker populations.

Note that the number of exposure routes included in these calculations exceeds that presented in RAGS, Part B, for each scenario. Including exposure routes beyond those discussed in RAGS, Part B, is consistent with material in Section 3.1.1 of RAGS, Part B, where it is stated: "Additional exposure pathways (e.g., dermal absorption) are possible and may be significant at some sites for some contaminants, while perhaps only one exposure pathway (e.g., direct ingestion of water only) may be relevant in others. In any case, the risk-based PRG for each chemical should be calculated by considering all of the relevant exposure pathways."

Exposure Route	Residential Scenario (Child and Adult)	Industrial Worker Scenario	Outdoor and Excavation Worker Scenarios	Recreational User Scenario (Child, Teen, and Adult)
Groundwater, Chemicals				
Ingestion of water	Table D.1	Table D.1*	N/A	N/A
Inhalation of vapors emitted from water during household uses (including showering)	Table D.2	Table D.2*	N/A	N/A
Dermal contact with water during showering	Table D.3	Table D.3*	N/A	N/A
Groundwater, Radionuclides				
Ingestion of water	Table D.1	Table D.1*	N/A	N/A
Soil and Sediment, Chemicals				
Incidental ingestion of contaminated soil or sediment	Table D.4	Table D.4	Table D.4	Table D.4
Dermal contact with contaminated soil or sediment	Table D.5	Table D.5	Table D.5	Table D.5
Inhalation of particulates emitted from soil or sediment	Table D.6	Table D.6	Table D.6	Table D.6
Inhalation of vapors emitted from soil or sediment	Table D.6	Table D.6	Table D.6	Table D.6
Soil and Sediment, Radionuclides				
Incidental ingestion of contaminated soil or sediment	Table D.4	Table D.4	Table D.4	Table D.4
Inhalation of particulates emitted from soil or sediment	Table D.6	Table D.6	Table D.6	Table D.6
Inhalation of vapors emitted from soil or sediment	Table D.6	Table D.6	Table D.6	Table D.6
External exposure to ionizing radiation from soil or sediment	Table D.7	Table D.7	Table D.7	Table D.7
Surface Water, Chemicals				
Dermal contact with contaminated surface water (wading)	Table D.9	Table D.9	N/A	Table D.9
Incidental ingestion of contaminated surface water (swimming)	Table D.8	N/A	N/A	Table D.8
Dermal contact with contaminated surface water (swimming)	Table D.10	N/A	N/A	Table D.10
Surface Water, Radionuclides				
Incidental ingestion of contaminated surface water (swimming)	Table D.8	N/A	N/A	Table D.8

*Because future use of groundwater at PGDP is uncertain, the industrial worker exposure to groundwater scenario is provided for informational purposes only. This hypothetical future exposure pathway (i.e., the industrial worker) should represent in most, if not all, locations an incomplete exposure pathway.
N/A = not applicable

Figure B.1. Equations for Calculating RME intakes in a PGDP Baseline Human Health Risk Assessment

B.1.2.3 Toxicity Values

The toxicity values used in the derivation of the risk-based concentrations are taken from a variety of sources. The sources of these values are discussed in Section 3.3.5 of the main text. The values are presented in a table at the back of this appendix (Table B.5).

B.1.2.4 Target Risk and Hazard Values

The target risk [i.e., target excess lifetime cancer risk (ELCR)] and hazard [i.e., target hazard quotient (HQ)] values used when deriving the risk-based concentrations for no action are 1E-06 and 0.1, respectively. The target risk and hazard values used when deriving the risk-based concentrations for action are 1E-04 and 3, respectively. Note, if five or more constituents are detected at a site, it may be appropriate during project scoping to reduce the chemical-specific target risk used to derive the risk-based concentrations for no action.

B.1.3 METHOD OF DERIVATION

Each risk-based PRG is calculated using the same method and generally follows the examples provided by EPA; equations for the derivation for PRGs can be found at the following link:

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

B.2. DERIVATION OF DOSE-BASED PRELIMINARY REMEDIATION GOALS FOR RADIONUCLIDES

The following describes the methods used to derive direct-contact dose-based screening. Methods for deriving the groundwater protection SSLs also are provided for comparison to direct-contact PRGs.

B.2.1 INTRODUCTION

Direct contact dose-based PRGs for radionuclides were derived using a modification of methods described by RAGS, Part B. This modified approach is similar to that used to develop risk-based PRGs for PGDP except for two additional modifications. These modifications are (1) the exposure duration (ED) term was dropped because dose limits are based on annual dose and not lifetime exposure, and (2) slope factors and reference doses were replaced with radiation dose conversion factors (DCFs).

B.2.2 MATERIALS

In order to derive dose-based screening levels, several pieces of information are required. These are the receptors of interest, the routes through which the receptors may be exposed and equations describing these routes, activity concentration- or concentration-to-dose conversion factors, and target dose values. Each of these is discussed in the following sections.

B.2.2.1 Receptors

The receptors considered in dose-based screening level calculations are described in the derivation of risk-based PRGs. The description is not repeated here, although it is noted that the ED term is not relevant for dose calculations. This is because dose-based values generally call for yearly rather than lifetime values and are the value that would yield the target dose in a given year (e.g., in units of mrem/yr). Direct contact screening levels were derived for the industrial worker, the resident (adult and child), the recreational user (adult, child, and teen), the excavation worker, and the outdoor worker. These receptors were chosen because they represent the most likely current and future receptors for most areas and units at PGDP. Also, it is believed that the screening levels derived for these receptors yield a range of values that are most useful for determining the cleanup priority for the various areas and units at PGDP.

Table B.2 lists the media evaluated, by receptor, and includes a series of notes that discuss how the screening levels are to be applied to data during site scoping. These notes should be considered before site scoping is attempted. Table B.2 varies slightly from the version used in nonradiological risk-based PRG development because dermal contact is not a relevant pathway for the radionuclides of interest.

Table B.2. Action and No Action Risk-Based Screening Levels and SSLs for Radionuclides Derived for PGDP by Medium

Scenario/Receptor	Medium		
	Groundwater	Surface Water	Soil/Sediment
Outdoor worker	No	No	Yes
Excavation worker	No	No	Yes
Industrial Worker	No	No	Yes
Adult Recreator	No	Yes	Yes
Teen Recreator	No	Yes	Yes
Child Recreator	No	Yes	Yes
Adult Resident	Yes	No	Yes
Child Resident	Yes	No	Yes

Notes:

1. Screening values for the residential scenario are used in data screening to develop the list of COPCs in a baseline human health risk assessment (see Section 3.3.3.2 "Procedures to screen or evaluate data to determine COPCs" of the main text for additional information). Additional scenarios/receptors should be used to determine early action screening.
2. All groundwater screening is to be performed using the resident. Note that values for soil deemed protective of groundwater also are available and are based on the resident only.
3. Dose-based values for surface water are provided only for recreators.
4. Determining which soil or sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker risk-based screening values is appropriate. However, if the scenario involves outdoor maintenance type activities, the outdoor worker risk-based screening values also should be considered. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (i.e., soil from the surface down to 10 or 16 ft bgs, as appropriate), use of the excavation worker risk-based screening values is appropriate. For locations, outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident risk-based screening values is appropriate. As with the surface water values, the child resident risk-based screening values are the smallest and most protective of human health. Generally, the recreator risk-based screening values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident risk-based screening values are more appropriate for grassy fields. Finally, the outdoor worker risk-based screening values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. If screening needs to consider shorter-term exposures to both surface and subsurface soil in locations outside the industrialized area, excavation worker screening values can be used.
5. As mentioned above, values for soil for protection of groundwater also are available. These should be used in all areas.

B.2.2.2 Exposure Routes and Equations

As discussed above, the exposure routes and equations used to calculate dose-based screening levels are similar to those used to develop risk-based PRGs. The only pathway-specific difference is that dermal contact is not considered (for radionuclides). Instead, the external gamma pathway is evaluated to account for non-uptake exposures. This being the only difference, the complete list of exposure routes considered for the various media-scenario combinations is not repeated here.

The equations used to calculate dose-based screening levels are similar to those used to develop risk-based values, but with two exceptions. First, dose-based limits are typically for a single year of exposure. Therefore, The ED terms appropriately are dropped from all equations to produce per-year PRG and SSL results. Second, slope factors and reference doses were replaced with DCFs given that the human-health-based limits are radiological doses (in units mrem/yr) rather than carcinogenic risk or non-carcinogenic hazard.

B.2.2.3 Toxicity Values

The toxicity values (i.e., DCFs) used in the derivation of the dose-based concentrations are taken from the latest version of Residual Radioactivity Materials Model (RESRAD) output (i.e., RESRAD 7.2). DCFs are consistent with International Commission on Radiological Protection (ICRP) Publication 60 and

Publication 72. The use of ICRP 60 and 72 is consistent with the requirements established by DOE Order 458.1. These DCFs are given in unit mrem/pCi for the inhalation and ingestion pathways or mrem/yr/pCi/g (i.e., pCi/g in soil/sediment) for the external gamma pathway. The values are provided in Table B.3.

Table B.3. Dose Conversion Factors for Radionuclides of Interest

	Pathway (units)		
Radionuclide	**Ingestion[a] (mrem/pCi)**	**Inhalation[a] (mrem/pCi)**	**External Gamma[a] (mrem/yr per pCi/g)**
Adult			
Americium-241	7.40E-04	3.55E-01	3.72E-02
Cesium-137+D	4.81E-05	1.44E-04	3.38E+00[b]
Neptunium-237+D	4.10E-04	1.85E-01	1.01E+00[c]
Plutonium-238	8.51E-04	4.07E-01	1.17E-04
Plutonium-239	9.25E-04	4.44E-01	2.64E-04
Plutonium-240	9.25E-04	4.44E-01	1.13E-04
Technetium-99	2.37E-06	4.81E-05	1.09E-04
Thorium-230	7.77E-04	3.70E-01	1.07E-03
Uranium-234	1.81E-04	3.48E-02	3.44E-04
Uranium-235+D	1.75E-04	3.15E-02	6.92E-01[d]
Uranium-238+D	1.79E-04	2.96E-02	1.20E-01[e]
Teen			
Americium-241	7.40E-04	3.40E-01	3.72E-02
Cesium-137+D	4.81E-05	1.55E-04	3.38E+00[b]
Neptunium-237+D	4.11E-04	1.74E-01	1.01E+00[c]
Plutonium-238	8.14E-04	3.70E-01	1.17E-04
Plutonium-239	8.88E-04	4.07E-01	2.64E-04
Plutonium-240	8.88E-04	4.07E-01	1.13E-04
Technetium-99	3.03E-06	5.55E-05	1.09E-04
Thorium-230	8.14E-04	3.66E-01	1.07E-03
Uranium-234	2.74E-04	3.70E-02	3.44E-04
Uranium-235+D	2.61E-04	3.40E-02	6.92E-01[d]
Uranium-238+D	2.63E-04	3.22E-02	1.20E-01[e]
Child			
Americium-241	9.99E-04	4.44E-01	3.72E-02
Cesium-137+D	3.55E-05	2.59E-04	3.38E+00[b]
Neptunium-237+D	5.30E-04	2.22E-01	1.01E+00[c]
Plutonium-238	1.15E-03	5.18E-01	1.17E-04
Plutonium-239	1.22E-03	5.55E-01	2.64E-04
Plutonium-240	1.22E-03	5.55E-01	1.13E-04
Technetium-99	8.51E-06	8.88E-05	1.09E-04
Thorium-230	1.15E-03	5.18E-01	1.07E-03
Uranium-234	3.26E-04	7.03E-02	3.44E-04
Uranium-235+D	3.19E-04	6.29E-02	6.92E-01[d]
Uranium-238+D	3.44E-04	5.93E-02	1.20E-01[e]

[a] From RESRAD version 7.2 output, November 2017. These values are consistent with ICRP 60 and 72, using ages 15 and 5 for the teen and child, respectively.
[b] External dose conversion factors for cesium-137+D are calculated by summing external dose conversion factors for cesium-137 and barium-137m. Other dose conversion factors for cesium-137 daughters are not summed.
[c] External dose conversion factors for neptunium-237+D are calculated by summing external dose conversion factors for neptunium-237, protactinium-233, and uranium-233.
[d] External dose conversion factors for uranium-235+D are calculated by summing external dose conversion factors for uranium-235 and thorium-231.
[e] External dose conversion factors for uranium-238+D are calculated by summing external dose conversion factors for uranium-238, thorium-234, and protactinium-234m.

B.2.2.4 Target Dose Values

The target dose values used when deriving the dose-based concentrations in soil and sediment are 1, 12, 25, and 100 mrem/yr. An additional target dose of 4 mrem/yr was added for the surface water and groundwater media in consideration of the federal drinking water standard (standards available at http://water.epa.gov/drink/contaminants/index.cfm) although these standards are applicable to public drinking water supplies.

B.2.3 METHOD OF DERIVATION

Each dose-based PRG is calculated in the same manner. The general equation used to calculate all PRGs reflects the direct, linear relationship between the environmental concentrations and the dose estimate. This calculation is shown in Eq. 1 to demonstrate the difference in calculation method from that used in developing risk-based PRGs. For this evaluation, PRGs were developed by combining the soil ingestion, dust inhalation, and external gamma pathways. Both surface water and groundwater ingestion were considered separately as these media should be considered on a case-by-case basis.

Table B.4 includes a list of exposure parameters used in calculation of default RME. Table B.4 is located at the back of the appendix. Tables B.3 and B.5 include the toxicity values and information used in PRG derivation. Table B.5 also includes other pertinent information (such as the dermal absorption value recommended by the Commonwealth of Kentucky) and reference codes (ref) for the values. Further, Table B.5 is split into Table B.5a for nonradionuclide information and Table B.5b for radionuclides. The table notes and footnotes are combined, following Table B.5b. Table B.5 is located at the back of the appendix.

$$C_i = \frac{TD}{\sum_{i,j}\left(DCF_i \times A_{ij}\right)} \qquad \textbf{Eq. 1}$$

where:

C_i	The dose-based concentration for radionuclide “i” (i.e., calculated screening level)
TD	The target doses (see Section B.2.2.4)
DCF_i	Dose conversion factor for radionuclide “i” (i.e., in mrem/pCi or mrem/yr per pCi/g)
A_{ij}	Activity of radionuclide “i” ingested or inhaled (in pCi) or specific activity in soil/sediment (in pCi/g) per unit concentration in medium “j”

B.3 EVALUATION FOR LEAD

For sites for which the concentration in soil exceeds the 400 mg/kg screening level, risks from lead should be analyzed using the Integrated Exposure Uptake Biokinetic (IEUBK) model. The model should be run using the EPA-recommended 10 µg/dl blood lead level cutoff and the site-specific values discussed in the next paragraph. The analysis of risks from lead also should show the probability of exceeding the recommended Commonwealth of Kentucky blood lead level of 2.5 µg/dl (note that this probability distribution can be developed in the IEUBK model from the previous model run by changing the cutoff value in the graph menu). The uncertainty section of the risk assessment should include text indicating that there is no safe level of lead exposure to children and comparing the risks predicted by the IEUBK analyses based on the two cutoff values.

Table B.6 includes parameters that can be used in the IEUBK model to develop more site-specific screening levels for lead. The IEUBK model calculates a blood lead level that includes the contribution from off-site sources such as food in lead and water. To make the model more site-specific, the updated nationwide averages for lead in food can be used in place of the default values in the model. In addition, if regional or site-specific concentrations of lead in food and water are available, the concentration of lead in water can be changed in the model to that value. PGDP values can be substituted with concurrence from regulatory agencies.

Table B.6. Parameters for IEUBK Model

	Age Range of Child (yr)	IEUBK Default Value (Residential)	Value Proposed for PGDP	Source/Reference for Value
Lead ingested in food (in µg/day)	0–1	5.53	3.16	Revised Food and Drug Administration 2001 total diet study values posted on Technical Review Workgroup for Metals and Asbestos Web site FAQs
	1–2	5.78	2.60	
	2–3	6.49	2.87	
	3–4	6.24	2.74	
	4–5	6.01	2.61	
	5–6	6.34	2.74	
	6–7	7.00	2.99	

Information compiled January 2008.

The revised diet values for the model are available in Table 2-1 of the User's Guide for the IEUBK Model (updated May 2007) found at https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals#users.

For recreational exposures, the time on-site versus the total time spent outdoors can be included in the model. The model allows only one soil concentration to be entered, but the exposure to on and off-site soil can be incorporated by weighting the soil concentration by the proportion of time spent on and off-site. This method and its limitations are described fully in Appendix A of EPA's review of the human health risk assessment for the Couer d'Alene basin (EPA 2000).

For industrial or outdoor worker scenarios, the Adult Lead Model is used to develop a PRG for soil. This model includes a default blood lead level based on the NHANES survey value for the western United States for all races combined, other measured adult blood lead concentrations from state or regional databases may be used in place of the default value if such values are available.

B.4 VOLATILIZATION

Volatilization factors (VFs) are developed for each chemical based on its physical properties. The soil parameters used in the calculation of VFs and the chemical-specific parameters used in the calculation of VFs and the VF values are presented in Tables B.7 and B.8.

Table B.7. Soil Parameters for VF Calculations

Parameter	Definition (units)		Default
Q/C	Inverse the mean conc. at the center of a 0.5-acres square source (g/m^2-s per kg/m^3)	Residential	64.177
		Industrial/commercial	43.07
T	Exposure interval (s)		9.50E+08
ρ_b	Dry soil bulk density (g/cm^3)		1.5
θ_a	Air filled soil porosity (L_{air}/L_{soil})		0.28
n	Total soil porosity (L_{pore}/L_{soil})		0.43
θw	Water-filled soil porosity (L_{water}/L_{soil})		0.15

Information compiled February 2011.

Table B.8. Volatilization Parameters

CAS #	Chemical	D_i (cm^2/s)	D_w (cm^2/s)	Unitless H'	K_{oc} [a] (cm^3/g)	
83-32-9	Acenaphthene	5.06E-02	8.33E-06	7.52E-03	5.03E+03	
208-96-8	Acenaphthylene	4.50E-02	6.98E-06	4.66E-03	5.03E+03	
107-13-1	Acrylonitrile	1.14E-01	1.23E-05	5.64E-03	8.51E+00	
120-12-7	Anthracene	3.90E-02	7.85E-06	2.27E-03	1.64E+04	
71-43-2	Benzene	8.95E-02	1.03E-05	2.27E-01	1.46E+02	
75-27-4	Bromodichloromethane	5.63E-02	1.07E-05	8.67E-02	3.18E+01	
56-23-5	Carbon Tetrachloride	5.71E-02	9.78E-06	1.13E+00	4.39E+01	
67-66-3	Chloroform	7.69E-02	1.09E-05	1.50E-01	3.18E+01	
75-71-8	Dichlorodifluoromethane (Freon-12)[b]	7.60E-02	1.08E-05	1.40E+01	4.39E+01	
75-34-3	Dichloroethane, 1,1- [b]	8.36E-02	1.06E-05	2.30E-01	3.18E+01	
107-06-2	Dichloroethane, 1,2-	8.57E-02	1.10E-05	4.82E-02	3.96E+01	
75-35-4	Dichloroethylene, 1,1-	8.63E-02	1.10E-05	1.07E+00	3.18E+01	
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	8.79E-02	1.12E-05	1.67E-01	3.96E+01	
156-59-2	Dichloroethylene, 1,2-*cis-*	8.84E-02	1.13E-05	1.67E-01	3.96E+01	
156-60-5	Dichloroethylene, 1,2-*trans-*	8.76E-02	1.12E-05	3.83E-01	3.96E+01	
1746-01-6	Dioxins/Furans (Total) (as TCDD)	4.70E-02	6.76E-06	2.04E-03	2.49E+05	
100-41-4	Ethylbenzene	6.85E-02	8.46E-06	3.22E-01	4.46E+02	
8673-7	Fluorene	4.40E-02	7.89E-06	3.93E-03	9.16E+03	
11874-1	Hexachlorobenzene	2.90E-02	7.85E-06	6.95E-02	6.20E+03	
91-20-3	Naphthalene	6.05E-02	8.38E-06	1.80E-02	1.54E+03	
85-01-8	Phenanthrene	3.45E-02	6.69E-06	1.73E-03	1.67E+04	
1336-36-3	Polychlorinated Biphenyls	2.43E-02	6.27E-06	1.70E-02	7.81E+04	
12674-11-2	~Aroclor 1016	1.71E-02	4.16E-06	8.18E-03	4.77E+04	
11104-28-2	~Aroclor 1221	3.25E-02	7.23E-06	9.32E-03	8.40E+03	
11141-16-5	~Aroclor 1232	3.34E-02	7.52E-06	3.01E-02	8.40E+03	
53469-21-9	~Aroclor 1242	2.39E-02	6.11E-06	1.40E-02	7.81E+04	
12672-29-6	~Aroclor 1248	1.63E-02	3.94E-06	1.80E-02	7.65E+04	
11097-69-1	~Aroclor 1254	2.37E-02	6.10E-06	1.16E-02	1.31E+05	
11096-82-5	~Aroclor 1260	2.20E-02	5.61E-06	1.37E-02	3.50E+05	
	cPAHs					
56-55-3	~Benz[a]anthracene	2.61E-02	6.75E-06	4.91E-04	1.77E+05	
129-00-0	Pyrene	2.78E-02	7.25E-06	4.87E-04	5.43E+04	
127-18-4	Tetrachloroethylene	5.05E-02	9.46E-06	7.24E-01	9.49E+01	
108-88-3	Toluene[c]	7.78E-02	9.20E-06	2.71E-01	2.34E+02	
71-55-6	Trichloroethane, 1,1,1-	6.48E-02	9.60E-06	7.03E-01	4.39E+01	
79-00-5	Trichloroethane, 1,1,2-	6.69E-02	1.00E-05	3.37E-02	6.07E+01	
79-01-6	Trichloroethylene	6.87E-02	1.02E-05	4.03E-01	6.07E+01	
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[b]	3.76E-02	8.59E-06	2.15E+01	1.97E+02	
75-01-4	Vinyl Chloride	1.07E-01	1.20E-05	1.14E+00	2.17E+01	
1330-20-7	Xylene, Mixture	6.85E-02	8.46E-06	2.71E-01	3.83E+02	
108-38-3	Xylene, m-	6.84E-02	8.44E-06	2.94E-01	3.75E+02	
95-47-6	Xylene, o-	6.89E-02	8.53E-06	2.12E-01	3.83E+02	
106-42-3	Xylene, P-	6.82E-02	8.42E-06	2.82E-01	3.75E+02	

Values taken from RAIS (http://rais.ornl.gov/) in November 2018.

[a] RAIS does not provide K_d values for organic chemicals, therefore, K_d values used in the calculation can be calculated as 0.2% of the K_{oc}.

[b] Analytes are not PGDP-significant COPCs (Table 2.1), but are provided for project support.

B.5. REFERENCES

DOE (U.S. Department of Energy) 2017. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky Volume 1. Human Health*, DOE/LX/07-0107&D2/R8/V1, Paducah, KY, July.

EPA (U.S. Environmental Protection Agency) 1991. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part B, Development of Risk-based Preliminary Remediation Goals*, EPA/540/R-92/003, OSWER Directive 9285.7-01b, Office of Emergency and Remedial Response, Washington, DC, December.

EPA 2000. *Review of Human Health Risk Assessment for the Coeur D'Alene Basin*. Technical Review Workgroup for Lead. Prepared for U.S. EPA, Region 10, Seattle, WA, October.

RAIS 2018. *Risk Assessment Information System* (RAIS) Web site, developed by Oak Ridge National Laboratory and the University of Tennessee, available at https://rais.ornl.gov/ (accessed November 2018).

Table B.4. Default Exposure Parameters Used in Calculation of RME

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
General Parameters Used in All Intake Models (unless otherwise noted)									
Exposure frequency (EF)	days/year	250[a]	185[b]	185[b]	350[a]	350[a]	104[c]	140[c]	140[c]
Exposure duration (ED)	years	25[a]	25[a]	5[b]	20[a]	6[a]	10[a]	10[a]	6[a]
Body weight (BW)	kg	80[a]	80[a]	80[a]	80[a]	15[a]	80[a]	44[d]	15[a]
Averaging time- cancer (AT-C)	year × days/year	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365
Averaging time-noncancer (AT-N)	year × days/year	25 × 365	25 × 365	5 × 365	20 × 365	6 × 365	10 × 365	10 × 365	6 × 365
Decay constant (λ)	unitless	0.693/ half-life[e]	0.693/ half-life[e]	0.693/ half-life[e]	0.693/ half-life[e]	0.693/ half-life[e]	0.693/ half-life[e]	0.693/ half-life[e]	0.693/ half-life[e]
Age-dependent adjustment factor (ADAF)	unitless	N/A	N/A	N/A	3×(10/70) [x] 1×(10/70) [x]	10×(2/70) [x] 3× (4/70) [x]	1×(10/70) [x]	3×(10/70) [x]	10×(2/70) [x] 3×(4/70) [x]
Ingestion of Water (Table D.1)									
Drinking water ingestion rate (IR)	L/day	1[c]	N/A	N/A	2.5[a]	0.78[a]	N/A	N/A	N/A
Inhalation RGA Groundwater (Table D.2)									
Indoor inhalation rate	m^3/hour	2.5[c]	N/A	N/A	0.833[c]	0.833[c]	N/A	N/A	N/A
Exposure time in the shower (ET_{shower})	hours/day	0.71[a]	N/A	N/A	0.71[a]	0.54[a]	N/A	N/A	N/A
Time of shower (t1)	hour	0.43[f]	N/A	N/A	0.43[f]	0.32[f]	N/A	N/A	N/A
Time after shower (t2)	hour	0.28[f]	N/A	N/A	0.28[f]	0.22[f]	N/A	N/A	N/A
Fraction volatilized while showering (f_{shower})	unitless	0.75[g]	N/A	N/A	0.75[g]	0.75[g]	N/A	N/A	N/A
Water flow rate (F_w)	L/hour	890[c]	N/A	N/A	890[c]	890[c]	N/A	N/A	N/A
Bathroom volume (V_a)	m^3	11[c]	N/A	N/A	11[c]	11[c]	N/A	N/A	N/A
Averaging time-cancer (AT-C)	hour/day × year × day/year	24 × 70 × 365	N/A	N/A	24 × 70 × 365	24 × 70 × 365	N/A	N/A	N/A
Averaging time-noncancer (AT-N)	hour/day × year × day/year	24 × 25 × 365	N/A	N/A	24 × 20 × 365	24 × 6 × 365	N/A	N/A	N/A
Exposure time household use (ET_{house})	hours/day	N/A	N/A	N/A	24[c]	24[c]	N/A	N/A	N/A
Exchange rate (ER)	changes/day	N/A	N/A	N/A	10[c]	10[c]	N/A	N/A	N/A
Mixing coefficient (MC)	unitless	N/A	N/A	N/A	0.5[c]	0.5[c]	N/A	N/A	N/A
Fraction volatilized household use (f_{house})	unitless	N/A	N/A	N/A	0.5[c]	0.5[c]	N/A	N/A	N/A
Water flow rate (WHF)	L/day	N/A	N/A	N/A	890[c]	890[c]	N/A	N/A	N/A
House volume (HV)	m^3/change	N/A	N/A	N/A	450[c]	450[c]	N/A	N/A	N/A
Dermal Contact with RGA Groundwater (showering) (Table D.3)									
Body surface area exposed [r] (SA)	m^2	1.9652[a]	N/A	N/A	1.9652[a]	0.6365[a]	N/A	N/A	N/A
Event time (t_{event})	hours/event	0.71[a]	N/A	N/A	0.71[a]	0.54[a]	N/A	N/A	N/A
Event frequency (EV)	events/day	1	N/A	N/A	1	1	N/A	N/A	N/A
Fraction absorbed (FA)	unitless	1[c]	N/A	N/A	1[c]	1[c]	N/A	N/A	N/A

Table B.4. Default Exposure Parameters Used in Calculation of RME (Continued)

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
Incidental Ingestion of Soil/Sediment (Table D.4)									
Incidental ingestion rate (IR)	mg/day	50[a]	480[b]	480[b]	100[a]	200[a]	100[a]	100[a]	200[a]
Fraction ingested	unitless	1[j]	1[j]	1[j]	1[j]	1[j]	1[j]	1[j]	1[j]
Dermal Contact with Soil/Sediment (Table D.5)									
Body surface area exposed[s] (SA)	m^2/day	0.3527[a]	0.3527[a]	0.3527[a]	0.6032[a]	0.2373[a]	0.6032[a]	0.75[c]	0.2373[a]
Soil-to-skin adherence factor (AF)	mg/cm^2–day	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Inhalation of Vapors and Particulates Emitted from Soil/Sediment (Table D.6)									
Exposure time (ET) (soil)	hours/day	8[a]	8[a]	8[a]	24[a]	24[a]	5[c]	5[c]	5[c]
Exposure time (ET) (sediment)	hours/day	2.6[c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Averaging time-cancer (AT-C)	hour/day × year × day/year	24 × 70 × 365	24 × 70 × 365	24 × 70 × 365	24 × 70 × 365	24 × 70 × 365	24 × 70 × 365	24 × 70 × 365	24 × 70 × 365
Averaging time-noncancer (AT-N)	hour/day × year × day/year	24 × 25 × 365	24 × 25 × 365	24 × 25 × 365	24 × 20 × 365	24 × 6 × 365	24 × 10 × 365	24 × 10 × 365	24 × 6 × 365
Particulate emission factor[t] (PEF)	m^3/kg	6.20E+08[c]	6.20E+08[c]	6.20E+08[c]	9.30E+08[c]	9.30E+08[c]	9.30E+08[c]	9.30E+08[c]	9.30E+08[c]
External Exposure to Ionizing Radiation from Soil/Sediment (Table D.7)									
Exposure frequency (EF)	(days/year)/ (days/year)	250/365[a]	185/365[b]	185/365[b]	350/365[a]	350/365[a]	104/365[c]	140/365[c]	140/365[c]
Gamma shielding factor (Se)	unitless	0.2[h]	0.2[h]	0.2[h]	0.2[h]	0.2[h]	0[i]	0[i]	0[i]
Gamma exposure time factor (Te) (soil)	(hour/day)/ (hour/day)	8/24[c]	8/24[c]	8/24[c]	18/24[u]	18/24[u]	5/24[c]	5/24[c]	5/24[c]
(sediment)	(hour/day)/ (hour/day)	2.6/24[c]	8/24[c]	8/24[c]	18/24[u]	18/24[u]	5/24[c]	5/24[c]	5/24[c]
Incidental Ingestion of Surface Water (swimming) (Table D.8)									
Ingestion rate (IR)	L/hour	N/A	N/A	N/A	N/A	N/A	0.05[c]	0.05[c]	0.05[c]
Exposure time (ET)	hour/day	N/A	N/A	N/A	N/A	N/A	2.6[c]	2.6[c]	2.6[c]
Exposure frequency (EF)	day/year	N/A	N/A	N/A	N/A	N/A	45[c]	45[c]	45[c]
Dermal Contact with Surface Water (wading) (Table D.9)									
Body surface area exposed[v] (SA)	m^2	0.3527[a]	0.3527[a]	0.3527[a]	N/A	N/A	1.06[c]	0.75[c]	0.33[c]
Exposure frequency (EF)	day/year	250[a]	20[b]	20[b]	N/A	N/A	52[c]	140[c]	140[c]
Exposure time (ET)	hour/day	2.6[c]	8[a]	8[a]	N/A	N/A	2.6[c]	2.6[c]	2.6[c]
Dermal Contact with Surface Water (swimming) (Table D.10)									
Body surface area exposed[w] (SA)	m^2	N/A	N/A	N/A	N/A	N/A	1.9652[a]	1.31[c]	0.6365[a]
Exposure frequency (EF)	days/year	N/A	N/A	N/A	N/A	N/A	45[c]	45[c]	45[c]
Exposure time (ET)	hours/day	N/A	N/A	N/A	N/A	N/A	2.6[c]	2.6[c]	2.6[c]
Event (EV)	events/day	N/A	N/A	N/A	N/A	N/A	1	1	1

Table B.4. Default Exposure Parameters Used in Calculation of RME (Continued)

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
Consumption of Fish (Table D.11)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	N/A	N/A	1 [j]	1 [j]	1 [j]
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	N/A	N/A	0.029[k]	0.029[k]	0.029[k]
Exposure Frequency (EF)	days/year	N/A	N/A	N/A	N/A	N/A	365	365	365
Consumption of Deer (Table D.13)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	N/A	N/A	1 [j]	1 [j]	1 [j]
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	N/A	N/A	0.032[m]	0.032[m]	0.007[m]
Exposure Frequency (EF)	days/year	N/A	N/A	N/A	N/A	N/A	350[m]	350[m]	350[m]
Consumption of Rabbit (Table D.15)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	N/A	N/A	1 [j]	1 [j]	1 [j]
Ingestion rate[l] (IR)	kg/meal	N/A	N/A	N/A	N/A	N/A	0.0165[n]	0.0082[n]	0.0033[n]
Exposure Frequency (EF)	meals/year	N/A	N/A	N/A	N/A	N/A	350[n]	350[n]	350[n]
Consumption of Quail (Table D.17)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	N/A	N/A	1 [j]	1 [j]	1 [j]
Ingestion rate (IR)	kg/meal	N/A	N/A	N/A	N/A	N/A	0.0047 [o]	0.0024 [o]	0.00094 [o]
Exposure Frequency (EF)	meals/year	N/A	N/A	N/A	N/A	N/A	350 [o]	350 [o]	350 [o]
Consumption of Homegrown Vegetables (Table D.19)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	0.4[p]	0.4[p]	N/A	N/A	N/A
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	0.72[q]	0.29[q]	N/A	N/A	N/A
Consumption of Beef (Table D.21)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	1 [j]	1 [j]	N/A	N/A	N/A
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	0.19[q]	0.07[q]	N/A	N/A	N/A
Consumption of Milk (Table D.23)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	1 [j]	1 [j]	N/A	N/A	N/A
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	1.25[q]	0.9[q]	N/A	N/A	N/A
Consumption of Poultry (Table D.25)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	1 [j]	1 [j]	N/A	N/A	N/A
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	0.17[q]	0.07[q]	N/A	N/A	N/A
Consumption of Pork (Table D.27)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	1 [j]	1 [j]	N/A	N/A	N/A
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	0.08[q]	0.03[q]	N/A	N/A	N/A
Consumption of Eggs (Table D.29)									
Diet fraction (FI)	unitless	N/A	N/A	N/A	1 [j]	1 [j]	N/A	N/A	N/A
Ingestion rate[l] (IR)	kg/day	N/A	N/A	N/A	0.11[q]	0.06[q]	N/A	N/A	N/A

Information compiled October 2017
N/A = not applicable

Table B.4. Default Exposure Parameters Used in Calculation of RME (Continued)

[a] EPA 2014, "Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors," OSWER Directive 9200.1-120, Assessment and Remediation Division, February 6 (accessed at https://www.epa.gov/sites/production/files/2015-11/documents/oswer_directive_9200.1-120_exposurefactors_corrected2.pdf on October 10, 2017).

[b] RAWG Meeting Minutes, September 2014 (see DOE 2017, Appendix E).

[c] KDEP (Kentucky Department for Environmental Protection) 2002. Kentucky Risk Assessment Guidance, Risk Assessment Branch, Kentucky Department for Environmental Protection, Commonwealth of Kentucky, Frankfort, KY.

[d] Frederick, T. 2015. U.S. EPA e-mail "RE: Paducah Risk Assessment Working Group: Poll Question re: Paducah-Specific Exposure Parameter," to Garner, L., et al., October 20 (see DOE 2017, Appendix E).

[e] See the RAIS Web site for additional information (http://rais.ornl.gov/)

[f] RAWG Meeting Minutes, June 15 2016 (see DOE 2017, Appendix E).

[g] Value selected by 2009 work group because KDEP (2002) does not specify this value for showering.

[h] EPA 1991. *Risk Assessment Guidance for Superfund: Volume I-Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*, OSWER Directive 9285.7-01B.

[i] RAWG 2007. Discussion on removing gamma shielding factor for recreational receptor, RAWG teleconference call, December (see DOE 2017, Appendix E).

[j] Maximum Value used; equivalent to 100%.

[k] Knuth, B. A., N. A. Connelly, and M. A. Shapiro 1993. Angler Attitudes and Behaviors Associated with Ohio River Health Advisories, Human Dimensions Research Unit (HDRU) Publication 93-6, Department of Natural Resources, New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, NY, 163 p.

[l] Ingestion values represent the 95th percentile of individuals who consume this food group.

[m] Based on taking 2 deer per year (consistent with regulation in the state of Kentucky), a 50% success rate (Kentucky Department of Fish and Wildlife, 1992, Deer Surveys, Project No: W-45-24), a dressed weight averaging 108.5 pounds per deer for Ballard and McCracken counties, 60% of venison recovered per deer carcass, 2.5 persons per household in Ballard and McCracken counties, and a child consumption rate 20% of that for adults. Intake values above correspond to 0.467 g/kg bw-day for the child, 0.744 g/kg bw-day for the teen, and 0.457 g/kg bw-day for the adult receptor.

[n] Based on 20 rabbits bagged per year at West Kentucky Wildlife Management Area, a personal communication stating that dressed weight equals 60% of average 1.2 kg rabbit, 2.5 persons per household in Ballard and McCracken counties, a child consumption rate 20% of that for adults, and a teen consumption rate 50% of that for adults. Intake values above correspond to 0.220 g/kg bw-day for the child, 0.191 g/kg bw-day for the teen, and 0.236 g/kg bw-day for the adult receptor.

[o] Based on 20 quail bagged per year at West Kentucky Wildlife Management Area, personal communication stating dressed weight equals 75% of average 0.183 kg quail, 2.5 persons per household in Ballard and McCracken counties, a child consumption rate 20% of that for adults, and a teen consumption rate 50% of that for adults. Intake values above correspond to 0.063 g/kg bw-day for the child, 0.558 g/kg bw-day for the teen, and 0.067 g/kg bw-day for the adult receptor.

[p] EPA 1989. *Exposure Factors Handbook*, EPA/600/8-89/043.

[q] EPA 2003. "CSFII Analysis of Food Intake Distributions," EPA/600/R-03/029, Washington, DC.

[r] Entire surface area of body for both adult and child.

[s] Includes areas of face, forearms, lower legs, and hands for adults; face, arms, hands, legs, and feet for teens; and face, forearms, hands, lower legs, and feet for children for residents and recreational users. Includes area of hands, arms, and head for workers.

[t] PEFs from Kentucky Risk Assessment Guidance use EPA default factors, except for the Q/C value, which is based on the lower 90% confidence interval of the mean dispersion factor of climactic zone VII of Table 3 in EPA 1996. *Technical Background Document for Soil Screening Guidance*, EPA/540/R95/128. Office of Emergency and Remedial Response, Washington, DC, May.

[u] RAWG Meeting Minutes, December 2012 (see DOE 2017, Appendix E).

[v] Includes areas of arms, hands, legs, and feet for adult, teen, and child for recreational users. Includes area of arms, hands, and head for workers.

[w] Includes whole body area for adult, teen, and child.

[x] EPA 2005. *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens*, Risk Assessment Forum, EPA/630/R-03/003F, March.

Table B.5a. Toxicity Values and Information[1]

Chemical Abstract Number	Analyte	Oral Slope Factor (SFo)[2]	Sfo Ref	Inhalation Unit Risk (IUR)[3]	IUR Ref	Oral RfD (RfDo)[4]	RfDo Ref	Inhalation (RfCi)[5]	RfCi Ref	Volatile Organic?[6]	Muta-gen?[7]	Gastro intestinal (GI) Absorption Factor (Unitless)	EPA ABS (Unitless)[8]	ABS Ref
742990-5	Aluminum	-	-	-	-	1.00E+00	P	5.00E-03	P	NO	NO	1.00E+00	-	RAGSE
744036-0	Antimony (metallic)	-	-	-	-	4.00E-04	I	3.00E-04	A	NO	NO	1.50E-01	-	RAGSE
744038-2	Arsenic, Inorganic	1.50E+00	I	4.30E-06	I	3.00E-04	I	1.50E-05	C	NO	NO	1.00E+00	3.00E-02	RAGSE
744039-3	Barium	-	-	-	-	2.00E-01	I	5.00E-04	H	NO	NO	7.00E-02	-	RAGSE
744041-7	Beryllium and compounds	-	-	2.40E-06	I	2.00E-03	I	2.00E-05	I	NO	NO	7.00E-03	-	RAGSE
744042-8	Boron And Borates Only	-	-	-	-	2.00E-01	I	2.00E-02	H	NO	NO	1.00E+00	-	RAGSE
744043-9	Cadmium (Diet)	-	-	1.80E-06	I	1.00E-03	I	1.00E-05	A	NO	NO	2.50E-02	1.00E-03	RAGSE
744043-9	Cadmium (Water)	-	-	1.80E-06	I	5.00E-04	I	1.00E-05	A	NO	NO	5.00E-02	1.00E-03	RAGSE
744047-3	Chromium (Total)[a]	-	-	-	-	-	-	-	-	NO	NO	1.30E-02	-	-
1606583-1	Chromium(III), Insoluble Salts	-	-	-	-	1.50E+00	I	-	-	NO	NO	1.30E-02	-	RAGSE
1854029-9	Chromium(VI)	5.00E-01	C	8.40E-05	S	3.00E-03	I	1.00E-04	I	NO	YES	2.50E-02	-	RAGSE
744048-4	Cobalt	-	-	9.00E-06	P	3.00E-04	P	6.00E-06	P	NO	NO	1.00E+00	-	RAGSE
744050-8	Copper	-	-	-	-	4.00E-02	H	-	-	NO	NO	1.00E+00	-	RAGSE
16984-48-8	Fluoride	-	-	-	-	4.00E-02	C	1.30E-02	C	NO	NO	1.00E+00	-	RAGSE
7439-89-6	Iron	-	-	-	-	7.00E-01	P	-	-	NO	NO	1.00E+00	-	RAGSE
7439-92-1	Lead[e]	-	-	-	-	-	-	-	-	NO	NO	-	-	-
7439-96-5	Manganese	-	-	-	-	2.40E-02	S	5.00E-05	I	NO	NO	4.00E-02	-	RAGSE
7439-97-6	Mercury, Inorganic Salts	-	-	-	-	3.00E-04	S	-	-	NO	NO	7.00E-02	-	RAGSE
7439-98-7	Molybdenum	-	-	-	-	5.00E-03	I	4.00E-04	A	NO	NO	1.00E+00	-	RAGSE
7440-02-0	Nickel Soluble Salts	-	-	2.60E-07	C	2.00E-02	I	9.00E-05	A	NO	NO	4.00E-02	-	RAGSE
7782-49-2	Selenium	-	-	-	-	5.00E-03	I	2.00E-02	C	NO	NO	1.00E+00	-	RAGSE
7440-22-4	Silver	-	-	-	-	5.00E-03	I	-	-	NO	NO	4.00E-02	-	RAGSE
7440-28-0	Thallium (Soluble Salts)	-	-	-	-	1.00E-05	P	-	-	NO	NO	1.00E+00	-	RAGSE
N/A	Uranium (Insoluble Compounds)	-	-	-	-	3.00E-03	I	4.00E-05	A	NO	NO	1.00E+00	-	RAGSE
N/A	Uranium (Soluble Salts)	-	-	-	-	2.00E-04	A	4.00E-05	A	NO	NO	1.00E+00	-	RAGSE
N/A	Vanadium and Compounds	-	-	-	-	5.04E-03	S	1.00E-04	A	NO	NO	2.60E-02	-	RAGSE
7440-66-6	Zinc and Compounds	-	-	-	-	3.00E-01	I	-	-	NO	NO	1.00E+00	-	RAGSE
83-32-9	Acenaphthene	-	-	-	-	6.00E-02	I	-	-	YES	NO	1.00E+00	1.30E-01	RAGSE
208-96-8	Acenaphthylene[b]	-	-	-	-	-	-	-	-	YES	NO	1.00E+00	1.30E-01	RAGSE
107-13-1	Acrylonitrile	5.40E-01	I	6.80E-08	I	4.00E-02	A	2.00E-03	I	YES	NO	1.00E+00	-	RAGSE
120-12-7	Anthracene	-	-	-	-	3.00E-01	I	-	-	YES	NO	1.00E+00	1.30E-01	RAGSE
71-43-2	Benzene	5.50E-02	I	7.80E-09	I	4.00E-03	I	3.00E-02	I	YES	NO	1.00E+00	-	RAGSE
117-81-7	Bis(2-ethylhexyl)phthalate[c]	1.40E-02	I	2.40E-09	C	2.00E-02	I	-	-	NO	NO	1.00E+00	1.00E-01	RAGSE
75-27-4	Bromodichloromethane	6.20E-02	I	3.70E-08	C	2.00E-02	I	-	-	YES	NO	1.00E+00	-	RAGSE
86-74-8	Carbazole	2.00E-02	H	-	-	-	-	-	-	NO	NO	1.00E+00	1.00E-01	RAGSE
56-23-5	Carbon Tetrachloride	7.00E-02	I	6.00E-09	I	4.00E-03	I	1.00E-01	I	YES	NO	1.00E+00	-	RAGSE
67-66-3	Chloroform	3.10E-02	C	2.30E-08	I	1.00E-02	I	9.77E-02	A	YES	NO	1.00E+00	-	RAGSE
75-71-8	Dichlorodifluoromethane (Freon-12)[c]	-	-	-	-	2.00E-01	I	1.00E-01	P	YES	NO	1.00E+00	-	RAGSE

Table B.5a. Toxicity Values and Information (Continued)

Chemical Abstract Number	Analyte	Oral Slope Factor (SFo)[2]	Sfo Ref	Inhalation Unit Risk (IUR)[3]	IUR Ref	Oral RfD (RfDo)[4]	RfDo Ref	Inhalation (RfCi)[5]	RfCi Ref	Volatile Organic?[6]	Muta gen?[7]	Gastro intestinal (GI) Absorption Factor (Unitless)	EPA ABS (Unitless)[8]	ABS Ref
75-34-3	Dichloroethane, 1,1-[c]	5.70E-03	C	1.60E-09	C	2.00E-01	P	5.00E-01	H	YES	NO	1.00E+00	-	RAGSE
107-06-2	Dichloroethane, 1,2-	9.10E-02	I	2.60E-08	I	6.00E-03	P	7.00E-03	P	YES	NO	1.00E+00	-	RAGSE
75-35-4	Dichloroethylene, 1,1-	-	-	-	-	5.00E-02	I	2.00E-01	I	YES	NO	1.00E+00	-	RAGSE
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	-	-	-	-	9.00E-03	H	-	-	YES	NO	1.00E+00	-	RAGSE
156-59-2	Dichloroethylene, 1,2-*cis*-	-	-	-	-	2.00E-03	I	-	-	YES	NO	1.00E+00	-	RAGSE
156-60-5	Dichloroethylene, 1,2-*trans*-	-	-	-	-	2.00E-02	I	6.00E-02	P	YES	NO	1.00E+00	-	RAGSE
60-57-1	Dieldrin	1.60E+01	I	4.60E-06	I	5.00E-05	I	-	-	NO	NO	1.00E+00	1.00E-01	RAGSE
1746-01-6	Dioxins/Furans, Total[f]	-	-	-	-	-	-	-	-	-	-	-	-	-
37871-00-4	~HpCDD	1.30E+03	W	3.80E-04	W	7.00E-08	W	4.00E-06	W	YES	NO	1.00E+00	3.00E-02	RAGSE
38998-75-3	~HpCDF, 2,3,7,8-	1.30E+03	W	3.80E-04	W	7.00E-08	W	4.00E-06	W	YES	NO	1.00E+00	3.00E-02	RAGSE
34465-46-8	~HxCDD, 2,3,7,8-	1.30E+04	W	3.80E-03	W	7.00E-09	W	4.00E-07	W	NO	NO	1.00E+00	3.00E-02	RAGSE
55684-94-1	~HxCDF, 2,3,7,8-	1.30E+04	W	3.80E-03	W	7.00E-09	W	4.00E-07	W	NO	NO	1.00E+00	3.00E-02	RAGSE
3268-87-9	~OCDD	3.90E+01	W	1.14E-05	W	2.33E-06	W	1.33E-04	W	NO	NO	1.00E+00	3.00E-02	RAGSE
39001-02-0	~OCDF	3.90E+01	W	1.14E-05	W	2.33E-06	W	1.33E-04	W	NO	NO	1.00E+00	3.00E-02	RAGSE
36088-22-9	~PeCDD, 2,3,7,8-	1.30E+05	W	3.80E-02	W	7.00E-10	W	4.00E-08	W	NO	NO	1.00E+00	3.00E-02	RAGSE
57117-41-6	~PeCDF, 1,2,3,7,8-	3.90E+03	W	1.14E-03	W	2.33E-08	W	1.33E-06	W	NO	NO	1.00E+00	3.00E-02	RAGSE
57117-31-4	~PeCDF, 2,3,4,7,8-	3.90E+04	W	1.14E-02	W	2.33E-09	W	1.33E-07	W	NO	NO	1.00E+00	3.00E-02	RAGSE
1746-01-6	~TCDD, 2,3,7,8-	1.30E+05	C	3.80E-02	C	7.00E-10	I	4.00E-08	C	YES	NO	1.00E+00	3.00E-02	RAGSE
51207-31-9	~TCDF, 2,3,7,8-	1.30E+04	W	3.80E-03	W	7.00E-09	W	4.00E-07	W	YES	NO	1.00E+00	3.00E-02	RAGSE
100-41-4	Ethylbenzene	1.10E-02	C	2.50E-09	C	1.00E-01	I	1.00E+00	I	YES	NO	1.00E+00	-	RAGSE
206-44-0	Fluoranthene	-	-	-	-	4.00E-02	I	-	-	NO	NO	1.00E+00	1.30E-01	RAGSE
86-73-7	Fluorene	-	-	-	-	4.00E-02	I	-	-	YES	NO	1.00E+00	1.30E-01	RAGSE
118-74-1	Hexachlorobenzene	1.60E+00	I	4.60E-07	I	8.00E-04	I	-	-	YES	NO	1.00E+00	-	RAGSE
91-20-3	Naphthalene	-	-	3.40E-08	C	2.00E-02	I	3.00E-03	I	YES	NO	1.00E+00	1.30E-01	RAGSE
88-74-4	Nitroaniline, 2-	-	-	-	-	1.00E-02	P	5.00E-05	P	NO	NO	1.00E+00	1.00E-01	RAGSE
621-64-7	Nitroso-di-N-propylamine, N-	7.00E+00	I	2.00E-06	C	-	-	-	-	NO	NO	1.00E+00	1.00E-01	RAGSE
87-86-5	Pentachlorophenol	4.00E-01	I	5.10E-09	C	5.00E-03	I	-	-	NO	NO	1.00E+00	2.50E-01	RAGSE
85-01-8	Phenanthrene[b]	-	-	-	-	-	-	-	-	YES	NO	1.00E+00	1.30E-01	RAGSE
1336-36-3	Polychlorinated Biphenyls (high risk)	2.00E+00	I	5.71E-07	I	-	-	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
1336-36-3	Polychlorinated Biphenyls (low risk)	4.00E-01	I	1.00E-07	I	-	-	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
12674-11-2	~Aroclor 1016	7.00E-02	S	2.00E-08	S	7.00E-05	I	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
11104-28-2	~Aroclor 1221	2.00E+00	S	5.71E-07	S	-	-	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
11141-16-5	~Aroclor 1232	2.00E+00	S	5.71E-07	S	-	-	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
53469-21-9	~Aroclor 1242	2.00E+00	S	5.71E-07	S	-	-	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
12672-29-6	~Aroclor 1248	2.00E+00	S	5.71E-07	S	-	-	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
11097-69-1	~Aroclor 1254	2.00E+00	S	5.71E-07	S	2.00E-05	I	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE
11096-82-5	~Aroclor 1260	2.00E+00	S	5.71E-07	S	-	-	-	-	YES	NO	1.00E+00	1.40E-01	RAGSE

Table B.5a. Toxicity Values and Information (Continued)

Chemical Abstract Number	Analyte	Oral Slope Factor (SFo)[2]	Sfo Ref	Inhalation Unit Risk (IUR)[3]	IUR Ref	Oral RfD (RfDo)[4]	RfDo Ref	Inhalation (RfCi)[5]	RfCi Ref	Volatile Organic?[6]	Muta gen?[7]	Gastro intestinal (GI) Absorption Factor (Unitless)	EPA ABS (Unitless)[8]	ABS Ref
50-32-8	Polycyclic aromatic hydrocarbons (cPAH), Total Carcinogenic[f]	-	-	-	-	-	-	-	-	-	-	-	-	-
56-55-3	~Benz[a]anthracene	1.00E-01	W	6.00E-08	W	-	-	-	-	YES	YES	1.00E+00	1.30E-01	RAGSE
50-32-8	~Benzo[a]pyrene	1.00E+00	I	6.00E-07	I	3.00E-04	I	2.00E-06	I	NO	YES	1.00E+00	1.30E-01	RAGSE
205-99-2	~Benzo[b]fluoranthene	1.00E-01	W	6.00E-08	W	-	-	-	-	NO	YES	1.00E+00	1.30E-01	RAGSE
207-08-9	~Benzo[k]fluoranthene	1.00E-02	W	6.00E-09	W	-	-	-	-	NO	YES	1.00E+00	1.30E-01	RAGSE
218-01-9	~Chrysene	1.00E-03	W	6.00E-10	W	-	-	-	-	NO	YES	1.00E+00	1.30E-01	RAGSE
53-70-3	~Dibenz[a,h]anthracene	1.00E+00	W	6.00E-07	W	-	-	-	-	NO	YES	1.00E+00	1.30E-01	RAGSE
193-39-5	~Indeno[1,2,3-cd]pyrene	1.00E-01	W	6.00E-08	W	-	-	-	-	NO	YES	1.00E+00	1.30E-01	RAGSE
129-00-0	Pyrene	-	-	-	-	3.00E-02	I	-	-	YES	NO	1.00E+00	1.30E-01	RAGSE
127-18-4	Tetrachloroethylene	2.10E-03	I	2.60E-10	I	6.00E-03	I	4.00E-02	I	YES	NO	1.00E+00	-	RAGSE
108-88-3	Toluene[c]	-	-	-	-	8.00E-02	I	5.00E+00	I	YES	NO	1.00E+00	-	RAGSE
71-55-6	Trichloroethane, 1,1,1-	-	-	-	-	2.00E+00	I	5.00E+00	I	YES	NO	1.00E+00	-	RAGSE
79-00-5	Trichloroethane, 1,1,2-	5.70E-02	I	1.60E-08	I	4.00E-03	I	2.00E-04	P	YES	NO	1.00E+00	-	RAGSE
79-01-6	Trichloroethylene	4.60E-02	I	4.10E-09	I	5.00E-04	I	2.00E-03	I	YES	YES	1.00E+00	-	RAGSE
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[c]	-	-	-	-	3.00E+01	I	5.00E+00	P	YES	NO	1.00E+00	-	RAGSE
75-01-4	Vinyl Chloride	7.20E-01	I	4.40E-09	I	3.00E-03	I	1.00E-01	I	YES	YES	1.00E+00	-	RAGSE
1330-20-7	Xylene, Mixture	-	-	-	-	2.00E-01	I	1.00E-01	I	YES	NO	1.00E+00	-	RAGSE
108-38-3	Xylene, m-	-	-	-	-	2.00E-01	S	1.00E-01	S	YES	NO	1.00E+00	-	RAGSE
95-47-6	Xylene, o-	-	-	-	-	2.00E-01	S	1.00E-01	S	YES	NO	1.00E+00	-	RAGSE
106-42-3	Xylene, P-	-	-	-	-	2.00E-01	S	1.00E-01	S	YES	NO	1.00E+00	-	RAGSE

Table B.5a. Toxicity Values and Information (Continued)

Analyte	PEF Res.[9]	PEF Ind./ Comm.[9]	VF Res.[10]	VF Ind./ Comm.[10]	KY ABS (Unitless)[11]	Permeability Constant[12]	Perm. Const. Ref	FA[13]	τ_{event} (hr/event)[14]	t (hr)[15]	B (Unitless)[16]
Aluminum	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	1.49E-01	3.57E-01	2.00E-03
Antimony (metallic)	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	5.05E-01	1.21E+00	4.24E-03
Arsenic, Inorganic[d]	1.36E+09	1.36E+09	-	-	3.00E-02	1.00E-03	RAGSE	1	2.76E-01	6.63E-01	3.33E-03
Barium	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	6.18E-01	1.48E+00	4.51E-03
Beryllium and compounds	1.36E+09	1.36E+09	-	-	7.00E-03	1.00E-03	RAGSE	1	1.18E-01	2.83E-01	1.15E-03
Boron And Borates Only	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	1.26E-01	3.02E-01	1.43E-03
Cadmium (Diet)	1.36E+09	1.36E+09	-	-	1.00E-03	1.00E-03	RAGSE	1	4.48E-01	1.08E+00	4.08E-03
Cadmium (Water)	-	-	-	-	1.00E-03	1.00E-03	RAGSE	1	4.48E-01	1.08E+00	4.08E-03
Chromium (Total)[a]	1.36E+09	1.36E+09	-	-	1.30E-02	1.00E-03	RAGSE	1	2.06E-01	4.93E-01	2.77E-03
Chromium(III), Insoluble Salts	1.36E+09	1.36E+09	-	-	1.30E-02	1.00E-03	RAGSE	1	2.06E-01	4.93E-01	2.77E-03
Chromium(VI)	1.36E+09	1.36E+09	-	-	2.50E-02	2.00E-03	RAGSE	1	2.06E-01	4.93E-01	5.55E-03
Cobalt	1.36E+09	1.36E+09	-	-	5.00E-02	4.00E-04	RAGSE	1	2.25E-01	5.40E-01	1.18E-03
Copper	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	2.39E-01	5.73E-01	3.07E-03
Fluoride	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	1.72E-01	4.12E-01	2.37E-03
Iron	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	2.16E-01	5.19E-01	2.87E-03
Lead[e]	-	-	-	-	-	-	-	-	-	-	-
Manganese	1.36E+09	1.36E+09	-	-	4.00E-02	1.00E-03	RAGSE	1	2.14E-01	5.13E-01	2.85E-03
Mercury, Inorganic Salts	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	0	-	-	-
Molybdenum	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	3.62E-01	8.70E-01	3.77E-03
Nickel Soluble Salts	1.36E+09	1.36E+09	-	-	4.00E-02	2.00E-04	RAGSE	1	2.24E-01	5.38E-01	5.89E-04
Selenium	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	2.91E-01	6.99E-01	3.42E-03
Silver	1.36E+09	1.36E+09	-	-	4.00E-02	6.00E-04	RAGSE	1	4.23E-01	1.01E+00	2.40E-03
Thallium (Soluble Salts)	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	1.47E+00	3.52E+00	5.50E-03
Uranium (Insoluble Compounds)	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	2.26E+00	5.43E+00	5.93E-03
Uranium (Soluble Salts)	1.36E+09	1.36E+09	-	-	5.00E-02	1.00E-03	RAGSE	1	2.26E+00	5.43E+00	5.93E-03
Vanadium and Compounds	1.36E+09	1.36E+09	-	-	2.60E-02	1.00E-03	RAGSE	1	2.03E-01	4.87E-01	2.75E-03
Zinc and Compounds	1.36E+09	1.36E+09	-	-	5.00E-02	6.00E-04	RAGSE	1	2.44E-01	5.86E-01	1.87E-03
Acenaphthene	1.36E+09	1.36E+09	1.41E+05	1.41E+05	1.30E-01	8.60E-02	EPI	1	7.68E-01	1.84E+00	4.11E-01
Acenaphthylene[b]	1.36E+09	1.36E+09	1.89E+05	1.89E+05	1.30E-01	9.11E-02	EPI	1	7.48E-01	1.80E+00	4.32E-01
Acrylonitrile	1.36E+09	1.36E+09	7.69E+03	7.69E+03	2.50E-01	1.16E-03	EPI	1	2.08E-01	5.00E-01	3.25E-03
Anthracene	1.36E+09	1.36E+09	5.23E+05	5.23E+05	1.30E-01	1.42E-01	EPI	1	1.05E+00	4.05E+00	7.29E-01
Benzene	1.36E+09	1.36E+09	3.54E+03	3.54E+03	2.50E-01	1.49E-02	EPI	1	2.88E-01	6.91E-01	5.07E-02
Bis(2-ethylhexyl)phthalate[c]	1.36E+09	1.36E+09	-	-	1.00E-01	1.13E+00	EPI	0.8	1.62E+01	7.29E+01	8.59E+00
Bromodichloromethane	1.36E+09	1.36E+09	3.97E+03	3.97E+03	2.50E-01	4.02E-03	EPI	1	8.70E-01	2.09E+00	1.98E-02
Carbazole	1.36E+09	1.36E+09	-	-	1.00E-01	5.36E-02	EPI	1	9.08E-01	2.18E+00	2.67E-02
Carbon Tetrachloride	1.36E+09	1.36E+09	1.49E+03	1.49E+03	2.50E-01	1.63E-02	EPI	1	7.64E-01	1.83E+00	7.78E-02
Chloroform	1.36E+09	1.36E+09	2.63E+03	2.63E+03	2.50E-01	6.83E-03	EPI	1	4.90E-01	1.18E+00	2.87E-02
Dichlorodifluoromethane (Freon-12)[c]	1.36E+09	1.36E+09	8.41E+02	8.41E+02	2.50E-01	8.95E-03	EPI	1	5.00E-01	1.20E+00	3.79E-02

Table B.5a. Toxicity Values and Information (Continued)

Analyte	PEF Res.[9]	PEF Ind./ Comm.[9]	VF Res.[10]	VF Ind./ Comm.[10]	KY ABS (Unitless)[11]	Permeability Constant[12]	Perm. Const. Ref	FA[13]	τ_{event} (hr/event)[14]	t (hr)[15]	B (Unitless)[16]
Dichloroethane, 1,1-[c]	1.36E+09	1.36E+09	2.08E+03	2.08E+03	2.50E-01	6.75E-03	EPI	1	3.77E-01	9.04E-01	2.58E-02
Dichloroethane, 1,2-	1.36E+09	1.36E+09	4.57E+03	4.57E+03	2.50E-01	4.20E-03	EPI	1	3.77E-01	9.04E-01	1.61E-02
Dichloroethylene, 1,1-	1.36E+09	1.36E+09	1.16E+03	1.16E+03	2.50E-01	1.17E-02	EPI	1	3.67E-01	8.81E-01	4.43E-02
Dichloroethylene, 1,2- (Mixed Isomers)	1.36E+09	1.36E+09	2.51E+03	2.51E+03	2.50E-01	1.10E-02	EPI	1	3.67E-01	8.81E-01	4.17E-02
Dichloroethylene, 1,2-*cis*-	1.36E+09	1.36E+09	2.50E+03	2.50E+03	2.50E-01	1.10E-02	EPI	1	3.67E-01	8.81E-01	4.17E-02
Dichloroethylene, 1,2-*trans*-	1.36E+09	1.36E+09	1.75E+03	1.75E+03	2.50E-01	1.10E-02	EPI	1	3.67E-01	8.81E-01	4.17E-02
Dieldrin	1.36E+09	1.36E+09	-	-	1.00E-01	3.26E-02	EPI	0.8	1.43E+01	3.43E+01	2.45E-01
Dioxins/Furans, Total[f]	-	-	-	-	-	-	-	-	-	-	-
~HpCDD	1.36E+09	1.36E+09	2.43E+06	2.43E+06	3.00E-02	1.33E+00	EPI	0	2.53E+01	1.15E+02	1.05E+01
~HpCDF, 2,3,7,8-	1.36E+09	1.36E+09	6.27E+06	6.27E+06	3.00E-02	1.45E+00	EPI	0	2.06E+01	9.37E+01	1.13E+01
~HxCDD, 2,3,7,8-	1.36E+09	1.36E+09	-	-	3.00E-02	2.86E+00	EPI	0	1.62E+01	7.51E+01	2.17E+01
~HxCDF, 2,3,7,8-	1.36E+09	1.36E+09	-	-	3.00E-02	1.35E+00	EPI	0	1.32E+01	5.99E+01	1.01E+01
~OCDD	1.36E+09	1.36E+09	-	-	3.00E-02	1.16E+00	EPI	0	3.95E+01	1.79E+02	9.57E+00
~OCDF	1.36E+09	1.36E+09	-	-	1.00E-01	2.63E+00	EPI	0	3.21E+01	1.49E+02	2.13E+01
~PeCDD, 2,3,7,8-	1.36E+09	1.36E+09	-	-	3.00E-02	2.41E-01	EPI	0.7	1.04E+01	4.20E+01	1.75E+00
~PeCDF, 1,2,3,7,8-	1.36E+09	1.36E+09	-	-	1.00E-01	6.27E-01	EPI	0.4	8.48E+00	3.69E+01	4.45E+00
~PeCDF, 2,3,4,7,8-	1.36E+09	1.36E+09	-	-	1.00E-01	6.27E-01	EPI	0.4	8.48E+00	3.69E+01	4.45E+00
~TCDD, 2,3,7,8-	1.36E+09	1.36E+09	1.96E+06	1.96E+06	3.00E-02	8.08E-01	EPI	0.5	6.68E+00	2.95E+01	5.58E+00
~TCDF, 2,3,7,8-	1.36E+09	1.36E+09	2.49E+06	2.49E+06	1.00E-01	6.57E-01	EPI	0.6	5.44E+00	2.36E+01	4.42E+00
Ethylbenzene	1.36E+09	1.36E+09	5.67E+03	5.67E+03	2.50E-01	4.93E-02	EPI	1	4.13E-01	9.92E-01	1.95E-01
Fluoranthene	1.36E+09	1.36E+09	-	-	1.30E-01	3.08E-01	EPI	1	1.43E+00	5.73E+00	1.68E+00
Fluorene	1.36E+09	1.36E+09	2.81E+05	2.81E+05	1.30E-01	1.10E-01	EPI	1	8.97E-01	2.15E+00	5.45E-01
Hexachlorobenzene	1.36E+09	1.36E+09	6.80E+04	6.80E+04	1.00E-01	2.54E-01	EPI	0.9	4.14E+00	1.66E+01	1.65E+00
Naphthalene	1.36E+09	1.36E+09	4.63E+04	4.63E+04	1.30E-01	4.66E-02	EPI	1	5.49E-01	1.32E+00	2.03E-01
Nitroaniline, 2-	1.36E+09	1.36E+09	-	-	1.00E-01	4.46E-03	EPI	1	6.24E-01	1.50E+00	2.02E-02
Nitroso-di-N-propylamine, N-	1.36E+09	1.36E+09	-	-	1.00E-01	2.33E-03	EPI	1	5.64E-01	1.35E+00	1.02E-02
Pentachlorophenol	1.36E+09	1.36E+09	-	-	2.50E-01	1.27E-01	EPI	0.9	3.26E+00	1.25E+01	7.97E-01
Phenanthrene[b]	1.36E+09	1.36E+09	6.43E+05	6.43E+05	1.30E-01	1.44E-01	EPI	1	1.05E+00	4.05E+00	7.39E-01
Polychlorinated Biphenyls (high risk)	1.36E+09	1.36E+09	5.32E+05	5.32E+05	1.40E-01	5.45E-01	EPI	0.7	4.54E+00	1.94E+01	3.58E+00
Polychlorinated Biphenyls (low risk)	1.36E+09	1.36E+09	5.32E+05	5.32E+05	1.40E-01	5.45E-01	EPI	0.7	4.54E+00	1.94E+01	3.58E+00
~Aroclor 1016	1.36E+09	1.36E+09	7.14E+05	7.14E+05	1.40E-01	3.05E-01	EPI	0	1.26E+02	5.27E+02	2.75E+00
~Aroclor 1221	1.36E+09	1.36E+09	2.04E+05	2.04E+05	1.40E-01	1.68E-01	EPI	1	1.20E+00	4.60E+00	8.88E-01
~Aroclor 1232	1.36E+09	1.36E+09	1.12E+05	1.12E+05	1.40E-01	1.68E-01	EPI	1	1.20E+00	4.60E+00	8.88E-01
~Aroclor 1242	1.36E+09	1.36E+09	5.91E+05	5.91E+05	1.40E-01	5.45E-01	EPI	0.7	4.54E+00	1.94E+01	3.58E+00
~Aroclor 1248	1.36E+09	1.36E+09	6.25E+05	6.25E+05	1.40E-01	4.75E-01	EPI	0	3.06E+02	1.33E+03	4.54E+00
~Aroclor 1254	1.36E+09	1.36E+09	8.43E+05	8.43E+05	1.40E-01	7.51E-01	EPI	0.5	7.08E+00	3.11E+01	5.22E+00
~Aroclor 1260	1.36E+09	1.36E+09	1.31E+06	1.31E+06	1.40E-01	9.86E-01	EPI	0	1.72E+01	7.71E+01	7.54E+00

Table B.5a. Toxicity Values and Information (Continued)

Analyte	PEF Res.[9]	PEF Ind./ Comm.[9]	VF Res.[10]	VF Ind./ Comm.[10]	KY ABS (Unitless)[11]	Permeability Constant[12]	Perm. Const. Ref	FA[13]	τ_{event} (hr/event)[14]	t (hr)[15]	B (Unitless)[16]
Polycyclic aromatic hydrocarbons (cPAH), Total Carcinogenic[f]	-	-	-	-	-	-	-	-	-	-	-
~Benz[a]anthracene	1.36E+09	1.36E+09	4.41E+06	4.41E+06	1.30E-01	5.52E-01	EPI	1	2.00E+00	8.48E+00	3.21E+00
~Benzo[a]pyrene	1.36E+09	1.36E+09	-	-	1.30E-01	7.13E-01	EPI	1	2.72E+00	1.18E+01	4.36E+00
~Benzo[b]fluoranthene	1.36E+09	1.36E+09	-	-	1.30E-01	4.17E-01	EPI	1	2.72E+00	1.13E+01	2.55E+00
~Benzo[k]fluoranthene	1.36E+09	1.36E+09	-	-	1.30E-01	6.91E-01	EPI	0.9	2.72E+00	1.18E+01	4.22E+00
~Chrysene	1.36E+09	1.36E+09	-	-	1.30E-01	5.96E-01	EPI	1	2.00E+00	8.53E+00	3.46E+00
~Dibenz[a,h]anthracene	1.36E+09	1.36E+09	-	-	1.30E-01	9.53E-01	EPI	0.6	3.81E+00	1.69E+01	6.12E+00
~Indeno[1,2,3-cd]pyrene	1.36E+09	1.36E+09	-	-	1.30E-01	1.24E+00	RAGSE	0.6	3.71E+00	1.67E+01	7.93E+00
Pyrene	1.36E+09	1.36E+09	2.38E+06	2.38E+06	1.30E-01	2.01E-01	EPI	1	1.43E+00	5.54E+00	1.10E+00
Tetrachloroethylene	1.36E+09	1.36E+09	2.35E+03	2.35E+03	2.50E-01	3.34E-02	EPI	1	8.92E-01	2.14E+00	1.65E-01
Toluene[c]	1.36E+09	1.36E+09	4.29E+03	4.29E+03	2.50E-01	3.11E-02	EPI	1	3.45E-01	8.28E-01	1.15E-01
Trichloroethane, 1,1,1-	1.36E+09	1.36E+09	1.65E+03	1.65E+03	2.50E-01	1.26E-02	EPI	1	5.87E-01	1.41E+00	5.60E-02
Trichloroethane, 1,1,2-	1.36E+09	1.36E+09	7.22E+03	7.22E+03	2.50E-01	5.04E-03	EPI	1	5.87E-01	1.41E+00	2.24E-02
Trichloroethylene	1.36E+09	1.36E+09	2.21E+03	2.21E+03	2.50E-01	1.16E-02	EPI	1	5.72E-01	1.37E+00	5.11E-02
Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[c]	1.36E+09	1.36E+09	1.29E+03	1.29E+03	2.50E-01	1.75E-02	EPI	1	1.18E+00	2.83E+00	9.21E-02
Vinyl Chloride	1.36E+09	1.36E+09	9.56E+02	9.56E+02	2.50E-01	8.38E-03	EPI	1	2.35E-01	5.65E-01	2.55E-02
Xylene, Mixture	1.36E+09	1.36E+09	5.74E+03	5.74E+03	2.50E-01	5.00E-02	EPI	1	4.13E-01	9.92E-01	1.98E-01
Xylene, m-	1.36E+09	1.36E+09	5.47E+03	5.47E+03	2.50E-01	5.32E-02	EPI	1	4.13E-01	9.92E-01	2.11E-01
Xylene, o-	1.36E+09	1.36E+09	6.46E+03	6.46E+03	2.50E-01	4.71E-02	EPI	1	4.13E-01	9.92E-01	1.87E-01
Xylene, P-	1.36E+09	1.36E+09	5.58E+03	5.58E+03	2.50E-01	4.93E-02	EPI	1	4.13E-01	9.92E-01	1.95E-01

Table B.5b. Toxicity Values and Information (Continued)

Chemical Abstract Number	Analyte	Inhalation Slope Factor (SFi)[3]	SFi Ref	Oral Slope Factor for Water (SFow)[17]	SFow Ref	Oral Slope Factor for Soil (SFos) Res.[17]	Oral Slope Factor for Soil (SFos) Ind./Comm.[17]	SFos Ref	Oral Slope Factor for Food (SFof)[17]	External Exposure Slope Factor (SFe)[18]	SFe Ref	Lambda[19]	Halflife[19]
14596-10-2	Am-241	3.77E-08	O	1.04E-10	O	1.84E-10	9.10E-11	O	1.34E-10	2.77E-08	O	1.60E-03	4.32E+02
10045-97-3	Cs-137+D	1.12E-10	O	3.05E-11	O	4.26E-11	3.18E-11	O	3.74E-11	2.53E-06	O	2.30E-02	3.02E+01
13994-20-2	Np-237+D	2.87E-08	O	6.85E-11	O	1.41E-10	4.96E-11	O	9.18E-11	8.55E-07	O	3.23E-07	2.14E+06
13981-16-3	Pu-238	5.22E-08	O	1.31E-10	O	2.25E-10	1.17E-10	O	1.69E-10	6.91E-11	O	7.90E-03	8.77E+01
15117-48-3	Pu-239	5.55E-08	O	1.35E-10	O	2.28E-10	1.21E-10	O	1.74E-10	2.09E-10	O	2.87E-05	2.41E+04
14119-33-6	Pu-240	5.55E-08	O	1.35E-10	O	2.28E-10	1.21E-10	O	1.74E-10	7.12E-11	O	1.06E-04	6.56E+03
14133-76-7	Tc-99	3.81E-11	O	2.75E-12	O	7.25E-12	1.32E-12	O	4.00E-12	8.28E-11	O	3.28E-06	2.11E+05
14269-63-7	Th-230	3.41E-08	O	9.14E-11	O	1.66E-10	7.73E-11	O	1.19E-10	8.45E-10	O	9.19E-06	7.54E+04
13966-29-5	U-234	2.78E-08	O	7.07E-11	O	1.48E-10	5.11E-11	O	9.55E-11	2.53E-10	O	2.82E-06	2.46E+05
15117-96-1	U-235+D	2.50E-08	O	7.18E-11	O	1.54E-10	5.00E-11	O	9.77E-11	5.76E-07	O	9.84E-10	7.04E+08
7440-61-1	U-238+D	2.37E-08	O	8.70E-11	O	1.97E-10	5.62E-11	O	1.21E-10	1.19E-07	O	1.55E-10	4.47E+09

Information compiled from RAIS November 2018.

Note that the toxicity values and information is presented in a split table format. Cells containing "-" indicate no value or information is available.

[a] Values for Chromium (Total) should use toxicity factors for Chromium VI, unless it is determined on a project-specific basis that chromium VI is not present. If chromium VI is not present, chromium III should be used. This approach is consistent with Screening Level note 9b (Appendix A).

[b] Values for Acenaphthylene and Phenanthrene, if not available use toxicity factors for Acenaphthene.

[c] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.

[d] Calculations for arsenic include a relative bioavailability factor for soil ingestion of 0.6. For additional information, see the EPA document, OSWER 9200.1-113, December 2012.

[e] Lead toxicity values are not included because lead is evaluated using Integrated Exposure Uptake Biokinetic modeling and Adult Lead Model modeling, as appropriate. See Section B.3.

[f] Toxicity values for Total Dioxins/Furans use those for 2,3,7,8-TCDD and cPAHs use those for benzo[a]pyrene.

Reference Codes:

A Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels
C The California EPA Office of Environmental Health Hazard Assessment's (OEHHA) Chronic Reference Exposure Levels (RELS) from December 18, 2008, and the Cancer Potency Values from July 21, 2009
EPI EPA's Estimation Programs Interface Suite
H EPA's Health Effects Assessment Summary Tables (HEAST)
I EPA's Integrated Risk Information System (IRIS)
O Oak Ridge National Laboratory (ORNL) Technical Memorandum (TM) (ORNL/TM-2013/00), September 2014
P The Provisional Peer Reviewed Toxicity Values (PPRTVs) derived by EPA's Superfund Health Risk Technical Support Center (STSC) for the EPA Superfund program
RAGSE Risk Assessment Guidance for Superfund, Part E
S Surrogate
W World Health Organization

Notes on Table B.5.

Prior to using the values in this table, a risk assessor must be consulted to determine if any values need to be updated and to verify that the values are being used appropriately.

1. Information used to derive PRGs for COPCs at the PGDP is shown.
2. The "Oral Slope Factor" is the chronic oral slope factor used for the ingestion routes of exposure. The units on this value for chemicals is $[mg/(kg \times day)]^{-1}$. The units on this value for radionuclides is $(pCi)^{-1}$.
3. The "Inhalation Unit Risk" is the chronic inhalation factor used for inhalation routes of exposure. The values listed for chemicals is in units of mg/m^3, although they typically are expressed in $\mu g/m^3$.
   For radionuclides, the inhalation slope factor continues to be used. The units on this value for radionuclides is $(pCi)^{-1}$.
4. The "Oral RfD" is the chronic oral reference dose used for ingestion routes of exposure. The units for Oral RfD are mg/(kg x day).
5. The "Inhalation RfC" is the chronic inhalation concentration used for inhalation routes of exposure. The units for Inhalation RfC are mg/m^3.
6. "Volatile Organic?" is a flag used to specify if the chemical should be assessed as a vapor. A chemical is considered volatile in this context if it has a vapor pressure greater than 1 mm Hg or a Henry's Law constant greater than 0.00001 atm-m^3/mole (RAIS 2018).
7. The column labeled "Mutagen?" is a flag used to specify if the chemical should be assessed as a mutagen. This assessment is made when PRGs are developed using the RAIS calculator. See Section 3.3.6.1 of the main text.
8. The "EPA ABS" is the dermal absorption value recommended by EPA in their guidance material, 2004 *RAGs, Part E*. The dermal absorption value is unitless.
9. The "Particle Emission Factor" is a value used to assess inhalation routes of exposure. The particle emission factor is in units of m^3/kg. The values for residential (Res.) and industrial/commercial (Ind./Comm.) scenario listed are taken from the 2002 *Kentucky Risk Assessment Guidance.*
10. The "Volatilization Factor" is a value used to assess inhalation routes of exposure. Values are given for residential (Res.) and industrial/commercial (Ind./Comm.) scenarios. The volatilization factor is in units of m^3/kg.
11. The "KY ABS" is the dermal absorption value recommended by the Commonwealth of Kentucky in their guidance material, 2002 *Kentucky Risk Assessment Guidance*. Dermal exposure to soil used default absorption values of 0.25 for volatiles, 0.1 for semivolatiles, and 0.05 for metals. The dermal absorption value is unitless.

    In RAGS Part E, 2004, Exhibit 4-1, the following GI absorption efficiencies are listed that are below the 5% dermal absorption KDEP has recommended as a default value for inorganics. For these constituents, the dermal absorption value should be modified from 5% to mimic the GI absorption efficiencies, as follows: Beryllium 0.007 = 0.7%; Chromium III 0.013 = 1.3%; Chromium VI 0.025 = 2.5%; Manganese 0.04 = 4%; Nickel 0.04 = 4%; Silver 0.04 = 4%; Vanadium 0.026 = 2.6%

    This is in addition to the chemical-specific dermal absorption fractions listed in RAGS, Part E, Exhibit 3-4, including: Arsenic 0.03 = 3% and Cadmium 0.001=0.1%

    Additional deviations from the 2002 *Kentucky Risk Assessment Guidance* are documented in the August 14, 2007, meeting minutes (see DOE 2017, Appendix E).
12. The "Permeability Constant" is a chemical-specific value used to estimate dermal absorption of chemicals in water. The permeability constant is in units of cm/hr.
13. The "FA" is the fraction absorbed water. The chemical-specific value is unitless. Values were taken from RAIS.
14. The "τ_{event}" is the lag time per event and is a chemical-specific value. The values were taken from RAIS and are in units of hours/event.
15. The variable "t" indicates time to reach steady-state. Values are chemical-specific in units of hours. Values were taken from RAIS.
16. "B" is the dimensionless ratio of the permeability coefficient of a compound through the stratum corneum, relative to its permeability coefficient across the viable epidermis. The chemical-specific values were taken from RAIS.
17. "Oral Slope Factor for Water," "Oral Slope Factor for Soil," and "Oral Slope Factor for Food" are the indicated values for radionuclides. The units for these factors are $(pCi)^{-1}$.
18. The "External Exposure Slope Factor" is the slope factor used for external exposure to ionizing radiation emitted by radioactive chemicals. The units for external exposure slope factor are $[(pCi \text{ x } year)/g]^{-1}$.
19. "Lambda" is a decay constant. It is equal to 0.693/half-life ($year^{-1}$) where 0.693 = ln(2). The units for lambda are ($year^{-1}$).
    "Half-life" is the time taken for the radioactivity of a specified isotope to fall to half its original value. The units for half-life are years.

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APPENDIX C

OUTLINE FOR BASELINE HUMAN HEALTH RISK ASSESSMENTS

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OUTLINE FOR BASELINE HUMAN HEALTH RISK ASSESSMENTS

*** Although the following outline can be used for baseline human health risk assessments for both source units and integrator units, not all sections may be relevant to all assessments and additional sections may be needed for some assessments. However, all baseline risk assessments completed for PGDP should include each of the first and second level headers listed below.

*** The document should begin with an introduction that presents the scope and objectives of the baseline human health risk assessment. This should include a description of the general problem at the site and an overview of the design of the baseline human health risk assessment.

1. Results of Previous Studies

*** The section should begin with a brief summary of the previous studies that are relevant to the baseline human health risk assessment. All relevant previous risk evaluations should be summarized.

1.1 Study #1
1.2 Study #2
Etc.

2. Identification of Chemicals of Potential Concern

*** The section should begin with an introduction that describes the purpose of the section and the order in which the material is presented.

2.1 Sources of Data

*** The sources of all data should be listed, and the projects in which the data were collected should be described.

2.2 General Data Evaluation Considerations

*** The eight steps of data evaluation as applied to the baseline risk assessment should be discussed.

2.2.1 Evaluation of Sampling Design
2.2.2 Evaluation of Analytical Methods
2.2.3 Evaluation of Sample Quantitation Limits
2.2.4 Evaluation of Data Qualifiers and Codes
2.2.5 Elimination of Chemicals not Detected
2.2.6 Examination of Toxicity of Detected Analytes
2.2.7 Examination of Essential Nutrients
2.2.8 Comparison of Analyte Concentrations and Activities Detected in Site Samples to Background Concentrations

2.3 Risk Assessment Specific Data Evaluation

*** This section should discuss in detail how the eight steps were applied to identify the chemicals of potential concern under both current and future conditions.

2.3.1 Current Conditions

*** This section should discuss the evaluation of the data set.

2.3.2 Future Conditions

*** This section should discuss any modeling performed to address potential future changes in the identity or concentration of contaminants.

2.4 Evaluation of Data from Other Sources

*** The section should introduce any "special data," especially nonnumeric data (such as activities of visitors at a site or types of vegetables grown by Kentucky residents) used to develop the exposure assessment that are not used quantitatively in the baseline human health risk assessment. Examples of special data that may be used are found in the survey forms and responses in Appendix E.

2.4.1 Other Source #1
2.4.2 Other Source #2
Etc.

2.5 Summary of Chemicals of Potential Concern

*** This section should present a summary of the quantitative data evaluation and its results.

3. Exposure Assessment

*** This section should begin with a description of the process used in exposure assessment, and the goal of the specific exposure assessment being performed.

3.1 Characterization of Exposure Setting

*** This section should describe either by reference or directly the following:

3.1.1 Surface Features
3.1.2 Meteorology
3.1.3 Geology
3.1.4 Demography and Land Use
3.1.5 Ecology
3.1.6 Hydrology
3.1.7 Hydrogeology

3.2 Identification of Exposure Pathways

*** This section should begin by describing what a pathway is and how a pathway can be complete or incomplete.

3.2.1 Land Use Considerations

*** The land use under current and expected and potential future conditions should be described.

3.2.2 Potential Receptor Populations

*** The potential receptors under both current and future uses should be described and justified.

3.2.3 Delineation of Exposure Points/Exposure Routes

*** All possible exposure routes should be presented and justified. The number of possible exposure routes should be reduced, if possible, so that only probable exposure routes with significant risk or hazard are quantified. The exposure equations used in the assessment to quantify exposure should be presented. Justification for not quantifying a possible route should be presented.

3.2.4 Development of Conceptual Site Models

*** Figures illustrating the pathways of exposure should be presented for each site under investigation. The model for each site should be justified.

3.3 Quantification of Exposure

*** The methods used to quantify exposure (i.e., estimate dose) should be described for each receptor. If modeling is used to determine concentration or activities of chemicals of potential concern in biota, the models should be presented.

3.4 Summary of Exposure Assessment

4. Toxicity Assessment

*** This section should begin by describing the goal and methods used for toxicity assessment. The source of all toxicity values should be discussed. Tables presenting the toxicity information should be presented.

4.1 Inorganics

*** The toxicity of each chemical of potential concern should be profiled. Each profile should include a listing of the carcinogenic and noncarcinogenic toxicity values used in the baseline human health risk assessment.

4.1.1 Chemical 1
4.1.2 Chemical 2
Etc.

4.2 Organics

*** The toxicity of each chemical of potential concern should be profiled. Each profile should include a listing of the toxicity values used in the baseline human health risk assessment.

4.2.1 Chemical 1
4.2.2 Chemical 2
Etc.

4.3 Radionuclides

*** The toxicity of each chemical of potential concern should be profiled. Each profile should include a listing of the toxicity values used in the baseline human health risk assessment.

4.3.1 Radionuclide 1
4.3.2 Radionuclide 2
Etc.

4.4 Chemicals for Which No EPA Toxicity Values Are Available

*** The chemicals of potential concern that fall in this class should be listed. If the baseline human health risk assessment is evaluating multiple units or areas, these chemicals should be listed by unit or area. This section should include the procedure for evaluating potential surrogate chemicals that may be available for some of the chemicals without toxicity values.

4.5 Uncertainties Related to Toxicity Assessment

*** A brief presentation of the uncertainties related to all toxicity assessments and toxicity values should be made.

4.6 Summary

*** The amount of toxicity information for the chemicals of potential concern should be discussed. If the baseline human health risk assessment is evaluating multiple units or areas, this information should be presented by unit or area.

5. Risk Characterization

*** The section should begin with a brief discussion of the purpose and goals of risk characterization and what will result from this step of the assessment.

5.1 Determination of Noncancer Effects

*** The methods used to quantify systemic toxicity for each chemical, both within and across pathways should be presented. If exposure over multiple scenarios or areas is possible, this should be noted.

5.2 Determination of Excess Cancer Risk

*** The methods used to quantify excess lifetime cancer risk for each chemical, both within and across pathways should be presented. If exposure over multiple scenarios or areas is possible, this should be noted.

5.3 Risk Characterization for Current Use Scenario(s)

*** Risk results for each unit or area should be presented in two-way tables and in a narrative summary. If subchronic effects are characterized, they should be presented separately from the chronic effects.

5.3.1 Systemic Toxicity

5.3.2 Excess Lifetime Cancer Risk

5.4 Risk Characterization for Future Use Scenario(s)

*** Risk results for each unit or area should be presented in two-way tables and in a narrative summary. If more than one future time is quantitatively evaluated, the results should be presented for each time period. If subchronic effects are characterized, they should be presented separately from the chronic effects.

5.4.1 Systemic Toxicity

5.4.2 Excess Lifetime Cancer Risk

5.5 Risk Characterization for Lead (if needed)

*** The special problems associated with risk characterization for lead should be discussed. Results from lead modeling and from comparisons against EPA and Kentucky screening values should be presented by unit or area.

5.6 Identification of Use Scenarios, Chemicals, Pathways, and Media of Concern

*** The section should begin with a listing of the rules used to identify use scenarios, chemicals, pathways and media of concern.

5.6.1 Use Scenarios of Concern

*** These should be listed within area or unit under investigation.

5.6.2 Chemicals of Concern

*** These should be listed within area or unit under investigation.

5.6.3 Pathways of Concern

*** These should be listed within area or unit under investigation.

5.6.4 Media of Concern

*** These should be listed within area or unit under investigation

5.7 Summary of Risk Characterization

*** This section should describe and present the risk characterization summary tables.

6. Uncertainty in the Risk Assessment

*** This section should begin with a general discussion of uncertainty. If a qualitative uncertainty analysis is being performed, "small," "moderate," and "large" uncertainties should be defined and the following subsections should be included. If a quantitative uncertainty analysis is being performed, the methods and results should be described in detail. Normally, a qualitative analysis, including sensitivity analyses, will be sufficient. Regardless, this section should continue with a discussion of each of the uncertainties affecting the major portions of the risk assessment. (Note, the uncertainties listed below are some of those found in past assessments. The uncertainties to be addressed in future assessments must be determined on a case-by-case basis.)

6.1 Uncertainties Associated with Data

*** The uncertainties to be discussed should be summarized in the introduction of this section. Categories of uncertainties to discuss are presented in the following.

6.1.1 Selection of Chemicals of Potential Concern
6.1.2 Determination of Exposure Point Concentrations—Current Conditions
6.1.3 Determination of Exposure Point Concentrations—Future Conditions
6.1.4 Use of Unfiltered versus Filtered Water Samples

6.2 Uncertainties Associated with Exposure Assessment

*** The uncertainties to be discussed should be summarized in the introduction of this section. Categories of uncertainties to discuss are presented in the following.

6.2.1 Uncertainties in Fate and Transport Modeling
6.2.2 Uncertainties in Use of Reasonable Maximum Exposure (RME) Scenarios

6.2.3 Uncertainties Related to Development of Conceptual Site Models
6.2.4 Uncertainties Related to Use of Default Values When Estimating Dermal Absorbed Dose

6.3 Uncertainties Associated with Toxicity Assessment

*** The uncertainties to be discussed should be summarized in the introduction of this section. Categories of uncertainties to discuss are presented in the following.

6.3.1 Uncertainties Due to Lack of Toxicity Values for Some Chemicals
6.3.2 Uncertainties in Deriving Toxicity Values
6.3.3 Uncertainties Due to Calculation of Absorbed Dose Toxicity Values from Administered Toxicity Values
6.3.4 Uncertainties Due to Use of Toxicity Values for Chronic Exposure for Subchronic Exposure Times

6.4 Uncertainties Associated with Risk Characterization

*** The uncertainties to be discussed should be summarized in the introduction of this section. Categories of uncertainties to discuss are presented in the following.

6.4.1 Uncertainties in Combining Chemical-Specific Risk and Hazard Estimates and Pathway-Specific Risk and Hazard Estimates
6.4.2 Uncertainties in Combining Risk Estimated for Chemical Exposure to those for Risk Estimated for Radioisotope Exposure

6.5 Summary of Uncertainties

*** This section should summarize the uncertainties discussed earlier in the section and present a table reviewing all uncertainties.

7. Conclusions and Summary

*** The purpose of this section is to review the results of the risk assessment without the use of tables and explanations and provide significant observations interpreting the results of the assessment for use by risk managers. When properly presented, it should be possible to insert this section as written into the feasibility study.

7.1 Chemicals of Potential Concern

*** A brief description of the screening process should be provided, and the chemicals of potential concern for each area or unit listed either by name (if the list is short) or by class.

7.2 Exposure Assessment

*** The exposure pathways quantitatively evaluated should be listed for each use scenario

7.3 Toxicity Assessment

*** The amount of available toxicity data for the chemicals of potential concern for each area should be listed. Chemicals of potential concern lacking toxicity values should be highlighted.

7.4 Risk Characterization

*** The use scenarios, chemicals, pathways, and media of concern should be listed for each area or unit, and the rules used to delineate the use scenarios, chemicals, pathways, and media of concern should be presented.

7.5 Observations

*** This section should integrate the risk estimates and the uncertainties to develop a list of salient issues to be considered by risk managers when making decisions in risk management documents. This includes a discussion for each of the chemicals of concern identified in the risk assessment. In addition, the results of the baseline human health risk assessment should be compared to results of previous risk evaluations, if any.

8 Remedial Goal Options

*** This section should present the methods used to derive the remedial goal options and list the remedial goal options for each chemical of concern. Because remedial goal options are medium- and scenario-specific, a separate list should be presented for each area (or unit), scenario, and medium combination.

8.1 Derivation of RGOs

*** This presentation should be as brief as possible.

8.2 Presentation of RGOs

*** These should be presented in tables. Very little narrative beyond directing the reader to the appropriate tables is needed.

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APPENDIX D

EXPOSURE EQUATIONS

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EXPOSURE EQUATIONS

This appendix contains the exposure equations used in environmental human health risk assessments for Department of Energy sites located at the Paducah Gaseous Diffusion Plant (PGDP). It should be noted that the equations shown in this appendix may not be the same as those used in preliminary remediation goal (PRG) calculations. PRG calculations were taken from the Risk Assessment Information System (RAIS) PRG calculator available at http://rais.ornl.gov/.

The equations in this appendix are consistent with all Region 4 U.S. Environmental Protection Agency (EPA) and Commonwealth of Kentucky guidance materials. Unless otherwise noted, equations are from EPA's Risk Assessment Guidance for Superfund, Volume 1 (EPA 1989). The exposure parameters are those used to produce daily intakes and absorbed doses used to complete environmental risk assessments performed for PGDP only. These exposure parameters are for a default reasonable maximum exposure (RME). While these exposure parameters generally are consistent with the exposure parameters recommended by Region 4 EPA, they do differ in some cases, as determined by the PGDP Risk Assessment Working Group. The source of each value is provided below the equation. Equations to complete dose assessments and to derive dose conversion factors are not presented; however, these can be derived from the information provided here.

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TABLES

Table D.1. Reasonable Maximum Exposure Assumptions for Ingestion of Water

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_w \times IR \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_w \times IR \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Radiological activity concentration in water = $\mathbf{A_w}$	pCi/L	Chemical-specific	-----
Ingestion rate = **IR**	L/day	See Table B.4	-----
Exposure frequency = **EF**	days/year	See Table B.4	-----
Exposure duration = **ED**	years	See Table B.4	-----
Body weight = **BW**	kg	See Table B.4	-----
Averaging time = **AT**	yr × day/yr	See Table B.4	-----

[a] References (noted in brackets [ ]) follow Table D.30.

NOTE: Because future use of groundwater at the PGDP is uncertain, the industrial worker exposure to groundwater scenario is provided for informational purposes only. This hypothetical future exposure pathway (i.e., the industrial worker) should represent in most, if not all, locations an incomplete exposure pathway.

Table D.2. Reasonable Maximum Exposure Assumptions for Inhalation of Volatile Organic Compounds in Water during Household Use (including Showering) [a]

Equations:

$$\text{Exposure Concentration } (\mu g/m^3) = \frac{[(C_{shower} \times EF \times ET_{shower}) + (C_{house} \times EF \times ET_{house})] \times ED}{AT} \times CF$$

$$C_{shower}\ (mg/m^3) = \frac{[(C_{amax}/2) \times t_1] + [C_{amax} \times t_2]}{t_1 + t_2}$$

$$C_{amax}\ (mg/m^3) = \frac{C_{gw} \times f_{shower} \times F_w \times t_1}{V_a}$$

$$C_{house}\ (mg/m^3) = \frac{C_{gw} \times WHF \times f_{house}}{HV \times ER \times MC}$$

Parameter	Units	Value used	References[b]
Time-adjusted concentration in shower = $\mathbf{C_{shower}}$	mg/m^3	Chemical-specific	Calculated
Indoor inhalation rate = $\mathbf{IR_{air}}$	m^3/hour	See Table B.4	-----
Exposure frequency = **EF**	day/year	See Table B.4	-----
Exposure duration = **ED**	years	See Table B.4	-----
Conversion factor = **CF**	µg/mg	1,000	-----
Exposure Time = $\mathbf{ET_{shower}}$	hours/day	See Table B.4	-----
Exposure Time = $\mathbf{ET_{house}}$	hours/day	See Table B.4	-----
Averaging time = **AT**	h/day × yr × day/yr	See Table B.4	-----
Maximum air concentration = $\mathbf{C_{amax}}$	mg/m^3	Chemical-specific	Calculated
Time of shower = $\mathbf{t_1}$	hour	See Table B.4	-----
Time after shower = $\mathbf{t_2}$	hour	See Table B.4	-----
Concentration in groundwater = $\mathbf{C_{gw}}$	mg/L	Chemical-specific	-----
Fraction volatilized = $\mathbf{f_{shower}}$	unitless	See Table B.4	-----
Water flow rate = $\mathbf{F_w}$	L/h	See Table B.4	-----
Bathroom volume = $\mathbf{V_a}$	m^3	See Table B.4	-----
Concentration in household air = $\mathbf{C_{house}}$	mg/m^3	Chemical-specific	Calculated
Water flow rate = **WHF**	L/day	See Table B.4	-----
Fraction volatilized = $\mathbf{f_{house}}$	unitless	See Table B.4	-----
House volume = **HV**	m^3/change	See Table B.4	-----
Exchange rate = **ER**	changes/day	See Table B.4	-----
Mixing coefficient = **MC**	unitless	See Table B.4	-----

[a] Equations from [1], [14], [33], and [38].
[b] References (noted in brackets [ ]) follow Table D.30.

NOTE: Because future use of groundwater at the PGDP is uncertain, the industrial worker exposure to groundwater scenario is provided for informational purposes only. This hypothetical future exposure pathway (i.e., the industrial worker) should represent in most, if not all, locations an incomplete exposure pathway. Household use for the industrial worker is assumed to be zero.

Table D.3. Reasonable Maximum Exposure Assumptions for Dermal Contact with Water while Showering

Equation:

$$\text{Absorbed Dose Inorganic } [\text{mg}/(\text{kg} \times \text{day})] = \frac{C_w \times SA \times K_p \times CF \times ED \times EF \times ET \times EV}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[\text{mg}/(\text{kg} \times \text{day})] = \frac{DA_{event} \times SA \times CF \times ED \times EF \times EV}{BW \times AT}$$

DA_{event} (mg/cm^2-event) is calculated for organic compounds as follows :

$$\text{If } t_{event} \leq t^*, \text{ then: } DA_{event} = 2\ FA \times K_p \times C_w \sqrt{\frac{6\ \tau_{event} \times t_{event}}{\pi}}$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = FA \times K_p \times C_w \left[\frac{t_{event}}{1 + B} + 2\ \tau_{event} \left(\frac{1 + 3\ B + 3\ B^2}{(1 + B)^2}\right)\right]$$

Parameter	Units	Value used	References[a]
Chemical concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Skin surface area exposed = **SA**	m^2	See Table B.4	-----
Skin permeability constant = $\mathbf{K_p}$	cm/hr	See Table B.5	[40]
Absorbed dose per event = $\mathbf{DA_{event}}$	mg/cm^2-event	Chemical-specific× $\mathbf{C_w}$	[34]
Fraction absorbed= F**A**	unitless	See Table B.4	-----
Event time = $\mathbf{t_{event}}$	hrs/event	Corresponds to **ET**	-----
Time to reach steady-state = **t***	hr	Chemical-specific	-----
Lag time per event = $\boldsymbol{\tau_{event}}$	hr/event	Chemical-specific	-----
Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis = **B**	dimensionless	Chemical-specific	-----
Conversion Factor = **CF**	(L-m)/(cm-m^3)	10	-----
Exposure duration = **ED**	years	See Table B.4	-----
Exposure frequency = **EF**	days/yr	See Table B.4	-----
Exposure time = **ET**	hrs/event	See Table B.4	-----
Event = **EV**	events/day	See Table B.4	-----
Body weight = **BW**	kg	See Table B.4	-----
Averaging time = **AT**	yr × day/yr	See Table B.4	-----

[a] References (noted in brackets [ ]) follow Table D.30.

NOTE: Because future use of groundwater at the PGDP is uncertain, the industrial worker exposure to groundwater scenario is provided for informational purposes only. This hypothetical future exposure pathway (i.e., the industrial worker) should represent in most, if not all, locations an incomplete exposure pathway.

Table D.4. Reasonable Maximum Exposure Assumptions for Incidental Ingestion of Soil/Sediment

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_s \times CF \times EF \times FI \times ED \times IR}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = \frac{A_s \times CF_{rad} \times EF \times FI \times ED \times IR \times (1 - e^{-\lambda \times ED})}{ED \times \lambda}$$

Parameter	Units	Value used	References[a]
Chemical concentration in soil/sediment = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Radiological activity concentration in soil/sediment = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Conversion factor = **CF**	kg/mg	0.000001	-----
Conversion factor = $\mathbf{CF_{rad}}$	g/mg	0.001	-----
Exposure frequency = **EF**	days/yr	See Table B.4	-----
Fraction ingested = **FI**	unitless	See Table B.4	-----
Exposure duration = **ED**	years	See Table B.4	-----
Ingestion rate = **IR**	mg/day	See Table B.4	-----
Body weight = **BW**	kg	See Table B.4	-----
Averaging time = **AT**	yr × day/yr	See Table B.4	-----
Decay constant = $\boldsymbol{\lambda}$	unitless	See Table B.4	-----

[a] References (noted in brackets [ ]) follow Table D.30.

NOTE: For the construction/excavation worker scenario, the ED and EF can be reduced and documented on a site-specific basis, based on guidance from the Exposure Factors Handbook or similar RAWG-approved guidance, and included in the uncertainties section of the baseline human health risk assessment.

Table D.5. Reasonable Maximum Exposure Assumptions for Dermal Contact with Soil/Sediment

Equation:

$$\text{Absorbed Dose}\ [\text{mg/(kg} \times \text{day)}] = \frac{C_s \times CF_d \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Parameter	**Units**	**Value used**	**References**[a]
Chemical concentration in soil/sediment = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Conversion factor = $\mathbf{CF_d}$	(kg-cm^2)/(mg-m^2)	0.01	-----
Surface area = **SA**	m^2/day	See Table B.4	-----
Adherence factor = **AF**	mg/cm^2	See Table B.4	-----
Absorption factor = **ABS**	unitless	See Table B.5	[14]
Exposure frequency = **EF**	day/yr	See Table B.4	-----
Exposure duration = **ED**	years	See Table B.4	-----
Body weight = **BW**	kg	See Table B.4	-----
Averaging time = **AT**	yr × day/yr	See Table B.4	-----

[a] References (noted in brackets [ ]) follow Table D.30.

NOTES:
1. Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].
2. For the construction/excavation worker scenario, the ED and EF can be reduced and documented on a site-specific basis, based on guidance from the Exposure Factors Handbook or similar RAWG-approved guidance, and included in the uncertainties section of the baseline human health risk assessment.

Table D.6. Reasonable Maximum Exposure Assumptions for Inhalation of Vapors and Particulates Emitted from Soil/Sediment[a]

Equations:

$$\text{Exposure Concentration } (\mu\text{g/m}^3) = \frac{C_s \times EF \times ED \times ET \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)}{AT} \times CF_1$$

$$\text{Radionuclide Intake (pCi)} = \frac{A_s \times EF \times ED \times ET \times CF_2 \times \left(\frac{1}{PEF}\right) \times (1 - e^{-\lambda \times ED})}{ED \times \lambda}$$

Parameter	**Units**	**Value used**	**References[b]**
Chemical concentration in soil/sediment = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Activity concentration in soil/sediment = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Exposure frequency = **EF**	days/year	See Table B.4	-----
Exposure duration = **ED**	years	See Table B.4	-----
Exposure time = **ET**	hours/day	See Table B.4	-----
Conversion factor = $\mathbf{CF_1}$	µg/mg	1,000	-----
Conversion factor = $\mathbf{CF_2}$	g/kg	1,000	-----
Volatilization factor = **VF**	m^3/kg	Chemical-specific	[18]
Particulate emission factor = **PEF**	m^3/kg	See Table B.4	-----
Averaging time = **AT**	hours/day × yr × day/yr	See Table B.4	-----
Decay constant = **λ**	unitless	See Table B.4	-----

[a] Equation from [38].
[b] References (noted in brackets [ ]) follow Table D.30.

NOTE: For the construction/excavation worker scenario, the ED and EF can be reduced and documented on a site-specific basis, based on guidance from the Exposure Factors Handbook or similar RAWG-approved guidance, and included in the uncertainties section of the baseline human health risk assessment.

Table D.7. Reasonable Maximum Exposure Assumptions for External Exposure to Ionizing Radiation from Soil/Sediment[a]

Equation:

$$\text{Absorbed Dose } [(\text{pCi} \times \text{year})/\text{g}] = \frac{A_s \times ED \times EF \times (1 - S_e) \times T_e \times (1 - e^{-\lambda \times ED})}{ED \times \lambda}$$

Parameter	Units	Value used	References[b]
Radiological activity concentration in soil/sediment = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Exposure duration = **ED**	year	See Table B.4	-----
Exposure frequency = **EF**	(days/year)/(days/year)	See Table B.4	-----
Gamma shielding factor = $\mathbf{S_e}$	unitless	See Table B.4	-----
Gamma exposure time factor = $\mathbf{T_e}$	(hour/day)/(hour/day)	See Table B.4	-----
Decay constant = $\boldsymbol{\lambda}$	unitless	See Table B.4	-----

[a] Equation from [19].
[b] References (noted in brackets [ ]) follow Table D.30.

NOTE: For the construction/excavation worker scenario, the ED and EF can be reduced and documented on a site-specific basis, based on guidance from the Exposure Factors Handbook or similar RAWG-approved guidance, and included in the uncertainties section of the baseline human health risk assessment.

Table D.8. Reasonable Maximum Exposure Assumptions for Incidental Ingestion of Surface Water while Swimming[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_w \times IR \times ET \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_w \times IR \times ET \times EF \times ED$$

Parameter	Units	Value used	References[b]
Chemical concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Radiological activity concentration in water = $\mathbf{A_w}$	pCi/L	Chemical-specific	-----
Ingestion rate = **IR**	L/hour	See Table B.4	-----
Exposure time = **ET**	hours/day	See Table B.4	-----
Exposure frequency = **EF**	days/year	See Table B.4	-----
Exposure duration = **ED**	years	See Table B.4	-----
Body weight = **BW**	kg	See Table B.4	-----
Averaging time = **AT**	year × day/year	See Table B.4	-----

[a] Equation intended for recreational users.
[b] References (noted in brackets [ ]) follow Table D.30.

Table D.9. Reasonable Maximum Exposure Assumptions for Dermal Contact with Surface Water (Wading)[a]

Equation:

$$\text{Absorbed Dose Inorganic } [\text{mg}/(\text{kg} \times \text{day})] = \frac{C_w \times SA \times K_p \times CF \times ED \times EF \times ET}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[\text{mg}/(\text{kg} \times \text{day})] = \frac{DA_{event} \times SA \times CF \times ED \times EF \times EV}{BW \times AT}$$

DA_{event} (mg/cm^2-event) is calculated for organic compounds as follows :

$$\text{If } t_{event} \leq t^*, \text{ then: } DA_{event} = 2\ FA \times K_p \times C_w \sqrt{\frac{6\ \tau_{event} \times t_{event}}{\pi}}$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = FA \times K_p \times C_w \left[\frac{t_{event}}{1+B} + 2\ \tau_{event}\left(\frac{1+3\ B+3\ B^2}{(1+B)^2}\right)\right]$$

Parameter	Units	Value used	References[b]
Chemical concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Surface area = **SA**	m^2	See Table B.4	-----
Conversion factor = **CF**	L/(cm - m^2)	10	-----
Skin permeability constant = $\mathbf{K_p}$	cm/hour	See Table B.5	[40]
Absorbed dose per event = $\mathbf{DA_{event}}$	mg/cm^2-event	Chemical-specific× $\mathbf{C_w}$	[34]
Fraction absorbed= FA	unitless	See Table B.4	-----
Event time = $\mathbf{t_{event}}$	hrs/event	Corresponds to **ET**	-----
Time to reach steady-state = **t***	hr	Chemical-specific	-----
Lag time per event = $\boldsymbol{\tau_{event}}$	hr/event	Chemical-specific	-----
Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis = **B**	dimensionless	Chemical-specific	-----
Exposure duration = **ED**	years	See Table B.4	-----
Exposure Frequency = **EF**	days/year	See Table B.4	-----
Exposure time = **ET**	hours/day	See Table B.4	-----
Event **= EV**	events/day	See Table B.4	-----
Body weight = **BW**	kg	See Table B.4	-----
Averaging time = **AT**	year × day/year	See Table B.4	-----

[a] Equation intended for recreational users, industrial workers, outdoor workers, and excavation workers.
[b] References (noted in brackets [ ]) follow Table D.30.

NOTES:
1. Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].
2. For the construction/excavation worker scenario, the ED and EF can be reduced and documented on a site-specific basis, based on guidance from the Exposure Factors Handbook or similar RAWG-approved guidance, and included in the uncertainties section of the baseline human health risk assessment.

Table D.10. Reasonable Maximum Exposure Assumptions for Dermal Contact with Surface Water (Swimming)[a]

Equation:

$$\text{Absorbed Dose Inorganic } [mg/(kg \times day)] = \frac{C_w \times SA \times K_p \times CF \times ED \times EF \times ET}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[mg/(kg \times day)] = \frac{DA_{event} \times SA \times CF \times ED \times EF \times EV}{BW \times AT}$$

DA_{event} (mg/cm^2-event) is calculated for organic compounds as follows :

$$\text{If } t_{event} \leq t^*, \text{ then: } DA_{event} = 2\ FA \times K_p \times C_w \sqrt{\frac{6\ \tau_{event} \times t_{event}}{\pi}}$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = FA \times K_p \times C_w \left[\frac{t_{event}}{1+B} + 2\ \tau_{event}\left(\frac{1+3\ B+3\ B^2}{(1+B)^2}\right)\right]$$

Parameter	Units	Value used	References[b]
Chemical concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Surface area = **SA**	m^2	See Table B.4	-----
Conversion factor = **CF**	L/(cm - m^2)	10	-----
Skin permeability constant = $\mathbf{K_p}$	cm/hour	See Table B.5	[40]
Absorbed dose per event = $\mathbf{DA_{event}}$	mg/cm^2-event	Chemical-specific× $\mathbf{C_w}$	[34]
Fraction absorbed= F**A**	unitless	See Table B.4	-----
Event time = $\mathbf{t_{event}}$	hrs/event	Corresponds to **ET**	-----
Time to reach steady-state = **t***	hr	Chemical-specific	-----
Lag time per event = $\boldsymbol{\tau_{event}}$	hr/event	Chemical-specific	-----
Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis = **B**	dimensionless	Chemical-specific	-----
Exposure duration = **ED**	years	See Table B.4	-----
Exposure Frequency = **EF**	day/year	See Table B.4	-----
Exposure time = **ET**	hour/day	See Table B.4	-----
Event **= EV**	event/day	See Table B.4	-----
Body weight = **BW**	kg	See Table B.4	-----
Averaging time = **AT**	year × day/year	See Table B.4	-----

[a] Equation intended for recreational users.
[b] References (noted in brackets [ ]) follow Table D.30.

NOTE: Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].

Table D.11. Reasonable Maximum Exposure Assumptions for Consumption of Fish

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{fish} \times FI_f \times IR_f \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{fish} \times FI_f \times IR_f \times EF \times ED$$

Parameter	**Units**	**Value used**	**References[a]**
Chemical concentration in fish = $\mathbf{C_{fish}}$	mg/kg	Chemical-specific	See Table D.12
Radiological activity concentration in fish = $\mathbf{A_{fish}}$	pCi/kg	Chemical-specific	See Table D.12
Fish ingestion rate = $\mathbf{IR_f}$	kg/day	See Table B.4	----
Diet fraction = $\mathbf{FI_f}$	unitless	See Table B.4	----
Exposure frequency = **EF**	days/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.12. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Fish

Equation:

$$C_{fish} = C_{sw} \times BAF_{fish}$$

Parameter	**Units**	**Value used**	**References**
Chemical concentration or radiological activity concentration in fish = $\mathbf{C_{fish}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Chemical concentration or radiological activity concentration in water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Bioaccumulation factor = $\mathbf{BAF_{fish}}$	L/kg	Chemical-specific See Appendix E	[40]

Table D.13. Reasonable Maximum Exposure Assumptions for Consumption of Deer

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{deer} \times FI_d \times IR_d \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{deer} \times FI_d \times IR_d \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in deer = $\mathbf{C_{deer}}$	mg/kg	Chemical-specific	See Table D.14
Radiological activity concentration in deer = $\mathbf{A_{deer}}$	pCi/kg	Chemical-specific	See Table D.14
Deer ingestion rate = $\mathbf{IR_d}$	kg/day	See Table B.4	----
Diet fraction = $\mathbf{FI_d}$	unitless	See Table B.4	----
Exposure frequency = **EF**	day/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.14. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Deer[a]

Equations:

$$C_{deer} = F_{deer} \times [(C_{forage} \times CF_{rad} \times AC \times f_s \times Q_f) + (C_s \times CF_{rad} \times AC \times Q_s) + (C_{sw} \times Q_{sw})]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration or radiological activity concentration in deer = $\mathbf{C_{deer}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-deer transfer factor = $\mathbf{F_{deer}}$	day/kg	Chemical-specific	use $\mathbf{F_{beef}}$ values
Chemical concentration or radiological activity concentration in forage = $\mathbf{C_{forage}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Area of contact[c] = **AC**	unitless	**AS/AD**	-----
Area of SWMU = **AS**	acres	SWMU-specific	-----
Area of deer range = **AD**	acres	494	[31]
Fraction of deer's food from site when on-site = $\mathbf{f_s}$	unitless	1.0	[5]
Quantity of forage ingested daily by deer = $\mathbf{Q_f}$	kg/day	1.74	[7]
Chemical concentration or radiological activity concentration in soil or sediment = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of soil ingested daily by deer = $\mathbf{Q_s}$	kg/day	0.034	[6]; 2% of forage
Contaminant concentration or radiological activity concentration in surface water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Quantity of surface water ingested daily by deer[d] = $\mathbf{Q_{sw}}$	L/day	3.61	[8]
Soil to plant uptake (dry) = $\mathbf{R_{upp}}$	unitless	Chemical-specific or $38 \times K_{ow}^{-0.58}$	[8]
Soil resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.25	[3]

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.
[d] All ingested water is assumed to be from SWMU or SWMU area.

Table D.15. Reasonable Maximum Exposure Assumptions for Consumption of Rabbit

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{rabbit} \times FI_r \times IR_r \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{rabbit} \times FI_r \times IR_r \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in rabbit = $\mathbf{C_{rabbit}}$	mg/kg	Chemical-specific	See Table D.16
Radiological activity concentration in rabbit = $\mathbf{A_{rabbit}}$	pCi/kg	Chemical-specific	See Table D.16
Rabbit ingestion rate = $\mathbf{IR_r}$	kg/meal	See Table B.4	----
Diet fraction = $\mathbf{FI_r}$	unitless	See Table B.4	----
Exposure frequency = **EF**	meals/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.16. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Rabbit[a]

Equations:

$$C_{rabbit} = F_{rabbit} \times [(C_{forage} \times CF_{rad} \times AC \times f_s \times Q_f) + (C_s \times CF_{rad} \times AC \times Q_s) + (C_{sw} \times Q_{sw})]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration or radiological activity concentration in rabbit = $\mathbf{C_{rabbit}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-rabbit transfer factor = $\mathbf{F_{rabbit}}$	day/kg	Chemical-specific	use $\mathbf{F_{beef}}$ values
Chemical concentration or radiological activity concentration in forage = $\mathbf{C_{forage}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Area of contact[c] = **AC**	unitless	**AS/AR**	-----
Area of SWMU = **AS**	acres	SWMU-specific	-----
Area of rabbit range = **AR**	acres	3.6	[28]
Fraction of rabbit's food from site when on-site = $\mathbf{f_s}$	unitless	1.0	-----
Quantity of forage ingested daily by rabbit = $\mathbf{Q_f}$	kg/day	0.237	[29]
Chemical concentration or radiological activity concentration in soil or sediment = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of soil ingested daily by rabbit = $\mathbf{Q_s}$	kg/day	0.0149	[29] 6.3% of forage
Contaminant concentration in surface water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Quantity of surface water ingested daily by rabbit[d] = $\mathbf{Q_{sw}}$	L/day	0.116	[29]
Soil to plant uptake (dry) = $\mathbf{R_{upp}}$	unitless	Chemical-specific or $38 \times K_{ow}^{-0.58}$	[8]
Soil resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.25	[3]

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.
[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.17. Reasonable Maximum Exposure Assumptions for Consumption of Quail

Equations:

$$\text{Chemical Intake}\,[\text{mg}/(\text{kg}\times\text{day})] = \frac{C_{quail}\times FI_q \times IR_q \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{quail}\times FI_q \times IR_q \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in quail = $\mathbf{C_{quail}}$	mg/kg	Chemical-specific	See Table D.18
Radiological activity concentration in quail = $\mathbf{A_{quail}}$	pCi/kg	Chemical-specific	See Table D.18
Quail ingestion rate = $\mathbf{IR_q}$	kg/meal	See Table B.4	----
Diet fraction = $\mathbf{FI_q}$	unitless	See Table B.4	----
Exposure frequency = **EF**	meals/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.18. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Quail[a]

Equations:

$$C_{quail} = F_{quail} \times [(C_{forage} \times CF_{rad} \times AC \times f_s \times Q_f) + (C_s \times CF_{rad} \times AC \times Q_s) + (C_{sw} \times Q_{sw}) + (C_i \times CF_{rad} \times AC \times Q_i)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es}) \qquad C_i = (C_s \times BAF_i)$$

Parameter	Units	Value used	References[b]
Chemical concentration or radiological activity concentration in quail = $\mathbf{C_{quail}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-quail transfer factor = $\mathbf{F_{quail}}$	day/kg	Chemical-specific	use $\mathbf{F_{poultry}}$ values
Chemical concentration or radiological activity concentration in forage = $\mathbf{C_{forage}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Area of contact[c] = **AC**	unitless	AS/AQ	-----
Area of SWMU = **AS**	acres	SWMU-specific	-----
Area of quail range = **AQ**	acres	15.4	[28]
Fraction of quail's food from site when on-site = $\mathbf{f_s}$	unitless	1.0	-----
Quantity of forage ingested daily by quail = $\mathbf{Q_f}$	kg/day	0.01499	[28] 88.2% of total food
Chemical concentration or radiological activity concentration in invertebrates = $\mathbf{C_i}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of invertebrates ingested daily by quail = $\mathbf{Q_i}$	kg/day	0.002006	[28] 11.8% of total food
Chemical concentration or radiological activity concentration in soil or sediment = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of soil ingested daily by quail = $\mathbf{Q_s}$	kg/day	0.00195	[17]
Contaminant concentration or radiological activity concentration in surface water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Quantity of surface water ingested daily by quail[d] = $\mathbf{Q_{sw}}$	L/day	0.02	[17]
Soil to plant uptake (dry) = $\mathbf{R_{upp}}$	unitless	Chemical-specific or $38 \times K_{ow}^{-0.58}$	[8]
Soil resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.25	[3]

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.
[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.19. Reasonable Maximum Exposure Assumptions for Consumption of Homegrown Vegetables

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{\text{vegetables}} \times FI_v \times IR_v \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{\text{vegetables}} \times FI_v \times IR_v \times EF \times ED$$

Parameter	**Units**	**Value used**	**References**[a]
Chemical concentration in vegetables = $\mathbf{C_{vegetables}}$	mg/kg	Chemical-specific	See Table D.20
Radiological activity concentration in vegetables = $\mathbf{A_{vegetables}}$	pCi/kg	Chemical-specific	See Table D.20
Diet fraction = $\mathbf{FI_v}$	unitless	See Table B.4	----
Vegetable ingestion rate = $\mathbf{IR_v}$	kg/day	See Table B.4	----
Exposure frequency = **EF**	days/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.20. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Homegrown Vegetables[a]

Equations:

$$C_{vegetables} = (C_w \times Irr_{rup}) + (C_s \times CF_{rad} \times AC \times R_{upv}) + (C_w \times Irr_{res}) + (C_s \times CF_{rad} \times AC \times R_{es}) + (C_w \times Irr_{dep})$$

$$Irr_{rup} = \frac{Ir \times F \times Bv_{wet} \times [1 - \exp(-\lambda_B \times t_b)]}{P \times \lambda_B}$$

$$Irr_{dep} = \frac{Ir \times F \times I_f \times T \times [1 - \exp(-\lambda_E \times t_v)]}{Y_v \times \lambda_E}$$

$$Irr_{res} = \frac{Ir \times F \times MLF \times [1 - \exp(-\lambda_B \times t_b)]}{P \times \lambda_B}$$

Parameter	Units	Value used	References[b]
Chemical concentration or radiological activity concentration in vegetable = $\mathbf{C_{vegetables}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Chemical concentration or radiological activity concentration in groundwater = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Root uptake from irrigation = $\mathbf{Irr_{rup}}$	L/kg	Chemical-specific	Calculated
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Chemical concentration or radiological activity concentration in soil = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Area of contact[c] = **AC**	unitless	**AS/AG**	-----
Area of SWMU = **AS**	acres	SWMU-specific	-----
Area of garden = **AG**	acres	0.25	[30]
Wet root uptake for leafy vegetables = $\mathbf{R_{upv}}$	kg/kg	Chemical-specific	[41]
Resuspension from irrigation = $\mathbf{Irr_{res}}$	L/kg	Chemical-specific	Calculated
Resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.26	[9]
Aerial deposition from irrigation = $\mathbf{Irr_{dep}}$	L/kg	Chemical-specific	Calculated
Irrigation rate = **Ir**	L/m^2-day	3.62	[10]
Irrigation period = **F**	unitless	0.25	[10]; 3 months a year
Soil to plant uptake, wet weight = $\mathbf{Bv_{wet}}$	kg/kg	Chemical-specific or $7.7 \times K_{ow}^{-0.58}$	[11]
Effective rate for removal = $\boldsymbol{\lambda_B}$	1/day	$\lambda_i + \lambda_{HL}$	[11]
Decay = $\boldsymbol{\lambda_i}$	1/day	$0.693/T_r$	[11]
Half-life = $\mathbf{T_r}$	day	Chemical-specific	[40]
Soil leaching rate = $\boldsymbol{\lambda_{HL}}$	1/day	2.7×10^{-5}	[11]
Long-term deposition and build-up = $\mathbf{t_b}$	day	10,950	[2]
Area density for root zone = **P**	kg/m^2	240	[8], [12], [13]
Plant mass leading factor = **MLF**	unitless	0.26	[9]
Interception fraction = $\mathbf{I_f}$	unitless	0.42	[7]
Translocation factor = **T**	unitless	1	[2]
Decay for removal on produce = $\boldsymbol{\lambda_E}$	1/day	$\lambda_i + (0.693/t_w)$	[11]
Weathering half-life = $\mathbf{t_w}$	day	14	[2]
Above ground exposure time = $\mathbf{t_v}$	day	60	[2]
Plant yield (wet) = $\mathbf{Y_v}$	kg/m^2	2	[2]

[a] Equations after [1], [2], [3], [4].
[b] References (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.

Table D.21. Reasonable Maximum Exposure Assumptions for Consumption of Beef

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{beef} \times FI_b \times IR_b \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{beef} \times FI_b \times IR_b \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in beef = $\mathbf{C_{beef}}$	mg/kg	Chemical-specific	See Table D.22
Radiological activity concentration in beef = $\mathbf{A_{beef}}$	pCi/kg	Chemical-specific	See Table D.22
Beef ingestion rate = $\mathbf{IR_b}$	kg/day	See Table B.4	----
Diet fraction = $\mathbf{FI_b}$	unitless	See Table B.4	----
Exposure frequency = **EF**	days/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.22. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Beef[a]

Equations:

$$C_{beef} = F_{beef} \times [(C_{forage} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_w \times CF_{rad} \times Q_w)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	**Units**	**Value used**	**References[b]**
Chemical concentration or radiological activity concentration in beef = $\mathbf{C_{beef}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-beef transfer factor = $\mathbf{F_{beef}}$	day/kg	Chemical-specific	[41]
Chemical concentration or radiological activity concentration in pasture = $\mathbf{C_{forage}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Area of contact[c] = **AC**	unitless	**AS/AD**	-----
Area of SWMU = **AS**	acres	SWMU-specific	-----
Area of beef range = **AD**	acres	2	[27]
Fraction of beef's food from site when on-site = $\mathbf{f_s}$	unitless	1.0	[5]
Quantity of pasture ingested daily by beef = $\mathbf{Q_f}$	kg/day	25	[23]
Chemical concentration or radiological activity concentration in soil or sediment = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of soil ingested daily by beef = $\mathbf{Q_s}$	kg/day	1	[24]
Contaminant concentration or radiological activity concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Quantity of water ingested daily by beef[d] = $\mathbf{Q_w}$	L/day	50	[23]
Soil to plant uptake (dry) = $\mathbf{R_{upp}}$	unitless	Chemical-specific or $38 \times K_{ow}^{-0.58}$	[8]
Soil resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.25	[3]

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.
[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.23. Reasonable Maximum Exposure Assumptions for Consumption of Milk

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{milk} \times FI_m \times IR_m \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_{milk} \times FI_m \times IR_m \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in milk = $\mathbf{C_{milk}}$	mg/kg	Chemical-specific	See Table D.24
Radiological activity concentration in milk = $\mathbf{A_{milk}}$	pCi/kg	Chemical-specific	See Table D.24
Milk ingestion rate = $\mathbf{IR_m}$	kg/day	See Table B.4	----
Diet fraction = $\mathbf{FI_m}$	unitless	See Table B.4	----
Exposure frequency = **EF**	day/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.24. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Milk[a]

Equations:

$$C_{milk} = F_{milk} \times [(C_{forage} \times CF_{rad} \times AC \times f_s \times Q_f) + (C_s \times CF_{rad} \times AC \times Q_s) + (C_w \times Q_w)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	**Units**	**Value used**	**References[b]**
Chemical concentration or radiological activity concentration in milk = $\mathbf{C_{milk}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-milk transfer factor = $\mathbf{F_{milk}}$	day/kg	Chemical-specific	[41]
Chemical concentration or radiological activity concentration in pasture = $\mathbf{C_{forage}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Area of contact[c] = **AC**	unitless	**AS/AD**	-----
Area of SWMU = **AS**	acres	SWMU-specific	-----
Area of dairy range = **AD**	acres	2	[27]
Fraction of dairy's food from site when on-site = $\mathbf{f_s}$	unitless	1.0	[5]
Quantity of pasture ingested daily by dairy = $\mathbf{Q_f}$	kg/day	25	[23]
Chemical concentration or radiological activity concentration in soil or sediment = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of soil ingested daily by dairy = $\mathbf{Q_s}$	kg/day	1	[24]
Contaminant concentration or radiological activity concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Quantity of water ingested daily by dairy[d] = $\mathbf{Q_w}$	L/day	60	[23]
Soil to plant uptake (dry) = $\mathbf{R_{upp}}$	unitless	Chemical-specific or $38 \times K_{ow}^{-0.58}$	[8]
Soil resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.25	[3]

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.
[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.25. Reasonable Maximum Exposure Assumptions for Consumption of Poultry

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{poultry} \times FI_p \times IR_p \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{poultry} \times FI_p \times IR_p \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in poultry = $\mathbf{C_{poultry}}$	mg/kg	Chemical-specific	See Table D.26
Radiological activity concentration in poultry = $\mathbf{A_{poultry}}$	pCi/kg	Chemical-specific	See Table D.26
Poultry ingestion rate = $\mathbf{IR_p}$	kg/day	See Table B.4	----
Diet fraction = $\mathbf{FI_p}$	unitless	See Table B.4	----
Exposure frequency = **EF**	day/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.26. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Poultry[a]

Equations:

$$C_{poultry} = F_{poultry} \times [(C_{forage} \times CF_{rad} \times AC \times f_s \times Q_f) + (C_s \times CF_{rad} \times AC \times Q_s) + (C_w \times Q_w)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration or radiological activity concentration in poultry = $\mathbf{C_{poultry}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-poultry transfer factor = $\mathbf{F_{poultry}}$	day/kg	Chemical-specific	[32], [39]
Chemical concentration or radiological activity concentration in pasture = $\mathbf{C_{forage}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Area of contact[c] = **AC**	unitless	**AS/AD**	-----
Area of SWMU = **AS**	Acres	SWMU-specific	-----
Area of poultry range = **AD**[d]	Acres	1	[27]
Fraction of poultry's food from site = $\mathbf{f_s}$	unitless	0.5	[27] assumes broilers get 50% bought grain
Quantity of pasture ingested daily by poultry = $\mathbf{Q_f}$	kg/day	0.12 (chicken) 0.35 (turkey)	[22] 20 wk old male turkey
Chemical concentration or radiological activity concentration in soil or sediment = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of soil ingested daily by poultry = $\mathbf{Q_s}$	kg/day	0.0024 (chicken 0.007 (turkey)	[8] same ratio for chicken
Contaminant concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Quantity of water ingested daily by poultry[e] = $\mathbf{Q_w}$	L/day	0.24 (chicken) 1.0 (turkey)	[22] 1:2 ratio of 20 wk old male turkey
Soil to plant uptake (dry) = $\mathbf{R_{upp}}$	unitless	Chemical-specific or $38 \times K_{ow}^{-0.58}$	[8]
Soil resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.25	[3]

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.
[d] Assumes 1 acre of pasture for 200 adult birds with a three year rotation.
[e] All ingested water is considered to be from SWMU or SWMU area.

NOTE: Under this model, poultry raised for use as broilers by subsistence farmers are allowed to forage on pasture where they ingest pasture and soil.

Table D.27. Reasonable Maximum Exposure Assumptions for Consumption of Pork

Equations:

$$\text{Chemical Intake}\,[\text{mg}/(\text{kg}\times\text{day})] = \frac{C_{pork} \times FI_{pork} \times IR_{pork} \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{pork} \times FI_{pork} \times IR_{pork} \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in pork = $\mathbf{C_{pork}}$	mg/kg	Chemical-specific	See Table D.28
Radiological activity concentration in pork = $\mathbf{A_{pork}}$	pCi/kg	Chemical-specific	See Table D.28
Pork ingestion rate = $\mathbf{IR_{pork}}$	kg/day	See Table B.4	----
Diet fraction = $\mathbf{FI_{pork}}$	unitless	See Table B.4	----
Exposure frequency = **EF**	days/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.28. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Pork[a]

Equations:

$$C_{pork} = F_{pork} \times [(C_{forage} \times CF_{rad} \times AC \times f_s \times Q_f) + (C_s \times CF_{rad} \times AC \times Q_s) + (C_w \times Q_w)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration or radiological activity concentration in pork = $\mathbf{C_{pork}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-pork transfer factor = $\mathbf{F_{pork}}$	day/kg	Chemical-specific	[32], [39]
Chemical concentration or radiological activity concentration in pasture = $\mathbf{C_{forage}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Area of contact[c] = **AC**	unitless	**AS/AD**	-----
Area of SWMU = **AS**	acres	SWMU-specific	-----
Area of swine range = **AD**	acres	1	[27]
Fraction of swine's food from site = $\mathbf{f_s}$	unitless	0.4	[27]
Quantity of pasture ingested daily by swine = $\mathbf{Q_f}$	kg/day	2.4	[32]
Chemical concentration or radiological activity concentration in soil or sediment = $\mathbf{C_s}$	mg/kg or pCi/g	Chemical-specific	-----
Quantity of soil ingested daily by swine = $\mathbf{Q_s}$	kg/day	0.034	[26]
Chemical concentration or radiological activity concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	g/kg	1,000	-----
Quantity of water ingested daily by swine[d] = $\mathbf{Q_w}$	L/day	6.14	[25] 2.56 to 1, water to feed ratio
Soil to plant uptake (dry) = $\mathbf{R_{upp}}$	unitless	Chemical-specific or $38 \times K_{ow}^{-0.58}$	[8]
Soil resuspension multiplier = $\mathbf{R_{es}}$	unitless	0.25	[3]

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.
[c] AC cannot be greater than 1.
[d] All ingested water is considered to be from SWMU or SWMU area.

NOTE: According to Morrison (1956), subsistence farmers allow 20% to 40% of the swine's diet to come from pasture, while the remaining comes from store bought grain.

Table D.29. Reasonable Maximum Exposure Assumptions for Consumption of Eggs

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{egg} \times FI_e \times IR_e \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{egg} \times FI_e \times IR_e \times EF \times ED$$

Parameter	Units	Value used	References[a]
Chemical concentration in egg = $\mathbf{C_{egg}}$	mg/kg	Chemical-specific	See Table D.30
Radiological activity concentration in egg = $\mathbf{A_{egg}}$	pCi/kg	Chemical-specific	See Table D.30
Egg ingestion rate = $\mathbf{IR}_e$	kg/day	See Table B.4	----
Diet fraction = $\mathbf{FI_e}$	unitless	See Table B.4	----
Exposure frequency = **EF**	day/year	See Table B.4	----
Exposure duration = **ED**	years	See Table B.4	----
Body weight = **BW**	kg	See Table B.4	----
Averaging time = **AT**	year × day/year	See Table B.4	----

[a] References (noted in brackets [ ]) follow Table D.30.

Table D.30. Reasonable Maximum Exposure Assumptions for Concentration or Activity Concentration of COPCs in Egg[a]

Equations:

$$C_{egg} = F_{egg} \times (C_w \times Q_w)$$

Parameter	Units	Value used	References[b]
Chemical concentration or radiological activity concentration in egg = $\mathbf{C_{egg}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Forage-egg transfer factor = $\mathbf{F_{egg}}$	day/kg	Chemical-specific	[32], [39]
Chemical concentration or radiological activity concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Quantity of water ingested daily by poultry = $\mathbf{Q_w}$	L/day	0.24 (chicken) 1.0 (turkey)	[22] 1:2 ratio of 20 wk old male turkey

[a] Equations after [1], [2], [3], [4].
[b] All references (noted in brackets [ ]) follow Table D.30.

NOTE: Model assumes that laying hens are in a hutch and are not allowed to forage on pasture. Therefore, they eat only store bought grain and are not exposed to pasture or soil. Drinking water is assumed to come from the SWMU or SWMU area.

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APPENDIX E

TECHNICAL INFORMATION (ON CD)

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APPENDIX E

TECHNICAL INFORMATION (CD)

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